

DIVISION 15

HVAC

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## **SECTION 15000 - SCOPE OF WORK:**

- A. This project shall include, but not be limited to the following HVAC improvements:

### North Todd County Elementary School

1. Remove existing split chiller with all associated refrigerant piping, control cabinet, etc... Chiller refrigerant and equipment to be disposed in approved site.
2. Remove existing boiler with all associated hot water piping, wiring, etc... Boiler and equipment to be disposed in approved site.
3. Remove existing pumps, power disconnects, piping and associated controls. Remove existing expansion tanks and associated piping.
4. Remove existing air compressor, air dryer and associated pneumatic control system.
5. Remove and replace existing water heaters located in mechanical room with new.
6. Remove classroom unit ventilator and replace as per new plans. Provide new controls for unit and tie into existing campus controller.
7. Remove existing air handling units serving gymnasium, library and office area. Replace units with new as indicated per plans. Provide new controls for each unit and tie into existing campus controller.
8. See electrical plans for new power connection for all new mechanical equipment.

### South Todd County Elementary School

1. Remove existing split chiller with all associated refrigerant piping, control cabinet, etc... Chiller refrigerant and equipment to be disposed in approved site.
2. Remove existing boiler with all associated hot water piping, wiring, etc... Boiler and equipment to be disposed in approved site.
3. Remove existing pumps, power disconnects, piping and associated controls. Remove existing expansion tanks and associated piping.

4. Remove existing air compressor, air dryer and associated pneumatic control system.
5. Remove and replace existing water heater located in mechanical room with new.
6. Remove classroom unit ventilator and replace as per new plans. Provide new controls for unit and tie into existing campus controller.
7. Remove existing air handling units serving gymnasium, library and office area. Replace units with new as indicated per plans. Provide new controls for each unit and tie into existing campus controller.
8. See electrical plans for new power connection for all new mechanical equipment.

#### Todd County Middle School

1. Remove and replace existing air cooled package chiller with associated refrigerant piping as indicated. Chiller refrigerant and equipment to be disposed in approved site.
2. Remove and replace existing water heaters located in west wing mechanical room with new. See plans for identification of water heaters to remove. Provide all necessary equipment for complete installation.
3. Remove and replace existing split chiller with all associated refrigerant piping, heat exchanger, etc... Chiller refrigerant and equipment to be disposed in approved site.
4. Remove and replace existing gas generator.
5. Remove and replace existing air handling unit serving east wing corridor. Provide new controls for unit and tie into existing campus controller.
6. Remove and replace existing pumps, provide new with variable frequency drives. See drawings for new location of pumps and accessories.
7. Remove and replace existing water heater located in east wing mechanical room with new. Provide all necessary equipment for complete installation.
8. See electrical plans for new power connection for all new mechanical equipment.

Todd County Central High School

1. Remove existing water heater and associated storage tank, replace with new water heater.
2. Remove and replace existing air handling units in gymnasium. Replace with two new gas heat RTU, see plan for location and size.

END OF SECTION 15000

## **SECTION 15006 – DEMOLITION**

### **A. GENERAL**

1. Contractor shall visit the site before submitting a bid to acquaint himself with existing conditions.
2. Work in the building shall be scheduled well in advance with the Owner. Work shall be performed at such times and under such conditions as suit the convenience of the Owner. Plan the work to minimize disruption of normal operations.
3. Equipment to be removed is to be removed from the site.
4. Remove existing ductwork, diffusers, piping, etc. not to be used or that interferes with new work and cap as required.
5. Do not interrupt any utility service, water, sewer, etc., until approval is obtained from Owner's Representative. Reconnect as required.

END OF SECTION 15006

## **SECTION 15010 – BASIC MECHANICAL REQUIREMENTS**

### **PART 1 - GENERAL**

#### **1.01 RELATED DOCUMENTS**

- A. Basic Requirements: Requirements of the Contract Forms, Conditions of the Contract, Specifications, Drawings, and Addenda and Contract Modifications (the Contract Documents),
- B. Conflicts: Nothing contained in this Section shall be construed to conflict in any way with other provisions or requirements of the Contract documents. The intent is that this Section will take precedence. Where differences arise, the Architect shall decide which directions or instructions take precedence.

#### **1.02 SUMMARY**

- A. General: Unless an item is specifically mentioned as being provided by others, the requirements of Division 15 Contract Documents shall be completed. The systems, equipment, devices and accessories shall be installed, finished, tested and adjusted for continuous and proper operation. Any apparatus, material or device not shown on the Drawings but mentioned in these Specifications, or vice versa, or any incidental accessories necessary to make the project complete and operational in all respects, shall be furnished, delivered and installed without additional expense to the Owner. Include all materials, equipment, supervision, operation, methods and labor for the fabrication, installation, start-up and tests necessary for complete and properly functioning systems.

#### **1.03 APPLICABLE STANDARDS**

- A. Code Compliance: Refer to Division 1. As a minimum, unless otherwise indicated, comply with all rules, regulations, standards, codes, ordinances and laws of local, state and federal governments and the amendments and interpretation of such rules, regulations, standards, codes, ordinances and laws of local, state and federal governments by the authorities having lawful jurisdiction.
- B. ADA: Comply with the requirements of the Americans with Disabilities Act (ADA).
- C. Comply: With the National Fire Protection Association (NFPA) Standards and other Codes and Standards as adopted by the Local Authority having Jurisdiction.
- D. Comply: With the National Fire Protection Association (NFPA) Standards and other Codes and Standards indicated
- E. International Building Code: Conform in strict compliance to the International Code Council, Inc. (ICC), International Building Code, 2009 Edition, and the amendments which are enforced by the local authority having jurisdiction.
  - 1. International Mechanical Code, 2012 Edition
  - 2. KY State Plumbing Law, 2013 Edition
  - 3. NFPA National Fuel Gas Code, 2009 Edition

4. International Fire Code, 2012 Edition
  5. International Energy Code, 2012 Edition
- F. Notification: Comply with all of the requirements of the Federal "Right-To-Know" Regulations and the Florida "Right-To-Know" Law and provide notification to all parties concerned as to the use of toxic substances.
- G. Owner Design Guidelines: Comply with all the requirements of the latest Owner MEP Engineering Design Guidelines and the latest Owner Architectural Construction Standards.

#### 1.04 DRAWINGS AND SPECIFICATIONS

- A. Intent: The intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable mechanical systems complete in every respect.
- B. Equipment Placement: The drawings are diagrammatic, intended to show general arrangement, capacity and location of various components, equipment and devices. Each location shall be determined by reference to the general building plans and by actual measurements in the building as built. Reasonable changes in locations ordered by the Architect prior to the performance of the affected Work shall be provided at no additional cost to the Owner.
- C. Drawing Scale: Due to the small scale of the drawings, and to unforeseen job conditions, all required offsets, transitions and fittings may not be shown but shall be provided at no additional cost.
- D. Conflict: In the event of a conflict, the Architect will render an interpretation in accordance with the General Conditions.

#### 1.05 DEFINITIONS

- A. Provide/Install: The word "provide" shall mean furnish, install, connect, test, complete, and leave ready for operation. The word "install" where used in conjunction with equipment furnished by the Owner or under another contract shall mean mount, connect, complete, and leave ready for operation.
- B. Concealed: The surface of insulated or non-insulated piping, ductwork or equipment is concealed from view when standing inside a finished room, such as inside a chase or above a ceiling.
- C. Exposed: The surface of insulated or non-insulated piping, ductwork or equipment is seen from inside a finished room, such as inside an equipment or air handling unit room.
- D. Protected: The surface of insulated or non-insulated piping, ductwork or equipment on the exterior of the building but protected from direct exposure to rain by an overhang, eave, in an unconditioned parking garage or building crawl space.
- E. Unprotected: The surface of insulated or non-insulated piping, ductwork or equipment on the exterior of the building and exposed to rain.

- F. Abbreviations: Abbreviations, where not defined in the Contract Documents, shall be interpreted to mean the normal construction industry terminology, as determined by the Architect. Plural words shall be interpreted as singular and singular words shall be interpreted as plural where applicable for context of the Contract Documents.

#### 1.06 SHOP DRAWINGS

- A. General: Refer to paragraph entitled "SUBMITTAL" in this section. Include the following data:

1. Shop Drawings:
  - a. Submit shop drawings for the following:
    - (1) Each piping system
    - (2) Ductwork systems
    - (3) Coordination drawings

#### 1.07 RECORD DRAWINGS

- A. Production: Maintain one set of black or blue line on white project record "as-built" drawings at the site. At all times the set shall be accurate, clear, and complete, indicating the actual installation. Record drawings shall be updated weekly to record the present stage of progress. These drawings shall be available to the Architect at all times. Equipment schedules, control diagrams, sequences of operation shall also be updated.
- B. Completion: Prior to substantial completion, transfer onto an unmarked second set of drawings all changes, marked in colored pencil, and submit them to the Architect. Upon completion of all punch lists, transfer all "As-Built" conditions to the AutoCAD drawing files, package three (3) print sets of full size drawings and two (2) CDs of the AutoCAD drawing files with associated reference files and submit them to the Architect for review and approval.

#### 1.08 SUBMITTAL

- A. General: The provisions of this section are supplemental to the requirements in Division 1, and only apply to the material and equipment covered in Division 15.
- B. Time: Submit manufacturer's literature, performance data and installation instructions covered in each Section of Division 15 under an individual letter of transmittal within 30 days after Notice to Proceed unless otherwise indicated.
- C. Submitter's Review: All items required for each section shall be reviewed before submittal. Submittal information for each item shall bear a review stamp of approval, indicating the name of the Contractor and Subcontractor (where applicable), the material suppliers, the initials of submitter and date checked. Responsibility for errors or omissions in submittals shall not be relieved by the Architect's review of submittals. Responsibility for submittals cannot be subrogated to material suppliers by Contractors or Subcontractors.
1. Review of the submittal data, whether indicated with "APPROVED" or with review comments, does not constitute authorization for or acceptance of a change in the contract price.



- D. Architect's Review: The submittal data shall be reviewed only for general conformance with the design concept of the project and for general compliance with the Contract Documents. Any action indicated is subject to the requirements of the Contract Documents. Reviews of submittal data review shall not include quantities; dimensions (which shall be confirmed and correlated at the job site); fabrication processes; techniques of construction; and co-ordination of the submittal data with all other trades. Copies of the submittal data will be returned marked "ACCEPTED AS SUBMITTED", "ACCEPTED AS NOTED", "REVISED AS NOTED AND RESUBMIT", "REJECTED, REVISED AS NOTED AND RESUBMIT".
- E. Submittal Items: Submittal items shall be inserted in a Technical Information Brochure. Mark the appropriate specification section or drawing reference number in the right hand corner of each item. All typewritten pages shall be on the product or equipment manufacturer's printed letterhead.
1. Manufacturer's Literature: Where indicated, include the manufacturer's printed literature. Literature shall be clearly marked to indicate the item intended for use.
  2. Performance Data: Provide performance data, wiring and control diagrams and scale drawings which show that proposed equipment will fit into allotted space (indicate areas required for service access, connections, etc.), and other data required for the Architect to determine that the equipment complies with the Contract Documents. Where noted, performance data shall be certified by the manufacturer at the design rating points.
  3. Installation Instructions: Where requested, each product submittal shall include the manufacturer's installation instructions. Generic installation instructions are not acceptable. Instructions shall be the same as those included with the product when it is shipped from the factory.
  4. Written Operating Instructions: Instructions shall be the manufacturer's written operating instructions for the specified product. If the instructions cover more than one model or type of product they shall be clearly marked to identify the instructions that cover the product delivered to the project. Operating Instructions shall be submitted immediately after the product or equipment submittal has been returned from the Architect marked "APPROVED" or "APPROVED AS NOTED".
  5. Maintenance Instructions: Information shall be the manufacturer's printed instructions and parts lists for the equipment furnished. If the instructions cover more than one model or type of equipment they shall be marked to identify the instructions for the furnished product. Submit maintenance instructions immediately after the product or equipment submittal has been returned from the Architect marked "APPROVED" or "APPROVED AS NOTED".
- F. Substitutions:
1. General: Refer to Division 1. Substitutions may be considered for any product or equipment of a manufacturer. See paragraph entitled "MANUFACTURER" in this Section. Any product or equipment may be submitted for review; however, only one substitution per item will be considered. If a substituted product or equipment item is rejected, provide the specified product or equipment.

- a. Submittal shall include the name of the material or equipment to be substituted, equipment model numbers, drawings, catalog cuts, performance and test data and any other data or information necessary for the Architect to determine that the equipment meets the specification requirements. If the Architect accepts any proposed substitutions, such acceptance will be set forth in writing.
  - b. Substituted equipment with all accessories installed or optional equipment where permitted and found acceptable, must conform to space requirements. Substituted equipment that cannot meet space requirements, whether accepted or not, shall be replaced at no additional expense to the Owner. If the substituted item affects the work of other trades, the Request for Substitution form shall include a list of the necessary modifications.
2. Deviations: The Request for Substitution form shall include a complete list of deviations from the scheduled item stating both the features and functions of the scheduled item and the comparable features and functions of the proposed substitution.
  - a. Any deviation not indicated in writing will be assumed to be identical to the specified item even if it is shown otherwise on the submittal data.
  - b. If a deviation not listed is found anytime after review and acceptance by the Architect and that deviation, in the opinion of the Architect, renders the substituted item as unacceptable, the item shall be removed and replaced by the scheduled item at no additional cost to the Owner.
  - c. The Architect shall retain the right to specify modifications to the substituted item, correcting or adjusting for the deviation, if the Architect deems it to be in the best interest of the Owner.
3. Scheduled Item: A scheduled item is a product or item of equipment indicated in the Contract Documents by manufacturer's name and model number identifying a single item. The manufacturer's trade name for a group of products that does not signify a single item including type, style, quality, performance, and sound rating shall not be classified as a scheduled item. Where more than one manufacturer and product model number are indicated, each shall be considered as a scheduled item.
4. Form: When a product or item of equipment is proposed as a substitution a "REQUEST FOR SUBSTITUTION" form shall be completed and submitted with the required data. A copy of the form is included after the end of this section.
5. Rejection: Substituted products or equipment will be rejected if, in the opinion of the Architect, the submittal does not meet any one of the following conditions or requirements:
  - a. The submittal data is insufficient or not clearly identified. The Architect may or may not request additional information.
  - b. The product or equipment will not fit the space available and still provide the manufacturers published service area requirements.
  - c. The product or equipment submitted is not equivalent to or better than the specified item. Products or equipment of lesser quality may be considered provided an equitable financial rebate, satisfactory to the Architect, is to be returned to the Owner.

- d. The product or equipment submitted has less capacity, efficiency and safety provisions than the specified item.
- e. The product or equipment submitted does not have warranty, service and factory representation equivalent to that specified.
- f. The Owner prefers not to accept the submitted product.

G. Technical Information Brochure:

1. Binder: Include binders with the first submittal for the Technical Information Brochure. Each binder shall be size 3 inch, hardcover, 3-ring type for 8-1/2" X 11" sheets. Provide correct designation on outside cover and on spine of each binder, i.e., MECHANICAL SUBMITTAL DATA, MECHANICAL OPERATION INSTRUCTION and MECHANICAL MAINTENANCE INSTRUCTIONS.
2. Number: Submit not less than five sets of binders for each of the three mechanical brochures indicated above. Each set shall consist of a minimum of two binders for submittal data and 1 binder each for operating instructions and for maintenance instructions. Additional binders shall be submitted at the request of the Architect. One set of binders shall be retained by the Architect. Three sets of binders shall be maintained for the Owner and the remaining set shall become the property of the Engineer.
3. Index: First sheet in each brochure shall be a photocopy of the "Division 15 Index" of the specifications. Second sheet shall list the firm name, address, phone number, superintendent's name for the contractor and all major subcontractors and suppliers associated with the project.
4. Dividers: Provide reinforced separation sheets tabbed with the appropriate specifications Section reference number for each Section in which submittal data or operation and maintenance instructions is required.
5. Specifications: Insert a copy of the specifications for each Section and all addenda applicable to the Section between each of the Section dividers.

1.09 SHOP DRAWINGS FOR PIPING SYSTEMS

- A. Requirements: Make Shop Drawings for piping systems at a minimum scale of 1/4 inch per foot in AutoCAD Version 2010 (or later) and print on reproducible transparencies to verify clearances and equipment locations. Show required maintenance and operational clearances. Identify Shop Drawings by project name and include names of Architect, Engineer, Contractors, Subcontractors and supplier, date in Shop Drawing title block. Number drawings sequentially and indicate:
1. Architectural and structural backgrounds with room names and numbers, etc., including but not limited to plans, sections, elevations, details, etc.
  2. Fabrication and erection dimensions.
  3. Arrangements and sectional views.
  4. Necessary details, including complete information for making connections to equipment.

5. Descriptive names of equipment.
  6. Modifications and options to standard equipment required by Contract Documents.
- B. Stamp Area: Leave 4 inch by 2-1/2 inch blank area near title block for Architect's shop drawing stamp. The acceptance of a shop drawing by indicating "APPROVED" does not relieve the contractor from full compliance with the sizes and equipment connections shown on the contract documents unless the changes are specifically indicated on the shop drawing.
- C. Reference Key: Indicate by cross-reference the Contract Drawings, notes, or Specification paragraph numbers where item(s) occur in the Contract Documents.
- D. Additional Requirements: See specific Sections for additional requirements.

#### 1.10 SHOP DRAWINGS FOR DUCT SYSTEMS

- A. Requirements: Make Shop Drawings for duct systems at a minimum scale of 1/4 inch per foot in AutoCAD Version 2010 (or later) and print on reproducible transparencies to verify clearances and equipment locations. Show required maintenance and operational clearances. Identify Shop Drawings by project name and include names of Architect, Engineer, Contractors, Subcontractors and supplier, date in Shop Drawing title block. Number drawings sequentially and indicate:
1. Architectural and structural backgrounds with room names and numbers, etc., including but not limited to plans, sections, elevations, details, etc.
  2. Fabrication and erection dimensions.
  3. Arrangements and sectional views.
  4. Necessary details, including complete information for making connections to air distribution devices and air handling equipment.
  5. Kinds of materials and finishes.
  6. Descriptive names of equipment.
  7. Modifications and options to standard equipment required.
- B. Stamp Area: Leave 4 inch by 2-1/2 inch blank area near title block for Architect's shop drawing stamp. The acceptance of a shop drawing by indicating "APPROVED" does not relieve the contractor from full compliance with the sizes and connections shown on the contract documents unless the changes are specifically indicated on the shop drawing.
- C. Reference Key: Indicate by cross-reference the Contract Drawings, notes, or Specification paragraph numbers where item(s) occur in the Contract Documents.
- D. Ceiling Plans: Provide Shop Drawings, using sepias of architectural reflected ceiling plans, which indicate locations of exposed air distribution devices, sprinkler heads, lights and access panel.
- E. Additional Requirements: See specific Sections for additional requirements.

#### 1.11 COORDINATION DRAWINGS

- A. General: Provide detailed (minimum 1/4 inch per foot) scaled coordination drawings showing locations and positions of all architectural, structural, (FF&E) equipment, electrical, plumbing, fire protection and mechanical elements for all installations. Provide overlay drawings, prior to beginning

work, indicating work in and above ceilings and in mechanical and electrical rooms with horizontal and vertical dimensions, to avoid interference with structural framings, ceilings, partitions and other services. Accommodate phasing and temporary conditions indicated on the contract drawings as necessary to complete the work without disruption to the Owner's use of the existing occupied areas of the building(s).

- B. Coordination of Space: Coordinate use of project space and sequence of installation of mechanical and electrical work which is indicated diagrammatically on drawings. Follow routings shown for pipes, ducts and conduits as closely as practicable, with due allowance for available physical space; make runs parallel with lines of building. Utilize space efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

In finished areas except as otherwise shown, conceal pipes, ducts, and wiring in construction. Coordinate locations of fixtures and outlets with finish elements. Contractor shall provide background drawings showing partitions, ceiling heights, and structural framing locations and elevations, and existing obstructions. Contractor shall resolve major interferences at initial coordination meeting prior to production of coordination drawings.

- C. Precedence of Services: In event of conflicts and interferences involving location and layout of work, use the following priority to resolve interferences:

1. Structure has highest priority.
2. Walls systems.
3. Ceiling grid/light fixtures.
4. Gravity drainage lines.
5. Large pipe mains.
6. Ductwork/diffusers, registers and grilles.
7. Sprinkler heads.
8. Small piping and tubing/electrical conduit.
9. Access panels.

- D. Drawings shall be developed on AutoCAD Version 2010 (or later), and utilize AIA Standard layering conventions. At the completion of the project construction, the Contractor shall provide two (2) full-sized print sets and two (2) CDs of all drawing files with related reference files representing as-built installations for Architect review. Upon approval that the submitted information is complete, a similar submittal shall be provided to the Owner.

- E. Stamp Area: Leave 4 inch by 2-1/2 inch blank area near title block for Architect's shop drawing stamp.

- F. Reference Key: Indicate by cross-reference the Contract Drawings, notes, or Specification paragraph numbers where item(s) occur in the Contract Documents.

- G. Additional Requirements: See specific Sections for additional requirements.

## 1.12 MANUFACTURER'S CHECKOUT

- A. Start-up and Checkout: At completion of installation and prior to performance verification, a factory-trained representative of the manufacturer shall provide start-up and checkout service. After the performance verification the manufacturer's representative shall examine performance information and check the equipment in operation, and sign "Check-Out Memo" for the record.

Submit a copy of Memo on each item of equipment where indicated in individual sections of these specifications for inclusion in each Technical Information Brochure. The "Check-Out Memo" shall be included with the performance verification data. Do not request "Instruction in Operation Conference" or request final inspection until Memos have been submitted and found acceptable.

#### 1.13 INSTRUCTION TO OWNER

- A. General: Instructions to the Owner shall be by competent representatives of the manufacturers involved, with time allowed for complete coverage of all operating procedures. Provide classroom instruction and field training in the design, operation and maintenance of the equipment and troubleshooting procedures. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, efficiency and similar provisions of the systems. On the date of substantial completion, turn over the prime responsibility for operation of the mechanical equipment and systems to the Owner's operating personnel.
- B. Scheduling: Submit any remaining required items for checking at least one week before final inspection of building. When submittal items are found acceptable, notify Owner, in writing, that an "Instruction in Operation Conference" may proceed. Conference will be scheduled by the Owner. After the conference, copies of a memo certifying that the "Instruction in Operation Conference" and "Completed Demonstration" have been made will be signed by Owner and the instructors, and one copy will be inserted in each Technical Information Brochure.

#### 1.14 ALLOWANCES

- A. General: Division 1.

#### 1.15 ALTERNATES

- A. Refer to Division 1.

#### 1.16 STRUCTURAL CALCULATIONS FOR ROOF-MOUNTED EQUIPMENT

- A. All roof-mounted devices, equipment and systems shall be constructed, designed and fastened to withstand wind loads of velocities up to 155 mph, as applicable to the wind zone of the project. Structural calculations for roof-mounted equipment shall be completed in accordance with Florida Building Code requirements and Florida Administrative Code Rule 9B-72 and submitted by a structural engineer registered in the State of Florida.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Specified Products: Manufacturer's names and product model numbers indicated on the drawings and in these specifications establish the type, style, quality, performance, and sound rating of the desired product. Listing of other manufacturers indicates that their equivalent products would be acceptable if they meet the specification requirements, the specific use and installation shown on the drawings, including space and clearance requirements, and the energy consumption and efficiency of the specified product. The listing of additional manufacturers in no way indicates that the manufacturer can provide an acceptable product.
- B. Space Requirements: All manufactured products furnished on this project must have the required space and service areas indicated in the manufacturer's printed literature or shown on their shop drawing. When the manufacturer does not indicate the space required for servicing the equipment, the space shown on the drawings or as required by the Architect must be provided.

## 2.02 MATERIAL AND EQUIPMENT

- A. General: Material and equipment used shall be produced by manufacturers regularly engaged in the production of similar items, and with a history of satisfactory use as judged by the Architect.
- B. Specified Equipment: Equipment shall be the capacity and types indicated or shall be equivalent in the opinion of the Architect. Material and equipment furnished and installed shall be new, recently manufactured, of standard first grade quality and designed for the specific purpose. Equipment and material furnished shall be the manufacturer's standard item of production unless specified or required to be modified to suit job conditions. Sizes, material, finish, dimensions and the capacities for the specified application shall be published in catalogs for national distribution. Ratings and capacities shall be certified by a recognized rating bureau. Products shall be complete with accessories, trim, finish, safety guards and other devices and details needed for a complete installation and for the intended use and effect.
- C. Compatibility: Material and equipment of one and the same kind, type or classification and used for identical or similar purposes shall be made by the same manufacturer. Where more than one choice is available, select the options which are compatible with other products already selected. Compatibility is a basic general requirement of product selection.

## PART 3 - EXECUTION

### 3.01 WORKMANSHIP

- A. General: The installation of materials and equipment shall be done in a neat, workmanlike and timely manner by an adequate number of craftsmen knowledgeable of the requirements of the Contract Documents. They shall be skilled in the methods and craftsmanship needed to produce a first-quality installation. Personnel who install materials and equipment shall be qualified by training and experience to perform their assigned tasks. All materials and equipment shall be installed per the manufacturer's written requirements.
- B. Acceptable Workmanship: Acceptable workmanship is characterized by first-quality appearance and function which conforms to applicable standards of building system construction and exhibits a degree of quality and proficiency which is judged by the Architect as equivalent or better than that ordinarily produced by qualified industry tradesmen.

- C. Performance: Personnel shall not be used in the performance of the installation of material and equipment who, in the opinion of the Architect, are deemed to be careless or unqualified to perform the assigned tasks. Material and equipment installations not in compliance with the Contract Documents, or installed with substandard workmanship in the opinion of the Architect, shall be removed and reinstalled by qualified craftsmen at no change in the contract price.

### 3.02 CORRECTION OF WORK

- A. General: At no additional cost to the Owner, rectify discrepancies between the actual installation and contract documents when in the opinion of the T&B Agency or the Architect the discrepancies will affect system balance and performance.
- B. Drive Changes: Include the cost of all pulley, belt, and drive changes, as well as balancing dampers, valves and fittings, and access panels to achieve proper system balance recommended by the T&B Agency.

### 3.03 PROTECTION OF MATERIALS AND EQUIPMENT

- A. Requirements: Do not store fiberglass insulation or any equipment within the building until it has been "dried in". If dry space is unavailable and the insulation and equipment must be installed or stored before the building is "dried in" and completely enclosed, provide polyethylene film cover for protection.
- B. Replacement of Damaged Stored Material and Equipment: Any material and equipment that has been wet or otherwise damaged prior to installation, in the opinion of the Architect, shall be replaced with new material regardless of the condition of the material and equipment at the time of installation.
- C. Repair of Damaged Installed Material and Equipment: After installation correct or repair dents, scratches and other visible blemishes. At the direction of Architect replace or repair to "as new" condition equipment which has been damaged during construction.
- D. All air diffusers serving critical care areas shall be disinfected per owner infection control guidelines with a commercial germicide complying with EPA regulations utilizing per manufacturer use standards prior to building occupancy.

### 3.04 COORDINATION OF SERVICES

- A. General: Coordinate interruption of services to Owner-occupied areas in writing in advance with the Architect. Shutdown time and duration of services interruption shall be decided by the Owner. Provide shutoff valves at points of interconnection to minimize downtime. Procedures incidental to the outage shall be prepared in advance to minimize downtime.
- B. General: Coordinate interruption of existing services in writing at least 1 week in advance with the Architect. Shutdown time and duration of services interruption shall be decided by the Owner. Provide shutoff valves at points of interconnection to minimize downtime. Procedures incidental to the outage shall be prepared in advance to minimize downtime.



- C. Fire Safety in Existing facilities: Do not decrease the fire rating of walls, partitions, ceilings, floors, doors or combinations thereof in adjacent areas or means of egress. Do not interrupt fire sprinkling or life safety systems without prior coordination with the Architect. Inform all necessary parties (Fire Department, Owner's insurance carrier, etc.) in advance, prior to and immediately after shutdown, disconnection or isolation of any portion of life safety or fire sprinkler system.
- D. Protection of Facilities: Portions of the building may be operational during construction. Maintain operation of the equipment and systems whenever the installation interfaces with existing equipment or systems. Provide protection for the building, its contents and occupants wherever installation under the contract is performed. As necessary, move, store, and protect furniture, office fixtures and carpets. Provide acoustical isolation of the work area with temporary doors, partitions, etc., to allow normal work functions. Provide exhaust fans, temporary dust barrier partitions and any containment measures required to prevent dirt, dust or fumes from reaching adjacent occupied spaces as required by the Owner or Architect. Access to the building, including exit stairs, doors and passageways, and loading dock and other delivery areas shall be kept open and continuously accessible to the occupants. Workmen shall be confined to those areas directly involved in the project installation, and only during time periods indicated and approved by the Owner.

### 3.05 OWNERSHIP OF REMOVED EQUIPMENT

- A. General: Construction materials and items of mechanical and electrical equipment which are removed and not reused shall be removed from the job-site unless indicated as to be retained for the Owner. Include rigging, removal and hauling cost, as well as any salvage value, in the contract.

### 3.06 CLEAN-UP

- A. General: Debris and rubbish shall not be disposed into the Owner's containers.

## END OF SECTION 15010

## **SECTION 15050 – BASIC MATERIALS & METHODS**

### **A. GENERAL**

1. **Scope.** This section outlines general requirements of fabrication, installation and materials of construction applicable for all piping and related materials.

### **B. PIPE AND PIPE FITTINGS**

1. **Concealment of Pipe.** Unless otherwise indicated, piping in finished portions of the building is concealed. Run exposed piping parallel to or perpendicular to walls.
2. **Materials and Workmanship.**
  - a. Piping shall be new, full weight, and of sizes as shown on the drawings. Piping and fittings shall conform to the latest ASTM specifications.
  - b. Pipe shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing. Ends of all piping shall be reamed and, where applicable, all threads shall be sharp and true. Ends of copper pipe shall be cleaned with emery cloth.
  - c. Welded joints or Victaulic couplings are acceptable. Pumps valves and couplings as follows:
    1. Couplings shall be Victaulic Styles 107H/W07. Gaskets shall be grade “EHP” EDPM designed for operating temperatures from -30 deg F to +250 deg F.
    2. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of flexible connectors at equipment connections and shall be placed in close proximity to the vibration source. Victaulic Style 177, W77.
    4. Victaulic 300-Series/WVic-300 Butterfly Valve and 716/W716 Check Valve may be used with grooved piping system. Utilization of “Tri-Service” Assembly is acceptable with Style 731D Suction Diffuser.
    5. Grooved Copper utilizing 607/608 components is acceptable.

3. Reducers shall be installed at all locations shown on drawings, and as required for reduction in pipe size.
4. Unions shall be installed in piping at all locations shown on drawings and as required for removal of equipment. Union to be ground joint, malleable iron, screwed, for a working pressure of 150 p.s.i. Provide dielectric couplings at dissimilar metals.
5. Flanges shall be weld-neck type, for welded pipe and cast iron for screwed pipe. All drilled to match companion flanges on adjacent equipment.
6. Welding
  - a. All welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks and reasonably free from oxidation, blow holes and non-metallic inclusions.
  - b. All welding shall meet the following qualifications:
    - 1.) No welding shall be permitted when base metal temperature is below 50 degrees F.
    - 2.) Pipe welding shall comply with the provisions of the latest revisions of the applicable code, whether A.S.M.E. boiler and pressure vessel code, ASA code for pressure piping, or such state or local requirements as may supercede codes mentioned above.
    - 3.) The Sub-Contractor shall submit to the Engineer the welder's qualification record, showing that the operator was tested and qualified in the trade. Welders certified by the National Pipe welding Bureau shall be considered as conforming to the above specifications.

**END OF SECTION 15050**

## **15077 - IDENTIFICATION FOR HVAC EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Equipment labels.

#### **1.2 ACTION SUBMITTAL**

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

### **PART 2 - PRODUCTS**

#### **2.1 EQUIPMENT LABELS**

**A. Metal Labels for Equipment:**

1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch
3. Minimum Letter Size: 1/4 inch

- B. Label Content:** Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

### **PART 3 - EXECUTION**

#### **3.1 PREPARATION**

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

#### **3.2 EQUIPMENT LABEL INSTALLATION**

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

**END OF SECTION 15077**

## **SECTION 15180 – INSULATION**

### **A. GENERAL**

1. Scope. This section outlines the general requirements for furnishing and installing insulation for the various systems as specified below:
  - a. Ductwork.
  - b. Condensate drain lines.
  - c. Chilled Water Piping.
  - d. Refrigerant Piping

### **B. PRODUCTS**

1. Insulation for duct liner and duct insulation shall be manufactured by Reflectix, Astro-Foil, or approved equal.
2. Insulation for piping shall be manufactured by Owens-Corning, Schuller, Armstrong or approved equal.
3. Type of insulation shall be as follows:
  - a. Ductwork – “Bubble foil type insulation” – See Section F  
  
Provide insulation on all supply, return, exhaust and outside air ductwork.  
  
Provide duct liners on all return air boots and as shown on the drawings.
  - b. Chilled Water – 1-1/2” flexible foam or Fiberglass with vapor barrier finish for interior use. Additional aluminum Jacket for weather exposed piping.
  - c. Condensate Drain Lines – 1/2” flexible foam or 1/2” fiberglass with universal jacket.
  - d. Refrigerant Piping – 1” Flexible foam, Additional PVC jacket for weather exposed refrigerant lines.

### **C. SUBMITTALS**

1. Submit to the Engineer product data and manufacturers installation.

#### D. DESCRIPTION

1. Flexible foam plastic – shall have flame spread rating of 25 or less. Insulation shall be suitable for temperature range of –40 degrees to +220 degrees F. with density of 5 to 7 pounds per cubic foot.

#### E. INSTALLATION OF PIPING INSULATION

1. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
2. Install insulation on pipe systems subsequent to testing and acceptance of tests.
3. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
4. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
5. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
6. Extend piping insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band. Condenser water pipe to be insulated as cold pipe.

#### F. INSTALLATION GUIDE FOR DOUBLE BUBBLE FOIL – BOTH SIDES

1. General
  - a. Scope: Specify to meet project requirements.
2. Requirements
  - a. Standard Products: The thermal insulation delivered under this specification shall be of the manufacturers commercially current standard product, except for any change necessary to comply with specification requirements.

- b. Material: All material shall be new and unused. All material shall be specified herein. Materials not specified shall be of the same quality used for the intended purpose in commercial practice. Materials used shall be free from defects that would adversely affect the performance or maintainability of individual component or overall assembly.

All products shall have been submitted and researched by ICBO, BOCA, SBCCI, or CCMC as is appropriate to the specific geographic location and code numbers issued.

- c. Foil: Foil used in insulation shall be a minimum of .00030 inch thick and not contain less than 99% aluminum.
- d. Polyethylene: Polyethylene used in insulation shall be as transparent as current technology will provide to limit the conductive transference of heat.
- e. Shall meet: ICBO Acceptance Criteria for Foil Insulations.

## 2. Size & Characteristics

- a. Thickness: Insulation composed of polyethylene bubble pack and foil laminated to both sides shall have a nominal thickness of 7.64 mm (.300").
- b. Widths: Insulation shall be furnished in 16, 24, or 48 inches as specified.
- c. Staple Tabs: When specified the insulation will be provided with .75 (3/4") stapling flanges on the sides of the product.
- d. Emittance: The foil shall have emittance not to exceed .05 when delivered, as certified by the aluminum foil manufacturer or by an independent laboratory.
- e. Water Vapor Permeability: When tested in accordance with 4.3.2, all classes of insulation shall have a permeability not in excess of 0.002 perms for vapor pressure differential 25 cm (1 inch) of mercury as per ASTM E96 or equivalent.
- f. Thermal Resistance: Thermal resistance shall be determined for the application specified in compliance with ASTM method C-236 or ASTM method C-976. All material shall be labeled to conform to FTC Part 4.60 Labeling and Advertising of Home Insulation.



- g. Flame Spread: Flame Spread and Smoke Density shall be determined in compliance with ASTM E-84 and shall have a Flame Spread of 25 or less and a Smoke Density of 450 or less.

3. Quality Assurance Provisions:

- a. Responsibility for Inspection: The contractor is responsible for the performance of all inspection requirements as specified herein.
- b. Examination: Insulation shall be examined for defects listed in Table 1. The Acceptable Quality Level (AQL) shall be 2.5 defects per 100 units (square feet) for major defects and 4.0 defects per 100 units for minor defects.
- c. Acceptance: The AQL for tests shall be 6.5 on the basis of defects per 100 units (square feet).

TABLE I – CLASSIFICATION OF DEFECTS

DEFECT	MAJOR	MINOR
Class not as specified	X	
Foil thickness less than specified	X	
Insulation not of correct width	X	
Torn or punctured (not repairable with tape)	X	
Damage or defect not affecting function		X

4. Test Methods

- a. Water Vapor Permeability: Each sample selected shall be tested in accordance with procedure A of ASTM E-96.
- b. Thermal Resistance: The R-value of the insulating material shall be calculated from the thermal conductance tests performed on specimens of production samples of the insulation, utilizing a guarded hot box and heat flow meter apparatus or similar apparatus in accordance with ASTM C-236 or ASTM C-976. The method used for calculating framing corrections, if any, must be stated.
- c. Inspection of Preparation for Delivery: The packaging and marking of the insulation shall be inspected to determine conformance to the applicable requirements of this specification.

5. Installation

- a. Performance of the reflective system depends upon reflective insulation facing an air space; any contact of the reflective insulation with wall surfaces will negate a portion of the assigned value.
- b. Insulation stops in ceilings should be installed around vents, lighting, or other heat producing fixtures, so that the system is not covering such fixtures to prevent overheating.
- c. The reflective system discourages condensation. Each layer of aluminum foil is essentially a vapor barrier and the temperature gradient is reduced across each successive air space, eliminating extreme temperature drops across any one space. This factor discourages condensation.

#### 6. Delivery & Storage of Materials

- a. All materials shall be delivered in original unopened rolls and stored in air-enclosed shelter providing protection from damage and exposure to the elements.

#### 7. Notes

- a. Intended Use: Reflective insulation is intended for insulating floors, walls and ceilings of buildings. It should be installed as flush or recessed installation subject to the manufacturer's recommendation.
- b. Insulation: Insulation should cover the required area, as specified. Length of a particular roll of the material is not a critical factor, since this type insulation is commonly packaged in continuous lengths.

**END OF SECTION 15180**

## **SECTION 15183 - REFRIGERANT PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. This Section includes refrigerant piping used for air-conditioning applications.

#### **1.2 PERFORMANCE REQUIREMENTS**

- A. Line Test Pressure for Refrigerant R-22:
  - 1. Suction Lines for Air-Conditioning Applications: 185 psig.
  - 2. Hot-Gas and Liquid Lines: 325 psig.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
  - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Field quality-control test reports.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

#### **1.6 QUALITY ASSURANCE**

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

## 1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

## PART 2 - PRODUCTS

### 2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L
- B. Flexible Connectors:
  - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
  - 2. End Connections: Socket ends.

### 2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
  - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
  - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
  - 3. Operator: Rising stem and hand wheel.
  - 4. Seat: Nylon.
  - 5. End Connections: Socket, union, or flanged.
- B. Service Valves:
  - 1. Body: Forged brass with brass cap including key end to remove core.
  - 2. Core: Removable ball-type check valve with stainless-steel spring.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Copper spring.
- C. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
  - 1. Body and Bonnet: Plated steel.
  - 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Threaded.
- D. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
  - 1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
  - 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Seat Disc: Polytetrafluoroethylene.

- 4. End Connections: Threaded.
- E. Moisture/Liquid Indicators:
  - 1. Body: Forged brass.
  - 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
  - 3. Indicator: Color coded to show moisture content in ppm.
  - 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
  - 5. End Connections: Socket or flare.

### PART 3 - EXECUTION

#### 3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground.

- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. Slope refrigerant piping as follows:
  - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
  - 2. Install horizontal suction lines with a uniform slope downward to compressor.
  - 3. Install traps and double risers to entrain oil in vertical runs.
  - 4. Liquid lines may be installed level.
- O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

### 3.2 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
  - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
  - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

### 3.3 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

### 3.4 FIELD QUALITY CONTROL

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

### 3.5 SYSTEM CHARGING

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

### 3.6 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
  - 1. Open shutoff valves in condenser water circuit.
  - 2. Verify that compressor oil level is correct.
  - 3. Open compressor suction and discharge valves.
  - 4. Open refrigerant valves except bypass valves that are used for other purposes.
  - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

**END OF SECTION 15183**



## SECTION 15216 – GAS PIPING SYSTEM

### A. GENERAL

1. Scope. This section shall include but is not limited to the following:
  - a. Gas Distribution System within the building to point outside of building as shown, including gas regulators on interior and shut-off valves, and all connections to gas appliances and equipment.

### B. MATERIALS AND EQUIPMENT

1. Codes. The complete installation shall conform to the standards of design and construction of the respective municipal department, or utility company. All gas piping and equipment shall be installed as required by N.F.P.A. Pamphlet No. 54 and No. 58.

<u>Materials</u>	<u>Size</u>	<u>Specifications</u>
Above ground	All	Standard weight black steel pipe, Fed. Spec. WW-P-406.
Above ground	2" & above	Standard weight welding fittings.
	Under 2"	Standard black threaded fittings.

2. Valve boxes shall be provided for all underground valves. Boxes shall be standard Buffalo Type cast-iron extension service boxes having lid held in place by a brass or bronze bolt. The casting shall be coated with two coats of coal-tar pitch varnish.
3. Tank (N.I.C.) and accessories by the propane supplier.
4. Pipe Coating. The exterior of all underground gas piping shall have a factory applied plastic coating consisting of an adhesive undercoating and polyethylene plastic extruded over the undercoating. The exterior of all ferrous underground joints, couplings, fittings, valves, etc., shall be field wrapped with plastic tape.

### C. INSTALLATION

1. Handling and Storing Materials. Exercise care in handling, storing and unloading coated pipe properly for necessary protection.
2. Field Coating Operation. After pipe has been jointed and all leaks eliminated, clean thoroughly all welded joints. Clean and prime as recommended by the manufacturer and wrap joints, couplings, fittings and valves with plastic tape. Lap the field coating at least 6 inches over the shop applied plastic. Plastic tape shall be applied in two separate

layers, with each layer overlapping the spiral turn at least ¼ inch. Repair all visible damage done to the shop applied coating in shipping and handling.

3. Pipe Laying. Lay piping true to line with continuous bearing on the trench bottom which shall be cut to even grades. Provide watertight plugs in openings for services and other branches and in end of piping laid services and other branches and in end of piping laid when work is suspended. Under no conditions lay pipes in water. Blow out all lines before final connections are made.
4. Piping Depth. The minimum depth of cover over gas lines shall be 30 inches for mains and 18 inches for services. At crossings with other utility lines maintain a clear vertical distance of at least 4 inches. Keep the number of low points at an absolute minimum.
5. Purging Lines. Purge with gas to remove all air from the distribution system.
6. Service entrance installation of gas piping shall be designed and constructed to prevent gas seepage into the building.
7. All gas piping within the buildings shall be exposed unless otherwise specifically noted and shown on the drawings. Where gas piping is shown in sleeves, same is to be installed in accordance with details on drawings and in accordance with Local and State Agencies.
8. Provide a gas shut-off valve and regulator on the vertical riser at each piece of equipment.

#### D. TESTING

1. Exterior Piping. Before coating joints, apply soapsuds thereto and test under an air pressure of at least 50 pounds per square inch. Eliminate all leaks. In welded lines, cut out leaks and repair by welding. In addition, after each section of piping is entirely coated and laid, test at an air pressure of at least 50 pounds per square inch for not less than two hours, and if the pressure gauge indicates any leak, make all necessary repairs.
2. Interior Piping. Gas piping system tests shall be made in accordance with the rules and regulations of the utility serving the building.

**END OF SECTION 15216**

## **SECTION 15600 - CHEMICAL TREATMENT**

### **A. GENERAL**

1. Scope. this section outlines the general requirements for furnishing and installing chemical treatment for the various systems as specified below:

Chilled / hot water loop.

### **B. CLOSED LOOP SYSTEMS**

1. Supply and install Guardian-IPSO Treatment Program, American Water Treatment, Kesco, Mogul, Dearborn, or Betz. All equipment, chemicals, and service to be supplied by and be the sole responsibility of a single water treatment company.
2. The water treatment supplier will be an established and reputable firm with not less than ten years previous experience in water treatment. The supplier's predominant business must be that of manufacturing, supplying, testing and servicing water treatment, with water analysis laboratory and full time personnel available to the owner.

### **C. CHEMICAL FEED & CONTROL EQUIPMENT**

1. The contractor will install all of the following Water Treatment Program CH-1 including all external piping as shown on the drawing:
  - a. One (1) - Minimum five gallon one shot filter feeder, designed to meet the specific capacity and pressure requirements of the system. An additional supply of twelve replacement filters will also be provided.

### **D. WATER TREATMENT CHEMICALS**

1. Provide a one year supply of Guardian-IPCO water treatment chemicals for the prevention of corrosion in the closed recirculating system. All formulations must be compatible with system construction materials and meet or exceed all environmental requirements. Formulas will be supplied in liquid form in DOT approved containers.

E. TESTING

1. The water treatment vendor will supply all testing equipment and reagents necessary to properly maintain the treatment program, and any additional equipment or reagents as specified for the bid.

END OF SECTION 15600

## **SECTION 15720 - HYDRONICS**

### **A. GENERAL**

1. Scope. This section shall include but is not limited to the following:
  - a. Loop Pumps
  - b. Air Separator
  - c. Piping

### **B. LOOP PUMPS**

1. Furnish and install centrifugal end suction single stage pump with capacities and characteristics as shown on the plans. Pump shall be Taco, Bell & Gossett, or Armstrong (no other manufacturer beyond these three will be accepted)
2. Pump volute or casing shall be center-line discharge for positive air venting constructed of class 35 cast iron with integrally cast mounting feet. The pump shall be fitted with replaceable bronze wear rings, drilled, and tapped for gauge ports at both the suction and discharge flanges and for drain port at the bottom of the casing.
3. The impeller shall be bronze and hydraulically balanced by either back vanes or back wear ring and balancing holes. The impeller shall be dynamically balanced and shall be fitted to the shaft with a key.
4. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The pump shaft shall be high tensile steel with replaceable bronze shaft sleeve.
5. The cast iron pump bearing housing shall have heavy duty regreaseable ball bearings replaceable without disturbing the piping connections and shall have a foot support at the driver end.
6. The pump shall have a self-flushing seal design or a positive external seal flushing line.
7. The pump seal shall be EPT Ceramic rated to 250 degrees F.
8. The base shall be made of structural steel and incorporate a guide rail system to allow the pump and motor to be slid apart for service without risking major misalignment or disturbing the piping. The base shall also include a built-in drain pan. A flexible coupler shall connect the pump to the motor and shall be covered by a coupler guard. Contractor shall level and grout each pump according to the manufacturers' recommendations to insure proper alignment prior to operation.
9. Pump to be mounted on 4" concrete pad.

C. AIR SEPARATOR

1. Provide a Taco, Armstrong, or Bell & Gossett coalescing air separation unit, size as shown on plans.
2. Unit to have flanged inlet and outlet connections and strainer. The removable strainer shall be stainless steel with 3/16" diameter perforations and a free area not less than 5 times the cross sectional area of the connecting pipe.
3. Unit shall have separate top fittings for connection to system expansion tanks and for air vent. Unit to be in accordance with ASME and stamped 125-psi design pressure.

D. PIPING

1. Condenser Water
  - a. Interior Condenser Water - HPDE Polyethylene
  - b. Hose kit shall be all stainless steel.
2. Condensate Drain - Type "L" hard copper.
3. Chilled / Hot water  
  
Schedule 40 Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

**END OF SECTION 15720**

## **SECTION 15812 – Packaged Outdoor Air Conditioning Units**

### **GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Packaged Outdoor air conditioners

#### **1.02 REFERENCES**

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AMCA 99—Standards Handbook
- C. AMCA 210—Laboratory Methods of Testing Fans for Rating Purposes
- D. AMCA 500—Test Methods for Louver, Dampers, and Shutters.
- E. AHRI 340/360 - Unitary Large Equipment
- F. NEMA MG1—Motors and Generators
- G. National Electrical Code.
- H. NFPA 70—National Fire Protection Agency.
- I. SMACNA—HVAC Duct Construction Standards—Metal and Flexible.
- J. UL 900—Test Performance of Air Filter Units.

#### **1.03 SUBMITTALS**

- A. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.
- B. Product Data:
  - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, and electrical characteristics and connection requirements.
  - 2. Provide computer generated fan curves with specified operating point clearly plotted.
  - 3. Manufacturer's Installation Instructions.

#### **1.04 OPERATION AND MAINTANENCE DATA**

- A. Maintenance Data: Provide instructions for installation, maintenance and service

#### **1.05 QUALIFICAITONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, who issues complete catalog data on total product.
- B. Startup must be done by trained personnel experienced with rooftop equipment.
- C. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters and remote controls are in place, bearings lubricated, and manufacturers' installation instructions have been followed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site.
- B. Accept products on site and inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Basis of Design: Rheem, Trane, Lennox, York, McQuay
  - 1. Request for other manufacturers accepted if added thru addendums.

2.02 GENERAL DESCRIPTION

- A. Furnish as shown on plans, Rheem Heating and Cooling Unit(s) models RKKL, RGEA, RKNL. Unit performance and electrical characteristics shall be per the job schedule.
- B. Configuration: Fabricate as detailed on prints and drawings:
  - 1. Return plenum / economizer section
  - 2. Filter section
  - 3. Cooling coil section
  - 4. Supply fan section
  - 5. Gas heating section.
  - 6. Condensing unit section
- C. The complete unit shall be cETLus listed.
- D. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-410 Refrigerant and oil.
- E. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.
- F. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
- G. Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.
- H. Warranty: The manufacturer shall provide 12-month parts only warranty. Defective parts shall be repaired or replaced during the warranty period at no charge. The warranty period shall commence at startup or six months after shipment, whichever occurs first.

2.03 CABINET, CASING, AND FRAME



- A. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 7.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.
- B. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.
- C. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.
- D. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

#### 2.04 FILTERS

- A. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2" prefilter and a 4" final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2" construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.

#### 2.05 COOLING COIL

- A. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.
- B. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.
- C. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.
- D. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.

- E. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

#### 2.06 HOT GAS REHEAT

- A. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser
- B. Hot gas reheat coil shall be a Micro Channel design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.
- C. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.
- D. Each coil shall be factory leak tested with high-pressure air under water.

#### 2.07 SUPPLY FAN

- A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft.
- B. Fan assembly shall be a slide out assembly for servicing and maintenance
- C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.
- D. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.
- E. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

#### 2.08 HEATING SECTION

- A. The rooftop unit shall include a natural gas heating section. The gas furnace design shall be one natural gas fired heating module factory installed downstream of the supply air fan in the heat section. The heating module shall be a tubular design with in-shot gas burners.

- B. Each module shall have two stages of heating control.
- C. The heat exchanger tubes shall be constructed of 20 ga, G160, aluminized steel.
- D. The module shall have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.
- E. Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber.
- F. The factory-installed DDC unit control system shall control the gas heat module. Field installed heating modules shall require a field ETL certification. The manufacturer's rooftop unit ETL certification shall cover the complete unit including the gas heating modules.

## 2.09 CONDENSING SECTION

- A. Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.
- B. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0~125°F. Mechanical cooling shall be provided to 25° F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.
- C. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.
- D. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature.
- E. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.
- F. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.
- G. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

## 2.10 ELECTRICAL

- A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.
- B. A GFI receptacle shall be unit mounted. The receptacle shall be powered by a factory installed and wired 120V, 15 amp power supply. The power supply shall be wired to the line side of the unit's main disconnect, so the receptacle is powered when the main unit disconnect is off. This option shall include a GFI receptacle, 2.0 KVA transformer and a branch circuit disconnect. The electrical circuit shall be complete with primary and secondary overload protection.
- C. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

## 2.11 CONTROLS

- A. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.
- B. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.
- C. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip
- D. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For

ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:

1. Return air temperature.
  2. Discharge air temperature.
  3. Outdoor air temperature.
  4. Space air temperature.
  5. Outdoor enthalpy, high/low.
  6. Compressor suction temperature and pressure
  7. Compressor head pressure and temperature
  8. Expansion valve position
  9. Condenser fan speed
  10. Inverter compressor speed
  11. Dirty filter indication.
  12. Airflow verification.
  13. Cooling status.
  14. Control temperature (Changeover).
  15. Cooling status/capacity.
  16. Unit status.
  17. All time schedules.
  18. Active alarms with time and date.
  19. Previous alarms with time and date.
  20. Optimal start
  21. Supply fan and exhaust fan speed.
  22. System operating hours.
    - a. Fan
    - b. Exhaust fan
    - c. Cooling
    - d. Individual compressor
    - e. Heating
    - f. Economizer
    - g. Tenant override
- E. The user interaction with the keypad shall provide the following:
1. Controls mode
    - a. Off manual
    - b. Auto
    - c. Heat/Cool
    - d. Cool only
    - e. Heat only
    - f. Fan only
  2. Occupancy mode
    - a. Auto
    - b. Occupied

- c. Unoccupied
  - d. Tenant override
- 3. Unit operation changeover control
  - a. Return air temperature
  - b. Space temperature
  - c. Network signal
- 4. Cooling and heating change-over temperature with deadband
- 5. Cooling discharge air temperature (DAT)
- 6. Supply reset options
  - a. Return air temperature
  - b. Outdoor air temperature
  - c. Space temperature
  - d. Network signal
  - e. External (0-10 vdc)
  - f. External (0-20 mA)
- 7. Temperature alarm limits
  - a. High supply air temperature
  - b. Low supply air temperature
  - c. High return air temperature
- 8. Lockout control for compressors.
- 9. Compressor interstage timers
- 10. Night setback and setup space temperature.
- 11. Currently time and date
- 12. Tenant override time
- 13. Occupied/unoccupied time schedule
- 14. One event schedule
- 15. Holiday dates and duration
- 16. Adjustable set points
- 17. Service mode
  - a. Timers normal (all time delays normal)
  - b. Timers fast (all time delays 20 sec)
- F. Unit with Remote wall flat wall sensor for local temperature read-out. Wall sensor shall be with metal flat finish for gymnasium use. Provide humidity sensor and install within return air duct of the system.
- G. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:
  - 1. Airflow
  - 2. Outside air temperature
  - 3. Space temperature
  - 4. Return air temperature
  - 5. External signal of 1-5 vdc

- 6. External signal of 0-20 mA
- 7. Network signal

2.12 ROOF CURB

- A. A prefabricated heavy gauge galvanized steel, mounting on roof.

## **SECTION 15815 - METAL DUCTS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

#### **1.2 PERFORMANCE REQUIREMENTS**

- A. Delegated Duct Design:** Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces:** Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data:** For each type of product indicated.
- B. Delegated-Design Submittal:**
1. Sheet metal thicknesses.
  2. Joint and seam construction and sealing.
  3. Reinforcement details and spacing.
  4. Materials, fabrication, assembly, and spacing of hangers and supports.

#### **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.

- B. Welding certificates.

## 1.5 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

## PART 2 - PRODUCTS

### 2.1 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 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.

## 2.3 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.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

## 2.4 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: 3 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. 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."

## 2.5 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 fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

### 3.2 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

### 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":

### 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.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. 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.
- E. 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 Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### 3.6 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

### 3.7 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
  - 1. Underground Ducts: Concrete-encased, [galvanized sheet steel] [PVC-coated, galvanized sheet steel with thicker coating on duct exterior] [stainless steel].
  - 2. <Insert requirements>.
- B. Supply, Return, and general exhaust Ducts:
  - 1. Ducts Connected to, Furnaces,
    - a. Pressure Class: Positive 1-inch wg
    - b. Minimum SMACNA Seal Class: A.
  - 2. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
    - a. Concealed: Carbon-steel sheet.
    - b. Welded seams and joints.
    - c. Pressure Class: Positive or negative 2-inch wg

- d. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- e. SMACNA Leakage Class: 3.

**END OF SECTION 15815**

## **SECTION 15820 – AIR-COOLED WATER CHILLERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Related Documents:**

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

**B. Section Includes:**

1. Design and construction of air-cooled chiller
2. Starters with disconnect switches
3. System control panel
4. Refrigerant charge, oil, and like start-up materials
5. Testing, start-up and instruction
6. Manufacturer's field services for start-up and instruction.

#### **1.2 REFERENCES**

**A. General:**

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

**B. Air Conditioning and Refrigeration Institute (ARI):**

1. ARI 550 Centrifugal and Rotary Screw Water-Chilling Packages
2. ARI 575 Method of Measuring Machinery Sound within an Equipment Space

**C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):**

1. ASHRAE 15 Safety Code for Mechanical Refrigeration
2. ASHRAE 30 Methods of Testing Liquid Chilling Packages

**D. American Society of Mechanical Engineers ASME:**

1. BPVC Boiler and Pressure Vessel Code

**E. ASTM International:**

1. ASTM C 117 Test Method for Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing
2. ASTM C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation

- F. National Electrical Manufacturers Association (NEMA):
  - 1. NEMA 250 Enclosures for Electrical Equipment (1000 Volt Maximum)
  - 2. NEMA ICS 6 Enclosures for Industrial Control and Systems
- G. National Fire Protection Association NFPA 70 National Electrical Code
- H. National Institute of Occupational Safety and Health NIOSH TC-13F-4
- I. Underwriters Laboratories, Inc. (UL)
- J. 40 CFR Part 82 Protection of Stratospheric Ozone
- K. National Electrical Manufacturers Association NEMA 250 Enclosures for Electrical Equipment (1000 Volt Maximum)

### 1.3 PERFORMANCE REQUIREMENTS

- A. The refrigeration machine system shall include piping within the machine up to and including the flanged connection for chilled-water and condenser-water inlets and outlets; and control equipment and wiring within the machine, including the chilled-water and condenser pressure-differential switches, the unit-mounted variable frequency drive, auxiliary oil-pump starter and control and instrumentation devices specified.
- B. Efficiency: Refrigeration machine shall have a full-load (conditions as described in ARI Standard 550-92) operating efficiency of 0.6 kW/ton or less when rated at scheduled operating conditions. Integrated part-load value (IPLV) at various part-load conditions as described in ARI Standard 550-92 shall be 0.56 kW/ton or less.
- C. Refrigerant: Refrigeration machine shall use HFC-134a refrigerant.
- D. Acoustical Performance:
  - 1. Sound-pressure levels for the complete unit shall not exceed 83 dBA. Provide acoustic treatment as required. Sound data shall be measured in accordance with ARI 575. Data shall be in dB, reference 0.0002 dyne/cm<sup>2</sup>, measured along a perimeter 1 m from machine and at a height of 1.5 m above floor. Data shall be at the highest levels recorded in three operating positions: 100 percent load, 75 percent load, 50 percent load, and 20 percent load.
  - 2. The maximum permissible noise level shall not exceed 88 dB in each octave band when measured as described in subparagraph 1. above.
  - 3. Chiller fan shall be provided with a fan shroud to lower the sound level further.
- E. Compressor assembly vibration shall not exceed 1.0 mil (0.03 mm) at the bearings.

### 1.4 SUBMITTALS



- A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."
- B. Shop Drawings:
  - 1. Drawings of refrigeration machine, including dimensions prior to manufacture.
  - 2. Complete wiring diagrams specifically for the proposed equipment. No typical diagram will be considered. Include required wiring between unit and starter. Indicate locations of conduit connections.
- C. Product Data:
  - 1. Refrigeration machine description and data, addressing items to be provided.
  - 2. ARI 550 certified performance curves (kW input vs. output) for full load and non-standard part load value (NPLV). Provide performance data for both ice-making and chilled-water temperature conditions as applicable.
  - 3. Sound-power data by octave band, at 100 percent, 75 percent, 50 percent and 20 percent of full load.
  - 4. Refrigerant gas monitor.
- D. Test Data: Certified test report as specified in subpart 2.12, "Source Quality Control."

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- 1. Rheem, Trane, Lennox, York, McQuay  
Request for other manufacturers accepted if added thru addendums.

### 2.2 CAPACITIES AND CHARACTERISTICS

### 2.3 AIR-COOLED CHILLERS

- A. General:
  - 1. Type: Motor-driven hermetic or open, rotary, scroll or centrifugal water-chilling machine, complete with accessories.
- B. Compressor:
  - 1. Each unit shall be equipped with a direct-drive compressor, operating at not more than 35,000 rpm, driven by a squirrel-cage induction motor. Units with speed-increasing gears shall operate between 10,000 and 30,000 rpm.
  - 2. The compressor shaft-and-impeller assembly, and the rotor-shaft [-gear] assembly shall both be statically and dynamically balanced. There shall be no critical speed within the compressor operating range.

3. Select compressor to ensure stable operation at operating points from 15 percent to maximum-rated load at design conditions.
4. Provide a separate feed-lubrication system for each compressor, consisting of an oil tank and oil sump, an immersed positive-displacement, hermetically-sealed, motor-driven pump to provide proper lubrication, and a filter for delivery of clean oil to the bearings. The oil sump shall contain a thermostatic control for maintaining proper oil temperature, to prevent dilution of oil by refrigerant. The oil shall be separately cooled for proper lubrication viscosity before being delivered to the bearings. Factory mount and field wire the oil pump starter to oil pump.
5. The rotor shall be built of noncorrosive material, unaffected by refrigerant contact. Compressor casing construction shall permit removal of rotor shaft. Provide casing joints with gaskets of suitable material to prevent inward and outward leakage.
6. Impellers shall be cast from high-strength aluminum alloy, balanced both statically and dynamically. Impeller shall be proof-tested at least 15 percent above design operation speed.
7. Capacity control shall be by variable inlet guide vanes, automatically controlled, and capable of modulating performance from 15 percent to 100 percent rated unit capacity without surging. Provide single-stage units or three-stage units with inlet vanes in front of only one compression stage.
8. Provide suitable means to prevent entrained liquid from entering the compressor, and uniformly distributing the liquid refrigerant. Provide float-valve housing and float box, ASME BPVC-approved receding-type, spring-loading, relief valve suitable for attachment of relief piping (in accordance with applicable codes) and liquid-level sight gauge. Isolate vent piping from the relief valve with an ASME BPVC-approved isolation device in the piping. Provide braided flexible pipe connections to vent piping. Valve shall vent only enough refrigeration to relieve pressure, not the full refrigeration charge. Install the vent piping in accordance with ASHRAE 15 and ASME BPVC.

C. Evaporator and Condenser:

1. Type: Construct of welded steel, in accordance with ASME BPVC Sec VIII for positive-pressure machines, and design for water circulation quantity scheduled. The total water side pressure drop from inlet to outlet shall not exceed that scheduled.
2. Tubes: Construct of 0.035 inch (9 mm) thick copper, rolled into grooved holes in the tube sheet and removable without affecting the strength or durability of the tube sheet or causing leakage at adjacent tubes. Water velocity in the tubes shall not exceed 10 fps.
3. Tube Sheet: Construct of carbon steel, welded to the shell. Provide sufficient intermediate tube sheets to prevent tube vibration, and space tube supports at no greater interval than 5 feet.
4. End Covers: Provide removable end covers on the condenser tube bundle constructed of high-grade fabricated steel, or other material suitable for the specified pressures. Each separable cover shall be removable so that the complete tube sheet can be exposed for cleaning.
5. Connections: Provide a 1 inch (25 mm) valved drain connection, and a 1 inch (25 mm) vent connection on each water box.

6. Relief Valve: Provide a relief valve to release refrigerant where recommended by the manufacturer.
  7. Baffles: Provide suitable baffles to prevent direct impingement of gases upon the tubes, and to distribute the gas uniformly over the length of the condenser. Provide a carbon-steel baffle sheet, to segregate and collect the noncondensable gases for purging. Sheet shall be sufficiently thick enough to prevent corrosion of the condenser shell. Include a properly located connection to remove noncondensable gases and water vapor through purge and recovery units.
- D. Motor:
1. Cable Connection Box: Provide a suitable cable connection box so mounted to provide full access to terminals. The cable connection box shall be capable of accepting the necessary feeder conductors. Size the cable terminals for the full-load current and suitabilities to accept copper conductors without excessive heating.
  2. Open-Drive Motor/Compressor: Submit calculations verifying that the ventilation system for the refrigeration machine room will maintain it at 99°F indoor ambient maximum, based on 95°F outdoor ambient ventilation air. Include in the calculations, the heat rejected from motors, condensers, and other inertia base equipment in the refrigeration machine room such as chillers, pumps, fans, compressors, and like equipment.
- E. Variable Frequency Drive
1. Unit mounted in a NEMA-4X stainless steel enclosure with padlock provision with power and control wiring between the drive and chiller factory installed or performed in the field by the chiller manufacturer, including power to the chiller oil pump. Field power wiring is a single point connection and electrical lugs for incoming power are provided.
    - a. The entire chiller package and variable speed drive shall be UL listed.
    - b. PWM drive type utilizes IGBT's.
    - c. Total power factor of 0.95 or better, as measured on the feeder side of the harmonic filter, at loads and speeds.
    - d. A door interlocked circuit breaker, capable of being padlocked.
    - e. UL listed ground fault protection.
    - f. Overvoltage and undervoltage protection.
    - g. 3 phase sensing motor overcurrent protection.
    - h. Single phase protection.
    - i. Insensitive to phase rotation.
    - j. Overtemperature protection.
    - k. Digital readout at the chiller Control Panel includes output frequency; output voltage; 3 phase output; current, input Kilowatts(KW) and Kilowatt hours (KWH); self diagnostic service parameters.
    - l. The entire chiller package shall have factory mounted VFD. When VFD s cooled by condenser water, piping to and from the VFD shall be factory installed.
  2. The variable speed drive must include a harmonic filter that meets IEEE Standard 519-1992.
    - a. The IEEE Std 519-1992 Filter Includes:

- 1) A harmonic filter that limits electrical power supply distortion (current and voltage) from the variable speed drive to comply with the guidelines of IEEE std. 519-1992.
- 2) The filter is unit mounted within the same NEMA-1 enclosure as the VSD and is UL listed.
- 3) Digital readouts provided at the chiller Control Panel as part of the filter package : input KVA; total power factor; 3 phase input voltage; 3 phase input current; 3 phase input voltage total harmonic distortion (THD); 3 phase input current total demand distortion (TDD); self diagnostic service parameters.

## 2.4 CONTROLS

- A. Microprocessor Panel: Provide microprocessor panel for each unit, with individual gauges, and minimum 20-character light-emitting diode (LED) screen indicating purge-condenser drum pressure, high-, low-, and differential-oil pressure, evaporator-refrigerant pressure, condenser refrigerant pressure, evaporator entering and leaving temperatures, condenser entering and leaving temperatures, percent motor current, and operating hours. This panel shall contain switches to permit manual or automatic operation of the oil pump and purge pump; switch to operate purge oil-separator heater and pilot light to indicate its operation; front mounted rocker-switch with separate pilot light providing system energization and refrigeration machine AUTO-OFF control. Provide monitoring of low-evaporator temperature and differential oil-pressure cutouts. The panel shall contain a capacity control mechanism that limits the maximum amperage drawn by the compressor motor, by monitoring motor amperage and the inlet guide vanes.
- B. limiter switch shall permit manual control of power demand to 40, 60, 80, and 100 percent of full-load power. Build into the control panel an anti-recycle timer to ensure 30 minute intervals between successive compressor starts. Also include an oil-pump time-delay relay to provide oil-pump operation during compressor coast-down, a time-delay feature to maintain the capacity inlet guide vanes in a closed position during compressor start-up, and meters to indicate the number of compressor starts and total elapsed-running time. Provide a numbered terminal strip for field interlock wiring.
- C. Electronic temperature controller shall be capable of maintaining the set-point temperature to within 1°F (0.5°C). It shall have field-adjustable ramp-function loading to permit the rate at which the refrigeration machine is allowed to load from start to full load to be varied between 6 to 24 minutes. Temperature set-point shall be adjustable with a calibrated dial on the front panel.

## 2.5 INSULATION

- A. Insulation: Flexible, elastomeric, closed-cell sheet insulation, 3/4 inch (20 mm) thick, suitable for outdoor installation; with a K factor not exceeding 0.27 at 75 deg F (24 deg C)

mean temperature in accordance with ASTM C 177, and a water-vapor permeability of 0.15 perm-inch or less in accordance with ASTM E 96, procedure B; Armstrong “AP Armaflex,” Rubatex Corp. “R1800FS,” or equal.

- B. Adhesive: Armstrong “520,” Rubatex Corp. “R373,” or equal adhesive recommended by the insulation manufacturer for this application.
- C. Factory insulate cold surfaces of the refrigeration machine, except uni-shell vessels (cooler/condenser in one shell) shall be insulated in their entirety, including the condenser section.
- D. Apply the insulation to the surface with adhesive over the entire surface and seal butt joints with adhesive. Insulation installation shall be in accordance with application recommendations described in the Armstrong pamphlet “Specifications - Installation of Armaflex Insulations,” IP-2268, or comparable manufacturer’s printed installation recommendations.
- E. Field insulate areas that show evidence of sweating during operation, using the same materials as the factory insulation.
- F. Factory paint insulation and joint material to match refrigeration machine color; Armstrong “WB Armaflex Finish,” Rubatex Corp. “R374,” or equal water-based latex enamel coating for use over insulation provided.

## 2.6 FACILITIES MONITORING AND CONTROL (FMCS) INTERFACE

- A. The chiller control system shall be Alerton Compatible and provide a single point of interface of the chillers to the facility FMCS. Be responsible for hardware, software required.
  - 1. The FMCS subcontractor shall wire the FACS to the chiller control panel termination point.
- B. The interface shall provide monitoring of information normally available at the chiller control panel, the ability to change manual settings normally made at the chiller control panel, as well as the ability to change settings automatically, such as chilled water temperature reset, demand limiting, etc.

## 2.7 SOURCE QUALITY CONTROL

- A. Notify the University at least 7 days in advance of tests to allow University Representative(s) to witness the tests.
- B. Completely assemble the compressor at the factory, and hydrostatically tested either before or after assembly of shaft and rotor. After assembly, pressure-test the compressor with a mixture of refrigerant and air, and test the casing, joints and connections with an electronic refrigerant detector.

- C. Conduct performance tests on the refrigeration machine in accordance with ARI 550 at the manufacturer's factory under 100 percent, 75 percent, 50 percent and 25 percent load conditions to check performance capacity and efficiency, vibration, operating controls, and safety cutouts.
- D. Pressure Test Requirements: The cooler waterside shall be hydrostatically tested at 225 psi gauge for a working pressure of 150 psi gauge, and the condenser waterside shall be hydrostatically tested at 225 psi gauge for a working pressure of 150 psi (1 035 kPa) gauge. The refrigerant side shall be tested at 1-1/2 times the working pressure.
- E. If the equipment fails to perform within the tolerances set forth in ARI 550, correct the problem and retest at no additional cost to the University. If the machine still fails to perform, the University will reject the refrigeration machine.
- F. Submit a certified test report confirming performance as specified.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install chiller package on concrete foundations, sole plates and sub-base. Align, level, grout, and bolt in place.
- B. Arrange piping for easy dismantling to permit tube cleaning.
- C. Provide auxiliary water piping necessary for oil-cooling units and purge condensers.
- D. Refrigerant Piping: Provide refrigerant hot-gas and liquid piping for remote condenser units in accordance with the manufacturer's requirements and the drawings.
- E. Provide pressure-relief discharge piping from relief valve to outdoors. Provide stainless-steel flexible connector at the refrigeration machine as detailed on the drawings. Discharge shall be at least 15 feet above grade, and 20 feet away from building opening. Provide size recommended by chiller manufacturer, terminated with gooseneck facing down.
- F. If no factory-mounted oil cooler chilled-water-piping circuit is provided, provide field piping in accordance with manufacturing recommendations, including valves, filters and drains.
- G. Connect purge-unit discharge piping into main system pressure-relief piping upstream of flexible connector.
- H. Before units are started, pump new grease into bearing housing to force out old grease and provide adequate lubrication.

#### 3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services:
  - 1. Provide service of a factory-trained service engineer to supervise testing, evacuation, hydration, charging of unit, and start-up; make necessary adjustments; and instruct the University's operator on the care, operation and maintenance of the system.
  - 2. Provide five 8-hour days of service for the first unit, and two 8-hour days for each additional unit.
- B. Notify the University at least 24 hours in advance of field tests to allow University Representative to witness the tests.
- C. Operational Control Tests:
  - 1. Demonstrate proper functioning of the entire operational control of the chiller. Verify proper operation as specified in part 2 of this section, including oil pumps, liquid-line solenoid valves, crankcase heaters, thermal-expansion valves, chilled-water and condenser water flow switches, and adjustable temperature controllers.
  - 2. Demonstrate chiller capacity control by varying the chiller load. The capacity range to be tested shall be from no-load to full-load and back to no-load. The chiller shall demonstrate stable operation without excess vibration or noise. Verify each step of the multi-step control (cylinder unloading and/or compressor staging).
- D. Safety Control Tests:
  - 1. Demonstrate proper functioning of safety cutouts in accordance with safety control requirements of part 2 of this section.
  - 2. Demonstrate that manual resetting is required to restart compressors for safety cutouts.
  - 3. Demonstrate proper operation of interlocking between chillers and condenser-water pumps, and between chillers and chilled-water pumps.
  - 4. Simulate variables to activate safety control actions.
  - 5. All safety control tests shall be verified by electric signals at the compressor motor starters or actual stopping of the compressors.
- E. Running and Warning Indicators Test:
  - 1. Demonstrate proper functioning of indicating lights.
  - 2. Testing of running and warning indicators may be performed concurrently with safety control tests.
- F. Site Tests:
  - 1. Pressure Test: After assembly of the complete unit on the job, pressure test the unit with a mixture of refrigerant and air, and test connections and welds with an electronic leak-detector torch and make refrigerant-tight. The complete unit shall be dehydrated by producing a vacuum to 0.3 inch Hg absolute and maintained for four hours. At the end of this period, stop the pump. The vacuum shall be maintained in the refrigeration unit for a period of 24 hours without gaining more than 0.1 inch Hg absolute pressure.
  - 2. Provide sufficient refrigerant and dry nitrogen for pressure testing under manufacturer's supervision.
  - 3. Provide instruments required for conducting tests.

3.3 DEMONSTRATION

- A. Schedule operation and maintenance instruction period with the University Representative.  
Submit operation and maintenance manuals in advance of instruction period.

END OF SECTION 15820



## **SECTION 15900 – TEMPERATURE CONTROLS**

### **A. GENERAL**

1. Existing campus control system is **Trane**. Expand this existing system to incorporate the new HVAC system renovation. See drawings for control schematics and sequence of operation.

### **B. DESCRIPTION**

1. Furnish and install automatic temperature controls as outlined in this section.

### **C. INTERLOCK DIAGRAM**

1. A detailed, point-to-point diagram of circuitry, including a typed sequence of operation and operation instructions, shall be submitted to the engineer by the Mechanical Contractor for review. As-built drawings shall be prepared after the engineer's final inspection to incorporate all changes made during installation. Provide copies for the engineer and owner's operating personnel.

### **D. CONTROL WIRING**

1. Provide control wiring and pilot circuit wiring to accomplish any control sequence or function shown on the drawings, mechanical systems, or equipment specifications.
2. Control wiring means to furnish wire, conduit, fitting, miscellaneous materials and labor as required for mounting and connecting the electrical control devices furnished under this section of the specifications. All electrical work shall be done in accordance with the latest edition of the National Electric Code. All 120volt control wiring shall be installed in metallic conduit. Low voltage control wiring does not require conduit, except as exposed in mechanical rooms. All thermostats, space sensors and wired remotes shall be mounted on an electrical junction box, with ½" conduit extended up thru the wall and stubbed into the ceiling or run to the controlled device. All wiring shall be concealed, except in equipment rooms, return air plenums, and mechanical or electrical closets. Conduit shall be fastened securely at regular intervals and shall be run parallel to the building lines.

E. INDOOR UNITS

1. Provide and mount one simplified wired remote control for each indoor unit, as indicated on the drawings. The wired remote control shall include system on/off, timer mode on/off, operating mode selection, fan speed control and temperature setting. The Electrical Contractor shall provide clear locking covers over all wired remotes and room sensors.

F. FRESH AIR UNIT

1. The Fresh Air Units provide outside air to the spaces. When in the occupied mode the fresh air units shall be enabled by the control system.

G. DAMPERS

1. The Mechanical Contractor shall furnish and install all automatic control dampers as indicated on the plans and required by the control sequences, unless dampers are specifically called out as a integral part of other equipment. The Electrical Contractor shall wire and interface to the control system all automatic control dampers indicated on the plans.
2. Dampers shall be sized to meet flow requirements of the application. Damper blades shall be 16-gauge galvanized steel construction. Bearings shall be oilite or nylon with 1/2" shafts. Damper blade edges shall be fitted with tight sealing chlorinated polyvinyl chloride gasketing. Dampers shall have stainless steel jamb seals. Dampers shall be suitable for operation from -40 to 200°F.

H. CALIBRATION AND ADJUSTMENTS

1. After completion of the installation, perform final calibration and adjustments of the controls provided under this contract. The HVAC Equipment Supplier's representative shall verify that all interfaces to the control panels are installed, functioning properly, and provide the sequences as specified. The Mechanical Contractor shall be responsible for all VRV control adjustments to provide proper system performance.

I. SYSTEM START-UP AND TRAINING

1. The HVAC Equipment Supplier shall provide three copies of an operator's manual describing all operating and routine maintenance service procedures to be used for controls provided. HVAC equipment supplier shall instruct the owner's designated representatives in operation and maintenance. The duration of these instructions shall be no less than 8 hours.

J. WARRANTY

1. The Mechanical Contractor shall warranty the control system for one (1) year.

L. HVAC CONTROL INTERFACE WIRING

1. Contractor shall be responsible for wiring the following but not limited to:  
indoor remote controllers, remote sensors, interface adaptors, daisy chaining  
indoor/outdoor units/fresh air units//auto dampers that are shown on the  
Mechanical Contract Documents and Specifications.
2. The control system shall be connected by using non-polarity, 2-wire multiplex  
transmission system links from the single outdoor unit to multiple indoor units.

END OF SECTION 15900

## **SECTION 15950 – MECHANICAL TEST AND BALANCE**

### **General: BALANCE OF SYSTEM**

1. All testing and balancing of the HVAC system airflow and hydronic will be on separate contract directly purchased by the owner. Mechanical contractor will be responsible to coordinate this work directly with successful balancing contractor and report any deficiencies to the owner and design engineer as to complete the work necessary in typical project manor.
2. This Specification Section is included herein to assist to inform the Contractor of the standards, requirements, and scope of work to be performed by the TAB Agency.

## **TESTING, ADJUSTING, AND BALANCING**

### **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. Section Includes:
  1. Balancing Air Systems:
    - a. Roof top units
    - b. Outside air duct connections to new indoor air-handlers / indoor units
  2. Balancing Hydronic Piping Systems:
    - a. Loop Pumps (Chilled / hot water)

#### **1.3 DEFINITIONS**

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Certified TAB reports.
- C. Sample report forms.
- D. Instrument calibration reports, to include the following:
  - 1. Instrument type and make.
  - 2. Application.
  - 3. Dates of calibration.

#### 1.5 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB.
  - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC and NEBB.
  - 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC as a TAB technician.
- B. TAB Conference: Meet with engineer and owner for approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
  - 1. Agenda Items:
    - a. The Contract Documents examination report.
    - b. The TAB plan.
    - c. Coordination and cooperation of trades and subcontractors.
    - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
  - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer and Owner.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

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

#### 1.6 PROJECT 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.

#### 1.7 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

### 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 systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 15

Section Metal Ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

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

### 3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
  - 1. Permanent electrical-power wiring is complete.
  - 2. Hydronic systems are filled, clean, and free of air.
  - 3. Automatic temperature-control systems are operational.

4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

### 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.
  1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- 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 Division 15 Section "Duct Accessories."
  3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 15 Section "HVAC 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 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. Crosscheck 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 Division 15 Section "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. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
  - 2. Measure fan static pressures as follows to determine actual static pressure:
    - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    - b. Measure static pressure directly at the fan outlet or through the flexible connection.
    - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
  - 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
    - a. Report the cleanliness status of filters and the time static pressures are measured.
  - 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
  - 5. 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.
  - 6. Obtain approval from Architect and Owner for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
  - B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
    1. Measure airflow of submain and branch ducts.
      - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
    2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
    3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
  - C. Measure air outlets and inlets without making adjustments.
    1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
  - D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
    1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
    2. Adjust patterns of adjustable outlets for proper distribution without drafts.
- 3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS
- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
  - B. Prepare schematic diagrams of systems' "as-built" piping layouts.
  - C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
    1. Open all manual valves for maximum flow.
    2. Check liquid level in expansion tank.
    3. Check makeup water-station pressure gage for adequate pressure for highest vent.
    4. Check flow-control valves for specified sequence of operation, and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

### 3.7 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
  1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
  2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
    - a. Monitor motor performance during procedures and do not operate motors in overload conditions.
  3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
  4. Report flow rates that are not within plus or minus 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
  1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
  2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
  3. Record settings and mark balancing devices.
- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings.

### 3.8 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
  2. Motor horsepower rating.
  3. Motor rpm.
  4. Efficiency rating.
  5. Nameplate and measured voltage, each phase.
  6. Nameplate and measured amperage, each phase.
  7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

### 3.9 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
  2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
  3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
  4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.

5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.
8. Measure flow through bypass.

### 3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

### 3.11 TOLERANCES

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

### 3.12 REPORTING

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

### 3.13 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.
- B. General Report Data: In addition to form titles and entries, include the following data:
  1. Title page.
  2. Name and address of the TAB contractor.

3. Project name.
  4. Project location.
  5. Architect's name and address.
  6. Engineer's name and address.
  7. Contractor's name and address.
  8. Report date.
  9. Signature of TAB supervisor who certifies the report.
  10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  11. Summary of contents including the following:
    - 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. Inlet vane settings for variable-air-volume systems.
    - g. Settings for supply-air, static-pressure controller.
    - h. Other system operating conditions that affect performance.
- C. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
  2. Water and steam flow rates.
  3. Duct, outlet, and inlet sizes.
  4. Pipe and valve sizes and locations.
  5. Terminal units.
  6. Balancing stations.
  7. Position of balancing devices.
- 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 air flow rate in **cfm**.
- b. Total system static pressure in **inches wg**.
- c. Fan rpm.
- d. Filter static-pressure differential in **inches wg**.
- e. Preheat-coil static-pressure differential in **inches wg**.
- f. Cooling-coil static-pressure differential in **inches wg**.
- g. Heating-coil static-pressure differential in **inches wg**.
- h. Outdoor airflow in **cfm**.
- i. Return airflow in **cfm**.
- j. Outdoor-air damper position.
- k. Return-air damper position.
- l. Vortex damper position.

E. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Make and model number.
- f. Tube and fin materials.

2. Test Data (Indicated and Actual Values):

- a. Air flow rate in **cfm**.
- b. Average face velocity in **fpm**.
- c. Air pressure drop in **inches wg**.
- d. Outdoor-air, wet- and dry-bulb temperatures in **deg F**.
- e. Return-air, wet- and dry-bulb temperatures in **deg F**.
- f. Entering-air, wet- and dry-bulb temperatures in **deg F**.

- g. Leaving-air, wet- and dry-bulb temperatures in **deg F**.
- h. Water flow rate in **gpm**.
- i. Entering-water temperature in **deg F**.
- j. Leaving-water temperature in **deg F**.
- k. Refrigerant expansion valve and refrigerant types.

F. Fan Test Reports: For supply, return, and exhaust fans, include the following:

- 1. Fan Data:
  - a. System identification.
  - b. Location.
  - c. Make and type.
  - d. Model number and size.
  - e. Manufacturer's serial number.
  - f. Arrangement and class.
  - g. Sheave make, size in **inches**, and bore.
  - h. Center-to-center dimensions of sheave, and amount of adjustments in **inches**.
- 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**.
  - g. Number, make, and size of belts.
- 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. Suction static pressure in **inches wg**.

G. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

- 1. Unit Data:
  - a. System and air-handling-unit identification.
  - b. Location and zone.
  - c. Room or riser served.
  - d. Coil make and size.
  - e. Flowmeter type.
- 2. Test Data (Indicated and Actual Values):
  - a. Air flow rate in **cfm**.



- b. Entering-water temperature in **deg F**.
  - c. Leaving-water temperature in **deg F**.
  - d. Water pressure drop in **feet of head or psig**.
  - e. Entering-air temperature in **deg F**.
  - f. Leaving-air temperature in **deg F**.
- H. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
  - 1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Service.
    - d. Make and size.
    - e. Model number.
    - f. Water flow rate in **gpm**.
    - g. Water pressure differential in **feet of head or psig**.
    - h. Required net positive suction head in **feet of head or psig**.
    - i. Pump rpm.
    - j. Impeller diameter in **inches**.
    - k. Motor make and frame size.
    - l. Motor horsepower and rpm.
    - m. Voltage at each connection.
    - n. Amperage for each phase.
    - o. Full-load amperage and service factor.
    - p. Seal type.
  - 2. Test Data (Indicated and Actual Values):
    - a. Static head in **feet of head or psig**.
    - b. Pump shutoff pressure in **feet of head or psig**.
    - c. Actual impeller size in **inches**.
    - d. Full-open flow rate in **gpm**.
    - e. Full-open pressure in **feet of head or psig**.
    - f. Final discharge pressure in **feet of head or psig**.
    - g. Final suction pressure in **feet of head or psig**.
    - h. Final total pressure in **feet of head or psig**.
    - i. Voltage at each connection.
    - j. Amperage for each phase.
- I. Instrument Calibration Reports:
  - 1. Report Data:
    - a. Instrument type and make.
    - b. Application.
    - c. Dates of calibration.

### 3.14 INSPECTIONS

#### A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
  - a. Measure airflow of at least 10percent of air outlets.
  - b. Measure water flow of at least 5 percent of terminals.
  - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
  - d. Verify that balancing devices are marked with final balance position.
  - e. Note deviations from the Contract Documents in the final report.

#### B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by engineer and owner.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of engineer and owner
3. Engineer and Owner shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

#### C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

#### D. Prepare test and inspection reports.

### 3.15 ADDITIONAL TESTS

- #### A.
- Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

**END OF SECTION 15950**

**DIVISION 16**

- 16050 BASIC ELECTRICAL MATERIALS AND METHODS
- 16060 GROUNDING
- 16071 SEISMIC CONTROLS FOR ELECTRICAL WORK
- 16120 CONDUCTORS AND CABLES
- 16130 RACEWAYS AND BOXES
- 16231 PACKAGED GENERATOR
- 16410 ENCLOSED SWITCHES AND CIRCUIT BREAKER
- 16415 TRANSFER SWITCH
- 16511 INTERIOR LIGHTING
- 16521 EXTERIOR LIGHTING

SECTION 16050 - 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 electrical materials and methods:
  - 1. Building wire, connectors, and splices for branch circuits and feeders.
  - 2. Supporting devices for electrical components.
  - 3. Concrete equipment bases.
  - 4. Electrical identification.
  - 5. Cutting and patching for electrical construction.
  - 6. Touchup painting.

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data for each type of product specified.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
  - 1. The Terms "Listed and Labeled": As defined in the National Electrical Code, Article 100.
  - 2.

1.5 SEQUENCING AND SCHEDULING

- A. Coordinate electrical equipment installation with other building components.
- B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.
- C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

- D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the work and to minimize outages. Coordinate installing large equipment requiring positioning prior to closing in the building.
- E. Coordinate connecting electrical service to components furnished under other Sections.
- F. Coordinate requirements for access panels and doors where electrical items requiring access are concealed by finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors."
- G. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.
- H. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

## PART 2 - PRODUCTS

### 2.1 SUPPORTING DEVICES

- A. Channel and angle support systems, hangers, anchors, sleeves, brackets, fabricated items, and fasteners are designed to provide secure support from the building structure for electrical components.
  - 1. Material: Steel, except as otherwise indicated, protected from corrosion with zinc coating or with treatment of equivalent corrosion resistance using approved alternative finish or inherent material characteristics.
  - 2. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel, except as otherwise indicated.
- B. Steel channel supports have 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
  - 1. Fittings and accessories mate and match with channels and are from the same manufacturer.
- C. Nonmetallic Channel and Angle Systems: Structural-grade, factory-formed, fiberglass-resin channels and angles with 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
  - 1. Fittings and accessories mate and match with channels or angles and are from the same manufacturer.
  - 2. Fitting and Accessory Material: Same as channels and angles, except metal items may be stainless steel.
- 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. Sheet-Metal Sleeves: 0.0276-inch or heavier galvanized sheet steel, round tube, closed with welded longitudinal joint.
- F. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- G. 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.

- H. Expansion Anchors: Carbon-steel wedge or sleeve type.
- I. Toggle Bolts: All-steel springhead type.
- J. Powder-Driven Threaded Studs: Heat-treated steel.

## 2.2 CONCRETE EQUIPMENT BASES

- A. Forms and Reinforcing Materials: As specified in Division 3 Section "Cast-in-Place Concrete."
- B. Concrete: 3000-psi, 28-day compressive strength as specified in Division 3 Section "Cast-in-Place Concrete."

## 2.3 ELECTRICAL IDENTIFICATION

- A. Manufacturer's Standard Products: Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Raceway and Cable Labels: Conform to ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.
  - 1. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is overlaminated with a clear, weather- and chemical-resistant coating.
  - 2. Color: Black legend on orange field.
  - 3. Legend: Indicates voltage.
- C. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch wide.
- D. Underground Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape with the following features:
  - 1. Size: Not less than 4 mils thick by 6 inches wide.
    - a. Compounded for permanent direct-burial service.
  - 2. Embedded continuous metallic strip or core.
    - a. Printed Legend: Indicates type of underground line.
- E. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- F. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.
- G. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched for mechanical fasteners 1/16-inch minimum thick for signs up to 20 sq. in., 1/8 inch thick for larger sizes. Engraved legend in black letters on white face.
- H. Interior Warning and Caution Signs: Preprinted, aluminum, baked-enamel finish signs, punched for fasteners, with colors, legend, and size appropriate to the application.

- I. Exterior Warning and Caution Signs: Weather-resistant, nonfading, preprinted, cellulose acetate butyrate signs with 0.0396-inch, galvanized steel backing, with colors, legend, and size appropriate to the application. 1/4-inch grommets in corners for mounting.
- J. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

#### 2.4 TOUCHUP PAINT

- A. For Equipment: Provided by equipment manufacturer and selected to match equipment finish.
- B. For Nonequipment Surfaces: Matching type and color of undamaged, existing adjacent finish.
- C. For Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

### PART 3 - EXECUTION

#### 3.1 EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.
- B. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.
- C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Give right of way to raceways and piping systems installed at a required slope.

#### 3.2 ELECTRICAL SUPPORTING METHODS

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
- B. Dry Locations: Steel materials.
- C. Support Clamps for PVC Raceways: Click-type clamp system.
- D. Conform to manufacturer's recommendations for selecting supports.



- E. Strength of Supports: Adequate to carry all present and future loads, times a safety factor of at least 4; 200-lb-minimum design load.

### 3.3 INSTALLATION

- A. Install wires in raceway according to manufacturer's written instructions and NECA's "Standard of Installation."
- B. Conductor Splices: Keep to the minimum and comply with the following:
  - 1. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - 2. Use splice and tap connectors that are compatible with conductor material.
- C. Wiring at Outlets: Install with at least 12 inches of slack conductor at each outlet.
- D. Connect outlets and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
- E. Install devices to securely and permanently fasten and support electrical components.
- F. Raceway Supports: Comply with NFPA 70 and the following requirements:
  - 1. Conform to manufacturer's recommendations for selecting and installing supports.
  - 2. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
  - 3. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
  - 4. Spare Capacity: Size supports for multiple conduits so capacity can be increased by a 25 percent minimum in the future.
  - 5. Support individual horizontal raceways with separate, malleable iron pipe hangers or clamps.
  - 6. Hanger Rods: 1/4-inch diameter or larger threaded steel, except as otherwise indicated.
  - 7. Spring Steel Fasteners: Specifically designed for supporting single conduits or tubing. May be used in lieu 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 channel and slotted angle supports.
  - 8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports, with no weight load on raceway terminals.
- G. Vertical Conductor Supports: Install simultaneously with conductors.
- H. Miscellaneous Supports: Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices except where components are mounted directly to structural features of adequate strength.
- I. In open overhead spaces, cast boxes threaded to raceways need not be separately supported, except where used for fixture support; support sheet-metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the 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.

- J. Sleeves: Install for cable and raceway penetrations of concrete slabs and walls, except where core-drilled holes are used. Install 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.
- K. Firestopping: Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform firestopping as specified in Division 7 Section "Firestopping" to reestablish the original fire-resistance rating of the assembly at the penetration.
- L. Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure. Perform fastening according to the following:
  - 1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and by machine screws, welded threaded studs, or spring-tension clamps on steel.
  - 2. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts, machine screws, or wood screws.
  - 3. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or any other items.
  - 4. In partitions of light steel construction use sheet-metal screws.
  - 5. Drill holes in concrete beams so holes more than 1-1/2 inches deep do not cut main reinforcing bars.
  - 6. Drill holes in concrete so holes more than 3/4 inch deep do not cut main reinforcing bars.
  - 7. Fill and seal holes drilled in concrete and not used.
  - 8. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load.
- M. Install concrete pads and bases according to requirements of Division 3 Section "Cast-in-Place Concrete."
- N. Install identification devices where required.
  - 1. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
  - 2. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated on the Contract Documents or required by codes and standards. Use consistent designations throughout the Project.
  - 3. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.
  - 4. Identify raceways and cables of certain systems with color banding as follows:
    - a. Bands: Colored adhesive marking tape. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of 2-color markings in contact, side by side.
    - b. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25 feet in congested areas.
    - c. Colors: As follows:
      - 1) Fire-Alarm System: Red.
      - 2) Security System: Blue and yellow.
      - 3) Sound/Telecommunications System: Green and yellow.
  - 5. Tag or label power circuits for future connection and circuits in raceways and enclosures with other circuits. Identify source and circuit numbers in each cabinet, pull box, junction box, and outlet box. Color coding may be used for voltage and phase indication.
  - 6. Identify Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, install continuous underground plastic line marker located directly above

power lines. Locate 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches, use a single line marker.

7. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

#### 3.4 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for electrical installations. Perform cutting by skilled mechanics of the trades involved.
- B. Repair disturbed surfaces to match adjacent undisturbed surfaces.

#### 3.5 TOUCHUP PAINTING

- A. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.
- B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

END OF SECTION 16050

SECTION 16060 - GROUNDING

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 grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
  - 1. Division 16 Section "Conductor and Cables" for requirements for grounding conductors.

1.3 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with UL 467.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Apache Grounding; Nashville Wire Products.
  - 2. Boggs: H. L. Boggs & Co.
  - 3. Chance: A. B. Chance Co.
  - 4. Dossert Corp.
  - 5. Erico Inc.; Electrical Products Group.
  - 6. Galvan Industries, Inc.
  - 7. Hastings Fiber Glass Products, Inc.
  - 8. Heary Brothers Lightning Protection Co.
  - 9. Ideal Industries, Inc.
  - 10. ILSCO.
  - 11. Kearney.
  - 12. Korns: C. C. Korns Co.

13. Lightning Master Corp.
14. Lyncole XIT Grounding.
15. O-Z/Gedney Co.
16. Raco, Inc.
17. Thomas & Betts, Electrical.

## 2.2 GROUNDING AND BONDING PRODUCTS

- A. Governing Requirements: Where types, sizes, ratings, and quantities indicated are in excess of National Electrical Code (NEC) requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

## 2.3 WIRE AND CABLE GROUNDING CONDUCTORS

- A. Comply with Division 16 Section "Conductor and Cables." Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.
- B. Equipment Grounding Conductors: Insulated with green color insulation.
- C. Grounding-Electrode Conductors: Stranded cable.
- D. Underground Conductors: Bare, tinned, stranded, except as otherwise indicated.
- E. Bare Copper Conductors: Conform to the following:
  1. Solid Conductors: ASTM B 3.
  2. Assembly of Stranded Conductors: ASTM B 8.
  3. Tinned Conductors: ASTM B 33.

## 2.4 MISCELLANEOUS CONDUCTORS

- A. Grounding Bus: Bare, annealed-copper bars of rectangular cross section.
- B. Braided Bonding Jumpers: Copper tape, braided No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. Bonding Straps: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

## 2.5 CONNECTOR PRODUCTS

- A. Pressure Connectors: High-conductivity-plated units.
- B. Bolted Clamps: Heavy-duty type.
- C. Exothermic-Welded Connections: Provided in kit form and selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

## 2.6 GROUNDING ELECTRODES

- A. Grounding Rods: Copper-clad steel.
  1. Size: 3/4 inch by 120 inches.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Equipment Grounding Conductors: Comply with NEC Article 250 for types, sizes, and quantities of equipment grounding conductors, except where specific types, larger sizes, or more conductors than required by NEC are indicated.
  - 1. Install equipment grounding conductor with circuit conductors for the items below in addition to those required by Code:
    - a. Feeders
    - b. Single-phase motor or appliance branch circuits.
    - c. Three-phase motor or appliance branch circuits.
    - d. Flexible raceway runs.
  - 2. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
  - 3. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and above, including air cleaners and heaters. Bond conductor to each unit and to air duct.
  - 4. Water Heater Circuits: Install a separate equipment grounding conductor to each electric water heater. Bond conductor to heater units, piping, connected equipment, and components.

### 3.2 INSTALLATION

- A. General: Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.
- B. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- C. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

### 3.3 CONNECTIONS

- A. General: Make connections so possibility of galvanic action or electrolysis 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 assure high conductivity and to make contact points closer in order of galvanic series.
  - 2. Make connections with clean, bare metal at points of contact.
  - 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - 4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
  - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

- B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding-Wire Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Noncontact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Moisture Protection: Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

#### 3.4 FIELD QUALITY CONTROL

- A. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method according to IEEE 81.
- B. Maximum grounding to resistance values are as follows:
  - 1. Equipment Rated 500 kVA and Less: 10 ohms.
- C. Excessive Ground Resistance: Where resistance to ground exceeds specified values, notify Owner promptly and include recommendations to reduce ground resistance and to accomplish recommended work.

END OF SECTION 16060

## SECTION 16071 - SEISMIC CONTROLS FOR ELECTRICAL WORK

### 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 seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

#### 1.3 DEFINITIONS

- A. BOCA: BOCA National Building Code.
- B. SBC: Standard Building Code.
- C. UBC: Uniform Building Code.
- D. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.
- E. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

#### 1.4 COORDINATION

- A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.
- B. Coordinate concrete bases with building structural system.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Amber/Booth Company, Inc.



2. Mason Industries, Inc,

- B. Provide calculations to determine restraint loads resulting from seismic forces presented in local building code or IBC, Chapter 16 latest edition. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum 5 years experience. Provide calculations for all floor or wall mounted equipment and lighting fixtures.
- C. Seismic restraint load ratings must be certified and substantiated by testing or calculations under direct control of a registered professional engineer.

2.2 MATERIALS

- A. Use the following materials for restraints:
  - 1. Indoor Dry Locations: Steel, zinc plated.
  - 2. Outdoors and Damp Locations: Galvanized steel.
  - 3. Corrosive Locations: Stainless steel.

2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

- A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.
  - 1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.
- B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.
- C. Concrete Inserts: Steel-channel type.
- D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
- E. Welding Lugs: Comply with MSS SP-69, Type 57.
- F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.
- G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.
- H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.4 SEISMIC BRACING COMPONENTS

- A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch (41-by-41-mm) cross section, formed from 0.1046-inch- (2.7-mm-) thick steel, with 9/16-by-7/8-inch (14-by-22-mm) slots at a maximum of 2 inches (50 mm) o.c. in webs, and flange edges turned toward web.
  - 1. Materials for Channel: ASTM A 570, GR 33.

2. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.
  3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
  4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.
- B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.
- C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.
1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
  2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.
- D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

#### 3.2 STRUCTURAL ATTACHMENTS

- A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.
- B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.
- C. Attachments to Existing Concrete: Use expansion anchors.
- D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.
- E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.
- F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.
- G. Attachments to Wood Structural Members: Install bolts through members.
- H. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

#### 3.3 ELECTRICAL EQUIPMENT ANCHORAGE

- A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.
- B. Anchor panelboards, motor controls, and transformers as follows:

1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

### 3.4 SEISMIC BRACING INSTALLATION

- A. Install bracing according to spacings and strengths indicated by approved analysis.
- B. Expansion and Contraction: Install to allow for thermal movement of braced components.
- C. Cable Braces: Install with maximum cable slack recommended by manufacturer.
- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

### 3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Make flexible connections in raceways, cables and wireways where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

### 3.6 FIELD QUALITY CONTROL

- A. Testing: Test pull-out resistance of seismic anchorage devices.
  1. Provide necessary test equipment required for reliable testing.
  2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
  4. Obtain Architect's approval before transmitting test loads to the structure. Provide temporary load-spreading members.
  5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
  6. Test to 90 percent of rated proof load of device.
  7. If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.
  8. Record test results.

END OF SECTION 16071

SECTION 16120 - CONDUCTORS AND CABLES

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 building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 SUBMITTALS

- A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver wires and cables according to NEMA WC 26.

1.6 COORDINATION

- A. Coordinate layout and installation of cables with other installations.
- B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Wires and Cables:

- a. Alcan Aluminum Corporation; Alcan Cable Div.
- b. American Insulated Wire Corp.; Leviton Manufacturing Co.
- c. BICC Brand-Rex Company.
- d. Carol Cable Co., Inc.
- e. Senator Wire & Cable Company.
- f. Southwire Company.

2. Connectors for Wires and Cables:

- a. AMP Incorporated.
- b. General Signal; O-Z/Gedney Unit.
- c. Monogram Co.; AFC.
- d. Square D Co.; Anderson.
- e. 3M Company; Electrical Products Division.

2.2 BUILDING WIRES AND CABLES

- A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Wire and Insulation Applications" Article.
- B. Thermoplastic Insulation Material: Comply with NEMA WC 5.
- C. Cross-Linked Polyethylene Insulation Material: Comply with NEMA WC 7.
- D. Conductor Material: Copper.
- E. Stranding: Solid conductor for No. 10 AWG and smaller; stranded conductor for larger than No. 10 AWG.

2.3 CONNECTORS AND SPLICES

- A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRE AND INSULATION APPLICATIONS

- A. Feeders: Type THHN/THWN, in raceway.
- B. Branch Circuits: Type THHN/THWN, in raceway.

- C. Fire Alarm Circuits: Power-limited, fire-protective, signaling circuit cable.
- D. Fire Alarm Circuits: Type THHN/THWN, in raceway.
- E. Class 1 Control Circuits: Type THHN/THWN, in raceway.
- F. Class 2 Control Circuits: Type THHN/THWN, in raceway.

### 3.3 INSTALLATION

- A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."
- B. Remove existing wires from raceway before pulling in new wires and cables.
- C. Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."
- G. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."
- H. Identify wires and cables according to Division 16 Section "Basic Electrical Materials and Methods."

### 3.4 CONNECTIONS

- A. Conductor Splices: Keep to minimum.
- B. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
- C. Use splice and tap connectors compatible with conductor material.
- D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.
- E. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.5 FIELD QUALITY CONTROL

- A. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
- B. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 16120

SECTION 16130 - RACEWAYS AND BOXES

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 raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
  - 1. Raceways include the following:
    - a. RMC.
    - b. IMC.
    - c. EMT.
    - d. FMC.
    - e. LFMC.
    - f. RNC.
    - g. Wireways.
  - 2. Boxes, enclosures, and cabinets include the following:
    - a. Device boxes.
    - b. Floor boxes.
    - c. Outlet boxes.
    - d. Pull and junction boxes.
    - e. Cabinets and hinged-cover enclosures.
- B. Related Sections include the following:
  - 1. Division 16 Section "Basic Electrical Materials and Methods" for raceways and box supports.
  - 2. Division 16 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RMC: Rigid metal conduit.
- F. RNC: Rigid nonmetallic conduit.



1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: Include layout drawings showing components and wiring for nonstandard boxes, enclosures, and cabinets.

1.5 QUALITY ASSURANCE

- A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
  - 2.
- B. Comply with NECA's "Standard of Installation."
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Metal Conduit and Tubing:
    - a. Alflex Corp.
    - b. Anamet, Inc.; Anaconda Metal Hose.
    - c. Anixter Brothers, Inc.
    - d. Carol Cable Co., Inc.
    - e. Cole-Flex Corp.
    - f. Electri-Flex Co.
    - g. Flexcon, Inc.; Coleman Cable Systems, Inc.
    - h. Grinnell Co.; Allied Tube and Conduit Div.
    - i. Monogram Co.; AFC.
    - j. Spiraduct, Inc.
    - k. Triangle PWC, Inc.
    - l. Wheatland Tube Co.
  - 2. Nonmetallic Conduit

- a. Anamet, Inc.; Anaconda Metal Hose.
  - b. Arnco Corp.
  - c. Breeze-Illinois, Inc.
  - d. Cantex Industries; Harsco Corp.
  - e. Certainteed Corp.; Pipe & Plastics Group.
  - f. Carlon
  - g. Condux International; Electrical Products.
  - h. Electri-Flex Co.
  - i. George-Ingraham Corp.
  - j. Hubbell, Inc.; Racor, Inc.
  - k. Lamson & Sessions; Carlon Electrical Products.
  - l. Sedco
  - m. Spiraduct, Inc.
  - n. Thomas & Betts Corp.
3. Conduit Bodies and Fittings:
- a. American Electric; Construction Materials Group.
  - b. Crouse-Hinds; Div. of Cooper Industries.
  - c. Emerson Electric Co.; Appleton Electric Co.
  - d. Hubbell, Inc.; Killark Electric Manufacturing Co.
  - e. Lamson & Sessions; Carlon Electrical Products.
  - f. O-Z/Gedney; Unit of General Signal.
  - g. Scott Fetzer Co.; Adalet-PLM.
  - h. Spring City Electrical Manufacturing Co.
4. Metal Wireways:
- a. Hoffman Engineering Co.
  - b. Keystone/Rees, Inc.
  - c. Square D Co.
5. Boxes, Enclosures, and Cabinets:
- a. American Electric; FL Industries.
  - b. Butler Manufacturing Co.; Walker Division.
  - c. Crouse-Hinds; Div. of Cooper Industries.
  - d. Electric Panelboard Co., Inc.
  - e. Erickson Electrical Equipment Co.
  - f. Hoffman Engineering Co.; Federal-Hoffman, Inc.
  - g. Hubbell Inc.; Killark Electric Manufacturing Co.
  - h. Hubbell Inc.; Racor, Inc.
  - i. Lamson & Sessions; Carlon Electrical Products.
  - j. O-Z/Gedney; Unit of General Signal.
  - k. Parker Electrical Manufacturing Co.
  - l. Robroy Industries, Inc.; Electrical Division.
  - m. Scott Fetzer Co.; Adalet-PLM.
  - n. Spring City Electrical Manufacturing Co.
  - o. Thomas & Betts Corp.
  - p. Woodhead Industries, Inc.; Daniel Woodhead Co.

## 2.2 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1.

- B. IMC: ANSI C80.6.
- C. EMT and Fittings: ANSI C80.3.
  - 1. Fittings: compression type.
- D. FMC: Zinc-coated steel.
- E. LFMC: Flexible steel conduit with PVC jacket.

## 2.3 NONMETALLIC CONDUIT

- A. RNC: NEMA TC 2, Schedule 40 or 80 PVC.
- B. RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

## 2.4 METAL WIREWAYS

- A. Material: Sheet metal sized and shaped as indicated.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- D. Wireway Covers: Screw-cover type.
- E. Wireway Covers: Flanged-and-gasketed type as required for environment .
- F. Finish: Manufacturer's standard enamel finish.

## 2.5 OUTLET AND DEVICE BOXES

- A. Sheet Metal Boxes: NEMA OS 1.
- B. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.

## 2.6 FLOOR BOXES

- A. Floor Boxes: See drawings.

## 2.7 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Boxes: NEMA OS 1.

- B. Cast-Metal Boxes: NEMA FB 1, cast aluminum with gasketed cover.

## 2.8 ENCLOSURES AND CABINETS

- A. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- B. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 WIRING METHODS

- A. Outdoors: Use the following wiring methods:
  - 1. Exposed: Rigid steel or IMC.
  - 2. Concealed: Rigid steel or IMC.
  - 3. Underground, Single Run: RNC.
  - 4. Underground, Grouped: RNC.
  - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 6. Boxes and Enclosures: NEMA Type 3R or Type 4.
- B. Indoors: Use the following wiring methods:
  - 1. Feeders (Between Distribution Equipment): RMC, IMC or EMT.
  - 2. Exposed: RMC, IMC or EMT.
  - 3. Concealed: RMC, EMT, IMC or MC cable.
  - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except in wet or damp locations, use LFMC.
  - 5. Damp or Wet Locations: Rigid steel conduit.
  - 6. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
    - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

### 3.3 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

- B. Minimum Raceway Size: 1/2-inch trade size.
- C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.
- D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- E. Install raceways level and square and at proper elevations. Provide adequate headroom.
- F. Complete raceway installation before starting conductor installation.
- G. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."
- H. Use temporary closures to prevent foreign matter from entering raceways.
- I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
- J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
- K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.
- L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.
- M. Raceways Embedded in Slabs: Install in middle third of slab thickness where practical, and leave at least 1-inch concrete cover.
  - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
  - 2. Space raceways laterally to prevent voids in concrete.
  - 3. Run conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
- N. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
  - 1. Run parallel or banked raceways together, on common supports where practical.
  - 2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- O. Join raceways with fittings designed and approved for the purpose and make joints tight.
  - 1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
  - 2. Use insulating bushings to protect conductors.
- P. Tighten set screws of threadless fittings with suitable tools.
- Q. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.

- R. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.
- S. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of the pull wire.
- T. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller: In addition to the 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.
- U. Install raceway sealing fittings according to manufacturer's written instructions. Locate 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 the boundaries of refrigerated spaces.
  - 2. Where otherwise required by NFPA 70.
- V. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.
- W. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
- X. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in a nonmetallic sleeve.
- Y. Do not install aluminum conduits embedded in or in contact with concrete.
- AB. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying the raceways to receptacle or fixture ground terminals.
  - 1. Select each surface raceway outlet box, to which a lighting fixture is attached, of sufficient diameter to provide a seat for the fixture canopy.
  - 2. Where a surface raceway is used to supply a fluorescent lighting fixture having central-stem suspension with a backplate and a canopy (with or without extension ring), no separate outlet box is required.
  - 3. Provide surface metal raceway outlet box, and the backplate and canopy, at the feed-in location of each fluorescent lighting fixture having end-stem suspension.
  - 4. Where a surface metal raceway extension is made from an existing outlet box on which a lighting fixture is installed, no additional surface-mounted outlet box is required. Provide a backplate slightly smaller than the fixture canopy.
- AC. Set floor boxes level and adjust to finished floor surface.
- AD. Set floor boxes level and trim after installation to fit flush to finished floor surface.
- AE. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.4 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.5 CLEANING

- A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 16130

## SECTION 16231 - PACKAGED ENGINE GENERATOR

### 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 packaged engine-generator sets for emergency power supply with the following features:
  - 1. Natural Gas engine.
  - 2. Unit-mounted cooling system.
  - 3. Unit-mounted control and monitoring.
  - 4. Outdoor enclosure.
- B. Related Sections include the following:
  - 1. Division 16 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

#### 1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

#### 1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
  - 1. Thermal damage curve for generator.
  - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.



2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
  4. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." 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 and the unit will be fully operational after the seismic event."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For installer and manufacturer.
- E. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
  2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
  3. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
  4. Report of sound generation.
  5. Report of exhaust emissions showing compliance with applicable regulations.
  6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For packaged engine generators 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. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- H. Warranty: Special warranty specified in this Section.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
  - 1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
  - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 37.
- G. Comply with NFPA 70.
- H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

## 1.6 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: Minus 15 to plus 40 deg C
  - 2. Relative Humidity: 0 to 95 percent.
  - 3. Altitude: As required.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 24 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Caterpillar; Engine Div.
  - 2. Generac Power Systems, Inc.
  - 3. Kohler Co.; Generator Division.
  - 4. Magnetek, Inc.
  - 5. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Natural gas

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Natural Gas
  - a. Carburetor.
  - b. Secondary Gas Regulators
  - c. Fuel-Shutoff Solenoid Valves
  - d. Flexible Fuel Connectors

- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
  - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
  - 3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
  - 4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
    - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- H. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
  - 1. Minimum sound attenuation of 25 dB at 500 Hz.
  - 2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
- I. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- J. Starting System: 12-V electric, with negative ground.
  - 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
  - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  - 3. Cranking Cycle: As required by NFPA 110 for system level specified.
  - 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
  - 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
  - 6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
  - 7. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
    - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery

terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

- b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
- c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

## 2.4 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- C. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
  - 1. AC voltmeter.
  - 2. AC ammeter.
  - 3. AC frequency meter.
  - 4. DC voltmeter (alternator battery charging).
  - 5. Engine-coolant temperature gage.
  - 6. Engine lubricating-oil pressure gage.
  - 7. Running-time meter.
  - 8. Ammeter-voltmeter, phase-selector switch(es).
  - 9. Generator-voltage adjusting rheostat.
  - 10. Generator overload.
- D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- E. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of

indications to remote data terminals. Data system connections to terminals are covered in Division 16 Section "Electrical Power Monitoring and Control."

- F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

## 2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

## 2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

## 2.7 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
  1. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
  2. Space Heater: Thermostatically controlled and sized to prevent condensation.
  3. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
  4. Hinged Doors: With padlocking provisions.
  5. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
  1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
  2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
- C. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
  1. AC lighting system and connection point for operation when remote source is available.
  2. DC lighting system for operation when remote source and generator are both unavailable.
- D. Convenience Outlets: Factory wired[, **GFCI**]. Arrange for external electrical connection.

## 2.8 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
  1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.



2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

## 2.9 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.10 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
  1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  2. Full load run.
  3. Maximum power.
  4. Voltage regulation.
  5. Transient and steady-state governing.
  6. Single-step load pickup.
  7. Safety shutdown.
  8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
  9. Report factory test results within 10 days of completion of test.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of **1 inch (25 mm)** on ~~4-inch-~~ (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."
  - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 15 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect engine exhaust pipe to engine with flexible connector.
- D. Connect fuel piping to engines with a gate valve and union and flexible connector.
- E. Ground equipment according to Division 16 Section "Grounding and Bonding."
- F. Connect wiring according to Division 16 Section "Conductors and Cables."

### 3.4 IDENTIFICATION

- A. Identify system components according to Division 15 Section "Mechanical Identification" and Division 16 Section "Electrical Identification."

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
  - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
  - 7. Exhaust Emissions Test: Comply with applicable government test criteria.
  - 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at eight locations on the property line and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switches and run them concurrently.
- F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and retest as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
  1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
  2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 16231

SECTION 16410 - 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 Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
  - 1. Feeder and branch-circuit protection.
  - 2. Motor and equipment disconnecting means.

1.3 DEFINITIONS

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

1.4 SUBMITTALS

- A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switch and circuit breaker.
  - 1. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Current and voltage ratings.
    - c. Short-circuit current rating.
    - d. UL listing for series rating of installed devices.
    - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:
  - 1. Basis of 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."
- D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.
- E. Field Test Reports: Submit written test reports and 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.
- F. Manufacturer's field service report.
- G. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
  - 1. Routine maintenance requirements for components.
  - 2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
  - 3. Time-current curves, including selectable ranges for each type of circuit breaker.

## 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 NEMA AB 1 and NEMA KS 1.
- C. Comply with NFPA 70.

## 1.6 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.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Switches:
    - a. Eaton Corp.; Cutler-Hammer Products.
    - b. General Electric Co.; Electrical Distribution & Control Division.
    - c. Siemens Energy & Automation, Inc.

- d. Square D Co.
- 2. Molded-Case Circuit Breakers:
  - a. Eaton Corp.; Cutler-Hammer Products.
  - b. General Electric Co.; Electrical Distribution & Control Division.
  - c. Klockner-Moeller.
  - d. Siemens Energy & Automation, Inc.
  - e. Square D Co.
- 2.2 ENCLOSED SWITCHES
  - A. Enclosed, Nonfusible Switch: NEMA KS 1, Type Heavy duty with lockable handle.
  - B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.
- 2.3 ENCLOSED CIRCUIT BREAKERS
  - A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
    - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
    - 1. Lugs: Mechanical or Compression style suitable for number, size, trip ratings, and material of conductors.
    - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; 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 3R.
    - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
    - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    - 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
- 2.5 FACTORY FINISHES
  - A. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before shipping.

## 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.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

- A. Enclosure Nameplates: Label each enclosure based on description on drawings with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

- A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
- B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.
- 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.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
  - 2. Test continuity of each line- and load-side circuit.
- B. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
  - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.6 ADJUSTING

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



3.7 CLEANING

- A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

SECTION 16415 - TRANSFER SWITCH

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
  - 1. Automatic transfer switch.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." 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 and the unit will be fully operational after the seismic event."
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Features and operating sequences, both automatic and manual.
  - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

#### 1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than four hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switch, remote annunciator and generator through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 110.
- H. Comply with UL 1008 unless requirements of these Specifications are stricter.

#### PART 2 - PRODUCTS

##### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Contactor Transfer Switches:
    - a. Caterpillar; Engine Div.
    - b. Generac Power Systems, Inc.
    - c. Kohler Power Systems; Generator Division.
    - d. Onan/Cummins Power Generation; Industrial Business Group.

##### 2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
  2. Switch Action: Double throw; mechanically held in both directions.
  3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide overlapping neutral contacts.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- K. Battery Charger: For generator starting batteries.
  1. Float type.
  2. Ammeter to display charging current.
  3. Fused ac inputs and dc outputs.
- L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
  1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
  2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- N. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

- O. Service Entrance rated with 600A main circuit breaker. Circuit breaker shall be selective coordinated with main breaker in main panel.

## 2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- J. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
- K. Automatic Transfer-Switch Features:
  - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is not available.

## 2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Floor-Mounting Switch: Anchor to floor by bolting.
  - 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
  - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.

- b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.
  - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
  - 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    - a. Verify grounding connections and locations and ratings of sensors.
- C. Testing Agency's Tests and Inspections:
- 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.
    - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.
  - 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.



5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
  - a. Verify grounding connections and locations and ratings of sensors.
- D. Coordinate tests with tests of generator and run them concurrently.
- E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- F. Remove and replace malfunctioning units and retest as specified above.
- G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
  1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
  2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

#### 3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

## SECTION 16511 - INTERIOR LIGHTING

### 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 interior lighting fixtures, lamps, drivers, emergency lighting units, and accessories.

#### 1.3 SUBMITTALS

- A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
  - 1. Dimensions of fixtures.
  - 2. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data.
  - 3. Certified results of laboratory tests for fixtures and lamps for photometric performance.
  - 4. Emergency lighting unit battery and charger.
  - 5. Led driver

#### 1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 for components and installation.
- B. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

#### 1.5 COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

#### 1.6 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last nine years.
- C. Special Warranties for LED driver and LED: Written warranty, executed by manufacturer agreeing to replace driver;LED that fail in materials or workmanship within specified warranty period.
  1. Special Warranty Period: Five years from date of manufacture, but not less than four years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products indicated in the Lighting Fixture Schedule located on the drawings.

### 2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

### 2.3 LED LAMPS AND DRIVER

- A. General Requirements: Unless otherwise indicated, features include the following:
  1. Designed for type and quantity of lamps indicated at full light output.

### 2.5 EMERGENCY FLUORESCENT POWER SUPPLY UNIT

- A. Internal Type: Self-contained, modular, battery-inverter unit factory mounted within fixture body. Comply with UL 924.
  1. Test Switch and Light-Emitting Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
  2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum 10-year nominal life.
  3. Charger: Fully automatic, solid-state, constant-current type.
  4. Operation: Relay automatically energizes lamp from unit when normal supply circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamp, and battery is automatically recharged and floated on charger.

### 2.6 LAMPS

- A. Fluorescent Color Temperature and Minimum Color-Rendering Index: 3500 K and 85 CRI, unless otherwise indicated.

- B. Noncompact Fluorescent Lamp Life: Rated average is 20,000 hours at 3 hours per start when used on rapid-start circuits.
- C. Metal-Halide Color Temperature and Minimum Color-Rendering Index: 3600 K and 70 CRI, unless otherwise indicated.

## 2.7 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section 260500 for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
- D. Rod Hangers: 3/16-inch- minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

## 2.8 FINISHES

- A. Fixtures: Manufacturer's standard, unless otherwise indicated.
  - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
  - 2. Metallic Finish: Corrosion resistant.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.
- B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.
  - 1. Seismic Clips: Install a minimum of four seismic fixture clamps (SFC) by AGI at each corner of fixture to attach to ceiling grid for each fixture. Locate not more than 4 inches from fixture corners.
  - 2. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- C. Suspended Fixture Support: As follows:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.

### 3.2 CONNECTIONS

#### A. Ground equipment.

1. 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.

### 3.3 FIELD QUALITY CONTROL

#### A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

#### B. Advance Notice: Give dates and times for field tests.

#### C. Provide instruments to make and record test results.

#### D. Tests: As follows:

1. Verify normal operation of each fixture after installation.
2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
3. Verify normal transfer to battery source and retransfer to normal.
4. Report results in writing.

#### E. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

### 3.4 CLEANING AND ADJUSTING

#### A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

#### B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION 265100

SECTION 16521 - EXTERIOR LIGHTING

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 exterior lighting units with luminaires, lamps, ballasts, poles/support structures, and accessories.
- B. Related Sections include the following:
  - 1. Division 16 Section "Interior Lighting" for interior fixtures, lamps, ballasts, emergency lighting units, and accessories; and for exterior luminaires normally mounted on buildings.

1.3 DEFINITIONS

- A. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.
- B. Luminaire (Light Fixture): A complete lighting device consisting of lamp(s) and ballast(s), when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect lamps to power supply.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting unit indicated, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
  - 1. Materials and dimensions of luminaires and poles.
  - 2. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data.
  - 3. Certified results of laboratory tests for fixtures and lamps for photometric performance.
  - 4. High-intensity-discharge luminaire ballasts.
- B. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.5 QUALITY ASSURANCE

- A. Luminaires and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use, location, and installation conditions by a testing agency acceptable to authorities having jurisdiction
- B. Comply with ANSI C2.

- C. Comply with NFPA 70.
- D. FM Compliance: Units for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent surface more than 1/4 inch deep. Do not apply tools to section of poles below ground-line.
- D. Retain factory-applied pole wrappings on fiberglass poles until just before pole installation. Handle poles with web fabric straps.
- E. Retain factory-applied pole wrappings on metal poles until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.7 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, signed by manufacturer and Installer agreeing to replace external parts of luminaires and poles exhibiting a failure of finish as specified below. This warranty is in addition to, and not a limitation of, other rights and remedies Owner may have under requirements of the Contract Documents.
  - 1. Protection of Metal from Corrosion: Warranty against perforation or erosion of finish due to weathering.
  - 2. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation.
  - 3. Warranty Period: Manufacturer's standard, but not less than three years from date of Substantial Completion.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 2. LED Driver: 1 for every 100 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products indicated in the Lighting Fixture Schedule located on the drawings.

2.2 LUMINAIRES

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- D. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect ballast when door opens.
- E. Exposed Hardware Material: Stainless steel.
- F. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.

2.3 LUMINAIRE SUPPORT COMPONENTS

- A. Description: Comply with AASHTO LTS-3 for pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
- B. Wind-Load Strength of Total Support Assembly: Adequate to carry support assembly plus luminaires at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mph with a gust factor of 1.3. Support assembly includes pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
  - 1. Strength Analysis: For each pole type and luminaire combination, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- C. Finish: Match finish of pole/support structure for arm, bracket, and tenon mount materials.
- D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Will not cause galvanic action at contact points.
  - 2. Mountings: Correctly position luminaire to provide indicated light distribution.
  - 3. Anchor Bolts, Nuts, and Washers: Hot-dip galvanized after fabrication unless stainless-steel items are indicated.
  - 4. Anchor-Bolt Template: Plywood or steel.



- E. Pole/Support Structure Bases: Anchor type with hold-down or anchor bolts, leveling nuts, and bolt covers.
- F. Fiberglass Poles: Comply with ANSI C136.20 with access handhole in pole wall.
- G. Concrete for Pole Foundations: Comply with Division 3 Section "Cast-in-Place Concrete."
  - 1. Design Strength: 3000-psig, 28-day compressive strength.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Concrete Foundations: Construct according to Division 3 Section "Cast-in-Place Concrete."
  - 1. Comply with details for reinforcement and for anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
  - 2. Finish for Parts Exposed to View: Trowel and rub smooth. Comply with Division 3 Section "Cast-in-Place Concrete" for exposed finish.
- B. Embedded Poles: Set poles to indicated depth, but not less than one-sixth of pole length below finish grade. Dig holes large enough to permit use of tampers the full depth of hole. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- C. Install poles as follows:
  - 1. Use web fabric slings (not chain or cable) to raise and set poles.
  - 2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
  - 3. Secure poles level, plumb, and square.
  - 4. Grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space.
  - 5. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- D. Luminaire Attachment: Fasten to indicated structural supports.
- E. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.
- F. Lamp luminaires with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

#### 3.2 CONNECTIONS

- A. Ground equipment.
  - 1. 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. Ground metal poles/support structures according to Division 16 Section "Grounding."

1. Nonmetallic Poles: Ground metallic components of lighting units and foundations. Connect luminaires to grounding system with No. 6 AWG conductor.

### 3.3 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
  1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
  2. Check intensity and uniformity of illumination.
  3. Check excessively noisy ballasts.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

### 3.4 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust amiable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 16521