

# **Specifications**

**Repair Heating System, B6215**

**Opp#: 1142434**

25 March 2024

**Barksdale AFB, Louisiana**

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SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS

**08/10**

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1 (2020) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

1.2 SUSTAINABILITY REQUIREMENTS

Materials in this technical specification may contribute towards contract compliance with sustainability requirements. See Section 01 33 29 SUSTAINABILITY REPORTING for project requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment Labels

Pipe Labels

Duct Labels

1.4 RELATED REQUIREMENTS

This Section applies to all Sections of DIVISIONS 22, PLUMBING and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this Project Specification, unless specified otherwise in the individual Section.

1.5 QUALITY ASSURANCE

1.5.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design, and workmanship. Standard products must have been in satisfactory commercial or industrial use for 2 years

prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

#### 1.5.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

#### 1.5.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the Contract.

#### 1.5.4 Manufacturer's Nameplate

For each item of equipment, provide a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

#### 1.5.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

##### 1.5.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the Contract Documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." References to the "permit holder" must be interpreted to mean the "Contractor."

##### 1.5.5.2 Administrative Interpretations

For ICC Codes referenced in the Contract Documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this Contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this Project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage

before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

#### 1.7 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects, and contactors with their respective pieces of equipment. Motors, controllers, disconnects, and contactors must conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

#### 1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other Sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished must be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the Contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

#### 1.9 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

### PART 2 PRODUCTS

#### 2.1 PRODUCT SUSTAINABILITY CRITERIA

For products in this Section, where applicable and to extent allowed by performance criteria, provide and document the following:

### 2.1.1 Energy Efficient Equipment for Motors

Provide documentation that the motors meet energy efficiency requirements as outlined in this Section.

## 2.2 EQUIPMENT LABELS

### a. Metal Labels for Equipment:

- (1) Material and Thickness: Brass, 0.032 inch, stainless steel, 0.025 inch or aluminum, 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 inches.
- (3) Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- (4) Fasteners: Stainless-steel rivets or self-tapping screws.
- (5) Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

### b. Plastic Labels for Equipment:

- (1) Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- (2) Letter Color: Black.
- (3) Background Color: White.
- (4) Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
- (5) Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inches.
- (6) Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- (7) Fasteners: Stainless-steel rivets or self-tapping screws.
- (8) Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

### c. 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.

- d. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11-inch bond paper. Tabulate equipment identification number and identify drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment Schedule shall be included in operation and maintenance data.

### 2.3 WARNING SIGNS AND LABELS

- a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- b. Letter Color: Black, unless otherwise indicated.
- c. Background Color: Yellow, unless otherwise indicated.
- d. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
- e. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inches.
- f. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- g. Fasteners: Stainless-steel rivets or self-tapping screws.
- h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- i. Label Content: Include caution and warning information, plus emergency notification instructions.

### 2.4 PIPE LABELS AND DUCT LABELS

- a. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- b. Pretensioned Pipe Labels: Precoiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- c. Self-Adhesive Pipe and Duct Labels: Printed plastic with contact-type, permanent-adhesive backing.
- d. Pipe and Duct Label Contents: Include identification of service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
  - (1) Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
  - (2) Lettering Size: At least 1-1/2 inches high.

## PART 3 EXECUTION

### 3.1 PAINTING OF NEW EQUIPMENT

New equipment painting must be factory applied or shop applied, and must be as specified herein, and provided under each individual section.

#### 3.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: Immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system must be designed for the temperature service.

#### 3.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F must be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat must be aluminum or light gray.

- a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of 1 mil; and two coats of enamel applied to a minimum dry film thickness of 1 mil per coat.
- b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F must receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

### 3.2 IDENTIFICATION AND LABELING

#### 3.2.1 Preparation

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

### 3.2.2 Equipment Label Installation

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

### 3.2.3 Pipe Label Installation

- a. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

(1) Identification Paint: Use for contrasting background.

(2) Stencil Paint: Use for pipe marking.

- b. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

(1) Near each valve and control device.

(2) Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

(3) Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

(4) At access doors, manholes, and similar access points that permit view of concealed piping.

(5) Near major equipment items and other points of origination and termination.

(6) Spaced at maximum intervals of 75 feet along each run.

(7) On piping above removable acoustical ceilings.

- c. Pipe Label Color Schedule:

(1) Chilled-Water Piping:

(a) Background Color: Safety Green.

(b) Letter Color: White.

(c) Legend: CHWS (for Supply), CHWR (for Return).

(2) Refrigerant Piping:

(a) Background Color: Safety Orange.

(b) Letter Color: Black.

(c) Legend: RS (for Suction), RL (for Liquid), RHG (for Hot Gas).

(3) Heating Water Piping:

(a) Background Color: Safety Yellow.

(b) Letter Color: Black.

(c) Legend: HWS (for supply), HWR (for return).

(4) Domestic and Non-Potable Water Piping:

(a) Background Color: Purple.

(b) Letter Color: White.

(c) Legend: DCW (for cold water), DHW (for hot water), DHWR (for hot water recirculation), NPW (for non-potable), DCWS (for domestic softened water).

(5) Sanitary Waste Piping:

(a) Background Color: Safety Gray.

(b) Letter Color: White.

(c) Legend: SS (for Sanitary Sewer).

(6) Natural Gas Piping:

(a) Background Color: Safety Yellow.

(b) Letter Color: Black.

(c) Legend: Natural Gas or NG.

(7) Wet Pipe Sprinkler Piping:

(a) Background Color: Safety Red.

(b) Letter Color: White.

(c) Legend: Sprinkler Piping.

(8) Cooling Coil Condensate Piping:

(a) Background Color: Safety Green.

(b) Letter Color: White.

(c) Legend: COND.

### 3.3 DUCT LABEL INSTALLATION

- a. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

(1) Blue: For cold-air supply ducts.

(2) Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

(3) ASME A13.1 Colors and Designs: For hazardous material exhaust.

- b. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- c. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

-- End of Section --

SECTION 23 05 48.19

BRACING FOR HVAC  
**05/18, CHG 2: 08/20**

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2017) Steel Construction Manual

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A53/A53M (2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A325 (2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A490 (2014a) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

ASTM A500/A500M (2021a) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A563 (2015) Standard Specification for Carbon and Alloy Steel Nuts

ASTM A603 (2019) Standard Specification for Zinc-Coated Steel Structural Wire Rope

METAL FRAMING MANUFACTURERS ASSOCIATION (MFMA)

MFMA-4 (2004) Metal Framing Standards Publication

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering
UFC 4-010-01	(2018; with Change 1, 2020; Change 2, 2022) DoD Minimum Antiterrorism Standards for Buildings

VIBRATION ISOLATION AND SEISMIC CONTROL MANUFACTURERS ASSOCIATION (VISCMA)

VISCMA 412	(2014) Installing Seismic Restraints for Mechanical Equipment
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1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for protection measures described in this section and on the drawings to the mechanical equipment and mechanical systems both inside and outside of the building along with exterior utilities and systems listed below. Where there is a conflict between the specifications and the drawings, the specifications will take precedence.

1.2.2 Mechanical Equipment

Design the bracing in accordance with UFC 3-301-01, UFC 4-010-01, and additional data furnished by the Contracting Officer. Provide sufficient braces for equipment to resist reactions for force protection as indicated in this paragraph. Submit details of equipment bracing for acceptance. The design for force protection for all overhead equipment weighing 31 pounds or more shall be mounted to resist forces of 0.5 times the component weight in any horizontal direction and 1.5 times the component weight in the downward direction.

The following specific items of equipment to be furnished shall be constructed and assembled to resist a horizontal lateral force of 1.5 times the operating weight of the equipment at the vertical center of gravity of the equipment in the downward direction and 0.5 times the operating weight of the equipment at the horizontal center of gravity of the equipment in any direction:

- a. Inline Fans.

1.2.3 Contractor Designed Bracing

Submit copies of the design calculations with the drawings. Calculations must be approved, certified, stamped and signed by a registered Professional Structural Engineer. Calculations must verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-301-01, UFC 4-010-01 and additional data furnished by the Contracting Officer. UFC 3-301-01 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas must be required. Loadings determined using UFC 3-301-01 are based on strength design; therefore, AISC 325 Specifications must be used for the design. The bracing for the mechanical equipment designated in paragraph 1.2.2 and

systems designated in paragraph 1.2.3 must be developed by the Contractor.

#### 1.2.4 Items Not Covered By This Section

##### 1.2.4.1 Fire Protection Systems

Install seismic protection of piping for fire protection systems as specified in Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION.

#### 1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

##### SD-02 Shop Drawings

Coupling and Bracing

Equipment Restraint

Contractor Designed Bracing; G

##### SD-03 Product Data

Bracing; G

Equipment Restraint; G

Contractor Designed Bracing; G

Snubbers

Vibration Isolators

##### SD-05 Design Data

Design Calculations

#### PART 2 PRODUCTS

##### 2.1 GENERAL DESIGN REQUIREMENTS

Submit detailed restraint drawings for mechanical equipment, along with calculations, catalog cuts, templates, and erection and installation details, as appropriate, for the items listed below. Indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction. Calculations must be stamped, by a registered structural engineer, and verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design must be based on actual equipment and system layout. Design must include calculated dead loads, and capacity of materials utilized for the connection of the equipment or system to the structure. Analysis must detail anchoring methods.

## 2.2 EQUIPMENT RESTRAINT

Equipment must be rigidly or flexibly mounted as indicated in the specifications and/or drawings depending on vibration isolation requirements as follows below.

### 2.2.1 Nonrigid or Flexibly-Mounted Equipment

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 1/4 inch. Equipment flexibly mounted on vibration isolators must have a bumper restraint or snubber in each horizontal direction and vertical restraints must be provided where required to resist overturning. Isolator housing and restraints must be constructed of ductile materials. A viscoelastic pad or similar material of appropriate thickness must be used between the bumper and components to limit the impact load. Restraints must be designed to resist the calculated horizontal lateral and vertical forces.

Spring vibration isolators must be seismically rated, restrained isolators for equipment subject to load variations and large external forces. The seismically rated housing must be sized to meet or exceed the force requirements applicable to the project and meet the required isolation criteria. Spring vibration isolator manufacturer's will be a member of VISCMA. Design force,  $F_p$ , must be doubled for vibration isolators with an air gap greater than 0.25 inches as specified in ASCE 7-16, Chapter 13. Housed springs must not be used for seismic restraint applications because they cannot resist uplift.

## 2.3 BOLTS AND NUTS

Hex head bolts, and heavy hexagon nuts must be ASTM A325 or ASTM A490 bolts and ASTM A563 nuts. Provide bolts and nuts galvanized in accordance with ASTM A153/A153M when used underground or exposed to weather.

## 2.4 FLEXIBLE JOINTS

Flexible joints must have same pressure and temperature ratings as adjoining pipe. Braided hoses must not be used where there is torsional or axial movement unless manufacturer allows it.

## 2.5 SWAY BRACING MATERIALS

Material used for members listed, must be structural steel conforming with the following:

- a. Plates, rods, and rolled shapes, ASTM A36/A36M.
- b. Wire rope, ASTM A603 pre-stretched. Class B galv coating. Ferrule clamps must be qualified by testing for use in seismic applications per VISCMA 412. A minimum of two clamps are required on each end of wire rope.
- c. Tubes, ASTM A500/A500M, Grade B.
- d. Pipes, ASTM A53/A53M, Grade B.
- e. Angles, ASTM A36/A36M.
- f. Channels (Struts) with in-turned lips and associated hardware for

fastening to channels at random points conforming to MFMA-4.

### PART 3 EXECUTION

#### 3.1 BRACING

- a. Submit detail drawings, as specified here and throughout this specification, along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals must be complete in detail; must indicate thickness, type, grade, class of metal, and dimensions; and must show construction details, reinforcement, anchorage, and installation with relation to the building construction.
- b. Size bracing components as required for the total load carried by the common supports. Bracing rigidly attached to pipe flanges, or similar, must not be used where it would interfere with thermal expansion of piping.
- c. Adjust isolators and restraints after piping systems has been filled and equipment is at its operating weight, following the manufacturer's written instructions.
- d. Install cables at a 45-degree slope. Where interference is present, the slope may be minimum of 30 degrees or a maximum of 60 degrees per VISCMA 412.

#### 3.2 EQUIPMENT

##### 3.2.1 General

Ensure housekeeping pads have adequate space to mount equipment and seismic restraint devices allowing adequate edge distance and embedment depth for restraint anchor bolts. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Install neoprene grommet washers or till the gap with epoxy on equipment anchor bolts where clearance between anchor and equipment support hole exceeds 0.125 inches.

#### 3.3 ANCHOR BOLTS

For post-installed anchors in existing or new concrete or masonry, comply with specifications Section 05 05 20 POST-INSTALLED CONCRETE AND MASONRY ANCHORS.

-- End of Section --

SOLICITATION NO: \_\_\_\_\_  
CONTRACT NO: \_\_\_\_\_

## SECTION 230923 - N2 DDC CONTROLS - BARKSDALE AFB

### PART 1 - GENERAL

#### 1.1 SUMMARY

Provide and install a complete Direct Digital Control (DDC) system in accordance with Barksdale Air Force Base standards, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as indicated and shown.

The existing Basewide Energy Management Control System (EMCS) is Johnson Controls Metasys with an existing ADX Server. Entire campus system is based only on N2 protocol at field level and BACnet IP at supervisory level. This Building is to receive a new Direct Digital Controls System (DDC) complete and ready for operation that is N2 protocol at field level and BACnet IP at supervisory level and completely compatible with the existing Johnson Controls Metasys System and ADX Server without the purchase or use of integrators, converters, or special software for use as a building operations terminal. JACE of any framework are not allowed. Barksdale AFB Central EMCS monitoring office shall have graphical monitor and control capability of all points on the existing front end.

Provide and install N2 DDC Controllers, actuators, and sensors for all equipment associated with, but not limited to air handlers, terminal units, pumps, boilers, and chillers. Install sensors needed for a complete control system to meet the sequence of operations. Controls Contractor shall be responsible for programming and integration with existing EMCS. When installing controllers and sensors in air-handling units, the cabinet shall be sealed to maintain air-handling unit manufacturer's published air leakage rates.

~~When equipped with dedicated split systems, communication rooms, server rooms, computer room units, split system fan coil units, unit heaters, and exhaust fans shall operate on local control and also include any other devices necessary to provide specified points to be monitored/alarmed to the existing Johnson Controls BMS via N2 protocol such as an space temperature and humidity sensor, condensate float switch alarm, fan status and discharge air temperature, etc., unless noted otherwise on plans.~~

Provide and install full project BAS Graphics of the system and equipment. Contractor shall be responsible for coordination with Barksdale AFB's EMCS staff to ensure that the BMS will be displayed in a Graphical Format at the existing Metasys ADX Server Workstation.

~~Provide trending and graphical display of formulated Total Chiller Capacity (MBH), EWT, LWT and GPM of each chilled water system.~~

~~Provide and install meters and metering capability including three years consumption trending for each installed meter. Provide monitor and alarms for all metering on the campus EMCS. Coordinate with Division 22 and Division 26 for water, natural gas, and electric meters.~~

Provide a PVT Plan, PVT Report and PVT Demonstration as described in Section 3.4 Performance Verification Test

~~Provide Controls Training as described in Section 3.3 Training.~~

#### 1.2 RELATED DOCUMENTS

- A. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.

SOLICITATION NO: \_\_\_\_\_  
CONTRACT NO: \_\_\_\_\_

- B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 23 Sections specifications for details.
- C. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
- D. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

### 1.3 DEFINITIONS

- A. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
- B. Binary: A two-state system where an "ON" condition is represented by one discrete signal level and an "OFF" condition is represented by a second discrete signal level.
- C. Building Management System (BMS): A total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials. The BMS shall be provided by this Division BMS Contractor and shall be interfaced to the associated work of other related trades.
- D. BMS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMS work.
- E. Control Sequence: A BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
- F. Direct Digital Control (DDC): The digital algorithms and pre-defined arrangements included in the BMS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
- G. BMS Network: The total digital on-line real-time interconnected configuration of BMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
- H. Node: A digitally programmable entity existing on the BMS network.
- I. BMS Integration: The complete functional and operational interconnection and interfacing of all BMS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.
- J. Provide: The term "Provide" and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

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- K. Furnish: The term "Furnish" and its derivatives when used in this Division shall mean supply at the BMS Contractor's cost to the designated third party trade contractor for installation. BMS Contractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.
- L. Wiring: The term "Wiring" and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.
- M. Install: The term "Install" and its derivatives when used in this Division shall mean receive at the jobsite and mount.
- N. Protocol: The term "protocol" and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMS network nodes.
- O. Software: The term "software" and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMS industry for real-time, on-line, integrated BMS configurations.
- P. Energy Management Control System (EMCS): A supervisory monitoring and supervisory control (front-end) of base-wide building control systems and utility control systems using N2. Barksdale AFB EMCS is N2.
- Q. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
- R. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.
- S. The following abbreviations and acronyms may be used in describing the work of this Division:

ADC	Analog to Digital Converter
AI	Analog Input
AN	Application Node
ANSI	American National Standards Institute
AO	Analog Output
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG	American Wire Gauge
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DAC	Digital to Analog Converter
DDC	Direct Digital Control
DI	Digital Input
DO	Digital Output
EEPROM	Electrically Erasable Programmable Read Only Memory
EMI	Electroftic Interference
FAS	Fire Alarm Detection and Annunciation System
GUI	Graphical User Interface
HOA	Hand-Off-Auto
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
LAN	Local Area Network

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LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCC	Motor Control Center
NC	Normally Closed
NIC	Not In Contract
NO	Normally Open
OWS	Operator Workstation
OAT	Outdoor Air Temperature
PC	Personal Computer
RAM	Random Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RH	Relative Humidity
ROM	Read Only Memory
RTD	Resistance Temperature Device
SPD	Single Pole Double Throw
SPS	Single Pole Single Throw
XVG	Extended Video Graphics Adapter
TBA	To Be Advised
TCP/IP	Transmission Control Protocol/Internet Protocol
TTD	Thermistor Temperature Device
UPS	Uninterruptible PowerSupply
VAC	Volts, Alternating Current
VAV	Variable Air Volume
VDC	Volts, Direct Current
WAN	Wide Area Network

#### 1.4 BMS DESCRIPTION

- A. The Building Management System (BMS) shall be a complete system designed for use at the existing Barksdale AFB Server Front End. Barksdale AFB uses a JCI Metasys N2 Front End. Contractor to verify requirements with Barksdale AFB EMCS Shop. This functionality shall extend into the equipment rooms.
- B. Devices residing on the BMS network located in equipment rooms and similar shall be fully compatible devices that mount and communicate directly on the EMCS Post Wide Area Network. Contractor shall be responsible for coordination with Barksdale AFB's EMCS staff to ensure that the BMS will be displayed in a Graphical Format at the existing Metasys ADX Server Workstation without disruption to any of the other activities taking place on Barksdale AFB's EMCS Network.
- C. The BMS shall include DDC Controllers for each major piece of equipment such as Meters, Air Handling Units, Chilled and Hot Water Systems and other HVAC terminal/unitary equipment.
- D. All DDC points shall not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. Software shall not live solely in a controller. Software shall be provided to the Government at no additional cost. The primary point of interface shall be the HMI Display Terminal in each building at the post-wide EMCS.
- E. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
- F. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples,

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submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

- G. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
- H. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
- I. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
  - 1. Operator information, alarm management and control functions.
  - 2. Enterprise-level information and control access.
  - 3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
  - 4. Diagnostic monitoring and reporting of BMS functions.
  - 5. Offsite monitoring and management access.
  - 6. Energy management
  - 7. Standard applications for terminal HVAC systems.
  - 8. Indoor Air Quality monitoring and control

## 1.5 QUALITY ASSURANCE

### A. GENERAL

- 1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
- 2. The BMS Contractor shall have a branch facility within a 20-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
- 3. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
- 4. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

### B. WORKPLACE SAFETY AND HAZARDOUS MATERIALS

- 1. Provide a safety program in compliance with the Contract Documents.
- 2. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
- 3. The Contractor and its employees and sub-trades shall comply with federal, state and local safety regulations.
- 4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.

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5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.
9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

## 1.6 REFERENCES

- A. All work shall conform to the following Codes and Standards, as applicable:
  1. National Fire Protection Association (NFPA) Standards.
  2. National Electric Code (NEC) and applicable local Electric Code.
  3. Underwriters Laboratories (UL) listing and labels.
  4. UL 864 UUKL Smoke Control
  5. UL 268 Smoke Detectors.
  6. UL 916 Energy Management
  7. NFPA 70 - National Electrical Code.
  8. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
  9. NFPA 92A and 92B Smoke Purge/Control Equipment.
  10. Factory Mutual (FM).
  11. American National Standards Institute (ANSI).
  12. National Electric Manufacturer's Association (NEMA).
  13. American Society of Mechanical Engineers (ASME).
  14. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
  15. Air Movement and Control Association (AMCA).
  16. Institute of Electrical and Electronic Engineers (IEEE).
  17. American Standard Code for Information Interchange (ASCII).
  18. Electronics Industries Association (EIA).
  19. Occupational Safety and Health Administration (OSHA).
  20. American Society for Testing and Materials (ASTM).
  21. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
  22. Americans Disability Act (ADA)
  23. ANSI/ASHRAE Standard 195
- B. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
- C. All work shall meet the approval of the Project Engineer and Contracting Officer at the project site.

## 1.7 SUBMITTALS

- A. SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

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1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the COR for Contract compliance.
3. Allow 15 working days for the review of each package by the COR in the scheduling of the total BMS work.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
6. The BMS Contractor shall correct any errors or omissions noted in the first review.
7. At a minimum, submit the following:
  - a. BMS network architecture diagrams including all nodes and interconnections.
  - b. Systems schematics, sequences and flow diagrams.
  - c. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
  - d. Samples of Graphic Display screen types and associated menus.
  - e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
  - f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
  - g. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
  - h. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
  - i. Details of all BMS interfaces and connections to the work of other trades.
  - j. Product data sheets or marked catalog pages including part number, photo and description for all products including software.
8. Performance Verification Plan (PVT Plan) and actual PVT once complete.

## 1.8 RECORD DOCUMENTATION

### A. OPERATION AND MAINTENANCE MANUALS

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall include the following for the BMS provided:
  - a. Table of contents.
  - b. As-built system record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal. Include as-built control drawings, schedules and sequence of operations.
  - c. Manufacturer's product data sheets or catalog pages for all products including software.
  - d. System & Equipment Operator's manuals.
  - e. Archive copy of all site-specific databases and sequences.
  - f. BMS network diagrams.

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- g. Interfaces to all third-party products and work by other trades.
- h. Alignment and calibration procedures for components
- i. Preventive maintenance requirements and a maintenance checklist
- j. Spare parts list data, including required tool kits and suggested method of repairs such as field repair, factory repair, or item replacement
- k. Controller configuration and parameter setting procedures
- l. Step-by-step procedures required for each HVAC control systems startup, operation, shutdown, recovery, and fault diagnosis

## 1.9 WARRANTY

### A. Standard Material and Labor Warranty:

- 1. Provide a one-year labor and material warranty on the BMS.
- 2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted by the BMS Contractor at the cost of the BMS Contractor.
- 3. Maintain an adequate supply of materials within 30 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

## PART 2 - PRODUCTS

### 2.1 GENERAL DESCRIPTION

- A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Management System shall consist of the following:
  - 1. Standalone Network Automation Engine(s)
  - 2. Field Equipment Controller(s)
  - 3. Input/Output Module(s)
  - 4. Local Display Device(s)
  - 5. Portable Operator's Terminal(s)
  - 6. Distributed User Interface(s)
  - 7. Network processing, data storage and communications equipment
  - 8. Other components required for a complete and working BMS
- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
  - 1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
  - 2. The System shall maintain all settings and overrides through a system reboot.
- E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

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## 2.2 BMS ARCHITECTURE

### A. Automation Network

1. The automation network shall be based on an industry standard of Ethernet TCP/IP. LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
2. All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
3. Network Automation Engines (SNE) shall reside on the automation network.
4. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

### B. Control Network

1. Network Automation Engines (SNE) shall provide supervisory control over the control network and shall support the following communication protocols:  
N2
2. Control networks shall provide either "Peer-to- Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
3. DDC Controllers shall reside on the control network.

## 2.3 USER INTERFACE

### A. Human Machine Interface (HMI)

1. BMS Contractor shall provide and install an HMI Display Terminal for command entry, information management, network alarm management, and database management including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability. The HMI shall be comprised of a workstation meeting Barksdale AFB IT requirements and located in the manager's office. Primary control is to occur from this workstation with central EMCS initially configured for monitoring capability, to including historian capability of meter data.
2. Dedicated User Interface Architecture - The architecture of the HMI shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers.
  - a. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries

## 2.4 NETWORK AUTOMATION ENGINE (SNE)

### A. Network Automation Engine (SNE)

1. The Network Automation Engine (SNE) shall be a fully user-programmable, supervisory controller. The SNE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer- to-peer basis with other Network Automation Engines.
2. Automation network - The SNE shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface - Each SNE shall have the ability to deliver a web based User Interface. All computers connected physically or virtually to the automation network shall have access to the web based UI.
  - a. The web based UI software shall be imbedded in the SNE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.

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- b. The SNE shall support up a minimum of four (4) concurrent users.
  - c. The web based user shall have the capability to access all system data through one SNE.
  - d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one SNE.
  - e. Systems that require the user to address more than one SNE to access all system information are not acceptable.
  - f. The SNE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the SNE.
  - g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
  - h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
    - Configuration Commissioning
    - Data Archiving Monitoring
    - Commanding System Diagnostics
  - i. Systems that require workstation software or modified web browsers are not acceptable.
  - j. The SNE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
4. Processor - The SNE shall be microprocessor-based with a minimum word size of 32 bits. The SNE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. SNE size and capability shall be sufficient to fully meet the requirements of this Specification.
  5. Memory - Each SNE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
  6. Hardware Real Time Clock - The SNE shall include an integrated, hardware-based, real-time clock.
  7. The SNE shall include troubleshooting LED indicators to identify the following conditions:
    - a. Power - On/Off
    - b. Ethernet Traffic - Ethernet Traffic/No Ethernet Traffic
    - c. Ethernet Connection Speed - 10 Mbps/100 Mbps
    - d. FC Bus A - Normal Communications/No Field Communications
    - e. FC Bus B - Normal Communications/No Field Communications
    - f. Peer Communication - Data Traffic between SNE Devices
    - g. Run - SNE Running/SNE in Startup/SNE Shutting Down/Software Not Running
    - h. Bat Fault - Battery Defective, Data Protection Battery Not Installed
    - i. 24 VAC - 24 VAC Present/Loss Of 24VAC
    - j. Fault - General Fault
    - k. Modem RX - SNE Modem Receiving Data
    - l. Modem TX - SNE Modem Transmitting Data
  8. Communications Ports - The SNE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry- standard computers, modems, and portable operator's terminals.
    - a. Two (2) USB port
    - b. Two (2) URS-232 serial data communication port
    - c. Two (2) RS-485 port
    - d. One (1) Ethernet port
  9. Diagnostics - The SNE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
  10. Power Failure - In the event of the loss of normal power, The SNE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an

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- orderly shutdown of all programs to prevent the loss of database or operating system software.
- a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
  - b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft- start sequence.
11. Certification - The SNE shall be listed by Underwriters Laboratories (UL). The Conformance Statement shall be submitted 10 days prior to bidding.
  12. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences.
  13. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
  14. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately.
  15. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable. The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
  16. The FEC shall include a removable base to allow pre-wiring without the controller.
  17. The FEC shall include troubleshooting LED indicators to identify the following conditions:
    - a. Power On
    - b. Power Off
    - c. Download or Startup in progress, not ready for normal operation
    - d. No Faults
    - e. Device Fault
    - f. Field Controller Bus - Normal Data Transmission
    - g. Field Controller Bus - No Data Transmission
    - h. Field Controller Bus - No Communication
    - i. Sensor-Actuator Bus - Normal Data Transmission
    - j. Sensor-Actuator Bus - No Data Transmission
    - k. Sensor-Actuator Bus - No Communication
  18. The FEC shall accommodate the direct wiring of analog and binary I/O field points.
  19. The FEC shall support the following types of inputs and outputs:
    - a. Universal Inputs - shall be configured to monitor any of the following:
      - Analog Input, Voltage
      - Mode Analog Input,
      - Current Mode Analog
      - Input, Resistive Mode
      - Binary Input, Dry Contact Maintained Mode
      - Binary Input, Pulse Counter Mode
    - b. Binary Inputs - shall be configured to monitor either of the following:
      - Dry Contact Maintained
      - Mode Pulse Counter
      - Mode
    - c. Analog Outputs - shall be configured to output either of the following:
      - Analog Output, Voltage Mode
      - Analog Output, current ModeBinary Outputs - shall output the following:
      - 24 VAC
    - d. Configurable Outputs - shall be capable of the following:
      - Analog Output, Voltage Mode
      - Binary Output Mode
  20. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
    - a. The FC Bus shall be a Master-Slave/Token- Passing (MS/TP) Bus supporting N2 Standard protocol.

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- b. The FC Bus shall support communications between the FECs and the SNE.
  - c. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the SNE.
  - d. The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.
  - e. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.
21. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
- a. The SA Bus shall be a Master-Slave/Token- Passing (MS/TP) Bus supporting N2 Standard Protocol.
  - b. The SA Bus shall support a minimum of 10 devices per trunk.
  - c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.
22. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.
23. The FEC shall support, but not be limited to, the following:
- a. Chilled water/central plant automation applications including but not limited to the selection and sequencing of up to 8 chillers of different sizes (constant or variable speed capacity control), 8 primary and secondary chilled water pumps, as well as selection and sequencing of cooling towers and bypass valve. Sequencing of the devices shall consider user- defined efficiency ratings, runtime equalization and number-of-starts/number-of - stops.
  - b. Heating central plant applications
  - c. Built-up air handling units for special applications
  - c. Terminal units
  - d. Special programs as required for systems control
24. The FEC shall support a Local Controller Display (DIS1710) either as an integral part of the FEC or as a remote device communicating over the SA Bus.
- a. The Display shall use an N2 Standard Master-Slave/Token-Passing protocol.
  - b. The Display shall allow the user to view monitored points without logging into the system.
  - c. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
  - d. The Display shall provide password protection with user adjustable password timeout.
  - e. The Display shall be menu driven with separate paths for:  
Input/Output  
Parameter/Setpoint Overrides
  - f. The Display shall use easy-to-read English text messages.
  - g. The Display shall allow the user to select the points to be shown and in what order.
  - h. The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
  - i. The display shall be a minimum of 4 lines and a minimum of 20 characters per line
  - j. The Display shall have a keypad with no more than 6 keys.
  - k. The Display shall be panel mountable.

## 2.5 SYSTEM TOOLS

### A. System Configuration Tool (SCT)

- 1. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Automation Engine (SNE) or a Network Integration Engine (NIE).

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2. The configuration tool shall provide an archive database for the configuration and application data.
  3. The configuration tool shall have the same look- and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.
  4. The configuration tool shall include the following features:
    - a. Basic system navigation tree for connected networks
    - b. Integration of Metasys N2 enabled devices
    - c. Customized user navigation trees
    - d. Point naming operating parameter setting
    - e. Graphic diagram configuration
    - f. Alarm and event message routing
    - g. Graphical logic connector tool for custom programming
    - h. Downloading, uploading, and archiving databases
  5. The configuration tool shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
    - a. N2 Bus devices
    - b. Metasys N1 networks
  6. The configuration tool shall be capable of programming the Field Equipment Controllers.
    - a. The configuration tool shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.
    - b. The configuration tool shall allow the FECs to be run in Simulation Mode to verify the applications.
    - c. The configuration tool shall contain a library of standard applications to be used for configuration.
  7. The configuration tool shall be capable of programming the field devices.
    - a. The configuration tool shall provide the capability to configure, simulate, and commission the field devices.
    - b. The configuration tool shall allow the field devices to be run in Simulation Mode to verify the applications.
    - c. The configuration tool shall contain a library of standard applications to be used for configuration
  8. A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
    - a. The wireless connection shall allow the PC to access configuration tool through the web browser using the User Interface (UI).
    - b. The wireless use of configuration tool shall be the same as a wired connection in every respect.
    - c. The wireless connection shall use the Bluetooth Wireless Technology.
- B. Wireless MS/TP Converter (BTCVT)
- a. The converter shall provide a temporary wireless connection between the SA or FC Bus and a wireless enabled portable PC.
  - b. The converter shall support downloading and troubleshooting FEC and field devices from the PC over the wireless connection.
  - c. The converter shall employ Bluetooth Wireless Technology.
  - d. The converter shall be powered through a connection to either the Sensor-Actuator (SA) or the Field Controller (FC) Bus.
  - e. The converter shall operate over a minimum of thirty three (33) feet within a building.
  - f. The converter shall have LED indicators to provide information regarding the following conditions:
    - Power - On/Off
    - Fault - Fault/No Fault
    - SA/FC Bus - Bus Activity/ No Bus Activity
    - Blue - Bluetooth Communication Established/ Bluetooth Communication Not Established

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- g. The SWCVT shall comply with FCC Part 15.247 regulations for low-power unlicensed transmitters.

2.6 INPUT DEVICES

A. GENERAL REQUIREMENTS

- 1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. TEMPERATURE SENSORS

- 1. General Requirements:
  - a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
  - b. The temperature sensor shall be of the resistance type, and shall be two-wire 1000 ohm nickel RTD.
  - c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	+ .5 Degrees F.
Room Temperature	+ .5 Degrees F.
Duct Temperature	+ .5 Degrees F.
All Others	+ .75 Degrees F.

- 2. Room Temperature Sensors with Integral Display:
  - a. Room sensors shall be constructed for either surface or wall box mounting.
  - b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:
    - Display room and outside air temperatures.
    - Display and adjust room comfort setpoint.
    - Display and adjust fan operation status.
    - Timed override request push button with LED status for activation of after-hours operation.
    - Display controller mode.
    - Password selectable adjustment of setpoint and override modes.
- 3. Thermo wells:
  - a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
  - b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
  - c. Thermo wells and sensors shall be mounted in a thread-o-let or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
  - d. Thermo wells shall be constructed of Series 300 stainless steel.
- 4. Outside Air Sensors:
  - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
  - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
  - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

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5. Duct Mount Sensors:
    - a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
    - b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
    - c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
  6. Averaging Sensors:
    - a. For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
    - b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
    - c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
- C. HUMIDITY SENSORS
1. Relative humidity, from 0 to 100 percent for high/low limit applications; from 20 to 80 percent min for space applications.
  2. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
  3. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
  4. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
  5. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite® fittings and stainless steel bushings.
  6. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
  7. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
  8. Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.
- D. DIFFERENTIAL PRESSURE TRANSMITTERS
1. General Air and Water Pressure Transmitter Requirements:
    - a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
    - b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
    - c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
    - d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
  2. Low Differential Water Pressure Applications (0" - 20" w.c.)
    - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

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- b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
  - .01-20" w.c. input differential pressure range. 4-20 mA output.
  - Maintain accuracy up to 20 to 1 ratio turndown.
  - Reference Accuracy: +0.2% of full span.
- 3. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
  - a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
    - Differential pressure range 10" w.c. to 300 PSI.
    - Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
  - b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
- 4. Building Differential Air Pressure Applications (- 1" to +1" w.c.)
  - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
  - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
    - 1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
    - 4-20 mA output.
    - Maintain accuracy up to 20 to 1 ratio turndown.
    - Reference Accuracy: +0.2% of full span.
- 5. Low Differential Air Pressure Applications (0" to 5" w.c.)
  - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
  - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
    - (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
    - 4-20 mA output.
    - Maintain accuracy up to 20 to 1 ratio turndown.
    - Reference Accuracy: +0.2% of full span.
- 6. Medium Differential Air Pressure Applications (5" to 21" w.c.)
  - a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
    - Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
    - Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG. Thermal Effects: <+.033 F.S./Deg. F. over 40 F. to 100 F. (calibrated at 70 F.).
  - b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

E. FLOW MONITORING

- 1. Air Flow Monitoring (when not integral to AHUs)

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- a. Duct Air Flow Measuring Stations:  
Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.  
Unless integral to a specific equipment with independent controls, Air Flow Measuring Station shall be in the ductwork with the proper straight length duct. Airflow measuring stations shall be of a thermal dispersion type, Ebtron Hybrid Series or prior approved equal. Pitot tube and other type Air Flow Measuring Stations when used as control sequence dependent are not allowed.  
The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.  
Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.
  - b. Static Pressure Traverse Probe:  
Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
  - c. Shielded Static Air Probe:  
A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.
2. Water Flow Monitoring:  
Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.

F. POWER MONITORING DEVICES

1. Current Measurement (Amps)
  - a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
  - b. Current Transformer - A split core current transformer shall be provided to monitor motor amps.  
Operating frequency - 50 - 400 Hz.  
Insulation - 0.6 Kv class 10Kv BIL.  
UL recognized.  
Five amp secondary.  
Select current ration as appropriate for application.
  - c. Current Transducer - A current to voltage or current to mA transducer shall be provided. The current transducer shall include:  
6X input over amp rating for AC inrushes of up to 120 amps.  
Manufactured to UL 1244.  
Accuracy: +.5%, Ripple +1%.  
Minimum load resistance  
30kOhm. Input 0-20 Amps.  
Output 4-20 mA.  
Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

G. STATUS AND SAFETY SWITCHES

1. General Requirements
  - a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS when a failure or abnormal condition occurs. Safety

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switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches
  - a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
  - b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
  - c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
3. Air Filter Status Switches
  - a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
  - b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
  - c. Provide appropriate scale range and differential adjustment for intended service.
4. Air Flow Switches
  - a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
5. Air Pressure Safety Switches
  - a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
  - b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
6. Water Flow Switches
  - a. Water flow switches shall be equal to the Johnson Controls P74.
7. Low Temperature Limit Switches
  - a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
  - b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
  - c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
  - d. The low temperature limit switch shall be equal to Johnson Controls A70.

## 2.7 OUTPUT DEVICES

### A. ACTUATORS

1. General Requirements
  - a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
2. Electronic Damper Actuators
  - a. Electronic damper actuators shall be direct shaft mount.
  - b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return

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unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

- c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
  - d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
3. Electronic Valve Actuators
- a. Electronic valve actuators shall be manufactured by the valve manufacturer.
  - b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
  - c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations.  
The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
  - d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
  - e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

**B. CONTROL DAMPERS**

1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.
2. All dampers used for variable airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-

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gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

5. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.
6. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

#### C. CONTROL RELAYS

1. Control Pilot Relays
  - a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
  - b. Mounting Bases shall be snap-mount.
  - c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
  - d. Contacts shall be rated for 10 amps at 120VAC.
  - e. Relays shall have an integral indicator light and check button.
  - f. Acceptable manufacturers: Johnson Controls, Lectro

#### D. CONTROL VALVES

1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule in specifications Division 23 "Hydronic Piping".
2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
4. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.
5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.
6. VAV modulating hot water valves shall have stainless steel trim and stem.

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7. Any control valves mounted outside exposed to ambient conditions shall be installed with an accessible water proof protective cover of sufficient size.

## 2.8 MISCELLANEOUS DEVICES

### A. LOCAL CONTROL PANELS

1. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices-such as relays, transducers, and so forth-that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All low voltage wiring inside panels shall be in flame retardant PVC wire duct raceway.
6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

### B. POWER SUPPLIES

1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply. 2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to the power supply.

## 2.9 ~~SPARE PARTS~~

~~A. Contractor shall provide Spare Parts equal to 10% of the total DDC Equipment for the following:~~

- ~~1. Controllers~~
- ~~2. Valve and Damper Actuators~~
- ~~3. Thermostats & Humidistats~~
- ~~4. Sensors~~
- ~~5. Switches~~
- ~~6. Relays~~

## PART 3 - EXECUTION

### 3.1 BMS SPECIFIC REQUIREMENTS

#### A. GRAPHIC DISPLAYS

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

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2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

**B. ACTUATION / CONTROL TYPE**

1. Primary Equipment
  - a. Controls shall be provided by equipment manufacturer as specified herein.
  - b. All damper and valve actuation shall be electric.
2. Air Handling Equipment
  - a. All air handlers shall be controlled with a HVAC-DDC Controller
  - b. All damper and valve actuation shall be electric.
3. Terminal Equipment:
  - a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.
  - b. All Terminal Units shall be controlled with HVAC-DDC Controller)

**3.2 INSTALLATION PRACTICES**

**A. BMS WIRING**

1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
2. All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BMS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
4. Class 2 Wiring
  - a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified. Color of conduit shall be blue.
  - b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

**B. BMS LINE VOLTAGE POWER SOURCE**

1. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
2. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.
3. DDC terminal unit controllers may use AC power from motor power circuits.

**C. BMS RACEWAY**

1. All low voltage wiring non-accessible/concealed or exposed shall be installed in a conduit raceway min ½", standardized blue in color for controls (EMT for inside and

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- Rigid for exterior). All other low voltage wiring shall be neatly installed with J-hooks or bridal rings spaced at 5' max with hangers specific to this system (do not use other trades hangers or structures).
2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) shall be used as approved by the Project Engineer.
  3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
  4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment.
  5. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
- D. Penetrations
1. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
  2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
  3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
  4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
- E. BMS IDENTIFICATION STANDARDS
1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
  2. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
- F. BMS Panel Installation
1. The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
  2. The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
- G. INPUT DEVICES
1. All Input devices shall be installed per the manufacturer recommendation.
  2. Locate components of the BMS in accessible local control panels wherever possible.
- H. HVAC INPUT DEVICES - GENERAL
1. All Input devices shall be installed per the manufacturer recommendation
  2. Locate components of the BMS in accessible local control panels wherever possible.
  3. The mechanical contractor shall install all in- line devices such as temperature wells, pressure taps, airflow stations, etc.
  4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
  5. Outside Air Sensors
    - a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
    - b. Sensors shall be installed with a rain proof, perforated cover.
  6. Water Differential Pressure Sensors

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- a. Differential pressure transmitters used for flow measurement shall be sized to the flow- sensing device.
- b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
- c. The transmitters shall be installed in an accessible location wherever possible.
7. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
  - a. Air bleed units, bypass valves and compression fittings shall be provided.
8. Building Differential Air Pressure Applications (- 1" to +1" w.c.):
  - a. Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
  - b. The interior tip shall be inconspicuous and located as shown on the drawings.
9. Air Flow Measuring Stations:
  - a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
  - b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
10. Duct Temperature Sensors:
  - a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
  - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
  - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
  - d. The sensor shall be mounted to suitable supports using factory approved element holders.
11. Space Sensors:
  - a. Shall be mounted per ADA requirements.
  - b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
12. Low Temperature Limit Switches:
  - a. Install on the discharge side of the first water or steam coil in the air stream.
  - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
  - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
13. Air Differential Pressure Status Switches:
  - a. Install with static pressure tips, tubing, fittings, and air filter.
14. Water Differential Pressure Status Switches:
  - a. Install with shut off valves for isolation.
- I. HVAC OUTPUT DEVICES
  1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
  2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke.
  3. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
  4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI.

### 3.3 TRAINING

- A. The BMS contractor shall provide the following training services:

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CONTRACT NO: \_\_\_\_\_

1. Provide (3) 8 hour days, total of 24 hours of on-site training by a system specialist who is fully knowledgeable of the specific installation details of the project. This training shall, at a minimum, consist of a review of the project Graphics, As-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

### 3.4 PERFORMANCE VERIFICATION TEST (PVT)

#### A. PVT Plan

Prior to the scheduling of the PVT, submit a PVT Plan for approval. The PVT Plan shall include the following, as a minimum:

1. Installed system one-line block diagram, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.
2. Installed system hardware description.
3. Installed system software description, including any software revisions made since the factory test.
4. Listing of control and status points installed in the system; plus a table with the following information:
  - a. Input and output variables.
  - b. SNVTs for each variable.
  - c. Expected engineering units for each variable.
  - d. Node ID.
  - e. Domain & subnet addressing.
5. Layout full plan to show what will be tested by the PVT
6. List of test equipment.

#### B. PVT Test

- Provide qualified on-site controls system specialist to perform the PVT.
- Contractor shall notify the Project Engineer and Inspector to observe testing minimum of 7 days prior to testing.
- Conduct the PVT to demonstrate that the control system maintains setpoints and that the control loops are tuned for the correct sequence of operation.
- Conduct the PVT during one week of continuous HVAC and control systems operation, after the TAB and before final acceptance of work.
- Specifically, the PVT shall demonstrate that the HVAC system operates properly through the complete sequence of operation (e.g., seasonal, occupied and unoccupied, warm up, etc.), for specified control sequences.
  - Provide a minimum of (4) days of trends in graphic format measured with the BAS while equipment is in full automatic mode to ensure that all system are working properly under all conditions. Include the project points, data in same time increments and clearly identify all trend data.
- Demonstrate that hardware interlocks and safety devices work as designed and alarm as specified.

SOLICITATION NO: \_\_\_\_\_  
CONTRACT NO: \_\_\_\_\_

- Demonstrate all equipment flow stations, dampers, sensors, end devices operate and alarm as specified. Record all data per design, actual and final. Record any notes for each component, as required.
- Demonstrate the Controls Graphics depict actual building / space / equipment layout, functioning properly, descriptions are user friendly & accurate, ECMS shop controls manager has reviewed graphics, monitor / alarms are set up and schedules are set up. Provide hard copies of the Controls Graphics with the PVT.
- If, during PVT testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed shall be re-performed. Give the Government a written report of those items which failed, what the problem was, and what was done to correct it.
- Other items to include in PVT:
  1. Test identification number(s)
  2. Test title
  3. Initial environmental conditions (if applicable)
  4. Test equipment (if required)

C. PVT Report

Submit a final, complete PVT test report, after completing the test, consisting of the following, as a minimum:

1. Section one of the submittal shall be a short summary of the performance verification test.
2. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

D. PVT Demonstration

Perform a PVT Demonstration. Explain the DDC System, review the PVT Report, demonstrate 10% of the tested components and make a punchlist of any deficiencies to be corrected. Contractor correct deficiencies and retest any items necessary based on the demonstration. Once all punchlist deficiencies are complete and resubmitted, the Government shall approve the PVT Test.

END OF SECTION 230923

SECTION 23 11 20

FACILITY GAS PIPING  
05/20

PART 1 GENERAL

1.1 SUMMARY

This specification section applies to gas piping installed within buildings incidental underground piping under building, above ground steel piping and corrugated stainless steel tubing (CSST) both outside (up to 5 feet beyond exterior walls) and within buildings in compliance with NFPA 54 /AGA Z223.1, "National Fuel Gas Code" NFPA 58, "Fuel Gas Piping".

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA Z223.1 (2012) National Fuel Gas Code

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1 (2009; Addenda A 2012, Addenda B 2013; R 2019) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

ANSI Z21.18/CSA 6.3 (2007; R 2017) Gas Appliance Pressure Regulators

ANSI Z21.21/CSA 6.5 (2019) Automatic Valves for Gas Appliances

AMERICAN PETROLEUM INSTITUTE (API)

API RP 2009 (2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants

API Spec 6D (June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves

API Std 598 (2009) Valve Inspecting and Testing

API Std 607 (2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2016) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME B31.9	(2020) Building Services Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
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NFPA 58 (2020; TIA 20-1; TIA 20-2; TIA 20-3)  
Liquefied Petroleum Gas Code

NFPA 70 (2023) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192 Transportation of Natural and Other Gas by  
Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE (2012) Flammable and Combustible Liquids  
and Gases Equipment Directory

### 1.3 SYSTEM DESCRIPTION

The gas piping system includes natural gas piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

#### 1.3.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

#### 1.3.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No. 4.

#### 1.3.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

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#### 1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

##### SD-02 Shop Drawings

Gas Piping System

##### SD-03 Product Data

Pipe and Fittings

Pressure Regulators

Valves

##### SD-06 Test Reports

Testing

Pressure Tests

Test with Gas

##### SD-07 Certificates

Welders Procedures and Qualifications

Assigned Number, Letter, or Symbol

##### SD-10 Operation and Maintenance Data

Gas Facility System and Equipment Operation

Gas Facility System Maintenance

#### 1.5 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Mark all valves, flanges and fittings in accordance with MSS SP-25.

##### 1.5.1 Welding Qualifications

- a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with API RP 2009, ASME BPVC SEC IX, and ASME B31.9. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.9. Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.
- b. Submit a certified copy of welders procedures and qualifications metal and PE in conformance with ASME B31.9 for each welder and welding operator. Submit the assigned number, letter, or symbol that will be

used in identifying the work of each welder to the Contracting Officer.

#### 1.5.2 Shop Drawings

Submit drawings for complete Gas Piping System showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of gas equipment connectors and supports.

### PART 2 PRODUCTS

#### 2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

#### 2.2 GAS PIPING SYSTEM AND FITTINGS

##### 2.2.1 Steel Pipe, Joints, and Fittings

- a. Pipe: Schedule 40 Black carbon steel in accordance with ASTM A53/A53M, Grade B Type E or ASTM A106/A106M Grade B, threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.
- b. Threaded Fittings: ASME B16.3, black malleable iron.
- c. Socket-Welding Fittings: ASME B16.11, forged steel.
- d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.
- e. Unions: ASME B16.39, black malleable iron.
- f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1, with flange faces having integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

##### 2.2.2 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. For taping, use tetrafluoroethylene tape conforming to UL FLAMMABLE & COMBUSTIBLE.

##### 2.2.3 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR) suitable for a maximum 600 degree F service, to be used for hydrocarbon service.

#### 2.2.4 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

#### 2.2.5 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

#### 2.2.6 Insulating Pipe Joints

##### 2.2.6.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

##### 2.2.6.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

##### 2.2.6.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts.

#### 2.3 VALVES

Provide lockable shutoff or service isolation valves conforming to the following:

##### 2.3.1 Valves 2 Inches and Smaller

Provide valves 2 inches and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used.

##### 2.3.2 Valves 2-1/2 Inches and Larger

Provide valves 2-1/2 inches and larger of carbon steel conforming to API Spec 6D, Class 150.

#### 2.4 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58, and as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

#### 2.5 APPLIANCE REGULATORS AND SHUTOFF VALVES

Provide regulators conforming to ANSI Z21.18/CSA 6.3 for appliance regulators. Provide shutoff valves conforming to ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves and ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances.

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## 2.6 NATURAL GAS SERVICE

## 2.7 SOLENOID SHUT-OFF VALVES

Provide valves 2 inches and smaller with brass body rated for 125 psig.

Provide normally closed valve with electronic solenoid actuator. Valve shall be UL listed.

## 2.8 GASKETS

Fluorinated elastomer, compatible with flange faces.

## 2.9 IDENTIFICATION FOR ABOVEGROUND PIPING

Labels and color code marking of piping and equipment shall be as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS.

# PART 3 EXECUTION

## 3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy or areas of conflict before performing the work.

## 3.2 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the existing outdoor shutoff valve, to the connections to each gas utilization device that is in compliance with NFPA 54.

### 3.2.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

### 3.2.2 Workmanship and Defects

Piping, tubing and fittings must be clear and free of cutting burrs and defects in structure or threading and must be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

## 3.3 PROTECTIVE COVERING

### 3.3.1 Aboveground Metallic Piping Systems

#### 3.3.1.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed. Mechanically clean surfaces that contain loose rust, loose mill scale and other foreign substances by power wire brushing SSPC SP 6/NACE No.3 and prime with ferrous metal primer. Finish primed surfaces with two coats of exterior oil paint.

### 3.4 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54, and as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable.

#### 3.4.1 Metallic Piping Installation

Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

#### 3.4.2 Concealed Piping in Buildings

Do not conceal piping within buildings.

#### 3.4.3 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than 6 inches from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

#### 3.4.4 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Provide accessible gas shutoff valve and coupling for each gas equipment item.

### 3.5 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

#### 3.5.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to 1-1/2 inches in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to 2 inches in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

#### 3.5.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to NFPA 54. Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that

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have been wetted or have lost any of their coating.

### 3.6 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54 and NFPA 58.

### 3.7 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. For post-installed anchors in existing or new concrete or masonry, comply with specifications Section 05 05 20 POST-INSTALLED CONCRETE AND MASONRY ANCHORS.

### 3.8 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-58 and as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 1/8 inch between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

### 3.9 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building that is electrically continuous and bonded to a grounding electrode as required by NFPA 54 and NFPA 70.

### 3.10 SHUTOFF VALVE

Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally.

### 3.11 APPLIANCE PRESSURE REGULATORS

Install appliance regulators in accordance with the manufacturer's requirements and in accordance with NFPA 54. Install each regulator in an accessible location and install shutoff valves ahead of each appliance regulator to allow for maintenance. Where vent limiting devices are not included in the regulators, install a vent pipe to the exterior of the building. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

### 3.12 GAS SERVICE INSTALLATION

Installations must be in accordance with 49 CFR 192 and ASME B31.8. Contractor must submit and use only tested and approved work procedures.

Contractor must use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product must be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

### 3.13 TESTING

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, purge the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

#### 3.13.1 Pressure Tests

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 0.1 pound. Isolate the source of pressure before the pressure tests are made.

#### 3.13.2 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54. If leakage is recorded, shut off the gas supply, repair the leak, and repeat the tests until all leaks have been stopped.

#### 3.13.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.

#### 3.13.4 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.14 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 23 03 00.00 20  
BASIC MECHANICAL MATERIALS AND METHODS.

-- End of Section --

23 80 20.236  
LOW-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes low-intensity, gas-fired, forced-draft and draft-induced radiant heaters.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.
    - a. Burner Assembly: Five years.
    - b. Combustion and Emitter Tubes: Five years.
    - c. Heater Controls: One year.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. CSA certified, with CSA Seal and certification number clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- B. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### 2.2 FORCED-DRAFT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Calcana Industries Ltd.
  - 2. Combustion Research Corporation.
  - 3. Detroit Radiant Products Company.
  - 4. Roberts-Gordon, LLC.
  - 5. Schwank Group.
  - 6. Solaronics, Inc.
  - 7. Space-Ray; Division of Gas Fired Products, Inc.
  - 8. Sterling Heating, Ventilation & Air-Conditioning Products; a Mestek company.
  - 9. Thomas & Betts Corporation.
- B. Description: Factory-assembled, indoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.
- C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- D. Burner Assembly:
  - 1. Combustion-Air Inlet: ducted, vented.
  - 2. Ignition System: Direct spark 24/25-V ac or 115/120-V ac with flame rod sensing capabilities and self-diagnostic control module.
- E. Combustion Chamber: 4-inch- (100-mm-) diameter, 16-gage, stainless-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
- F. Emitter Tube: 4-inch- (100-mm-) diameter, 16-gage, stainless-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Emitter tubing shall be equipped with baffles to maximize heating efficiency.
  - 1. Tubing Connections: Stainless-steel threaded couplings.

- G. Reflector: Polished aluminum, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.
- H. Capacities and Characteristics: Provide forced draft radiant heaters as noted on the drawings.

### 2.3 DRAFT-INDUCED HEATERS

- A. Manufacturers: Subject to compliance with requirements,:
  - 1. Combustion Research Corporation.
  - 2. Detroit Radiant Products Company.
  - 3. Roberts-Gordon, LLC.
  - 4. Schwank Group.
  - 5. Solaronics, Inc.
  - 6. Space-Ray; Division of Gas Fired Products, Inc.
- B. Description: Factory-assembled, indoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.
- C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- D. Burner Assembly:
  - 1. Combustion-Air Inlet: ducted, vented.
  - 2. Ignition System: Direct spark 24/25-V ac or 115/120-V ac with flame rod sensing capabilities and self-diagnostic control module.
- E. Combustion Chamber: 4-inch- (100-mm-) diameter, 16-gage, stainless-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
- F. Emitter Tube: 4-inch- (100-mm-) diameter, 16-gage, stainless-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Emitter tubing shall be equipped with baffles to maximize heating efficiency.
  - 1. Tubing Connections: Stainless-steel threaded couplings.
- G. Vacuum Exhaust Fan: Dynamically balanced, direct-driven, isolated from emitter tubing exhaust system by high-temperature flexible vibration isolation connector. Fan and connector to have a minimum temperature rating of 450 deg F (232 deg C).
  - 1. Motors: General requirements for motors are specified in Specifications section "Common Motor Requirements for HVAC Equipment."
  - 2. Balancing Dampers: Plate type, mounted in cast, double-flange fitting with vacuum test plug.
  - 3. Filter: Cartridge type for mounting on burner housing.
  - 4. Vent Termination: Vertical through roof or Horizontal through side-wall with vent caps.

- H. Reflector: Polished aluminum, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.
- I. Capacities and Characteristics: Provide draft induced radiant heaters as noted on the drawings.

## 2.4 CONTROLS AND SAFETIES

- A. Gas Control Valve: Single or Two-stage, regulated redundant 24-V ac gas valve that contains pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
- B. Failure Safeguards: 100 percent shutoff of gas flow in the event of flame or power failure.
- C. Prepurge of air control system prior to burner ignition.
- D. Safety lockout of burner after three consecutive ignition failures and flame is not reestablished within trial ignition period.
- E. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.
- F. Control Panel Interlock: Stops burner if panel is open.
- G. Indicator Lights: "Airflow-on" and "burner-on" indicator lights.
- H. Thermostat: Single-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
  - 1. Control Transformer: Integrally mounted.
- I. Thermostat: Two-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
  - 1. Control Transformer: Integrally mounted.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54.
- B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments or Mount to substrate using manufacturer's rigid mounting kits or custom fabricated brackets.
  - 1. Comply with requirements for hangers and supports specified in Specifications Section "Hangers and Supports for HVAC Piping and Equipment."

- C. Maintain manufacturers' recommended clearances for combustibles.
- D. Gas Piping: Comply with Section "Fuel Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
  - 1. Gas Connections: Connect gas piping to radiant heaters according to NFPA 54.
- E. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.
- F. Vent Connections: Comply with Section "Breechings, Chimneys, and Stacks."
- G. Electrical Connections: Comply with applicable requirements in Section "Conductors and Cables."
  - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 2. Verify bearing lubrication.
  - 3. Verify proper motor rotation.
  - 4. Test Reports: Prepare a written report to record the following:
    - a. Test procedures used.
    - b. Test results that comply with requirements.
    - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- B. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.3 ADJUSTING

- A. Adjust initial-temperature set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.
- C. Adjust vacuum airflow and controls per drawings.

END OF SECTION

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM  
**08/19, CHG 3: 11/21**

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013; R 2018) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
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NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1	(2015) Standard for Good Workmanship in Electrical Construction
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less

NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2021) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1 (2020e) Commercial Building  
Telecommunications Infrastructure Standard

TIA-569 (2019e; Add 1 2022) Telecommunications  
Pathways and Spaces

TIA-607 (2019d) Generic Telecommunications Bonding  
and Grounding (Earthing) for Customer  
Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431 Energy Efficiency Program for Certain  
Commercial and Industrial Equipment

29 CFR 1910.147 The Control of Hazardous Energy (Lock  
Out/Tag Out)

29 CFR 1910.303 Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1 (2005; Reprint Jan 2020) UL Standard for  
Safety Flexible Metal Conduit

UL 5 (2016; Reprint Jul 2022) UL Standard for  
Safety Surface Metal Raceways and Fittings

UL 5A (2015; Reprint Aug 2020) Nonmetallic  
Surface Raceways and Fittings

UL 6 (2007; Reprint Sep 2019) UL Standard for  
Safety Electrical Rigid Metal Conduit-Steel

UL 20 (2018; Reprint Jan 2021) UL Standard for  
Safety General-Use Snap Switches

UL 44 (2018; Reprint May 2021) UL Standard for  
Safety Thermoset-Insulated Wires and Cables

UL 50 (2015) UL Standard for Safety Enclosures  
for Electrical Equipment,  
Non-Environmental Considerations

UL 67 (2018; Reprint Jul 2020) UL Standard for  
Safety Panelboards

UL 83 (2017; Reprint Mar 2020) UL Standard for  
Safety Thermoplastic-Insulated Wires and  
Cables

UL 248-12 (2011; Reprint Aug 2020) Low Voltage Fuses  
- Part 12: Class R Fuses

UL 360 (2013; Reprint Aug 2021) UL Standard for  
Safety Liquid-Tight Flexible Metal Conduit

UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Jul 2022) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 857	(2009; Reprint Apr 2021) UL Standard for Safety Busways
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021) UL Standard for Safety Surge Protective Devices

UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1569	(2018) UL Standard for Safety Metal-Clad Cables
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

## 1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

## 1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

Panelboards

Transformers

### SD-03 Product Data

Receptacles

Switches

Transformers

Surge Protective Devices

### SD-06 Test Reports

600-volt Wiring Test

Transformer Tests

Ground-fault Receptacle Test

### SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5

## 1.4 QUALITY ASSURANCE

### 1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

### 1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

#### 1.4.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

#### 1.4.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

## 1.5 MAINTENANCE

### 1.5.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

- a. Single line diagram of the "as-built" building electrical system.
- b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).
- c. Manufacturers' operating and maintenance manuals on active electrical

equipment.

## 1.6 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

## PART 2 PRODUCTS

### 2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

### 2.2 CONDUIT AND FITTINGS

Conform to the following:

#### 2.2.1 Rigid Metallic Conduit

##### 2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

#### 2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40 in accordance with NEMA TC 2, UL 651.

#### 2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

#### 2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

#### 2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40 (40 mils thick).

#### 2.2.6 Flexible Metal Conduit

UL 1, limited to 6 feet.

##### 2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

#### 2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: Cadmium- or zinc-coated in accordance with UL 514B.

##### 2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

#### 2.2.7.2 Fittings for EMT

Steel compression type.

#### 2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

### 2.3 SURFACE RACEWAY

#### 2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type.

#### 2.3.2 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type.

### 2.4 BUSWAY

NEMA BU 1.1, UL 857.

#### 2.4.1 Plug-In Busways

Unventilated type. Provide the following:

- a. Plug-in units: Circuit breaker-type.
- b. Bus bars: Covered with insulating material throughout, except at joints and other connection points.
- c. Capable of allowing installation or removal of plug-in units without the need to de-energize the bus.

### 2.5 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

#### 2.5.1 Outlet Boxes for Telecommunications System

Provide the following:

- a. Standard type 4 inches square by 2 1/8 inches deep.
- b. Depth of boxes: Large enough to allow manufacturers' recommended conductor bend radii.
- c. Outlet boxes for fiber optic telecommunication outlets: Include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum one inch conduit system.

### 2.6 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type 4X.

## 2.7 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

### 2.7.1 Conductors

Provide the following:

- a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.
- b. Conductors No. 8 AWG and larger diameter: Stranded.
- c. Conductors No. 10 AWG and smaller diameter: Solid.
- d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: Stranded unless specifically indicated otherwise.
- e. All conductors: Copper.

#### 2.7.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

- a. Branch circuits: No. 12 AWG.
- b. Class 1 remote-control and signal circuits: No. 14 AWG.
- c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.
- d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

### 2.7.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

#### 2.7.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

- a. Grounding conductors: Green.
- b. Neutral conductors: White.
- c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: White with a different colored (not green) stripe for each.

#### 2.7.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

- a. 208/120 volt, three-phase.

(1) Phase A - black.

(2) Phase B - red.

(3) Phase C - blue.

b. 480/277 volt, three-phase.

(1) Phase A - brown.

(2) Phase B - orange.

(3) Phase C - yellow.

c. 120/240 volt, single phase: Black and red.

### 2.7.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

### 2.7.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

#### 2.7.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 750 kcmil. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

#### 2.7.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

### 2.7.5 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

## 2.8 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: Insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

## 2.9 DEVICE PLATES

Provide the following:

- a. UL listed, one-piece device plates for outlets to suit the devices installed.
- b. For metal outlet boxes, plates on unfinished walls: Zinc-coated sheet steel or cast metal having round or beveled edges.
- c. For nonmetallic boxes and fittings, other suitable plates may be provided.
- d. Plates on finished walls: Satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.
- e. Screws: Machine-type with countersunk heads in color to match finish of plate.
- f. Sectional type device plates are not be permitted.
- g. Plates installed in wet locations: Gasketed and UL listed for "wet locations.

## 2.10 SWITCHES

### 2.10.1 Toggle Switches

NEMA WD 1, UL 20, single pole, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

- a. Handles: Gray thermoplastic.
- b. Wiring terminals: Screw-type, side-wired.
- c. Contacts: Silver-cadmium and contact arm - one-piece copper alloy.
- d. Switches: Rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

### 2.10.2 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA 1, enclosure per NEMA ICS 6.

## 2.11 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

#### 2.11.1 Fuseholders

Provide in accordance with UL 4248-1.

#### 2.11.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 248-12. Provide only Class R associated fuseholders in accordance with UL 4248-12.

#### 2.12 RECEPTACLES

Provide the following:

- a. UL 498, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.
- b. Ratings and configurations: As indicated.
- c. Bodies: Gray as per NEMA WD 1.
- d. Face and body: Thermoplastic supported on a metal mounting strap.
- e. Dimensional requirements: Per NEMA WD 6.
- f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.
- g. Grounding pole connected to mounting strap.
- h. The receptacle: Containing triple-wipe power contacts and double or triple-wipe ground contacts.
- i. Controlled receptacles: As required per ASHRAE 90.1. Provide marking for controlled receptacle per NFPA 70.

#### 2.12.1 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

#### 2.12.2 Special Purpose Receptacles

Receptacles serving communications racks are special purpose. Provide in ratings indicated.

#### 2.13 PANELBOARDS

Provide panelboards in accordance with the following:

- a. UL 67 and UL 50 having a short-circuit current rating as indicated.
- b. Panelboards: Circuit breaker-equipped.
- c. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as

required by UL.

- d. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, obtain Government approval prior to device installation.
- e. Use of "Subfeed Breakers" is not acceptable.
- f. Main breaker: "Separately" mounted "above" or "below" branch breakers.
- g. Where "space only" is indicated, make provisions for future installation of breakers.
- h. Directories: Indicate load served by each circuit in panelboard.
- i. Directories: Indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).
- j. Provide new directories for existing panels modified by this project as indicated.
- k. Type directories and mount in holder behind transparent protective covering.
- l. Panelboards: Listed and labeled for their intended use.
- m. Panelboard nameplates: Provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

#### 2.13.1 Enclosure

Provide panelboard enclosure in accordance with the following:

- a. UL 50.
- b. Front edges of cabinets: Form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.
- c. All cabinets: Fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.
- d. Holes: Provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.
- e. Flush doors: Mounted on hinges that expose only the hinge roll to view when the door is closed.
- f. Each door: Fitted with a combined catch and lock latch.
- g. Keys: Two provided with each lock, with all locks keyed alike.
- h. Finished-head cap screws: Provided for mounting the panelboard fronts on the cabinets.

## 2.13.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

### 2.13.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:

- a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.
- b. Panelboard: Heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.
- c. Verification of the testing procedure: Provided upon request.
- d. Two neutral assemblies paralleled together with cable is not acceptable.
- e. Nameplates for panelboard rated for use on non-linear loads: Marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.
- f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

## 2.13.3 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

### 2.13.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

### 2.13.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

## 2.14 TRANSFORMERS

Provide transformers in accordance with the following:

- a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated.
- b. Provide transformers in NEMA 1 enclosure.
- c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and four 2.5 percent taps Full Capacity Below Nominal (FCBN).
- d. Transformer insulation system:
  - (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.
  - (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.
- e. Transformer of 80 degrees C temperature rise: Capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.
- f. Transformers: Quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

#### 2.14.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

#### 2.14.2 Transformers With Non-Linear Loads

Provide transformers for non-linear loads in accordance with the following:

- a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.
- b. Transformers are to be UL listed and labeled for K-Factor rating as indicated in accordance with UL 1561.
- c. Transformers evaluated by the UL K-Factor evaluation: Listed for 80 degrees C average temperature rise only.
- d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.
- e. K-Factor rated transformers impedance: Allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

#### 2.15 MOTORS

Provide motors in accordance with the following:

- a. NEMA MG 1.
- b. Hermetic-type sealed motor compressors: Also comply with UL 984.
- c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.
- d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.
- e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.
- f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.
- g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.
- h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- i. Use Inverter-Duty motors designed to operate with adjustable speed drive (ASD).

#### 2.15.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: High efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

#### 2.15.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

#### 2.15.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and

overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

#### 2.15.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment as specified herein. Power wiring and conduit: Conform to the requirements specified herein. Control wiring: Provided under, and conform to, the requirements of the section specifying the associated equipment.

#### 2.16 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

- a. UL 508, NEMA ICS 1, and NEMA ICS 2.
- b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.
- c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.
- d. Provide protection for motors from immediate restart by a time adjustable restart relay.
- e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.
- f. Connections to selector switch: Wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.
- g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: Connected in motor control circuit in "hand" and "automatic" positions.
- h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: Made in accordance with indicated or manufacturer's approved wiring diagram.
- i. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.
- j. Overload protective devices: Provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.
- k. Cover of combination motor controller and manual switch or circuit breaker: Interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or

circuit breaker is in "off" position.

#### 2.16.1 Control Wiring

Provide control wiring in accordance with the following:

- a. All control wire: Stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.
- b. Hinge wire: Class K stranding.
- c. Current transformer secondary leads: Not smaller than No. 10 AWG.
- d. Control wire minimum size: No. 14 AWG.
- e. Power wiring for 480-volt circuits and below: The same type as control wiring with No. 12 AWG minimum size.
- f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

#### 2.16.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

- a. NEMA ICS 4.
- b. Control circuit terminal blocks for control wiring: Molded or fabricated type with barriers, rated not less than 600 volts.
- c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.
- d. Terminals: Not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.
- e. Terminal arrangement: Subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.
- f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.
- g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

##### 2.16.2.1 Types of Terminal Blocks

- a. Short-Circuiting Type: Short-circuiting type terminal blocks: Furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: Comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

- b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: Provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

#### 2.16.3 Control Circuits

Control circuits: Maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: Conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits: Provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded.

#### 2.16.4 Enclosures for Motor Controllers

NEMA ICS 6.

#### 2.16.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: Include compelling relays and multiple-button, station-type with pilot lights for each speed.

#### 2.16.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: Heavy duty, oil-tight design.

#### 2.16.7 Pilot and Indicating Lights

Provide LED cluster lamps.

#### 2.17 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single pole designed for surface mounting with overload protection and pilot lights.

#### 2.18 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

## 2.19 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: Outlet boxes, conduits with pull wires cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

## 2.20 GROUNDING AND BONDING EQUIPMENT

### 2.20.1 Ground Bus

Copper ground bus: Provided in the electrical equipment rooms as indicated.

### 2.20.2 Secondary Bonding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with TIA-607. Busbars: Plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility and a Secondary bonding busbar (SBB) in all other telecommunications rooms and equipment rooms. The Primary bonding busbar (PBB) and the Secondary bonding busbar (SBB): Sized in accordance with the immediate application requirements and with consideration of future growth. Provide Secondary bonding busbars with the following:

- a. Predrilled copper busbar provided with holes for use with standard sized lugs.
- b. Minimum dimensions of 0.25 in thick by 4 in wide for the PBB and 2 in wide for SBBs with length as indicated;
- c. Listed by a nationally recognized testing laboratory.

## 2.21 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

## 2.22 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

- a. ASTM D709.
- b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.
- c. Each nameplate inscription: Identify the function and, when applicable, the position.
- d. Nameplates: Melamine plastic, 0.125 inch thick, white with black

center core.

- e. Surface: Matte finish. Corners: Square. Accurately align lettering and engrave into the core.
- f. Minimum size of nameplates: 1 by 2.5 inches.
- g. Lettering size and style: A minimum of 0.25 inch high normal block style.

#### 2.23 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

#### 2.24 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

#### 2.25 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-  
Phase to phase ( L-L )  
Each phase to neutral ( L-N )  
Neutral to ground ( N-G )  
Phase to ground ( L-G )

Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

700V for 208Y/120V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

## 2.26 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

- a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.
- b. Interior and exterior steel surfaces of equipment enclosures: Thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.
- c. Exterior surfaces: Free from holes, seams, dents, weld marks, loose scale or other imperfections.
- d. Interior surfaces: Receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.
- e. Exterior surfaces: Primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.
- f. Equipment located indoors: ANSI Light Gray.
- g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

## 2.27 SOURCE QUALITY CONTROL

### 2.27.1 Transformer Factory Tests

Submittal: Include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

## 2.28 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: Conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

#### 3.1.1 Service Entrance Identification

##### 3.1.1.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: Indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated

plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: Provided only as permitted by NFPA 70.

### 3.1.2 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: Separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: Made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

#### 3.1.2.1 Pull Wire

Install pull wires in empty conduits. Pull wire: Plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

#### 3.1.2.2 Metal-Clad Cable

For lighting fixtures and mechanical equipment (only). Install in accordance with NFPA 70, Type MC cable.

### 3.1.3 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

#### 3.1.3.1 Restrictions Applicable to Aluminum Conduit

- a. Do not install underground or encase in concrete or masonry.
- b. Do not use brass or bronze fittings.

#### 3.1.3.2 Restrictions Applicable to EMT

- a. Do not install underground.
- b. Do not encase in concrete, mortar, grout, or other cementitious materials.
- c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.
- d. Do not use in hazardous areas.

e. Do not use outdoors.

### 3.1.3.3 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

### 3.1.3.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS.

### 3.1.3.5 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC or PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: Installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

### 3.1.3.6 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: Supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for

lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

#### 3.1.3.7 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

#### 3.1.3.8 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

#### 3.1.3.9 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

#### 3.1.3.10 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

- a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: Installed and cabling length requirements in accordance with TIA-568.1. Size conduits, and cable trays in accordance with TIA-569 and as indicated.
- b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): Installed in accordance with TIA-569. Size conduits, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

#### 3.1.4 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Support in

accordance with manufacturer recommendations. Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly. Adjacent cable tray sections: Bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00 FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

### 3.1.5 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 4 ft to 5 ft centers to adequately support and distribute the cable's weight. Use these types of supports to support a maximum of 50 0.25 in diameter cables. Install suspended cables with at least 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: Suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

### 3.1.6 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: Cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, and when specifically indicated. Boxes in other locations: Sheet steel, except that nonmetallic boxes may be used with nonmetallic conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: Minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: Square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. 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 building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

#### 3.1.6.1 Boxes

Boxes for use with raceway systems: Minimum 1 1/2 inches deep, except

where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: Minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Mount outlet boxes flush in finished walls.

#### 3.1.6.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

#### 3.1.6.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

#### 3.1.7 Mounting Heights

Mount panelboards, motor controller and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets: Mounted at height 60 inches above finished floor.

#### 3.1.8 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

##### 3.1.8.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

- a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.
- b. Use permanent ink for the wire numbers.
- c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.
- d. Size marking strips to accommodate the two sets of wire numbers.
- e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's

schematic and connection diagrams.

- f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.
- g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

### 3.1.9 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

### 3.1.10 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

### 3.1.11 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

### 3.1.12 Grounding and Bonding

Provide in accordance with NFPA 70. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems.

Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70.

Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system.

In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

### 3.1.12.1 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: Effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment.

### 3.1.12.2 Telecommunications System

Provide telecommunications grounding in accordance with the following:

- a. **Telecommunications Grounding Busbars:** Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility. Install the PBB as close to the electrical service entrance grounding connection as practicable. Provide a Secondary bonding busbar (SBB) in all other telecommunications rooms and telecommunications equipment rooms. Install the SBB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the SBB near the backbone cabling and associated terminations. In addition, locate the SBB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a SBB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the SBB. Install Secondary bonding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.
- b. **Telecommunications Bonding Conductors:** Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a SBB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and

GE to the pathway ground, except at the PBB or the SBB.

- c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB or SBB: Utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the PBB or SBB to the PBB or SBB respectively. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB and SBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the SBB or PBB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the SBB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

#### 3.1.13 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

#### 3.1.14 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

#### 3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

#### 3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

#### 3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: As specified in Section 09 90 00 PAINTS AND COATINGS. Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.

### 3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test. Where applicable, test electrical equipment in accordance with NETA ATS.

#### 3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

#### 3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused must also be tested.

#### 3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

#### 3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

-- End of Section --