

DIVISION 16
ELECTRICAL

SECTION 16010
ELECTRICAL: BASIC REQUIREMENTS

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

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A. Section Includes:

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- 1. Basic requirements for electrical systems.

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B. Related Sections include but are not necessarily limited to:

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- 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

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- 2. Division 1 - General Requirements.

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- 3. Section 05505 – Metal Fabrications.

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- 4. Section 11005 - Equipment: Basic Requirements.

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1.2 DEFINITIONS

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A. For the purposes of providing materials and installing electrical work the following definitions shall be used.

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- 1. Outdoor Area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.

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- 2. Architecturally Finished Area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.

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- 3. Non-architecturally Finished Area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.

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- 4. Corrosive Areas: Rooms or areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.

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- 5. Shop Fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

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1.3 QUALITY ASSURANCE

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A. Referenced Standards:

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- 1. Aluminum Association Inc. (AA):

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- a. 1, Aluminum Standards and Data.

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- 2. American Iron and Steel Institute (AISI).

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- 3. American National Standards Institute (ANSI):

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- a. C2, National Electrical Safety Code.

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- b. Z535.1, Safety Color Code.

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- c. Z535.2, Environmental and Facility Safety Signs.

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- d. Z535.3, Criteria for Safety Symbols.

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- e. Z535.4, Product Safety Signs and Labels.

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- 4. American Society for Testing and Materials (ASTM):

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- a. A123, Standard Specification for Zinc Coating (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

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- b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

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- c. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

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- d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

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- 5. ETL Testing Laboratories, Inc (ETL).

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- 6. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. ICS 6, Enclosures for Industrial Controls and Systems.
 - 7. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 8. Occupational, Health and Safety Administration (OSHA):
 - a. 1910.145, Specification for Accident Prevention Signs and Tags.
- B. Where UL test procedures have been established for the product type, use UL or ETL approved electrical equipment and provide with the UL or ETL label.

1.4 SUBMITTALS

- A. Shop Drawings:
 - 1. See Section 01340.
 - 2. See Section 11005 and individual specification sections for submittal requirements for equipment.
 - 3. Non-equipment requirements.
 - a. Provide manufacturer's technical information on products to be used, including product descriptive bulletin.
 - b. Include data sheets that include manufacturer's name and product model number. Clearly identify all optional accessories.
 - c. Acknowledgement that products are UL or ETL listed or is constructed utilizing UL or ETL recognized components.
 - d. Manufacturer's delivery, storage, handling and installation instructions.
 - e. Product installation details.
 - f. See individual specification sections for any additional requirements.
- B. Operation and Maintenance Manuals:
 - 1. See Section 01340.
- C. When a narrow scope specification include products specified in another narrow scope specification, each section shall have the required shop drawing transmittal form per Section 01340 and all sections shall be submitted simultaneously.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01600.
- B. Ensure that equipment is not used as steps, ladders, scaffolds, platforms, or for storage-either inside or on top of enclosures.
- C. Protect nameplates on electrical equipment to prevent defacing.

1.6 AREA DESIGNATIONS

- A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
 - 1. Outdoor areas are considered wet unless specifically designated on the Drawings or in the specifications as corrosive and/or hazardous.
 - 2. Indoor areas are considered dry unless specifically designated on the Drawings or in the specifications as wet, corrosive and/or hazardous.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Refer to specific Division 16 sections and specific material paragraphs below.
- B. Provide all components of a similar type by one manufacturer.

1 **2.2 MATERIALS**

- 2 A. Electrical Equipment Supports:
- 3 1. Approved manufacturers:
- 4 a. Unistrut Building Systems.
- 5 2. Material requirements:
- 6 a. Galvanized steel: ASTM A123 or ASTM A153.
- 7 b. Stainless steel: AISI Type 316.
- 8 c. PVC coat galvanized steel: ASTM A123 or ASTM A153 and 20 mil PVC coating.
- 9 B. Nameplates for labeling equipment enclosures and equipment that is visible with the enclosure
- 10 door closed:
- 11 1. Approved manufacturers catalog numbers:
- 12 a. W. H. Brady Co., #B-1.
- 13 b. Seton, "Setonply".
- 14 2. Materials: Phenolic, 2-ply engraved.
- 15 3. Size:
- 16 a. Surface: As required for the text.
- 17 b. Thickness: 1/16 IN.
- 18 4. Fabrication:
- 19 a. Two layer laminated.
- 20 b. Legend engraved through top lamination into bottom lamination.
- 21 c. Drilled holes in each corner, for screw mounting.
- 22 5. Colors: Black top surface, white core, unless otherwise indicated.
- 23 6. Fasteners: Self-tapping stainless steel screws.
- 24 C. Nameplates for labeling components inside equipment enclosures:
- 25 1. Approved manufacturers catalog numbers:
- 26 a. W. H. Brady Co., "Industrial Strength Tape" #42018.
- 27 b. Seton, "Component and General Identification Labels" #45553.
- 28 c. Panduit, "Standard Labeling Tape" LS4-33.
- 29 2. Materials: vinyl tape or vinyl cloth with printable topcoat.
- 30 3. Colors: White background, black printing.
- 31 D. Safety Signs:
- 32 1. Approved manufacturers catalog numbers:
- 33 a. W. H. Brady Co., #B-302 or #B-120.
- 34 b. Seton, Pressure Sensitive Vinyl or Tedlar Coated Plastic.
- 35 c. Panduit, GMM Polyester Film (Type PPS) or GMPE1 Rigid Polyethylene (Type PRS).
- 36 2. Materials, size and fabrication:
- 37 a. For indoor use: Polyester or vinyl, surface area as required by the text, 4 mil minimum
- 38 thickness, self-adhesive.
- 39 b. For outdoor use and on entrances to electrical rooms or stations: Fiberglass or coated
- 40 plastic, surface area as required by the text, minimum area 7 x 10 IN, 60 mil thickness,
- 41 drilled holes for screw mounting.
- 42 3. Color in accordance with ASME (ANSI Z535.1, .2, .3 and .4) and OSHA 1910.145.
- 43 4. Minimum letter size on indoor signs, 3/16 IN.
- 44 5. Maximize the letter size on outdoor signs to sufficiently fill the printable area on the sign.
- 45 6. Standards: ASME/ANSI Z535.1, Z535.2, Z535.3 and Z535.4, OSHA 1910.145.

46 **PART 3 - EXECUTION**

47 **3.1 INSTALLATION**

- 48 A. Install and wire all equipment, including prepurchased equipment, and perform all tests
- 49 necessary to assure conformance to the Drawings and Specifications and ensure that equipment
- 50 is ready and safe for energization.

- 1 B. Install equipment in accordance with the requirements of:
- 2 1. NFPA 70 (NEC).
- 3 2. ANSI C2.
- 4 3. The manufacturer's instructions.
- 5 C. Do not use equipment that exceed dimensions or reduces working clearances indicated on the
- 6 Drawings or as required by the NEC.
- 7 D. Coordinate the installation of electrical equipment with other trades.
- 8 1. Arrange for the building-in of equipment during structure construction.
- 9 2. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs,
- 10 openings, etc., as required to allow installation of equipment after structure construction is
- 11 complete.
- 12 E. Install equipment plumbed, square and true with construction features and securely fastened.
- 13 F. Install electrical equipment, including pull and junction boxes, minimum of 6 IN from process,
- 14 gas, air and water piping and equipment.
- 15 G. Install equipment so it is readily accessible for operation and maintenance, is not blocked or
- 16 concealed and does not interfere with normal operating and maintenance requirements of other
- 17 equipment.
- 18 H. Device Mounting Schedule:
- 19 1. Mounting heights as indicated below:
- 20 a. Light switch (to center): 48 IN.
- 21 b. Receptacle in architecturally finished areas (to center): 18 IN.
- 22 c. Receptacle on exterior wall of building (to center): 18 IN.
- 23 d. Receptacle in non-architecturally finished areas (to center): 48 IN.
- 24 e. Telephone outlet in architecturally finished areas (to center): 18 IN.
- 25 f. Telephone outlet for wall-mounted phone (to center): 54 IN.
- 26 g. Safety switch (to center of operating handle): 54 IN.
- 27 h. Separately mounted motor starter (to center of operating handle): 54 IN.
- 28 i. Pushbutton or selector switch control station (to center): 48 IN.
- 29 j. Panelboard (to top): 72 IN.
- 30 I. Avoid interference of electrical equipment operation and maintenance with structural members,
- 31 building features and equipment of other trades. When it is necessary to adjust the intended
- 32 location of electrical equipment, unless specifically dimensioned or detailed, the Contractor may
- 33 make adjustments in equipment locations in accordance with the following without obtaining the
- 34 Engineer's approval:
- 35 1. 1 FT at grade, floor and roof level in any direction in the horizontal plane.
- 36 2. 1 FT for equipment other than lighting at ceiling level in any direction in the horizontal
- 37 plane.
- 38 3. 1 FT for lighting fixtures at ceiling level in any direction in the horizontal plane.
- 39 4. 1 FT on walls in a horizontal direction within the vertical plane.
- 40 5. Changes in equipment location exceeding those defined above require the Engineer's
- 41 approval.
- 42 J. Provide electrical equipment support system per the following area designations:
- 43 1. Dry areas, including areas that are also designated as hazardous:
- 44 a. Galvanized system consisting of: galvanized steel channels and fittings, nuts and
- 45 hardware and conduit clamps.
- 46 2. Corrosive and/or wet areas, including areas that are also designated as hazardous:
- 47 a. Stainless steel system consisting of: Stainless steel channels and fittings, nuts and
- 48 hardware and conduit clamps.
- 49 b. PVC coated steel system consisting of: PVC coated steel channels and fittings and
- 50 conduit clamps with stainless steel nuts and hardware.

- 1 K. Provide all necessary anchoring devices and supports rated for the equipment load based on
2 dimensions and weights verified from approved submittals, or as recommended by the
3 manufacturer.
4 1. See Section 05505.
5 2. Do not cut, or weld to, building structural members.
6 3. Do not mount safety switches or other equipment-to-equipment enclosures, unless enclosure
7 mounting surface is properly braced to accept mounting of external equipment.
- 8 L. Provide corrosion resistant spacers to maintain 1/4 IN separation between equipment and
9 mounting surface in wet areas, on below-grade walls, and on walls of liquid containment or
10 processing areas such as clarifiers, digesters, basins, storage tanks, etc.
- 11 M. Do not place equipment fabricated from aluminum in direct contact with earth or concrete.
- 12 N. Screen or seal all openings into equipment mounted outdoors to prevent the entrance of rodents
13 and insects.
- 14 O. Do not use materials that may cause the walls or roof of a building to discolor or rust.
- 15 P. Tag equipment enclosures and components that are visible with the enclosure door closed in
16 accordance with the following:
17 1. Use equipment name and number indicated on the Drawings.
18 2. Switchgear, switchboards, distribution panelboards, motor control centers:
19 a. Equipment main tag lettering:
20 1) Height: 1 IN minimum.
21 2) Equipment name (i.e., "MAIN SWITCHBOARD MSB100").
22 b. Main and feeder device tag lettering:
23 1) Height: 3/8 IN minimum.
24 2) Description of load (i.e., "PUMP P-101" or "PANELBOARD HP101").
25 3. Panelboards and transformers:
26 a. Equipment tag lettering:
27 1) Height: 3/8 IN minimum.
28 2) Equipment name (i.e., "PANELBOARD LP101" or "TRANSFORMER T101").
29 4. Transfer switches:
30 a. Equipment tag lettering:
31 1) Height: 3/8 IN minimum.
32 2) Equipment name (i.e., "AUTOMATIC TRANSFER SWITCH ATS101").
33 3) Normal source of power (i.e., "NORMAL SOURCE FED FROM MCC101").
34 4) Emergency source of power (i.e., "EMERGENCY SOURCE FED FROM
35 SGEN101").
36 5. Safety switches, separately mounted circuit breakers, motor starters, VFDs, etc.:
37 a. Equipment tag lettering:
38 1) Height: 1/4 IN minimum.
39 2) Description of load equipment is connected to (i.e., "PUMP P-101").
40 6. Control panels:
41 a. Equipment tag lettering:
42 1) Height: 1/4 IN minimum.
43 2) Equipment name (i.e., "FAN CONTROL PANEL FCP101").
- 44 Q. Tag components inside equipment enclosures in accordance with the following:
45 1. All components including, but not limited to, circuit breakers, fuses, control power
46 transformers, relays, contactors, and timers.
47 2. Lettering:
48 a. Height: 3/16 IN minimum.
49 b. Description or function of component such as M-101, CR-101 and TR-101.
- 50 R. Install Safety Signs as indicated in the following:
51 1. Legend in accordance with the following tabulation:

- 1 a. Entrances to electrical rooms and stations: In accordance with OSHA Danger Sign
2 requirements, ELECTRICAL ROOM, HIGH VOLTAGE (define voltage, example 480
3 V AC) KEEP OUT, AUTHORIZED PERSONNEL ONLY.
4 b. Equipment enclosures, cable tray and wireway where 120 V AC or higher and 50 V DC
5 and higher exist: In accordance with OSHA Danger Sign requirements, HIGH
6 VOLTAGE (define voltage, example 480 V AC) AUTHORIZED PERSONNEL
7 ONLY.
8 c. Equipment such as motor control centers, control panels, etc., where more than one
9 source may be present in an enclosure or cubicle: In accordance with OSHA Danger
10 Sign requirements, VOLTAGE (define voltage, example 120 V AC control voltage or
11 480 V AC power) FROM MULTIPLE SOURCES IN THIS ENCLOSURE.
12 d. Equipment such as switchboards, switchgear, panelboards and motor control centers:
13 In accordance with OSHA Warning Sign requirements, WARNING, SERVICE
14 ENTRANCE DISCONNECT FOR 1 OF ___ (define quantity) SERVICES TO THIS
15 BUILDING. OTHER SERVICE ENTRANCE DISCONNECTS ARE LOCATED AT
16 (define locations),
17 e. Equipment capable of being started remotely or automatically: In accordance with
18 OSHA Danger Sign requirements – “CAUTION! THIS EQUIPMENT STARTS
19 AUTOMATICALLY.”

20 **3.2 FIELD QUALITY CONTROL**

- 21 A. Verify exact rough-in location and dimensions for connection to electrified equipment.
22 1. Secure shop drawings from those furnishing the equipment.
23 2. See Section 01800 for openings and penetrations in structures.
24 B. Replace equipment and systems found inoperative or defective and re-test.
25 C. Cleaning:
26 1. See Section 01710.
27 2. Apply touch-up paint as required to repair scratches and other marks.
28 3. Replace nameplates damaged during installation.

29 **3.3 DEMONSTRATION**

- 30 A. Demonstrate equipment in accordance with Section 01650.

31 **END OF SECTION**

1 01C09

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SECTION 16060

3

GROUNDING

4 PART 1 - GENERAL

5 1.1 SUMMARY

6 A. Section Includes:

7 1. Grounding.

8 B. Related Sections include but are not necessarily limited to:

9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

10 2. Division 1 - General Requirements.

11 3. Section 01800 - Openings and Penetrations in Construction.

12 4. Section 16010 - Electrical: Basic Requirements.

13 5. Section 16120 - Wire and Cable - 600 Volt and Below.

14 6. Section 16130- Raceways and Boxes.

15 1.2 QUALITY ASSURANCE

16 A. Referenced Standards:

17 1. American Association of State Highway and Transportation Officials (AASHTO).

18 a. Standard Specification for Highway Bridges.

19 2. American Society for Testing and Materials (ASTM):

20 a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard,
21 Medium-Hard, or Soft.

22 3. Institute of Electrical and Electronics Engineers (IEEE):

23 a. 837, Qualifying Permanent Connections Used in Substation Grounding.

24 4. National Fire Protection Association (NFPA):

25 a. 70, National Electrical Code (NEC).

26 5. Underwriters Laboratories, Inc. (UL):

27 a. 467, Electrical Grounding and Bonding Equipment.

28 B. Assure ground continuity is continuous throughout the entire Project.

29 1.3 SUBMITTALS

30 A. Shop Drawings:

31 1. See Section 16010.

32 2. Fabrication and/or layout drawings:

33 a. Plan drawing(s) showing type, size and locations of all grounding system equipment,
34 wiring and connections.

35 B. Miscellaneous:

36 1. Ground rod and/or grounding system resistance and continuity test reports signed by the
37 project supervising electrical foreman.

38 PART 2 - PRODUCTS

39 2.1 ACCEPTABLE MANUFACTURERS

40 A. Subject to compliance with the Contract Documents, the following manufacturers are
41 acceptable:

42 1. Ground rods and bars and grounding clamps, connectors and terminals:

43 a. Burndy.

- 1 b. Harger Lightning Protection
- 2 c. Heary Brothers.
- 3 d. Joslyn.
- 4 e. Robbins Lightning Protection.
- 5 f. Thompson.
- 6 2. Exothermic weld connections:
- 7 a. Burndy.
- 8 b. Erico Products Inc., Cadweld.
- 9 c. Harger Lightning Protection
- 10 B. Submit requests for substitution in accordance with Specification Section 01640.

11 **2.2 COMPONENTS**

- 12 A. Wire and Cable:
- 13 1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
- 14 2. Insulated conductors: Green colored insulation, per Section 16120.
- 15 B. Conduit: As specified in Section 16130.
- 16 C. Ground Rods:
- 17 1. 3/4 IN x 10 FT.
- 18 2. Copperclad:
- 19 a. Heavy uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
- 20 b. Corrosion resistant bond between the copper and steel.
- 21 c. Hard drawn for a scar-resistant surface.
- 22 D. Grounding Clamps, Connectors and Terminals:
- 23 1. Mechanical type:
- 24 a. Standards: UL 467.
- 25 b. High copper alloy content.
- 26 2. Compression type for interior locations:
- 27 a. Standards: UL 467.
- 28 b. High copper alloy content.
- 29 c. Non-reversible.
- 30 d. Terminals for connection to bus bars shall have two bolt holes.
- 31 3. Compression type suitable for direct burial in earth or concrete:
- 32 a. Standards: UL 467, IEEE 837.
- 33 b. High copper alloy content.
- 34 c. Non-reversible.
- 35 E. Exothermic Weld Connections:
- 36 1. Copper oxide reduction by aluminum process.
- 37 2. Molds properly sized for each application.

38 **PART 3 - EXECUTION**

39 **3.1 INSTALLATION**

- 40 A. General:
- 41 1. Install products in accordance with manufacturer's instructions.
- 42 2. Size conductors as required by NEC Article 250, except use larger size conductors where
- 43 indicated on the Drawings.
- 44 3. Remove paint, rust, or other nonconducting material from contact surfaces before making
- 45 ground connections.
- 46 4. Where ground conductors pass through floor slabs or building walls provide sleeves per
- 47 Section 01800.
- 48 5. Do not splice grounding conductors except at ground rods.

- 1 6. Install ground rods and grounding conductors in firm soil outside of areas excavated during
- 2 construction of the structure.
- 3 a. Provide excavation required for installation of ground rods and ground conductors.
- 4 b. Use driving studs or other suitable means to prevent damage to threaded ends of
- 5 sectional rods.
- 6 c. Provide sufficient slack in grounding conductor to prevent conductor breakage during
- 7 backfill or due to ground movement.
- 8 d. Backfill excavation completely, thoroughly tamping to provide good contact between
- 9 backfill materials and ground rods and conductors.
- 10 7. Do not use exothermic welding if it will damage the structure the grounding conductor is
- 11 being welded to.

- 12 B. Grounding Electrode System:
- 13 1. Provide a grounding electrode system in accordance with NEC Article 250 and as indicated
- 14 on the Drawings.
- 15 2. Bond the following to the service entrance electrical gear ground bus using mechanical type
- 16 connectors.
- 17 a. Main water pipe:
- 18 1) Bare conductor #6 AWG conductor minimum, or as indicated on the Drawings.
- 19 2) Grounding conductor connected to the water pipe with mechanical type connectors.
- 20 b. Ground ring grounding system.
- 21 3. Ground Ring Grounding System:
- 22 a. Ground ring consists of ground rods and a grounding conductor looped around each
- 23 structure.
- 24 b. Placed at a minimum of 3 FT from the structure foundation and 2 FT-6 IN below grade.
- 25 c. Provide a minimum of four ground rods placed at the corners of the structure and
- 26 additional rods so that the maximum distance between ground rods does not exceed 50
- 27 FT.
- 28 d. Grounding conductor:
- 29 1) Bare conductor, size as indicated on the Drawings.
- 30 2) Grounding conductor connected to the ground rods with compression type
- 31 connector or exothermic weld.

- 32 C. Bonding of Miscellaneous Structures:
- 33 1. Other metal piping:
- 34 a. As indicated on the Drawings and as required by NEC 250.
- 35 b. Bare conductor, size as required by NEC 250.
- 36 c. Grounding conductor connected to the pipes with mechanical type connectors.

- 37 D. Step-down Transformers:
- 38 1. Ground separately mounted step-down transformer XO terminal to closest grounding
- 39 electrode, building steel or water pipe.
- 40 2. Ground motor control center (MCC) mounted step-down transformer XO terminal to the
- 41 MCC ground bus.

- 42 E. Raceway Grounding:
- 43 1. All metallic conduit shall be installed so that it is electrically continuous.
- 44 2. Provide grounding-type insulating bushings:
- 45 a. For all equipment not supplied with a conduit hub.
- 46 b. On ends of metallic ductbank conduit.
- 47 3. Provide double locknuts at all panels and wireways.
- 48 4. Bond all metal conduit, at entrance and exit of equipment, to the equipment ground bus or
- 49 lug.
- 50 5. Provide bonding jumpers if conduits are installed in concentric knockouts.
- 51 6. Make all metallic raceway fittings and grounding clamps tight to ensure equipment
- 52 grounding system will operate continuously at ground potential to provide low impedance
- 53 current path for proper operation of overcurrent devices during possible ground fault
- 54 conditions.

- 1 7. Bonding jumpers shall be sized in accordance with NEC 250.
- 2 F. Equipment Grounding:
- 3 1. Ground all equipment supplied from electrical gear through the gear's equipment ground
- 4 bus. Provide an equipment grounding conductor connected to the ground bus and equipment
- 5 ground lug.
- 6 a. Grounding conductor insulation shall be identical to phase conductor insulation.
- 7 b. Where green-colored insulated wire is not available, green electrical tape shall be
- 8 applied to all equipment grounding conductors where exposed, to include, but not be
- 9 limited to, in manholes and handholes, pull and junction boxes, wireways, and inside
- 10 equipment enclosures. Tape shall be applied continuously where exposed.

11 **3.2 FIELD QUALITY CONTROL**

- 12 A. Leave grounding system uncovered until observed by Owner/Engineer.
- 13 B. Provide a continuity test on the components of the grounding electrode system.
- 14 C. Complete grounding system: Resistance of 5 ohms or less.
- 15 D. Test resistance of installed ground system after backfilling and before connection to any other
- 16 grounded system including underground piping, utility services or other building ground
- 17 systems.
- 18 1. Test ground grid resistance by fall-of-potential method.
- 19 2. Perform test at the main ground bar.

20

END OF SECTION

2 **SECTION 16120**
3 **WIRE AND CABLE - 600 VOLT AND BELOW**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

6 A. Section Includes:

7 1. Material and installation requirements for:

- 8 a. Building wire.
- 9 b. Power and control cable.
- 10 c. Instrumentation cable.
- 11 d. Fiber optic cable.
- 12 e. Wire connectors.
- 13 f. Insulating tape.
- 14 g. Pulling lubricant.
- 15 h. Wire markers.

16 B. Related Sections include but are not necessarily limited to:

- 17 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
- 18 2. Division 1 - General Requirements.
- 19 3. Section 16010 - Electrical: Basic Requirements.

20 **1.2 QUALITY ASSURANCE**

21 A. Referenced Standards:

- 22 1. Insulated Cable Engineers Association:
 - 23 a. S-58-679, Control Cable Conductor Identification.
- 24 2. National Electrical Manufacturers Association (NEMA):
 - 25 a. ICS 4, Terminal Blocks for Industrial Use.
- 26 3. National Electrical Manufacturers Association/Insulated Cable Engineers Association
 - 27 (NEMA/ICEA):
 - 28 a. WC 70/ICEA S-95-658, Standard for Nonshielded Power Cables Rated 2000 Volts or
 - 29 Less for the Distribution of Electrical Energy.
- 30 4. National Fire Protection Association (NFPA):
 - 31 a. 70, National Electrical Code (NEC).
- 32 5. Underwriters Laboratories, Inc. (UL):
 - 33 a. 44, Thermoset-Insulated Wires and Cables.
 - 34 b. 83, Thermoplastic-Insulated Wires and Cables.
 - 35 c. 467, Grounding and Bonding Equipment.
 - 36 d. 486A, Wire Connectors and Soldering Lugs for use with Copper Conductors.
 - 37 e. 486C, Splicing Wire Connectors.
 - 38 f. 510, Insulating Tape.
 - 39 g. 910, Test for Cable Flame-Propagation and Smoke-Density Values for Electrical and
 - 40 Optical-Fiber Cables Used in Spaces Transporting Environmental Air.
 - 41 h. 1277, Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - 42 i. 1581, Reference Standard for Electrical Wires, Cables, and Flexible Cords.
 - 43 j. 1666, Test for Flame Propagation Height of Electrical and Optical-Fiber Cable Installed
 - 44 Vertically in Shafts.
 - 45 k. 2250, Instrument Tray Cable.

46 **1.3 DEFINITIONS**

- 1 A. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or
- 2 instrumentation wire.
- 3 B. Instrumentation Cable: Multiple conductor, insulated, twisted or untwisted, with outer sheath.
- 4 The following are specific types of instrumentation cables:
- 5 1. Analog signal cable: Used for the transmission of low current (e.g. 4-20mA DC) or low
- 6 voltage (e.g. 0-10 V DC) signals, using No. 16 AWG and smaller conductors. Commonly
- 7 used types are defined in the following:
- 8 a. UTP: Unshielded twisted pair.
- 9 b. TSP: Twisted shielded pair.
- 10 c. TST: Twisted shielded triad.
- 11 2. Digital signal cable: Used for the transmission of digital signals between computers, PLC's,
- 12 RTU's, etc.
- 13 C. Power Cable: Multi-conductor, insulated, with outer sheath containing building wire, #8 AWG
- 14 and larger.
- 15 D. Control Cable: Multi-conductor, insulated, with outer sheath containing building wires, #14, #12
- 16 or #10 AWG.
- 17 E. Building Wire: Single conductor, insulated, with or without outer jacket depending upon type.

18 **1.4 SUBMITTALS**

- 19 A. Shop Drawings:
- 20 1. See Section 16010.
- 21 B. Samples: Provide sample of largest size of each type of wire or cable for review prior to
- 22 installation. Sample shall have a legible and complete surface printing of identification.

23 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 24 A. See Section 16010.

25 **PART 2 - PRODUCTS**

26 **2.1 ACCEPTABLE MANUFACTURERS**

- 27 A. Subject to compliance with the Contract Documents, the following manufacturers are
- 28 acceptable:
- 29 1. Building wire, power and control cable:
- 30 a. American Insulated Wire Corporation.
- 31 b. General Cable.
- 32 c. Southwire Company.
- 33 2. Instrumentation cable:
- 34 a. Analog cable:
- 35 1) Alpha Wire Corporation.
- 36 2) American Insulated Wire Corporation.
- 37 3) Belden Wire and Cable.
- 38 4) General Cable.
- 39 3. Wire connectors:
- 40 a. Burndy Corporation.
- 41 b. Buchanan.
- 42 c. Ideal.
- 43 d. IlSCO.
- 44 e. 3M Co.
- 45 f. Teledyne Penn Union.
- 46 g. Thomas and Betts.
- 47 h. Phoenix Contact.

- 1 4. Insulating tape:
- 2 a. 3M Co.
- 3 b. Plymouth Bishop Tapes.
- 4 c. Red Seal Electric Co.
- 5 5. Wire Markers:
- 6 a. W. H. Brady Co.
- 7 b. Seton.
- 8 c. Panduit.
- 9 d. HellermannTyton.
- 10 B. Submit requests for substitution in accordance with Specification Section 01640.

11 2.2 MANUFACTURED UNITS

- 12 A. Building Wire:
- 13 1. Conductor shall be Class B stranded copper with 600 Volt rated insulation.
- 14 a. Conductor size #12 AWG for lighting and receptacle circuits only may be solid, not
- 15 stranded.
- 16 2. Surface mark with manufacturers name or trademark, conductor size, insulation type and
- 17 UL label.
- 18 3. When direct buried, UL Listed and marked as suitable for direct burial.
- 19 4. When exposed to sunlight, UL Listed and marked as sunlight resistant.
- 20 5. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 for type THHN/THWN and
- 21 THHN/THWN-2 insulation.
- 22 6. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 for type XHHW and XHHW-2
- 23 insulation.
- 24 B. Power and Control Cable:
- 25 1. Conductors shall be Class B stranded copper with 600 Volt rated insulation.
- 26 2. Surface mark with manufacturers name or trademark, conductor size, insulation type and
- 27 UL label.
- 28 3. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 and 1277 for type THHN/THWN
- 29 insulation with an overall PVC jacket.
- 30 4. Number of conductors as required, including a ground conductor as follows:
- 31 a. Power Cable: Provided with bare ground conductor.
- 32 b. Control Cable: Provided with or without bare ground conductor of the same AWG size.
- 33 When a bare ground conductor is not provided an additional insulated conductor shall
- 34 be provided and used as the ground conductor (e.g. 6/c #14 w/g and 7/c #14 are equal)
- 35 5. Individual conductor color coding:
- 36 a. Power Cable: ICEA Method 4.
- 37 b. Control Cable: ICEA Method 1, Table E-2.
- 38 c. See Part 3 of this specification for additional requirements.
- 39 6. When direct buried, UL Listed and marked as suitable for direct burial.
- 40 7. When exposed to sunlight, UL Listed and marked as sunlight resistant.
- 41 8. Conform to NFPA 70 Type TC.
- 42 C. Instrumentation Cable:
- 43 1. Surface mark with manufacturers name or trademark, conductor size, insulation type and
- 44 UL label.
- 45 2. Analog cable:
- 46 a. Copper conductors.
- 47 b. 600 Volt PVC insulation with PVC jacket.
- 48 c. Twisted pair(s) or triad(s) with 100 percent aluminum-polyester foil shield coverage
- 49 with stranded copper drain wire.
- 50 d. When direct buried, UL Listed and marked as suitable for direct burial.
- 51 e. When exposed to sunlight, UL Listed and marked as sunlight resistant.
- 52 f. Individual conductor color coding: ICEA Method 1, Table K-1.
- 53 g. Conform to UL 1581, UL 1277 and NFPA 70 Type TC.

- 1 3. Digital cable:
- 2 a. As recommended by equipment (e.g. PLC, RTU) manufacturer.
- 3 D. Fiber Optic Cable:
- 4 1. Design and fabrication:
- 5 a. Type:
- 6 1) Indoor: Tight buffered or loose tube with a dry gel water blocking system.
- 7 2) Outdoor: Loose tube with a wet or dry gel water blocking system.
- 8 b. Multi-mode.
- 9 c. Number of fibers: As indicated on Drawings.
- 10 d. Fiber size: 62.5/125 micrometer (core diameter/cladding diameter).
- 11 e. Glass fiber core.
- 12 f. Step index.
- 13 g. Maximum attenuation:
- 14 1) At 850 nm: 3.75 dB/km
- 15 2) At 1300 nm: 1.5dB/km.
- 16 h. Minimum bandwidth:
- 17 1) At 850 nm: 160 MHz/km.
- 18 2) At 1300 nm: 500 MHz/km.
- 19 i. Maximum tensile load:
- 20 1) Installation: 225 LBS.
- 21 2) Long term: 67 LBS.
- 22 j. Cable shall be resistant to spread of fire in accordance with NEC.
- 23 k. Cable jacket material:
- 24 1) In rigid steel conduit: PVC, or polyethylene.
- 25 2) In plenum or riser: Flame retardant material, PVC not allowed.
- 26 a) Plenum applications: Cable materials shall pass UL 910 and NFPA 262
- 27 requirements.
- 28 b) Riser applications: Cable materials shall pass UL 1666 requirements.
- 29 3) In cable tray: Polyethylene or equivalent; PVC not allowed.
- 30 a) Meet vertical flame tray test requirements of UL 1581 and CSA C22.2 No.
- 31 0.3-M.
- 32 4) Cables shall be listed and marked in accordance with the requirements of NEC.
- 33 5) Optical fiber cable type utilized shall be in accordance with NEC.
- 34 l. Design and fabrication:
- 35 1) Utilize ST type connectors:
- 36 a) Tip material: Ceramic or ceramic/glass composite.
- 37 b) Utilize connectors which do not require adhesive, epoxy, or polish.
- 38 E. Wire Connectors:
- 39 1. Twist/Screw on type:
- 40 a. Insulated pressure or spring type solderless connector.
- 41 b. 600 Volt rated.
- 42 c. Ground Conductors: Conform to UL 468C and/or UL 467 when required by local
- 43 codes.
- 44 d. Phase and neutral conductors: Conform to UL 486C.
- 45 2. Compression and mechanical screw type:
- 46 a. 600 Volt rated.
- 47 b. Ground conductors: Conform to UL 467.
- 48 c. Phase and neutral conductors: Conform to UL 486A.
- 49 3. Terminal block type:
- 50 a. High density, screw-post barrier-type with white center marker strip
- 51 b. 600 Volt and ampere rating as required, for power circuits.
- 52 c. 600 Volt, 20 Ampere rated for control circuits.
- 53 d. 600 Volt, 15 Ampere rated for instrumentation circuits.
- 54 e. Conform to NEMA ICS 4 and UL 486A.

- 1 F. Insulating Tape:
- 2 1. Pressure sensitive vinyl.
- 3 2. Premium grade.
- 4 3. Heat, cold, moisture, and sunlight resistant.
- 5 4. Thickness, depending on use conditions: 7, 8.5, or 10 mil.
- 6 5. For cold weather or outdoor location, tape must also be all-weather.
- 7 6. Comply with UL 510.
- 8 G. Pulling Lubricant: Cable manufacturer's standard containing no petroleum or other products that
- 9 will deteriorate insulation.
- 10 H. Wire markers for wiring inside control panels, electrical gear, terminal boxes:
- 11 1. Material: Vinyl or polyester tape.
- 12 a. Approved catalog numbers:
- 13 1) W. H. Brady Co., Indoor/Outdoor Vinyl Tape, B-580.
- 14 2) Seton, "Self-Laminating Wire Marker Labels" M7340.
- 15 3) Panduit, LS4M "Industrial Labeling Tape".
- 16 2. Material: Heat shrinkable polyolefin:
- 17 a. Approved catalog numbers:
- 18 1) Seton, Welded Wire Marking Sleeves.
- 19 2) HellermannTyton.
- 20 3. Colors: White background, black printing.
- 21 I. Wire markers for wiring in cable vaults, cable trays, manholes and handholes:
- 22 1. Material: Fiberglass reinforced plastic.
- 23 a. Approved manufacturer's catalog numbers:
- 24 1) W. H. Brady Co., B-120.
- 25 2. Legend: Preprinted and permanently embedded.
- 26 3. Colors: White background, black printing.
- 27 4. Fasteners: Nylon, urethane or polypropylene strap.

28 **PART 3 - EXECUTION**

29 **3.1 INSTALLATION**

- 30 A. Permitted Usage of Insulation Types:
- 31 1. Type XHHW or XHHW-2:
- 32 a. Building wire and power cable No. 6 AWG and larger.
- 33 2. Type THHN/THWN and THHN/THWN-2:
- 34 a. Building wire and control cable No. 8 AWG and smaller.
- 35 B. Conductor Size Limitations:
- 36 1. Feeder and branch power conductors shall not be smaller than No. 12 AWG unless
- 37 otherwise indicated on the Drawings.
- 38 2. Control conductors shall not be smaller than No. 14 AWG unless otherwise indicated on the
- 39 Drawings.
- 40 3. Instrumentation conductors shall not be smaller than No. 18 AWG unless otherwise
- 41 indicated on the Drawings.
- 42 C. Color Code All Wiring as Follows:
- 44 1. Building wire:

	240V, 208V, 240/120 V, 208/120 V	480 V, 480/277 V
Phase 1	Black	Brown
Phase 2	Red	Yellow
Phase 3	Blue	Purple

Neutral Ground	White Green	Gray Green
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- a. Conductors #6 AWG or smaller: Insulated phase, neutral and ground conductors shall be identified by a continuous colored outer finish along its entire length.
 - b. Conductors larger than #6 AWG:
 - 1) Insulated phase and neutral conductors shall be identified by one of the following methods:
 - a) Continuous colored outer finish along its entire length.
 - b) 3 IN of colored tape applied at the termination.
 - 2) Insulated grounding conductor shall be identified by one of the following methods:
 - a) Continuous green outer finish along its entire length.
 - b) Stripping the insulation from the entire exposed length.
 - c) Using green tape to cover the entire exposed length.
 - 3) The color coding shall be applied at all accessible locations, including but not limited to: junction and pull boxes, wireways, manholes and handholes.
 - 2. Power cables: ICEA Method 4 with:
 - a. Phase and neutral conductors identified with 3 IN of colored tape, per the Table herein, applied at the terminations.
 - b. Ground conductor: Bare.
 - 3. Control cables ICEA Method 1, Table E-2:
 - a. When a bare ground is not provided, one of the colored insulated conductors shall be reidentified by stripping the insulation from the entire exposed length or using green tape to cover the entire exposed length.
 - b. When used in power applications the colored insulated conductors used as phase and neutral conductors may have to be reidentified with 3 IN of colored tape, per the Table herein, applied at the terminations.
- D. Install all wiring in raceway unless otherwise indicated on the Drawings.
- E. Feeder, branch, control and instrumentation circuits shall not be combined in a raceway, cable tray, junction or pull box, except as permitted in the following:
 - 1. Where specifically indicated on the Drawings.
 - 2. Where field conditions dictate and written permission is obtained from the Engineer.
 - 3. AC control circuits shall be isolated from all DC circuits.
 - 4. Instrumentation circuits shall be isolated from feeder and branch power and AC control circuits but combining of instrumentation circuits is permitted. The combinations shall comply with the following:
 - a. Analog signal circuits may utilize a common raceway.
 - b. Digital signal circuits may utilize a common raceway but isolated from analog signal circuits.
 - 5. For lighting and receptacle circuits, multiple branch circuits may be installed in a raceway as allowed by the NEC, with the wire ampacity derated in accordance with the requirements of the NEC. Raceway fill shall not exceed the limits established by the NEC.
- F. Ground the drain wire of shielded instrumentation cables at one end only. The preferred grounding location is at the load (e.g., control panel), not at the source (e.g., field mounted transmitter).
- G. Splices and taps for the following circuit types shall be made in the indicated enclosure type using the indicated method.
 - 1. Feeder and branch power circuits.
 - a. Device outlet boxes:
 - 1) Twist/screw on type connectors.
 - b. Junction and pull boxes and wireways:
 - 1) Twist/screw on type connectors for use on #8 and smaller wire.
 - 2) Compression, mechanical screw or terminal block or terminal strip type connectors for use on #6 AWG and larger wire.

- 1 c. Motor terminal boxes:
- 2 1) Twist/screw on type connectors for use on #10 AWG and smaller wire.
- 3 2) Mechanical screw type connectors for use on #8 AWG and larger wire.
- 4 d. Manholes or handholes:
- 5 1) Twist/screw on type connectors pre-filled with epoxy for use on #8 AWG and
- 6 smaller wire.
- 7 2) Watertight compression or mechanical screw type connectors for use on #6 AWG
- 8 and larger wire.
- 9 2. Control circuits.
- 10 a. Junction and pull boxes: Terminal block type connector.
- 11 b. Manholes or handholes: Twist/screw on type connectors pre-filled with epoxy.
- 12 c. Control panels and motor control centers: Terminal block or strips provided within the
- 13 equipment or field installed within the equipment by the contractor.
- 14 3. Instrumentation circuits can be spliced where field conditions dictate and written permission
- 15 is obtained from the Engineer. Maintain electrical continuity of the shield when splicing
- 16 twisted shielded conductors.
- 17 a. Junction and pull boxes: Terminal block type connector.
- 18 b. Control panels and motor control centers: Terminal block or strip provided within the
- 19 equipment or field installed within the equipment by the contractor.
- 20 4. Non-insulated compression and mechanical screw type connectors shall be insulated with
- 21 tape or hot or cold shrink type insulation to the insulation level of the conductors.
- 22 H. Insulating Tape Usage:
- 23 1. For insulating connections of #8 AWG wire and smaller: 7 mil vinyl tape.
- 24 2. For insulating splices and taps of #6 AWG wire or larger: 10 mil vinyl tape.
- 25 3. For insulating connections made in cold weather or in outdoor locations: 8.5 mil, all weather
- 26 vinyl tape.
- 27 I. Kellums, or equal, woven grips shall support wire and cable in vertical risers where necessary to
- 28 prevent heavy loading on wire or cable connections.
- 29 J. Wire and cable shall not be pulled tight against bushings nor pressed heavily against enclosures.
- 30 K. After wire and cable have been installed and connected, conduit ends shall be sealed with a non-
- 31 hardening sealing compound (Duxseal or equal), forced into conduits to a minimum depth equal
- 32 to the conduit diameter. This shall apply for all conduits entering any structures or electrical
- 33 enclosures from underground.
- 34 L. Fiber Optic Cable:
- 35 1. Unless indicated otherwise, install all fiber optic cable in conduit.
- 36 2. Splicing:
- 37 a. Optical fibers shall not be spliced.
- 38 3. Utilize dust tight wall-mounted interconnect center to provide the following:
- 39 a. Interconnect fiber optic cable to jumper cable assemblies for connection to the opto-
- 40 electronic interface.
- 41 4. Where exposed to contact with electric light or power conductors, the noncurrent carrying
- 42 metallic members (if applicable) of optical fiber cables entering buildings shall be grounded
- 43 as close to the point of entrance as practicable in accordance with the NEC.
- 44 5. Install cables in accordance with the requirements of the NEC.
- 45 6. Test installed fiber optic cable system to verify the following:
- 46 a. Continuity of all installed fibers and associated connectors.
- 47 b. Maximum attenuation requirements of specification are not exceeded.
- 48 M. Tag wires with wire markers in control panels, electrical gear, terminal boxes:
- 49 1. Tag wire at both ends.
- 50 2. Lettering:
- 51 a. Height: 1/8 IN minimum.
- 52 b. Circuit number or wire number as scheduled on the Drawings or as furnished with the
- 53 equipment.

- 1 N. Tag wires with wire markers in cable vaults, cable trays, manholes and handholes:
- 2 1. Lettering:
- 3 a. Height: 1/8 IN minimum.
- 4 b. Circuit number or wire number as scheduled on the Drawings.

5

END OF SECTION

SECTION 16130
RACEWAYS AND BOXES

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Material and installation requirements for:
- 8 a. Conduits.
- 9 b. Conduit bodies and fittings.
- 10 c. Conduit supports.
- 11 d. Wireways.
- 12 e. Outlet boxes.
- 13 f. Pull and junction boxes.
- 14 B. Related Sections include but are not necessarily limited to:
- 15 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
- 16 2. Division 1 - General Requirements.
- 17 3. Section 03431 - Precast and Prestressed Concrete.
- 18 4. Section 05505 - Metal Fabrications.
- 19 5. Section 09905 - Painting and Protective Coatings.
- 20 6. Section 16010 - Electrical: Basic Requirements.
- 21 7. Section 16140 - Wiring Devices.

22 **1.2 QUALITY ASSURANCE**

- 23 A. Referenced Standards:
- 24 1. Aluminum Association Inc. (AA):
- 25 a. 1, Aluminum Standards and Data.
- 26 2. American Iron and Steel Institute (AISI).
- 27 3. American National Standards Institute (ANSI):
- 28 a. C80.1, Rigid Steel Conduit - Zinc-Coated.
- 29 b. C80.5, Aluminum Rigid Conduit - (ARC).
- 30 4. ASTM International (ASTM):
- 31 a. A123, Standard Specification for Zinc Coating (Hot-Dip Galvanized) Coatings on Iron
- 32 and Steel Products.
- 33 b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- 34 c. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and
- 35 Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- 36 d. D2564, Solvent Cements for (PVC) Plastic Pipe, Tubing, and Fittings.
- 37 e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
- 38 f. F512, Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Conduit
- 39 and Fittings for Underground Installation.
- 40 5. National Electrical Manufacturers Association (NEMA):
- 41 a. OS 1, Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- 42 b. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit
- 43 and Intermediate Metal Conduit.
- 44 c. TC 2, Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
- 45 d. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
- 46 e. TC 6, PVC Plastic Utilities Duct for Underground Installations.
- 47 f. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- 48 6. Underwriters Laboratories, Inc. (UL):
- 49 a. 1, Flexible Metal Conduit.

- 1 b. 6, Rigid Metal Conduit.
- 2 c. 50, Standard for Safety Enclosures for Electrical Equipment.
- 3 d. 360, Liquid-Tight Flexible Steel Conduit.
- 4 e. 467, Grounding and Bonding Equipment.
- 5 f. 514A, Standard for Safety Metallic Outlet Boxes.
- 6 g. 514B, Fittings for Cable and Conduit.
- 7 h. 651, Schedule 40 and 80 Rigid PVC Conduit.
- 8 i. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
- 9 j. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.
- 10 k. 1660, Liquid-Tight Flexible Nonmetallic Conduit.

11 **1.3 SUBMITTALS**

- 12 A. Shop Drawings:
- 13 1. See Section 16010.
- 14 2. Identify dimensional size of pull and junction boxes to be used.

15 **1.4 DELIVERY, STORAGE, AND HANDLING**

- 16 A. See Section 16010.

17 **PART 2 - PRODUCTS**

18 **2.1 ACCEPTABLE MANUFACTURERS**

- 19 A. Subject to compliance with the Contract Documents, the following manufacturers are
- 20 acceptable:
- 21 1. Rigid metallic conduits.
- 22 a. Allied Tube and Conduit Corporation.
- 23 b. Triangle PWC Inc.
- 24 c. Western Tube and Conduit Corporation.
- 25 d. Wheatland Tube Company.
- 26 e. LTV Steel Company.
- 27 f. ALUMAX Extrusions, Inc.
- 28 g. INDALEX.
- 29 h. VAW of American, Inc.
- 30 2. PVC coated rigid metallic conduits and repair kits.
- 31 a. Occidental Coating Company.
- 32 b. Rob-Roy Ind.
- 33 c. Perma-Cote.
- 34 d. Raychem "GelTek" tape.
- 35 3. Rigid non-metallic conduit.
- 36 a. Carlon.
- 37 b. Certainteed Corporation.
- 38 c. Canadian General Electric Company.
- 39 d. Western Plastics Corporation.
- 40 4. Flexible conduit.
- 41 a. AFC Cable Systems.
- 42 b. Anamet, Inc.
- 43 c. Electri-Flex.
- 44 d. Flexible Metal Hose Company.
- 45 e. International Metal Hose Company.
- 46 f. Triangle PWC Inc.
- 47 g. LTV Steel Company.
- 48 5. Wireway.
- 49 a. Hoffman Engineering Company.
- 50 b. Wiegmann.

- 1 c. Square D.
- 2 6. Conduit Bodies and Fittings, and accessories.
- 3 a. Appleton.
- 4 b. Carlon.
- 5 c. Crouse-Hinds.
- 6 d. Killark.
- 7 e. OZ Gedney Company.
- 8 f. RACO.
- 9 g. Steel City.
- 10 h. Thomas and Betts.
- 11 i. Western Plastics Company.
- 12 7. Support systems.
- 13 a. Unistrut Building Systems.
- 14 b. B-Line Systems Inc.
- 15 c. Kindorf.
- 16 d. Minerallac Fastening Systems.
- 17 e. Caddy.
- 18 8. Outlet, pull and junction boxes:
- 19 a. Appleton Electric Co.
- 20 b. Crouse-Hinds.
- 21 c. Killark.
- 22 d. O-Z/Gedney.
- 23 e. Steel City.
- 24 f. Raco.
- 25 g. Bell.
- 26 h. Hoffman Engineering Co.
- 27 i. Wiegmann.
- 28 j. B-Line Circle AW.
- 29 k. Adalet.
- 30 B. Substitution: Submit requests for substitution in accordance with Specification Section 01640.

31 **2.2 RIGID METALLIC CONDUITS**

- 32 A. Rigid galvanized steel conduit (RGS):
- 33 1. Mild steel with continuous welded seam.
- 34 2. Metallic zinc applied by hot-dip galvanizing or electro-galvanizing. Threads galvanized
- 35 after cutting.
- 36 3. Internal Coating: Baked lacquer, varnish or enamel for a smooth surface.
- 37 4. Standards: ANSI C80.1, UL 6.
- 38 B. PVC-Coated rigid steel conduit (PVC-RGS):
- 39 1. Nominal 40 mil Polyvinyl Chloride Exterior Coating:
- 40 a. Coating: Bonded to hot-dipped galvanized rigid steel conduit conforming to ANSI
- 41 C80.1.
- 42 b. The bond between the PVC coating and the conduit surface: Greater than the tensile
- 43 strength of the coating.
- 44 2. Nominal 2 mil, minimum, urethane interior coating.
- 45 3. Urethane coating on threads.
- 46 4. Conduit: Epoxy prime coated prior to application of PVC and urethane coatings.
- 47 5. Female Ends: Have a plastic sleeve extending a minimum of 1 pipe diameter or 2 IN,
- 48 whichever is less beyond the opening. The inside diameter of the sleeve shall be the same as
- 49 the outside diameter of the conduit to be used with it.
- 50 6. Standards: ANSI C80.1, UL 6, NEMA RN 1.
- 51 C. Rigid aluminum conduit (RAC):
- 52 1. AA-6063 aluminum alloy, T-1 temper.
- 53 2. Maximum copper content of 0.10 percent.

- 1 3. Extruded, seamless.
- 2 4. Standards: ANSI C80.5, UL 6.

3 **2.3 RIGID NON-METALLIC CONDUIT**

- 4 A. Schedules 40 (PVC-40) and 80 (PVC-80):
 - 5 1. Polyvinyl-chloride (PVC) plastic compound which meets, as a minimum, ASTM D1784 cell
 - 6 classification PVC 12233-A, B, or C.
 - 7 2. Rated for direct sunlight exposure.
 - 8 3. Fire retardant and low smoke emission.
 - 9 4. Shall be suitable for use with 90 DegC wire and shall be marked "maximum 90 DegC".
 - 10 5. Standards: ASTM D1784, NEMA TC 2, UL 651.

11 **2.4 FLEXIBLE CONDUIT**

- 12 A. Flexible galvanized steel conduit (FLEX):
 - 13 1. Formed of continuous, spiral wound, hot-dip galvanized steel strip with successive
 - 14 convolutions securely interlocked.
 - 15 2. Standard: UL 1.
- 16 B. PVC-Coated flexible galvanized steel (liquid-tight) conduit (FLEX-LT):
 - 17 1. Core formed of continuous, spiral wound, hot-dip galvanized steel strip with successive
 - 18 convolutions securely interlocked.
 - 19 2. Extruded PVC outer jacket positively locked to the steel core.
 - 20 3. Liquid and vaportight.
 - 21 4. Standard: UL 360.

22 **2.5 WIREWAY**

- 23 A. General.
 - 24 1. Designed for continuous grounding.
 - 25 2. Covers:
 - 26 a. Hinged in accessible areas.
 - 27 b. Non-removable when passing through partitions
 - 28 3. Finish: Rust inhibiting primer and manufacturer's standard paint inside and out except for
 - 29 stainless steel type.
 - 30 4. Standards: UL 870, NEMA 250.
- 31 B. Watertight (NEMA 4X rated) Wireway:
 - 32 1. 16 gage Type 304 or 316 stainless steel bodies and covers with out knockouts and 10 gage
 - 33 stainless steel flanges.
 - 34 2. Cover: Fully gasketed and held in place with captive clamp type latches.
 - 35 3. Flanges: Fully gasketed and bolted.
- 36 C. Dusttight (NEMA 12 rated) Wireway:
 - 37 1. 14 gage steel bodies and covers without knockouts and 10 gage steel flanges.
 - 38 2. Cover: Fully gasketed and held in place with captive clamp type latches.
 - 39 3. Flanges: Fully gasketed and bolted.

40 **2.6 CONDUIT BODIES AND FITTINGS AND ACCESSORIES**

- 41 A. Fittings for Use with RGS and RAC:
 - 42 1. In hazardous locations listed for use in Class I, Groups C and D locations.
 - 43 2. Locknuts:
 - 44 a. RGS: Threaded steel or malleable iron.
 - 45 b. RAC: Stainless steel.
 - 46 c. Gasketed or nongasketed.
 - 47 d. Grounding or non-grounding type.
 - 48 3. Bushings:
 - 49 a. Threaded, insulated metallic.

- 1 b. Grounding or non-grounding type.
- 2 4. Hubs: Threaded, insulated and gasketed metallic for raintight connection.
- 3 5. Couplings:
- 4 a. Threaded straight type: Same material and finish as the conduit with which they are
- 5 used on.
- 6 6. Unions:
- 7 a. RGS: Threaded galvanized steel or zinc plated malleable iron.
- 8 b. RAC: Copper free cast aluminum.
- 9 7. Conduit bodies (elbows and tees):
- 10 a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded
- 11 hubs.
- 12 b. Standard and mogul size.
- 13 c. Cover: Clip-on type with stainless steel screws. Gasketed or non-gasketed galvanized
- 14 steel, zinc plated cast iron (RGS) or cast copper free aluminum (RAC).
- 15 8. Conduit bodies (round):
- 16 a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded
- 17 hubs.
- 18 b. Cover: Threaded screw on type, gasketed, galvanized steel, zinc plated cast iron (RGS)
- 19 or cast copper free aluminum (RAC).
- 20 9. Sealing fittings:
- 21 a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded
- 22 hubs.
- 23 b. Standard and mogul size.
- 24 c. With or without drain and breather.
- 25 d. Fiber and sealing compound: UL listed for use with the sealing fitting.
- 26 10. Expansion couplings:
- 27 a. 2 IN nominal straight-line conduit movement in either direction.
- 28 b. Galvanized steel with insulated bushing.
- 29 c. Gasketed for wet locations.
- 30 d. Internally or externally grounded.
- 31 11. Expansion/deflection couplings:
- 32 a. 3/4 IN nominal straight-line conduit movement in either direction.
- 33 b. 30-degree nominal deflection from the normal in all directions.
- 34 c. Metallic hubs, neoprene outer jacket and stainless steel jacket clamps.
- 35 d. Internally or externally grounded.
- 36 e. Watertight, raintight and concrete tight.
- 37 12. Standards: UL 467, 514B, 886.
- 38 B. Fittings for Use with PVC-RGS:
- 39 1. The same material and construction as those fittings listed under paragraph "Fittings for Use
- 40 with RGS and RAC" and coated as defined under paragraph "PVC Coated Rigid Steel
- 41 Conduit (PVC-RGS)."
- 42 C. Fittings for Use with FLEX:
- 43 1. Connector:
- 44 a. Zinc plated malleable iron.
- 45 b. Squeeze or clamp-type.
- 46 2. Standard: UL 514B.
- 47 D. Fittings for Use with FLEX-LT:
- 48 1. Connector:
- 49 a. Straight or angle type.
- 50 b. Metal construction, insulated and gasketed.
- 51 c. Composed of locknut, grounding ferrule and gland compression nut.
- 52 d. Liquid tight.
- 53 2. Standard: UL 467, 514B.
- 54 E. Fittings for Use with FLEX-NM:

- 1 1. Connector:
 - 2 a. Straight or angle type.
 - 3 b. Composed of locknut, ferrule and gland compression nut.
 - 4 c. Liquid tight.
- 5 2. Standard: UL 514B, 1660.
- 6 F. Fittings for Use with Rigid Non-Metallic Conduit:
 - 7 1. Coupling and adapters shall be of the same material, thickness, and construction as the
 - 8 conduits with which they are used.
 - 9 2. Standards: UL 651, NEMA TC 3.
 - 10 3. Solvent cement for welding fittings shall be supplied by the same manufacturer as the
 - 11 conduit and fittings.
 - 12 a. Standard: ASTM D2564.
- 13 G. Weather and Corrosion Protection Tape:
 - 14 1. PVC based tape, 10 mils thick.
 - 15 2. Protection against moisture, acids, alkalis, salts and sewage and suitable for direct bury.
 - 16 3. Used with appropriate pipe primer.

17 2.7 ALL RACEWAY AND FITTINGS

- 18 A. Mark Products:
 - 19 1. Identify the nominal trade size on the product.
 - 20 2. Stamp with the name or trademark of the manufacturer.

21 2.8 OUTLET BOXES

- 22 A. Metallic Outlet Boxes:
 - 23 1. Hot-dip galvanized steel.
 - 24 2. Conduit knockouts and grounding pigtail.
 - 25 3. Styles:
 - 26 a. 2 IN x 3 IN rectangle.
 - 27 b. 4 IN square.
 - 28 c. 4 IN octagon.
 - 29 d. Masonry/tile.
 - 30 4. Accessories:
 - 31 a. Flat blank cover plates.
 - 32 b. Barriers.
 - 33 c. Extension, plaster or tile rings.
 - 34 d. Box supporting brackets in stud walls.
 - 35 e. Adjustable bar hangers.
 - 36 5. Standards: NEMA OS 1, UL 514A.
- 37 B. Cast Outlet Boxes:
 - 38 1. Zinc plated cast iron or die-cast copper free aluminum with manufacturers standard finish.
 - 39 2. Threaded hubs and grounding screw.
 - 40 3. Styles:
 - 41 a. "FS" or "FD".
 - 42 b. "Bell".
 - 43 c. Single or multiple gang and tandem.
 - 44 d. "EDS" or "EFS" for hazardous locations.
 - 45 4. Accessories: 40 mil PVC exterior coating and 2 mil urethane interior coating when used in
 - 46 conjunction with PVC coated rigid conduit systems.
 - 47 5. Standards:
 - 48 a. UL 514A.
- 49 C. See Section 16140 for wiring devices, wallplates and coverplates.

50 2.9 PULL AND JUNCTION BOXES

- 1 A. NEMA 1 rated:
- 2 1. Body and cover: 14 GA, galvanized steel or steel finished with rust inhibiting primer and
- 3 manufacturers standard paint inside and out.
- 4 2. With or without concentric knockouts on four sides.
- 5 3. Flat cover fastened with screws.
- 6 B. NEMA 4 rated:
- 7 1. Body and cover: 14 GA steel finished with rust inhibiting primer and manufacturers
- 8 standard paint inside and out.
- 9 2. Seams continuously welded and ground smooth.
- 10 3. No knockouts.
- 11 4. External mounting flanges.
- 12 5. Hinged or non-hinged cover held closed with stainless steel screws and clamps.
- 13 6. Cover with oil resistant gasket.
- 14 C. NEMA 4X rated (metallic):
- 15 1. Body and cover: 14 GA Type 304 or 316 stainless steel.
- 16 2. Seams continuously welded and ground smooth.
- 17 3. No knockouts.
- 18 4. External mounting flanges.
- 19 5. Hinged door and stainless steel screws and clamps.
- 20 6. Door with oil-resistant gasket.
- 21 D. NEMA 4X rated (non-Metallic):
- 22 1. Body and cover: Ultraviolet light protected fiberglass-reinforced polyester boxes.
- 23 2. No knockouts.
- 24 3. External mounting flanges.
- 25 4. Hinged door with quick release latches and padlocking hasp.
- 26 5. Door with oil resistant gasket.
- 27 E. NEMA 12 rated:
- 28 1. Body and cover: 14 GA steel finished with rust inhibiting primer and manufacturers
- 29 standard paint inside and out.
- 30 2. Seams continuously welded and ground smooth.
- 31 3. No knockouts.
- 32 4. External mounting flanges.
- 33 5. Non-hinged cover held closed with captivated cover screws threaded into sealed wells or
- 34 hinged cover held closed with stainless steel screws and clamps.
- 35 6. Flat door with oil resistant gasket.
- 36 F. Miscellaneous Accessories:
- 37 1. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
- 38 2. Split covers when heavier than 25 LBS.
- 39 3. Weldnuts for mounting optional panels and terminal kits.
- 40 4. Terminal blocks: Screw-post barrier-type, rated 600 volt and 20 ampere minimum.
- 41 G. Standards: NEMA 250, UL 50.

42 2.10 SUPPORT SYSTEMS

- 43 A. Multi-conduit surface or trapeze type support and pull or junction box supports:
- 44 1. Material requirements.
- 45 a. Galvanized steel: ASTM A123 or ASTM A153.
- 46 b. Stainless steel: AISI Type 316.
- 47 c. PVC coat galvanized steel: ASTM A123 or ASTM A153 and 20 mil PVC coating.
- 48 B. Single conduit and outlet box support fasteners:
- 49 1. Material requirements.
- 50 a. Zinc plated steel.
- 51 b. Stainless steel.

- 1 c. Malleable iron.
- 2 d. PVC coat malleable iron or steel: 20 mil PVC coating.
- 3 e. Steel protected with zinc phosphate and oil finish.

4 **2.11 OPENINGS AND PENETRATIONS IN WALLS AND FLOORS**

- 5 A. Sleeves, smoke and fire stop fitting through walls and floors:
- 6 1. See Section 01800.

7 **PART 3 - EXECUTION**

8 **3.1 RACEWAY INSTALLATION - GENERAL**

- 9 A. Shall be in accordance with the requirements of NFPA 70.
- 10 B. Size of Raceways:
- 11 1. Raceway sizes are indicated on the Drawings; if not indicated on the Drawings, then size in
- 12 accordance with NFPA 70.
- 13 2. Unless specifically indicated otherwise, the minimum raceway size shall be:
- 14 a. Conduit: 3/4 IN.
- 15 b. Wireway: 2.5 IN x 2.5 IN.
- 16 C. Field Bending and Cutting of Conduits:
- 17 1. Utilize tools and equipment recommended by the manufacturer of the conduit, designed for
- 18 the purpose and the conduit material to make all field bends and cuts.
- 19 2. Do not reduce the internal diameter of the conduit when making conduit bends.
- 20 3. Prepare tools and equipment to prevent damage to the PVC coating.
- 21 4. Degrease threads after threading and apply a zinc rich paint.
- 22 5. Debur interior and exterior after cutting.
- 23 D. Male threads of conduit systems shall be coated with an electrically conductive anti-seize
- 24 compound.
- 25 E. The protective coating integrity of conduits, fittings, and accessories shall be maintained.
- 26 1. Repair RGS utilizing a zinc rich paint.
- 27 2. Repair PVC-RGS utilizing a patching compound, of the same material as the coating,
- 28 provided by the manufacturer of the conduit; or a self-adhesive, highly conformable, cross-
- 29 linked silicone composition strip, followed by a protective coating of vinyl tape. The total
- 30 nominal thickness: 40 mil.
- 31 3. Repair surfaces that will be inaccessible after installation prior to installation.
- 32 F. Remove moisture and debris from conduit before wire is pulled into place.
- 33 1. Pull mandrel with diameter nominally 1/4 IN smaller than the interior of the conduit, to
- 34 remove obstructions.
- 35 2. Swab conduit by pulling a clean, tight-fitting rag through the conduit.
- 36 3. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.
- 37 G. Only nylon or polyethylene rope shall be used to pull wire and cable in conduit systems.
- 38 H. Where portions of a raceway are subject to different temperatures and where condensation is
- 39 known to be a problem, as in cold storage areas of buildings or where passing from the interior
- 40 to the exterior of a building, the raceway shall be sealed to prevent circulation of warm air to
- 41 colder section of the raceway.
- 42 I. Fill openings in walls, floors, and ceilings and finish flush with surface.
- 43 1. See Section 01800.

44 **3.2 RACEWAY ROUTING**

- 45 A. Raceways shall be routed in the field unless otherwise indicated.

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1. Conduit and fittings shall be installed, as required, for a complete system that has a neat appearance and is in compliance with all applicable codes.
 2. Run in straight lines parallel to or at right angles to building lines.
 3. Do not route conduits:
 - a. Through areas of high ambient temperature or radiant heat.
 - b. In suspended concrete slabs.
 4. Conduit shall not interfere with, or prevent access to, piping, valves, ductwork, or other equipment for operation, maintenance and repair.
 5. Provide pull boxes or conduit bodies as needed so that there is a maximum of 360 degrees of bends in the conduit run or in long straight runs to limit pulling tensions.
- B. All rigid conduits within a structure shall be installed exposed except as follows:
1. As indicated on the Drawings.
 2. Concealed above gypsum wall board or acoustical tile suspended ceilings.
 3. Concealed within stud frame, poured concrete, concrete block and brick walls of an architecturally finished area.
 4. Embedded in floor slabs or buried under floor serving equipment in non-architecturally finished areas that are not located on or near a wall or column and the ceiling height is greater than 12 FT.
 5. Embedded in floor slabs or buried under floor slabs where shown on the Contract Drawings or with the Engineer's permission.
- C. Maintain minimum spacing between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 FT:
1. Between instrumentation and telecommunication: 1 IN.
 2. Between instrumentation and 600 V and less AC power or control: 6 IN.
 3. Between telecommunication and 600 V and less AC power or control: 6 IN.
 4. Between 24 V DC and 600 V and less AC power or control: 2 IN.
 5. Between process, gas, air and water pipes: 6 IN.
- D. Conduits shall be installed to eliminate moisture pockets. Where water cannot drain to openings, provide drain fittings in the low spots of the conduit run.
- E. Conduit shall not be routed on the exterior of structures except as specifically indicated on the Drawings.
- F. Where sufficient room exists within the housing of roof-mounted equipment, the conduit shall be stubbed up inside the housing.
- G. Provide all required openings in walls, floors, and ceilings for conduit penetration.
1. See Section 01800.
- H. Conduit embedded in columns and floor slabs or buried under slab-on-grade:
1. Run in the most direct, practical route.
 2. Not to be installed under equipment pads.
 3. No crossovers.
 4. Secured in place to prevent movement during the backfill and pour.
- I. Conduits and accessories embedded in concrete where shown on the Contract Drawings:
1. Shall not be considered to replace structurally the displaced concrete except as indicated in the following:
 - a. Conduit and fittings shall not displace more than 4 percent of the area of the cross-section of a column on which stress is calculated or which is required for fire protection.
 - b. Size and locate sleeves or conduits passing through floors, walls, or beams so as not to significantly impair the strength of the construction.
 - c. Sleeves or conduits passing through floors, walls or beams may be considered as replacing the displaced concrete structurally in compression.
 - 1) Shall not be exposed to rusting or other deterioration.
 - 2) Nominal inside diameter shall not exceed 2 IN.

- 1 3) Minimum spacing: 3 DIA OC.
- 2 2. Shall not be larger in outside diameter than one-third the thickness of the slab, column or
- 3 beam.
- 4 3. Shall have a minimum spacing of 3 DIA OC.
- 5 4. In reinforced concrete construction:
- 6 a. Conduit shall not be run in beams.
- 7 b. Place conduit after reinforcing steel has been laid.
- 8 c. The reinforcement steel shall not be displaced by the conduit.
- 9 d. Provide a minimum of 1-1/2 IN of cover over conduit, excluding surface finish.
- 10 e. Conduits parallel to main reinforcement shall be run near the center of the wall.
- 11 f. Conduits perpendicular to main reinforcement shall be run midway between wall or
- 12 slab supports.

13 3.3 RACEWAY APPLICATIONS

- 14 A. Permitted conduit types per wire or cable types:
- 15 1. Power wire or cables: All conduit types.
- 16 2. Control wire or cables: All conduit types.
- 17 3. Instrumentation cables: Metallic conduit.
- 18 4. Motor leads from a VFD: Metallic conduits.
- 19 5. Telecommunication cables: All conduit types.
- 20 B. Permitted conduit types per area designations:
- 21 1. Dry areas:
- 22 a. RAC.
- 23 2. Wet areas:
- 24 a. RAC.
- 25 3. Corrosive areas:
- 26 a. PVC-RGS.
- 27 b. RAC, except in chlorine and other chemical storage/feed rooms.
- 28 C. Permitted conduit types per routing locations:
- 29 1. In concrete block or brick walls:
- 30 a. PVC-40.
- 31 b. RGS.
- 32 2. Embedded in poured concrete walls and floors:
- 33 a. PVC-40.
- 34 b. RGS.
- 35 c. RGS wrapped with factory applied weather and corrosion protection tape when
- 36 emerging from concrete into areas designated as dry, wet, or corrosive.
- 37 d. PVC-RGS when emerging from concrete into areas designated as wet or corrosive.
- 38 3. Beneath floor slab-on-grade:
- 39 a. PVC-40.
- 40 b. RGS.
- 41 4. Through floor penetrations, see Section 01800:
- 42 a. RGS wrapped with factory applied weather and corrosion protection tape when
- 43 emerging from concrete into areas designated as dry, wet, or corrosive.
- 44 b. PVC-RGS in areas designated as wet, or corrosive.
- 45 5. Direct buried conduits and duct banks:
- 46 a. PVC-80.
- 47 b. PVC-RGS for instrumentation circuits.
- 48 c. 90 degree elbows for transitions to above grade:
- 49 1) RGS wrapped with factory applied weather and corrosion protection tape.
- 50 2) PVC-RGS.
- 51 d. Long sweeping bends greater than 15 degrees:
- 52 1) RGS wrapped with factory applied weather and corrosion protection tape.
- 53 2) PVC-RGS.
- 54 6. Concrete encased duct banks:

- 1 a. PVC-40.
- 2 b. RGS for instrumentation circuits.
- 3 c. 90 degree elbows for transitions to above grade:
- 4 1) RGS wrapped with factory applied weather and corrosion protection tape.
- 5 2) PVC-RGS.
- 6 d. Long sweeping bends greater than 15 degrees:
- 7 1) RGS for sizes 2 IN and larger.

- 8 D. FLEX conduits shall be installed for connections to light fixtures, HVAC equipment and other
- 9 similar devices above the ceilings. The maximum length shall not exceed:
- 10 1. 6 FT to light fixtures.
- 11 2. 3 FT to all other equipment.

- 12 E. FLEX-LT conduits shall be install as the final conduit connection to light fixtures, dry type
- 13 transformers, motors, electrically operated valves, instrumentation primary elements, and other
- 14 electrical equipment that is liable to vibrate. The maximum length shall not exceed:
- 15 1. 6 FT to light fixtures.
- 16 2. 3 FT to motors.
- 17 3. 2 FT to all other equipment.

- 18 F. NEMA 4X rated wireway:
- 19 1. Surface mounted in areas designated as wet and/or corrosive.

- 20 G. NEMA 12 rated wireway:
- 21 1. Surface mounted in areas designated as dry in architecturally and non-architecturally
- 22 finished areas.

- 23 H. Underground conduit: See Section 16135.

24 **3.4 CONDUIT FITTINGS AND ACCESSORIES**

- 25 A. Conduit Seals:
- 26 1. Installed in conduit systems located in the following corrosive areas and as required by the
- 27 following:
- 28 a. Chemical Storage/Feed Rooms designated as corrosive on the drawings.
- 29 b. In each conduit entering or leaving the area.
- 30 2. Filler plug and drain shall be accessible.

- 31 B. Rigid non-metallic conduit and fittings shall be joined utilizing solvent cement.
- 32 1. Immediately after installation of conduit and fitting, the fitting or conduit shall be rotated
- 33 1/4 turn to provide uniform contact.

- 34 C. Install expansion fittings:
- 35 1. Where conduits span structural expansions joints.
- 36 2. Where conduits are exposed to the sun and conduit run is greater than 200 FT.
- 37 3. Elsewhere as identified on the Drawings.

- 38 D. Install expansion/deflection fittings:
- 39 1. Where conduits enter a structure.
- 40 a. Except electrical manholes and handholes.
- 41 b. Except where the ductbank is tied to the structure with rebar.
- 42 2. Elsewhere as identified on the Drawings.

- 43 E. Threaded connections shall be made wrench-tight.

- 44 F. Conduit joints shall be watertight.
- 45 1. Where subjected to possible submersion.
- 46 2. In areas classified as wet.
- 47 3. Underground.

- 48 G. Terminate conduits:
- 49 1. In outlet boxes.

- 1 a. With an insulated grounding bushing and locknut.
- 2 b. With an insulated compression type connector.
- 3 2. In NEMA 1 rated enclosures:
- 4 a. With an insulated grounding bushing and locknut.
- 5 3. In NEMA 12 rated enclosures:
- 6 a. With an insulated grounding bushing and a gasketed locknut.
- 7 4. In NEMA 4 and 4X rated enclosures:
- 8 a. With a threaded, insulated and gasketed hub.
- 9 5. When stubbed up through the floor into floor mount equipment:
- 10 a. With an insulated grounding bushing.

11 3.5 CONDUIT SUPPORT

- 12 A. Permitted multi-conduit surface or trapeze type support system per conduit types:
- 13 1. Galvanized steel system used with RGS.
- 14 2. Stainless steel system used with PVC-RGS and RAC.
- 15 3. PVC coated galvanized steel system may be used with PVC-RGS.
- 16 B. Permitted single conduit support fasteners per area designations and conduit types:
- 17 1. Zinc plated steel, steel protected with zinc phosphate and oil finish and malleable iron
- 18 fasteners used with RGS.
- 19 2. Stainless steel system used with all PVC-RGS, and RAC.
- 20 3. PVC coated fasteners used with PVC-RGS.
- 21 C. In seismic locations provide required sway bracing per local building codes.
- 22 D. Conduit support general requirements:
- 23 1. Maximum spacing between conduit supports per NFPA 70.
- 24 2. Support conduit from the building structure.
- 25 3. Do not support conduit from process, gas, air or water piping; or from other conduits.
- 26 4. Provide hangers and brackets to limit the maximum uniform load on a single support to 25
- 27 LBS or to the maximum uniform load recommended by the manufacturer if the support is
- 28 rated less than 25 LBS.
- 29 a. Do not exceed maximum concentrated load recommended by the manufacturer on any
- 30 support.
- 31 b. Conduit hangers: Continuous threaded rods combined with struts or conduit clamps: Do
- 32 not use perforated strap hangers and iron bailing wire.
- 33 c. Do not use suspended ceiling support systems to support raceways.
- 34 d. Hangers in metal roof decks:
- 35 1) Utilize fender washers.
- 36 2) Not extend above top of ribs.
- 37 3) Not interfere with vapor barrier, insulation, or roofing.
- 38 5. Conduit support system fasteners:
- 39 a. Use sleeve-type expansion anchors as fasteners in masonry wall construction. Do not
- 40 use concrete nails and powder-driven fasteners.

41 3.6 OUTLET, PULL AND JUNCTION BOX INSTALLATION

- 42 A. General:
- 43 1. Install products in accordance with manufacturer's instructions.
- 44 2. See Section 16010 and the Drawings for area classifications.
- 45 3. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
- 46 4. Size boxes to accommodate quantity of conductors enclosed and quantity of conduits
- 47 connected to the box.
- 48 B. Outlet Boxes:
- 49 1. Permitted uses of metallic outlet boxes.
- 50 a. Housing of wiring devices:
- 51 1) Recessed in all stud framed walls and ceilings.

- 1 2) Recessed in poured concrete, concrete block and brick walls of architecturally
2 finished areas and exterior building walls.
- 3 b. Pull or junction box:
- 4 1) Above gypsum wallboard or acoustical tile ceilings.
- 5 2) Above 10 FT in an architecturally finished area where there is no ceiling.
- 6 2. Permitted uses of cast outlet boxes:
- 7 a. Housing of wiring devices surface mounted in non-architecturally finished dry, wet
8 corrosive, and hazardous areas.
- 9 b. Pull and junction box surface mounted in non-architecturally finished dry, wet, and
10 corrosive.
- 11 3. Mount device outlet boxes where indicated on the Drawings and at heights as scheduled in
12 Section 16010.
- 13 4. Set device outlet boxes plumb and vertical to the floor.
- 14 5. Outlet boxes recessed in walls:
- 15 a. Install with appropriate stud wall support brackets or adjustable bar hangers so that they
16 are flush with the face of the wall.
- 17 b. Locate in ungrouted cell of concrete block with bottom edge of box flush with bottom
18 edge of block and flush with the face of the block.
- 19 6. Place barriers between switches in boxes with 277 V switches on opposite phases.
- 20 7. Back-to-back are not permitted.
- 21 8. Cast outlet boxes in corrosive areas shall be PVC coated in the same manner as the conduit.
- 22 C. Pull and Junction Boxes:
- 23 1. Install pull or junction boxes in conduit runs where indicated or required to facilitate pulling
24 of wires or making connections. Make covers of boxes accessible.
- 25 2. Permitted uses of NEMA 1 enclosure:
- 26 a. Pull or junction box surface mounted above removable ceiling tiles of an architecturally
27 finished area.
- 28 3. Permitted uses of NEMA 4 enclosure:
- 29 a. Pull or junction box surface mounted in areas designated as wet.
- 30 4. Permitted uses of NEMA 4X metallic enclosure:
- 31 a. Pull or junction box surface mounted in areas designated as wet and/or corrosive.
- 32 5. Permitted uses of NEMA 12 enclosure:
- 33 a. Pull or junction box surface mounted in areas designated as dry.

34

END OF SECTION

2 **SECTION 16135**
3 **ELECTRICAL: EXTERIOR UNDERGROUND**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
7 1. Handholes.
8 2. Underground conduits and ductbanks.
- 9 B. Related Sections include but are not necessarily limited to:
10 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
11 2. Division 1 - General Requirements.
12 3. Section 02221 - Trenching, Backfilling and Compacting for Utilities.
13 4. Section 03002 - Concrete.
14 5. Section 16010 - Electrical: Basic Requirements.
15 6. Section 16130 - Raceways and Boxes.
16 7. Section 16120 - Wire and Cable - 600 Volt and Below.
17 8. Section 16060 - Grounding.

18 **1.2 QUALITY ASSURANCE**

- 19 A. Referenced Standards:
20 1. American Association of State Highway & Transportation Officials (AASHTO).
21 a. Standard Specifications for Highway Bridges.
22 2. American Society for Testing Materials (ASTM):
23 a. A536, Standard Specification for Ductile Iron Castings.
24 3. National Fire Protection Association (NFPA):
25 a. 70, National Electrical Code (NEC).

26 **1.3 DEFINITIONS**

- 27 A. Direct-buried conduit means individual (single) underground conduits without concrete
28 encasement.
- 29 B. Direct-buried ductbank means multiple underground conduits, arranged in one or more planes, in
30 a common trench, without concrete encasement.
- 31 C. Concrete encased ductbank means an individual (single) or multiple conduit(s), arranged in one
32 or more planes, encased in a common concrete envelope.

33 **1.4 SUBMITTALS**

- 34 A. Shop Drawings:
35 1. See Section 16010.
- 36 B. Operation and Maintenance Manuals:
37 1. See Section 01340.

38 **PART 2 - PRODUCTS**

39 **2.1 ACCEPTABLE MANUFACTURERS**

- 40 A. Subject to compliance with the Contract Documents, the following manufacturers are
41 acceptable:

- 1 1. Sidewalk type handhole.
- 2 a. Crouse-Hinds.
- 3 b. OZ-Gedney.
- 4 c. Appleton Electric Company.
- 5 d. Killark.
- 6 2. Prefabricated composite handholes:
- 7 a. Quazite Composolite.
- 8 b. Armorcast Products Company.
- 9 c. Or equal.
- 10 3. Precast handholes:
- 11 a. Utility Vault Co.
- 12 b. Oldcastle Precast, Inc.
- 13 c. Or equal.
- 14 4. Handhole and ductbank accessories:
- 15 a. Neenah.
- 16 b. Unistrut.
- 17 c. Condux International, Inc.
- 18 d. Underground Devices, Inc.
- 19 e. Condux International, Inc.
- 20 f. W. H. Brady Company.
- 21 g. Seton Nameplate Company.
- 22 B. Submit requests for substitution in accordance with Specification Section 01640.

23 **2.2 HANDHOLES**

- 24 A. Sidewalk Type Handholes:
- 25 1. Cast-iron box and cover, hot-dip galvanized.
- 26 2. Flange for flush mounting.
- 27 3. Checkered cover with neoprene gasket, pry bar slots and stainless steel screws.
- 28 4. Drilled and tapped holes.
- 29 5. Watertight NEMA 4 classification.
- 30 B. Prefabricated Composite Material Handholes:
- 31 1. Fiberglass reinforced polymer concrete.
- 32 2. Body and cover shall sustain a minimum vertical load test of 22,000 LBS over a 10 IN
- 33 square or be H-20 rated per AASHTO.
- 34 3. Solid bottom.
- 35 4. Stackable design as required for specified depth.
- 36 5. Cover shall have an engraved legend of "ELECTRIC" or "COMMUNICATIONS".
- 37 C. Precast Handholes:
- 38 1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures.
- 39 2. Shall have an AASHTO live load rating of H-20.
- 40 3. Mating edges shall be tongue and groove type.
- 41 D. Cast-in-Place Handholes:
- 42 1. Comply with Section 03002.

43 **2.3 PRECAST AND CAST-IN-PLACE HANDHOLE ACCESSORIES**

- 44 A. Unless otherwise detailed on the Drawings:
- 45 1. Cover and frame: As indicated on the Drawings.
- 46 a. Paint covers yellow.
- 47 B. Cable Racks and hooks:
- 48 1. 3/16 IN hot-dipped galvanized steel.
- 49 2. 120 LBS minimum loading capacity.
- 50 3. Minimum 7 1/2 IN long hooks with three-point locking to resist twisting.

- 1 C. Cable Pulling Irons:
- 2 1. 7/8 IN DIA hot-dipped galvanized steel.
- 3 2. 6000 LB minimum pulling load.
- 4 D. Ground Rods and Grounding Equipment: See Section 16060.

5 **2.4 UNDERGROUND CONDUIT AND ACCESSORIES**

- 6 A. Concrete: Comply with Section 03002.
- 7 B. Duct Terminators:
- 8 1. Window type.
- 9 2. ABS plastic.
- 10 3. Provide for conduit entrance.
- 11 4. Designed for installation into handhole walls for a watertight seal.
- 12 5. Sufficient space between terminator walls to allow for placement of rebar and concrete.
- 13 C. Conduit: See Section 16130.
- 14 D. Duct Spacers/Supports:
- 15 1. High density polyethylene or high impact polystyrene.
- 16 2. Interlocking.
- 17 3. Provide 2 IN minimum spacing between conduits.
- 18 E. Warning Tape:
- 19 1. Approved manufacturers and catalog numbers:
- 20 a. W H Brady Company, Catalog S-10, #91296.
- 21 2. Material: Polyethylene.
- 22 3. Thickness: 3.5 mils.
- 23 4. Tensile strength: 1750 psi.
- 24 5. Size: 6 IN wide (minimum).
- 25 6. Legend:
- 26 a. Preprinted and permanently imbedded.
- 27 b. Message continuously printed.

28 **PART 3 - EXECUTION**

29 **3.1 GENERAL**

- 30 A. Drawings indicate the intended location of handholes; and routing of ductbanks and direct
- 31 buried conduit. Field conditions may affect actual routing.
- 32 B. Handhole locations.
- 33 1. Approximately where shown on the Drawings.
- 34 2. As required for pulling distances.
- 35 3. As required to keep pulling tensions under allowable cable tensions.
- 36 4. As required for number of bends in ductbank routing.
- 37 5. Shall not be installed in a swale or ditch.
- 38 6. Determine the exact locations after careful consideration has been given to the location of
- 39 other utilities, grading, and paving.
- 40 7. Locations are to be approved by the Engineer prior to excavation and placement or
- 41 construction of handholes.
- 42 C. Install products in accordance with manufacturer's instructions.
- 43 D. Install handholes in conduit runs where indicated or as required to facilitate pulling of wires or
- 44 making connections.
- 45 E. Comply with Section 02221 for trenching, backfilling and compacting.

46 **3.2 HANDHOLES**

- 1 A. Sidewalk Type Handholes:
- 2 1. For use in on grade sidewalks and bridge deck sidewalks where not subjected to vehicular
- 3 traffic.
- 4 2. Install flush with concrete surface and embedded in the concrete with a minimum of 1-1/2
- 5 IN of concrete.
- 6 3. Place handhole after reinforcement steel has been laid. The reinforcing steel shall not be
- 7 displaced without approval by the Engineer.
- 8 4. Size: As indicated on the Drawings or in accordance with the NEC for the number and size
- 9 of conduits entering.
- 10 B. Prefabricated Composite Material Handholes:
- 11 1. For use in non-vehicular traffic areas.
- 12 2. Place handhole on a foundation of compacted 1/4 to 1/2 IN crushed rock or gravel a
- 13 minimum of 8 IN thick and 6 IN larger than handholes footprint on all sides.
- 14 3. Install so that the surrounding grade is 1 IN lower than the top of the handhole.
- 15 4. Size: As indicated on the Drawings or in accordance with the NEC for the number and size
- 16 of conduits entering.
- 17 C. Precast Handholes:
- 18 1. For use in non-vehicular traffic areas.
- 19 2. Construction:
- 20 a. Grout or seal all joints, per manufacturers instructions.
- 21 b. Covers and frames: Paint with two coats asphalt paint before setting.
- 22 c. Support cables on walls by cable racks:
- 23 1) Provide a minimum of two racks, install symmetrically on each wall of handholes.
- 24 Provide additional cable racks, as required, so that both ends of cable splices will
- 25 be supported horizontally.
- 26 2) Equip cable racks with adjustable hooks: Minimum of two cable hooks per rack or
- 27 as required by the number of conductors to be supported with one spare hook on
- 28 each rack.
- 29 d. Install a cable-pulling iron in each wall opposite each ductbank entrance.
- 30 e. In each handhole, drive 3/4 IN x 10 FT long copper clad ground rod into the earth with
- 31 approximately 6 IN exposed above finished floor.
- 32 1) Drill opening in floor for ground rod.
- 33 2) Connect all metallic conduits, racks, and other metallic components to ground rod
- 34 by means of #8 AWG minimum copper wire and approved grounding clamps.
- 35 f. Provide french drain in the bottom of each handhole. Provide a sump with aluminum
- 36 grate in the bottom of each handhole.
- 37 3. Place handhole on a foundation of compacted 1/4 to 1/2 IN crushed rock or gravel a
- 38 minimum of 8 IN thick and 6 IN larger than handholes footprint on all sides.
- 39 4. Unless otherwise noted on the Drawings install so that the top of cover is 1 IN above
- 40 finished grade. Where existing grades are higher than finished grades, install sufficient
- 41 number of courses of curved segmented concrete block between top of handhole frame to
- 42 temporarily elevate cover to existing grade level.
- 43 5. After installation is complete, backfill and compact soil around handholes.
- 44 6. Handhole size:
- 45 a. As indicated on the Drawings or as required for the number and size of conduits
- 46 entering.
- 47 b. Minimum floor dimension of 4 FT x 4 FT and minimum depth of 4 FT.
- 48 D. Cast-in-Place Handholes:
- 49 1. For use in non-vehicular traffic areas.
- 50 2. Constructed as detailed on the Drawings.
- 51 a. Covers and frames: Paint with two coats asphalt paint before setting.
- 52 b. Support cables on walls by cable racks:

- 1) Provide a minimum of two racks, install symmetrically on each wall of handholes. Provide additional cable racks, as required, so that both ends of cable splices will be supported horizontally.
 - 2) Equip cable racks with adjustable hooks: Minimum of two cable hooks per rack or as required by the number of conductors to be supported with one spare hook on each rack.
- c. Install a cable-pulling iron in each wall opposite each ductbank entrance.
 - d. In each handhole, drive 3/4 IN x 10 FT long copper clad ground rod into the earth with approximately 6 IN exposed above finished floor.
 - 1) Connect all metallic conduits, racks, and other metallic components to ground rod by means of #8 AWG minimum copper wire and approved grounding clamps.
 - e. Place handhole on a foundation of compacted 1/4 to 1/2 IN crushed rock or gravel a minimum of 8 IN thick and 6 IN larger than the handhole footprint on all sides.
3. Unless otherwise noted on the Drawings, in unpaved areas install so that the top of cover is 1 IN above finished grade. In paved areas install so that cover is flush with finished surface. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of handhole frame to temporarily elevate cover to existing grade level.
 4. After installation is complete, backfill and compact soil around handholes.
 5. Handhole size: As indicated on the Drawings.

3.3 UNDERGROUND CONDUITS:

A. General Installation Requirements:

1. Do not place concrete or soil until conduits have been observed by the Engineer.
2. Ductbanks shall be sloped a minimum of 4 IN per 100 FT or as detailed on the Drawings. Low points shall be at handholes.
3. During construction and after conduit installation is complete, plug the ends of all conduits.
4. Provide conduit supports and separators of concrete, plastic, or other suitable nonmetallic non-decaying material designed for that purpose.
 - a. Place supports and separators for rigid nonmetallic conduit on maximum centers as indicated for the following trade sizes:
 - 1) 1 IN and less: 3 FT.
 - 2) 1-1/4 to 3 IN: 5 FT.
 - 3) 3-1/2 to 6 IN: 7 FT.
 - b. Place supports and separators for rigid steel conduit on maximum centers as indicated for the following trade sizes:
 - 1) 1 IN and less: 10 FT.
 - 2) 1-1/4 to 2-1/2 IN: 14 FT.
 - 3) 3 IN and larger: 20 FT.
 - c. Securely anchor conduits to supports and separators to prevent movement during placement of concrete or soil.
5. Stagger conduit joints at intervals of 6 IN vertically.
6. Make conduit joints watertight and in accordance with manufacturer's recommendations.
7. Accomplish changes in direction of runs exceeding a total of 15 degrees by long sweep bends having a minimum radius of 25 FT. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
8. Furnish manufactured bends at end of runs. Minimum radius of 18 IN for conduits less than 3 IN trade size and 36 IN for conduits 3 IN trade size and larger.
9. Field cuts requiring tapers shall be made with the proper tools and shall match factory tapers.
10. After the conduit run has been completed, pull a standard flexible mandrel having a length of not less than 12 IN and a diameter approximately 1/4 IN less than the inside diameter of the conduit through each conduit. Then pull a brush with stiff bristles through each conduit to remove any foreign material left in conduit.
11. Pneumatic rodding may be used to draw in lead wire.
 - a. Install a heavy nylon cord free of kinks and splices in all unused new ducts.

- 1 b. Extend cord 3 FT beyond ends of conduit.
- 2 12. Transition from rigid PVC conduit to rigid metallic conduit, per Section 16130, prior to
- 3 entering a structure or going above ground. Rigid PVC conduit may be extended directly to
- 4 handholes, and other exterior pad mounted electrical equipment.
- 5 a. Terminate rigid PVC conduits with end bells.
- 6 b. Terminate steel conduits with insulated bushings.
- 7 13. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-
- 8 buried wire and cable.
- 9 a. 6 IN below finished grade where conduit or ductbank is 12 IN or more below finished
- 10 grade.
- 11 b. 3 IN below finished grade where conduit or ductbank is less than 12 IN below finished
- 12 grade.
- 13 c. Trenches containing electrical power:
- 14 1) Legend: CAUTION CAUTION CAUTION (1st line), BURIED ELECTRIC LINE
- 15 (2nd line).
- 16 2) Letters: 1-1/4 IN minimum.
- 17 3) Interval: Continuous.
- 18 4) Color: Red and black letters.
- 19 B. Concrete Encased Ductbank:
- 20 1. Ductbank system consists of conduits completely encased in minimum 2 IN of concrete and
- 21 with separations between different cabling types as required in Section 16130 or as detailed
- 22 on the Drawings.
- 23 2. Install so that top of concrete encased duct, at any point:
- 24 a. Is not less than 24 IN below grade.
- 25 b. Is below pavement sub-grading.
- 26 3. Under traffic areas (roadways, parking lots, etc.) and for a distance 10 FT either side of the
- 27 traffic area, and elsewhere as defined on the Drawings, the concrete shall be reinforced. The
- 28 reinforcement shall be in accordance with Section 03002 and as detailed on the Drawings.
- 29 4. Conduit supports shall provide a uniform minimum clearance of 2 IN between the bottom of
- 30 the trench and the bottom row of conduit.
- 31 5. Conduit separators shall provide a uniform minimum clearance of 2 IN between conduits or
- 32 as required in Section 16130 for different cabling types.
- 33 C. Direct-Buried Ductbank:
- 34 1. Ductbank system consists of conduits directly buried in earth with separations between
- 35 different cabling types as required in Section 16130 or as detailed on the Drawings.
- 36 2. Install so that the top of the uppermost conduit, at any point:
- 37 a. Is not less than 24 IN below grade.
- 38 b. Is below pavement sub-grading.
- 39 3. Provide a uniform minimum clearance of 2 IN between conduits or as required in Section
- 40 16130 for different cabling types. Maintain the separation by:
- 41 a. The use of conduit supports and separators.
- 42 b. Installing the multilevel ductbank one level at a time. Each level is backfilled with the
- 43 appropriate amount of soil to maintain the required separations.
- 44 D. Direct-Buried Conduit:
- 45 1. Ductbank system consisting of a conduit directly buried in earth.
- 46 2. Install so that top of conduit, at any point:
- 47 a. Is not less than 24 IN below grade.
- 48 b. Is below pavement sub-grading.
- 49 E. Conduits embedded in concrete structure (e.g., sidewalks, bridge decks) where shown on the
- 50 Contract Drawings:
- 51 1. Shall not be considered to replace structurally the displaced concrete except as indicated in
- 52 the following:
- 53 2. Shall not be larger in outside diameter than one-third the thickness of concrete.
- 54 3. Shall have a minimum spacing of 3 DIA OC.

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4. In reinforced concrete construction:
 - a. Place conduit after reinforcing steel has been laid.
 - b. The reinforcement steel shall not be displaced by the conduit.
 - c. Provide a minimum of 1-1/2 IN of cover over conduit.

END OF SECTION

1 01C09

2 **SECTION 16140**
3 **WIRING DEVICES**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Light switches.
 - 8 2. Receptacles.
 - 9 3. Device wallplates and coverplates.
- 10 B. Related Sections include but are not necessarily limited to:
- 11 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 12 2. Division 1 - General Requirements.
 - 13 3. Section 16010 - Electrical: Basic Requirements.
 - 14 4. Section 16130 - Raceways and Boxes.

15 **1.2 QUALITY ASSURANCE**

- 16 A. Referenced Standards:
- 17 1. National Electrical Manufacturers Association (NEMA):
 - 18 a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 19 b. WD-1, Wiring Devices.
 - 20 c. WD-6, Wiring Devices - Dimensional Requirements.
 - 21 2. Underwriters Laboratories, Inc. (UL):
 - 22 a. 20, General Use Snap Switches.
 - 23 b. 498, Attachment Plugs and Receptacles.
 - 24 c. 514A, Metallic Outlet Boxes.
 - 25 d. 943, Ground-Fault Circuit-Interrupters.

26 **1.3 SUBMITTALS**

- 27 A. Shop Drawings:
- 28 1. See Section 16010.

29 **PART 2 - PRODUCTS**

30 **2.1 ACCEPTABLE MANUFACTURERS**

- 31 A. Subject to compliance with the Contract Documents, the following manufacturers are
32 acceptable:
- 33 1. Light switches and receptacles:
 - 34 a. Hubbell.
 - 35 b. Bryant.
 - 36 c. Pass & Seymour.
 - 37 d. Arrow Hart.
 - 38 e. General Electric.
 - 39 f. Leviton.
 - 40 g. Crouse-Hinds.
 - 41 h. Appleton Electric Co.
 - 42 i. Killark.
- 43 B. Submit requests for substitution in accordance with Specification Section 01640.

1 **2.2 LIGHT SWITCHES**

- 2 A. General requirements unless modified in specific requirements paragraph of switches per
3 designated areas:
4 1. Toggle type, quiet action, Standard Specification grade.
5 2. Self grounding with grounding terminal.
6 3. Back and side wired.
7 4. Solid silver cadmium oxide contacts.
8 5. Rugged urea housing and one-piece switch arm.
9 6. Rated 20 A, 120/277 V AC.
10 7. Switch handle color: Ivory.
11 8. Types as indicated on the Drawings:
12 a. Single pole.
13 b. Double pole.
14 c. 3-way.
15 d. 4-way.
16 9. Standards: UL 20, 514A; NEMA WD-6.
- 17 B. Architecturally Finished Areas:
18 1. Wallplate: Type 302 stainless steel. Single or multiple gang as required.
- 19 C. Dry Non-architecturally Finished Areas:
20 1. Coverplate: Type 302 stainless steel. Single or multiple gang as required.
- 21 D. Wet Non-architecturally Finished Areas:
22 1. Coverplate: Gasketed zinc plated malleable iron or aluminum with stainless steel screws
23 utilizing rocker, front mounted toggle or pull type switch. Single or multiple gang as
24 required.
- 25 E. Corrosive Areas:
26 1. Corrosion resistant nickel plated metal parts.
27 2. Coverplate: Gasketed zinc plated malleable iron or copper free aluminum with stainless
28 steel screws utilizing rocker, front mounted toggle or pull type switch. Single or multiple
29 gang as required. Use PVC coated zinc plated malleable iron for PVC coated rigid conduit
30 systems.

31 **2.3 RECEPTACLES**

- 32 A. General requirements unless modified in specific requirements paragraph of receptacles per
33 designated areas:
34 1. Straight blade, Standard Specification grade.
35 2. Brass triple wipe line contacts.
36 3. One piece grounding system with double wipe brass grounding contacts and self grounding
37 strap.
38 4. Back and side wired.
39 5. Rated 20 A, 125 V AC.
40 6. High impact nylon body.
41 7. Receptacle body color:
42 a. Normal power: Ivory.
43 b. Generator or UPS power: Red.
44 c. Isolated ground systems: Orange triangle on face with body color as specified above.
45 8. Types as indicated on the Drawings:
46 a. Normal: Self grounding with grounding terminal.
47 b. Ground fault circuit interrupter: Feed-through type with test and reset buttons.
48 c. Isolated grounding: Grounding terminal is isolated from the grounding strap.
- 49 B. Duplex type, unless otherwise indicated on the Drawings.
50 1. Configuration: NEMA 5-20R.
51 2. Standards: UL 498, 514A, 943; NEMA WD-1, WD-6.

- 1 C. Architecturally Finished Areas:
- 2 1. Wallplate: Type 302 stainless steel.
- 3 D. Dry Non-architecturally Finished Areas:
- 4 1. Coverplate: Type 302 stainless steel. Single or multiple gang as required.
- 5 E. Wet Non-architecturally Finished Areas:
- 6 1. Coverplate: Weather resistant zinc plated or aluminum, gasketed, self-closing cover using
- 7 stainless steel spring.
- 8 2. Coverplate: Raintight while in use, gasketed, flame retardant, UV stabilized polycarbonate,
- 9 2.25 IN cover depth.
- 10 F. Corrosive Areas:
- 11 1. Corrosion resistant nickel plated metal parts.
- 12 2. Color: Yellow.
- 13 3. Coverplate: Weather resistant zinc plated or aluminum, gasketed, self-closing cover using
- 14 stainless steel spring.

15 **PART 3 - EXECUTION**

16 **3.1 INSTALLATION**

- 17 A. Mount devices where indicated on the Drawings and as scheduled in Section 16010.
- 18 B. See Section 16130 for device outlet box requirements.
- 19 C. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.
- 20 D. Provide blank plates for empty outlets.
- 21 E. Use tamper proof screws on pull and junction box covers in the following locations:

22 **END OF SECTION**

1 2003/05/06

2 **SECTION 16230**
3 **STANDBY ENGINE GENERATOR**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Emergency/standby engine generator set and accessories.
- 8 B. Related Sections include but are not necessarily limited to:
- 9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 10 2. Division 1 - General Requirements.
 - 11 3. Section 16010 - Electrical: Basic Requirements.
 - 12 4. Section 16411 – Transfer Switches.

13 **1.2 QUALITY ASSURANCE**

- 14 A. System Standards:
- 15 1. National Electrical Manufacturers Association (NEMA):
 - 16 a. MG-1, Motors and Generators.
 - 17 2. National Fire Protection association (NFPA):
 - 18 a. 30, Flammable and Combustible Liquids Code.
 - 19 b. 37, Stationary Combustion Engines and Gas Turbines.
 - 20 c. 110, Emergency and Standby Power Systems.
- 21 B. The engine generator set manufacturer is designated to have single source responsibility for the
22 supply of all components and installation of the unit.

23 **1.3 SUBMITTALS**

- 24 A. Shop Drawings:
- 25 1. See Section 16010.
 - 26 2. Unit sizing calculations.
- 27 B. Operations and Maintenance Manuals:
- 28 1. See Section 01340.
- 29 C. Miscellaneous:
- 30 1. Unit installation, startup and operational statement.

31 **1.4 SITE CONDITIONS**

- 32 A. Ambient air temperature: 100 DegF.
- 33 B. Altitude: 1000 FT above sea level.

34 **PART 2 - PRODUCTS**

35 **2.1 ACCEPTABLE MANUFACTURERS**

- 36 A. Subject to compliance with the Contract Documents, the following manufacturers are
37 acceptable:
- 38 1. Engine generator unit:
 - 39 a. Caterpillar.
 - 40 b. Cummins Onan.
 - 41 c. Kohler.

- 1 d. Generac.
- 2 2. Silencers:
- 3 a. Manufacturer's standard.
- 4 3. Battery charger:
- 5 a. Manufacturer's standard.
- 6 4. Governor:
- 7 a. Manufacturer's standard.
- 8 5. Radiator:
- 9 a. Manufacturer's standard.
- 10 6. Vibration isolators:
- 11 a. Manufacturer's standard.
- 12 B. Submit requests for substitution in accordance with Specification Section 01640.

13 2.2 COMPONENTS

- 14 A. Engine Generator Unit General.
- 15 1. Engine direct-connected to alternating current generator mounted on suitable rigid steel skid
- 16 supports.
- 17 2. Mount unit on skid suitable for installation on concrete foundation.
- 18 3. Base rating on operation at rated RPM when equipped with all operating accessories.
- 19 4. Suitable for use on Natural Gas and LP Vapor.
- 20 B. Engine:
- 21 1. Heavy Duty, spark-ignited, in-line 4 cylinder, liquid cooled.
- 22 2. Make engine perform satisfactorily on Natural Gas and LP Vapor.
- 23 3. Capable of operating at idle or light loads for extended periods of time.
- 24 C. Governor: Fully enclosed electronic type governor with actuator capable of providing accurate
- 25 speed control within 2 percent of rated speed, complete with panel-mounted electronic assembly
- 26 with ramp generator and speed-sensing modules.
- 27 D. Air Cleaners: Engine-mounted, dry type air cleaners of sufficient capacity.
- 28 E. Electric Starting System:
- 29 1. Sufficient capacity to crank at speed which will start engine under normal operating
- 30 conditions.
- 31 2. Automatic controls to provide automatic cranking of engine when normal power fails.
- 32 3. Prevent excessive cranking which could damage cranking motor.
- 33 4. Automatic stop controls.
- 34 5. Starter motors with positive-engagement feature.
- 35 F. Cooling System:
- 36 1. Capacity for cooling engine at the specified operating conditions.
- 37 2. Engine driven, centrifugal type water circulating pump and thermostatic valve to maintain
- 38 the engine at recommended temperature level.
- 39 3. Unit mounted radiator.
- 40 a. Core guard flexible duct adapter.
- 41 b. Engine driven blower fan.
- 42 4. Provide fan guards.
- 43 G. Heater:
- 44 1. Thermostatically controlled jacket water heater to maintain cooling jacket and oil pan at the
- 45 manufacturer's recommended temperature for a 10 second start time in 40 DegF ambient.
- 46 2. 120 V, single phase.
- 47 H. Silencer:
- 48 1. Suitable type for critical residential silencing.
- 49 2. Seamless, stainless steel, flexible, exhaust adapter for exhaust outlet to silencer.
- 50 3. Exhaust pipe roof thimble:

- 1 a. Type 304 stainless steel.
- 2 b. Carrier pipe of the same diameter and wall thickness as the interconnecting engine
- 3 exhaust pipe. Thimble to be self ventilating by means of holes drilled in metal plates at
- 4 either end of the roof thimble.
- 5 c. Mounting plate to completely support the thimble from the wall and support the carrier
- 6 pipe.
- 7 d. Exhaust pipe fitted with a hinged stainless steel rain cap.
- 8 4. Exhaust system insulation:
- 9 a. Rigid insulation: High temperature 3 IN calcium silicate type with aluminum jacket
- 10 fastened with aluminum or stainless steel hardware.
- 11 b. Flexible insulation: High temperature fiberglass, 9 LB per cubic FT.
- 12 I. Batteries:
- 13 1. Dry-charged, lead-acid type.
- 14 2. Furnish electrolyte separately for use when installation is complete and unit is ready for
- 15 testing.
- 16 J. Battery Charger:
- 17 1. Output current rating of at least 1/20th of ampere hour capacity of battery and capable of
- 18 automatically switching between low rate (float) mode and high rate (equalize) mode.
- 19 2. Solid state rectifiers, DC voltmeter and ammeter, fuse input and output, and 115 Vac input.
- 20 3. Malfunction alarm contacts for loss of AC power voltage, low and high battery voltage, loss
- 21 of charge and loss of high rate charge.
- 22 K. Generator:
- 23 1. Brushless, 4 pole drip-proof revolving field type with permanent magnet, 2/3 pitch stator,
- 24 direct-coupled rotor, Class F insulation.
- 25 2. Minimum continuous standby ratings: As indicated on the Drawings, substantiated by
- 26 manufacturer's standard published curves and conform to NEMA MG-1 specification.
- 27 Special ratings or maximum ratings are not acceptable.
- 28 3. Rated to serve up to 50 percent non-linear load without exceeding standard NEMA
- 29 temperature rise.
- 30 4. Minimum efficiency: 92 percent at 50 to 110 percent of nominal standby rating, less than
- 31 30 percent instantaneous voltage dip at full load and rated power factor and suitable for
- 32 simultaneous operation with other future units connected in parallel.
- 33 5. Stator and rotor: 125 DegC temperature rise with minimum Class F insulated with 100
- 34 percent epoxy impregnation and overcoat of resilient insulating material to reduce possible
- 35 fungus and/or abrasive deterioration.
- 36 6. Directly connect stator to engine flywheel housing.
- 37 7. Drive rotor through semiflexible driving flange to ensure permanent alignment.
- 38 8. Self ventilating with suitable blower, air inlet and outlet openings.
- 39 9. Provide terminal box of adequate size for entrance of flexible conduit for generator leads
- 40 out bottom from either side.
- 41 10. Generator drive free from critical torsional vibration within operating range.
- 42 11. Provide generator mounted main circuit breaker: Solid state molded case type. Ratings as
- 43 indicated.
- 44 L. Voltage Regulator:
- 45 1. SCR type, to maintain 2 percent voltage regulation from 0 to full load with steady state
- 46 modulation not exceeding plus 1/2 percent including cross-current compensation to provide
- 47 maximum of 5 percent unbalance in kVA load sharing between this unit and possible future
- 48 generators.
- 49 2. Automatic protection against short circuits on system.
- 50 3. Permit unit to operate at no load below rated frequency for engine start up and shut down
- 51 procedures.
- 52 4. Provide voltage level and gain controls for normal operating adjustments.
- 53 5. Provide voltage level control with minimum range of plus or minus 5 percent from rated
- 54 voltage.

- 1 6. Mount regulator, volts per hertz type, in generator housing on suitable vibration isolators.
- 2 M. Generator Instruments and Controls:
- 3 1. Generator mounted NEMA 1 type, vibration isolated instrument and control panel(s).
- 4 2. AC voltmeter.
- 5 3. AC ammeter.
- 6 4. Frequency meter.
- 7 5. Run-off-auto engine, start-stop control switch.
- 8 6. Emergency stop.
- 9 7. Run time meter.
- 10 8. Cool down time delay.
- 11 N. Vibration Isolators: Vibration system shall consist of engine and generator mount isolators with
- 12 or without additional mechanical spring isolators rubber pads to control both high and low
- 13 frequency vibrations between major components, sub-base and structural foundation and to
- 14 provide required vibration isolation for the seismic zone of the Project.

15 **2.3 ACCESSORIES**

- 16 A. Provide interposing relays (24 Vdc to 120 Vac) as required for interfacing with customer's 120
- 17 Vac monitoring system.
- 18 B. Generator set non-walk-in weather protective enclosure:
- 19 1. Sheet steel with side servicing panels, air intake louvers and rear control panel access door.
- 20 2. Side servicing panels shall have two (2) locking points; all panels and doors are key
- 21 lockable.
- 22 3. Pitched roof with silencing exhaust muffler mounted inside the enclosure.
- 23 4. Completely install enclosure on generator set mounting base.

24 **2.4 SOURCE QUALITY CONTROL**

- 25 A. Individually test each prime mover. Apply derating factors for the proposed site to test data.
- 26 Continuously test for a period no less than 2 HRS. Test procedure shall be as follows:
- 27 1. Start prime mover and upon reaching rated RPM, pick up 100 percent of nameplate KW
- 28 rating at rated power factor in one step.
- 29 2. Observe and record the cranking time(s) required to start and run for each prime mover.
- 30 3. Observe and record the time required to come up to operating speed for each prime mover.
- 31 4. Record voltage and frequency overshoot for each prime mover.
- 32 5. Record voltage, frequency and amperes.
- 33 6. Record oil pressure at 5-minute intervals for the first 15 minutes and at 15 minute intervals
- 34 thereafter for each prime mover.

35 **2.5 MAINTENANCE MATERIALS**

- 36 A. Spare Parts:
- 37 1. Provide manufacturer's recommended spare parts.

38 **PART 3 - EXECUTION**

39 **3.1 INSTALLATION**

- 40 A. Install all components as indicated and in accordance with manufacturer's recommendations and
- 41 instructions.
- 42 B. Fill cooling system with manufacturers recommended cooling fluid.
- 43 C. Install all wiring on engine in conduit except control wiring may be factory installed in high
- 44 temperature loom.
- 45 D. Provide control wiring in conduit between generator and transfer switch.

1 E. Mount on concrete pad, see structural drawings for details.

2 F. Install exhaust piping to the exterior of the building.

3 **3.2 FIELD QUALITY CONTROL**

- 4 A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
- 5 1. Inspect equipment covered by this Section.
 - 6 2. Supervise pre-startup adjustments and installation checks.
 - 7 3. Conduct initial startup of equipment and perform operational checks.
 - 8 4. Provide Owner written statement that manufacturer's equipment has been installed properly,
9 started up, and is ready for operation by Owner's personnel.
 - 10 5. Provide 4 HRS of the manufacturer's technical representative's time for on-site training of
11 Owner's personnel.
- 12 B. Provide two load tests and one cycle crank tests. Tests one and two shall be for continuous
13 period of no less than two hours each. Engineer and Owner shall be notified 7 days prior to
14 testing.
- 15 1. Test number one:
 - 16 a. With prime mover(s) in a "cold start" condition and emergency load at normal
17 operating level, initiate a normal power failure by opening all switches or breakers
18 supplying normal power to facility.
 - 19 b. Observe and record the time delay on engine start.
 - 20 c. Observe and record the cranking time(s) required to start and run for each prime mover.
 - 21 d. Observe and record the time required to come up to operating speed for each prime
22 mover.
 - 23 e. Record voltage and frequency overshoot for each prime mover.
 - 24 f. Observe and record time required to achieve steady-state condition with all switches
25 transferred to emergency position.
 - 26 g. Record voltage, frequency and amperes.
 - 27 h. Record oil pressure at 5-minute intervals for the first 15 minutes and at 15 minute
28 intervals thereafter for each prime mover.
 - 29 i. Return normal power to facility , record time delay on retransfer to normal and
30 cooldown time delay for each prime mover.
 - 31 2. Test number two:
 - 32 a. Immediately after completion of test number one, start prime mover and upon reaching
33 rated RPM, pick up 100 percent of nameplate KW rating in one step. Unity power
34 factor is acceptable for on-site testing
 - 35 b. Observe and record the cranking time(s) required to start and run for each prime mover.
 - 36 c. Observe and record the time required to come up to operating speed for each prime
37 mover.
 - 38 d. Record voltage and frequency overshoot for each prime mover.
 - 39 e. Observe and record time required to achieve steady-state condition.
 - 40 f. Record voltage, frequency and amperes.
 - 41 g. Record oil pressure, water temperature where applicable and battery charge rate at first
42 load acceptance and at 15 minute intervals thereafter for each prime mover.
 - 43 3. Furnish load banks of required ratings necessary for tests.
 - 44 4. Record engine fuel consumption by means of test equipment.
 - 45 5. Test all safeties specified for generator instruments and controls as recommended by
46 manufacturer and as required to verify proper operation.

47 **END OF SECTION**

2 **SECTION 16265**
3 **VARIABLE FREQUENCY DRIVES - LOW VOLTAGE**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Variable frequency drives (VFDs) for operation of 460 V AC, 3 PH, 60 HZ rated squirrel-cage induction motors. This includes both separately mounted and motor control center
 - 8 mounted VFDs.
 - 9
- 10 B. Related Sections include but are not necessarily limited to:
- 11 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 12 2. Division 1 - General Requirements.
 - 13 3. Section 09905 - Painting and Protective Coatings.
 - 14 4. Section 10400 - Identification, Stenciling, and Tagging Systems.
 - 15 5. Section 16010 - Electrical: Basic Requirements.
 - 16 6. Section 16442 - Motor Control Equipment.
 - 17 7. Section 16490 - Overcurrent and Short Circuit Protective Devices.

18 **1.2 QUALITY ASSURANCE**

- 19 A. Referenced Standards:
- 20 1. American National Standards Institute (ANSI):
 - 21 a. C62.41, Guide for Surge Voltages in Low Voltage AC Power Circuits.
 - 22 b. C62.45, Guide on Surge Testing for Equipment Connected to Low Voltage AC Power
 - 23 Circuits.
 - 24 2. Canadian Standards Association (CSA).
 - 25 3. ETL Testing Laboratories (ETL).
 - 26 4. Institute of Electrical and Electronic Engineers (IEEE):
 - 27 a. 519, Recommended Practices and Requirements for Harmonic Control in Electrical
 - 28 Power Systems.
 - 29 5. National Electrical Manufacturer's Association (NEMA):
 - 30 a. ICS 6, Enclosures for Industrial Controls and Systems.
 - 31 b. MG-1, Motors and Generators.
 - 32 6. National Fire Protection Association (NFPA):
 - 33 a. 70, National Electrical Code.
 - 34 7. Underwriter's Laboratory (UL):
 - 35 a. Standard 508, Electrical Industrial Control Equipment.
- 36 B. Qualifications:
- 37 1. Provide drives that have the standard factory configuration of the variable speed drive listed
 - 38 and labeled by Underwriter's Laboratories, Inc. (UL), Canadian Standards Association
 - 39 (CSA), ETL Testing Laboratories (ETL), or that shall be capable of field inspection and
 - 40 subsequent field labeling by a UL-recognized field inspector. Where drives and controlling
 - 41 equipment are mounted in a custom enclosure, the assembly when complete must be UL,
 - 42 CSA, or ETL labeled, or shall be capable of field inspection and subsequent field labeling
 - 43 by a UL field inspector.
 - 44 2. VFD Supplier shall maintain an authorized service organization within 300 miles of the
 - 45 project site.
- 46 C. Source Quality Control:
- 47 1. Factory Tests:

- 1 a. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure
- 2 conformance to Specification requirements.
- 3 b. Prior to final assembly:
- 4 1) Inspect incoming components.
- 5 2) Test and inspect power devices.
- 6 3) Circuit cards:
- 7 a) Component and functional tests:
- 8 b) Burn-in chamber or temperature cycling test.
- 9 c) System test after burn-in, or temperature cycling.
- 10 c. After final assembly:
- 11 1) Continuity and insulation test of 480 V AC circuits.
- 12 a) Test voltage shall be 2500 V DC.
- 13 2) Continuity and insulation test of 120 V AC circuits.
- 14 a) Test voltage shall be 500 V DC.
- 15 3) Drive tests:
- 16 a) Burn-in complete drive at full load for 24 HRS.
- 17 b) Verify all auxiliary circuits operation.
- 18 c) Monitor output variables.
- 19 4) Systems test:
- 20 a) Provide inputs to field connections and simulate on-site operation.
- 21 b) Test all auxiliary equipment.
- 22 D. Coordination:
- 23 1. The Contractor shall provide a letter of certification from both the VFD manufacturer and
- 24 the driven equipment manufacturer that the VFD and the drive motor are compatible,
- 25 including any motor horsepower deviations from indicated "nominal horsepower", and that
- 26 the VFD will operate the driven equipment motor over its required operating range.
- 27 2. Provide verification that the critical frequency of the driven equipment has been identified
- 28 and that the VFD has been set to lockout this frequency.
- 29 3. Verify plan dimensions with equipment space requirements as indicated on the Drawings.
- 30 a. Equipment that exceeds the allotted maximum dimensions may not be acceptable.
- 31 4. Contractor shall coordinate submittal with submittals from the motor manufacturer and the
- 32 equipment manufacturer to provide concurrent submittals.

33 1.3 SUBMITTALS

- 34 A. Shop Drawings:
- 35 1. See Section 16010.
- 36 2. Product technical data:
- 37 a. Rated VFD input kVA and current.
- 38 b. Rated output kVA and current.
- 39 c. Overload current.
- 40 d. Control schematics and wiring diagrams.
- 41 e. Percent efficiency and power factor at 50, 75, and 100 percent speed.
- 42 f. Maximum BTU heat release data and verification of the drive cooling requirements.
- 43 g. Panel interior, and front and side exterior views, with details showing maximum overall
- 44 dimensions of VFD and isolation transformer (if provided).
- 45 h. Locations and sizes of electrical connections, ground terminations, and shielded wire
- 46 usage.
- 47 i. Harmonic calculations by the VFD manufacturer with detailed drawings and/or
- 48 information showing how protection is applied to comply with harmonic limits.
- 49 j. Identification and location of closest authorized service organization.
- 50 3. Certifications:
- 51 a. Submit with Shop Drawings:
- 52 1) Compliance with IEEE 519.
- 53 2) Compliance with "Factory Tests".

- 1 3) That the VFD can withstand the same level of fault current as that imposed on the
- 2 equipment feeding the VFD.
- 3 b. Submit prior to shipment:
- 4 1) From the VFD manufacturer and each VFD driven equipment manufacturer that
- 5 the specific application has been reviewed and that the combination will satisfy the
- 6 drive duties required with the actual motor furnished.
- 7 2) That the testing described under "Factory Tests" in Part 2 has been successfully
- 8 completed.
- 9 c. Submit after installation:
- 10 1) That the critical frequency of the drive system has been identified and the VFD has
- 11 been set to lockout these frequencies.
- 12 2) Installation test reports that show:
- 13 a) Each VFD is operational.
- 14 b) Each VFD and its driven equipment motor is compatible.
- 15 c) Each VFD responds correctly to the input control signals.
- 16 3) That by on-site field measurements the VFD is not introducing harmonics to the
- 17 power distribution system in excess of those recommended by IEEE 519.
- 18 B. Operations and Maintenance Manuals:
- 19 1. See Section 01340.
- 20 2. Troubleshooting procedures with a cross-reference between symptoms and corrective
- 21 recommendations.
- 22 3. Connection data to permit removal and installation of recommended smallest field-
- 23 replaceable parts.

24 **PART 2 - PRODUCTS**

25 **2.1 ACCEPTABLE MANUFACTURERS**

- 26 A. Subject to compliance with the Contract Documents, the following Manufacturers are
- 27 acceptable:
- 28 1. ASEA-Brown Bovari (ABB).
- 29 2. Cutler-Hammer.
- 30 3. General Electric Company.
- 31 4. Halmar Robicon Group.
- 32 5. Allen-Bradley.
- 33 6. Square D Company.
- 34 7. Toshiba.

- 35 B. Submit requests for substitution in accordance with Specification Section 01640.

36 **2.2 TYPE OF DRIVE**

- 37 A. Pulse-Width Modulated (PWM) type with IGBT technology.

38 **2.3 PERFORMANCE AND DESIGN REQUIREMENTS**

- 39 A. Application:
- 40 1. VFD(s) shall be of sufficient capacity and shall provide a quality output waveform for
- 41 stepless motor control from 10 to 100 percent of base speed for squirrel cage induction
- 42 motors complying with Section 11005 of these specifications and other special purpose
- 43 motors (such as submersible pump motors) as specified in narrow scope equipment sections
- 44 of these specifications.
- 45 2. The drives shall be suitable for Constant Torque (CT) or Variable Torque (VT) applications.
- 46 VFD manufacturer shall coordinate with the manufacturer of the driven equipment to
- 47 identify CT and VT applications.
- 48 3. VFDs shall be designed to operate successfully under the following conditions:
- 49 a. Ambient:

- 1) Temperature: 0-40 DegC.
 - 2) 95 percent non-condensing relative humidity.
 - b. Elevation: 1700 FT above MSL.
 - c. Input power to VFD:
 - 1) Nominal 480 V AC (± 10 percent).
 - 2) 3 PH, 60 HZ (± 3 percent).
 - d. Line voltage imbalance ± 5 percent of rated voltage.
 - e. Available fault current withstand rating shall be equal to that of the equipment from which the VFD is fed (MCC, switchboard, etc.).
- 10 B. Performance:
- 11 1. The VFD shall have the following capabilities:
 - 12 a. Continuous current rating:
 - 13 1) 100 percent of rated VFD current shall be equal to or greater than the motor full
 - 14 load nameplate rating including motor service factor.
 - 15 b. Current overload capacity:
 - 16 1) VT: 110 percent for 1 min.
 - 17 2) CT: 150 percent for 1 min.
 - 18 c. Efficiency:
 - 19 1) 97 percent at full speed and full load.
 - 20 2) 93 percent at 1/2 speed and full load.
 - 21 3) Efficiency shall be determined excluding isolation transformer and input and
 - 22 output reactor losses.
 - 23 d. Power Factor:
 - 24 1) 94 percent at full speed and load.
 - 25 e. Frequency drift:
 - 26 1) ± 0.5 percent of set frequency.
 - 27 f. Speed regulation (motor dependent):
 - 28 1) 3 percent.
 - 29 g. Speed range:
 - 30 1) 10:1.
 - 31 h. Critical frequency lockout:
 - 32 1) Minimum of three.
 - 33 i. Continued operation with momentary voltage dips of 25 percent of rated voltage for a 4
 - 34 second duration.
 - 35 j. Volts/Hertz ratio; constant over the entire operating range of the VFD except:
 - 36 1) When operating under voltage boost.
 - 37 2) At frequencies over 60 HZ.
 - 38 k. Automatic restart with one restrike following a power outage.
 - 39 l. Spinning load restart: Synchronization of VFD starting frequency with spinning or
 - 40 coasting load.
 - 41 2. The VFD shall be supplied with line side and load side reactors:
 - 42 a. Minimum impedance:
 - 43 1) 5 percent.
 - 44 b. Current overload: 150 percent for 1 min.
 - 45 c. Insulation temperature rating: 180 DegC.
 - 46 d. Copper windings.
 - 47 e. Saturation current rating: 3.5 to 5 times rated current.
 - 48 f. Hi-potential rating: 2500 V AC line to ground and line-to-line, for 1 min.
 - 49 g. Noise reducing:
 - 50 1) Epoxy over cast coil.
 - 51 2) Extra dips and bakes of varnish over continuous wound coil.
- 52 C. The VFD shall be provided with the following adjustments:
- 53 1. Independent maximum and minimum speed.
 - 54 2. Independent linear acceleration and deceleration time.
 - 55 3. Volts/Hertz ratio.

- 1 4. Voltage boost.
- 2 5. Torque limit.
- 3 6. Overcurrent trip point.
- 4 D. The VFD shall have the power circuit designed such that the power circuit components are
- 5 protected:
- 6 1. Input protection:
- 7 a. Line side molded case circuit breaker type disconnect.
- 8 1) Padlockable in the OFF position.
- 9 2) Overcurrent and short circuit device per Section 16490.
- 10 b. Undervoltage trip:
- 11 1) Auto restart.
- 12 2) Ride through a momentary power dip, magnitude and duration as previously
- 13 specified.
- 14 3) Ride through a one cycle loss of power.
- 15 c. Incoming line transient suppression.
- 16 d. Loss of phase trip:
- 17 1) Auto restart.
- 18 e. Reverse phase trip:
- 19 1) Auto restart.
- 20 f. Overvoltage trip:
- 21 1) Auto restart.
- 22 2) Relay installed in the VFD.
- 23 2. Internal protection:
- 24 a. Surge suppression and power device snubbers.
- 25 b. Power devices rated at 2.5 times line voltage.
- 26 c. Instantaneous overcurrent trip with manual reset.
- 27 d. DC bus overvoltage trip with manual reset.
- 28 e. Power device overtemperature trip with manual reset.
- 29 f. Control logic circuit malfunction trip with manual reset.
- 30 3. Output protection:
- 31 a. Inverse-time overload trip:
- 32 1) Manual restart.
- 33 b. Overvoltage trip:
- 34 1) Manual restart.
- 35 c. Overfrequency trip:
- 36 1) Manual restart.
- 37 d. Short circuit trip:
- 38 1) Line to line and line to ground.
- 39 2) Manual restart.
- 40 e. Ground fault trip:
- 41 1) Manual restart.

42 **2.4 OPERATOR AND REMOTE CONTROL INTERFACE**

- 43 A. Control circuits shall be 115 V AC supplied by CPT in the VFD.
- 44 1. CPT shall have minimum additional capacity of 60 VA greater than that required by control
- 45 devices.
- 46 2. CPT shall have both primary sides fused and one fuse on the secondary side with the other
- 47 secondary side grounded.
- 48 3. CPT shall have surge protection on the primary side independent of any other surge
- 49 protection in the VFD.
- 50 B. Operator interface:
- 51 1. Door mounted sealed keypad, membrane type with LED or LCD display.
- 52 a. Messages shall be in English and engineering units.
- 53 b. Drive operating parameters shall be programmable.
- 54 c. Menu driven.

- 1 d. Password security.
 - 2 e. Display fault and diagnostic data.
 - 3 f. Operating parameters, fault and diagnostic data maintained in non-volatile memory
 - 4 with historic log of fault and diagnostic data.
 - 5 g. Gold plated plug-in contacts.
 - 6 2. Hand-Off-Auto control and speed reference selector switch.
 - 7 3. Manual speed adjustment.
 - 8 4. Manual start and stop control.
 - 9 5. Indicating lights:
 - 10 a. POWER ON.
 - 11 b. VFD RUN.
 - 12 c. VFD FAULT.
 - 13 6. Speed indication:
 - 14 a. Calibrated in percent.
 - 15 b. Open-loop, function of VFD frequency.
 - 16 7. Diagnostic indicators located externally on the face of the drive shall show the type of fault
 - 17 responsible for drive warning, shutdown or failure. On occurrence of more than one
 - 18 condition each shall be recorded or indicated by the diagnostics.
- 19 C. Remote Control Interface:
- 20 1. PLC/Computer interface card with serial communications port:
 - 21 a. Capability to:
 - 22 1) Start-Stop VFD.
 - 23 2) Control VFD Speed.
 - 24 3) Access fault and diagnostic data.
 - 25 2. Analog and discrete inputs:
 - 26 a. See Drawings for control schematics.
 - 27 b. Isolated process signal follower with offset, gain and span adjustment for accepting a
 - 28 remote 4-20 mA DC speed reference signal.
 - 29 c. Drive disable permissive:
 - 30 1) From local disconnect auxiliary contact.
 - 31 3. Analog and discrete outputs:
 - 32 a. 4-20 mA DC output for remote speed indication, as a function of frequency, calibrated
 - 33 0 to 100 percent.
 - 34 b. Drive FAULT contacts.
 - 35 c. Drive RUNNING contacts.
 - 36 d. Drive selector switch in AUTO status contacts.
 - 37 4. Contacts:
 - 38 a. Contacts shall be rated 2 A inductive at 120 V AC.
 - 39 b. All contacts shall be wired to terminal boards.
 - 40 5. Drive shutdown on motor winding overtemperature:
 - 41 a. Manual reset.
 - 42 b. Motor winding overtemperature switch to initiate VFD shutdown. Wire to terminal
 - 43 board in the VFD.

44 2.5 HARMONIC PROTECTION REQUIREMENTS

- 45 A. Each VFD shall be designed and provided with all necessary equipment to protect the VFD and
- 46 the power system ahead of the VFD from voltage and current distortion. The VFD manufacturer
- 47 shall provide harmonic filters as required.
- 48 1. In accordance with and as defined by IEEE 519:
 - 49 a. Each VFD shall be designed to operate from a power bus that may contain up to 5
 - 50 percent voltage distortion.
 - 51 b. Each single or multiple set of VFDs powered from the same bus shall be designed to
 - 52 limit percent distortion factor to a maximum total of 5 percent voltage distortion.
 - 53 c. Current distortion limits shall not exceed the values listed in Table 10.3 of IEEE 519.

- d. Line-to-line notching at the input to the drive shall have a maximum notch depth of 20 percent and a maximum notch area of 22,800 volt-microseconds reflected back to the power source.
2. The Point of Common Coupling (PCC) for all harmonic calculations and field measurements for both the voltage and current distortion shall be defined as the primary (line side) connection of each VFD.

2.6 EQUIPMENT CONSTRUCTION

A. Fabrication and Assembly:

1. Each VFD system shall be shop assembled for installation in an MCC or in an enclosure for remote mounting:
 - a. See Drawings for each VFD system application.
2. Utilize interchangeable plug-in printed circuit boards and power conversion components wherever possible.
3. Shop assembly shall be performed by the VFD manufacturer or his authorized agent. Systems fabricated or assembled in whole or in part by parties other than the VFD manufacturer or his authorized agent will not be acceptable.
4. VFDs, where required, shall be mounted within standard 20 IN wide motor control center sections, and included as part of the overall motor control center.
5. Reactors and/or filters, where required, shall be mounted within or in an ancillary enclosure adjacent to the drive enclosure, or with the Engineer's permission may be mounted in a separate enclosure.
6. Cooling fans shall be provided to run when drive is running.
7. Enclosures for separately mounted VFD's:
 - a. NEMA Type 1 for installation in enclosed Electrical Rooms.
 - b. NEMA Type 12 for installation in other unclassified areas.

B. Wiring:

1. The wiring in the VFD shall be neatly installed in wire ways or with wire ties where wire ways are not practical. Where wire ties are used, the wire bundles are to be held at the back panel with a screw-mounted wire tie-mounting base. Bases with a self-sticking back will not be allowed.
2. All plug-in contacts shall be gold-plated.
3. Terminal blocks shall be complete with marking strip, covers and pressure connectors. They shall be nonbrittle, interlocking, track-mounted type. Screw terminals will not be allowed. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable. For free-standing panels, 8 IN of clearance shall be provided between terminals and the panel base for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Terminals shall be labeled to agree with identification indicated on the suppliers submittal drawings. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.
4. All grounding wires shall be attached to the enclosure sheet metal with a ring tongue terminal. The surface of the sheet metal shall be prepared to assure good conductivity and corrosion protection.
5. Wiring shall not be kinked or spliced and shall have markings on both ends or be color coordinated. Markings or color coordination shall comply with the manufacturer's drawings.
6. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 V, with a moisture-resistant and flame-retardant covering rated for not less than 90 DegC.

C. Nameplates:

1. All devices mounted on the face of the drive shall be provided with a suitable nameplate as specified in Section 10400. Push buttons, selector switches, and pilot lights shall have the device manufacturer's standard legend plate. All other devices shall have an engraved, laminated plate. All lettering shall be a minimum of 3/16 IN high and shall be white or silver on a black background.

- 1 2. Relays, terminals and special devices inside the control enclosure shall have permanent
- 2 markings to match identification used on manufacturer's wiring diagrams.
- 3 3. Use stainless steel screws to attach nameplates.
- 4 D. Painting: Equipment, after being phosphate washed, shall be thoroughly cleaned and given at
- 5 least one coat of rust-inhibiting primer on all inner surfaces prior to fabrication.

6 **PART 3 - EXECUTION**

7 **3.1 INSTALLATION**

- 8 A. Install products in accordance with manufacturer's instructions and as indicated on the Drawings.
- 9 B. Verify the installed motor nameplate electrical requirements do not exceed the VFD capacity.
- 10 C. Provide services of manufacturer's representative to perform start-up services.

11 **3.2 START UP**

- 12 A. Pre-startup services:
 - 13 1. Shall be completed a minimum of 30 days prior to the startup and demonstration period
 - 14 described in Section 01650.
 - 15 2. Shall consist of:
 - 16 a. Physical and electrical installation check.
 - 17 b. Final adjustments and calibration of drive parameters.
 - 18 c. VFD operation from simulated input signals.
 - 19 3. Shall be complete when VFD(s) are fully operational.
- 20 B. Startup and demonstration services:
 - 21 1. Supervise startup of all units including recheck of settings made during the pre-startup tests.
 - 22 a. Perform all work in the presence of the Owner's designated representatives.
 - 23 2. Simulate operation of the VFD and its associated control and instrumentation system in both
 - 24 the manual and automatic modes.
 - 25 a. Ensure compatibility of VFD with associated control and instrumentation signals.
 - 26 3. Simulate VFD failures and demonstrate troubleshooting aids.
 - 27 4. Instruct Owner's designated personnel:
 - 28 a. Minimum of 8 hours at the jobsite.
 - 29 b. Include both field and classroom instruction.
 - 30 c. Instructions shall include proper operation and maintenance procedures including, but
 - 31 not limited to:
 - 32 1) Lubrication.
 - 33 2) Troubleshooting.
 - 34 3) Repair and replacement.
 - 35 4) Parts inventory.
 - 36 5) Maintenance records.
- 37 C. Perform onsite field measurement of harmonics at the PCC.
 - 38 1. For each individual VFD.
 - 39 2. For the maximum number of VFDs that will be operational at the same time.
- 40 D. Perform onsite field measurement of the maximum voltage peak, measured line-to-line, at the
- 41 terminals of each motor fed from a VFD.
 - 42 1. Use a high speed oscilloscope to produce a plot of Voltage (Y axis) versus Time (X axis).
 - 43 a. Time shall be measured in microseconds.
 - 44 2. Tests shall be performed at full voltage and speed.
 - 45 a. Peak voltage shall not exceed 1200 V line-to-line.
 - 46 b. Peak voltage in excess of 1200 V line-to-line:
 - 47 1) Contractor shall coordinate with the VFD manufacturer to solve the problem and at
 - 48 no cost to the Owner.

- 1 a) VFD manufacturer shall increase the impedance of the output line reactor, or
2 provide an output filter, to limit the motor terminal voltage peak to 1200 V or
3 less, line-to-line.
4 b) Contractor shall perform a complete retest of all affected drives.
- 5 E. Record all data necessary for the preparation of required test reports.

6 **3.3 SPARE PARTS**

- 7 A. Provide manufacturer's recommended spare parts.
- 8 B. When not included in the recommended spare parts provide for each type and rating of drive:
9 1. Complete set of all plug-in drive components.
10 2. One set of 3 of each type power fuse.
11 3. One set of 12 of each type control fuse.
12 4. One main control board.
13 5. One inverter module.
14 6. One inverter snubber module.
15 7. One inverter base drive module.
16 8. One set of other field replaceable components.
- 17 C. Spare parts shall be labeled and packed in containers suitable for storage.
- 18 D. Spare parts utilized during pre-startup or startup and demonstration testing shall be immediately
19 restocked, at no cost to the Owner.

20

END OF SECTION

1 01C12

2

SECTION 16410
SAFETY SWITCHES

3

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

6 A. Section Includes:

7 1. Safety switches.

8 B. Related Sections include but are not necessarily limited to:

- 9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
10 2. Division 1 - General Requirements.
11 3. Section 16010 - Electrical: Basic Requirements.
12 4. Section 16490 - Overcurrent and Short Circuit Protective Devices.

13 **1.2 QUALITY ASSURANCE**

14 A. Referenced Standards:

- 15 1. National Electrical Manufacturers Association (NEMA):
16 a. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).
17 b. KS-1, Enclosed and Miscellaneous Distribution Equipment Switches.
18 2. National Fire Protection Association (NFPA):
19 a. 70, National Electrical Code (NEC).
20 3. Underwriters Laboratories, Inc. (UL):
21 a. 98, Enclosed and Dead-Front Switches.

22 **1.3 SUBMITTALS**

23 A. Shop Drawings:

- 24 1. See Section 16010.
25 2. Identify each safety switch by type and rating with associated equipment tag number.

26 B. Operation and Maintenance Manuals:

- 27 1. See Section 01340.

28 **PART 2 - PRODUCTS**

29 **2.1 ACCEPTABLE MANUFACTURERS**

30 A. Subject to compliance with the Contract Documents, the following safety switch manufacturers
31 are acceptable:

- 32 1. Cutler-Hammer.
33 2. General Electric Company.
34 3. Square D Company.
35 4. Siemens.
36

37 B. Submit requests for substitution in accordance with Specification Section 01640.

38 **2.2 SAFETY SWITCHES**

39 A. General:

- 40 1. Non-fusible or fusible as indicated on the Drawings.
41 2. Rated for service entrance use where required on the Drawings.
42 3. NEMA Type HD heavy-duty construction.

- 1 4. Switch blades will be fully visible in the OFF position with the enclosure door open.
2 5. Quick-make/quick-break operating mechanism.
3 6. Deionizing arc chutes.
4 7. Double-break rotary action shaft and switchblade shall be manufactured as one common
5 component.
6 8. Clear line shields to prevent accidental contact with line terminals.
7 9. Provide 10 amp, 120 volt electrical interlock contact where required on the Drawings.
8 Contact shall be normally open, with contact closed when safety switch is closed.
9 10. Operating handle:
10 a. Red, and easily recognizable.
11 b. Padlockable in the OFF position
12 c. Interlocked to prevent door from opening when the switch is in the ON position with a
13 defeater mechanism.
- 14 B. Ratings:
15 1. Horsepower rated for connected motor.
16 2. Voltage and ampere rating: As indicated on Drawings.
17 3. Short circuit withstand rating when provided with fuses: Equal to or greater than the
18 upstream equipment.
- 19 C. Enclosures:
20 1. NEMA 4X rated:
21 a. Body and cover: Type 304 or 316 stainless steel.
22 b. No knockouts.
23 c. External mounting flanges.
24 d. Hinged and gasketed door.
25 2. NEMA 12 rated:
26 a. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturers
27 standard paint inside and out.
28 b. No knockouts. External mounting flanges.
29 c. Hinged and gasketed door.
- 30 D. Overcurrent and short circuit protective devices:
31 1. Fuses.
32 2. See Section 16490 for overcurrent and short circuit protective device requirements.
- 33 E. Standards: NEMA KS-1, UL 98.

34 **PART 3 - EXECUTION**

35 **3.1 INSTALLATION**

- 36 A. Install as indicated and in accordance with manufacturer's instructions and recommendations.
37 B. Switches shall be installed adjacent to the equipment they are intended to serve unless otherwise
38 indicated on the Drawings.
- 39 C. Permitted uses of NEMA 4X enclosure:
40 1. Surface mounted in areas designated as wet and/or corrosive.
- 41 D. Permitted uses of NEMA 12 enclosure:
42 1. Surface mounted in areas not otherwise designated.

43 **END OF SECTION**

1 2001/03/12

2 **SECTION 16411**
3 **TRANSFER SWITCHES**

4 **1.1 GENERAL**

- 5 A. Section Includes:
6 1. Automatic transfer switches.
7 B. Related Sections include but are not necessarily limited to:
8 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
9 2. Division 1 - General Requirements.
10 3. Section 16010 - Electrical: Basic Requirements.
11 4. Section 16230 - Standby Engine Generator.

12 **1.2 QUALITY ASSURANCE**

- 13 A. Referenced Standards:
14 1. National Electrical Manufacturers Association (NEMA):
15 a. KS-1, Enclosed and Miscellaneous Distribution Equipment Switches.
16 2. National Fire Protection Association (NFPA):
17 a. 70, National Electric Code (NEC).
18 3. Underwriters Laboratories, Inc. (UL):
19 a. 98, Enclosed and Dead-Front Switches.
20 b. 1008, Standard for Safety Switch Equipment.

21 **1.3 SUBMITTALS**

- 22 A. Shop Drawings:
23 1. See Section 16010.
24 B. Operation and Maintenance Manuals:
25 1. See Section 01340.

26 **1.4 DELIVERY, STORAGE, AND HANDLING**

- 27 A. See Section 16010.

28 **PART 2 - PRODUCTS**

29 **2.1 ACCEPTABLE MANUFACTURERS**

- 30 A. Subject to compliance with the Contract Documents, the listed manufacturers are acceptable:
31 1. Automatic transfer switches:
32 a. Automatic Switch Company.
33 b. Kohler.
34 c. Onan.
35 d. Russelectric.
36 e. Zenith Products.
37 B. Substitution: Submit requests for substitution in accordance with Specification Section 01640.

38 **2.2 AUTOMATIC TRANSFER SWITCH**

- 39 A. Construction:
40 1. Electrically operated mechanically interlocked contactors.
41 2. Silver-surface main contacts and protect by arcing contacts.
42 3. Switch shall have provisions for visual inspection of contacts.

- 1 4. Mechanical design will positively open all ungrounded conductors from normal source
- 2 before connection is made to alternate source and will positively open alternate source
- 3 before connection is made to normal source.
- 4 5. Mechanical interlock to ensure the switch cannot be readily disabled, disconnected,
- 5 improperly adjusted, removed or otherwise made inoperative.
- 6 6. Make all contacts and coils readily accessible for replacement from front of panel without
- 7 major disassembly.
- 8 7. Ratings:
- 9 a. Continuous duty in both normal and emergency.
- 10 b. Single-phase, three wire.
- 11 c. Voltage and current ratings as indicated on the Drawings.
- 12 d. Short circuit withstand rating equal to or greater than the normal source electrical gear.
- 13 8. Standards: ANSI/UL 1008.
- 14 B. Operation:
- 15 1. Fully automatic control.
- 16 2. Red and green indicating lights with fuses, identification nameplates, and test switch to
- 17 simulate normal power failure at switch.
- 18 3. Engine starting contacts and all other auxiliary contacts and accessory devices for functions
- 19 to be performed.
- 20 4. Switch enclosure shall contain the battery charger for the generator, powered from the load
- 21 side of the transfer switch.
- 22 5. Supervisory voltage relays on each phase of normal source and single phase supervisory
- 23 voltage and frequency relay for emergency source.
- 24 a. Normal source voltage sensing.
- 25 1) Pickup at 90 percent of rated voltage.
- 26 2) Dropout at 80 percent of rated voltage.
- 27 b. Emergency source voltage and frequency sensing:
- 28 1) Adjustable pickup at 90 percent of rated voltage.
- 29 2) Adjustable pickup at 95 percent of rated frequency.
- 30 6. Time delays:
- 31 a. Engine start, time delay at 5 seconds, to avoid unnecessary starting caused by short time
- 32 outages.
- 33 b. Transfer to generator, 20 seconds.
- 34 c. Retransfer to normal, 5 minutes to avoid erratic operation caused by short time
- 35 reestablishment of normal source. Automatically bypassed when emergency source
- 36 fails and normal source is available.
- 37 d. Generator cooldown, 5 minutes.
- 38 7. Exerciser timer:
- 39 a. Enable and disable function.
- 40 b. Selectable to exercise with or without transferring load.
- 41 c. Adjustable exercise duration from 1 minute to 24 HRS, factory set at 15 minutes.
- 42 d. Adjustable day of the week exercise setting, factory set for Monday.
- 43 C. Enclosure:
- 44 1. NEMA 1 rated.
- 45 2. Body and cover: Sheet steel finished with a rust inhibiting primer and manufacturers
- 46 standard paint inside and out.
- 47 3. No knockouts, hinged and lockable door.

48 PART 3 - EXECUTION

49 3.1 INSTALLATION

- 50 A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
- 51 B. Connect as indicated in one-line diagram.

- 1 C. Mounting of automatic transfer switches:
- 2 1. Wall-mounted.

3 **3.2 FIELD QUALITY CONTROL**

- 4 A. Automatic Transfer Switch Testing:
- 5 1. Simulate power outage by opening normal source overcurrent device. Verify engine
- 6 generator starts and switch transfers in the specified time.
- 7 2. Close normal source overcurrent device to simulate the return of normal power. Verify the
- 8 switch retransfers and engine generator shuts down in the specified time.
- 9 3. Perform a manual transfer and retransfer.
- 10 4. Verify the indicator lights function properly.

11

END OF SECTION

1 01C12

2 **SECTION 16440**
3 **SWITCHBOARDS**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Low voltage switchboards.
- 8 B. Related Sections include but are not necessarily limited to:
- 9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
- 10 2. Division 1 - General Requirements.
- 11 3. Section 16010 - Electrical: Basic Requirements.
- 12 4. Section 16490 - Overcurrent and Short Circuit Protective Devices.
- 13 5. Section 16491 - Low Voltage Surge Protective Devices.
- 14 6. Section 16492 - Electrical Metering Accessories.

15 **1.2 QUALITY ASSURANCE**

- 16 A. Referenced Standards:
- 17 1. National Electrical Manufacturers Association (NEMA):
- 18 a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- 19 b. PB-2, Deadfront Distribution Switchboards.
- 20 2. Underwriters Laboratories (UL):
- 21 a. 891, Standard for Dead-Front Switchboards.
- 22 B. Verify the space required for the switchboard is equal to or less than the space allocated.

23 **1.3 SUBMITTALS**

- 24 A. Shop Drawings:
- 25 1. See Section 16010.
- 26 2. Fabrication and/or layout drawings:
- 27 a. Switchboard layout with alphanumeric designation, protective devices size and type, as
- 28 indicated in the one-line diagram or switchboard schedule.
- 29 b. Conduit space locations within the assembly.
- 30 c. Front elevation and plan drawing of the assembly.
- 31 d. Three-line and schematic diagrams.
- 32 B. Operation and Maintenance Manuals:
- 33 1. See Section 01340.
- 34 C. Miscellaneous:
- 35 1. Ground fault protection system test report signed by the projects supervising electrical
- 36 foreman.

37 **PART 2 - PRODUCTS**

38 **2.1 ACCEPTABLE MANUFACTURERS**

- 39 A. Subject to compliance with the Contract Documents, the following manufacturers are
- 40 acceptable:
- 41 1. Cutler-Hammer.
- 42 2. General Electric Company.

- 1 3. Square D Company.
- 2 4. Siemens.
- 3 B. Submit requests for substitution in accordance with Specification Section 01640.
- 4 **2.2 SWITCHBOARDS**
- 5 A. Ratings:
- 6 1. Voltage, number of phases, number of wires, and main bus current rating as indicated on the
- 7 Drawings.
- 8 2. Bus withstand and circuit breaker interrupting fault rating as indicated on the Drawings.
- 9 3. Service Entrance Equipment rated.
- 10 B. Construction:
- 11 1. Standards: NEMA PB-2, UL 891.
- 12 2. Completely enclosed, dead-front, self-supporting metal structure.
- 13 3. Vertical panel sections bolted together.
- 14 4. Frames bolted together to support and house bus, cables and other equipment.
- 15 5. Frames and insulating blocks to support and brace main buses for short circuit stresses up to
- 16 ratings indicated on the Drawings.
- 17 6. All sections rear aligned .
- 18 7. Devices front removable and load connections front and rear accessible.
- 19 8. NEMA 3R rated weatherproof enclosure:
- 20 a. Nonwalk-in type with sloping roof downward toward rear.
- 21 b. Thermostatically controlled space heaters to minimize internal condensation. Power for
- 22 heater derived internal to the switchboard.
- 23 9. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and
- 24 manufacturers standard paint.
- 25 C. Buses:
- 26 1. Material: Silver-plated copper.
- 27 2. Main horizontal bus:
- 28 a. Fully rated and continuous over length of switchboard with all three phases arranged in
- 29 the same vertical plane.
- 30 b. Sufficient size to limit temperature rise to 65 DegC over average air temperature
- 31 outside the enclosure of 40 DegC.
- 32 3. Neutral bus: Fully rated and continuous over length of switchboard.
- 33 4. Ground bus: 1/4 x 2 IN copper, continuous over length of switchboard and solidly grounded
- 34 to each vertical section structure.
- 35 5. Bus joints connected using through bolts and conical spring-type washers for maximum
- 36 conductivity.
- 37 D. Overcurrent and Short Circuit Protective Devices:
- 38 1. Main overcurrent protective device:
- 39 a. Individually mounted molded case circuit breaker.
- 40 2. Feeder overcurrent protective devices:
- 41 a. Group mounted molded case circuit breaker.
- 42 3. See Section 16490 for overcurrent and short circuit protective device requirements.
- 43 4. Factory installed.
- 44 5. Means to padlock all main and feeder devices in the open position.
- 45 E. Surge protective device: Integrally mounted, see Section 16491.
- 46 F. Metering:
- 47 1. As required on the Drawings. See Section 16492 for meter requirements.

48 **PART 3 - EXECUTION**

49 **3.1 INSTALLATION**

- 1 A. Install switchboard in accordance with manufacturer's instructions.
- 2 B. Arrange switchboard as shown on the Drawings.
- 3 C. Outdoor location:
 - 4 1. NEMA 3R enclosure.
 - 5 2. Install on concrete pad, align front of switchboard with top edge of pad chamfer and
 - 6 securely fasten to pad.
- 7 D. Miscellaneous:
 - 8 1. Provide circuit protective devices and other associated equipment as indicated on the
 - 9 Documents.
 - 10 2. All control wiring shall be neatly laced and have flexibility at hinge locations.
 - 11 3. Tag switchboard and all circuit breakers identifying equipment and circuit fed.

12 **3.2 FIELD QUALITY CONTROL**

- 13 A. Test the ground fault protection system as indicated in Section 16490.

14

END OF SECTION

1 01C13

2 **SECTION 16441**
3 **PANELBOARDS**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

- 6 A. Section Includes:
- 7 1. Lighting and appliance panelboards.
 - 8 2. Power distribution panelboards.
 - 9 3. Panelboards mounted in Motor Control Centers.
- 10 B. Related Sections include but are not necessarily limited to:
- 11 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 12 2. Division 1 - General Requirements.
 - 13 3. Section 16010 - Electrical: Basic Requirements.
 - 14 4. Section 16442 - Motor Control Equipment.
 - 15 5. Section 16490 - Overcurrent and Short Circuit Protective Devices.
 - 16 6. Section 16491 - Low Voltage Surge Protective Devices.

17 **1.2 QUALITY ASSURANCE**

- 18 A. Referenced Standards:
- 19 1. National Electrical Manufacturers Association (NEMA):
 - 20 a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 21 b. PB 1, Panelboards.
 - 22 2. Underwriters Laboratories, Inc (UL):
 - 23 a. 67, Panelboards.
 - 24 b. 50, Cabinets and Boxes.

25 **1.3 SUBMITTALS**

- 26 A. Shop Drawings:
- 27 1. See Section 16010.
 - 28 2. Fabrication and/or layout drawings:
 - 29 a. Panelboard layout with alphanumeric designation, branch circuit breakers size and type,
 - 30 as indicated in the panelboard schedules.
- 31 B. Operation and Maintenance Manuals:
- 32 1. See Section 01340.

33 **PART 2 - PRODUCTS**

34 **2.1 ACCEPTABLE MANUFACTURERS**

- 35 A. Subject to compliance with the Contract Documents, the following manufacturers are
- 36 acceptable:
- 37 1. Cutler-Hammer.
 - 38 2. General Electric Company.
 - 39 3. Square D Company.
 - 40 4. Siemens.
- 41 B. Submit requests for substitution in accordance with Specification Section 01640.

42 **2.2 MANUFACTURED UNITS**

- 1 A. Standards: NEMA PB 1, NFPA 70, UL 50, UL 67.
- 2 B. Ratings as follows unless indicated otherwise on Drawings:
- 3 1. Current, voltage, number of phases, number of wires as indicated on the Drawings.
- 4 2. Panelboards rated 240 V AC or less: 10,000 amp minimum short circuit rating.
- 5 3. Panelboards rated 480 V AC: 14,000 amp minimum short circuit rating.
- 6 C. Construction:
- 7 1. Service entrance rated where indicated on Drawings.
- 8 2. Interiors factory assembled and designed such that switching and protective devices can be
- 9 replaced without disturbing adjacent units and without removing the main bus connectors.
- 10 3. Multi-section panelboards: Feed-through or sub-feed lugs.
- 11 4. Main lugs: Solderless type approved for copper wire.
- 12 D. Bus bars:
- 13 1. Main bus bars: Copper sized to limit temperature rise to a maximum of 65 DegC above an
- 14 ambient of 40 DegC. Drilled and tapped and arranged for sequence phasing of the branch
- 15 circuit devices.
- 16 2. Ground bus and isolated ground bus, when indicated on Drawings: Solderless mechanical
- 17 type connectors.
- 18 3. Neutral bus bars: Insulated 100 percent rated or 200 percent rated, when indicated on the
- 19 Drawings and with solderless mechanical type connectors.
- 20 E. Enclosure:
- 21 1. Boxes: Code gage galvanized steel, furnish without knockouts.
- 22 2. Trim assembly: Code gage steel finished with rust inhibited primer and manufacturers
- 23 standard paint inside and out.
- 24 3. Lighting and appliance panelboard:
- 25 a. Trims supplied with hinged door over all circuit breaker handles.
- 26 b. Trims for surface mounted panelboards, same size as box.
- 27 c. Trims for flush mounted panelboards, overlap the box by 3/4 IN on all sides.
- 28 d. Doors lockable with corrosion resistant chrome-plated combination lock and catch, all
- 29 locks keyed alike.
- 30 e. Nominal 20 IN wide and 5-3/4 IN deep with gutter space in accordance with NEC.
- 31 f. Clear plastic cover for directory card mounted on the inside of each door.
- 32 g. NEMA 3R, 4 or 12 rated: Door gasketed.
- 33 4. Power distribution panelboard:
- 34 a. Trims cover all live parts with switching device handles accessible.
- 35 b. Less than or equal to 12 IN deep with gutter space in accordance with NEC.
- 36 c. Clear plastic cover for directory card mounted front of enclosure.
- 37 d. NEMA 3R or 12 rated: Doors gasketed and lockable with corrosion resistant chrome-
- 38 plated combination lock and catch, all locks keyed alike.
- 39 5. Overcurrent and short circuit protective devices:
- 40 a. Main overcurrent protective device:
- 41 1) Molded case circuit breaker.
- 42 b. Branch overcurrent protective devices:
- 43 1) Mounted molded case circuit breaker.
- 44 c. See Section 16490 for overcurrent and short circuit protective device requirements.
- 45 d. Factory installed.
- 46 F. Integral surge protective device: See Section 16491.

47 PART 3 - EXECUTION

48 3.1 INSTALLATION

- 49 A. Install as indicated on Drawings, in accordance with the NEC, and in accordance with
- 50 manufacturer's instructions.

- 1 B. Support panelboard enclosures from wall studs or modular channels support structure, per
2 Section 16010.
- 3 C. Provide NEMA rated enclosure as indicated on the Drawings.
- 4 D. Provide panelboard labeling as specified in Section 16010.
- 5 E. Provide each panelboard with a typed directory:
6 1. Identify all circuit locations in each panelboard with the load type and location served.
7 2. Mechanical equipment shall be identified by Owner-furnished designation if different than
8 designation indicated on Drawings.
9 3. Room names and numbers shall be final building room names and numbers as identified by
10 the Owner if different than designation indicated on Drawings.

11

END OF SECTION

1 00E11

2

3

SECTION 16442
MOTOR CONTROL EQUIPMENT

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

6

A. Section Includes:

7

1. Motor control centers.

8

2. Separately mounted motor starters (including those supplied with equipment).

9

3. Manual motor starters.

10

4. Modifications and /or additions to existing motor control centers.

11

B. Related Sections include but are not necessarily limited to:

12

1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

13

2. Division 1 - General Requirements.

14

3. Section 16010 - Electrical: Basic Requirements.

15

4. Section 16265 - Variable Frequency Drives – Low Voltage.

16

5. Section 16441 – Panelboards.

17

6. Section 16460 - Dry-Type Transformers.

18

7. Section 16490 – Overcurrent and Short Circuit Protective Devices.

19

8. Section 16491 – Low Voltage Surge Protective Devices.

20

9. Section 16492 – Electrical Metering Accessories.

21

10. Section 16493 – Control Equipment Accessories.

22

1.2 QUALITY ASSURANCE

23

A. Referenced Standards:

24

1. American National Standards Institute (ANSI).

25

2. Institute of Electrical and Electronics Engineers (IEEE).

26

3. National Electrical Manufacturers Association (NEMA):

27

a. ICS 2, Industrial Control Devices, Controllers, and Assemblies.

28

b. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).

29

4. Underwriters Laboratories, Inc (UL):

30

a. 845, Electric Motor Control Centers.

31

b. 508, Industrial Control Equipment.

32

B. Miscellaneous:

33

1. Verify motor horsepower loads, other equipment loads, and controls from approved shop drawings and notify Engineer of any discrepancies.

34

2. Verify the required instrumentation and control wiring for a complete system and notify Engineer of any discrepancies.

35

36

37

1.3 SUBMITTALS

38

A. Shop Drawings:

39

1. See Section 01340.

40

2. MCC elevation drawings and complete description of units in the MCC.

41

3. MCC unit wiring diagrams.

42

4. Wiring diagrams for all control equipment.

43

B. Operation and Maintenance Manuals:

44

1. See Section 01340.

1 **PART 2 - PRODUCTS**

2 **2.1 ACCEPTABLE MANUFACTURERS**

- 3 A. Subject to compliance with the Contract Documents, the following manufacturers are
4 acceptable:
5 1. General Electric.
6 2. Square D.
7 3. Cutler Hammer.
8 4. Siemens.
9 5. Allen Bradley.
10 B. Submit requests for substitution in accordance with Specification Section 01640.

11 **2.2 MOTOR CONTROL CENTERS**

- 12 A. Ratings:
13 1. 600 Volt class, 3 phase, 60 hertz, with operating voltage and number of wires as indicated
14 on the Drawings.
15 2. Main horizontal bus ratings: As indicated on the Drawings.
16 3. Vertical bus ratings: Same ratings as main horizontal bus when incoming service conductors
17 terminate in that section. 150 percent of vertical section loads otherwise.
18 4. Short circuit withstand rating: 42 KAIC symmetrical.
19 a. Unless otherwise indicated on the Drawings.
20 B. Construction:
21 1. NEMA Class II, Type B.
22 2. NEMA Type 1A, gasketed, freestanding.
23 3. Unit structures:
24 a. Totally enclosed.
25 b. Joined together to form one assembly:
26 1) Each unit structure will be nominal 20 IN wide, 20 IN deep, and 90 IN high, unless
27 otherwise indicated on the Drawings.
28 4. Fabricate of not less than 14 GA steel with 16 GA steel doors in standardized units.
29 5. Provide main horizontal bus in each structure; full capacity, full-length, with provisions for
30 extension.
31 6. Provide each structure with full length vertical bus to distribute incoming power to each
32 circuit breaker and starter in structure:
33 1) Vertical bus shall be extended to spaces provided for future equipment
34 7. Bus bars:
35 a. High-strength plated copper.
36 b. Rectangular cross section.
37 c. Support in each structure by means of bus supports.
38 8. Provide ground bus:
39 a. Continuous.
40 b. 1/4 x 2 IN tin-plated copper.
41 c. Solidly grounded to each structure.
42 d. Locate near bottom of structure.
43 e. Provide for lug connection of equipment ground wires.
44 9. Provide guides for supporting and aligning starters.
45 10. Provide each structure with two horizontal wiring spaces.
46 a. One at top.
47 b. One at bottom.
48 c. Spaces will line up with adjacent units to form convenient wiring raceway entire length
49 of control center.
50 11. Provide each structure with one vertical wireway for unit wiring.
51 a. With cable tie supports to hold wiring in place.
52 b. With a separate door.

- 1 12. Bottom shall have ample unrestricted space for conduit entry.
- 2 13. Doors:
- 3 a. Formed round corners and rolled edges.
- 4 b. Gasketed.
- 5 c. Minimum of two heavy-duty hinges or continuous piano hinge.
- 6 d. Held closed by means of captive fasteners.
- 7 14. Fabricate doors to be a part of the structure and not part of the starter.
- 8 15. Cubicles:
- 9 a. Totally enclosed.
- 10 b. Effectively baffled to isolate any ionized gases that may occur within unit starter.
- 11 16. Assemblies effectively ventilated, to allow relocation of starters and other components:
- 12 a. Within the assembly and with the same load.
- 13 b. Without having to compensate for changes in location.
- 14 17. Space Units:
- 15 a. Minimum of 1 full size space unit (12 IN) for any combination magnetic motor starter
- 16 or starter without overload relay.
- 17 C. Starters and feeder breakers mounted in motor control centers:
- 18 1. Line plug-in, pull-out, lock-out type:
- 19 a. Except starters NEMA size 5 and larger:
- 20 1) Fixed mounted with the approval of the Engineer.
- 21 b. Circuit breakers rated above 400 amp shall be fixed mounted.
- 22 c. Provide guides in structure for supporting and aligning unit starter and/or breaker
- 23 during removal or replacement.
- 24 d. Plug-in units:
- 25 1) Silver-plated.
- 26 2) Pressure type line disconnecting stabs.
- 27 3) High-strength copper alloy.
- 28 e. Lock-out latch to padlock unit in "pull-out" position and at same time isolate stabs and
- 29 entire unit from bus. Hold each unit in place by means of quick-captive fasteners.

30 2.3 MOTOR STARTERS

- 31 A. All Motor Starters:
- 32 1. Combination circuit breaker, magnetic type, full voltage unless otherwise noted:
- 33 a. Other starter types as may be indicated on the Drawings, such as 2-speed, wye-delta,
- 34 and autotransformer, shall be combination type, closed-transition.
- 35 b. Contactors of reversing or multispeed starters shall be mechanically and electrically
- 36 interlocked.
- 37 2. Circuit Breakers:
- 38 a. Motor circuit protector (MCP) type for motors sized 200 horsepower and below.
- 39 Thermal-magnetic for motors sized above 200 horsepower. See Section 16490.
- 40 3. Starter contactors shall be NEMA full size rated.
- 41 a. NEMA half sizes and IEC contactors are not permitted.
- 42 b. Solid-state reduced voltage starters shall be ampere rated in accordance with the
- 43 indicated motor horsepower, sized for motor service factor of 1.15.
- 44 4. Operating handle shall clearly indicate whether circuit breaker is ON, OFF, or TRIPPED.
- 45 a. Provide means to lock each circuit breaker handle in OFF position with cover closed by
- 46 means of up to three padlocks.
- 47 b. Interlock so that circuit breaker must be in OFF position before door can be opened:
- 48 1) Provide defeater mechanism for use by authorized personnel.
- 49 2) Exceptions: NEMA 7 and 9 enclosures.
- 50 5. Provide starter unit with an adjustable solid-state, externally manually resettable, overload
- 51 relay. Coordinate size with actual motor full load current.
- 52 a. Overload adjustment shall be accessible to maintenance personnel only.
- 53 6. Provide heavy-duty control devices: See Section 16493.
- 54 a. Devices shall be accessible with the door closed.

- 1 7. In addition to those contacts indicated on the Drawings, provide each starter with two extra,
- 2 field-reversible auxiliary contacts for future use.
- 3 8. Provide each starter with line voltage to 120 V control power transformer:
- 4 a. Fused on both primary sides and one secondary side, with the other secondary side
- 5 grounded.
- 6 b. Sized for 140 percent of required load.
- 7 9. Provide elapsed time meter:
- 8 a. Where indicated on Drawings. See Section 16493.
- 9 10. Separately mounted motor starter units shall have the same fault current withstand rating as
- 10 the main bus fault current rating from which they are fed.
- 11 11. Starters mounted in an existing MCC shall fit in the space provided.
- 12 12. Unless otherwise indicated on the Drawings, provide each starter with the following status
- 13 signals, wired to terminal boards:
- 14 a. Motor run contact (N.O.).
- 15 b. Motor stop contact (N.C.).
- 16 c. Auxiliary overload relay contact (N.O.).
- 17 13. Reduced voltage solid state starter:
- 18 a. Starter shall be provided with:
- 19 1) Phase loss, phase unbalance and phase reversal protection.
- 20 2) Shorted SCR protection.
- 21 3) Contactor to bypass/isolate the starter from the load after load up to speed.
- 22 4) Diagnostic module, visible with the starter door closed, to include:
- 23 a) Control power.
- 24 b) Shorted SCR.
- 25 c) Start inhibit.
- 26 d) Trip.
- 27 e) Phase loss.
- 28 f) Phase unbalance.
- 29 g) Phase reversal.
- 30 5) Independently adjustable acceleration and deceleration current limit:
- 31 a) 150 to 400 percent of motor full load current.
- 32 b) Current limit adjustment accessible only to maintenance personnel.
- 33 6) Adjustable current ramp to provide breakaway torque to the motor.
- 34 a) 0 to 150 percent of motor full load current.
- 35 b) Current ramp adjustment accessible only to maintenance personnel.
- 36 14. Separately Mounted Starter Enclosures:
- 37 a. NEMA 4X rated:
- 38 1) Body and cover: Type 304 or 316 stainless steel.
- 39 2) No knockouts.
- 40 3) External mounting flanges.
- 41 4) Hinged and gasketed door.
- 42 b. NEMA 12 rated:
- 43 1) Body and cover: Sheet steel finished with rust inhibiting primer and manufacturers
- 44 standard paint inside and out.
- 45 2) No knockouts.
- 46 3) External mounting flanges.
- 47 4) Hinged and gasketed door.
- 48 B. Main and Feeder Circuit Breakers in MCC: See Section 16490.
- 49 1. Provide main circuit breaker with service entrance label where indicated on the Drawings.
- 50 C. Metering Equipment:
- 51 1. Where indicated on the Drawings, provide microprocessor-based monitoring, protection and
- 52 indicating devices on the incoming service: See Section 16492.
- 53 D. Manual Starters with Thermal Element:
- 54 1. Quick-make, quick-break toggle mechanism.

1 01C13

2

3

SECTION 16460
DRY-TYPE TRANSFORMERS

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

6 A. Section Includes:

7 1. Dry-type transformers, 1000 kVA and less.

8 B. Related Sections include but are not necessarily limited to:

9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

10 2. Division 1 - General Requirements.

11 3. Section 16010 - Electrical: Basic Requirements.

12 4. Section 16060 - Grounding.

13 **1.2 QUALITY ASSURANCE**

14 A. Referenced Standards:

15 1. American National Standards Institute (ANSI):

16 a. C57.96, Loading Dry-Type Distribution and Power Transformers.

17 b. C89.2, Dry-Type Transformers for General Applications.

18 2. National Electrical Manufacturers Association (NEMA):

19 a. ST 20, Dry-Type Transformers for General Applications.

20 3. Underwriters Laboratories Inc.(UL):

21 a. 506, Specialty Transformers.

22 b. 1561, Dry-Type General Purpose and Power Transformers.

23 **1.3 SUBMITTALS**

24 A. Shop Drawings:

25 1. See Section 16010.

26 2. Product technical data:

27 a. UL nameplate data.

28 3. Certifications:

29 a. Sound level certifications.

30 B. Operation and Maintenance Manuals:

31 1. See Section 01340.

32 **PART 2 - PRODUCTS**

33 **2.1 ACCEPTABLE MANUFACTURERS**

34 A. Subject to compliance with the Contract Documents, the following manufacturers are
35 acceptable:

36 1. Cutler-Hammer.

37 2. General Electric Company.

38 3. Square D Company.

39 4. Siemens.

40 5. Sola/Hevi-Duty.

41 B. Submit requests for substitution in accordance with Specification Section 01640.

42 **2.2 GENERAL PURPOSE DRY-TYPE TRANSFORMERS**

- 1 A. Ventilated or non-ventilated, air cooled, two winding type.
- 2 B. Cores: High grade, non-aging silicon steel with high magnetic permeability, and low hysteresis
3 and eddy current losses. Magnetic flux densities are to be kept well below the saturation point.
- 4 C. Coils: Continuous wound with electrical grade aluminum.
- 5 D. Non-ventilated units:
- 6 1. Core and coil assembly encapsulated in a proportioned mixture of resin and aggregate to
7 provide a moistureproof, shock resistant seal.
- 8 2. Totally enclosed, NEMA 3R, steel enclosure finished with a weather-resistant enamel.
- 9 E. Ventilated units:
- 10 1. Core and coils assembly impregnated with non-hygroscopic, thermosetting varnish and
11 cured to reduce hot spots and seal out moisture and completely isolated from the enclosure
12 by means of vibration dampening pads.
- 13 2. Dripproof, NEMA 2, steel enclosure finished with a weather-resistant enamel and
14 ventilation openings protected from falling dirt.
- 15 F. Furnish taps for transformers as follows:
- 16 1. 1 PH, 2 kVA and below: None.
- 17 2. 1 PH, 3 to 25 kVA: Two 5 percent FCBN.
- 18 3. 1 PH, 25 kVA and above: Two 2.5 percent FCAN and four 2.5 percent FCBN.
- 19 4. 3 PH, 3 to 15 kVA: Two 5 percent FCBN.
- 20 5. 3 PH, 15 kVA and above: Two 2.5 percent FCAN and four 2.5 percent FCBN.
- 21 G. Sound levels: Manufacturer shall guarantee not to exceed the following:
- 22 1. Up to 9 kVA: 40 dB.
- 23 2. 10 to 50 kVA: 45 dB.
- 24 H. Insulating material (600 V and below):
- 25 1. 3 to 15 kVA units: 185 DegC insulation system with a 115 DegC rise.
- 26 2. 15 kVA and above units: 220 DegC insulation system with a 150 DegC rise.
- 27 I. Ratings: 60 Hertz, Voltage, KVA and phase, as indicated on the Drawings.
- 28 J. Finish: Rust inhibited primer and manufacturers standard paint inside and out.
- 29 K. Standards: ANSI C57.96, ANSI C89.2, NEMA ST 20, UL 506, UL 1561.

30 PART 3 - EXECUTION

31 3.1 INSTALLATION

- 32 A. Install products in accordance with manufacturer's instructions.
- 33 B. Indoor locations:
- 34 1. Provide ventilated type for 15 kVA units and above.
- 35 2. Provide non-ventilated type for 9 kVA units and below and where indicated on the
36 Drawings.
- 37 3. Mount 9 kVA units and below on wall.
- 38 4. Mount 15 kVA units and above on chamfered 4 IN high concrete housekeeping pad or from
39 wall and/or ceiling, at 7 FT above finished floor, using equipment support brackets per
40 Section 16010.
- 41 5. Provide rubber vibration isolation pads.
- 42 C. Outdoor locations:
- 43 1. Mount non-ventilated type on concrete pad for units weighting greater than 400 LBS and
44 mount units weighting less than 400 LBS on channel support structure per detail on
45 Drawings.
- 46 D. Enclosures: Painted steel in all areas except stainless steel in corrosive areas.

1 E. Ground in accordance with Section 16060.

2 **END OF SECTION**

1 01C13

2

SECTION 16490

3

OVERCURRENT AND SHORT CIRCUIT PROTECTIVE DEVICES

4 PART 1 - GENERAL

5 1.1 SUMMARY

6

A. Section Includes:

7

1. Low voltage circuit breakers.

8

2. Low voltage fuses.

9

B. Related Sections include but are not necessarily limited to:

10

1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

11

2. Division 1 - General Requirements.

12

3. Section 16010 - Electrical: Basic Requirements.

13

1.2 QUALITY ASSURANCE

14

A. Referenced Standards:

15

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

16

a. 242, Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

17

b. 399, Power System Analysis (Brown Book).

18

2. National Electrical Manufacturers Association (NEMA):

19

a. AB 1, Molded Case Circuit Breakers.

20

3. Underwriters Laboratories (UL):

21

a. 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures.

22

b. 943, Ground Fault Circuit Interrupters.

23

24

1.3 SUBMITTALS

25

A. Shop Drawings:

26

1. See Section 16010.

27

B. Operation and Maintenance Manual:

28

1. See Section 01340.

29

C. Miscellaneous:

30

1. Ground fault protection system test report.

31

PART 2 - PRODUCTS

32

2.1 ACCEPTABLE MANUFACTURERS

33

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

34

1. Circuit breakers:

35

a. Cutler-Hammer.

36

b. General Electric Company.

37

c. Square D Company.

38

d. Siemens.

39

2. Fuses:

40

a. Bussmann, Inc.

41

b. Littlefuse, Inc.

42

c. Gould Shawmut.

43

1 B. Submit requests for substitution in accordance with Specification Section 01640.

2 **2.2 CIRCUIT BREAKERS**

3 A. Molded case type:

4 1. General:

- 5 a. Standards: NEMA AB 1, UL 489.
- 6 b. Unit construction.
- 7 c. Over-center, toggle handle operated.
- 8 d. Quick-make, quick-break, independent of toggle handle operation.
- 9 e. Manual and automatic operation.
- 10 f. All poles open and close simultaneously.
- 11 g. Three position handle: on, off and tripped.
- 12 h. Molded-in ON and OFF markings on breaker cover.
- 13 i. One-, two- or three-pole as indicated on the Drawings.
- 14 j. Current and interrupting ratings as indicated on the Drawings.
- 15 k. Bolt on type.

16 2. Thermal magnetic type:

- 17 a. Inverse time overload and instantaneous short circuit protection by means of a thermal
18 magnetic element.
- 19 b. Frame size 150 amp and below:
 - 20 1) Non-interchangeable, non-adjustable thermal magnetic trip units.
- 21 c. Frame sizes 225 to 250 amp:
 - 22 1) Interchangeable and adjustable instantaneous thermal magnetic trip units.
- 23 d. Ground Fault Circuit Interrupter (GFCI) Listed:
 - 24 1) Standard: UL 943.
 - 25 2) One- or two-pole as indicated on the Drawings.
 - 26 3) Class A ground fault circuit.
 - 27 4) Trip on 5 mA ground fault (4-6 mA range).
- 28 e. HACR Listed:
 - 29 1) Heating, air conditioning and refrigeration applications.

30 3. Solid state trip type:

- 31 a. Inverse time overload, instantaneous short circuit and ground fault protection by means
32 of a solid state trip element, associated current monitors and flux shunt trip mechanism.
- 33 b. Frame size 400 amp and above:
 - 34 1) Interchangeable current sensor or rating plug:
 - 35 2) Adjustable long time pickup setting. Adjustable from 50 to 100 percent of the
36 current sensor or rating plug.
 - 37 3) Adjustable short time pickup setting.
 - 38 4) Adjustable instantaneous pick-up.
 - 39 5) Fixed ground fault pickup.

40 4. Motor Circuit Protector:

- 41 a. Adjustable instantaneous short circuit protection by means of a magnetic or solid state
42 trip element.

43 **PART 3 - EXECUTION**

44 **3.1 INSTALLATION**

45 A. Current and interrupting ratings as indicated on the Drawings.

46 B. Series rated systems not acceptable.

47 C. Devices shall be ambient temperature compensated.

48 D. Molded case circuit breakers shall incorporate the following, unless indicated otherwise on the
49 Drawings:

1. Frame sizes 250 amp and less shall be thermal magnetic type.
2. Frame sizes 400 amp and larger shall be solid state trip type.
 - a. Current sensor or rating plugs long time pickup setting shall be set so that the indicated trip level is near the 75 percent trip point.
3. Frame sizes 1000 amp and above shall include integral ground fault protection.
4. Motor circuit protectors sized for the connected motor.

3.2 FIELD QUALITY CONTROL

A. Adjustable Circuit Breakers:

1. Set all circuit breaker adjustable taps as defined in the coordination study.
2. Test and verify all circuit breaker trip functions using a test set provided by the manufacturer for that purpose.

B. Ground Fault Protection System.

1. Single source system:

- a. Main breaker coordinated with individual feeder breakers using the residual sensing method.
- b. The main and feeder breakers shall utilize four individual current sensors, the phase sensors are integral to the circuit breaker and the neutral sensor is external to the circuit breaker.

C. Ground Fault Protection System Testing:

1. Performance test installed ground fault protection system as required by the NEC.
2. Use high current injection method to test system.
3. Test report shall indicated:
 - a. Device settings.
 - b. Tripping time in cycles for each device.
 - c. Test current.
 - d. Date of test.
 - e. Name of certified testing firm that performed the test.

END OF SECTION

SECTION 16491

LOW VOLTAGE SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 SPD - Service Entrance equipment locations (switchgear, switchgear, panelboards or motor control centers), integrally mounted.

2. Type 3 SPD - Switchboard, Panelboard and Motor Control Center locations, integrally mounted.

3. Type 6 SPD - Individual equipment locations, single phase, series connection.

4. Type 8 SPD - Analog instrumentation signal device, field mounted.

5. Type 9 SPD - Analog instrumentation signal device, control panel mounted.

6. Type 10 SPD - Discrete instrumentation signal and data line device, control panel mounted.

B. Related Sections include but are not necessarily limited to:

1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

2. Division 1 - General Requirements.

3. Section 16010 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronics Engineers (IEEE):

a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

b. C62.45, Guide on Surge Testing For Equipment Connected to Low-Voltage AC Power Circuits.

2. National Electrical Manufacturers Association (NEMA):

a. LS 1, Low Voltage Surge Protective Devices.

3. Underwriters Laboratories, Inc. (UL):

a. 497B, Standard for Safety - Protectors for Data Communication and Fire Alarm Circuits.

b. 1283, Standard for Safety - Electromagnetic Interference Filters.

c. 1363, Standard for Safety - Relocatable Power Taps.

d. 1449, Standard for Safety - Transient Voltage Surge Suppressors.

B. Qualifications:

1. Provide devices for a manufacturer who has been regularly engaged in the development, design, testing, listing and manufacturing of SPDs of the types and ratings required for a period of ten years or more and whose products have been in satisfactory use in similar service. Upon request, suppliers or manufacturers shall provide a list of not less than three customer references showing satisfactory operation.

1.3 DEFINITIONS

A. Clamping Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the SPD and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the SPD and from the system peak voltage to the peak of the surge.

- 1 C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which
2 the SPD device can operate and meet its specification within its rated temperature.
- 3 D. Maximum Surge Current: The maximum 8 x 20 microsecond surge current pulse the SPD device
4 is capable of surviving on a single-impulse basis without suffering either performance
5 degradation or more than 10 percent deviation of clamping voltage at a specified surge current.
6 Listed by mode, since number and type of components in any SPD may vary by mode.
- 7 E. MCC: Motor Control Center.
- 8 F. Protection Modes: This parameter identifies the modes for which the SPD has directly connected
9 protection elements, i.e. line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-
10 to-ground (N-G).
- 11 G. Surge Current per Phase: The per phase rating is the total surge current capacity connected to a
12 given phase conductor. For example, a wye system surge current per phase would equal L-N
13 plus L-G; a delta system surge current per phase would equal L-L plus L-G. The N-G mode is
14 not included in the per phase calculation.
- 15 H. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e. for a
16 480/277 volt system the L-L peak voltage is 679V and the L-N peak voltage is 392V).

17 1.4 SUBMITTALS

- 18 A. Shop Drawings:
19 1. See Section 16010.
20 2. Product technical data:
21 a. Manufacturer's experience.
22 b. Electrical and mechanical drawing showing unit dimensions, weights, mounting
23 provisions, connection details and layout diagram of the unit.
24 c. SPD Types 1 through 5:
25 1) UL 1449 product listing data.
26 2) Signed and Certified Clamping Voltage data from a third party testing laboratory,
27 including oscilloscope waveform snapshots for the indicated IEEE C62.41
28 Category waveforms. Testing shall be in accordance with IEEE C62.45. Clearly
29 identify the voltage reference level.
30 3) Signed and Certified spectrum analysis from a third part testing laboratory
31 verifying the device meets the indicated noise attenuation. Testing shall be in
32 accordance with MIL-STD-220A.
33 4) Signed and Certified Surge Current data from a third party testing laboratory.
34 5) Signed and Certified Repetitive Surge Current data from a third party testing
35 laboratory.
36 d. SPD Type 6 and 7:
37 1) UL 1449 product listing data.
38 2) Applicable manufacturer laboratory test data verifying catalog data sheet
39 performance (i.e., clamping voltage, surge current, noise attenuation, etc.)
40 e. SPD Types 8 through 10:
41 1) UL 497B product listing data.
42 2) Applicable manufacturer laboratory test data verifying catalog data sheet
43 performance (i.e., clamping voltage, surge current, noise attenuation, etc.)
- 44 B. Operation and Maintenance Manual:
45 1. See Section 01340.

46 1.5 WARRANTY

- 47 A. The manufacturer shall provide a 5-year Limited Warranty from date of shipment against failure
48 when installed in compliance with applicable national/local electrical codes and the
49 manufacturer's installation, operation and maintenance instructions.

1 **PART 2 - PRODUCTS**

2 **2.1 TYPE 1 SPD**

- 3 A. Product:
- 4 1. Integrally mounted in switchgear, switchboards or MCCs.
 - 5 2. Hybrid solid-state high performance suppression system. Do not use a suppression system
6 with gas tubes, spark gaps or other components which might short or crowbar the line
7 resulting in interruption of normal power flow to connected loads.
 - 8 3. Do not connect multiple SPD modules in series to achieve the specified performance.
 - 9 4. Designed for parallel connection.
 - 10 5. Field connection: Use mechanical or compression lugs for each phase, neutral and ground
11 that will accept bus bar or #10 through #1/0 conductors.
 - 12 6. Device Monitor: Provide long-life, solid state, externally visible indicators and Form C dry
13 contact(s) that monitors the on-line status of each mode of the units suppression filter
14 system and power loss in any of the phases. A fuse status only monitor system is not
15 acceptable.
 - 16 7. Test reports shall represent the installed SPD, including any internal fusing and 6 IN lead
17 length.
- 18 B. Operating Voltage: The nominal unit operating voltage and configuration as indicated on
19 Drawings.
- 20 C. Modes of Protection: All modes.
- 21 1. Three phase (delta): L-L, L-G.
 - 22 2. Three phase (wye): L-N, L-L, L-G and N-G.
 - 23 3. Single phase (2 pole): L-L, L-N, L-G and N-G.
 - 24 4. Single phase: L-N, L-G and N-G.
- 25 D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.
- 26 E. Operating Frequency: 45 to 65 Hertz.
- 27 F. Maximum Surge Current: 250,000A per phase, 125,000A per mode minimum.
- 28 G. Minimum Repetitive Surge Current Capacity: 5000 impulses with no degradation greater than
29 10 percent deviation of the clamping voltage.
- 30 H. Fusing: The SPD may contain internal fuses, but a C3 or B3 combination wave shall not cause
31 the fuse to open the circuit to the SPD circuitry.
- 32 I. Maximum Clamping Voltages, including 6 IN lead length and measured from the zero voltage
33 reference:
- 34 1. ANSI/IEEE C3 combination wave: 500 percent of system peak voltage.
 - 35 2. ANSI/IEEE B3 combination wave: 350 percent of system peak voltage.
 - 36 3. Mode N-G clamping voltage may be 175 percent higher than the L-G levels.
- 37 J. EMI-RFI Noise Rejection: Provide attenuation greater than 55 dB for frequencies between 100
38 kHz and 100 MHz.

39 **2.2 TYPE 3 SPD**

- 40 A. Product:
- 41 1. Integrally mounted in a switchboard, panelboards or motor control centers.
 - 42 2. Hybrid solid state high performance suppression system. Do not use gas tubes, spark gaps
43 or other components in suppression system which might short or crowbar the line resulting
44 in interruption of normal power flow to connected loads.
 - 45 3. Do not connect multiple SPD modules in series to achieve the specified performance.
 - 46 4. Designed for parallel connection.
 - 47 5. Field connection: Provide the unit with mechanical or compression lugs for each phase,
48 neutral and ground that will accept bus bar or #10 through #1/0 conductors.

- 1 6. Device Monitor: Long-life, solid state, externally visible indicators and Form C contact(s)
- 2 that monitor the on-line status of each mode of the units suppression filter system or power
- 3 loss in any of the phases. A fuse status only monitor system is not acceptable.
- 4 7. Test reports shall represent the installed SPD, including any internal fusing and 6 IN lead
- 5 length.
- 6 B. Operating Voltage: The nominal unit operating voltage and configuration as indicated on the
- 7 Drawings.
- 8 C. Modes of Protection: All modes.
- 9 1. Three phase (delta): L-L, L-G.
- 10 2. Three phase (wye): L-N, L-L, L-G and N-G.
- 11 3. Single phase (2 pole): L-L, L-N, L-G and N-G.
- 12 4. Single phase: L-N, L-G and N-G.
- 13 D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.
- 14 E. Operating Frequency: 45 to 65 Hertz.
- 15 F. Maximum Surge Current: 160,000A per phase, 80,000A per mode minimum.
- 16 G. Minimum Repetitive Surge Current Capacity: 5000 impulses with no degradation of more than
- 17 10 percent deviation of the clamping voltage.
- 18 H. Fusing: The SPD may contain internal fuses, but a B3 combination wave or B3 ring wave shall
- 19 not cause the fuse to open the circuit to the SPD circuitry.
- 20 I. Maximum Clamping Voltages, including 6 IN lead length and measured from the zero voltage
- 21 reference:
- 22 1. ANSI/IEEE B3 combination wave: 350 percent of system peak voltage.
- 23 2. ANSI/IEEE B3 ring wave: 250 percent of system peak voltage.
- 24 3. Mode N-G clamping voltage may be 175 percent higher than the L-G levels.
- 25 J. EMI-RFI Noise Rejection: Provide attenuation greater than 55 dB for frequencies between 100
- 26 kHz and 100 MHz.

27 **2.3 TYPE 6 SPD**

- 28 A. Product:
- 29 1. Mounted internally to control panels for point-of-use loads.
- 30 2. Hybrid solid state high performance suppression system. Do not use gas tubes, spark gaps
- 31 or other suppression system components which might short or crowbar the line resulting in
- 32 interruption of normal power flow to connected loads.
- 33 3. Designed for series connection.
- 34 4. Enclosure: Metallic or plastic, flange or DIN rail mounting.
- 35 5. Field connection: Provide unit with external terminal screws for each phase, neutral and
- 36 ground that will accept #14 through #10 conductors.
- 37 6. Device Monitoring: Long-life, solid state, externally visible indicators that monitor the on-
- 38 line status of the units suppression filter system or power loss in any of the phases. A fuse
- 39 status only monitor system is not acceptable.
- 40 7. Test reports shall represent the installed SPD, including any internal fusing.
- 41 B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the
- 42 Drawings.
- 43 C. Modes of Protection: All modes, L-N, L-G and N-G.
- 44 D. Maximum Continuous Operating Voltage: less than 130 percent of system peak voltage.
- 45 E. Operating Frequency: 45 to 65 Hertz.
- 46 F. Maximum Surge Current: 20,000A per phase, 10,000A per mode minimum.

- 1 G. Minimum Repetitive Surge Current Capacity: 1000 impulses with no degradation of more than
2 10 percent deviation of the clamping voltage.
- 3 H. Fusing: The SPD may contain internal fuses, but a B3 combination wave or B3 ring wave shall
4 not open the circuit to the SPD circuitry.
- 5 I. Maximum Clamping Voltages, measured from the zero voltage reference:
6 1. ANSI/IEEE B3 combination wave: 300 percent of system peak voltage.
7 2. ANSI/IEEE B3 ring wave: 200 percent of system peak voltage.
8 3. ANSI/IEEE A3 ring wave: 200 percent of system peak voltage.
9 4. Mode N-G clamping voltage may be 175 percent higher than the L-G levels.
- 10 J. EMI-RFI Noise Rejection: Provide attenuation greater than 55 dB for frequencies between 100
11 kHz and 100 MHz.

12 2.4 TYPE 8 SPD

- 13 A. Product:
14 1. For protection of equipment connected to 4-20mA analog signal loops.
15 2. Mounted directly to an unused conduit entry on a process transmitter housing.
16 3. Hybrid solid state high performance suppression system.
17 4. Designed for series connection.
18 5. Enclosure: ½ IN stainless steel conduit pipe nipple.
19 6. Field connection: Minimum of 6 IN of conductor lead wires. Provide five conductors
20 a. Input: positive, negative and ground.
21 b. Output: positive and negative.
22 7. Test reports shall represent the installed SPD.
- 23 B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the
24 Drawings.
- 25 C. Modes of Protection: All modes, L-L and L-G.
- 26 D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.
- 27 E. Minimum Repetitive Surge Current Capacity: The SPD shall meet one of the following.
28 1. 1000 occurrences of a 200A, 10x1000 microsecond waveform.
29 2. 400 occurrences of a 500A, 10x1000 microsecond waveform.
30 3. 100 occurrences of a 400A, 10x700 microsecond waveform
31 4. 100 occurrences of a 2000A, 8x20 microsecond waveform.
32 5. 10 occurrences of a 10,000A, 8x20 microsecond waveform.
- 33 F. Maximum Clamping Voltages, L-L. The SPD shall meet one of the following:
34 1. 400A, 10x700 microsecond waveform: 200 percent of system voltage.
35 2. ANSI/IEEE B3 combination wave: 225 percent of system voltage.
- 36 G. Maximum Clamping Voltages, L-G. The SPD shall meet one of the following:
37 1. 400A, 10x700 microsecond waveform: 400 percent of system voltage.
38 2. ANSI/IEEE B3 combination wave: 300 percent of system voltage.

39 2.5 TYPE 9 SPD

- 40 A. Product:
41 1. Mounted internally to control panels for protection of equipment connected to analog signal
42 loops.
43 2. Hybrid solid state high performance suppression system.
44 3. Designed for series connection.
45 4. Enclosure: Metallic or plastic, flange or DIN rail mounting.
46 5. Field connection: The unit shall have external terminal screws for line and ground
47 conductors.
48 6. Test reports shall represent the installed SPD.

- 1 B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the
- 2 Drawings.
- 3 C. Modes of Protection: All modes, L-L and L-G.
- 4 D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.
- 5 E. Minimum Repetitive Surge Current Capacity: The SPD shall meet one of the following.
- 6 1. 1000 occurrences of a 200A, 10 x 1000 microsecond waveform.
- 7 2. 400 occurrences of a 500A, 10 x 1000 microsecond waveform.
- 8 3. 100 occurrences of a 400A, 10 x 700 microsecond waveform
- 9 4. 100 occurrences of a 2000A, 8 x 20 microsecond waveform.
- 10 5. 10 occurrences of a 10,000A, 8 x 20 microsecond waveform.
- 11 F. Maximum Clamping Voltages, L-L. The SPD shall meet one of the following:
- 12 1. 400A, 10x700 microsecond waveform: 200 percent of system voltage.
- 13 2. ANSI/IEEE B3 combination wave: 225 percent of system voltage.
- 14 G. Maximum Clamping Voltages, L-G. The SPD shall meet one of the following:
- 15 1. 400A, 10x700 microsecond waveform: 400 percent of system voltage.
- 16 2. ANSI/IEEE B3 combination wave: 300 percent of system voltage.

17 **2.6 TYPE 10 SPD**

- 18 A. Product:
- 19 1. Mounted internally to control panels for protection of equipment connected to a discrete
- 20 signals.
- 21 2. Hybrid solid state high performance suppression system.
- 22 3. Designed for series connection.
- 23 4. Enclosure: Metallic or plastic, flange or DIN rail mounting.
- 24 5. Field connection: Provide unit with external terminal screws for line and ground conductors.
- 25 6. Test reports shall represent the installed SPD.
- 26 B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the
- 27 Drawings.
- 28 C. Modes of Protection: All modes, L-L (Pos-Neg) and L-G.
- 29 D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.
- 30 E. Minimum Repetitive Surge Current Capacity: The SPD shall meet one of the following.
- 31 1. 1000 occurrences of a 200A, 10 x 1000 microsecond waveform.
- 32 2. 400 occurrences of a 500A, 10 x 1000 microsecond waveform.
- 33 3. 100 occurrences of a 400A, 10 x 700 microsecond waveform
- 34 4. 100 occurrences of a 2000A, 8 x 20 microsecond waveform.
- 35 5. 10 occurrences of a 10,000A, 8 x 20 microsecond waveform.
- 36 F. Maximum Clamping Voltages, L-L (Pos-Neg). The SPD shall meet one of the following:
- 37 1. 400A, 10x700 microsecond waveform: 200 percent of system voltage.
- 38 2. ANSI/IEEE B3 combination wave: 225 percent of system voltage.
- 39 G. Maximum Clamping Voltages, L-G. The SPD shall meet one of the following:
- 40 1. 400A, 10x700 microsecond waveform: 400 percent of system voltage.
- 41 2. ANSI/IEEE B3 combination wave: 300 percent of system voltage.

42 **PART 3 - EXECUTION**

43 **3.1 INSTALLATION**

- 44 A. Install products in accordance with manufacturer's instructions.
- 45 B. Type 1 SPD

- 1 1. Connected in parallel to the equipment.
- 2 2. Install in dedicated service equipment compartment or bucket at the factory before
- 3 shipment.
- 4 3. Provide leads that are as short and straight as possible.
- 5 4. Maximum lead length: 12 IN.
- 6 5. Minimum lead size: #2 stranded AWG or bus bar.
- 7 6. Connect leads to the service equipment bus through a 40A circuit breaker if the SPD is not
- 8 internally fused or molded case switch or knife blade type switch.
- 9 a. Provide circuit breaker or switch operable from the service equipment exterior or from
- 10 behind a hinged door.
- 11 C. Type 3 SPD
- 12 1. Install in dedicated electrical equipment compartment, bucket or panelboard box at the
- 13 factory before shipment.
- 14 2. Provide leads that are as short and straight as possible.
- 15 a. Maximum lead length: 12 IN.
- 16 b. Minimum lead size: #2 stranded AWG or bus bar.
- 17 3. Connect leads to the electrical equipment bus through a 40A circuit breaker if the SPD is
- 18 not internally fused or molded case switch.
- 19 4. Provide circuit breaker or switch operable from the service equipment exterior or from
- 20 behind a hinged door.
- 21 D. Type 6 SPD
- 22 1. Connected in series with the equipment.
- 23 2. Flange mount or DIN rail mount in control panel.
- 24 3. Connect all SPDs in the panel to the same grounding point.
- 25 E. Type 8 SPD
- 26 1. Connect in series with the equipment.
- 27 2. Attach to spare conduit entry to transmitter.
- 28 3. Bond transmitter to a grounded structure or provide a ground rod.
- 29 4. Ground shield at control panel end.
- 30 5. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.
- 31 F. Type 9 SPD
- 32 1. Connect in series with the equipment.
- 33 2. Mount inside control panel.
- 34 3. Connect all SPDs in the control panel to the same grounding point.
- 35 4. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.
- 36 G. Type 10 SPD
- 37 1. Connect in series with the equipment.
- 38 2. Mount inside control panel.
- 39 3. Connect all SPDs in the control panel to the same grounding point.
- 40 4. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.

41

END OF SECTION

1 01C13

2

SECTION 16492

3

ELECTRICAL METERING DEVICES

4 PART 1 - GENERAL

5 1.1 SUMMARY

6 A. Section Includes:

7 1. Digital metering equipment.

8 B. Related Sections include but are not necessarily limited to:

- 9 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
10 2. Division 1 - General Requirements.
11 3. Section 16010 - Electrical: Basic Requirements.

12 1.2 QUALITY ASSURANCE

13 A. Referenced Standards:

- 14 1. American National Standards Institute (ANSI):
15 a. C12.16, Solid-state Electricity Meters.
16 2. Underwriters Laboratories, Inc (UL):
17 a. 508, Industrial Control Equipment.

18 1.3 SUBMITTALS

19 A. Shop Drawings:

20 1. See Section 16010.

21 B. Operation and Maintenance Manuals:

22 1. See Section 01340.

23 PART 2 - PRODUCTS

24 2.1 ACCEPTABLE MANUFACTURERS

25 A. Subject to compliance with the Contract Documents, the following manufacturers are 26 acceptable:

- 27 1. Cutler Hammer.
28 2. General Electric Company.
29 3. Square D Company.
30 4. Siemens.

31 B. Submit requests for substitution in accordance with Specification Section 01640.

32 2.2 DIGITAL METERING DEVICES

33 A. General:

- 34 1. Direct reading metered or calculated values.
35 2. Microprocessor based.
36 3. Integral LED or LCD display.
37 4. Current and potential transformers as required.
38 5. Integral fusing.
39 6. Operating temperature: 0 DegF to 150 DegF.
40 7. Standards:
41 a. ANSI C12.16.
42 b. UL 508.

- 1 B. Display the following minimum electrical parameters (accuracy):
- 2 1. RMS current per phase (± 0.2 percent full scale).
- 3 2. RMS voltage line-to-line and line-to-neutral (± 0.2 percent full scale).
- 4 3. Real power (W): Three phase total (± 0.4 percent full scale).
- 5 4. Apparent power (VA): Three phase total (± 0.4 percent full scale).
- 6 5. Reactive power (VAR): Three phase total (± 0.4 percent full scale).
- 7 6. Power factor (± 1.0 percent).
- 8 7. Frequency (± 0.04 percent).
- 9 8. Percent current total harmonic distortion (50 th).
- 10 9. Percent voltage total harmonic distortion (50 th).
- 11 10. Watt-hours (0.5 percent).
- 12 11. VAR-hours (1.0 percent).
- 13 12. VA-hours (0.5 percent).
- 14 13. Ampere demand (± 0.2 percent full scale).
- 15 14. Watt demand (± 0.4 percent full scale).
- 16 15. VAR demand (± 0.4 percent full scale).
- 17 16. VA demand (± 0.4 percent full scale).
- 18 17. ANSI C12.16 accuracy.

19 **2.3 TRANSFORMERS**

- 20 A. Current transformer (CT):
- 21 1. Dry, indoor type.
- 22 2. 600 V, with ratio as required by the main bus rating, unless otherwise noted on the
- 23 Drawings.
- 24 3. Short circuiting device.
- 25 4. Minimum ANSI metering accuracy class of 0.3 thru B-0.5.
- 26 5. Mount and brace to withstand mechanical stresses resulting from short circuit currents.

27 **PART 3 - EXECUTION**

28 **3.1 INSTALLATION**

- 29 A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
- 30 B. Current transformers shall be connected to shorting type terminal blocks.

31 **END OF SECTION**

1 01C13

2

SECTION 16493

3

CONTROL EQUIPMENT ACCESSORIES

4 PART 1 - GENERAL

5 1.1 SUMMARY

6

A. Section Includes:

7

1. Operator control devices (selector switches, pushbuttons, indicator lights, etc.).

8

2. Control devices (timers, relays, contactors, etc.).

9

3. Control panels and operator stations.

10

B. Related Sections include but are not necessarily limited to:

11

1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.

12

2. Division 1 - General Requirements.

13

3. Section 16010 - Electrical: Basic Requirements.

14

1.2 QUALITY ASSURANCE

15

A. Referenced Standards:

16

1. National Electrical Manufacturers Association (NEMA):

17

a. ICS 2, Industrial Control Devices, Controllers, and Assemblies.

18

b. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).

19

2. Underwriters Laboratories, Inc (UL):

20

a. 508, Industrial Control Equipment.

21

1.3 SUBMITTALS

22

A. Shop Drawings:

23

1. See Section 16010.

24

B. Operation and Maintenance Manuals:

25

1. See Section 01340.

26

PART 2 - PRODUCTS

27

2.1 ACCEPTABLE MANUFACTURERS

28

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

29

1. Timers and Relays:

30

a. Idec.

31

b. Potter & Brumfield.

32

c. Time Mark.

33

d. ATC Diversified Electronics.

34

2. Pilot Devices:

35

a. Cutler-Hammer.

36

b. General Electric.

37

c. Square D Company.

38

d. Allen Bradley.

39

e. Senasys.

40

3. Contactors:

41

a. Automatic Switch Company (ASCO).

42

b. Cutler-Hammer.

43

- 1 c. General Electric Company.
- 2 d. Square D Company.
- 3 e. Siemens.
- 4 f. Allen Bradley.
- 5 4. Photocells and Time Clocks:
- 6 a. Grasslin.
- 7 b. Tork.
- 8 c. Intermatic.
- 9 d. Paragon.
- 10 5. Alarm Devices:
- 11 a. Edwards Signaling.
- 12 b. Federal Signal Corp.
- 13 6. Terminal Blocks:
- 14 a. Phoenix Contact.
- 15 b. Allen-Bradley.
- 16 7. Enclosures:
- 17 a. Hoffman Engineering Co.
- 18 b. Wiegmann.
- 19 c. B-Line Circle AW.Adalet.
- 20 B. Submit requests for substitution in accordance with Specification Section 01640.

21 **2.2 PILOT DEVICES**

- 22 A. General Requirements:
- 23 1. Standards: NEMA ICS 2, UL 508.
- 24 2. Heavy-duty NEMA 4/13 watertight/oiltight.
- 25 3. Heavy-duty NEMA 4/4X corrosion resistant.
- 26 4. Heavy-duty factory sealed, explosion-proof and dust ignition-proof (Class I and II).
- 27 5. Mounting hole: 30.5 mm.
- 28 6. Contact blocks: 10 amp, NEMA A600 rated, number as required to fulfill functions shown
- 29 or specified.
- 30 7. Legend plate marked as indicated on Drawings or specified.
- 31 B. Selector Switches:
- 32 1. Two, three- or four-position rotary switch as required to fulfill functions indicated on the
- 33 Drawings or specified.
- 34 2. Maintained contact type.
- 35 3. Knob or lever type operators.
- 36 C. Pushbuttons:
- 37 1. Non-illuminated type:
- 38 a. Protective boot.
- 39 b. Momentary contact.
- 40 c. Standard flush and mushroom operators.
- 41 d. Red colored buttons for START or ON and green color for STOP or OFF.
- 42 e. Emergency stop pushbuttons: Mushroom head operator and maintained contact.
- 43 D. Indicating Lights:
- 44 1. Allowing replacement of bulb without removal from control panel.
- 45 2. Lamp: LED, 120 V or 24 V as required.
- 46 3. Full voltage type.
- 47 4. Glass lens.
- 48 5. Color code lights as follows:
- 49 a. Green: OFF or stopped; valve closed.
- 50 b. Amber: Fail.
- 51 c. Red: ON or running; valve open.
- 52 E. Combination Selector Switch/Indicating Lights:

- 1 1. Four quadrant with black control knob.
- 2 2. Separate Motor Start and Motor Stop output contacts.
- 3 3. Spring return type knob, return to top center position.
- 4 a. Turn to left for stop, output contact momentarily opens.
- 5 b. Turn to right for start, output contact momentarily closes.
- 6 4. Push for Lamp Test in any position, lamp in all 4 quadrants to illuminate.
- 7 5. Quadrant Colors/Label:
- 8 a. Upper Right, Red/Run.
- 9 b. Upper Left, Green/Stop.
- 10 c. Lower Left, White/Lamp Test.
- 11 d. Lower Right, Amber/Low Water Lockout.
- 12 6. Lamp: LED, 120 V.
- 13 7. Full voltage type.

14 2.3 RELAYS

- 15 A. General Requirements:
- 16 1. Standards: NEMA ICS 2, UL 508.
- 17 B. Control Relays:
- 18 1. General purpose (ice cube) type:
- 19 a. Plug-in housing.
- 20 b. Clear polycarbonate dust cover with clip fastener.
- 21 c. Coil voltage: 120 V AC or as required.
- 22 d. Contacts:
- 23 1) 10 amp continuous.
- 24 2) Silver cadmium oxide.
- 25 3) Minimum of 3 SPDT contacts.
- 26 e. Sockets: DIN rail mounted.
- 27 f. Internal neon or LED indicator is lit when coil is energized.
- 28 g. Manual operator switch.
- 29 2. Industrial type:
- 30 a. Coil voltage: 120 V AC or as required.
- 31 b. Contacts:
- 32 1) 10 amp, NEMA A600 rated.
- 33 2) Double break, silver alloy.
- 34 3) Convertible from normally open to normally closed or vice versa, without
- 35 removing any wiring.
- 36 4) Expandable from 2 poles to 12 poles.
- 37 c. Provide contacts for all required control plus two spares.
- 38 C. Time Delay Relays:
- 39 1. General purpose type:
- 40 a. Timing modes: On and Off delay, interval, one shot and repeat cycle.
- 41 b. Plug-in housing.
- 42 c. Polycarbonate dust cover with clip fastener.
- 43 d. Coil voltage: 120 V AC or as required.
- 44 e. Contacts:
- 45 1) 10 amp continuous.
- 46 2) Silver cadmium oxide.
- 47 3) Two normally open and two normally closed DPDT contacts.
- 48 f. Sockets: DIN rail mounted.
- 49 g. External timing adjustment knob.
- 50 h. Timing ranges: 0.05 seconds to 16.65 HRS.
- 51 i. Repeat accuracy: ± 1 percent.
- 52 2. Solid State industrial type:
- 53 a. Timing modes: On and Off delay and repeat cycle.
- 54 b. Industrial housing.

- 1 c. Coil voltage: 120 V AC or as required.
- 2 d. Contacts:
- 3 1) 5 amp, NEMA B150 rated.
- 4 2) Silver alloy.
- 5 3) Convertible On Delay and Off Delay contacts.
- 6 4) One normally open and one normally closed timed contacts.
- 7 5) One normally open and one normally closed instantaneous contacts.
- 8 e. Furnish with "on" and "timing out" indicators.
- 9 f. External timing adjustment knob.
- 10 g. Timing ranges: 0.05 seconds to 10 HRS.
- 11 h. Repeat accuracy: ± 1 percent.
- 12 3. Mechanical industrial type.
- 13 a. Timing modes: On and Off delay.
- 14 b. Coil voltage: 120 V AC or as required.
- 15 c. Contacts:
- 16 1) 10 amp, NEMA A600 rated.
- 17 2) Double break, silver alloy.
- 18 3) Convertible On Delay and Off Delay contacts.
- 19 4) Convertible normally open and normally closed timed contacts.
- 20 5) Convertible normally open instantaneous contacts.
- 21 d. External timing adjustment knob.
- 22 e. Timing ranges: 0.2 – 60 sec or 5 – 180 sec.
- 23 f. Repeat accuracy: greater than ± 10 percent.

24 2.4 CONTACTORS

- 25 A. General Requirements:
- 26 1. Standards: NEMA ICS 2, UL 508.
- 27 B. Lighting and Remote Control Switches.
- 28 1. Electrically operated, electrically held. {Electrically operated, mechanically held.}
- 29 2. Coil voltage: 120 V AC or as required.
- 30 3. Contacts: Totally enclosed, double-break silver-cadmium-oxide.
- 31 4. Rated for ballasted lighting, tungsten and general use loads.
- 32 5. Number of poles, continuous ampere rating and voltage, as indicated on Drawings or as
- 33 specified.
- 34 6. Auxiliary control relays, as indicated on Drawings or as specified.
- 35 7. Auxiliary contacts, as indicated on Drawings or as specified.
- 36 C. Definite Purpose:
- 37 1. Coil voltage: 120 V AC or as required.
- 38 2. Contacts: Totally enclosed, double-break silver-cadmium-oxide.
- 39 3. Resistive load and horsepower rated.
- 40 4. Number of poles, continuous ampere rating and voltage, as indicated on Drawings or as
- 41 specified.
- 42 5. Auxiliary contacts, as indicated on Drawings or as specified.

43 2.5 PHOTOCELLS

- 44 A. Photocells. Weatherproof enclosure.
- 45 2. Adjustable turn-on range, initially set at 1.0 footcandles. Turn-off level approximately three
- 46 times turn-on.
- 47 3. Provide time delay device to eliminate nuisance switching.
- 48 4. Voltage, amperage and/or wattage ratings as required for the application.

49 2.6 ALARM DEVICES

- 50 A. Alarm Horns:
- 51 1. Vibrating horn type.

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2. PLC compatible as required.
 3. Heavy-duty die cast housing with corrosion resistant finish.
 4. Adjustable volume: 78 to 103 dB at 10 FT.
 5. Voltage: 120 V AC or as required.
 6. Enclosures/mountings:
 - a. Flush wall or panel mounting in dry areas.
 - b. NEMA 4X panel mounting in wet areas.
 - c. Surface mounting in dry areas.
 - d. NEMA 4X surface mounting in wet areas.
 - e. NEMA 4X, hazardous location surface mounting in wet and hazardous areas.
 - 1) Fixed volume: 97 dB at 10 FT.
- B. Alarm Lights:
1. Panel mounted:
 - a. Strobe type.
 - b. Shatter resistant polycarbonate lens and base.
 - c. Lens color as indicated on Drawings.
 - d. NEMA 4X enclosure.
 - e. PLC compatible.
 - f. Voltage: 120 V AC.
 2. Wall mounted:
 - a. Heavy-duty strobe type.
 - b. Weatherproof shatter resistant polycarbonate lens and cast base.
 - c. Optically designed fresnel lens with color as indicated on Drawings.
 - d. Immune to shock and vibration, no moving parts.
 - e. Xenon flash tube providing a minimum of 65 single flashes per minute.
 - f. Mounting: Wall or corner wall brackets.
 3. Hazardous and corrosive locations:
 - a. Heavy-duty strobe type.
 - b. Weatherproof and rated for the indicated hazardous location.
 - c. Body: Zinc plated cast iron or cast copper free aluminum and/or coated with 20 mils of PVC.
 - d. High impact glass dome with guard.
 - e. Shatter resistant polycarbonate lens with color as indicated on Drawings.
 - f. Immune to shock and vibration, no moving parts.
 - g. Xenon flash tube providing a minimum of 65 single flashes per minute.
 - h. Mounting: Wall bracket or pendant.

37 **2.7 MISCELLANEOUS DEVICES**

- 38 A. Run Time Meters:
 - 39 1. Six-digit wheels including a 1/10 digit.
 - 40 2. Non-reset type.
 - 41 3. Time range in hours.
 - 42 4. Automatic recycle at zero.
 - 43 5. Accuracy: 1 percent.
 - 44 6. Sealed against dirt and moisture.
 - 45 7. Tamperproof.

46 **2.8 TERMINATION EQUIPMENT**

- 47 A. General Requirements:
 - 48 1. Modular type with screw compression clamp.
 - 49 2. Screws: Stainless steel.
 - 50 3. Current bar: Nickel-plated copper alloy.
 - 51 4. Thermoplastic insulation rated for -40 to +90 DegC.
 - 52 5. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
 - 53 6. End sections and end stops at each end of terminal strip.

- 1 7. Machine-printed terminal markers on both sides of block.
- 2 8. Spacing: 6 mm.
- 3 9. Wire size: 22-12 AWG.
- 4 10. Rated voltage: 600 V.
- 5 11. Din rail mounting.
- 6 B. Standard-type block.
- 7 1. Rated current: 30 A.
- 8 2. Color: Gray body.
- 9 C. Bladed-type disconnect block:
- 10 1. Terminal block with knife blade disconnect which connects or isolated the two sides of the
- 11 block.
- 12 2. Rated current: 10 A.
- 13 3. Color:
- 14 a. Panel control voltage leaves enclosure - normal: Gray body, orange switch.
- 15 b. Foreign voltage entering enclosure: Orange body, orange switch.
- 16 D. Grounded-type block:
- 17 1. Electrically grounded to mounting rail.
- 18 2. Terminal ground wires and analog cable shields.
- 19 3. Color: Green and yellow body.
- 20 E. Fuse Holders:
- 21 1. Blocks can be ganged for multi-pole operation.
- 22 2. Spacing: 9.1 mm.
- 23 3. Wire size: 30-12 AWG.
- 24 4. Rated voltage: 300 V.
- 25 5. Rated current: 12 A.
- 26 6. Fuse size: 1/4 x 1-1/4.
- 27 7. Blown fuse indication.
- 28 8. DIN rail mounting.

29 2.9 ENCLOSURES

- 30 A. Control Panels:
- 31 1. NEMA 4 rated:
- 32 a. Seams continuously welded and ground smooth.
- 33 b. No knockouts.
- 34 c. External mounting flanges.
- 35 d. Hinged or non-hinged cover held closed with stainless steel screws and clamps.
- 36 e. Cover with oil resistant gasket.
- 37 2. NEMA 4X rated:
- 38 a. Body and cover: 14 GA Type 304 or 316 stainless steel.
- 39 b. Seams continuously welded and ground smooth.
- 40 c. No knockouts.
- 41 d. External mounting flanges.
- 42 e. Hinged door and stainless steel screws and clamps.
- 43 f. Door with oil-resistant gasket.
- 44 3. NEMA 12 enclosure:
- 45 a. Body and cover: 14 GA steel finished with rust inhibiting primer and manufacturers
- 46 standard paint inside and out.
- 47 b. No knockouts.
- 48 c. External mounting flanges.
- 49 d. Non-hinged stainless steel cover held closed with captivated cover screws threaded into
- 50 sealed wells or hinged cover held closed with stainless steel screws and clamps.
- 51 e. Flat door with oil resistant gasket.
- 52 4. Control Panel Miscellaneous Accessories:

- 1 a. Back plane mounting panels: Steel with white enamel finish or Type 304 stainless steel.
- 2 b. Interiors shall be white or light gray in color.
- 3 c. Wire management duct:
- 4 1) Bodies: PVC with side holes.
- 5 2) Cover: PVC snap-on.
- 6 3) Size as required.
- 7 d. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
- 8 e. Split covers when heavier than 25 LBS.
- 9 f. Floor stand kits made of same material as the enclosure.
- 10 g. Weldnuts for mounting optional panels and terminal kits.
- 11 5. Standards: NEMA 250, UL 50.
- 12 B. Operator Control Stations:
- 13 1. NEMA 4/13 rated:
- 14 a. Die cast aluminum body with manufacturers standard finish.
- 15 b. Gasketed die cast aluminum cover with manufacturers standard finish.
- 16 c. Number of device mounting holes as required.
- 17 2. NEMA 4X rated.
- 18 a. Type 304 or 316 stainless steel body.
- 19 b. Gasketed Type 304 or 316 stainless steel cover.
- 20 c. Number of device mounting holes as required.

21 **2.10 MAINTENANCE MATERIALS**

- 22 A. Provide 100 percent replacement lamps for indicating lights.
- 23 B. Provide 10 percent replacement caps for indicating lights.

24 **PART 3 - EXECUTION**

25 **3.1 INSTALLATION**

- 26 A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
- 27 B. Control Panels:
- 28 1. Size as required to mount the equipment.
- 29 2. Permitted uses of NEMA 4 enclosure:
- 30 a. Surface mounted in areas designated as wet.
- 31 3. Permitted uses of NEMA 4X enclosure:
- 32 a. Surface mounted in areas designated as wet and/or corrosive or highly corrosive.
- 33 4. Permitted uses of NEMA 12 enclosure:
- 34 a. Surface mounted in areas designated as dry architecturally or non-architecturally
- 35 finished areas.
- 36 C. Operator Control Stations:
- 37 1. Permitted uses of NEMA 4/13 enclosure:
- 38 a. Surface mounted in areas designated as dry architecturally or non-architecturally
- 39 finished areas.
- 40 2. Permitted uses of NEMA 4X enclosure:
- 41 a. Surface mounted in areas designated as wet and/or corrosive or highly corrosive.

42 **3.2 FIELD QUALITY CONTROL**

- 43 A. See Section 16010.

44 **END OF SECTION**

2 **SECTION 16500**
3 **LIGHTING**

4 **PART 1 - GENERAL**

5 **1.1 SUMMARY**

6 A. Section Includes:

- 7 1. Material and installation requirements for:
8 a. Interior building lighting fixtures.
9 b. Exterior building and site lighting fixtures.
10 c. Lamps.
11 d. Ballasts.

12 B. Related Sections include but are not necessarily limited to:

- 13 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
14 2. Division 1 - General Requirements.
15 3. Section 03002 - Concrete.
16 4. Section 16010 - Electrical: Basic Requirements.

17 **1.2 QUALITY ASSURANCE**

18 A. Referenced Standards:

- 19 1. American National Standards Institute (ANSI):
20 a. C82 Series, Standards for Electric Lamp Ballasts.
21 2. Certified Ballast Manufacturers (CBM).
22 3. Code of Federal Regulations (CFR):
23 a. 47 CFR 18, Industrial, Scientific and Medical Equipment.
24 4. Institute of Electrical and Electronics Engineers (IEEE):
25 a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
26 5. National Electric Manufacturers Association (NEMA):
27 a. 250, Enclosures for Electrical Equipment (1000Volts Maximum).
28 b. LE-4, Recessed Luminaires, Ceiling Compatibility.
29 6. National Fire Protection Association (NFPA):
30 a. 101, Life Safety Code.
31 7. Underwriters Laboratories, Inc. (UL):
32 a. 198C, High-Interrupting-Capacity Fuses, Current Limiting Type.
33 b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
34 c. 924, Emergency Lighting and Power Equipment.
35 d. 935, Fluorescent Lamp Ballasts.
36 e. 1029, High Intensity Discharge Lamp Ballasts.
37 f. 1570, Fluorescent Lighting Fixtures.
38 g. 1571, Incandescent Lighting Fixtures.
39 h. 1572, High Intensity Discharge Lighting Fixtures.
40 8. United States Department of Energy (USDOE):
41 a. EPACT, the National Energy Policy Act.

42 **1.3 SUBMITTALS**

43 A. Shop Drawings:

- 44 1. See Section 16010.
45 2. Product technical data:
46 a. Identify fixtures by Fixture Schedule number.
47 b. Fixture data sheet including:

- 1) Photometric performance data including candlepower distribution and coefficient of utilization (CU) table.
- 2) Fixture EPA's for pole mounted fixtures.
- c. Pole data shall include:
 - 1) Pole wind loading.
 - 2) Anchor bolt template.
- d. UL nameplate data for fixtures used in Class 1 Division 1 and 2 areas.

8 PART 2 - PRODUCTS

9 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Lighting fixtures: See Lighting Fixture Schedule on the Drawings.
 - 2. Lamps:
 - a. Osram/Sylvania.
 - b. General Electric.
 - c. Philips.
 - 3. Ballasts: Fixture manufacturer's standard.
 - 4. Emergency Ballasts: Bodine.
- B. Submit requests for substitution in accordance with Specification Section 01640.

20 2.2 GENERAL REQUIREMENTS

- A. All lighting fixtures and electrical components:
 - 1. UL labeled.
 - 2. Fixtures complete with lamps and ballasts.
 - 3. Rated for area classification as indicated on Drawings.
 - a. In Class I, Division 1 and 2 areas, the temperature rating of the luminaires and lamp combination shall not exceed the auto-ignition temperature of the atmosphere in which the fixture is used.
- B. Provide all recessed fixtures with gaskets of rubber, fiberglass, or equivalent material to prevent light leaks around flush trim. Provide recessed fixtures with trim gaskets cemented in proper position.
- C. Reflector coating having a minimum 89 percent reflectance factor.
- D. No live parts normally exposed to contact.
- E. When intended for use in wet areas: Mark fixtures "Suitable for wet locations."
- F. When intended for use in damp areas: Mark fixtures "Suitable for damp locations" or "Suitable for wet locations."

36 2.3 LIGHT FIXTURES

- A. Incandescent:
 - 1. UL 1571.
 - 2. Lamp base.
 - a. Less than or equal to 300W: Medium base.
 - b. Greater than 300W: Mogul base.
 - 3. Visibly marked to indicate maximum lamp wattage that can be used with the fixture.
- B. Fluorescent:
 - 1. UL 1570.
 - 2. NEMA LE 4 for recessed locations.
 - 3. Lenses: As indicated in Fixture Schedule, with the following minimums:

- a. Troffer: 100 percent virgin acrylic, conical shaped, female 0.1875 IN, square based prisms, aligned 45 degrees to the length and width, 0.125 IN nominal thickness.
 4. Finish: Manufacturer's standard polyester, acrylic enamel or epoxy powder coating applied after fabrication. Manufacturer's standard color or special color specified in Fixture Schedule.
 5. Prewired and provided with lamps that are properly mated to the ballast operating characteristics.
- C. High Intensity Discharge:
1. UL 1572.
 2. Finish: Manufacturer's standard polyester, acrylic enamel or epoxy powder coating applied after fabrication. Manufacturer's standard color or special color specified in Fixture Schedule.
 3. Prewired and provided with lamps that are properly mated to the ballast operating characteristics.
 4. Provided with safety chain.
- D. Exit Signs and Emergency Lighting Units:
1. UL 924.
 2. NFPA 101.

2.4 LAMPS

- A. Incandescent:
1. Type as indicated in fixture schedule.
 2. Meet the current Federal Energy Standards (EPACT 1992).
- B. Fluorescent:
1. T8 (265 mA) rapid-start medium bipin lamps.
 - a. Correlated color temperature of 3500 degrees Kelvin.
 - b. Minimum color rendering index (CRI) of 70.
 - c. Minimum initial lumen ratings for each lamp type shall be:
 - 1) 1300 lumens for 24 IN, 17 watt F17T8 lamp.
 - 2) 2025 lumens for 36 IN, 25 watt F25T8 lamp.
 - 3) 2800 lumens for 48 IN, 32 watt F32T8 lamp.
 - 4) 5700 lumens for 96 IN, 59 watt F96T8 lamp.
- C. High Intensity Discharge (HID) Lamps:
1. Metal halide lamps.
 - a. Correlated color temperature of 4000 degrees Kelvin.
 - b. Minimum color rendering index (CRI) of 65.
 2. High pressure sodium lamps.
 - a. Correlated color temperature of 2100 degrees Kelvin.
 - b. Minimum color rendering index (CRI) of 21.
 - c. High pressure sodium lamps are designated on the lighting Fixture Schedule by the prefix HPS.
 3. Uncoated (clear) unless identified as coated in the fixture schedule.
 4. The specified fixture in the fixture schedule shall dictate the required lamp operating position and base type.
 5. Provide lamps that have the correct bulb shape for the fixture specified.

2.5 BALLASTS

- A. Fluorescent Electromagnetic Ballasts:
1. UL 935.
 2. High-efficiency energy saving electromagnetic core and coil design.
 3. CBM certification for full light output.
 4. Operate lamps at a frequency of 60 Hz.
 5. Power Factor: Greater than 90 percent.

- 1 6. Input current with Total Harmonic Distortion (THD) of less than 32 percent.
- 2 7. Lamp current Crest Factor: Less than 1.7, in accordance with lamp manufacturer's
- 3 recommendations and ANSI C82.1.
- 4 8. Ballast Factor: Greater than 0.925 for rapid start 265 mA (T8) and 430 mA (T12) ballasts
- 5 per ANSI C82.1.
- 6 9. Audible noise rating: Greater than or equal to Class A for rapid start 265 mA (T8) and 430
- 7 mA (T12) ballasts.
- 8 10. Coil temperature not to exceed (150 DegF) temperature rise over (105 DegF) ambient.
- 9 Maximum case temperature not to exceed .
- 10 11. Meet the requirements of the Federal Communications Commission Rules and Regulations,
- 11 Part 18 (47 CFR 18), for non-consumer equipment for EMI and RFI.
- 12 12. Meet all applicable ANSI and IEEE standards regarding harmonic distortion and transient
- 13 protection such as ANSI/IEEE C62.41, Cat. A, for transient protection.
- 14 13. Underwriters' Laboratories (UL) listed (Class P).
- 15 14. Fully encapsulated (potted) to ensure maximum thermal and structural integrity.
- 16 15. Contain no Polychlorinated Biphenyls (PCB's).

- 17 B. Fluorescent High Frequency Electronic Ballasts:
- 18 1. UL 935.
- 19 2. "High Frequency" electronic operating lamps at a frequency of 20 KHz or higher without
- 20 visible flicker.
- 21 3. Power Factor: Greater than 90 percent.
- 22 4. Input current Total Harmonic Distortion (THD) of less than 20 percent.
- 23 5. Lamp Current Crest Factor: Less than 1.7, in accordance with lamp manufacturer's
- 24 recommendations and ANSI C82.11.
- 25 6. Instant start with lamps wired in parallel.
- 26 7. Support a sustained short to ground or open circuit of any output leads without damage to
- 27 the ballast.
- 28 8. Ballast Factor: Greater than 0.85 per ANSI C82.11.
- 29 9. Audible noise rating: Class A or better.
- 30 10. Operation in ambient temperatures up to (105 DegF) without damage.
- 31 11. Light output to remain constant for a line voltage fluctuation of ± 5 percent.
- 32 12. Meet the requirements of the Federal Communications Commission Rules and Regulations,
- 33 Part 18 (47 CFR 18), for non-consumer equipment for EMI and RFI.
- 34 13. Meet ANSI C82.11 standards regarding harmonic distortion.
- 35 14. Meet ANSI C62.41 Cat. A for transient protection.
- 36 15. Comply with all applicable state and federal efficiency standards.
- 37 16. Underwriters' Laboratories (UL) listed (Class P).
- 38 17. Contain no Polychlorinated Biphenyls (PCB's).

- 39 C. Fluorescent Emergency Ballasts:
- 40 1. UL 924, NFPA 101.
- 41 2. High temperature, 24 Watt-hour, maintenance-free nickel cadmium battery with charger.
- 42 3. Charging indicator light (LED) to monitor the charger and battery.
- 43 4. Double-pole test switch.
- 44 5. Light one lamp for 90 minutes in 1, 2 and 3-lamp fixtures. Light two lamps for 90 minutes
- 45 in 4-lamp fixtures.
- 46 6. Dual input voltage (120/277V), 4 Watts input.
- 47 7. Compatible with the install lamp type.
- 48 8. Initial lumen output: 975 to 1400.
- 49 9. Contain no Polychlorinated Biphenyls (PCB's).

- 50 D. High Intensity Discharge Ballasts:
- 51 1. ANSI C82.4, UL 1029.
- 52 2. Metal halide:
- 53 a. Input voltage variation: ± 10 percent.
- 54 b. Maximum lamp regulation spread: 20 percent.

- 1 c. Minimum power factor: 90 percent.
- 2 d. Starting current: not greater than operating current.
- 3 e. Maximum input voltage dip: 40 percent.
- 4 f. Crest factor: 1.5 to 1.8.
- 5 g. Types:
- 6 1) Lead-Type Regulators: constant wattage autotransformer (CWA) and pulse start.
- 7 2) Lag-Type Regulators: magnetic regulator and pulse start.
- 8 h. Contain no Polychlorinated Biphenyls (PCB's).
- 9 3. High pressure sodium:
- 10 a. Input voltage variation: ± 10 percent.
- 11 b. Maximum lamp regulation spread: 30 percent.
- 12 c. Minimum power factor: 90 percent.
- 13 d. Starting current: not greater than operating current.
- 14 e. Maximum input voltage dip: 20 percent.
- 15 f. Crest factor: 1.6 to 1.8.
- 16 g. The Volts-Watts trace shall be within the lamp manufacturer's trapezoid.
- 17 h. Types:
- 18 1) Lead-Type Regulators: constant wattage autotransformer (CWA).
- 19 2) Lag-Type Regulators: magnetic regulator and regulated lag.
- 20 i. Ballast shall not contain Polychlorinated Biphenyls (PCB's).
- 21 4. Ballasts for interior use:
- 22 a. Encased and potted type.
- 23 b. Audible noise rating of B or better.
- 24 c. Built-in automatic resetting thermal protection switch.
- 25 5. Ballasts for exterior use:
- 26 a. Starting temperature: -20 DegF.

27 2.6 LIGHTING CONTROL

- 28 A. See Section 16493 for lighting control equipment.

29 2.7 MAINTENANCE MATERIALS

- 30 A. Furnish a minimum of 2 or 10 percent of total of each type and wattage of lamps, whichever is
- 31 greater.
- 32 B. Furnish a minimum of 10 percent of total of each type and amperage of fuses for fixtures
- 33 indicated to be fused.
- 34 C. Spare parts are to be stored in a box clearly labeled as to its contents.

35 PART 3 - EXECUTION

36 3.1 INSTALLATION

- 37 A. Coordinate fixture types with ceiling construction. Provide mounting hardware for the ceiling
- 38 system in which the fixture is to be installed.
- 39 B. Fasten lighting fixtures supported by suspended ceiling systems to ceiling framing system with
- 40 hold down clips. Provide mounting brackets and/or structural mounting support for wall-mounted
- 41 fixtures.
- 42 1. Do not support fixture from conduit system.
- 43 2. Do not support fixture from outlet boxes.
- 44 D. Provide pendant incandescent, compact fluorescent, and/or HID fixtures with swivel hangers
- 45 which will allow fixture to swing in any direction but will not permit stem to rotate.
- 46 1. Provide hangers with enclosure rating (NEMA 1, 4, or 7) equal to enclosure requirements of
- 47 area in which they are installed.

