

SPECIFICATIONS - DETAILED PROVISIONS
Section 16480 - Motor Control Centers, Switchboards, and Panelboards

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SECTION 16480
MOTOR CONTROL CENTERS, SWITCHBOARDS, AND PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

- A. This section specifies the requirements for the design, fabrication, assembly, wiring, testing, delivery, and installation of low voltage (600 volt) motor control centers (MCCs), switchboards, and panelboards. Switchboards shall include utility service switchboards and distribution switchboards.
- B. Contractor shall furnish and install MCCs, utility service switchboards, distribution switchboards, and panelboards as specified herein and indicated on the Drawings.

1.02 RELATED SECTIONS

- A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.
- B. Related Specification Sections include, but are not limited to, the following:
 - 1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and control.
 - 2. Division 16 – Electrical
 - 3. Division 17 – Instrumentation and Controls

1.03 REFERENCE STANDARDS, SPECIFICATIONS, AND CODES

- A. Equipment and materials shall meet or exceed the applicable requirements of the following standards, specifications, and codes (latest edition):

Underwriters Laboratories (UL)

UL 44 Standard for Thermoset-Insulated Wires and Cables

UL 50 Standard for Enclosures for Electrical Equipment, Non-environmental Considerations

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UL 50E	Standard for Enclosures for Electrical Equipment, Environmental Considerations
UL 67	Standard for Panelboards
UL 98	Standard for Enclosed and Dead-Front Switches
UL 489	Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	Standard for Industrial Control Equipment
UL 845	Standard for Safety for Motor Control Centers
UL 891	Standard for Dead-Front Switchboards
UL 943	Standard for Ground-Fault Circuit Interrupters
UL 1063	Standard for Machine-Tool Wires and Cables
UL 1561	Standard for Dry Type General Purpose and Power Transformers

National Electrical Manufacturers Association (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	Molded Case Circuit Breakers and Molded Case Switches
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 V
NEMA ICS 2.3	Instructions for Handling, Operation and Maintenance of Motor Control Centers
NEMA ICS 4	Terminal Blocks
NEMA ICS 5	Industrial Control Systems, Control Circuit and Pilot Devices
NEMA ICS 6	Enclosures
NEMA ICS 18	Industrial Control and Systems: Motor Control Centers

NEMA KS 1	Heavy Duty Enclosed and Dead-Front Switches
NEMA PB 1	Panelboards
NEMA PB 1.1	General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts, or Less
NEMA PB 2	Deadfront Distribution Switchboards
NEMA PB 2.1	Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts, or Less
NEMA ST 1	Specialty Transformers (Except General Purpose Type)
NEMA ST 20	Standard for Dry-Type Transformers for General Applications
NEMA TP 1	Standard for the Labeling of Distribution Transformer Efficiency
NEMA TP 2	Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 70E	Standard for Electrical Safety in the Workplace

- B. Equipment shall bear the appropriate labels and markings in accordance with above standards, specifications and codes. Equipment shall be designed, manufactured, and tested in certified International Organization for Standardization (ISO) 9001 facilities.

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11" x 17" for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

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1. Manufacturer's product literature and specifications for all major components including, but not limited to, the following: circuit breakers and fuse information (including time current characteristics), motor starters, overload relays, control power transformers, pilot devices, relays, timers, fans, heaters, thermostats. Product literature and specifications shall be marked to clearly identify all applicable information and crossing out all inapplicable information. Sufficient data and detail shall be provided to demonstrate compliance with these specifications.
2. Drawings showing structure elevation and plan views with dimensional information, including, but not limited to: structure height and depth, section widths, location of shipping splits, required bus splices, conduit stub up locations, and anchorage holes.
3. Single line diagrams and schematic wiring diagrams for each structure. Schematic wiring diagrams shall clearly identify internal and external devices, and all remote contacts and signals.
4. Structure descriptions with the following: bus ratings, enclosure ratings, short-circuit withstand rating, and other information to demonstrate compliance with Contract Document requirements.
5. Component schedule, including, but not limited to: circuit breakers, disconnect switches, motor circuit protectors, and motor starters.
6. Drawings showing proposed control unit layouts for each different unit configuration with the location of all control pilot devices clearly shown (control station plate or control unit door). Each pilot device shall be clearly labeled on the drawings.
7. Unit descriptions including information such as, starter sizes, circuit breaker frame sizes, circuit-breaker continuous amperage ratings and interrupting ratings, and all proposed options/accessories.
8. Terminal size ranges for all cable connections (line and load sides).
9. Nameplate schedule for all structures and sections.
10. Short-circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study per Section 16040.
11. Utility company's written approval of electrical service equipment drawings.

12. Design calculations and details for equipment seismic design and restraint. Calculations and anchorage details shall be prepared and stamped by a Registered Professional Civil or Structural Engineer in the State of California. Equipment seismic design and restraint calculations shall be provided for all motor control centers and switchboards. Calculations shall include anchor bolt type, size, locations, and embedment depth. Anchor bolt embedment depth shall be based on the thickness of the structure floor slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment structures. Calculations shall be performed in accordance with the California Building Code (latest edition) for Occupancy Category IV, Essential Facilities.
13. Manufacturer's installation instructions, including:
 - a. Receiving, handling, and storage instructions.
 - b. General information for nameplate data, serial numbers, UL markings, and short-circuit ratings.
 - c. Installation procedures including seismic requirements, splicing procedures, and bus torque specifications.
 - d. Conduit and cable installation.
 - e. Grounding requirements.
 - f. Installing and removing plug-in units.
 - g. Arc-flash protection labeling.
 - h. Operation of operator handles and unit interlocks.
 - i. Checklists before energizing.
 - j. Procedures for energizing equipment.

B. Operation and Maintenance Manuals

Contractor shall submit a detailed Operation and Maintenance Manual for the equipment specified herein and incorporated into the Work. The Operation and Maintenance Manual shall be provided in accordance with the requirements of the District's General Conditions, and Section 01430.

Operation and maintenance manuals shall include, but not be limited to, the following:

1. Installation instructions, as specified herein.
2. Safety precautions, including protective equipment and clothing.
3. Pre-energizing and energizing procedures for MCCs, switchboards, and panelboards.
4. Maintenance procedures, including: inspection and cleaning, servicing, disconnect switch and contact lubrication, and testing
5. Maintenance procedures after a fault condition.
6. Troubleshooting procedures.
7. Technical data and illustrations.
8. Replacement parts list.
9. Manufacturer warranties.
10. Contact Information, including name, address, and telephone number of manufacturer and manufacturer's local service representative.

1.05 DESIGN REQUIREMENTS

- A. Provide equipment conforming to the requirements of NFPA 70, unless more stringent requirements are specified herein or indicated on the Drawings. NEMA rated and UL listed equipment is specified, and shall be provided when available. Equipment shall meet NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the District of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.
- B. Equipment, conduit, and wiring sizes indicated on the Drawings, including motor sizes and associated electrical equipment ratings, are minimum requirements. Contractor shall verify all actual equipment and motor full-load and locked rotor current ratings. Contractor shall coordinate the actual current rating of equipment furnished with the size of the branch circuit conductors, motor controller, motor overload relay, and branch circuit overcurrent protection.

The branch circuit conductors shall have a carrying capacity of not less than 125% of the actual motor full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2% when the equipment is running at full load and rated voltage. Conductor ampacities shall be derated in accordance with NEC, Table 310-16 for ambient temperatures of 114 to 122°F.

The motor running overcurrent protection devices shall be ambient temperature compensated for temperatures up to 50°C and be rated or selected to trip at no more than 125% of the motor full-load current rating for motors marked to have a temperature rise not over Class B above 50°C ambient or motors marked with a service factor not less than 1.15, and at no more than 115% for all other types of motors.

The motor branch circuit overcurrent protection device shall trip open in 10 seconds or less on locked-rotor current of the motor. This device shall also protect the motor branch circuit conductors and the motor controller against overcurrent due to short-circuits or grounds. The motor control circuits shall have overcurrent protection of the type indicated on the Drawings and specified herein.

Contractor shall make the necessary adjustments to wiring, conduit, motor controllers, disconnects, branch circuit protection, and other affected material or equipment to accommodate the motors actually furnished, all at no additional cost to the District.

- C. Contractor shall verify that proposed equipment will fit into the available space for same. Prior to equipment fabrication, Contractor shall notify the District of any potential interferences or conflicts between the proposed equipment and corresponding installation locations, including associated conduit and conductors.

1.06 ARC-FLASH LIMIT

- A. Contractor shall provide an Arc-Flash Hazard Study per Section 16040 to determine potential arc-flash incident energies, arc-flash boundaries, shock hazard boundaries; required personal protective equipment (PPE) for all energized electrical equipment; and arc-flash and shock hazard warning labels.
- B. Unless specified otherwise, the study shall include all switchboard, emergency power transfer switch, MCC, and panelboard electrical circuits from the electric utility power source(s) and emergency power source(s) to and including all electrical equipment and panelboards rated 208 V and greater.

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- C. Wherever possible, the proposed electrical equipment, including MCCs, switchboards, and panelboards, shall be designed, manufactured, and supplied to limit the potential arc-flash incident energy to 8 cal/sq cm or less (PPE Category 2). The firm performing the studies shall coordinate with Contractor, the District, and the electrical equipment manufacturers to assist in achieving this requirement.
- D. Arc-flash and shock hazard warning labels shall be provided for MCCs, switchboards, and panelboards per Section 16040. Where the main protective device is specified to be equipped with an arc-flash reduction maintenance system, all MCCs, switchboards, and panelboards shall be provided with two (2) sets of labels. One (1) set shall be provided for the normal operating mode and one (1) set shall be provided for the arc-flash reduction maintenance system operating mode.

1.07 COORDINATION

- A. The general arrangement of the MCCs, switchboards, and panelboards is shown on the Contract Drawings. Any modifications of the equipment arrangement or device requirements as indicated on the Drawings shall be subject to District approval. If any conflicts occur necessitating a departure from the Drawings, a written explanation and details for said departure shall be submitted and approved by the District prior to implementing any change. All equipment shall be completely factory assembled. The MCCs and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.
- B. Where project requirements include construction of a new electrical service or upgrading an existing electrical service, Contractor shall coordinate all required work with Southern California Edison (SCE) and the District. All electrical service equipment and material shall be in strict accordance with SCE requirements. Prior to commencing construction of electrical service facilities, Contractor shall submit shop drawings of proposed electrical service equipment and material to SCE and District for review and approval.

1.08 QUALITY ASSURANCE

- A. The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these specifications.

- B. Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

PART 2 - MATERIALS

2.01 MOTOR CONTROL CENTERS

A. General

MCCs shall be 600 V class suitable for operation on a three-phase, 480 V, 60 Hz system. MCCs shall be configured for 3-wire or 4-wire systems, as indicated on the Drawings. MCCs shall be manufactured by Eaton/Cutler-Hammer, Schneider Electric/Square D, Allen Bradley, or General Electric (no substitutes).

B. Structures

1. Structures shall be totally enclosed, dead-front, free-standing assemblies. Structures shall be capable of being bolted together to form a single assembly.
2. The overall height of MCCs shall be 90 inches (nominal), not including base channels, lifting angles, baffles, or plenums. Structures shall contain horizontal wireways at the top and bottom of each section. A minimum of 72 inches of vertical compartments shall be available for mounting of control units, protective devices, transformers, lighting panelboards, etc.
3. For shipment and installation, each MCC shall be provided with rigid removable or non-removable base channels enclosing all four-sides of the equipment, and removable lifting angles. Non-removable base channels shall be provided with welded closing plates at the open ends the channels.
4. The total width of one section shall be 20 inches; widths of 25 inches, 30 inches, or 35 inches shall be provided where required for larger devices or where indicated on the Drawings.
5. The minimum depth of the MCC shall be 20 inches.
6. Each 20 inch wide standard section shall be provided with all the necessary hardware and bussing for modular plug-on units to be installed. All unused space shall be covered by hinged blank doors and equipped to accept future units. Vertical bus openings shall be covered by manual bus shutters.

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7. Each section shall include a top plate (single piece or two-piece). Top plates shall be removable for ease in cutting conduit entry openings.

8. MCC Structures Located Indoors

Unless indicated otherwise on the Drawings, MCC structures located indoors shall be provided with NEMA Type 1A (gasketed general purpose) enclosures.

9. MCC Structures Located Outdoors

Unless indicated otherwise on the Drawings, MCC structures located outdoors shall be provided with NEMA Type 3R, non-walk-in (rainproof) enclosures. MCC NEMA Type 3R, non-walk-in enclosures shall be based on NEMA Type 1A enclosures with a NEMA 3R wrapper. The additional housing and gasketing supplied by the NEMA 3R wrapper shall provide protection from rain, sleet, and ice. As a minimum, MCC NEMA Type 3R, non-walk-in enclosures shall comply with the following requirements:

- a. The enclosing NEMA 3R wrapper shall be constructed of 12 gauge galvaneal steel with a flat or sloped roof line. Sloped roof lines shall be sloped from front to rear at a minimum of 1/2 inch per foot. Doors constructed of 14 gauge steel are acceptable if the doors are provided with suitable welded-in stiffening pans to prevent deflection. Doors constructed of 14 gauge steel without stiffening pans are not acceptable. Gasketing shall be provided all around door closing flanges (four sides).
- b. Each NEMA 3R wrapper split or section shall have a minimum of 29 inches working clearance from hinge flange to door closure flange or hinge to hinge with double doors. The width of open unobstructed area when door(s) are open shall be 29 inches minimum.
- c. NEMA 3R wrapper splits shall be coordinated with the MCC section splits. Cabinet spacers shall be provided at MCC section splits to permit full opening (90 degrees, minimum) of all MCC doors without interfering with the NEMA 3R wrapper doors. MCC shall be provided with all cabinet spacers, wireway extensions, horizontal bus splice kits, and ground bus splice kits required to interconnect MCC sections and provide the necessary separation for MCC doors to fully open. All MCC cabinet connections shall be provided with gaskets to maintain the specified NEMA 1 gasketed rating.
- d. The rear access covers shall be flanged on four sides, and gasketed. One piece flat or multi-piece flat lipped covers are not acceptable.

- e. The distance in front of a NEMA 1A MCC section to the inside of the outer NEMA 3R wrapper door(s) shall be 11 inches, minimum.
- f. Lighting shall be provided using LED lighting fixtures, single-tube, with length as necessary for width of NEMA 3R wrapper split. A light switch shall be provided on side extension for each MCC shipping split, and shall be furnished with a stainless steel cover plate.
- g. Convenience receptacles shall be provided for each MCC shipping split. Receptacles shall be duplex GFCI type, with stainless steel cover.
- h. Control power transformers with primary and secondary fuse protection shall be provided to supply power to the NEMA 3R wrapper interior lighting and convenience receptacles, unless indicated otherwise on the Drawings. Supply voltage shall be 120 volts, 60 Hz. The control power transformers shall be prewired at the factory to all lights and receptacles.
- i. Where required for MCC ventilation, NEMA 3R wrapper doors shall be provided with louvered or hooded ventilation openings at the top and bottom. Louvered openings shall be integrally molded into the doors and covered by interior mounted air filters. Hooded openings shall be clear door openings covered by exterior weatherproof hoods and interior mounted air filters. Each weatherproof hood shall be provided with a removable insect screen at the bottom. Air filters shall be washable aluminum mesh type, gasketed on all sides, and removable (without the use of tools) for cleaning.
- j. NEMA 3R wrapper front door handles shall have provisions for padlocking and shall be equipped with wind stops.
- k. Both MCCs and Switchboards (if applicable) shall have the same NEMA 3R wrapper design and appearance, and shall be UL approved.

C. Materials

1. Steel material shall comply with UL 845 requirements.
2. Each MCC shall consist of one or more vertical sections of heavy gauge steel bolted together to form a rigid, free-standing assembly. Vertical sections shall be made of welded side-frame assemblies formed from a minimum of 12 gauge steel. Internal reinforcement structural parts shall be of 12 and 14 gauge steel to provide a strong, rigid assembly. The entire assembly shall be constructed and packaged to withstand normal stresses included in transit and during installation.

D. MCC Finish

1. All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC Powder Coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.
2. Pre-treatment shall include:
 - a. Hot alkaline cleaner to remove grease and oil.
 - b. Iron phosphate treatment to improve adhesion and corrosion resistance.
3. The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.
4. The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.
5. Paint color for MCC NEMA 1 enclosures shall be #49 medium light gray per ANSI Standard Z55.1 (60-70 gloss) on all exterior surfaces, unless specified otherwise. Control station plates and escutcheon plates shall be painted a contrasting gray. All unit interior surfaces shall be painted white for better visibility inside the unit, except for unit handle mechanism side plates.
6. Paint color for MCC NEMA 3R enclosures (NEMA 3R wrappers) shall be white (60-70 gloss) on all surfaces unless specified otherwise.

E. Wireways

1. Horizontal Wireways
 - a. Wireways shall be located at the top and bottom of the MCC.
 - b. Wireways shall be a minimum of 6 inches in height and shall extend the full depth of the vertical sections to allow maximum flexibility in locating conduit and routing field wiring for the MCC. Where indicated on the Drawings, pull boxes shall be provided to extend the height of the top horizontal wireway by 12 inches.
 - c. Wireways shall be continuous across the length of the MCC, except where access needs to be restricted for horizontal isolation requirements.

- d. Wireways shall be isolated from the power buses.
- e. Wireways shall have removable covers held in place by captive screws.

2. Vertical Wireways

- a. A full height vertical wireway, independent of the plug-in units, shall be provided in each standard vertical section.
- b. Wireways shall be isolated from the vertical and horizontal buses.
- c. Isolation shall be provided between the wireway and unit compartments.
- d. Wireway tie bars shall be provided in each section.
- e. Wireways shall be covered with hinged and secured access doors. Access to the wireways shall not require opening control unit doors.

F. Barriers

- 1. All power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be mounted onto a glass filled polyester support assembly that braces the bus against the forces generated during a short-circuit. The horizontal bus shall be isolated from the top horizontal wireway by a rigid non-conductive barrier.
- 2. Isolation of the vertical bus compartment from the unit compartment shall be by means of a full height insulating barrier. Vertical busing shall be provided with a glass-filled polyester barrier that provides bus insulation and braces the bus against the forces generated during a short-circuit. These barriers shall have openings at a maximum spacing of 6 inches for unit stab-on connections. Openings shall be provided with manual or automatic shutters to close-off the stab openings when plug-in units are removed. Manual covers shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the MCC.

G. Busing

1. The main horizontal busing shall be tin-plated copper and shall be rated at the amperage indicated on the Drawings; however, the bus shall have a minimum ampere rating of 600 A. The vertical bus connecting an incoming power feeder cable to the horizontal bus shall have the same ampere rating as the main horizontal bus. Unless specified otherwise, horizontal bus bars shall extend the length of the MCC. Bus ratings shall be continuous and shall be based on a 65°C maximum temperature rise over a 40°C ambient temperature in compliance with UL standards. The main bus shall be isolated from the horizontal wireways, and all bus connections shall be front-accessible for ease of maintenance. Provisions shall be provided for splicing additional sections onto either end of the MCC.
2. Vertical busing feeding unit compartments shall be tin-plated copper and shall be securely bolted to the horizontal main busing. The vertical busing shall be rated at the amperage indicated on the Drawings; however, the busing shall have a minimum effective ampere rating of 600 A. If center horizontal bus construction is utilized, then the rating shall be 300 A above and below the horizontal bus for an effective rating of 600 A. If a top or bottom mounted horizontal bus is utilized, the full vertical bus shall be rated for 600 A. The vertical buses shall be continuously braced by a high strength, non-conductive, non-tracking, glass-filled polyester material and isolated from the unit compartments by a non-conductive, polycarbonate molded cover. The vertical power bus shall be isolated from the horizontal power bus, except where necessary to connect the vertical bus to the horizontal bus.
3. Unit power stabs for engaging the power bus shall be tin-plated copper and shall be provided with stainless back-up springs to provide and maintain a high pressure connection to the vertical busing. Power cable terminations at the plug-in stabs shall be maintenance-free compression type connections.
4. A tin-plated copper ground bus shall be provided that runs the entire length of the MCC. The ground bus shall be a minimum of 0.25 inch x 2.0 inch and be rated for 600 A (minimum). A mechanical lug shall be provided at each end of the MCC for connecting #1/0 AWG to 250 kcmil external ground cables. The ground bus shall be provided with a minimum of six (6) 3/8 inch diameter holes for each vertical section to accept Contractor-supplied ground lugs for any loads requiring a ground conductor.
5. Each vertical section shall be provided with a copper vertical ground bus that is solidly connected to the horizontal ground bus. This vertical ground bus shall be installed so that the plug-in units engage the ground bus prior to engagement of the power stabs and shall disengage only after the power stabs are disconnected upon removal of the plug-in unit.

6. The horizontal and vertical busing shall be mounted on supports constructed of materials having high dielectric strength, high impact strength, and low moisture absorbency.
7. The system shall be rated for an available short-circuit capacity of not less than 65,000 RMS amperes in accordance with NEMA standards. If the results of the Contractor's Electrical Short-circuit and Protective Device Evaluation and Coordination Study, as accepted by the District, indicate that a higher short-circuit duty rating of the MCC is required, Contractor shall furnish the MCC with that higher rating.

H. Disconnects

1. Main Lug Compartment (if indicated on the Drawings)
 - a. If no overcurrent protection is indicated on the Drawings for incoming power, MCC shall be provided with a main incoming-line lug compartment.
 - b. Lug connections shall be located at the back of the enclosure to reduce the potential hazard of contacting the lugs when opening the compartment door.
 - c. Lugs shall accommodate the incoming power conductors as indicated on the Drawings. Lugs shall be provided by the MCC manufacturer.
2. Main Circuit Breaker Disconnect (if indicated on the Drawings)
 - a. Lugs to accommodate the incoming power conductors as indicated on the Drawings shall be provided by the MCC manufacturer.
 - b. Circuit breaker frame and trip rating shall be as indicated on the Drawings.
 - c. The interrupting capacity rating shall meet or exceed the main bus rating of the MCC.
 - d. The main circuit breaker shall be a molded case circuit breaker with solid-state trip unit or insulated case power circuit breaker per Part 2.04 herein.
 - e. Provide a removable protective barrier to reduce the possibility of contact with the line terminals.

- f. Where specified on the Drawings, provide one normally open and one normally closed circuit breaker auxiliary contact that follows the position of the circuit breaker main contacts for indication of 'On' or 'Off/Tripped'.

3. Feeder Disconnects and Transformer Disconnects

- a. The disconnecting means for feeders and transformers shall be molded case circuit breakers per Part 2.04 herein.
- b. The interrupting capacity rating shall meet or exceed the main bus rating of the MCC.
- c. Circuit breaker frame and trip rating shall be as indicated on the Drawings.

4. Motor Starter Disconnects

- a. Combination Full-Voltage Starters:
 - i. The disconnecting means for combination full-voltage starters (across-the-line starters) shall be motor circuit protectors. Motor circuit protectors shall be provided per Part 2.01K herein.
 - ii. The short-circuit rating of the motor circuit protector shall be greater than or equal to the MCC main bus rating.
- b. Solid-State Controllers (Solid-State Reduced Voltage Motor Controllers) and Variable Frequency Drives
 - i. The disconnecting means for a solid-state controller or a variable frequency drive shall be a molded case circuit breaker.
 - ii. The short-circuit rating of the circuit breaker shall be greater than or equal to the MCC main bus rating.

I. Typical Motor Control Unit Construction

- 1. Units with circuit breaker disconnects through 400 A frame, and fusible switch disconnects through 400 A, shall connect to the vertical bus through a spring reinforced stab-on connector. Units with larger disconnects shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.
- 2. All conducting parts on the line side of the unit disconnect shall be shrouded by a suitable insulating material to prevent accidental contact with those parts.

3. Unit mounting shelves shall include hanger brackets to support the unit weight during installation and removal. All plug-in units shall use a twin-handle camming lever located at the top of the bucket to rack in and out the plug-in unit. The cam lever shall work in conjunction with the hanger brackets to ensure positive stab alignment.
4. A lever handle operator must be provided on each disconnect. With the unit stabs engaged onto the vertical bus and the unit door closed, the handle mechanism shall allow complete "On/Off" control of the unit. All circuit breaker operators shall include a separate "Tripped" position to clearly indicate a circuit breaker trip condition. It shall be possible to reset a tripped circuit breaker without opening the control unit door. Clear indication of disconnect status shall be provided by the following operator handle positions:
 - a. Handle "On" position shall be up or to the left and within 45 degrees of being parallel to the face of the equipment.
 - b. Handle "Off" position shall be down or to the right and within 45 degrees of being parallel to the face of the equipment.
 - c. The minimum separation between the "On" and "Off" positions shall be 90 degrees.
 - d. On circuit breaker disconnects, the handle "Tripped" position shall be perpendicular to the face of the equipment +/- 30 degrees. Minimum separation between "On" and "Tripped" shall be 30 degrees. Minimum separation between "Tripped" and "Off" shall be 45 degrees.
5. A mechanical interlock shall prevent an operator from opening the unit door when the disconnect is in the "On" position. Another mechanical interlock shall prevent an operator from placing the disconnect in the "On" position while the unit door is open. It shall be possible for authorized personnel to defeat these interlocks.
6. A non-defeatable interlock shall be provided to prevent installing or removing a plug-in unit unless the disconnect is in the "Off" position.
7. The plug-in unit shall have a grounded stab-on connector which engages the vertical ground bus prior to, and releases after, the power bus stab-on connectors.
8. Provisions shall be provided for locking all disconnects in the "Off" position with up to three padlocks.

9. Unit construction shall combine with the vertical wireway isolation barrier to provide a fully compartmentalized design.
10. Unit interior surfaces (back, sides and bottom plates) shall be painted white, except for handle mechanism side plates.

J. Wiring and Terminations

1. Wherever possible, copper compression type lugs shall be provided for all line and load terminations, and shall be suitable for copper cable rated for 75°C of the size as indicated on the Drawings.
2. Copper compression type lugs shall be provided for all grounding conductor terminations to the ground bus.
3. Unless indicated otherwise on the Drawings, MCC wiring shall be NEMA Class II, Type B, with wiring schematics showing field devices and connections.
4. Where fine stranded conductors, Class C and higher (such as DLO cable) are utilized for internal wiring, all terminations in mechanical lugs shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.
5. Control Wiring Terminal Blocks
 - a. All starter units shall be provided with unit control terminal blocks (Type B wiring).
 - b. Terminal blocks shall be the pull-apart type with a minimum rating of 250 VAC and 10 A. All current carrying parts shall be tin plated. Terminals shall be accessible from inside the unit when the unit door is opened. Terminal blocks shall be DIN rail mounted with the stationary portion of the block secured to the unit. The stationary portion shall be used for factory connections, and shall remain attached to the unit when removed. The terminals used for field connections shall face forward so they can be wired without removing the unit or any of its components.

- c. When Type C wiring is specified, all starter units shall be provided with unit control terminal blocks as described for Type B wiring along with power terminal blocks for NEMA size 1-3 units. An additional set of terminal blocks shall be provided in a terminal compartment located in each section. These terminal blocks shall be pre-wired to the unit terminals so that all field control connections can be made at the terminal compartments.
 6. All internal wires shall be labeled at each termination. Terminals shall also be identified with labels showing the terminal block and terminal numbers.
 7. Control wires connected to door mounted components shall be tied and bundled in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall allow the door to swing full open without undue stress or abrasion. Bundles shall be held on each side of hinge by mechanical fastening devices.
 8. Terminals on door mounted components shall be provided with finger-safe protective barriers; or alternatively, a single clear plastic protective barrier shall be provided covering all terminals.
- K. Combination Full-Voltage Motor Controllers (Across-the-Line Starters)
1. Combination motor controllers shall be full-voltage non-reversing, unless otherwise specified herein or on the Drawings. Combination full-voltage motor controllers shall utilize motor circuit protectors and magnetic motor starters. Each combination unit shall have a short-circuit rating greater than or equal to the MCC main bus rating. The motor circuit protector shall provide adjustable magnetic protection, and shall be adjustable to 1700% of motor nameplate full load current in compliance with NEC requirements. All motor circuit protector combination starter units shall have a "tripped" position on the unit disconnect and a push-to-test button on the motor circuit protector. Motor circuit protectors shall be Eaton Type HMCP, or equal.
 2. Where specified on the Drawings, motor circuit protectors shall be provided with auxiliary contacts (one normally open and one normally closed) that follow the position of the motor circuit protector main contacts for indication of "On" or "Off/Tripped".

3. Magnetic motor starters shall be NEMA ICS 2, alternating current Class A magnetic controllers for induction motors rated in horsepower. Magnetic motor starters shall be equipped with totally enclosed, double-break silver alloy contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring. Starter wiring shall be straight-through with all terminals clearly marked. Each starter shall be provided with necessary number of normally open and/or normally closed auxiliary contacts to perform all functions shown on the control ladder diagrams in the Drawings.
4. Starter coils shall be of molded construction and permanently marked with voltage, frequency and manufacturer part number. Unless specified otherwise, starter coil voltage shall be 120 VAC.
5. Starters shall be provided with bimetallic-type overload relays or solid-state overload relays for motor protection. Overload relays for motor protection shall be as indicated on the Drawings and as specified herein. Unless specified otherwise, bimetallic-type overload relays shall be provided on starters for motors of less than 5 HP, and solid-state overload relays shall be provided on starters for motors of 5 HP and greater. For each combination motor controller, Contractor shall verify motor rating and coordinate starter and overload relay size with the horsepower and starting characteristics of the actual motor furnished.
6. Bi-metallic overload relays shall be ambient compensated with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated normally open and normally closed contacts shall be provided on the relay. The relay shall be capable of accepting additional auxiliary contacts. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. The overload shall be capable of 20% (minimum) adjustability (plus or minus) and single-phase sensitivity. The overload relay shall be provided with an isolated alarm contact, and manual reset.
7. Solid-state overload relays shall be integral with the motor starter, and shall be listed under UL Standard 508. Solid-state overload relays separate from the motor starter are not acceptable. As a minimum, solid-state overload relays shall have the following features and capabilities:
 - a. Self-powered.
 - b. Class 10, 20, or 30 selectable tripping characteristics.

- c. Manual or automatic reset. Automatic reset shall be provided if indicated on the Drawings. Reset shall be electronic 120 VAC.
- d. Selectable "On/Off" phase loss protection. The relay shall trip in 10 seconds or less under phase loss condition.
- e. Selectable "On/Off" phase imbalance protection. The relay shall trip in 10 seconds or less under phase imbalance condition.
- f. Visible trip indication.
- g. One normally open and one normally closed isolated auxiliary contact and capable of accepting additional auxiliary contacts.
- h. Test button that operates the normally closed contact.
- i. Test trip function that trips both the normally and normally closed contacts.
- j. A current adjustment range of 3:1, or greater.
- k. Embedded, selectable "On/Off" ground fault protection shall be an available option, and shall be provided where indicated on the Drawings. Relay shall trip when ground fault is detected at 50% of full load ampere setting.
- l. An LED that provides self-diagnostic information.
- m. An LED that aids in commissioning by indicating running current is too high compared to the FLA dial.

Solid-state overload relays shall be Eaton Type C440, or equal.

L. Solid-State Reduced Voltage Motor Controllers (Soft Starters)

- 1. The solid-state reduced voltage motor controller unit shall be a combination disconnect/soft starter, MCC-style unit. A molded case circuit breaker shall be provided for NEC required branch circuit protection. The branch circuit protection shall have an external operator. Wiring between the soft starter and the disconnect shall not be disturbed when removing or installing the soft starter controller unit from the MCC. Units shall be of modular construction so that units of the same size can be interchanged without modifications to the MCC structure.

2. All conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.
3. Soft starter units rated for standard duty (up to 156 A, FLA for 125 HP motor per NEC) shall be plug-in units which connect to the MCC vertical bus through a spring-reinforced stab-on connector. Units rated higher than 156 A shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.
4. The soft starter disconnect shall be a molded case circuit breaker per Part 2.04 herein.
5. For each soft starter unit, Contractor shall verify motor rating and coordinate soft starter and disconnect size with the horsepower and starting characteristics of the actual motor furnished.
6. All plug-in soft starter units shall have a grounded stab-on connector which engages the vertical ground bus prior to, and releases after, the power bus stab-on connectors engage/release.
7. All soft starter units shall be provided with unit control terminal blocks for use in terminating field wiring. Terminal blocks shall be pull-apart type, 250 V, and rated for 10 A. All current-carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is opened. The terminals used for field connections shall be accessible so they can be wired without removing the unit or any of its components.
8. The enclosure shall include a door-mounted digital keypad for adjusting the soft starter parameters and viewing the motor, soft starter, and fault status without opening the enclosure door.
9. Each soft starter shall include a shorting contactor which closes after full voltage has been applied to the motor by the soft starter to reduce the current carrying duty on the SCRs. The shorting contactor shall be rated to carry the motor full load current during steady state operation.
10. Electrical Ratings
 - a. The soft starter unit shall be designed to operate from an input voltage between -10% and +10% of nominal voltage rating.
 - b. The soft starter unit shall operate from an input voltage frequency range of +/-5%.

- c. The soft starter unit shall be capable of supplying 350% of rated full load current for 20 seconds at the maximum ambient temperature.
- d. All soft starter unit power and control devices shall be rated for: severe duty capable of 3 evenly spaced starts per hour at 350% of full rated current for 24 seconds per start without tripping.
- e. The soft starter unit shall be provided with silicon-controlled rectifiers (SCRs) having a minimum peak inverse voltage (PIV) rating of 1800 VAC. Lower rated SCRs with protection by metal oxide varistors (MOVs) are not acceptable.

11. Protection

- a. A microprocessor-based thermal protection system shall be included that continuously calculates the temperature rise of the motor and soft starter and provides:
 - i. A motor overload fault that shall stop the motor if the windings have exceeded 125% of their rated temperature rise.
 - ii. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time-constant that ensures memorization of the thermal state even if power is removed from the soft starter.
- b. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection.
- c. The soft starter integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation.
- d. All units and options shall be constructed with protection provisions to pass UL 845 short-circuit testing criteria at a minimum of 100,000 A short-circuit current.
- e. Diagnostic faults and soft starter status shall be displayed on the door-mounted keypad after a fault condition.
- f. The motor shall be automatically protected from solid state component failure by one of the following means:
 - i. Shunt trip coil to trip the disconnect in the event of a soft starter fault condition, including a shorted SCR.

- ii. Isolation contactor that opens when the motor is stopped or when the controller detects a fault condition including a shorted SCR.

12. Adjustments and Configurations

- a. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the soft starter control module. All control circuit boards and electrical power devices shall be isolated to prevent exposure and accidental contact during routine adjustments.
- b. Digital indication shall provide, as a minimum, the following conditions:
 - i. Soft starter status—ready, starting/stopping, run.
 - ii. Motor status—current, torque, thermal state, power factor, operating time, power in kW.
 - iii. Fault status—motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor underload, maximum start time exceeded, external fault, line phase reversal fault, and motor overcurrent fault.
- c. As a minimum, a digital keypad shall be used to configure the following operating parameters:
 - i. Motor full load amps, adjustable from 40 to 100% of the soft starter's rating.
 - ii. Current limitation on starting, adjustable from 200 to 700% of the motor current rating, not to exceed 350% of the soft start rating.
 - iii. Voltage ramp, adjustable from 1 to 60 seconds.
 - iv. Initial voltage, adjustable from 10 to 50% of nominal motor torque.
 - v. Maximum start time, adjustable from 1 to 250 seconds.
 - vi. Voltage boost duration, adjustable from 0.1 to 1 second.
 - vii. Selection of freewheel or soft stop.
 - viii. Linear (torque-controlled) deceleration ramp time, adjustable from 1 to 60 seconds.
 - ix. Selection of Class 10, 20, or 30 motor thermal overload protection.

- d. As a minimum, a digital keypad shall be used to configure the following controller parameters:
 - i. Assignment of soft starter inputs and outputs.
 - ii. Activation of phase reversal protection.
 - iii. Reset of motor thermal state.
 - iv. Return to factory parameter settings.
 - v. Activation of self-test mode.
 - vi. Indication of elapsed time in hours of starting, running and stopping.
 - e. As a minimum, output relays shall provide the following status indications:
 - i. One normally open SPST for indication of trip.
 - ii. One normally open SPST for indication that soft starter is running.
 - f. As a minimum, additional inputs and outputs shall be available to provide the following status indications:
 - i. Two assignable control inputs for the following functions: external fault input, disable serial link control, second set of operating and controller parameters, or general fault reset.
 - g. Relay and I/O functions listed above shall be isolated with respect to common.
 - h. Serial communication shall be provided with a communications card capable of ModBus RTU or ModBus TCP.
13. Control Options
- a. The soft starter's control circuit shall be fed from a fused line supply and shall be completely independent of the power circuit and separate from relay control logic.
 - b. The peripheral soft starter control circuitry shall be operated from a control power transformer included within the enclosure.
 - c. Operator devices shall be door-mounted. Unless indicated otherwise on the Drawings, the following operator devices shall be provided:
 - i. Green "Start" and red "Stop" pushbuttons.

- ii. Three position "H-O-A" switch which provides for manual "Hand" start or remote "Auto" start from input relay contacts.
- iii. Green "Run" pilot light illuminated whenever the soft starter run output is activated and no fault condition is present.
- iv. White "Off" pilot light illuminated whenever the soft starter is supplied with control power and no run command is present.

14. Full-Voltage Bypass Starter

- a. Where indicated on the Drawings, the soft starter unit shall include full-voltage starting capability to start and control the motor instead of the reduced voltage soft start method of starting the motor.
- b. The full-voltage bypass starter shall include a magnetic motor starter as specified herein, and shall be capable of carrying the motor inrush and motor full load current.
- c. A door-mounted "Normal/Bypass" selector switch shall be provided to enable the user to manually select the motor starting method. "Normal" mode shall provide reduced voltage starting using the soft starter. In "Bypass" mode, the soft starter shall be left inactive and the motor shall be started using the full-voltage (across-the-line) starter.
- d. To protect the motor in "Bypass" mode, the magnetic motor starter shall be equipped with a bi-metallic or solid-state overload relay, independent of the soft starter.
- e. The bypass starter components shall be fully integrated inside the soft starter control unit and shall be factory tested by the MCC manufacturer.

M. Control Devices and Miscellaneous Components

1. Control Transformers

Except as otherwise indicated on the Drawings, each motor control unit shall be provided with a control transformer. Control transformers shall comply with the following requirements:

- a. Each control transformer shall be rated 480/120 V, single phase, 2 wire, 60 Hz, and shall conform to the applicable requirements of NEMA ST 1. The transformer shall have adequate volt-ampere capacity for the motor starter coil and all connected control function loads indicated, plus an additional 10 percent capacity. Transformer capacity shall be increased as required for any additional non-control function loads, such as

condensation heaters and ventilation fans. The transformer shall have a minimum rating of 150 VA.

- b. Each control transformer shall be feed from the load side of the motor controller disconnect. Control transformers shall be provided with two primary fuses rated to interrupt 100,000 A at 600 V. One transformer secondary lead shall be provided with a time-delay, slow-blow fuse rated to interrupt 10,000 A at 250 V, and the other secondary lead shall be grounded. All fuses shall be provided with blown fuse indicators.

Where Drawings indicate control circuit power is provided from a source other than a unit transformer (e.g. a lighting panel circuit breaker) and an interlock is required with the motor controller disconnect, the disconnect shall be equipped with a normally open contact to isolate the externally powered control circuit from the source when the controller disconnect is open.

2. Control Relays

Control relays shall be general purpose, electrically operated, magnetically held, plug-in blade or pin style with DIN rail mountable socket and LED indicator. Control relays shall be UL listed with 10 A rated contacts (thermal continuous current at 120 VAC), and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles and pole arrangement shall be as indicated on the Drawings and as specified herein. Control relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

3. Time Delay Relays

Time delay relays shall be general purpose, multi-range, multi-function, plug-in blade or pin style with DIN rail mountable socket and LED indicators (timing and timed out). Time delay relays shall be provided with multiple programmable timing ranges (0.5 sec to 24 hours, minimum) and multiple operating modes. As a minimum, relay operating modes shall include: on-delay, off-delay, repeat cycle off start, repeat cycle on start, and signal on/off delay. Time delay relays shall be UL listed with 5 A rated contacts (thermal continuous current at 120 VAC) non-inductive load, and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles, pole arrangement, and maximum timing adjustment shall be as indicated on the Drawings and as specified herein. Time delay relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

4. Elapsed Time Meters

Elapsed time meters shall be electromechanical, NEMA Type 4X rated, with rectangular or round case suitable for flush panel mounting. Each meter shall have 6-digit (minimum) registers with counter numbers at least 3 mm high, and shall be non-resettable. White counter numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Each meter shall operate on 120 VAC input power. Elapsed time meters shall be as manufactured by Eaton, Honeywell/Hobbs, or equal.

5. Pilot Devices

- a. Pilot devices consisting of pushbuttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).
- b. Pilot devices shall be suitable for mounting on MCCs, switchgear, control panels, and control stations. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.
- c. Pushbuttons and switch knobs shall be heavy duty plastic. Unless indicated otherwise on the Drawings, switch knobs shall be black and pushbuttons shall colors shall be as follows:

Color	Function	Examples
Red	Emergency Stop, Stop, Off	Emergency Stop button, Master Stop button, Stop of one or more motors
Yellow (Amber)	Return, Emergency Return, Intervention (suppress abnormal conditions)	Return of machine to safe position, override other functions previously selected
Green	Start-On	General or machine start. Start of cycle or partial sequence.
Black	No specific function assigned	Permitted to be used for any function except for those listed above.

- d. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.

- e. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power. Pilot light lenses shall be shatter resistant plastic. Unless indicated otherwise on the Drawings, pilot light lens colors shall be as follows:

Color	Function	Examples
Red	Fail or Alarm (abnormal condition requiring immediate attention)	Indication that a protective device has stopped the machine, e.g. overload
Yellow (Amber)	Warning (marginal condition, change or impending change of conditions)	Some value (e.g. pressure) is approaching its permissible limits. Overload permitted for a limited time. Ground fault indication.
Green	Machine Ready, Machine Running, Safety	Machine ready for operation with all conditions normal. Machine run.
White	Normal Condition, Confirmation	Normal pressure. Control power on.

- f. Where MCC control pushbuttons, switches and lights are shown on the Drawings, each motor control unit shall be provided with a hinged/removable control station plate, suitable for accommodating a minimum of three (3) 30.5 mm pilot devices. Additional pilot devices, where shown, shall be located on the control unit door. Manufacturer shall confirm the location of the pilot devices with the District prior to commencing equipment fabrication.

6. Power Meter

- a. The power meter shall be UL listed. The meter shall be designed for multifunction electrical measurement on three-phase power systems. The meter shall perform as specified in harsh electrical applications in high and low voltage power systems.
- i. The meter shall support 3 element wye, 2.5 element wye, 2 element delta, and 4 wire delta systems.
 - ii. The meter shall accept universal voltage input.
 - iii. The meter shall be user programmable for voltage range to any potential transformer ratio.

- b. The meter shall use a dual input method for current inputs. One method shall allow the current transformer (CT) to pass directly through the meter without any physical termination on the meter, ensuring the meter cannot be a point of failure on the CT circuit. The second method shall provide additional termination pass-through bars, allowing the CT leads to be terminated on the meter. The meter shall support both termination methods.
 - i. Fault current withstand shall be 100 A for 10 seconds, 300 A for 3 seconds, and 500 A for 1 second.
 - ii. The meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable.
 - iii. All inputs and outputs shall be galvanically isolated to 2500 VAC.
 - iv. The meter shall accept current inputs of Class 10: 0 to 10 A (5 A nominal), and Class 2: 0 to 2 A (1A nominal) secondary.
- c. The meter shall have an accuracy of +/- 0.1% or better for voltage and current, and 0.2% for power and energy functions. The meter shall have a frequency measurement accuracy of not less than 0.001 Hz.
 - i. The meter shall provide true RMS measurements of voltage (phase-to-neutral, phase-to-phase) and current (per phase and neutral).
 - ii. The meter shall calculate RMS readings, sampling at over 400 samples per cycle on all channels measured readings continuously with no cycle blind spots.
 - iii. The meter shall provide voltage and current distortion measurements (% of total harmonic distortion). Harmonic magnitude recording to the 40th order shall be available for voltage and current harmonics.
- d. The meter shall be capable of simultaneously recording voltage and current waveforms.
 - i. The meter shall be capable of recording 512 samples per cycle for a voltage sag or swell or a current fault event.
 - ii. The meter shall provide pre-event and post-event recording capability.
 - iii. The meter shall allow up to 170 events to be recorded.
- e. The meter shall be suitable for flush door mounting. The meter shall be provided with a three-line, LED display. The meter shall display a percent of load bar on the front panel. The percent of load bar shall have not less than 10 segments.

- f. The meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.
- g. Power meter shall include virtual measurement upgrade packs, which shall allow field upgrades without removing the installed meter.
 - i. As a minimum, the meter shall be provided with an upgrade pack that provides multifunction metering consisting of: volts, amps, kW, kVAR, PF, kVA, frequency, kWh, kVAh, kVARh, and I/O expansion.
 - ii. The meter shall be provided with 2 MB of memory for data logging.
- h. The meter shall include 2 independent communications ports on the back and face plate, with advanced features. The back plate communication port shall provide RS485 communication in Modbus protocol. The face plate communication port shall be an optical IrDA port (through faceplate), which shall allow the unit to be set up and programmed using a handheld device or remote laptop without need for a communication cable.
- i. The meter shall provide a user configured fixed window or rolling window demand for a variable user utility demand profile. The meter shall provide an update rate of every 6 cycles for watts, VAR and VA. All other parameters shall be updated every 60 cycles.
- j. The meter shall support a power supply of 90 to 265 VAC and 100 to 370 VDC, and shall have a burden of less than 11VA.
- k. The meter shall have data logging capability with 2 MB memory. The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created. The meter shall be capable of maintaining six logs:
 - i. The meter shall have three historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs.
 - ii. The meter shall have a log for limits alarms. The limits log shall provide magnitude and duration of an event, time-stamp, and log value. The log must be capable of recording to 2048 events.

- iii. The meter shall have a log for system events. The system events log shall record the following occurrences with a time-stamp: demand resets, password requests, system startup, energy resets, log resets, log reads, programmable settings changes.
- iv. The meter shall have a log for I/O changes. The I/O change log shall provide a time-stamped record of any relay outputs and any input status changes. The log must be capable of recording up to 2048 events.
- l. The meter shall have I/O expandability through two option card slots on the back. The meter shall auto-detect the presence of any I/O option cards. The meter shall be furnished with an option card that provides four pulse outputs and 4 status inputs.
- m. The pulse output/digital input option card shall provide the following features:
 - i. 4 KYZ pulse/4 status inputs.
 - ii. Programmable to any energy parameter and pulse value.
 - iii. Programmable to end of interval pulse.
 - iv. 120mA continuous load current.
 - v. DNP input.
- n. The power meter shall be rated NEMA Type 12, and shall be capable of operating in ambient temperatures of -20 to +70°C. The meter shall have a standard 4-year warranty. The power meter shall be Electro Industries/Gauge Tech Model Shark 200-60-10-V1-D2-PO1S-X (no substitutes).

N. Lighting Panelboards and Transformers

Lighting panelboards and transformers shall be as specified in Part 2.03 herein and as indicated on the Drawings.

O. Heating and Ventilation

Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. MCCs shall be equipped with heating and ventilation equipment and components as specified herein, and in accordance with the manufacturer's design requirements.

1. MCCs Located Indoors

Unless indicated otherwise on the Drawings, MCCs located indoors shall be provided with NEMA 1A, gasketed enclosures. As a minimum, MCC NEMA 1A enclosures shall comply with the following heating and ventilation requirements:

- a. All MCC sections, except sections with bottom feed main lugs, bottom feed mains and branches over 600 A, and lighting panel transformers, shall be provided with space heaters to prevent condensation. Space heaters shall operate on 120 V, 60 Hz power. Line voltage thermostats shall be provided for controlling the space heaters. The thermostats shall monitor the temperature inside the NEMA 1A enclosures with temperature adjustment accessible from the outside face of the enclosures.
- b. Unless specified otherwise, MCC sections equipped with variable frequency drives or soft starters, shall be provided with forced air ventilation cooling as required to maintain the ambient temperature for the housed equipment to no greater than its maximum ambient temperature rating for continuous operation at full rated capacity.
- c. Forced air ventilation shall be provided with supply fans mounted at the bottom of the enclosure doors. The bottom door fans shall force fresh air into the enclosure through ventilation louvers located at the bottom of the doors to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, and moving warm air out through ventilation louvers located at the top of the doors. A factory installed thermostat shall control the fans based on the MCCs internal temperature; or alternatively, fan operation shall be controlled by “run” operation of the variable frequency drive or soft starter. Door interlock switches shall be provided to turn the fans off when the door is opened. Unless specified otherwise, each ventilation louver (top and bottom) shall be covered by an air filter. Air filters shall be washable aluminum mesh type, gasketed on all sides, and removable (without the use of tools) for cleaning.
- d. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the enclosure heating and ventilating equipment, unless Drawings show otherwise. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all fans, space heaters, and temperature controls. Separate line voltage thermostats shall be provided for heating and cooling.

2. MCCs Located Outdoors

Unless indicated otherwise on the Drawings, MCCs located outdoors shall be provided with NEMA 3R, non-walk-in enclosures. Heating and ventilation requirements for MCC NEMA 3R, non-walk-in enclosures shall be in addition to the requirements specified above for NEMA 1A enclosures. As a minimum, MCC NEMA 3R enclosures shall be comply with the following heating and ventilation requirements:

- a. All heating and ventilation requirements for NEMA 1A, gasketed enclosures specified above shall apply for the interior MCC sections.
- b. Where NEMA 1A enclosures are provided with fans for ventilation, NEMA 3R wrapper doors shall be provided with supply fans mounted at the bottom of the enclosure doors. The bottom door fans shall force fresh air into the vestibule space between the wrapper doors and NEMA 1A enclosure to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, supplying fresh air to interior MCC sections, and moving warm air out through ventilation louvers located at the top of the doors. NEMA 3R wrapper line voltage thermostats (separate from the MCC cooling thermostats) shall control the outer door mounted fans based on the temperature in the vestibule space; or alternatively, fan operation shall be controlled by “run” operation of the variable frequency drive or soft starter. Door interlock switches shall be provided to turn the fans off when the outer doors are opened.
- c. Heating shall consist of the space heaters and thermostats specified above for the NEMA 1A enclosure. No additional heating is required for the NEMA 3R wrapper.
- d. Openings for supply air and exhaust air in NEMA 3R wrapper doors shall be provided with integral louvers or weatherproof hoods as specified herein.
- e. Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. If the NEMA 3R wrapper is fabricated by a third party manufacturer, the MCC manufacturer shall review the ventilation design and certify in writing that the proposed ventilation system is properly designed and the MCC manufacturer’s warranty for the MCC equipment is in full effect.

- f. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the NEMA 3R wrapper fans and thermostats, unless Drawings show otherwise. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all fans and temperature controls.

2.02 SWITCHBOARDS

A. General

1. Service and distribution switchboards shall be 600 V class suitable for operation on a three-phase, 480 V, 60 Hz system. Switchboards shall be configured for 3-wire or 4-wire systems, as indicated on the Drawings. Switchboards shall be manufactured by Eaton/Cutler-Hammer, Schneider Electric/Square D, or General Electric (no substitutes).
2. Switchboards shall be manufactured in compliance with UL 891 and shall be UL labeled.
3. Switchboard amperage ratings, including all devices, shall be based on a maximum ambient temperature of 40°C per UL Standard 891. With no de-rating required, temperature rise of switchboards and devices shall not exceed 65°C in a 40°C ambient environment. Where specified, switchboards and devices shall be suitable for operation in a 50°C ambient environment with the appropriate de-rating factors incorporated into the equipment design as certified by the manufacturer.

B. Structure

1. Switchboards shall be front accessible with fixed individually mounted or drawout mounted main protective devices and fixed individually mounted or panel mounted bolt-on protective devices.
2. Switchboards shall be fully self-supporting structures with 90 inch (nominal) tall vertical sections (excluding lifting eyes and pull boxes) bolted together to form the required arrangement.
3. Switchboard frame shall be die formed, 12 gauge (minimum) steel with reinforced corner gussets. Frame shall be rigidly bolted to support cover plates (code gauge steel), bus bars and installed devices during shipment and installation. All covers shall be attached with hex head bolts.

4. Switchboards shall be capable of being bolted directly to a concrete floor or slab without the use of floor sills. All switchboard sections shall have open bottoms and removable top plate(s) to install conduit as shown on the Drawings.
5. Front covers shall be screw removable with a single tool and doors shall be hinged and provided with removable hinge pins. All edges of front covers shall be formed.
6. Unless indicated otherwise herein or on the Drawings, the incoming pull section shall be bused. Incoming cable entry into the pull section shall be as shown on the Drawings.
7. Distribution sections shall be bused and shall be matched and aligned with the basic switchboard. Bus transition and incoming cable pull sections shall be matched and aligned with the basic switchboard.
8. Barriers shall be provided between adjacent switchboard sections. A vertical insulating barrier shall be provided between the incoming cable pull section and the main bus to protect against inadvertent contact with main or vertical bus bars. Through-busing shall be taped to provide insulation and isolation.
9. Service switchboard shall be suitable for use as service entrance equipment. Service switchboard incoming pull section, and utility metering compartment and section shall be fabricated in accordance with utility company's requirements and UL service entrance requirements, including UL service entrance label, incoming line isolation barriers, and removable neutral bond to switchboard ground for solidly grounded wye systems. If a separate vertical section is required for utility metering, it shall be matched and aligned with the basic switchboard.
10. Where indicated on the Drawings, switchboard shall be provided with top mounted pull box. Adequate ventilation shall be provided to maintain temperature in pull box within the same limits as the switchboard. Bottom of pull box shall be constructed of insulating, fire-resistive material with separate holes for cable drops into switchboard.
11. The switchboard assembly shall be provided with adequate lifting means (e.g. lifting eyes or lifting bars).

C. Buses

1. All bus bars shall be hard-drawn tin-plated copper of 98 percent conductivity. Plating shall be applied continuously to bus work.

2. The phase through-busing shall have a minimum ampacity as indicated on the Drawings. The main incoming bus bars shall be rated for the same ampacity as the through-busing. For four-wire systems, the neutral bus shall be of equivalent ampacity as the phase bus bars. Tapered bus is not permitted. Busing shall be of sufficient cross-sectional area to meet UL 891 temperature rise requirements. Plating shall be applied continuously to bus work.
3. Ground bus shall be sized per NEC and UL 891 Tables 28.1 and 28.2. Ground bus shall be firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
4. Where indicated on the Drawings, full provisions for the addition of future sections shall be provided. Bussing shall include, but not be limited to, all necessary hardware to accommodate splicing for future additions.
5. Where indicated on the Drawings, equip compartments designated for future protective devices with mounting brackets, supports, bus connections, and appurtenances at the full rating of the future device. Compartments for future devices shall be provided with all necessary straps, hardware, and filler plates to completely cover the openings.
6. Isolation barriers shall be configured to permit access to busing for verification of bus bolt torque.
7. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.
8. The bus system shall be rated for an available short-circuit capacity of not less than 65,000 RMS amperes. If the results of the Contractor's Electrical Short-circuit and Protective Device Evaluation and Coordination Study, as accepted by the District, indicate that a higher short-circuit duty rating of the switchboard is required, Contractor shall furnish the switchboard with that higher rating.

D. Instrument Transformers

1. All instrument transformers shall be UL listed.
2. Current transformers shall be provided with ratios, accuracy class and burden to support connected meters, relays and instruments, as required by ANSI/IEEE C57.13.

3. Potential transformers shall be provided with secondary voltage rating of 120 V (unless specified otherwise) and shall be provided with burden and accuracy to support connected meters, relays and instruments, as required by ANSI/IEEE C57.13.
4. Control power transformers shall be dry type and mounted in separate compartments for units larger than 3 KVA.
5. Where current transformers for neutral and ground fault current sensing are required, connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker (where specified). Coordinate with feeder circuit breaker ground fault protection.

E. Control Power

1. Control Circuits: 120 volts, supplied through secondary disconnecting devices from control power transformer.
2. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. Wiring and Terminations

1. Copper compression type lugs shall be provided for all line and load terminations, and shall be suitable for copper cable rated for 75°C of the size as indicated on the Drawings.
2. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors, including branch circuit ground conductors, shall be provided as indicated on the Drawings.
3. Where fine stranded conductors, Class C and higher (such as DLO cable) are utilized for internal wiring, all terminations in mechanical lugs shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.

4. Control wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control wiring shall be factory installed with bundling, lacing and protection included. Factory control wiring shall include conductors for interconnections between shipping units.
5. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
6. All control wire shall be bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle-type terminals provided are integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.
7. Control wires connected to door mounted components shall be tied and bundled in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall allow the door to swing full open without undue stress or abrasion. Bundles shall be held on each side of hinge by mechanical fastening devices.

G. Enclosures

1. Switchboards Located Indoors

Unless indicated otherwise on the Drawings, switchboards located indoors shall be provided with free standing NEMA Type 1 enclosures. As a minimum, switchboard NEMA 1 enclosures shall comply with the following requirements:

- a. Enclosures shall be provided in accordance with UL 891 requirements. Each enclosure shall be adequately ventilated to limit the temperature rise of the switchboard and all devices to 65°C in a 40°C ambient environment. Top and bottom conduit areas shall be clearly indicated on the shop drawings.
- b. Ventilation openings shall be covered by interior mounted air filters. Air filters shall be washable aluminum mesh type and shall be removable (without the use of tools) for cleaning.

2. Switchboards Located Outdoors

Unless indicated otherwise on the Drawings, switchboards located outdoors shall be provided with NEMA Type 3R, non-walk-in (rainproof) enclosures. Switchboard NEMA Type 3R, non-walk-in enclosures shall be based on free standing NEMA Type 1 enclosures with a NEMA 3R wrapper. The additional housing supplied by the NEMA 3R wrapper shall provide protection from rain, sleet, and ice. As a minimum, switchboard NEMA Type 3R, non-walk-in enclosures shall comply with the following requirements:

- a. The enclosing NEMA 3R wrapper shall be constructed of 12 gauge galvanized steel with a flat or sloped roof line. Sloped roof lines shall be sloped from front to rear at a minimum of 1/2 inch per foot. Doors shall be louvered and hooded at top and bottom, and gasketing shall be provided around four door closing flanges.
- b. Each NEMA 3R wrapper split or section shall have a minimum of 30 inches working clearance from hinge flange to door closure flange. The width of open unobstructed area when door is open shall be 30 inches minimum.
- c. NEMA 3R wrapper splits shall be coordinated with the switchboard section splits. Cabinet spacers shall be provided at switchboard section splits to permit full opening (90 degrees, minimum) of all switchboard doors without interfering with the NEMA 3R wrapper doors. Switchboard shall be provided with all cabinet spacers, through-bus splice kits, neutral bus splice kits, and ground bus splice kits required to interconnect switchboard sections and provide the necessary separation for switchboard doors to fully open.
- d. The distance between the front of the interior switchboard section and the outer doors shall be 11 inches, minimum.
- e. Interior lighting shall be provided in the NEMA 3R wrapper vestibule using LED lighting fixtures, single-tube, with length as necessary for width of NEMA 3R wrapper split. A light switch shall be provided on side extension for each switchboard shipping split, and shall be furnished with a stainless steel cover plate.
- f. Convenience receptacles shall be provided for each switchboard shipping split, and shall be duplex GFCI type, with stainless steel cover.

- g. All switchboard sections, except pull sections, shall be provided with space heaters. Space heaters shall be provided with adequate wattage to prevent condensation. Space heaters shall be installed within the NEMA 1 switchboard sections and shall operate on 120 V, 60 Hz power. Line voltage thermostats shall be provided for controlling the space heaters. The thermostats shall monitor the temperature inside the NEMA 1 enclosures with temperature adjustment accessible from the outside face of the enclosures.
- h. NEMA 3R wrapper doors shall be provided with ventilation openings as required for proper cooling of the switchboard and devices. As a minimum, each ventilation opening shall be provided with louvers integrally molded into the door and covered by interior mounted air filters with gasketing. Air filters shall be washable aluminum mesh type and shall be removable (without the use of tools) for cleaning. Alternatively, ventilation openings in doors may be clear openings covered by exterior weatherproof hoods. Openings shall be provided with washable air filters as specified above. In addition, openings at the bottom of the hoods shall be provided with removable insect screens.
- i. Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. If the NEMA 3R wrapper is fabricated by a third party manufacturer, the switchboard manufacturer shall review the ventilation design and certify in writing that the proposed ventilation system is properly designed and the switchboard manufacturer's warranty for the switchboard equipment is in full effect.
- j. NEMA 3R wrapper front door handles shall have provisions for padlocking and shall be equipped with wind stops.
- k. Control power transformers shall be provided within the switchboard to supply power to the space heaters, interior lighting, and receptacles. Control power transformers shall be equipped with primary and secondary fuse protection. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all space heaters, temperature controls, interior lighting, and receptacles.

H. Finish

- 1. All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC Powder Coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.

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2. Pre-treatment shall include:
 - a. Hot alkaline cleaner to remove grease and oil.
 - b. Iron phosphate treatment to improve adhesion and corrosion resistance.
3. The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.
4. The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.
5. Paint color for switchboard NEMA 1 enclosures shall be #49 medium light gray per ANSI Standard Z55.1 (60-70 gloss) on all surfaces, unless specified otherwise.
6. Paint color for switchboard NEMA 3R enclosures (NEMA 3R wrappers) shall be white (60-70 gloss) on all surfaces, unless specified otherwise.

I. Protective Devices

1. Switchboard protective devices shall be furnished as indicated on the Drawings and specified herein, including interconnections, instrumentation and control wiring.
2. Main protective devices shall be fixed individually mounted or drawout mounted. Branch protective devices shall be fixed individually mounted or group mounted with bolted connections.
3. Protective devices shall be provided with frame sizes as indicated on the Drawings. Protective devices with frame sizes less than or equal to 2000 A shall be molded case circuit breakers as specified in Part 2.04D, herein. Unless specified otherwise, protective devices with frame sizes greater than 2000 A shall be insulated case power circuit breakers as specified in Part 2.04E herein. The short-circuit current rating of the protective devices shall be greater than or equal to the switchboard bus rating.

J. Utility Metering and Main Disconnect

1. Main Service Switchboard

Where indicated on the Drawings, main service switchboard shall consist of pull section, utility service (metering) section, and main protective device. Main service switchboard shall be provided in accordance with the requirements specified herein and as indicated on the Drawings.

Equipment shall include a separate, barriered-off, utility metering compartment complete with hinged sealable door as approved by the utility company. Bus work shall include provisions for mounting utility company current transformers, potential transformers, potential taps, test devices, and metering as required by the utility company. Switchboard neutral to ground bonding connection shall be in accordance with utility company requirements. Provide Service Entrance Label and provide necessary applicable service entrance features per NEC, local code requirements, and utility company requirements.

All electrical service equipment shall be in strict accordance with utility company requirements and requirements specified herein. In cases of conflict between the requirements specified herein and the requirements of the utility company, the more stringent requirement shall prevail. Prior to commencing fabrication of electrical service equipment, Contractor shall submit shop drawings of proposed equipment to utility company and District for review and approval.

2. Main Protective Device

Main protective device shall be a molded case circuit breaker or insulated case power circuit breaker as specified in Part 2.04 herein. Circuit breaker shall be provided with a microprocessor-based RMS sensing trip unit, and shall be equipped with ground fault protection and arc-flash reduction maintenance system. Circuit breaker frame size and shall be as indicated on the Drawings. Circuit breaker short-circuit current rating shall be greater than or equal to the switchboard bus rating.

Main circuit breaker shall be equipped with ground fault protection and arc-flash reduction maintenance mode and be capable of remote operation via a switch located in the MCC.

2.03 LIGHTING PANELBOARDS AND TRANSFORMERS

A. Manufacturers

Lighting panelboards and transformers shall be manufactured by Eaton/Cutler-Hammer, Schneider/Square D, or General Electric (no substitutes).

B. General

1. Lighting panelboards mounted in MCCs shall be constructed integrally with the MCC and shall match the finish of the MCC. Lighting panelboards, branch circuit breakers, and transformers mounted in MCCs shall meet the applicable requirements specified herein.
2. Standalone lighting panelboards and transformers shall be provided in accordance with the requirements specified herein. Standalone lighting panelboards shall be suitable surface mounting or flush mounting as indicated on the Drawings.

C. Ratings

1. 240 V lighting panelboards shall be rated to withstand a minimum fault current of 22,000 amperes symmetrical, unless a higher fault current is indicated on the Drawings or determined by Contractor's Electrical Short-circuit and Protective Device Evaluation and Coordination Study.
2. Equipment shall meet both UL891 and UL67 thermal standards.

D. Interior

1. Panelboard interiors mounted in MCCs shall be flush mounted with the front of the enclosure to allow easy access to line and/or load conductors entering/exiting top or bottom. Recessing the panel interior more than 3 inches from the front of the enclosure will not be acceptable.
2. Panelboard interior shall be compartmentalized with steel walls on all four sides. Panelboard shall be sized to provide a minimum of 4 inches of gutter space on all sides.
3. Panelboard main breakers shall be integral to the panel interior. Main breakers separate from the interior will not be acceptable.
4. Provide one continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors suitable for bolt-on branch circuit breakers. The bussing shall be fully rated. Panelboard bus current ratings shall be determined by heat-rise tests conducted in accordance with UL 67. Bussing shall be plated copper. Aluminum bussing will not be acceptable. Bus bar plating shall run the entire length of the bus bar.
5. Current carrying parts shall be insulated from ground and phase-to-phase by high dielectric strength thermoplastic.

6. Panelboard shall be provided with a solidly bonded, plated copper, equipment ground bar(s). Ground bar(s) shall be adequate for terminating ground conductors for the maximum number of panel circuits.
7. Panelboard shall be provided with full size neutral bars with suitable lugs for the maximum number of panel circuits. Neutral bars shall be plated copper and shall be located in the main compartment so incoming neutral cable may be of the same length.
8. Panelboard interior shall be provided with nameplates containing system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, UL-listed label, and short-circuit current rating shall be displayed on the interior.

E. Fronts

1. Trim front shall one-piece, bolt-on type with door, and shall meet strength and rigidity requirements of applicable UL 50 standards. Door shall have rounded corners and edges free of burrs.
2. Interior trim shall be of deadfront construction to shield user from energized parts. Deadfront trim shall have filler plates covering unused circuit breaker mounting spaces.
3. Fronts for NEMA Type 1 enclosures shall have flush cylindrical tumbler lock with catch and spring-loaded stainless steel door pull. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. Front shall not be removable with the door locked.
4. A clear plastic directory cardholder with typed circuit directory shall be mounted on the inside of the door. Adhesive circuit directories are not acceptable.

F. Enclosures

1. Enclosures for lighting panelboards mounted in MCCs shall be constructed integrally with the MCC enclosure.

2. Enclosures for standalone lighting panelboards shall be provided in accordance with the following:
 - a. Enclosures shall be constructed of galvanized steel with a ANSI #49 gray enamel electrodeposited over cleaned phosphatized steel. Enclosures shall be constructed in accordance with UL 50 and 50E requirements.
 - b. Unless indicated otherwise on the Drawings, indoor enclosures shall be NEMA Type 1 gasketed, and outdoor enclosures shall be NEMA Type 3R gasketed.
 - c. Outdoor NEMA Type 3R enclosures shall be provided with a padlockable hasp to secure the door.

G. Main Circuit Breaker

1. Main circuit breakers for lighting panelboards shall be molded case thermal-magnetic circuit breakers. Circuit breakers shall be provided with inverse time-current elements for low-level overloads and instantaneous magnetic trip elements for short-circuits. Circuit breakers shall be UL listed with amperage ratings and number of poles as indicated on the Drawings.
2. Main circuit breaker interrupting rating shall be selected to match the lighting panelboard short-circuit current rating (minimum 22,000 RMS symmetrical amperes).
3. Main circuit breaker shall have an over-center, trip-free, toggle mechanism which shall provide quick-make, quick-break contact action. Circuit breaker shall have a permanent trip unit with thermal and magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and shall be factory calibrated to operate in a 40°C ambient environment. Thermal elements shall be ambient compensating above 40°C.
4. Two-pole and three-pole circuit breakers shall have common tripping of all poles. Circuit breaker frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker that shall allow the user to simultaneously select the desired trip level of all poles. Circuit breakers shall have a push-to-trip button for maintenance and testing purposes.
5. Circuit breaker handle and faceplate shall indicate rated ampacity. Circuit breaker shall be provided with handle accessories for locking handle in the off position.

6. Circuit breaker lugs shall be UL-listed to accept solid or stranded copper conductors only. Lug sizes shall be based on conductor ampacities corresponding to those shown in NEC Table 310-16 for 75°C rated wire.
7. Circuit breakers shall be bolted-on type. Snap-in designs are not acceptable.
8. Main circuit breakers shall be UL-listed for use with the following factory installed accessories: shunt trip, under voltage trip, ground fault trip, auxiliary switch, alarm switch, and mechanical lug kits. Main circuit breaker accessories shall be provided as indicated on the Drawings.

H. Branch Circuit Breakers

1. Branch circuit breakers for lighting panelboards shall be molded case thermal-magnetic circuit breakers. Circuit breakers shall be provided with inverse time-current elements for low-level overloads and instantaneous magnetic trip elements for short-circuits.
2. Branch circuit breakers shall be HACR type, unless specified otherwise. Breakers shall be UL-listed with amperage ratings and number of poles as indicated on the Drawings. Unless specified otherwise, minimum amperage rating for branch circuit breakers shall be 20 A, and amperage rating for spare circuit breakers shall be 20A.
3. Interrupting ratings of branch circuit breakers shall match rating of main circuit breaker.
4. Molded case branch circuit breakers shall be bolt-on type. Snap-in designs are not acceptable.
5. Circuit breakers shall have an over-center, trip-free, toggle mechanism which shall provide quick-make, quick-break contact action. Circuit breakers shall have thermal and magnetic trip elements in each pole. Two-pole and three-pole circuit breakers shall have common tripping of all poles. Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true RMS sensing and thermally responsive to protect circuit conductors in a 40°C ambient temperature.
6. Circuit breakers shall be provided with two forms of visible trip indication. The circuit breaker handle shall reside in a position between on and off. In addition, there shall be a red indicator appearing in the clear window of the circuit breaker housing.

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7. The exposed faceplates of branch circuit breakers shall be flush with one another.
8. Ground Fault Current Interrupting (GFCI) circuit breakers shall be provided where indicated on the Drawings. GFCI circuit breakers shall be UL Class A with 30 mA sensitivity.
9. Circuit breaker lugs shall be UL-listed to accept solid or stranded copper conductors only. Lug sizes shall be based on conductor ampacities corresponding to those shown in NEC Table 310-16 for 75°C rated wire.

I. Lighting Panel Transformers

1. Transformers for lighting panels shall be energy efficient (NEMA TP-1 compliant or Energy Star labeled), dry type, and UL listed with a minimum KVA rating as indicated on the Drawings. Unless specified otherwise, transformers shall be single phase, 480 V primary and 120/240 V secondary.
2. Transformer shall be "K" rated for high harmonic loads when non-linear loads are present.
3. Transformers shall be provided with a minimum of 4 full capacity primary winding taps. Unless specified otherwise, 2 winding taps shall be provided at 2.5 percent above nominal, and 2 winding taps shall be provided at 2.5 percent below nominal.
4. Transformer insulation system shall be rated at 220°C and designed for full load operation at a maximum of 115°C temperature rise above 40°C ambient. Transformers shall be capable of carrying a 15 percent continuous overload without exceeding a 150°C temperature rise above 40°C ambient.
5. Transformer coils shall be copper continuous wound construction and shall be impregnated with non-hygroscopic thermosetting varnish.
6. Each transformer winding shall be provided with an electrostatic shield arranged to minimize inter-winding capacitance.
7. Fan cooled transformers will not be acceptable.
8. Sound level shall be warranted by the manufacturer not exceed 45 decibels measured at 5 feet from the transformer.
9. The secondary side neutral conductor of the transformer shall be factory grounded.

10. The core of the transformer shall be grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
11. Transformers shall be factory installed in a freestanding enclosure (except for MCC applications), NEMA Type 1 for indoor locations and NEMA Type 3R for outdoor locations. Transformer enclosures shall be ventilated and fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI #49, gray.

2.04 PROTECTIVE DEVICES

A. General Requirements for Molded Case Circuit Breakers

1. Molded case circuit breakers shall be UL listed and conform to UL 489 and NEMA AB1. Molded case circuit breakers shall be as manufactured by Eaton/Cutler-Hammer, Schneider/Square D, General Electric, or approved equal.
2. Unless specified otherwise, mold case circuit breakers shall be thermal-magnetic type with inverse time-current thermal element for low-level overloads, and instantaneous magnetic trip element for short-circuits.
3. Circuit breakers shall be provided with ambient temperature compensating thermal trips for a minimum range of 10 to 50 °C.
4. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
5. Breakers specified for operation on a 480 V, 60 Hz system shall be rated for 600 V and shall have a minimum symmetrical interrupting capacity of 65,000 A. Breakers shall be provided with a higher interrupting capacity, if indicated on the Drawings or required by the Contractor's Electrical Short-circuit and Protective Device Evaluation and Coordination Study.

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6. Circuit breaker amperage rating shall be as required to protect the specified branch circuit and equipment. Contractor shall coordinate circuit breaker amperage rating with actual equipment to be furnished. Minimum circuit breaker amperage rating shall be as indicated on the Drawings.
7. Contractor shall coordinate the applicable circuit breaker sensor, trip unit, and rating plug with the required amperage rating.
8. Where indicated on the Drawings, circuit breakers shall be UL listed for application in their intended enclosures at 100% of their continuous ampere rating.
9. Ground fault protection shall be provided where indicated on the Drawings.
10. Where indicated on the Drawings, circuit breakers shall be current limiting.
11. Unless specified otherwise, circuit breaker load connections shall be compression style, suitable for copper conductors of the number, size, and type indicated on the Drawings.

B. Molded Case Circuit Breakers with Non-Interchangeable Trip Units

1. Unless specified otherwise, circuit breakers with 100 A frames and below shall be provided with factory installed non-interchangeable trip units.
2. Unless specified otherwise, circuit breakers with non-interchangeable trip units shall be provided with fixed magnetic trip elements.

C. Molded Case Circuit Breakers with Interchangeable Trip Units

1. Unless specified otherwise, circuit breakers with 225 A to 600 A frames shall be provided with interchangeable trip units. Trip units shall be field interchangeable. Factory interchangeable trip units are not acceptable.
2. Circuit breaker magnetic trip element shall be provided with front-mounted, field adjustable trip setting. As a minimum, the adjustable magnetic trip shall provide high, low, and intermediate trip settings.

D. Molded Case Circuit Breakers with Solid-State Trip Units

1. Unless specified otherwise, circuit breakers identified on the Drawings as “main circuit breakers” (located in the main service switchboard, distribution switchboards, or MCCs), or circuit breakers with 800 A frames and above shall have solid-state trip units. In addition, the “main circuit breaker” located in the main service switchboard shall be equipped with ground fault protection.
2. As a minimum the solid-state trip units shall be provided with the following components, features, and capabilities:
 - a. Microprocessor-based trip device, flux-transfer shunt trip, and three (3) integral current sensors. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors, and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached. The trip unit shall be Eaton type Digitrip 310, General Electric type MicroVersaTrip Plus, or approved equal.
 - b. An adjustable trip setting dial mounted on the front of the trip unit and interchangeable ratings plugs shall establish the continuous trip ratings of each circuit breaker as a function of the rating plug amperage. Rating plugs shall be field interchangeable. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
 - c. As a minimum, system coordination shall be provided by the following microprocessor-based time-current curve shaping features: adjustable long-time setting and delay, adjustable short-time setting and delay, adjustable instantaneous pick-up, adjustable instantaneous setting (pick-up), and where specified, adjustable ground fault setting and delay.
 - d. The microprocessor-based trip unit shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.
 - e. When the adjustable instantaneous setting is omitted, the trip unit shall be operate with an instantaneous override.

- f. Where internal ground fault protection is specified, adjustable settings shall not exceed 1200 A. Provide neutral ground fault sensor for four-wire loads.
- g. Breakers shall have built-in jack located on the front to accept a test cable from a test kit. Provide one portable, battery operated test kit capable of testing all breakers 225 A frame and above. The test kit shall test the circuit breaker while the circuit breaker is carrying load, and shall provide either a trip or no trip test. The test kit shall simulate a time-over current condition for the long-time, short-time and ground fault functions. The test kit shall also read trip unit switch settings and provide a report of the trip unit self-test feature.
- h. Where specified herein or indicated on the Drawings, the trip unit shall be provided with an arc-flash reduction maintenance system capability. The arc-flash reduction maintenance system shall allow the operator to enable a maintenance mode using a keyed switch which enables a preset accelerated instantaneous override to reduce arc-flash energy. A LED light on the trip unit shall indicate the trip unit is in the maintenance mode.

E. Insulated Case Power Circuit Breakers

- 1. Unless specified otherwise, circuit breakers with frame ratings greater than 2,500 A, shall be insulated case power circuit breakers. Insulated case power circuit breakers shall be drawout type. Insulated case power circuit breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
- 2. Unless specified otherwise, insulated case power circuit breakers shall be electrically operated. To facilitate lifting, the insulated case circuit breaker shall have integral handles on the side of the breaker.
- 3. Electrically operated breakers shall be complete with close/open pushbuttons, plus red and green status lights to indicate breaker contact position, and 120 VAC motor operators. The AC source shall be supplied by a control power transformer internal to the panel assembly.

4. Breakers shall have a minimum symmetrical interrupting capacity of 65,000 A at 600 V. Breakers shall be provided with a higher interrupting capacity, if indicated on the Drawings or required by the Contractor's Electrical Short-circuit and Protective Device Evaluation and Coordination Study. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to 18 times their frame ratings. Insulated case circuit breakers without an instantaneous trip element adjustment shall be equipped with a fixed internal instantaneous override set at that level.
5. All insulated case power circuit breakers shall be constructed and tested in accordance with UL requirements, and shall carry a UL label.
6. Each insulated case circuit breaker shall be equipped with a solid-state trip unit. As a minimum the solid-state trip unit shall be provided with the following components, features, and capabilities:
 - a. Microprocessor-based trip device, flux-transfer shunt trip, and three current sensors. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker. The trip unit shall be Eaton type Digitrip RMS 520, or equal.
 - b. The trip unit shall be provided with individually adjustable time/current curve shaping solid-state elements for protective device coordination, and shall, as a minimum, include: long delay pickup and time, short delay pickup and time, and instantaneous pickup. Unless specified otherwise, trip units provided on insulated case circuit breakers in main service switchboards shall be provided with ground fault protection, including adjustable ground fault current pickup and time. The trip unit shall have provisions for a single test kit to test each of the trip functions.
 - c. The trip unit shall be provided with an information system that indicates mode of trip with LEDs following an automatic trip operation. The unit shall also be equipped with a display panel that provides a representation of the time/current curve which shall indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

- d. The solid-state trip unit shall be provided with an arc-flash reduction maintenance system capability. The arc-flash reduction maintenance system shall allow the operator to enable a maintenance mode using a keyed switch which enables a preset accelerated instantaneous override trip to reduce arc-flash energy. A LED light on the trip unit shall indicate the trip unit is in the maintenance mode.
7. The insulated case circuit breaker shall have a closing time of not more than 3 cycles. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.
8. The insulated case circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.
9. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a “Positive On” feature. The breaker flag will read “Closed” if the contacts are welded and the breaker is attempted to be tripped or opened.
10. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug shall provide indication of the rating on the front of the trip unit.
11. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.

12. Drawout breaker cells shall be equipped with drawout rails and primary and secondary disconnecting contacts. The stationary part of the primary disconnecting devices for each insulated case circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the insulated case circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs.
 - a. The secondary disconnecting devices shall consist of plug-in connectors mounted on the removable unit and engaging floating plug-in connectors at the front of the compartment. The secondary disconnecting devices shall be gold-plated and pin and socket contact engagement shall be maintained in the “connected” and “test” positions.
 - b. The removable insulated case circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for drawout application. It shall have four (4) positions: CONNECTED, TEST, DISCONNECTED and REMOVED all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall secure the breaker in the connected, test or disconnected position by preventing levering.

2.05 NAMEPLATES AND PLAQUES

- A. Engraved laminated plastic nameplates shall be provided to identify MCCs, switchboards, panelboards, door mounted components, and internal components. Nameplates shall be mounted on the face of the assembly.
- B. Nameplates shall be 1/16" thick with beveled edges and satin finish. Nameplates shall be provided with black background and white letters. Letters shall be a minimum of 3/16" high. Nameplates shall be fastened with round head stainless steel screws.

- C. Nameplates shall be provided for each MCC and each unit compartment. MCC nameplate shall designate: name of manufacturer, system voltage, main bus rating, main bus short-circuit rating, and vertical bus rating. MCC compartment nameplates shall designate the descriptions indicated on the Drawings. Nameplates shall be provided for each pilot device or instrument mounted on the MCC compartment doors. Pilot device nameplates shall be manufacturer's standard style. Device nameplates shall designate the descriptions indicated on the Drawings.
- D. Nameplates shall be provided for each switchboard and each circuit breaker and device mounted on front of the switchboard. Switchboard nameplate shall designate: name of manufacturer, system voltage, bus rating, and bus short-circuit rating. Nameplates for the branch circuit breakers shall designate the equipment fed through the breaker.
- E. Nameplates shall be provided for each panelboard and transformer. Panelboard nameplate shall designate: system voltage, bus rating, and number of circuits. Transformer nameplate shall designate: primary and secondary voltage, and KVA rating.
- F. All nameplates shall be approved by the District prior to fabrication. Contractor shall submit for District approval, a master nameplate spreadsheet, listing: nameplate description (each line), letter height, and nameplate dimensions.
- G. A plaque displaying a mimic bus diagram shall be provided for each switchboard. The mimic bus diagram shall be a concise visual presentation of principal switchboard components and connections. The mimic bus diagram shall be arranged in single-line diagram format, using symbols and letter designations consistent with the as-built bus diagram. The mimic bus diagram shall be engraved on an anodized aluminum plaque.

2.06 SPARE PARTS AND ACCESSORIES

- A. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished. Spare parts shall be properly packaged for shipment and storage, and shall be labeled with the manufacturer's part number(s).
- B. As a minimum, Contractor shall furnish the following spare parts:
 - 1. Two (2) fuses of each type and size for three-phase power.
 - 2. Five (5) fuses of each type and size for single-phase power (including control power).
 - 3. One (1) circuit breaker auxiliary switch of each type.
 - 4. Two (2) operating coils for each size AC contactor.

5. Two (2) complete sets of 3-pole stationary and moving contact assemblies for each size AC contactor.
6. Three (3) contactor overload relays of each type and rating, each relay with a complete set of contact blocks.
7. One (1) spare set of heater elements for each heater rating provided.
8. Two (2) indicating light assemblies of each type.
9. One (1) control relay of each type and rating.
10. One (1) contactor auxiliary contact of each type.
11. Two (2) one quart containers of finish paint for indoor MCC and switchboard enclosures. One quart for each, if finish paint differs for MCC and switchboard enclosures.
12. Two (2) one quart containers of finish paint for the outdoor MCC and switchboard enclosures. One quart for each, if finish paint differs for MCC and switchboard enclosures.
13. 4 keys for each type of door lock and keying.
14. Portable test kit(s) for circuit breaker microprocessor trip units to test each of the trip unit functions without removal from the panel. One test kit shall be provided for each type of trip unit supplied.
15. MCC and switchboard accessory sets, including, but not limited to, tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
16. One (1) remote racking device for drawout circuit breakers.
17. One (1) portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments and suitable for the largest circuit breaker furnished.

PART 3 – EXECUTION

3.01 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be performed in accordance with the latest version of ANSI and NEMA standards.

The MCCs and switchboards shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete MCCs and switchboards shall be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities. The wiring and control circuits shall be given a functional test at rated voltage.

- B. The manufacturer shall provide certified copies of factory test reports to District for approval prior to shipment.

3.02 INSTALLATION

- A. Contractor shall install all equipment in accordance with the manufacturer's written instructions, NEC standards, requirements and standards specified herein, and as indicated on the Drawings.
- B. Each assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position.
- C. Contractor shall anchor MCCs and switchboards to reinforced concrete pads and floor slabs in accordance with the calculations and details prepared by the manufacturer's engineer. Anchor bolt embedment depth shall be based on the thickness of the structure slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment.
- D. Verify the compatibility of conductor size, type, and stranding versus the power lugs furnished. Utilize correct lugs in all applications. Crimp compression lugs with manufacturer recommended tools.
- E. Support incoming line conductors and outgoing load conductors to withstand the effects of a fault current. Support (brace) incoming and outgoing conductors in accordance with the manufacturer's written requirements and per NEC, including brace material and spacing.

- F. Tighten all bus splices, lugs, connectors, terminals, etc. in accordance with the equipment manufacturer's published torque tightening values for same.
- G. Perform all pre-energizing checks as recommended by the manufacturer, including, but not limited to, the following:
 - 1. Verify field wiring for proper conductor sizing.
 - 2. Verify field wiring connection points with the Drawings and manufacturer's electrical schematics.
 - 3. Verify the integrity of all field connections, including proper torquing of connections.
 - 4. Verify field connections for proper spacing between adjacent phases and/or phases to ground.
 - 5. Verify proper support (bracing) of all incoming and outgoing conductors.
 - 6. Verify that all ground connections have been properly made, including: ground bar connections to facility grounding system, and ground conductor connections to equipment or facility grounding systems.
 - 7. Verify that all barriers and parts that may have been removed during installation have been re-installed.

3.03 FIELD QUALITY CONTROL

- A. Contractor shall provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this Section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
- B. The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.
 - 1. Rig the assembly into final location and install on level surface.
 - 2. Check all removable circuit breakers and starter units for easy removal and re-insertion.

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3. Perform insulation tests on each power phase and verify low resistance ground connection on ground bus.
4. Connect all power wiring and control wiring and verify basic operation of each starter from control power source.
5. Torque all bolted connections made in the field and verify all factory bolted connections.
6. Calibrate any solid-state metering or control relays for their intended purpose and make written notations of adjustments on record drawings. Perform startup of any solid-state starters and variable frequency drives.

3.04 FIELD ADJUSTMENTS AND TESTING

- A. Contractor shall perform all equipment field adjustments and testing in accordance with the manufacturer's written instructions and Contract Document requirements, including, but not limited to: short-circuit protective device settings, overload relay settings, timing relays, and startup and testing.
- B. Contractor shall coordinate and set circuit breaker tripping sequence from main service protective device to individual motors.
- C. MCCs, switchboards, and panelboards shall be tested as stipulated in the NETA testing procedures for same and as specified in Section 16010.
- D. Contractor shall prepare formal field reports on all tests performed, providing a written description of each test, test values recorded, parameter limits, deficiencies, equipment adjustments, etc., and shall provide same to District for review and approval.

3.05 MANUFACTURER'S CERTIFICATION

- A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the performance of field testing and the generation of any reports.
- B. Manufacturer's written certification shall be provided in accordance with Section 16010.

3.06 CLEANUP

- A. All parts of the electrical equipment and materials shall be left in a clean condition. Exposed parts shall be clean of dust, dirt, cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and cleaned. Paint touch-up shall be applied to all scratches on panels and cabinets. Electrical cabinets or enclosures shall be free of spider webs.
- B. Paint touch-up matching factory color and finish shall be applied to all scratches on panels and cabinets.

3.07 INSTRUCTION

After the equipment has been installed, tested, and adjusted, and placed in satisfactory operating condition, the equipment manufacturer shall provide classroom instruction to District's personnel in the use and maintenance of the equipment. Four (4) hours of instruction shall be provided unless otherwise specified. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall answer any questions from District personnel. The manufacturer's obligation shall be considered ended when he and the District agree that no further instruction is needed.

END OF SECTION 16480

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