

**READ THIS FIRST**

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (\*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

**<https://www.portseattle.org/page/guide-specifications>.**

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY AND NOTES TO DESIGNER**

- A. Section includes enclosed controllers rated 600 V and less. Starting methods may include, but are not limited to, the following:
  - 1. Full-voltage manual.
  - 2. Full-voltage magnetic reversing (FVR) and non-reversing (FVNR).
  - 3. Magnetic Reduced-voltage autotransformer (RVAT).
  - 4. Magnetic Reduced Voltage Part Winding.
  - 5. Magnetic Reduced Voltage Wye-Delta open or closed transition.
  - 6. Magnetic two-speed, one or two windings.
  - 7. Reduced-voltage solid state.
  - 8. Reduced voltage solid state with contactor bypass.
  - 9. Solid State soft start.
- B. Provide reduced voltage starters for centrifugal horsepower motors for voltages and sizes as noted below:
  - 1. 5 HP and larger – 208V, 3 phase.
  - 2. 5 HP and larger – 480V, 3 phase.
- C. Positive displacement loads shall have reduced voltage starters.
- D. Specify Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays as required by engineering considerations.

- E. Training: For large projects, engage a factory-authorized service representative to train Port's maintenance personnel. For small projects, Contractor shall perform training. Coordinate with F&I and AV Maintenance on training requirements.
- F. Related Section:
  - 1. Section 262419 "Motor Control Centers".
- G. Comply with the following:
  - 1. NEMA standards
  - 2. IEC standards: IEC fixed overload type controllers are approved only when included in original equipment manufacturer (OEM) equipment. For other applications, IEC controllers shall not be used.
  - 3. NFPA 70 as adopted and administered by the Authority Having Jurisdiction.
  - 4. Provide motor controllers that are UL listed and labeled.

### **1.3 DEFINITIONS**

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.

### **1.4 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

### **1.5 ACTION SUBMITTALS**

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
  - 1. Show tabulations of the following:
    - a. Each installed unit's type and details.
    - b. Factory-installed devices.
    - c. Nameplate legends.
    - d. Short-circuit current rating of integrated unit.
    - e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
    - f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
  - 2. Wiring Diagrams: For power, signal, and control wiring.

## **1.6 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- E. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

## **1.7 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  - 1. Manufacturer's product literature.
  - 2. Parts list.
  - 3. Wiring schematics/diagrams.

4. Heater tables.
5. Routine maintenance requirements for enclosed controllers and installed components.
6. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
7. Manufacturer's written instructions for setting field-adjustable overload relays.
8. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

#### **1.8 MATERIALS MAINTENANCE SUBMITTALS**

- A. Furnish standby materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: Furnish one standby for every five installed units, but no fewer than one set of three of each size and type.
  2. Indicating Lights: Furnish one standby for every five installed units, but no less than one set of three of each size and type used.

#### **1.9 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
  1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.
- D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

#### **1.10 DELIVERY, STORAGE, AND HANDLING**

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

**1.11 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  - 2. Altitude: Not exceeding 1000 feet.

**1.12 COORDINATION**

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

**PART 2 - PRODUCTS**

**2.1 GENERAL**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. EATON Electrical Inc.
  - 2. General Electric Company.
  - 3. Rockwell Automation, Inc., Allen Bradley brand.
  - 4. Square D.

**2.2 FULL-VOLTAGE CONTROLLERS**

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
  - 1. Configuration: Nonreversing OR Reversing OR Two speed.
  - 2. Pilot Light:
    - a. Mounted in front of panel.
    - b. Red indicates "running".
    - c. Green indicates "ready".

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- d. Standard pilot lights are 120V, transformer type, push-to-test.
  - 3. Additional Nameplates: FORWARD and REVERSE for reversing switches, HIGH and LOW for two-speed switches.
- C. Fractional Horsepower Single phase Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
- 1. Configuration: Nonreversing OR Two speed.
  - 2. Lockout means required in all applications.
  - 3. Fault duty to meet available fault current.
  - 4. Interchangeable overload heater elements.
  - 5. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type or melting alloy type.
  - 6. Red pilot light to indicate "running."
  - 7. Additional Nameplates: HIGH and LOW for two-speed controllers.
- D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
- 1. Configuration: Nonreversing, OR reversing OR two speed.
  - 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type or melting alloy type.
  - 3. Red and Green pilot light.
  - 4. Additional Nameplates: FORWARD and REVERSE for reversing controllers OR HIGH and LOW for two-speed controllers.
  - 5. One each N.O. and N.C. reversible auxiliary contact.
- E. Magnetic Controllers: Full voltage, across the line, electrically held.
- 1. Configuration: Nonreversing OR reversing.
  - 2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  - 3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - 4. Control Circuits: 120V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - a. CPT Spare Capacity: Size CPT at least one size above minimum VA requirements.
  - 5. Melting Alloy Overload Relays:
    - a. Inverse-time-current characteristic.
    - b. Class 10 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 6. Bimetallic Overload Relays:

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- a. Inverse-time-current characteristic.
  - b. Class 10 tripping characteristic.
  - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - d. Ambient compensated where indicated.
  - e. Automatic resetting.
  - 7. Solid-State Overload Relay:
    - a. Switch or dial selectable for motor running overload protection. Software selectable is not acceptable.
    - b. Sensors in each phase.
    - c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - e. IP addressable communication module.
  - 8. One each N.C. and N.O. reversible isolated overload alarm contact.
  - 9. External overload reset push button.
- F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
- 1. Sizes 1 through 5 are standard for all applications.
  - 2. Motor controller preferred features include:
    - a. Current sensor/microprocessor-type overload protection with adjustable parameters including overcurrent, ground fault, phase loss, phase unbalance, undervoltage and overvoltage.
    - b. Melting alloy or bimetallic strip type overload relays with ambient compensated inverse time-current characteristics are acceptable.
    - c. Control pushbuttons, industrial oil-tight type.
    - d. Push-to-test pilot lights.
  - 3. Fusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
  - 4. Auxiliary Contacts: Minimum two N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  - 5. Nonfusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: Minimum two N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  - 6. MCP Disconnecting Means:
    - a. Use where available fault current is 65,000 Amps symmetrical or less.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable up to 1300% of motor FLA, short-circuit trip coordinated with motor locked-rotor amperes.

- c. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
- 7. MCCB Disconnecting Means:
  - a. Use where available fault current exceeds 65,000 AIC.
  - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
  - c. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - d. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.

### **2.3 REDUCED-VOLTAGE MAGNETIC CONTROLLERS**

- A. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
- B. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
  - 1. Configuration:
    - a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank. Open or closed transition.
    - b. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
    - c. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
  - 2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  - 3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - 4. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT sized at least one size above the minimum VA requirements. Should an external power source be required, provide auxiliary contacts mechanically tied to the combination starter disconnect switch and wire so that control power within the motor starter module will be disconnected when the motor power disconnect is opened. The secondary of the CPT shall have one leg grounded. No switching of coils shall be allowed between the coil and the ground side.
  - 5. Melting Alloy Overload Relays:
    - a. Inverse-time-current characteristic.
    - b. Class 10 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 6. Bimetallic Overload Relays:

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- a. Inverse-time-current characteristic.
    - b. Class 10 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 7. Solid-State Overload Relay:
    - a. Switch or dial selectable for motor running overload protection. Software selectable controls are not allowed.
    - b. Sensors in each phase.
    - c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - e. IP addressable communication module.
  - 8. One each N.C. and N.O. reversible, isolated overload alarm contact.
  - 9. External overload reset push button.
- C. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
- 1. Sizes 1 through 5 are standard for all applications.
  - 2. Motor controller preferred features include:
    - a. Current sensor/microprocessor-type overload protection with adjustable parameters including overcurrent, ground fault, phase loss, phase unbalance, undervoltage and overvoltage.
    - b. Melting alloy or bimetallic strip type overload relays with ambient compensated inverse time-current characteristics are acceptable.
  - 3. Fusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: Minimum two N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  - 4. Nonfusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: Minimum two N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  - 5. MCP Disconnecting Means:
    - a. Use where available fault current is 65,000 Amps symmetrical or less.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - c. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
  - 6. MCCB Disconnecting Means:
    - a. Use where available fault current exceeds 65,000 Amps symmetrical.

- b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- c. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250A and larger.
- d. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.

## **2.4 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS**

- A. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
- B. Reduced-Voltage Solid-State Controllers: An integrated unit with power semiconductors, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
  - 1. Configuration: Heavy duty, reversible OR non-reversible.
  - 2. Starting Mode: Voltage ramping OR Current limit OR Torque control OR Torque control with voltage boost OR; field selectable, depending on application.
  - 3. Stopping Mode: Coast to stop OR Adjustable torque deceleration OR Adjustable braking OR field selectable, depending on application.
  - 4. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the power semiconductors. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
  - 5. Shorting and Input Isolation Contactor Coils, if required by project parameters: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors.
  - 6. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
  - 7. Control Circuits: 120V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - a. CPT Spare Capacity: Size CPT at least one size above minimum VA requirements.
  - 8. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
  - 9. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
    - a. Adjusting motor full-load amperes, as a percentage of the controller's rating.
    - b. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
    - c. Adjusting linear acceleration and deceleration ramps, in seconds.

- d. Initial torque, as a percentage of the nominal motor torque.
  - e. Adjusting torque limit, as a percentage of the nominal motor torque.
  - f. Adjusting maximum start time, in seconds.
  - g. Adjusting voltage boost, as a percentage of the nominal supply voltage.
  - h. Selecting stopping mode, and adjusting parameters.
  - i. Selecting motor thermal overload protection class between 5 and 30.
  - j. Activating and de-activating protection modes.
10. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
- a. Controller Condition: Ready, starting, running, stopping.
  - b. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
  - c. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted power semiconductors, line or phase loss, phase reversal, and line frequency over or under normal.
11. Controller Diagnostics and Protection:
- a. Microprocessor-based thermal protection system for monitoring power semiconductor and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
  - b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
  - c. input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.
  - d. For combination motor starter/disconnect, provide shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
12. Remote Output Features:
- a. All outputs prewired to terminal blocks.
  - b. Form C status contacts that change state when controller is running.
  - c. Form C alarm contacts that change state when a fault condition occurs.
13. Optional Features:
- a. Analog output for field-selectable assignment of motor operating characteristics; 4 to 20-mA dc.
  - b. Additional field-assignable Form C contacts, as indicated, for alarm outputs.
  - c. Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - d. Melting Alloy Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 tripping characteristic.
    - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - e. Bimetallic Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 tripping characteristic.

- 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - 4) Ambient compensated.
  - f. Solid-State Overload Relay:
    - 1) Switch or dial selectable for motor running overload protection. Software selectable controls are not allowed.
    - 2) Sensors in each phase.
    - 3) Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - 5) IP addressable communication module.
  - g. One each N.C. and N.O. reversible, isolated overload alarm contact.
  - h. External overload reset push button.
- C. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
  - 1. Fusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: Minimum two N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  - 2. MCP Disconnecting Means:
    - a. Use where available fault current is 65,000 Amps symmetrical or less.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - c. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
  - 3. MCCB Disconnecting Means:
    - a. Use where available fault current exceeds 65,000 Amps symmetrical.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - c. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - d. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
  - 4. Molded-Case Switch Disconnecting Means:
    - a. UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.

- b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.

## **2.5 MULTISPEED MAGNETIC CONTROLLERS**

- A. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
  - 1. Configuration: One or two winding, reversing or non-reversing, depending on project requirements.
  - 2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  - 3. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - 4. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - a. CPT Spare Capacity: Size CPT at least one size above minimum VA requirements.
  - 5. Compelling relays shall ensure that motor will start only at low speed.
  - 6. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
  - 7. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
  - 8. Melting Alloy Overload Relays:
    - a. Inverse-time-current characteristic.
    - b. Class 10 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 9. Bimetallic Overload Relays:
    - a. Inverse-time-current characteristic.
    - b. Class 10 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - d. Ambient compensated.
  - 10. Solid-State Overload Relay:
    - a. Switch or dial selectable for motor running overload protection. Software selectable controls are not allowed.
    - b. Sensors in each phase.
    - c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - e. IP addressable communication module.

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11. One each N.C. and N.O. reversible, isolated overload alarm contact.
  12. External overload reset push button.
- C. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
1. Fusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
    - b. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: One each N.O./N.C. reversible contacts, arranged to activate before switch blades open.
  2. Nonfusible Disconnecting Means:
  3. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - a. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
    - b. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  4. MCP Disconnecting Means:
    - a. Use where available fault current is 65,000 Amps symmetrical or less.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - c. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.
  5. MCCB Disconnecting Means:
    - a. Use where available fault current is greater than 65,000 Amps symmetrical.
    - b. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - c. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - d. Lockable Handle: Accepts 3/8 inch hasp padlocks and interlocks with cover in closed position.

## **2.6 ENCLOSURES**

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: NEMA Type 1.
  2. Indoor locations subject to wet or dry contaminants: NEMA Type 12.
  3. Outdoor Locations: NEMA Type 3R.
  4. Indoor or Outdoor Corrosive Environments: NEMA Type 4X stainless steel.
  5. Other Wet or Damp Indoor Locations: Type 4.
  6. Hazardous Locations: NEMA type to meet NFPA hazard classification.

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**2.7 ACCESSORIES**

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
  - 1. Push Buttons, Pilot Lights, and Selector Switches: Industrial-duty, oiltight type where required.
    - a. Push Buttons: 120V, 20A, industrial grade, nylon, NEMA 13.
    - b. Pilot Lights: 120V LED transformer types, red (running) and green (ready), push to test, mounted in front of panel.
    - c. Selector Switches: Rotary hand-off-auto mounted in front panel.
  - 2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable.
  - 3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
- B. Two reversible N.C./N.O. auxiliary contacts.
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays as indicated: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
- E. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 and Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- F. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in enclosures installed outdoors.
- G. Spare control wiring terminal blocks, quantity as indicated; unwired.

**PART 3 - INSTALLATION**

**3.1 EXAMINATION**

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Provide working space in front of motor controllers as required by NEC article 110-26.
- C. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

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**3.2 CONTROLLER INSTALLATION**

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Floor-Mounted Controllers: Install enclosed controllers on 3-1/2 -inch nominal-thickness concrete base. Concrete shall be rated minimum 3000 psi.
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. For individual magnetic motor starters, provide an overcurrent protection and disconnect device ahead of controller. This device shall be in an enclosure with lockout means.
- F. Torque all lugs per manufacturer's written recommendations. When manufacturer's recommendations are unavailable, use UL 486A and UL 486B for torque values.
  - 1. Place a spot of red paint on lugs after torqueing such that paint will be visibly disturbed if lugs are disturbed.
- G. Install fuses in each fusible-switch enclosed controller.
- H. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."
- I. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- J. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- K. Install power factor correction capacitors. Connect to the line or load side of overload relays as required by project parameters. If connected to the load side of overload

relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

- L. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved nameplate.
  - 3. Label each enclosure-mounted control and pilot device.

### **3.4 CONTROL WIRING INSTALLATION**

- A. Install wiring between enclosed controllers and remote devices and facility's central control system where required. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.
  - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
  - 2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service – to be engaged at discretion of design engineer: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
  - 1. Manufacturer's Field Service – where required: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify continuity and tightness of ground connections.
5. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Resident Engineer before starting the motor(s).
6. Check phase rotation of all conductors and ensure proper color coding.
7. Test each motor for proper phase rotation.
8. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
9. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
10. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
  - a. Initial Infrared Scanning: After Substantial Completion, but not more than two weeks prior to Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
  - b. Follow-up Infrared Scanning: The Port shall have the option of performing its own infrared scan.
11. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.6 ADJUSTING**

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Set motor overloads per manufacturer's tables for actual motor nameplate full load amps.
- C. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

- D. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Port Resident Engineer before increasing settings. If initial setting of six times the motor nameplate FLA rating does not cause tripping, adjust settings down so that setting is as low as possible without causing nuisance tripping.
- E. Set the taps on reduced-voltage autotransformer controllers as required as part of field certification.
- F. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.
- G. Where motor controllers with CT/Microprocessor overloads are provided, set all adjustable parameters per Engineer's instructions.
- H. Set field-adjustable circuit-breaker trip ranges as indicated on contract documents.

### **3.7 PROTECTION**

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

### **3.8 TRAINING**

- A. Provide training session for Port maintenance personnel, for three separate shifts with ten attendees per training session. Training shall include how to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers, where applicable.

END OF SECTION 262913