

## Section 16480

### LOW VOLTAGE MOTOR CONTROL

#### PART 1 - GENERAL

##### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install all group-mounted and unit low voltage motor control as required for each motor furnished for installation all in accordance with the requirements of the Contract Documents.
- B. When motors furnished differ from the indicated, the CONTRACTOR shall, at no additional cost to the DISTRICT, make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection and other affected material or equipment to accommodate the motors actually installed.
- C. Make like items of equipment provided hereunder the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service.
- D. Low-voltage MCCs shall be factory assembled, factory tested, with functions and circuit assignments for each unit, and types, characteristics, and ratings of buses and motor starters, and protective devices shall be as indicated on the Contract Documents. Low-voltage MCCs shall comply with ANSI/NEMA Standard ICS 2 "Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts" and UL 845 "Motor Control Centers". The vertical sections and individual units shall bear a UL label, as evidence of compliance with UL 845.
- E. Nameplates shall be furnished as specified in Section 16075, Electrical Identification Nameplates and Warning Signs, of these Specifications.
- F. Painting shall be manufacturer's standard. Color shall be ANSI 61, light gray.
- G. Low-voltage MCCs shall be suitable for application on a 3-phase, 60 Hz, high resistance grounded neutral system with a nominal system voltage of 480 VAC and a design voltage of 600 VAC. The specific voltage for each application shall be as indicated on the Contract Documents.

##### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

###### 1. Codes and Standards:

NEC	National Fire Protection Agency (NFPA) –70 National Electrical Code (NEC), latest adopted edition.
CCR	Title 8, Industrial Relations, Subchapter 5, Electrical Safety Orders, California Code of Regulations. National Electrical Code

2. Industrial Standards:

NEMA ICS-1	Industrial Control and Systems General Requirements
NEMA ICS-2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts
UL 508	Industrial Control Equipment
UL 845	Motor Control Centers

1.3 CONTRACTOR SUBMITTALS

- A. Shop drawing submittals shall comply with the "CONTRACTOR Submittals" paragraph of Section 16010, Electrical General Provisions.
- B. Final submittal shall include spare parts lists, catalog data for various motor control elements in addition to the submittals required by Section 16010, Electrical General Provisions.
- C. The following submittals and specific information shall be provided.
  - 1. One-line diagrams
  - 2. Schematic Control (Elementary) diagrams
  - 3. Connection diagrams
  - 4. Interconnection diagrams
  - 5. Protective device time-current characteristics
  - 6. Operational description
  - 7. Installation instructions
  - 8. Maintenance instructions
  - 9. Spare parts list
  - 10. Test reports, including procedures, test conditions and results.
  - 11. A copy of this specification section and the referencing section and all other applicable specification sections governing the pump, drive and driver, supports and specified appurtenances. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. The submittal shall be

accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

12. A copy of the contract single line, process and instrumentation, and schematic drawings with addenda updates. Mark drawings to reflect requested changes or "no changes required."

D. MCC Submittal shall not be submitted until the mechanical submittal loads are submitted for review and approved.

#### 1.4 QUALITY ASSURANCE

A. Quality assurance shall be in accordance with Section 16010, Electrical General Provisions.

B. Electrical and Mechanical Testing: All components shall be factory tested in accordance with the applicable NEMA ICS and UL requirements.

C. Field Testing: Field tests shall be performed in accordance with Section 16080, Electrical Testing.

### **PART 2 - PRODUCTS**

#### 2.1 MOTOR CONTROL, GENERAL

A. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, the NEC, and UL.

B. Each motor control center shall be NEMA Class 1 Type B with all remote control and signal circuits wired to a separate terminal board compartment in each motor control center lineup.

#### 2.2 MOTOR CONTROL CENTERS

A. Each assembly shall consist of metal-enclosed, free-standing, dead-front, vertical, steel structures containing power buses, ground bus, combination magnetic motor starters, combination lighting or heating controllers, feeder breakers, metering, control equipment and other devices as specified on the Contract Documents.

B. MCCs shall be designed to withstand fault currents of not less than 65,000 A RMS symmetrical or as specified on the Contract Documents

C. Each MCC section shall be 90-inches high, 20-inches wide, 20-inch deep for front-of-board unit arrangement. Full depth horizontal wireways at top and bottom shall be provided. Vertical wireways shall be provided as applicable. MCCs shall be suitable for back-to-wall or back-to-back installation in accordance with the contract drawings. When installed back-to-back, MCCs shall be completely independent assemblies, not sharing structural components or busing. Rear access shall not be required for inspection or maintenance. MCCs shall have NEMA Type 1 gasketed enclosures. Structure doors shall be constructed with removable pin hinges and secured with quarter-turn indicating-type fasteners.

- D. MCCs shall be provided with front-accessible main lug compartments for connection of incoming cables in the top or bottom section as indicated on the Contract Documents.
- E. MCCs shall be designed so that either end of the lineup can be extended without using transition sections, and shall be provided with removable end and top cover plates to close off openings.
- F. The MCC Individual compartments shall be separated by steel barriers for each starter, feeder, or other unit and be capable of being wired from front without unit removal
  - 1. Unit Construction:
    - a. Unit connections for NEMA Size 5 starters and below shall be provided by plug-on connections for each electrical power phase. Contact fingers shall be free floating and self-aligning with tin plated contacts for a low resistance connection. Stabs shall be backed by spring clips to maintain a high pressure connection to the vertical bus.
    - b. Disconnect operators shall have external operator handles for disconnect switches and circuit breakers. Handles shall be designed with up-down motion and with the down position being the OFF position. The operator handle shall be lockable in the OFF position with three 3/8" shank padlocks.
    - c. Unit doors shall be securely mounted with rugged, concealed-type hinges which allow the doors to swing open a minimum of 115 degrees for ease of unit maintenance and removal. Doors shall be fastened to the MCC structure so that they remain in place when the unit is removed. The closed unit door must cover the unit space when the unit has been temporarily removed.
    - d. An interlock between each unit door and the associated disconnect mechanism shall prevent the door from opening when the unit is energized. Defeater mechanism shall be provided for test or maintenance purposes.
    - e. The operator handle shall be interlocked with the unit door so the disconnect can not be switched on unless the unit door is closed. A defeater mechanism shall be provided for test or maintenance purposes.
  - 2. Cable Entrance: Main circuits shall enter from bottom; control and feeder circuits shall enter from top and bottom.
  - 3. Buses:
    - a. Power buses shall be tin-plated copper.
    - b. The horizontal power bus shall have a minimum rating as indicated on the Contract Documents. Horizontal power bus bars shall be fully supported, braced and isolated. Protective barriers shall be provided to prevent people from accidentally contacting the bus with front cover open. Horizontal power bus shall allow for future extension at both ends. Mechanical type solderless lugs shall be supplied for each incoming line cable.

- c. Vertical bus bars shall be fully supported, braced and isolated so that the bus will only be exposed where the draw-out unit stab-on assembly makes contact. Suitable automatic shutters shall be provided to cover these bus stab openings when the units are withdrawn. Vertical power bus shall be rated 300 amps minimum.
- d. A ground bus shall be provided running the full length of the MCC at the bottom of the lineup. The ground bus shall be drilled and supplied with lugs suitable for a #2/0 AWG copper conductor at each end of the MCC as indicated on the Contract Documents. Ground Bus shall be tin-plated copper, 400 A minimum capacity.

G. Acceptable Manufacturers:

1. Low Voltage MCCs shall be manufactured by Allen Bradley, Cutler Hammer, General Electric, Siemens, or equal.
2. The MCC manufacturer shall comply with other sections of the Specifications describing components such as dry-type transformers, panelboards, circuit breakers, magnetic starters, and other such equipment that will be a part of the completed MCC.

H. Control Power Transformer:

1. A 480-120 V control power transformer shall be supplied for each magnetic motor starter, lighting controller or heating controller, and shall be one standard size larger than is required for the motor space heater, control devices, and/or indicating lights shown on the Contract Documents. Refer to schematics.
2. Each control transformer shall have both primary legs fused, one secondary leg fused, and the other secondary leg grounded. Connections to both secondary legs shall be provided at the control terminal strip.

I. Motor Starter Units:

1. Motor starters shall be of the combination circuit breaker, magnetic-contactor-type, 3-pole and minimum NEMA Size 1 contactor size. The magnetic contactor shall operate with a coil voltage of 115 V, 60 Hz, single phase.
2. Each combination motor starter assembly shall have a short circuit withstand rating equal to or greater than the system level indicated on Contract Drawings or specified herein.
3. Each motor starter shall have a three phase adjustable electronic overload relay with manual reset from a door-mounted pushbutton. Each overload relay shall have both a normally open alarm contact and normally closed contact used to trip the starter coil. Overload relay setting shall be based on actual motor nameplate full-load current.
4. Each motor starter shall include a minimum of four auxiliary contacts, two normally open and two normally closed, for the DISTRICT'S use in addition to those required to fulfill the intent of the control scheme specified on the Contract Documents. All spare auxiliary contacts shall be wired to the terminal blocks in the respective unit compartment.

5. Combination motor starters and controller units shall be of the draw-out type for NEMA Sizes 1 through 4. NEMA Size 5 starters may be of the bolted-on type, although draw-out type is preferred. Draw-out units of the same NEMA size shall be interchangeable with each other.
  6. Motor starter units smaller than 18-inch high shall not be acceptable.
  7. Units shall be equipped with pilot devices such as START-STOP buttons, selector switches and indicating lights as specified on the Contract Documents. Pilot devices shall be heavy-duty oil-tight type. Pilot lights shall be push-to-test type, lens color per schematics.
  8. Two-Speed Motor starters shall be suitable for two-speed, two-winding motors as indicated.
  9. Load Detector Relays shall have adjustable trip current and differential. Relays shall be Allen-Bradley Bulletin 809S, Cutler-Hammer Type D60LA or equal.
- J. Motor Starter Circuit Breakers:
1. The circuit breaker used in combination motor starters shall be of the 3 pole molded case, motor circuit protector (MCP) type, consisting of an adjustable instantaneous magnetic trip device.
  2. Operating handles for the circuit breaker mechanism shall be provided with indication showing the "ON", "OFF", and "TRIPPED" positions.
  3. Molded case motor circuit protectors (MCP) sizing shall be based on the MCC manufacturer's UL listed standard for maximum motor protection.
- K. Feeder Circuit Breakers:
1. Individual circuit breaker units shall consist of factory-assembled, molded-case circuit breakers with permanent instantaneous magnetic and thermal trips in each pole, fault-current limiting protection, and current ratings as indicated on the Contract Documents.
  2. Circuit breakers shall be capable of being mounted and operated in any position and in an ambient temperature of 40°C. Circuit breakers shall be provided with tin plated Al/Cu rated mechanical screw-type removable connector lugs.
  3. Feeder circuit breakers through 250 A frame size shall be of the draw-out type. Frames larger than the 250 A frame size may be of the bolted-on type. Draw-out units of the same frame size shall be interchangeable with each other.
  4. Feeder Circuit Breakers shall be suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
- L. Solid State Reduced Voltage Starters:
1. The starter shall provide a smooth, stepless acceleration and deceleration of the motor from start to full speed and from full speed to stop. When specified in the Contract Documents, a bypass contactor shall be supplied to bypass the solid-state starter when the motor reaches full speed.

2. A circuit breaker shall be used for overcurrent protection and main disconnect. The breaker shall be lockable in the "OFF" position. A control power transformer with primary and secondary fuse protection shall provide control power to the entire unit. When motor space heaters are used, they shall be energized from the control power transformer in the starter.
3. The reduced voltage starter shall be equipped with a micro-processor type protection relay to control, monitor and protect the motor.
4. The starter shall consist of a self-contained unit for the control of 3-pole, 460-volt, 60-Hertz electric motors. The starter shall use solid-state components to limit current during motor starting and stopping.
5. Controls shall permit selection among soft-start with selectable kickstart, current limiting with starting that is programmable 50 to 600 percent of full load current and field set as required. Full voltage start with ramp time less than 0.25 second, dual ramp start, or a start profile designed per OEM equipment requirements. Controls shall permit field selection among ramp to stop, coast to stop, or stop profile designed for use with equipment specified.
6. Provide an alphanumeric, backlit LCD display. Example: four-line 16-character, for controller set-up, diagnostics, status and monitoring. Provide a keypad for parameter adjustment.
7. Provide 2-ampere, 120 Vac rated auxiliary contacts for the following output signals: "Solid-State Controller Trouble", "Overload Trip, Solid-State Controller On", Solid-State Controller Off". Provide provisions for the following 120 Vac input signals: "Reset", "Lockout-Stop", "Jog". In addition, there shall be provisions for "System Ready", and "Run Request" signals. Refer to the schematic diagram drawing for additional control requirements specific to the Blower starters.
  - a. Provide the following monitoring functions indicated through the LCD display:
    - (1) Three-phase current
    - (2) Three-phase voltage
    - (3) Power in kW
    - (4) Power usage in kWh
    - (5) Power factor
    - (6) Elapsed time.
  - b. Provided as standard:
    - (1) Pre-start line fault alarm
    - (2) Running line fault advising power loss
    - (3) Shorted or missing load connection
    - (4) Pre-start power loss with phase indication

- (5) Over-temperature
  - (6) Fault alarm with phase problem indication.
  - c. Provide the following defeatable protection as standard:
    - (1) Under-load
    - (2) Under-voltage
    - (3) Over-load
    - (4) Over-voltage
    - (5) Voltage Unbalance
    - (6) Excessive Starts Per Hour
    - (7) Phase Reversal
    - (8) Stall
    - (9) Jam.
  - d. When fault conditions are detected, the controller shall inhibit starting or shut down. Fault diagnostics shall be indicated in descriptive text on the LCD display. The exclusive use of fault codes is unacceptable. Provide an auxiliary contact that is programmable for fault indication.
  - 8. The manufacturer shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
  - 9. Manufacturer shall be prepared to show proper evidence of having tested for noise immunity on both input and output power connections. Noise testing shall be performed in accordance with NEMA ICA 2-230.40.
  - 10. Acceptable manufacturers: Allen-Bradley Bulletin 150 SMC Flex, Cutler Hammer, Siemens or equal.
  - 11. Reduced voltage starters submittal for blowers shall not be submitted until the entire blower system submittal is reviewed and approved.
- M. Control Wiring and Terminal Blocks:
- 1. All internal control wiring shall be installed with flexible, stranded copper conductors, #14 AWG minimum size, with type TBS or SIS (cross-linked thermosetting polyethylene) insulation. All wiring shall be bundled and supported by plastic strip lock straps in a neat and workmanlike manner. Adhesive "stick-on" type bundle supports are not allowed.

2. Terminal blocks shall be clearly labeled to identify connection points for field wiring that will be installed by the CONTRACTOR, including wiring between shipping sections.
3. Control terminal blocks shall be pull-apart type on all draw-out units for easy removal of the unit from the structure.
4. Terminal blocks shall not be located inside the vertical section.
5. Each end of the internal interconnecting wire shall be identified by a permanent label showing the wire number. Wire numbers shall match the manufacturer's detailed connection diagrams. All wires originating from the same electrical node or point shall carry the same wire number.
6. When practical, all screw-type wire terminations shall use compression-type locking-spade connectors which firmly grip on the conductor and employ insulated compression sleeves to grip the wire insulation. Connectors terminating on terminal blocks shall also be of the locking-spade type.
7. All wires shall be labeled with permanent sleeve type markers.

N. Instruments:

1. When specified, voltmeter shall be electronic digital type.
2. When specified, ammeter shall be electronic digital type.

O. Nameplates:

1. Nameplates shall be engraved with inscription as shown on the single-line diagrams and in accordance with Specification 16075.
2. An engraved nameplate shall be provided for each compartment door. Legend plates shall be supplied for all pilot devices.
3. Nameplates shall be fastened using threaded fasteners. Adhesive tape is not acceptable.
4. Warning labels shall be provided on each compartment with external power sources. Warning labels shall be white letters on a red background and shall read:

"CAUTION - THIS UNIT CONTAINS AN EXTERNAL VOLTAGE SOURCE"
5. Inside the compartment, permanently attached engraved nameplates shall be provided for each device identical to its external nameplate and to indicate location of remote disconnecting means. Circuit identification and location of remote disconnecting means shall be furnished to manufacturer by the CONTRACTOR during shop drawings review. Manufacturer shall provide space for 15 letters on each tag.

## 2.3 INDIVIDUAL MOTOR CONTROL UNITS

### A. Controller Enclosures:

1. Motor controllers shall be housed in NEMA Type 1 enclosures.
2. Motor controller enclosures shall be painted per manufacturer's standard. Color shall be ANSI 61, light gray.

### B. Solid-state reduced voltage starter shall consist of a power section, a one piece printed circuit logic board and a field wiring interface terminal board. Internal construction shall consist of the following:

1. The power section shall be three-phase, 60 hertz, and rated for the HP, current, and voltage as indicated. It shall consist of three sets of back-to-back phase controlled power semi-conductors. Maximum current-limit shall be 500 percent for standard units.
2. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.
3. Fan cooled units shall be supplied with thermal sensors on the heat sink to trip the control protective logic for over-temperature condition. Thermal sensors shall be rated 90 degree C maximum.
4. The one piece logic board shall be mounted for easy testing, service and replacement.
5. Three-phase current sensing via current transformers for closed loop control to ensure motor stability shall be provided.
6. The logic board shall use a quick disconnect plug-in connector for current transformer inputs, line and load voltage inputs, SCR gate firing output circuits and status panel.
7. The logic circuitry shall include as a minimum:
  - a. Short circuit electronic trip overcurrent protection. Time not to exceed 1/2 cycle.
  - b. Inverse time running overcurrent protection.
  - c. Auxilliary trip circuit.
  - d. Gate firing circuit lockout protection on trip.
  - e. Fault relay lockout protection.
  - f. 250 percent to 500 percent current limit adjustments.
  - g. Minimum and maximum voltage adjustments.
  - h. Voltage stability adjustment.

- i. Dwell time at current limit with ramp continuation after acceleration.
  - j. Individual light emitting diodes (LEDS) to indicate run, undervoltage, phase loss, phase current unbalance, overcurrent trip, overtemperature, current limit, end of ramp and incorrect phase rotation.
  - k. Single phase protection with built-in short time delay.
  - l. Undervoltage protection with built-in short time delay.
- 8. The logic board shall include, current and motor slip sensing circuitry that will continually monitor load and regulate motor voltage to minimize motor kwh energy consumption.
  - 9. External interface circuitry shall include 120 volt relay logic interface capability.
  - 10. Tripped functions shall be designed to be cleared by removing power from the solid-state logic board.
  - 11. The logic board shall provide phase sequence protection.
  - 12. The solid-state logic shall provide phase sequence protection.
  - 13. Two ground lugs shall be furnished, one for incoming and one for outgoing ground connections.
  - 14. Power terminations shall consist of pressure type terminals for top or bottom entrance.
  - 15. The power section for motors above 200 HP shall have metal oxide varistor (MOV) type surge suppressors across the SCRs rated 10 percent above the SCR rated voltage. The power semi-conductors shall be rated with peak inverse voltage at least 2.5 times SCR rated line-to-line voltage. Suitably rated snubbers for voltage suppression shall be included. Data shall be made available on tolerances to incoming line voltage surges or line spikes. Data shall include both magnitude and time content of each spike (voltage peaks and volt-seconds) plus tolerance to repetitive surges.
  - 16. 100 percent to 200 percent load running current trip adjustment.
- C. Manually Operated Starters, Fractional Horsepower: Single-phase fractional horsepower manual motor controllers rated 115 or 230 volts shall be provided for motors as indicated on the Contract Documents. Manual motor controllers shall be equipped with manually operated quick-make, quick-break toggle mechanisms and with one-piece solid state or bimetallic type thermal units. The controllers shall become inoperative when the thermal unit is removed. Controllers shall be provided with double break silver alloy contacts, visible from both sides of the controller, and the switch shall be capable of being padlocked in the "OFF" position.
  - D. Manually Operated Starters, Integral Horsepower: Provide starters meeting NEMA ICS 2 of the horsepower rating, voltage, number of phases, and enclosure shown and with solid state or thermal overload protection, and pushbutton or toggle switch operation. Provide for locking the starter in the OFF position.

E. Control Devices:

1. All contactor and relay coils shall be rated 115 VAC.
2. Timing relays shall be pneumatic or electronic type with time dial and settings in seconds, Agastat 7000 Series or equal.
3. All pilot devices shall be of the heavy-duty oil-tight type. All pilot lights shall be of the push-to-test type.
4. All spare relay and pilot device contacts shall be wired to the terminal blocks in the respective unit.
5. All wires shall be labeled with permanent sleeve type markers.

F. Nameplates: Nameplates shall be in accordance with the nameplate requirements above.

**PART 3 - EXECUTION**

3.1 GENERAL

A. Perform work in a workmanlike manner with craftsmen skilled in the particular trade. Provide work presenting a neat and finished appearance.

3.2 INSTALLATION

- A. Install and secure equipment in strict accordance with submittal drawings and manufacturer's recommendations and in accordance with NEMA ICS 2.3 as a minimum. Grout mounting channels if provided with motor control center into the floor or mounting pads.
- B. Provide a qualified, factory-trained representative to supervise installation, final adjustment, and initial energization of this equipment. Make this representative available for as long as the services are required.
- C. Retighten all bolted current-carrying bus connections per manufacturer's recommendations.
- D. Adjust the trip settings of all motor starter circuit breakers and overload relays per manufacturer's recommendations. Determine motor full load current from motor nameplate following installation. Prepare a typed tabulation of motor name, horsepower, nameplate full load current, measured full load current, overload trip setting and breaker trip setting. Include a copy of the tabulation in the final Technical Manual.
- E. After the equipment is installed, touch up any scratches, marks, etc., incurred during shipment or installation of equipment. If required by the ENGINEER because of undue amount of scratches, repaint the entire assembly.

3.3 FIELD TESTS

A. Field tests shall be in accordance with Section 16080, Electrical Testing.

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