SECTION 16100

MOTOR CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Description Of System
   1. Provide motor control as required, and all material and equipment, including motor control centers, adjustable frequency controllers, motor starters, control devices, safety switches, fuses, as indicated or specified.

1.2 RELATED WORK SPECIFIED UNDER OTHER SECTIONS

1.3 SUBMITTALS

A. Furnish submittals for items that are identified in this SECTION by a different typeface and a bracketed code (e.g., *Item [L]*). Refer to SECTION 01340 for definition of codes for types of submittals and the administrative requirements governing submittal procedure. Additional submittal requirements pertaining to this SECTION are specified herein under this Article.

B. Include complete data on each item. Coordinate the items as they relate to the work prior to submittal.

PART 2 PRODUCTS

2.1 480 VOLT MOTOR CONTROL CENTERS

A. *Motor Control Centers and Components [B,D,P]*: NEMA Standard ICS and requirements herein, and consisting of an incoming line compartment, fusible switch type, combination starters or feeder fusible switches, other equipment as specified, and spaces fully equipped to receive future units, all mounted individually in sectionalized free-standing compartments joined together to give a complete dead front assembly having a NEMA 12, enclosure in Building 600A, NEMA 1 enclosure in Building 600 with wiring for NEMA Class I, Type B terminal arrangement with all equipment and wiring accessible from the front.The MCC shall be pre-configured with a DeviceNet trunkline and DeviceNet to ControlNet bridge.
   1. Rockwell Automation Allen-Bradley Bulletin 2100.

Item	Allen Bradley Part. No.
MCC-600A-2	01399914/1
MCC-600-3	01399916/1
MCC-600-4	01399917/1

B. The MCC shall meet or exceed the requirements for MCC's in the following standards:
   1. NEMA ICS 18
   2. UL 845

3. NEC/NFPA 70
4. CSA
5. EN 60439-1
6. MCC manufacture shall be ISO 9001 certified.

C. Structure: Fabricate from sheet metal and weld and bolt together as necessary to form a rigid self-supporting section approximately 90 inches high by 20 inches wide by 20 inches deep. Bolt the required number of uniform sections together on suitable floor sills and coordinate overall length with the floor space shown.

D. Formed Cover Plates: Equip compartments to contain equipment with hinged doors. Provide hinged doors or bolted removable cover plates on blank compartments and on compartments reserved for future installation of equipment. Provide cover plates at the rear of each section of the bolted removable type. Provide bolted removable covers for openings necessary for the bolting on of future full height vertical sections and for future bus and wiring trough extensions.

E. Wiring Troughs: Provide wiring troughs vertically and horizontally in each section, complete with wiring clamps. Align horizontal troughs in each section with troughs in each adjacent section to form a convenient pullbox throughout the entire length of the control center.

F. Control Units: Provide control units in minimum 12-inch high modules and locate as indicated, using guide supports for positioning plug-in units in place on all applicable sizes. Provide control center assembled and wired, ready to receive line, motor and control circuit connections, and finished in manufacturer's standard synthetic enamel, lacquer, or acrylic finish.

G. Control Center Buses: Design buses for 480 volt, 3 phase, 3 wire, 60 hertz service, as indicated. Provide main horizontal bus rated 800 amperes minimum capacity with 1/4 inch by 2 inch high conductivity copper bar as the minimum allowable size. Provide vertical branch buses of copper bar with a minimum rating of 300 amperes. Ampere ratings are continuous ratings required at a maximum of 50 degC rise above an ambient temperature of 40 degC. Contact surfaces of all bus connections shall be silver or tin plated. Provide mechanical bracing for all bus bars to withstand a phase to phase or phase to ground short circuit current of 42,000 RMS symmetrical amperes. Provide taps from individual units to vertical bus having a capacity equivalent to No. 4 AWG copper as a minimum. Provide a 300 ampere copper minimum ground bus continuous for the entire length of the motor control center.

H. Incoming Line Compartment: Provide adequate space for termination of incoming line conductors and equip main buses with lugs as specified in SECTION 16120, except where a main fusible switch is indicated. Provide main fusible switch as indicated and specified.
   1. Main Fusible Switch: 3 pole, single throw, visible blade, NEMA "HD" heavy duty, quick-make quick-break type rated 600 volts, with continuous current and fuse rating as indicated. Silver or cadmium plate all contact surfaces including fuse clips.
   2. Interlocking: Equip switch with an external operating handle. Interlock the operating handle with the cover door such that the door cannot be opened unless the switch is in the "off" position. Provide means for padlocking the operating handle in the "off" position

I. Single-Speed Nonreversing Starter Units: Combination type consisting of a fusible switch as indicated, a full voltage magnetic starter, thermal overloads, control transformer and control devices as indicated and as specified, all mounted in a unit door frame assembly.
   1. Fusible Switch: 600 volt, 3 pole, single throw, visible blade, NEMA “HD” heavy duty, quick-make quick-break type, horsepower rated, with continuous current and fuse ratings as indicated. Where ratings are not indicated, provide fuse clips to accommodate a dual-element type fuse as hereinafter specified and having a minimum current rating of 150% of the motor full load current, with switch of equivalent rating. Silver or cadmium plate all contact surfaces including fuse clips.
   2. Interlocking: Equip switch with an external operating handle. Interlock the operating handle with the cover door such that the door cannot be opened unless the switch is in the “off” position. Provide means for padlocking the operating handle in the “off” position with three, 5/16-inch shackle padlocks such that when the operating handle is padlocked in the “off” position, the cover door cannot be opened and the switch cannot be closed.
   3. Starter: Size starters in accordance with NEMA Standards for the horsepower of the motors with which they will be used, except do not furnish starters smaller than NEMA Size 1 for motors of 5 horsepower or less. Provide coils for operation on 120 volts unless other requirements are indicated. Equip each starter with a minimum of two normally open and two normally closed spare auxiliary contacts or two spare convertible auxiliary contacts in addition to the normally-open seal-in contact, unless additional requirements are indicated. Provide additional contacts as indicated.
   4. Thermal Overloads: One in each phase wire, external manual reset type. Select overloads after final installed horsepower and nameplate data of motors is determined. Do not use overload heater elements with listed “full load amperes” exceeding 100% of motor full load current adjusted for ambient temperatures. Provide thermal overload heater table inside each door of each motor starter.
   5. Control Transformer: Provide a 480-120 volt control transformer in each individual starter unit, except where a common 120 volt control power source is indicated. Fuse the primary winding as required by the NEC. Fuse and ground the secondary winding as required. Where indicating lights, solenoid valves or other control components are to be energized from the control transformer, increase the capacity of the control transformer proportionately for loading above the minimum requirements of the operating coil. Minimum acceptable size shall be 250 VA.

J. Two-Speed Starter Units: Combination type consisting of a fusible switch as indicated, two full voltage starters for two-speed, two-winding type motors, two sets of thermal overloads, control transformer and control devices as indicated and as specified, with similar features to those specified for single-speed nonreversing starter units. Interlock starters mechanically and electrically to prevent both starters from being closed at the same time

K. Solid State Motor Controllers (SMC/Soft Start): Consisting of a SMC unit in combination with a separate bypass contactor.
   1. The unit shall be provided with a 120V control power transformer with primary and secondary fusing.

2. The SMC unit shall be provided with a separate bypass contactor for NEMA 12 designs. The bypass contactor shall be energized once the motor is up to full speed. The bypass contactor shall be fully rated for the motor load and be capable of starting the motor if so wired in the field. The unit shall be provided with a converter module so that the SMC overload can be utilized at all times.
3. Voltage ramp-up time adjustable from 5 to 30 seconds and initial voltage adjustable from 20% to 80% of rated voltage to provide for optimum starting torque.
4. The SMC unit shall be a SMC-Dialog Plus and applications shall include integrated bypass and electronic overload, motor starting capabilities. The integrated bypass automatically closes when the motor reaches full speed.
5. The SMC unit shall be provided with line side protective modules. The modules shall contain capacitors and metal oxide varistors (MOVs) that protect the internal power circuitry from severe electrical transients and/or high electrical noise.
6. Provide a door mounted selector switch for Auto-Manual control. In the auto mode, the start command shall be provided through a remote contact. In the manual mode, the start-stop control shall be provided through the door mounted push buttons. Provide extra contact blocks on the selector switch for monitoring of switch position.
7. Provide door mounted pushbuttons for start-stop and pump stop control. Stop pushbuttons shall always be active.
8. Provide door mounted transformer type pilot lights for indication of On (Red) and Off (Green).

L. Feeder Units: Consisting of a fusible switch as indicated and as specified.
1. Fusible Switches: 600 volt, 3 pole, single throw, visible blade, NEMA “HD” heavy duty, quick-make, quick-break type, horsepower rated, with continuous current and fuse ratings as indicated. Silver or cadmium plate all contact surfaces including fuse clips.
2. Interlocking: Equip switch with an external operating handle. Interlock the operating handle with the cover door such that the door cannot be opened unless the switch is in the “off” position. Provide means for padlocking the operating handle in the “off” position with three 5/16 inch shackle padlocks such that when the operating handle is padlocked in the “off” position, the cover door cannot be opened and the switch cannot be closed.

M. Control Devices: Locate control devices at individual unit compartments except where common control compartments are indicated. Provide a hinged and bolted door over common control compartments.
1. Push Buttons and Selector Switches: Heavy duty, oil-tight type, with contacts rated 10 amperes continuous, 600 volts AC, with legend plate and operation as indicated.
2. Indicating Lights: Heavy duty, oil-tight type with 6 volt lamp, integral 120-6 volt transformer, push-to-test feature, color cap and legend plate as indicated.
3. Control Relays: Heavy duty industrial type with convertible contacts rated 10 amperes continuous, 600 volts AC. Provide coils for operation on 120 volts AC unless other requirements are indicated. Provide number and type of contacts as indicated.
4. Timing Relays in General: Electrically-operated, pneumatically-controlled type, convertible from time-delay after de-energization to time-delay after energization, or vice-versa, in the field, with timing range adjustable from 0.2 seconds to 180 seconds, repeat accuracy of plus or minus 10%, one single pole double throw time contact rated 10 amperes continuous, 600 volts AC, and coil for operation on 120 volts AC unless other requirements are indicated. Provide instantaneous contacts as indicated.

5. Motor-Driven Timing Relays: As indicated.
6. ControlNet Interface
7. Voltage indicating devices

N. Wiring: NEMA Type and Class as specified. Use single conductor stranded copper wire with insulation for 600 volts working and 1500 volts test, rated 90 degC for switchboard wiring. Do not use wire sizes smaller than No. 14 AWG. Terminate all outgoing wiring on molded, barrier type terminal blocks rated 600 volts, with white-face marking strip. Identify all wires by numbers or letters corresponding to elementary diagrams at terminal blocks and devices. Provide lugs for incoming line and outgoing power cable connections as specified in SECTION 16120.

O. Spaces: Where future positions are designated as “space” are indicated on the drawings, equip the MCC with bus and minimum hardware to receive future devices. Furnish a plank removable spacer plate to cover the “space” until future use.

P. Nameplates: Black-white-black laminated plastic with white engraved letters, identifying the circuit and equipment served on each unit door. Provide a similar nameplate, 1 inch by 3 inch size, near the top of the control center identifying the motor control center by numbers and letters as indicated on the drawings.

Q. DeviceNet Communications: The MCC shall have DeviceNet wiring with ControlNet interface configured into its design.
1. Each motor starter and solid state motor controller/soft start unit in the MCC shall be supplied with a means to communicate via DeviceNet.
2. The DeviceNet cable shall be in compliance with Article 300.3 (c) (1) of the NEC.
3. DeviceNet trunk line cable and cable use to connect to a DeviceNet port shall be 600V Class 1.
4. The MCC manufacture shall provide 24Vdc power supplies as required for the DeviceNet system and DeviceNet requirements.
5. Motor starter units shall have an electronic overload relay that incorporates the following features:
   a. On-board DeviceNet communications.
   b. LEDs for status indication.
   c. Test/Reset Button.
   d. Adjustable trip of NEMA Class 5 to 30. Unless indicated, the trip class shall be set for NEMA Class 20 operation.
   e. Four inputs and two outputs.
   f. Protective funtions:
      1) Functions shall provide a programmable trip level, warning level, time delay and inhibit window.
      2) Protective functions shall include thermal overload, underload, jam, current imbalance, stall , phase loss, zero sequence ground fault and PTC thermistor input.
   g. Current monitoring functions shall include phase current, average current, full load current, current imbalance percent, percent thermal capacity utilized and ground fault current.

h. Diagnostic information shall include device status, warning status, time to reset, trip status, time to overload trip and history of last five trips.

6. DeviceNet communication shall be supplied to allow for communications between soft start starters and the DeviceNet system.
7. The MCC manufacturer shall provide programming and testing.
   a. The manufacturer shall load the DeviceNet MAC ID number (node address) into each unit.
   b. The DeviceNet MAC ID number shall be as indicated or as provided by the contractor.
   c. The DeviceNet network shall be designed and programmed for use at 250kB or 500kB.
   d. The MCC manufacturer shall test the MCC to insure that each unit communicates properly prior to shipment.
   e. Each DeviceNet device shall have a label showing the unit location, node address and baud rate.
   f. The MCC manufacturer shall provide a disk containing applicable Electronic Data Sheet (EDS) files for the DeviceNet devices.
8. The MCC shall have a plug-in metering unit. The power monitor meter shall include min/max logs and trend logs with up to 45,867 data points and shall be capable of performing distortion analysis with THD, Crest Factor (I, V) and Distortion power factor. The power monitor shall be able to display the following:
   a. Line current for all three phases with plus or minus 0.2 percent full-scale accuracy.
   b. Average three phase current with plus or minus 0.2 percent full-scale accuracy.
   c. Line-to-neutral and line-to-line voltage with plus or minus 0.2 percent of full-scale accuracy.
   d. Current and voltage unbalance.
   e. Real, reactive, apparent and true power with plus or minus 0.4 percent full-scale accuracy.
   f. KWh, KVARh and kVAHnet.
   g. True RMS to the 45th harmonic.
   h. Frequency at plus or minus 0.5 percent.
   i. Power factor at plus or minus 0.4 percent.

   The power monitor shall include a DeviceNet communication port as standard and shall have options available for RS-232, RS-485, ControlNet, Remote I/O, EtherNet. The power monitor shall also include two form-C relays.

2.2 ADJUSTABLE FREQUENCY CONTROLLERS

A. *Adjustable Frequency Controllers and Components [B,D,P]*: Each unit shall consist of an adjustable frequency controller, bypass solid state motor controller/soft start (SMC) and fusible switch as indicated, complete with control transformer and control devices as indicated and specified, all mounted in a common free standing enclosure.
   1. Adjustable frequency controller (AFC), variable speed drive shall be a completely solid state, pulse-width-modulated type, variable torque controller, which shall be capable of transforming 480 volt (+10% -5%), three phase, 60 Hertz (+/-2 Hz) input power into variable voltage, adjustable frequency, three phase output power of suitable capacity and waveform to control the speed and the torque of NEMA Standard Design B, squirrel-cage

induction motors throughout a stepless speed range of 10 to 110 percent of rated synchronous RPM on a continuous basis with variable torque loads.

2. Unit shall be provided with a door-mounted command/control center, microprocessor based, with digital display. Center shall incorporate all operating controls; programmable parameter controls; and frequency, voltage, current, speed, fault indications, and programmable settings display. Program and factory presets shall be held in a non-volatile memory.
3. All devices and features required for compliance with ANSI/IEEE Standard 519 shall be provided. The controller shall also be equipped with a filter circuit to reduce the harmonics of the waveform applied to the motors to five percent or less of the fundamental RMS value under all conditions to minimize motor heating and to protect the controller from AC line disturbances. Equip controller with a reactor to prevent nuisance opening of line protective devices due to capacitor charging currents.
4. Enclosure shall be gasketed NEMA 1, arranged to be mounted as an individual unit.
5. Provide drive input contactor.
6. Provide manual bypass factory installed. Bypass starter shall be a solid state motor controller/soft start SMC-Dialog Plus unit. SMC-Dialog plus shall include integrated bypass and electronic overload and motor starting capabilities.
7. Both the AFC and SMC-Dialog Plus bypass starter shall be configured with ControlNet for interfacing into the ControlNet system (two ControlNet nodes).

B. AFC shall include the following design features:
1. Electronic current limit circuitry, adjustable to 110 percent of motor full-load current, to safely limit the current under any fault condition of inverter or motor and to provide soft-start acceleration and running without exceeding 150% of motor rated current. The current limit shall be of the type for variable torque load, which acts to reduce output voltage and frequency without directly causing a protective fuse to blow.
2. Controller shall be designed to accept a 4-20 mA analog speed signal from a ground-isolated process controller in the automatic mode or from programmed speed control input parameter in the manual mode. Provide programmable automatic-manual mode selection. The selected signal shall control the motor speed between the preadjusted minimum and maximum speed settings. Maximum speed shall be field adjustable to 100% of rated speed.
3. AFC shall be equipped with a door-mounted Bypass-Off-Automatic selector switch. By this bypass switch, the controller shall have a stand-alone-operation to facilitate for startup, adjustment or trouble-shooting, while the motor is on the bypass operation. Provide a normally closed dry contact from the bypass starter into the controller; (“Auto” control circuit) to confirm the bypass operation.
4. Fusible Switch: 600 volt, 3 pole, single throw, visible blade, NEMA “HD” heavy duty, quick-make, quick-break type, horsepower rated, with continuous current and fuse ratings as indicated. Where ratings are not indicated, provide fuse clips to accommodate a UL Class RK5 dual-element type fuse as specified and having a minimum current rating of 150% of the motor full load current, with switch of equivalent rating. Silver or cadmium plate all contact surfaces including fuse clips.
5. Interlocking: Equip switch with an external operating handle. Interlock the operating handle with the enclosure door such that the door cannot be opened unless the switch or breaker is in the “off” position. Provide means for padlocking the operating handle in the “off” position with three, 5/16-inch shackle padlocks such that when the operating handle

is padlocked in the “off” position, the enclosure door cannot be opened and the switch cannot be closed.

6. Starter: Size starters in accordance with NEMA Standards for the horsepower of the motors with which they will be used, except do not furnish starters smaller than NEMA Size 1. Provide coils for operation on 120 volts unless other requirements are indicated. Equip each starter with a minimum of two normally open and two normally closed spare auxiliary contacts or two spare convertible auxiliary contacts in addition to the normally-open seal-in contact, unless additional requirements are indicated. Provide additional contacts as indicated.
7. Thermal Overloads: One in each phase, externally manual reset type with normally open alarm contact. Select overloads after final installed horsepower of motors is determined. Do not use ratings exceeding 100% of motor full load current adjusted for ambient temperatures.
8. Control Transformer: Provide a 480-120 volt control transformer in each individual starter unit. Fuse the primary winding as required by the NEC. Fuse and ground the secondary winding as required. Where indicating lights, solenoid valves or other control components are to be energized from the control transformer, increase the capacity of the control transformer proportionately for loading above the minimum requirements of the operating coil.

C. Provisions for Metering, Control, Diagnosis Devices and Interlocking:
1. Motor Speed Indication shall be a selectable display on an integral liquid crystal display (LCD) or equivalent device.
2. Automatic Reset and Restart, immediately after the power outage.
3. Fault/Problem Diagnostics Display “LCD” Readout; to indicate running fault conditions of
   a. Over/Under Voltage trip
   b. Overcurrent trip
   c. Overtemperature trip
   d. Low Speed
   e. DC bus charged
4. Controller shall accept input from dry contacts from external fault circuit or alarm equipment to shut down the input power automatically and safely.
5. Provide programmed safety interlocking on normal and bypass mode operations to inhibit unauthorized startup if accidental shutdown has occurred, and equip with a “DISABLED” indication.
6. Control Net Interface
7. Remote Voltage Indication

D. Provision for Programmable Adjustments:
1. The output voltage to frequency ratio shall be adjusted to save the maximum amount of energy by optimizing volt/Hertz ratio to match the actual load requirements.
2. Provide adjustable maximum and minimum frequency (speed) limits.
3. Provide 3 adjustable band width (0.2 - 10 Hz band width) frequency avoidance bands for skipping over mechanical resonance frequency regions.
4. Acceleration/Deceleration, internally adjusted within 2 to 20 seconds range, with the torque limit overriding the acceleration protection as well as the regeneration protection during deceleration.

5. Output V/Hz ramp shall be automatically controlled to provide a voltage boost to increase the output torque limit to match the load torque which may override the speed command and decrease the frequency while maintaining the correct V/Hz ratio whenever the load level surpasses the drive design level.

E. Include the following features of self-protection and reliable operation:
   1. Current Limit; to limit output current to 110% for continuous operation and 150% for one minute operation of the inverter rating. The current limit shall be designed to function automatically to prevent overcurrent trip due to momentary overload condition, allowing the drive to continue operation.
   2. Instantaneous Overcurrent Trip; to safely limit the output current in under 50 microseconds due to short circuit or severe overload condition.
   3. Undervoltage Trip; to protect the drive due to non-momentary power or phase loss. The undervoltage trip will activate automatically when the line voltage drops 15% below the rated input voltage. Provide adjustable line dip ride-through (0-500 msec).
   4. Overvoltage Trip; to protect the drive due to voltage levels in excess of its rating. The overvoltage trip will activate automatically when the inverter bus in the controller exceeds 650 VDC.
   5. Overtemperature Trip; to protect the drive from elevated temperatures in excess of its rating. Provide an indicating light which begins to flash within 10 degC of the trip point, this light to alert the operator of the increasing temperature condition. When the overtemperature trip point is reached, this light shall be continuously illuminated until the cause is removed or repaired.
   6. Automatic Reset/Restart: The drive shall be equipped such that a trip condition resulting from overcurrent, undervoltage, overvoltage or overtemperature shall be automatically reset and the drive shall automatically restart upon removal or correction of the causative condition. The number of reset/restart attempts for overcurrent, undervoltage, overvoltage and overtemperature shall be limited to five. If in five attempts of reset/restart it is not successful, the drive shall shut down safely requiring a manual restart. If within five attempts a successful reset/restart occurs, the automatic reset/restart circuit shall reset the attempts counted to zero after approximately 10 minutes of continuous operation.
   7. LCD display messages, shall be provided for indication of fault conditions as described above in paragraphs C.3.a. through C.3.e. Provide an SPDT contact for remote indication of these conditions. Additionally, provide indication to show power “ON”, “RUNNING” and the drive “DISABLED”.

F. Manufacturers:

<u>Variable Frequency Drives (Allen Bradley)</u>

CHWP (Chilled Water Pumps)

Allen Bradley Part Number:

21CD385BPCANNBCB0NNNN-HD-B1X-ACDT-C1-DCDT-J2-J4-P4-P11-PB4M3RF3-S1-S9-S10-S13-S14-S18

CWP (Condenser Water Pumps)

Allen Bradley Part Number:

21CD261BPCANNBCB0NNNN-HD-B1X-ACDT-C1-DCDT-J2-J4-P4-P11-PB4M3RF3-S1-S9-S10-S13-S14-S18

Cooling Tower Fans

Allen Bradley Part Number:

21BD156ACANNACD0NNNN-HD-B1X-ACDT-C1-DCDT-J2-J4-L1-P4-P11-PB4M3RF3-S1-S9-S10-S13-S14-S18

2.3 THREE PHASE MAGNETIC MOTOR STARTERS FULL VOLTAGE COMBINATION TYPE

A. *Single-Speed Nonreversing Starters [U]*: Per NEMA Standard ICS and consisting of a fused disconnect switch, a full voltage magnetic starter, thermal overloads, control transformer and control devices as indicated and as specified, all mounted and wired in a NEMA 12 enclosure and a NEMA 3R in outdoor areas unless otherwise indicated.

1. Fused Disconnect Switch: 600 volt, 3 pole, single throw, visible blade, NEMA “HD” heavy duty, quick-make, quick-break type, horsepower rated, with continuous current and fuse ratings as indicated. Where ratings are not indicated, provide fuse clips to accommodate a dual element type fuse as specified and having a minimum current rating of 150% of the motor full load current, with switch of equivalent rating. Silver or cadmium plate all contact surfaces including fuse clips.
2. Interlocking: Equip switch with an external operating handle. Interlock the operating handle such that the door cannot be opened unless the switch is in the “off” position. Provide means for padlocking the operating handle in the “off” position with three, 5/16-inch shackle padlocks such that when the operating handle is padlocked in the “off” position, the cover door cannot be opened and the switch cannot be closed.
3. Starter: Size starters per NEMA Standards for the horsepower of the motors with which they will be used, except do not furnish starters smaller than NEMA Size 1 for motors of 5 horsepower or less. Provide coils for operation on 120 volts AC unless other requirements are indicated. Equip each starter with a minimum of two normally open and two normally closed spare auxiliary contacts or two spare convertible auxiliary contacts in addition to the normally-open seal-in contact, unless additional requirements are indicated. Provide additional contacts as indicated.
4. Thermal Overload: One in each phase wire, external manual reset type. Select overloads after final installed horsepower of motor is determined. Do not use ratings exceeding 100% of motor full load current adjusted for ambient temperatures.
5. Control Transformer: Provide a 480-120 volt control transformer in the starter enclosure. Fuse the primary winding as required by the NEC. Fuse and ground the secondary winding as required. Where indicating lights, solenoid valves or other control components are to be energized from the control transformer, increase the capacity of the control transformer proportionately for loading above the minimum requirements of the operating coil.
6. Control Devices: Provide control devices as specified, in starter enclosures when required by elementary diagrams.

B. *Reversing Starters [U]*: Per NEMA Standard ICS and consisting of a fused disconnect switch, two full voltage magnetic starters, thermal overloads, control transformer and control devices as indicated and as specified, with similar features to those specified for single-speed nonreversing starters. Interlock starters mechanically and electrically to prevent both starters from being closed at the same time.

C. *Two-Speed Starters [U]*: Per NEMA Standard ICS and consisting of a fused disconnect switch, two full voltage starters for two-speed two-winding type motors, two sets of thermal overloads, control transformer and control devices as indicated and as specified, with similar features to those specified for single-speed nonreversing starters. Interlock starters mechanically and electrically to prevent both starters from being closed at the same time.

D. Manufacturers:
   1. Allen-Bradley.
   2. Eaton Corp., Cutler-Hammer/Westinghouse.
   3. General Electric.
   4. Siemens-Allis.
   5. Square D.
   6.

2.4 SINGLE PHASE MANUAL MOTOR STARTERS FRACTIONAL HORSEPOWER TYPE

A. *Single-Speed Starters for 115 Volt Motors [U]*: Per NEMA Standard ICS and consisting of a toggle-operated, single pole, quick-make, quick-break type starter, one thermal overload element, and pilot lights in cover as indicated all mounted in a NEMA 1 surface mounting enclosure, or with a stainless steel plate for flush mounting in an outlet box, as indicated. Provide means for padlocking the toggle operator in the “off” position.

B. Manufacturers:
   1. Allen-Bradley Bulletin 600.
   2. General Electric CR101.
   3. Square D Class 2510.
   4. Eaton/Cutler Hammer Type MS.

2.5 SAFETY SWITCHES

A. *Safety Switches [U]*: General Description. Fusible or nonfusible as indicated, quick-make, quick-break, NEMA “HD” heavy duty visible blade type, horsepower rated, in NEMA 12 enclosures in general in buildings 600 & 600A and NEMA 1 enclosures in building 600 Electrical Mezzanine unless otherwise noted. Furnish 3 pole, single throw switches unless otherwise indicated, with voltage and current ratings as indicated. Short circuit rating with fuses shall not be less than 200,000 A.I.C. Silver or cadmium plate all contact surfaces including fuse clips.

B. Interlocking: Equip switches with an external operating handle and interlock the operating handle with the cover door such that the cover door cannot be opened unless the switch is in the “off” position. Provide means for padlocking the operating handle in the “off” position such that when the operating handle is padlocked in the “off” position, the cover door cannot be opened and the switch cannot be closed. Equip switches with auxiliary contacts when such are indicated.

C. Fuse Clips: Standard rejection type for dual element cartridge type fuses as specified unless otherwise required.

D. Manufacturers:
   1. General Electric Type TH.
   2. Square “D” Heavy Duty.
   3. Westinghouse H-600.

2.6 FUSES

A. *Fuses [U]*; in General. Up to and including 600 Amps, provide one-time high interrupting capacity, UL Class RK5 dual element type or UL Class RK1 current-limiting fuses. Class H fuses are not acceptable. For fuse sizes over 600 Amps, provide UL Class L, current limiting time delay type.

B. *Class RK5 Fuses [U]*:
   1. Bussmann “Fusetron”.
   2. Gould-Shawmut “Trionic”.
   3. Reliance Fuse “ESCR” or “ECNR”.
   4. Littelfuse “FL SLO-BLO”.

C. *Class RK1 Fuses [U]*:
   1. Bussmann “Low-Peak”.
   2. Gould-Shawmut “Amp-Trap”.
   3. Reliance Fuse “LESRK” or “LENRK”.
   4. Littelfuse “LL Series”.

D. *Class L Fuses [U]*:
   1. Bussmann “KRP-C”.
   2. Gould-Shawmut “A4BY”.
   3. Reliance Fuse “LCL”.
   4. Littelfuse “KLPC”.

PART 3 EXECUTION

3.1 INSTALLATION

A. Motors: Refer to SECTION 16025 for furnishing and mounting responsibility for all electric motors. Motors 1/2 horsepower and larger are 460 volts, 3 phase, 60 hertz, and motors less than 1/2 horsepower are 115 volts, single phase, 60 hertz, unless other requirements are indicated. In all cases where the capacity or rating of equipment being furnished under this SECTION is based on the rating of equipment being furnished under other SECTIONS, confirm such ratings before purchasing the equipment.

B. Control Equipment: Install equipment at locations indicated. Install motor starters, safety switches and control devices at uniform heights in general throughout the building with operating means at convenient heights above the floor and as indicated. Do not locate the operating means for individually mounted equipment at a height greater than 66 inches above the floor unless prior approval is obtained from the ARCHITECT-ENGINEER.

C. Fuses: Install fuses, of required ampere rating, in all fusible equipment installed under 16000 Series SECTIONS. Verify all fuse ratings based on actual motor horsepower provided and manufacturer's requirements for equipment protection.

3.2 ADJUSTABLE FREQUENCY CONTROLLER TESTING AND PERFORMANCE REQUIREMENTS

A. Every AFC shall be functionally tested and factory adjusted; but it may be necessary to readjust the controller to meet a specific requirement of the speed range (maximum/minimum limits) as well as to obtain a sufficient torque for a soft starting and smooth running of the motor under various actual load conditions.

B. Run the unit up to full speed and measure voltage and current; then calculate the efficiency which shall be in excess of 95% at full load and the power factor in excess of 0.85. All readings must fall within the predetermined design values to assure compliance with the SPECIFICATIONS.

C. Standard: Adjustable frequency drive system installations shall comply with the recommendations and requirements of ANSI/IEEE Standard 519.

D. Upon final installation of the entire system and equipment, provide factory personnel for two full 8-hour training sessions on site to fully acquaint the plant personnel (drive operators) with the equipment and its operation.

E. Provide two sets of standard drawings, three sets of instruction manual and a certified test record for each particular controller. In addition, provide one complete spare parts kit for each size of drive. The kit shall include a control board, thyristor block, diode set, fuses, and all other field-replaceable elements as necessary.

END OF SECTION

Revision History	
Date	**Rev. No.**
A	0
B	0
D	0
E	0
F	0
02-19-09	0

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