SECTION 26 24 19.30 [16443]
LOW VOLTAGE INDUSTRIAL MOTOR CONTROL CENTERS

Square D™ by Schneider Electric
Model 6 Motor Control Center
Adjustable Frequency AC Drives

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: This section includes, but shall not be limited to, requirements for a motor control center (MCC) and required control devices as shown on the Drawings and specified to be part of the MCC equipment. The MCC shall be 480 volt, 3-phase, 3-wire, 60 hertz unless otherwise indicated (600 volt in Canada).

1.2 REFERENCES

A. General: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

B. American National Standards Institute (ANSI):

1. ANSI Z55.1, “Gray Finishes for Industrial Apparatus and Equipment.”

C. ASTM International (ASTM):

1. ASTM B117, "Standard Practice for Operating Salt Spray (Fog) Apparatus."

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

1. IEEE 519, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters."

E. International Electrotechnical Commission (IEC):

1. IEC 60947, “Low Voltage Switchgear and Control Gear - Part 2: Circuit Breakers.”

F. International Organization for Standardization (ISO):

1. ISO 9001, "Quality Management Systems - Requirements."

G. Military Standardization Documents (MIL):

1. MIL-STD-202, "Test Methods for Electronic and Electrical Component Parts."

H. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 18, "Motor Control Centers."

I. National Fire Protection Association (NFPA):

1. NFPA 70, "National Electrical Code," hereinafter referred to as NEC.

J. SAE International (SAE):

1. SAE H1738-2, “Specification for Mini, Micro, and Nano Plugs and Receptacles."

K. Underwriters Laboratories, Inc. (UL):

1. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations.”

1. UL 498, "Standard for Attachment Plugs and Receptacles."

1. UL 508, "Standard for Industrial Control Equipment."

1. UL 845, "Motor Control Centers."

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of the Contract and Division 01 - General Requirements.

B. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.

C. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data.

D. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.

E. Operation and Maintenance Manuals: Submit with the delivery of the MCC an operation and maintenance manual and one copy of the manufacturer's drawings per shipping block.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of low voltage industrial MCCs of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of five years.

2. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing low voltage industrial MCCs similar in type and scope to that required for this Project and shall be approved by the manufacturer.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

1. The MCC shall conform to UL 845, current revision, Canadian Standards Association (CSA), Electrical Equipment Manufacturers Association of Canada (EEMAC), NEMA ICS 18, the NEC, and the Canadian Electrical Code. The MCC shall be manufactured in an ISO 9001 certified facility.

C. Pre-Installation Conference: Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, manufacturer's representatives, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Architect.

D. Single Source Responsibility: Obtain low voltage industrial MCCs and required accessories from a single source with resources to produce products of consistent quality in appearance and physical properties without delaying the work. Any materials which are not produced by the manufacturer shall be acceptable to and approved by the manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The MCC shall be separated into shipping blocks no more than three vertical sections each. Shipping blocks shall be shipped on their sides to permit easier handling at the job site. Each shipping block shall include, but shall not be limited to, a removable lifting angle, which shall allow an easy means of attaching an overhead crane or other suitable lifting equipment.

B. If the MCC cannot be placed into service reasonably soon after its receipt, store it in a clean, dry, and ventilated building free from temperature extremes. Acceptable storage temperatures are from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).

1.6 WARRANTY

A. The MCC shall be warranted to be free from defects in materials and workmanship for a period of 18 months from date of invoice from manufacturer or authorized sales channel.

B. The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Shall be Square D® brand or equal.

B. Additions to existing MCCs shall be the same as the original manufacturer.

2.2 MATERIALS

A. Steel material shall comply with UL 845 and CSA requirements.

B. Each MCC shall consist of one or more vertical sections of heavy gage steel bolted together to form a rigid, freestanding assembly. A removable 7 gage structural steel lifting angle shall be mounted full width of the MCC shipping block at the top. Removable 7 gage bottom channel sills shall be mounted underneath front and rear of the vertical sections extending the full width of the shipping block. Vertical sections shall be made of welded side-frame assembly formed from a minimum of 12 gage steel. Internal reinforcement structural parts shall be of 12 gage and 14 gage steel to provide a strong, rigid

assembly. The entire assembly shall be constructed and packaged to withstand normal stresses included in transit and during installation.

2.3 MCC FINISH

A. Steel parts shall be provided with UL and CSA listed acrylic/alkyd baked enamel paint finish or triglycidyl isocyanurate (TGIC) powder coat, except plated parts used for ground connections. Painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.

B. Pre-treatment shall include, but shall not be limited to, the following:

1. Hot alkaline cleaner to remove grease and oil.

2. Iron phosphate treatment to improve adhesion and corrosion resistance.

C. The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.

D. The standard paint finish shall be tested to UL 50 per ASTM B117 (5 percent ASTM salt spray) with no greater than 0.125 inch (3.18 mm) loss of paint from a scribed line.

E. Paint color shall be #49 medium light gray per ANSI Z55.1 (60 to 70 gloss) on all surfaces unless specified otherwise. Control station plates and escutcheon plates shall be painted a contrasting gray. Unit interior saddles shall be painted white for better visibility inside the unit.

2.4 STRUCTURES

A. Structures shall be totally enclosed, deadfront, freestanding assemblies. Structures shall be capable of being bolted together to form a single assembly.

B. The overall height of the MCC shall not exceed 90 inches (2286 mm), not including base channel or lifting angle. Base channels, 1.5 inches (38 mm) in height, and lifting angles, 3 inches (76 mm) in height, shall be removable. The total width of one section shall be 20 inches (508 mm). Widths of 25 inches (635 mm), 30 inches (762 mm), and 35 inches (889 mm) can be used for larger devices.

C. Structures shall be NEMA/EEMAC Type [1 (general purpose)] [1A (gasketed general purpose)] [12 (industrial duty)] [3R non-walk-in (rainproof)].

D. Each 20 inch (508 mm) wide standard section shall have all the necessary hardware and bussing for modular plug-on units to be added and moved around. Unused space shall be covered by hinged blank doors or appropriate cover plate and equipped to accept future units. Vertical bus openings shall be covered by manual bus shutters.

E. Each section shall include, but shall not be limited to, a top plate (single piece or two-piece). NEMA/EEMAC Type 12 shall also include a bottom plate. Top and bottom plates shall be removable for ease in cutting conduit entry openings.

2.5 WIREWAYS

A. Structures shall contain a minimum 12 inch (305 mm) high horizontal wireway at the top of each section and a minimum 6 inch (152 mm) high horizontal wireway at the bottom of each section. These wireways shall run the full length of MCC to allow room for power and control cable to connect

between units in different sections.

B. A full-depth vertical wireway shall be provided in each MCC section that shall accept modular plug-on units. The vertical wireway shall connect with both the top and bottom horizontal wireway. The vertical wireway shall be 4 inches (102 mm) wide minimum with a separate hinged door. There shall be a minimum of 60 square inches (387 square centimeters) of cabling space available for 15 inch (381 mm) deep sections and 80 square inches (516 square centimeters) of cabling space available for 20 inch (508 mm) deep sections. Access to the wireways shall not require opening control unit doors. Structures that house a single, full section control unit are not required to have vertical wireways. Those control units shall open directly into the MCC horizontal wireways.

2.6 BARRIERS

A. Power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be mounted onto a glass-filled polyester support assembly that shall brace the bus against the forces generated during a short circuit. The horizontal bus shall be isolated from the top horizontal wireway by a two-piece rigid non-conductive barrier. The barrier design shall allow qualified personnel to slide the barriers both left and right, to allow access to the bus and connections for maintenance without having to remove the barrier. Barrier sliding shall occur via an upper and lower track system.

B. The vertical bus shall be housed in a molded glass-filled polyester support that shall provide bus insulation and shall brace the bus against the forces generated during a short circuit. These supports shall have openings every 3 inches (76 mm) for unit stab-on connections. Each opening shall be provided with a manual shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they shall be retained in the structure and shall be readily accessible for use should a plug-in unit be removed from the MCC.

C. [Barriers shall be provided in the vertical structure and unit designs to prevent the contact of any energized bus or terminal by a fishtape inserted through the conduit or wireway areas.]

2.7 BUSSING

A. Bussing and connectors shall be [tin-plated aluminum] [tin-plated copper] [silver-plated copper].

B. The main horizontal bus shall be rated at [600 amperes] [800 amperes] [1200 amperes] [1600 amperes] [2000 amperes] [2500 amperes (NEMA/EEMAC Type 1 enclosure only)] continuous and shall extend the full length of the MCC. Bus ratings shall be based on 149 degree F (65 degree C) maximum temperature rise in a 104 degree F (40 degree C) ambient. Provisions shall be provided for splicing additional sections onto either end of the MCC.

C. The horizontal bus splice bars shall be pre-assembled into a captive bus stack. This bus stack shall be installed into the end of the MCC power bus to allow the installation of additional sections. The main bus splice shall utilize four bolts, two on each side of the bus split, for each phase. Additional bolts shall not be required when splicing higher amperage bus. The splice bolts shall secure to self-clenching nuts installed in the bus assembly. It shall be possible to maintain any bus connection with a single tool.

D. Each section that accepts plug-in units shall be provided with a vertical bus for distributing power from the main bus to the individual plug-in starter units. This bus shall be of the same material and plating as the main bus, and shall be rated at [300] [600] amperes continuous. The vertical bus shall be connected directly to the horizontal bus stack without the use of risers or other intervening connectors. It shall be possible to maintain the vertical to horizontal bus connection with a single tool. Nut-and-bolt bus connections to the power bus shall not be permitted. When a back-to-back unit arrangement is utilized, separate vertical bus shall be provided for both the front and rear units.

E. A [tin-plated] [silver-plated] copper ground bus shall be provided that shall run the entire length of the MCC. [The ground bus shall be 0.25 inch (6.35 mm) by 1 inch (25 mm) and shall be rated for 300 amperes] [The ground bus shall be 0.25 inch (6.35 mm) by 2 inches (51 mm) and shall be rated for 600 amperes]. A compression lug shall be provided in the MCC for a 4/0-250 kcmil ground cable. The ground bus shall be provided with six 0.38 inch (9.65 mm) holes for each vertical section to accept user-supplied ground lugs for any loads requiring a ground conductor.

F. Each vertical section shall have a [steel] [copper] vertical ground bus that shall be connected to the horizontal ground bus. This vertical ground bus shall be installed so that the plug-in units engage the ground bus prior to engagement of the power stabs and shall disengage only after the power stabs are disconnected upon removal of the plug-in unit.

G. The system shall be rated for an available short circuit capacity of [42,000] [65,000] [85,000] [100,000] amperes rms.

2.8 TYPICAL UNIT CONSTRUCTION

A. Units with circuit breaker disconnects through 400 ampere frame, and fusible switch disconnects through 400 amperes, shall connect to the vertical bus through a spring reinforced stab-on connector. Units with larger disconnects shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.

B. Conducting parts on the line side of the unit disconnect shall be shrouded by a suitable insulating material to prevent accidental contact with those parts.

C. Unit mounting shelves shall include, but shall not be limited to, hanger brackets to support the unit weight during installation and removal. Plug-on units shall use a twin-handle camming lever located at the top of the bucket to rack in and out the plug-on unit. The cam lever shall work in conjunction with the hanger brackets to ensure positive stab alignment.

D. A lever handle operator shall be provided on each disconnect. With the unit stabs engaged onto the vertical phase bus and the unit door closed, the handle mechanism shall allow complete on/off control of the unit. Circuit breaker operators shall include, but shall not be limited, a separate tripped position to clearly indicate a circuit breaker trip condition. It shall be possible to reset a tripped circuit breaker without opening the control unit door. Clear indication of disconnect status shall be provided, by adhering to the following operator handle positions:

1. Handle on position shall be up or to the left and within 45 degrees of being parallel to the face of the equipment.

2. Handle off position shall be down or to the right and within 45 degrees of being parallel to the face of the equipment.

3. The minimum separation between the on and off positions shall be 90 degrees.

4. On circuit breaker disconnects, the handle tripped position shall be perpendicular to the face of the equipment ±30 degrees. Minimum separation between on and tripped shall be 30 degrees. Minimum separation between tripped and off shall be 45 degrees.

E. A mechanical interlock shall prevent the operator from opening the unit door when the disconnect is in the on position. Another mechanical interlock shall prevent the operator from placing the disconnect in the on position while the unit door is open. It shall be possible for authorized personnel to defeat these interlocks.

F. A non-defeatable interlock shall be provided to prevent installing or removing a plug-on unit unless the disconnect is in the off position.

G. The plug-in unit shall have a grounded stab-on connector which shall engage the vertical ground bus prior to, and shall release after, the power bus stab-on connectors.

H. Provisions shall be provided for locking disconnects in the off position with up to three padlocks.

I. Handle mechanisms shall be located on the left side to encourage operators to stand to the left of the unit being switched.

J. Unit construction shall combine with the vertical wireway isolation barrier to provide a fully compartmentalized design.

K. [Surfaces (back, side, and bottom plates) of the unit interior shall be painted white.]

2.9 COMPONENTS FOR TYPICAL UNITS

A. Combination Starters:

1. Combination starters shall use a unit disconnect as described in Typical Unit Construction Article above. Magnetic starters shall be furnished in combination starter units. Starters shall utilize NEMA/EEMAC rated contactors. Starters shall be provided with a three-pole, external manual reset, overload relay for [eutectic melting alloy] [ambient compensated bimetallic] [solid state] thermal overload units.

2. When provided, control circuit transformers shall include, but shall not be limited to, two primary protection fuses and one secondary fuse (in the non-ground secondary conductor). The transformer shall be sized to accommodate the contactor(s) and connected control circuit loads. The transformer rating shall be fully visible from the front when the unit door is opened.

3. When a unit control circuit transformer is not provided, the disconnect shall include, but shall not be limited to, an electrical interlock for disconnection of externally powered control circuits.

4. Auxiliary control circuit interlocks shall be provided where indicated. Auxiliary interlocks shall be field convertible to normally open or normally closed operation.

5. NEMA/EEMAC Size 1-4 starters shall be mounted directly adjacent to the wireway so that power wiring (motor leads) shall connect directly to the starter terminals without the use of interposing terminals. Larger starters shall be arranged so that power wiring may exit through the bottom of the starter cubical without entering the vertical wireway.

B. Terminal Blocks:

1. When Type B wiring is specified, starter units shall be provided with unit control terminal blocks.

2. Terminal blocks shall be the pull-apart type with a minimum rating of 250 volts and 10 amperes. Current carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is opened. Terminal blocks shall be DIN rail-mounted with the stationary portion of the block secured to the unit bottom plate. The stationary portion shall be used for factory connections, and shall remain attached to the unit when removed. The terminals used for field connections shall face forward so they can be wired without removing the unit or any of its components.

3. When Type C wiring is specified, starter units shall be provided with unit control terminal blocks as described for Type B wiring along with power terminal blocks for Size 1-3 units. An additional set of terminal blocks shall be provided in a terminal compartment located in each section. These terminal blocks shall be pre-wired to the unit terminals so that field control connections can be made at the terminal compartments.

C. Nameplates: Provide engraved phenolic nameplates for each MCC and unit compartment. Provide gray background with white letters, measuring a minimum of 1.5 inches (38 mm) high by 6.25 inches (159 mm) wide total outside dimensions.

D. Pilot Device Panel: Each combination starter unit shall be proved with a hinged/removable control station plate, which can accommodate up to five 0.87 inch (22 mm) pilot devices or three 1.18 inch (30 mm) pilot devices. [The control station plate can be deleted if no local unit pilot devices are required.]

2.10 SIX INCH (152 MM) UNIT CONSTRUCTION

A. Units with circuit breaker disconnects through 250 ampere frame and fusible switch disconnects through 100 amperes shall connect to the vertical bus through a spring-reinforced, stab-on connector. Stab-on plug-on units shall be cable connected to the unit disconnect. Six inch (152 mm) fusible units shall accept Class J fuses only.

B. Conducting parts on the line side of the unit disconnect shall be shrouded by a suitable insulating material.

C. Unit mounting shelves shall include, but shall not be limited to, hanger brackets to support the unit weight during installation and removal. Six inch (152 mm) plug-on units shall be installable without the assistance of a camming device so as to allow maximum accessibility with the unit installed.

D. A lever handle operator shall be provided on each disconnect. With the unit stabs engaged into the vertical phase bus and the unit door closed, the handle mechanism shall allow complete on/off control of the unit disconnect with clear indication of the disconnects status. Circuit breaker operators shall include, but shall not be limited to, a separate tripped position to clearly indicate a circuit breaker trip

condition. It shall be possible to reset a tripped circuit breaker without opening the control unit door.

1. A mechanical interlock shall prevent an operator from opening the unit door when the disconnect is in the on position. Another mechanical interlock shall prevent an operator from placing the disconnect in the on position while the door is open. It shall be possible for authorized personnel to defeat these interlocks.

2. A non-defeatable interlock shall be provided between the handle operator and the structure to prevent installing or removing a plug-on unit unless the disconnect is in the off position. The plug-on unit shall have a grounded stab-on connector which shall engage the vertical ground bus prior to, and shall release after, the power bus stab-on connectors.

E. Provisions shall be made for locking disconnects in the off position with up to three padlocks.

F. Handle mechanisms shall be located on the bottom left side of the unit and operate horizontally to encourage operators to stand to the left of the unit being switched.

G. Unit construction shall combine with the vertical wireway isolation barrier to provide a fully compartmentalized design.

H. Up to a maximum of twelve 6 inch (152 mm) units shall be able to be installed per vertical section without placement restrictions in new or existing applications.

2.11 COMPONENTS FOR 6 INCH (152 MM) UNITS

A. Six Inch (152 mm) Combination Starters

1. Six inch (152 mm) combination starters shall use a unit disconnect as described in Six Inch (152 mm) Unit Construction Article above. Starters shall use [NEMA/EEMAC] [IEC] rated contactors. Starter units shall be provided with a 3-pole, external manual reset, overload relay for [eutectic melting alloy (NEMA rated units only)] [solid state (NEMA rated units only)] [ambient compensated bi-metal (application-rated units)] motor overload protection.

2. When provided, control circuit transformers shall include, but shall not be limited to, two primary protection fuses and one secondary fuse (in the non-ground secondary conductor). The transformer shall be sized to accommodate the contactor(s) and connected control circuit loads.

3. When a unit control circuit transformer is not provided, the disconnect shall include, but shall not be limited to, an electrical interlock for disconnection of externally powered control circuits.

4. Auxiliary control circuit interlocks shall be provided where indicated. For NEMA rated starters, auxiliary interlocks shall be field convertible to normally open or normally closed operation.

5. NEMA/EEMAC Size 1 starters shall be mounted directly adjacent to the wireway so that power wiring (motor leads) shall connect directly to the starter terminals.

B. Terminal Blocks for Six Inch (152 mm) Units:

1. Starter units shall be provided with unit control terminal blocks.

2. Terminal blocks shall be pull-apart type, 250 volts, and rated for 10 amperes. Current-carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is

opened. The stationary portion of the terminal block shall be used for factory connections and shall remain attached to the unit when the portion used for field connections is removed. The terminals used for field connections shall be accessible so they can be wired without removing the unit or any of its components.

C. Nameplates: Engraved phenolic nameplates shall be provided for each MCC and unit compartment. Each nameplate shall have a gray background, white lettering, and shall measure a minimum of 1.5 inches (38 mm) high by 6.25 inches (159 mm) wide total outside dimensions.

D. Pilot Device Control Panel: Each unit shall be provided with a control panel for up to a maximum of four pilot devices. [Pilot device control panel can be deleted if no local unit pilot devices are required.] Control panel shall be removable by loosening two semi-captive fasteners for user access.

2.12 ADJUSTABLE FREQUENCY AC DRIVE UNIT CONSTRUCTION

A. The AC drive controller unit shall be a combination disconnect-drive MCC style unit. The input [circuit breaker] [fusible switch] shall provide NEC required branch circuit protection. The branch circuit protection shall have an external operator. The adjustable frequency drives shall be [variable] [constant] torque AC drives. Wiring between the AC drive and the disconnect shall not be disturbed when removing or installing the AC drive controller unit from the MCC.

B. Units shall be of modular construction so that it shall be possible to readily interchange units of the same size without modifications to the MCC structure.

C. Conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.

D. AC drive controller units up to 50 horsepower variable torque shall be plug-on units which shall connect to the vertical bus through a spring-reinforced, stab-on connector. Units larger than 50 horsepower variable torque shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.

E. AC drive controller unit interior mounting panels shall be white for better visibility.

F. A disconnect operator shall be provided per Typical Unit Construction Article above.

G. Plug-on AC drive controller units shall have a grounded stab-on connector which shall engage the vertical ground bus prior to, and shall release after, the power bus stab-on connectors engage/release.

H. AC drive controller units shall be provided with unit control terminal blocks for use in terminating field wiring. Terminal blocks shall be pull-apart type, 250 volts, and rated for 10 amperes. Current-carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is opened. The stationary portion of the terminal block shall be used for factory connections and shall remain attached to the unit when the portion used for field connections is removed. The terminals used for field connections shall be accessible so they can be wired without removing the unit or any of its components.

I. The AC drive controller unit shall incorporate a self-contained, air-based cooling system. Air exhaust vents shall be louvered to help direct air flow away from personnel operating the AC drive controller

unit. Fans, ductwork, or filters shall be easily accessible for maintenance.

J. The AC drive controller unit cooling system shall be sized to cool the drive regardless of mounting location within the MCC. The AC drive controller unit shall not be restricted to a specific location in the MCC.

K. An internal overtemperature trip shall be provided to detect cooling system failure or blockage. Upon occurrence of an overtemperature trip, the cooling system fans shall continue running to provide a rapid cool down.

L. Power for the cooling system shall be provided internal to the AC drive controller unit by use of a control power transformer that shall include, but shall not be limited to, two primary fuses and one secondary fuse (in the non-ground secondary conductor).

M. Electrical Ratings:

1. The AC drive controller unit shall be designed to operate from an input voltage of [208] [240] [480] [600] volts AC, ±10 percent.

2. The AC drive controller unit shall operate from an input voltage frequency range of 57 to 63 hertz.

3. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.

4. The efficiency of the AC drive at 100 percent speed and load shall not be less than 96 percent.

5. The variable torque overtorque capacity shall be 130 percent for 1 minute. [The constant torque overtorque capacity shall be 170 percent for 1 minute.]

6. The output carrier frequency of the AC drive shall be selectable between 1 kHz and 16 kHz, depending on inverter rating for low noise operation. The output carrier frequency of the AC drive shall be randomly modulated to avoid resonance.

7. AC drive controller unit feeder equipment, including, but not limited to, conductors, lugs, disconnects, contactors, etc., shall be sized per NEC Article 430 for the AC drive input current rating. An impedance range corresponding to a 22,000 to 100,000 amperes fault availability level shall be assumed for the input current rating.

N. Protection:

1. The AC drive controller unit shall be protected against fault currents up to and including 100,000 amperes rms symmetrical at 480 volts AC and shall be UL 845 listed as verification.

2. Upon power-up, the AC drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, dynamic brake failure, DC-to-DC power supply, control power, and the pre-charge circuit.

3. The AC drive controller unit shall be protected against short circuits between output phases, between output phases and ground, on the internal power supplies, and on the logic and analog outputs.

4. The AC drive controller unit shall have a minimum AC undervoltage power loss ride-through of 200 milliseconds (12 cycles). The AC drive shall have the user-defined option of frequency fold-back to increase the duration of the power-loss ride-through.

5. The AC drive shall have a selectable ride-through function which shall allow the logic to maintain control for a minimum of 1 second (60 cycles) without faulting.

6. For a fault condition other than a ground fault, short circuit, or internal fault, an auto restart function shall provide restart attempts for a period of 5 minutes and up to an unlimited amount time depending on setting. The restart attempts shall be separated by increasingly longer waiting periods to allow the condition to be cleared.

7. The deceleration mode of the AC drive shall be programmable. The stop modes shall include, but shall not be limited to, freewheel stop, ramp stop, fast stop, and DC injection braking.

8. Upon loss of the analog process follower reference signal, the AC drive shall be programmable to fault and freewheel stop, ramp stop, fast stop, stop without trip, automatically restart, run at last speed, or maintain an user-defined low speed setting.

9. The AC drive shall have solid-state I^2t protection that shall be UL listed, shall meet UL 508 as a Class 10 overload protection, and shall meet IEC 60947. The minimum adjustment range shall be from 25 to 150 percent of the nominal current rating of the AC drive controller unit.

10. The AC drive shall have three skip frequency ranges with hysteresis adjustment that can each be programmed independently, back-to-back, or overlapping.

11. The AC drive shall be include, but shall not be limited to, an adjustable thermal alarm which can be assigned to a relay or logic output to indicate the drive temperature has reached the thermal alarm setting.

O. Adjustment and Configuration:

1. The AC drive shall have an user selectable auto tune feature. The auto tune shall automatically send motor-rated current to the connected motor and store the resulting resistance data into memory. The AC drive shall automatically optimize the operating characteristics according to the stored data.

2. The AC drive motor and control parameters shall be factory preset to operate most common applications. Necessary adjustments for factory supplied unit operator controls and sequencing shall be pre-programmed and tested by the manufacturer.

3. A choice of three types of acceleration and deceleration ramps shall be available in the AC drive software; linear, S curve, and U curve, as well as custom.

4. The acceleration and deceleration ramp times shall be adjustable from 0.01 to 6000 seconds.

5. The volts per frequency ratios shall be user selectable to meet variable torque loads, normal, and high torque machine applications.

6. The memory shall retain and record run status and fault type of the past eight faults for operator

review.

7. The software shall have an energy saving function that shall optimize the energy consumed. A constant volts/hertz ratio shall be maintained during acceleration. The output voltage shall then automatically adjust to meet the torque requirement of the load.

8. Slip compensations shall be a software-enabled function.

9. The AC drive shall offer programmable DC injection braking that shall brake the AC motor by injecting DC current and creating a stationary magnetic pole in the stator. The level of current shall be adjustable between 10 to 110 percent of rated current and available from 0.1 to 30 seconds continuously. For continuous operation after 30 seconds, the current shall be automatically reduced to 50 percent of the nameplate current of the motor.

10. Sequencing logic shall coordinate the engage and release thresholds and time delays for the sequencing of the AC drive output, mechanical actuation, and DC injection braking in order to accomplish smooth starting and stopping of a mechanical process.

P. Graphic Display Terminal Interface:

1. The graphic display terminal shall provide eight lines of 240 by 160 pixels in plain English to control, adjust, and configure the AC drive, including, but not limited to, electrical values, bar charts, configuration parameters, I/O assignment, application and activity function access, faults, local control, adjustment storage, self-test, and diagnostics. There shall be a standard selection of six additional languages built into the operating software as standard.

2. The AC drive model number, torque type, software revision number, horsepower, output current, motor frequency, and motor voltage shall be listed on the drive identification display as viewed on the graphic display terminal.

3. The graphic display shall be able to indicate one, two, or five digital values, or up to two values by bar graph. As a minimum, the selectable display values shall consist of speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference, and machine speed.

4. The graphic display terminal shall consist of programmable function keys. The functions shall allow both operating commands and programming options to be preset by the operator.

5. The graphic display terminal shall offer levels of settings from simple start-up to advanced user menus consisting of parameter setting, I/O map, fault history, and drive configuration. Password protection shall be available to limit unauthorized access to various levels of the menus.

6. The navigation wheel shall provide the ability to scroll through menus and screens, select or activate functions, or increase the value of a selected parameter.

7. An escape key shall allow a parameter to return the existing value if adjustment is not required and the value is displayed. The escape function shall also return to a previous menu display.

8. A run key and a stop key shall command normal starting and stopping as programmed when the AC drive is in keypad control mode. The stop key shall be active in all control modes.

9. A [Windows based personal computer] [serial communication link] [detachable graphic terminal display] user interface shall be available.

10. The keypad shall store up to four user configuration programs in nonvolatile memory. An operator shall have the ability to download a stored configuration to multiple AC drives.

11. The operator interface shall be MCC door-mounted on the AC drive controller unit for ease of access and increased visibility.

12. Door-mounted controls shall be NEMA/EEMAC Type 12 rated.

Q. Control:

1. Pilot devices shall be industrial rated [0.87 inch (22 mm)] [1.18 inch (30 mm)] type control operators and used independently of the keypad display. Software assignments for control inputs and outputs to operate factory-supplied controls shall be pre-configured from the factory. The following basic controls shall be provided:

    a. [Hand-off-auto selector switch. The hand mode shall allow manual operation of start, stop, and speed control. The AC drive shall start when the control operation is in the hand mode. A door-mounted, manual speed potentiometer shall be used to control speed in the hand mode. The AC drive shall run at the low speed setting or higher as required by the position of the manual speed potentiometer. This mode shall function as 2-wire control and automatically restart after a power outage or auto restart after a fault. The off position of the control operation shall stop the AC drive and prevent it from restarting. The auto (automatic) mode shall receive an [auto start contact] [serial link command] to control starting and stopping of the AC drive. This contact shall also start and stop bypass (if used) when both the automatic and bypass modes of operation are selected. Speed control shall be from an user supplied [4–20 mAdc] [serial link communication] signal.]

    b. [Start-stop pushbuttons. Start-stop pushbuttons shall provide 3-wire start/stop control.]

    c. [Power on pilot light, red.]

    d. [Fault pilot light, yellow, push-to-test.]

    e. [Run pilot light, green, push-to-test.]

    f. [Stopped pilot light, red, push-to-test.]

    g. [Hand/auto pilot lights, yellow, push-to-test.]

    h. Note, Additional controls can be found on the equipment electrical diagrams.

2. Two-wire or 3-wire control strategy shall be defined within the software.

3. The control power for the digital inputs and outputs shall be 24 volts DC.

4. The internal power supply shall incorporate an automatic current fold-back that shall protect the internal power supply if incorrectly connected or shorted. The transistor logic outputs shall be current limited and shall not be damaged if shorted or if excess current is pulled.

5. Logic connections shall be furnished on pull-apart terminal strips.

6. There shall be two software assignable analog inputs with interference filtering. The analog inputs shall be software selectable and consisting of user defined configurations: x-y mA or x-y V.

7. There shall be five software assignable logic inputs that shall be selected and assigned in the software. The selection of assignments shall consist of forward, reverse, jog, plus/minus speed (two inputs required), setpoint memory, preset speeds (up to eight inputs), auto/manual control, controlled stop, terminal or keypad control, output contactor (two inputs required), motor switching, and fault reset.

8. There shall be two software assignable analog outputs with interference filtering. The analog outputs shall be able to be selected and assigned in the software. The analog output assignments shall be proportional to the following motor characteristics: frequency, current, power, torque, voltage, and thermal state. The output signal shall be user-defined configurations: x-y mA or x-y V.

9. Two voltage-free Form C relay output contacts shall be provided. One of the contacts shall indicate AC drive fault status. The other contact shall be user assignable.

10. [Drives shall include, but shall not be limited to, network communication interface for data acquisition only over [Modbus] [Modbus Plus] [Ethernet (Modbus TCP)] [DeviceNet] [PROFIBUS DP]. Drive control and speed control via PLC hardwired I/O shall include, but shall not be limited to, the following:]

    a. [PLC analog output (4–20 mA) speed reference signal.]

    b. [PLC analog input (4–20 mA) speed feedback signal.]

    c. [PLC digital output drive start control] [PLC digital outputs for drive preset speed control.]

    d. [PLC digital input drive run (run =1).]

    e. [PLC digital input drive fault (fault = 1).]

11. [Drives shall include, but shall not be limited to, network communication interface for control and data acquisition over [Modbus] [Modbus Plus] [Ethernet (Modbus TCP)] [DeviceNet] [PROFIBUS DP] [Ethernet IP].

    a. [At a minimum, drive units shall allow configuration of the following parameters:]

        1) [Motor frequency.]

        2) [Motor voltage.]

        3) [Ramp profiles.]

        4) [I/O assignments.]

        5) [Current limitation.]

b. [Drive units shall be capable of making these adjustments:]

1) [Speed range.]

2) [Ramp time.]

3) [Thermal protection.]

c. [Drive units shall allow control of these parameters:]

1) [Start/stop.]

2) [Braking.]

3) [Frequency reference.]

4) [Fault resets.]

R. Optional Isolation/Bypass Contactors:

1. As a UL listed option, the AC drive controller unit shall include, but shall not be limited to, [NEMA rated isolation and bypass contactors packaged as a separate MCC unit with steel barriers segregating the AC drive from the bypass starter] [IEC rated isolation and bypass contactors integrated with the AC drive as one MCC unit to reduce space].

2. The isolation and bypass contactors shall be mechanically and electrically interlocked complete with a Class 10 thermal overload relay, disconnect interlocked with the door, control circuit transformer, AFC/off/bypass switch, and bypass/run and AFC run lights.

3. The operator shall have full control of the bypass starter by operation of the door-mounted selector switch.

4. When the drive is supplied with a hand-off-auto selector switch, the auto mode shall also control the run/stop of the bypass operation.

S. Optional Harmonic Study:

1. A harmonic distortion analysis shall be performed and priced as a separate line item by the AC drive manufacturer based upon system documentation supplied by the Contractor. The documentation shall consist of one-line diagrams, distribution transformer information (kVA, %Z, and X/R ratio), and emergency standby generator performance specifications. The harmonic distortion analysis report shall be part of the shop drawing process, submitted to the Architect/Engineer for review and acceptance. If the calculations determine that harmonic distortion values are higher than the voltage and current values specified in IEEE 519, the drive manufacturer shall provide the equipment specified in Optional Harmonic Equipment Paragraph below to meet the IEEE specified values.

T. Optional Harmonic Equipment:

1. Three percent impedance line reactor shall be provided that shall be mounted in the MCC enclosure, factory wired and tested with the AC drive controller unit.

2. Five percent impedance line reactor shall be provided that shall be mounted in the MCC enclosure, factory wired and tested with the AC drive controller unit.

3. An active harmonic filter shall be provided to perform electronic cancellation of load produced harmonic currents such that the upstream power harmonic current and voltage shall be reduced below the IEEE 519 guidelines for load demand and voltage distortion limits. Filter shall be Square D® brand Accusine or equivalent. Performance of the filter shall be independent of the impedance of the power source, AC lines or back-up generator. Necessary current transducers, reactors, and operator interfaces shall be supplied with the MCC. A factory certified start-up technician shall be used to start up each harmonic filter to achieve optimum system performance.

4. For AC Drives rated 480 volts, [50 to 400 horsepower variable torque] [40 to 350 horsepower constant torque], the AC drive manufacturer shall supply an 18-pulse design using a multiple bridge rectifier with integral reactor and phase shifting transformer. The 18-pulse configuration shall result in a multiple pulse current waveform that approximates near sinusoidal input current waveform. The power section shall be insensitive to phase rotation of the AC line.

U. Optional Load Filters: As a UL listed option, the AC drive controller unit shall include, but shall not be limited to, a motor protection filter unit designed to limit peak voltages and reduce electrical stress on the motor insulation. This option shall be required for motor lead lengths above 150 feet (45.72 m). The filter unit shall be ventilated to limit heat build up within the MCC.

2.13 SOLID STATE REDUCED VOLTAGE STARTER UNIT CONSTRUCTION

A. The soft start controller unit shall be a combination disconnect/soft starter, MCC-style unit. The input [circuit breaker] [fusible switch] shall provide NEC required branch circuit protection. The branch circuit protection shall have an external operator. Wiring between the soft starter and the disconnect shall not be disturbed when removing or installing the soft start controller unit from the MCC. Units shall be of modular construction so that units of the same size can be interchanged without modifications to the MCC structure.

B. Conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.

C. Soft start controller units rated for standard duty (up to 156 amperes) shall be plug-on units which connect to the vertical bus through a spring-reinforced stab-on connector. Units rated higher than 156 amperes shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.

D. Soft start controller unit interior mounting panels shall be white for better interior visibility.

E. A disconnect operator shall be provided per Typical Unit Construction Article.

F. Plug-on soft start controller units shall have a grounded stab-on connector which shall engage the vertical ground bus prior to, and shall release after, the power bus stab-on connectors engage/release.

G. Handle mechanisms shall be located on the left side to encourage operators to stand to the left of the

unit being switched.

H. Soft start controller units shall be provided with unit control terminal blocks for use in terminating field wiring. Terminal blocks shall be pull-apart type, 250 volts, and rated for 10 amperes. Current-carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is opened. The stationary portion of the terminal block shall be used for factory connections and shall remain attached to the unit when the portion used for field connections is removed. The terminals used for field connections shall be accessible so they can be wired without removing the unit or any of its components.

I. The enclosure shall include, but shall not be limited to, a door-mounted digital keypad for adjusting the soft start parameters and viewing the motor, soft start, and fault status without opening the enclosure door.

J. A shorting contactor shall be supplied in each soft start controller unit to reduce temperature rise within the unit and MCC enclosure. The shorting contactor shall be rated to carry the motor full load current during steady state after full voltage has been applied to the motor by the soft starter.

K. Electrical Ratings:

1. The soft start controller unit shall be designed to operate from an input voltage between -10 percent and +10 percent of nominal voltage rating.

2. The soft start controller unit shall operate from an input voltage frequency range of ±5 percent.

3. The soft starter shall be capable of supplying 350 percent of rated full load current for 20 seconds at the maximum ambient temperature.

4. Soft start controller unit power and control devices shall be rated for [standard duty capable of three evenly spaced starts per hour at 300 percent of full rated current for 20 seconds per start without tripping] [severe duty capable of three evenly spaced starts per hour at 350 percent of full rated current for 24 seconds per start without tripping].

5. The silicon-controlled rectifiers (SCRs) shall have a minimum peak inverse voltage (PIV) rating of 1800 volts AC. Lower rated SCRs with protection by metal oxide varistors (MOVs) are not acceptable.

L. Protection:

1. A microprocessor-based thermal protection system shall be included that shall continuously calculate the temperature rise of the motor and soft starter and shall provide the following:

a. A motor overload pre-alarm that shall indicate by relay contact or logic output that the motor windings have exceeded 110 percent of their rated temperature rise. This function shall be for alarm only.

b. A motor overload fault shall stop the motor if the windings have exceeded 125 percent of their rated temperature rise.

c. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time-constant that shall ensure memorization of the thermal state even if power is removed

from the soft starter.

2. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection.

3. The soft start controller unit shall include, but shall not be limited to, a shorting contactor which shall close after full voltage has been applied to the motor by the soft starter to reduce the current carrying duty on the SCRs. The integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation.

4. Units and options shall be constructed with protection provisions to pass UL 845 short circuit testing criteria at a minimum of 100,000 amperes short circuit current.

5. Diagnostic faults and soft start status shall be displayed on the door-mounted keypad after a fault condition.

6. The motor shall be automatically protected from solid state component failure by one of the following means:

   a. Shunt trip coil to trip disconnect in the event of a soft start fault condition, including, but not limited to, a shorted SCR.

   b. Isolation contactor that shall open when the motor is stopped or when the controller detects a fault condition, including, but not limited to, a shorted SCR.

M. Adjustments and Configurations:

1. Programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the control module. Exposure to control circuit boards or electrical power devices during routine adjustments is prohibited.

2. Digital indication shall provide, as a minimum, the following conditions:

   a. Soft starter status; ready, starting/stopping, run.

   b. Motor status; current, torque, thermal state, power factor, operating time, power in kW.

   c. Fault status; motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor underload, maximum start time exceeded, external fault, serial communication fault, line phase reversal fault, motor overcurrent fault.

3. The starter shall be preset to the following for operation without adjustment in most applications:

   a. Linear (torque-controlled) acceleration ramp of 10 seconds.

   b. Current limitation to 350 percent of the motor full load current rating.

   c. Class 10 overload protection.

   d. Motor current preset per NEC Table 430.150 for standard horsepower motors.

4. A digital keypad shall be used to configure the following operating parameters as required:

a. Motor full load amperes adjustable from 40 to 100 percent of the controller's rating.

b. Current limitation on starting adjustable from 200 to 700 percent of the motor current rating, not to exceed 350 percent of the soft start rating.

c. Voltage ramp adjustable from 1 to 60 seconds.

d. Initial voltage adjustable from 10 to 50 percent of nominal motor torque.

e. Maximum start time adjustable from 1 to 250 seconds.

f. Voltage boost duration adjustable from 0.1 to 1 second.

g. Selection of freewheel or soft stop.

h. Linear (torque-controlled) deceleration ramp time adjustable from 1 to 60 seconds.

i. Threshold to change to freewheel following a soft stop from 0 to 10 percent of the nominal motor torque.

j. Selection of Class 10, Class 20, or Class 30 motor thermal overload protection.

5. A digital keypad shall be used configure the following controller parameters as required:

a. Assignment of soft start inputs and outputs.

b. Activation of phase reversal protection.

c. Reset of motor thermal state.

d. Return to factory parameter settings.

e. Activation of self test mode.

f. Indication of elapsed time in hours of starting, running, and stopping.

6. Output relays shall provide the following status indications:

a. One Form A (normally open) minimum for indication of trip.

b. One Form A (normally open) for indication that soft start is running.

7. Additional inputs and outputs shall be available to provide the following status indications:

b. Two assignable control inputs for the following functions: external fault input, disable serial link control, second set of parameters, or general fault reset.

8. Relay and I/O functions listed above shall be isolated with respect to common.

N. Control Options:

1. The soft starter's control circuit shall be fed from a fused line supply and shall be completely independent of the power circuit and separate from relay control logic.

2. The peripheral soft starter control circuitry shall be operated from a control power transformer included within the enclosure.

3. Operator devices shall be door-mounted and shall be as follow:

   a. Black start and red stop pushbuttons.

   b. Three position hold-open-auto switch which shall provide for manual (hand) start or remote signal.

   c. Auto start from user-supplied relay contacts.

   d. Three position forward/off/reverse selector switch mounted on the door control island (available with reversing starter only).

   e. Red run pilot light illuminated whenever the soft starter is provided a run command and no fault condition is present.

   f. Green off pilot light illuminated whenever the soft starter is supplied with control power and no run command is present.

O. [Full Voltage Emergency Starter:]

1. [The soft start controller unit shall include, but shall not be limited to, full voltage starting capability to start and control the motor instead of the reduced voltage soft start method of starting the motor.]

2. [The full voltage emergency starter shall be UL listed and shall include, but shall not be limited to, an IEC rated contactor capable of carrying the motor inrush and motor full load current.]

3. [A door-mounted bypass/normal selector switch shall be provided to enable the user to manually select the motor starting method. Normal mode shall provide a reduced voltage start using the soft starter. In bypass mode, the soft starter shall be left inactive and the motor shall be started using an across-the-line full voltage starting method.]

4. [An overload provision independent of the soft starter shall be provided to protect the motor in the bypass mode.]

5. [The full voltage emergency starter components shall be integrated inside the soft start controller unit and shall be fully tested by the MCC manufacturer.]

2.14 GENERAL COMMUNICATION CABLING

A. The MCC shall employ a pre-engineered communication cabling system to interconnect units within the MCC.

B. Network cabling shall be routed through the lower horizontal wireway to isolate the network from the horizontal bussing routed through the top.

C. The full-depth vertical wireway shall serve to separate communications from power cabling to prevent noise interference on the network cable.

D. The communication cabling installation shall meet Class 2 wiring practices under the provisions of NEC Articles 725 and 800.

E. Provisions for appropriate terminators and grounding shall be provided.

F. Addition, removal, or rearrangement of units shall not interrupt the trunk line and shall not affect the cabling of other units attached to the trunk line.

G. Cable assemblies shall use 5-pole micro-style connectors with a single keyway and shall comply with SAE H1738-2 specifications.

H. Connectors shall be epoxy-coated for a 500-hour salt-spray test per MIL-STD-202.

I. Cable coupler design shall include, but shall not be limited to, a vibration-resistant ratchet to prevent loosening.

J. The system shall be constructed of molded PVC material.

2.15 MODBUS COMMUNICATION CABLING

A. The Modbus cabling system shall be UL 498 listed.

B. An extended ground pin shall ensure first make/last break ground connections.

C. The cabling system shall consist of individual trunk line segments in each MCC section. A trunk/drop topology shall be used. Trunk line segments shall be routed from the lower wireway into each vertical section. The trunkline for sections containing plug-on vertical bus shall have six taps spaced 12 inches (305 mm) apart. Unused tee connectors shall be capped at the factory.

D. A 36 inch (915 mm) pigtail cable shall connect the communication device in each MCC unit to the trunk cable via a pre-engineered tap. One end of the pigtail cable shall terminate in a micro-style connector and shall be attached to the trunk. The other end shall terminate at the communication device in the MCC unit.

2.16 ETHERNET (MODBUS TCP) COMMUNICATION CABLING

A. The Ethernet (Modbus TCP) communications network shall be configured in a star topology.

B. The cabling system shall consist of multiple, custom length Ethernet patch cables that each connect a single network device to a central Ethernet switch unit located in the MCC.

C. Ethernet switches located in the MCC shall be Connexium, Hirschmann, or approved equal.

2.17 DEVICENET COMMUNICATION CABLING

A. The DeviceNet cabling system shall be ODVA rated with a trunkline-dropline topology.

B. Control power shall be provided through individual unit transformers that shall be separate from the network to reduce network power demand. This shall allow devices to operate independently of the network power supply.

C. Sectioned cabinets shall have six pre-molded trunklines with tees. Full length cabinets shall have one trunkline with a tee. A tee at the bottom of each section shall provide the means of connection to the next section with a pre-molded section of cable.

D. A 36 inch (915 mm) pigtail cable shall connect the tee in the dropline to the DeviceNet device located in the MCC unit.

2.18 CANOPEN COMMUNICATION CABLING

A. The CANopen cabling system shall be configured in a trunkline-dropline topology.

B. Control power shall be provided through individual unit transformers that shall be separate from the network to reduce network power demand. This shall allow devices to operate independently of the network power supply.

C. Sectioned cabinets shall have six pre-molded trunklines with tees. Full length cabinets shall have one trunkline with a tee. A tee at the bottom of each section shall provide the means of connection to the next section with a pre-molded section of cable.

D. A 36 inch (915 mm) pigtail cable shall connect the tee in the dropline to the CANopen device located in the MCC unit.

2.19 PROFIBUS DP COMMUNICATION CABLING

A. The PROFIBUS DP cabling system shall consist of individual trunk line segments in each MCC section. A trunkline-dropline topology shall be used. Trunk line segments shall be routed from the lower wireway into each vertical section. The trunkline for sections containing plug-on vertical bus shall have six taps spaced 12 inches (305 mm) apart. Unused tee connectors shall be capped at the factory.

B. Sectioned cabinets shall have six pre-molded trunklines with tees. Full length cabinets shall have one trunkline with a tee. A tee at the bottom of each section shall provide the means of connection to the next section with a pre-molded section of cable.

C. A 36 inch (915 mm) pigtail cable shall connect the tee in the dropline to the PROFIBUS DP device located in the MCC unit.

2.20 QUALITY CONTROL

A. The entire MCC shall go through a quality inspection before shipment. This inspection shall include, but shall not be limited to, the following:

1. Physical Inspection of the following:

a. Structure.

b. Electrical conductors, including, but not limited to, the following::

1) Bussing.

2) General wiring.

3) Units.

2. Electrical Tests:

    a. General electrical tests shall include, but shall not be limited to, the following:

        1) Power circuit phasing.

        2) Control circuit wiring.

        3) Instrument transformers.

        4) Meters.

        5) Ground fault system.

        6) Device electrical operation.

    b. AC dielectric tests shall be performed on the power circuit.

3. Markings/labels include, but shall not be limited to, the following:

    a. Instructional type.

    b. UL/CSA.

    c. Inspector's stamps.

4. Each device shall be configured and addressed to correspond with software settings.

5. A read/write test shall be performed prior to shipment on network devices, including, but not limited to, overloads, drives, and soft starters.

6. Testing shall be designed to verify system operation and shall include, but shall not be limited to, these verifications as a minimum:

    a. Drawings and bill of materials.

    b. I/O addressing.

    c. Correct device operation by I/O address.

    d. Host communications.

    e. Control network interface.

7. The manufacturer shall use integral quality control checks throughout the manufacturing process to ensure that the MCC meets operating specifications.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until

unsatisfactory conditions have been corrected.

1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 INSTALLATION

A. Install low voltage industrial MCCs in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.

B. MCCs shall not be placed in hazardous locations. The area chosen shall be well ventilated and totally free from humidity, dust, and dirt. The temperature of the area shall be no less than 32 degrees F (0 degrees C) and no greater than 104 degrees F (40 degrees C). For indoor locations, protection shall be provided to prevent moisture entering the enclosure.

C. MCCs shall be located in an area with a minimum of 3 feet (914 mm) of free space in front of front-of-board construction. An additional 3 feet (914 mm) shall be allowed in the rear of back-to-back construction. This free space shall give adequate room to remove and install units. A minimum of 0.5 inch (13 mm) space shall be provided between the back of front-of-board MCCs and a wall, 6 inches (152 mm) required for damp locations).

D. The MCCs shall be assembled in the factory on a smooth level surface so that sections are properly aligned. A similar smooth and level surface shall be provided for installation. An uneven foundation will cause misalignment of shipping blocks, units, and doors. The surface under a MCC shall be of a non-combustible material unless bottom plates are installed in each vertical section.

3.3 DEMONSTRATION

A. Provide the services of a factory-authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Owner's personnel.

1. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

2. Train the Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive maintenance.

3. Review data in operation and maintenance manuals with the Owner's personnel.

4. Schedule training with the Owner, through the Architect, with at least seven day's advanced notice.

3.4 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, that shall ensure that the low voltage industrial MCCs shall be without damage at time of Substantial Completion.

END OF SECTION