

**SECTION 26 18 39 03
MEDIUM-VOLTAGE CONTROLLERS
ARC RESISTANT**

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes NEMA class E2 medium-voltage metal-enclosed motor controllers as specified in this section and as shown on the contract drawings.

1.2 RELATED DOCUMENTS

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

1.3 SUBMITTALS

- A. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by purchaser name, purchaser location and purchaser's order number.
- B. Approval documents shall include:
 - 1. Dimensioned plans, sections and elevations showing minimum service space, installed devices and major components
 - 2. Nameplate engraving drawings
 - 3. Electrical bill of material.
- C. Product data shall include features, characteristics and ratings of:
 - 1. Individual contactors
 - 2. Fuse assemblies
 - 3. Other components.
- D. Final documents shall include:
 - 1. Documents listed in 1.3.B above
 - 2. Wiring diagrams
 - 3. Three-line diagrams
 - 4. Recommended spare parts list for start-up support
 - 5. Instruction manual.
- E. Shop documents shall include:
 - 1. General arrangement drawing showing dimensioned plan, elevation and details, including required service space around equipment. Show tabulations of installed devices, equipment features and ratings. Include the following:
 - a. Enclosure types and details
 - b. Nameplate legends
 - c. Bus configuration with current capacity of conductors in each bus run, including phase and ground conductors of main and feeder buses
 - d. Short-circuit current rating of controller assembly
 - e. Wiring diagrams: Diagram power, signal and control wiring including differentiation between manufacturer-installed and field-installed wiring.

1.4 QUALITY ASSURANCE

- A. Manufacturer qualifications: The bidder must have at least 15-years experience in manufacturing medium-voltage class E2 controllers.
- B. The assemblies shall be produced by a single manufacturer in an ISO-9000 certified facility.
- C. Comply with requirements of latest revisions of applicable industry standards, specifically including the following:

1. UL 347 6th Edition or equivalent CSA C22.2 no. 253-09 (supercedes NEMA ICS-3)
 2. IEEE C37.20.7, accessibility type 2B.
- D. Equipment shall be qualified and major components suitable for seismic applications to meet all applicable seismic requirements of the 2006 International Building Code (IBC) for the site classification shown on the drawings. Equipment qualification shall be based upon successful shaker-table tests of the design, supported by analysis when the actual equipment to be furnished differs from the configuration tested. The acceptance criteria for the certification of the equipment shall be based on the ability of the equipment to retain its functionality and be returned to service immediately after a seismic event as outlined in the above requirements without the need for repair.
- 1.5 DELIVERY, STORAGE AND HANDLING
- A. Deliver in convenient shipping groups. Shipping groups shall not exceed 12 feet in length.
 - B. Equipment to be shipped with the top-mounted pressure relief channel (PRC) installed. The shipping groups will be connected together in the field by the owner.
 - C. Exhaust plenum system (exhaust duct from pressure relief channel to the outside) for venting the arc-fault byproducts out of the equipment room is shipped separate for field installation at the job site.
 - D. Exhaust system is to be provided for exhausting the gases outside of the power equipment center or building to a human-free area. This location to be determined by the owner. Where the plenum is intended to penetrate an external wall, the exhaust outlet shall meet the rain test according to UL 347 or ANSI/IEEE C37.20.2.
 - E. Bus bars with associated hardware for connections between shipping groups shall be shipped attached to the controller in the approximate locations where they shall be needed.
 - F. Contractor shall store the equipment in accordance with manufacturer's recommendations.
 - G. Contractor shall install temporary heaters, if necessary, to prevent condensation during storage.
 - H. Contractor shall handle and move the controller in accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. *[The arc-resistant medium-voltage controller assembly shall be as manufactured by SIEMENS or approved equal. Approved manufacturers are as follows:*
 1. **SIEMENS**
 2. **.]**

2.2 RATINGS

- A. System configuration: The controller assembly shall be suitable for application in three-phase, three-wire **[60 Hz] [50 Hz], [grounded] [ungrounded]** system.
- B. Electrical ratings:
 1. Nominal system voltage, kV: **[2.3] [3.3] [4.0] [6.9] [7.2].**
 2. Horizontal bus continuous amperes: **[1,200] [2,000] [3,000].**
 3. Vertical bus continuous amperes: **[as required for equipment arrangement]**
 4. Ground bus size: ¼ x 2".
 5. Short-circuit rating: 50 kA (or the short-circuit rating of the switch if non-fused load-interrupter switches are specified).
 6. Impulse-withstand voltage: 60 kV peak.

2.3 CONTROLLER GENERAL CONSTRUCTION

- A. ***[The arc-resistant medium-voltage controller assembly shall be UL listed where the arrangement and device selection allows.]***
- B. The controller assembly shall be factory assembled and tested in convenient shipping groups and tested. The controller assembly shall be of a coordinated design so shipping groups can be easily connected together at the site into a continuous lineup. Necessary shipping split connecting bus bars, boots (if applicable) and hardware shall be furnished and shall be attached to the controller assembly in the approximate locations where they will be needed.
- C. Assembly shall be classified as arc resistant, as defined in ANSI/IEEE C37.20.7 with a type 2B accessibility rating. These arc-resistant features shall provide an additional degree of protection to personnel in close proximity to the equipment in the event of an internal arcing fault while the equipment is operating under normal conditions.
- D. The enclosure shall withstand the pressures and elevated temperatures of an internal arcing fault and direct hot gases and arcing byproducts into the top-mounted pressure relief channel. These arc byproducts shall then be exhausted to the outside environment through an exhaust plenum system.
- E. The exhaust plenum (or duct) shall be provided separately, in modular shipping lengths that are easily installed and connected together at the site.
- F. Except for connections of the units and exhaust plenum sections of the installation site, the pressure relief channel and exhaust plenum shall be fully factory assembled.
- G. In cases where a transition section is used to close-couple the controllers to medium-voltage switchgear, the arcing byproducts shall be exhausted in a common pressure relief channel for both controllers and switchgear, before being exhausted to the outside through a common exhaust plenum.
- H. The controller assembly shall consist of one or more metal-enclosed sections in an indoor NEMA 1 enclosure.
- I. Individual controller vertical sections shall be two-high to accommodate fixed-mounted or plug-in type contactor controller assemblies and shall include:
 - 1. Fabricated of minimum 11-gauge steel for the frame and doors. Typical dimensions shall be 112" (2,845 mm) high, 36" (914 mm) wide and 40.5" (1,028 mm) deep.
 - 2. End sections shall include provisions for main bus extension and installation of future vertical sections, where the configuration allows.
 - 3. The design shall incorporate pre-formed steel channels, angles and side sheets bolted together and reinforced to form a rigid, self-supporting assembly.
- J. Fabricate with dead-front construction utilizing sheet steel barriers for isolation of the power bus compartments from the no-load isolation switch controller area. Include sliding shutter mechanism to automatically cover the line-side stab connections whenever the no-load isolation switch is open. When open, the load side of the isolation switch shall be connected to ground.
- K. Power (horizontal) bus shall connect vertical sections and shall not be tapered.
 - 1. Main bus shall be accessible from front, side, rear and top, for ease of maintenance and extension of lineups.
 - 2. Bus bars shall be 98-percent minimum conductivity copper with ***[silver-plated joints]*** ***[tin-plated joints]***.
 - 3. Ground bus shall be copper of 98-percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size ¼" x 2".
 - 4. Phase busbars shall be insulated with an epoxy insulation applied by a fluidized-bed method.
 - 5. ***[Optional: Preformed boots shall be provided for insulating bus joints.]***
- L. Each vertical section shall have main busbar that extends the length of the section.
- M. Vertical bus shall be insulated with an epoxy insulation applied by a fluidized bed method.

- N. Medium-voltage compartments door latching shall be six-point latching mechanism for 400 A controllers. For 720 A controllers, load-interrupter switches, and other compartments, front doors shall be hinged and bolted.
- O. Finish: steel parts shall be prepared for painting by a five-stage wash system consisting of an alkaline cleaner, fresh water rinse, iron-phosphate treatment, fresh water rinse and non-chromate sealer. After cleaning and stabilization, the steel parts shall be coated with a thermosetting polyester-urethane powder applied with electrostatic equipment at a nominal two mils dry-film thickness and then cured properly. The paint finish shall have a pencil hardness of 2H, a salt-spray rating as defined in ASTM B-117 of at least 600 hours. Paint color shall be ANSI light gray.

2.4 COMPONENTS

- A. Instrument transformers: Comply with ANSI/IEEE C57.13.
 1. Voltage transformers (VTs): Secondary voltage rating of 120 volts and accuracy class of 0.3 with burdens of WX and 0.6 Y for VTs connected to incoming line or main bus. The VTs shall be connected to an isolating switch similar to the isolating switch provided for controllers. When the switch is open, the load side of the switch shall be connected to ground. The isolating switch shall be provided with a shutter that blocks access to the line-side conductors when the switch is open. The arrangement shall not allow opening the access door unless the isolating switch is open, and shall not allow closing the switch if the door is open.
 2. Voltage transformers: Secondary voltage rating of 120 volts, with accuracy class of 0.3 WX, 1.2 Y, in a three-phase (open delta-open delta) assembly, for connection to the load side in a controller unit.
 3. Current transformers (CTs): Ratios as indicated; burden and accuracy class, suitable for connected relays, meters and instruments.
- B. Multifunction digital-metering monitors shall be microprocessor-based UL-Listed or UL-Recognized units. Units shall be flush mounted on the instrument compartment door and be Siemens model 3200, 4200, 9350 or equal, and shall be provided as follows:
- C. **Note: Select clause C if a microprocessor motor protection relay is desired in place of the standard ambient-compensated thermal overload relay.**
[Motor protection device shall be:
 1. *The relay shall be Siemens 7SK80 protective relay or equivalent. The relay shall provide the following functions: 50/51, 50N/51N, 67N, 67Ns, 50Ns, 59N/64, 37, 48, 66, 14, 51M, 49, 46, 27, 59, 81O/U, 50BF, 46, 47 and 86.*
 2. *The relay shall have four analog CT inputs and three voltage inputs.*
 3. *The relay shall accept up to five RTD inputs.*
 4. *The relay shall have the option to connect 12 external RTD inputs through an Ethernet connection.*
 5. *The relay shall monitor the CT circuits and alarm on circuit failure.*
 6. *The relay shall be capable of being used in reverse interlocking bus protection scheme.*
 7. *The relay shall provide logic programmability to create starting schemes, for example, reduced-voltage starting.*
 8. *The relay shall provide demand alarms.*
 9. *The relay shall have nine programmable function keys to replace control switches.*
 10. *The relay shall have programmable logic capabilities to permit use in protection and control systems. Programming software must be compliant with IEC 1131 standard for PLC programming.*
 11. *The relay shall have a modular communications processor to permit field change between IEC61850, Modbus RTU, Profibus-DP, DNP3.0 and IEC60870-5-103 protocols. The relay must be able to support either RS-485 or fiber-optic communications.*

12. *The relay shall provide complete sequence-of-events recording, time stamped in milliseconds. The relay shall provide oscillography (waveform) capture, with configurable pre- and post-fault data capture times.*
13. *All relay connectors including CT connectors will be pluggable to ensure ease of relay replacement and maintenance testing.*
14. *The housing must be a sealed dust-proof environment for the relay internal electronics. Heat buildup must be dissipated through the surface area of the steel enclosure. The relay thus will maintain its insulation capability even if deployed in harsh, dusty environments.*
15. *The relay must provide 20 flexible functions that can be used to create additional protection functions to maximize application flexibility.*

D. **Note: Select clause D if non-motor feeders are included.**

[Feeder overcurrent protection with communication shall be:

1. *The relay shall be Siemens 7SJ80 protective relay or equivalent. The relay shall provide the following functions: 50/51, 50N/51N, 67, 67N, 64, 87N, 37, 49, 46, 27, 59, 81O/U, 50BF, 46, 47, 25, 79, 21FL and 86.*
2. *The relay shall have four analog CT inputs and three voltage inputs.*
3. *The relay shall provide trip circuit supervision of the trip coils on latched contactor feeders and alarm on trip circuit failure.*
4. *The relay shall monitor the CT circuits and alarm on circuit failure.*
5. *The relay shall be capable of being used in a reverse-interlocking bus protection scheme.*
6. *The relay shall provide demand alarms.*
7. *The relay shall have nine programmable function keys to replace control switches.*
8. *The relay shall have programmable logic capabilities to permit use in protection and control systems. Programming software must be compliant with IEC 1131 standard for PLC programming.*
9. *The relay shall have a modular communications processor to permit field change between IEC61850, Modbus RTU, Profibus-DP, DNP3.0 and IEC60870-5-103 protocols. The relay must be able to support either RS-485 or fiber-optic communications.*
10. *The relay shall provide complete sequence-of-events recording, time stamped in milliseconds. The relay shall provide oscillography (waveform) capture, with configurable pre- and post-fault data capture times.*
11. *All relay connectors including CT connectors will be pluggable to ensure ease of relay replacement and maintenance testing.*
12. *The housing must be a sealed dust-proof environment for the relay internal electronics. Heat buildup must be dissipated through the surface area of the steel enclosure. The relay thus will maintain its insulation capability even if deployed in harsh, dusty environments.*
13. *The relay must provide 20 flexible functions that can be used to create additional protection functions to maximize application flexibility.*

E. Control power supply: control power transformer (CPT) supplying 120 Vac control circuits shall be dry-type transformers with primary current-limiting fuses.

1. Units rated 3 kVA and below shall be fixed mounted in the medium-voltage compartment.
2. Single-phase **[0.75] [2.0] [3.0]** kVA.
3. Primary current-limiting fuses shall be provided.

2.5 CONTROLLER COMPARTMENT

A. The 400 A rated vacuum contactor shall be **[fixed-mounted] [plug-in]** and **[magnetically-held] [latched]** type. The 720 A rated vacuum contactor shall be fixed-mounted and **[magnetically-held] [latched]** type. The bolt-in type primary current-limiting fuses shall be located inside the medium-voltage controller compartment. A non-load-break isolation switch shall disconnect and isolate the line side of controllers from the controller compartment when

the switch is open. Each controller shall consist of a contactor **[400] [720]** A, primary fuses for short-circuit protection and to include the following:

1. Overload or overcurrent relay as described in paragraph 2.4.C or 2.4.D as selected above.
2. When specified, the 400 A plug-in contactor shall be removable or insertable without the need of special tools or manual extra steps, which include reconnecting interlock linkages.
3. Non-load-break isolation switch assembly shall be provided to isolate line-side bus with the medium-voltage compartment door open. A glass-polyester shutter shall automatically cover the line-side stabs when the non-load-break isolation switch is in the open position.
4. When the isolation switch is open, the load side of the isolation switch shall be grounded.
5. Current-limiting fuses with minimum short-circuit rating of 50 kA symmetrical. Fuses shall be ANSI class R (class X for 57X size) for motor starting duty, class E for transformer or capacitor feeder duty. Fuses shall be Siemens type FM or A720R or approved equal. The bolt-in fuses shall be fixed mounted inside the medium-voltage compartment.
6. Vacuum interrupter main contact design shall have a minimum electrical life of 200,000 operations. Contactor shall be equipped with a means for visual verification of the contact wear.
7. Single-phase CPT as specified in paragraph 2.4.E.
8. The primary of the CPT shall be energized only when the non-load-break isolation switch is closed. When the isolation switch is open, the CPT secondary shall be disconnected.
9. The operating handle for the non-load-break isolation switch shall be equipped with padlock provisions.
10. The non-load-break isolation switch mechanism shall combine the following safety interlocks:
 - a. Prevent closing and opening of the non-load-break isolation switch unless the contactor is open.
 - b. Prevent the opening of the high-voltage compartment door unless the non-load-break isolation switch is in the off position.
11. Each controller shall be provided with a built-in test circuit for operation of the contactor from an external source of control power when the non-load-break isolation switch is open. This shall allow maintenance and operation of the main contactor and low-voltage control circuitry without disconnecting any load cables, and prevent back-energization of the CPT.
12. A control receptacle shall be furnished that connects to the pre-wired auxiliary and coil circuits of the vacuum contactor.
13. Low-voltage compartment with front accessible door-in-door construction shall be provided:
 - a. Compartment shall be isolated from high-voltage compartments and house components including terminal blocks, overload relay, microprocessor relays (if specified in 2.4.C or 2.4.D), and control wiring. Overload reset button shall be in door for units with ambient-compensated thermal-overload relay.
 - b. All control wiring within the assembly shall be continuous and shall terminate on each end at a suitable terminal block. Control wiring shall be 14-gauge minimum, stranded-type SIS and shall be labeled at each end with sleeve-type wire markers.
 - c. Wire markers shall be machine imprinted with the wire name as indicated on the wiring diagrams.
 - d. Terminals shall be insulated locking fork or ring-tongue type except where connecting to components that do not accept these terminations.
 - e. Opening low-voltage compartment door shall not compromise the arc-resistant rating.
14. ***[Optional: Anti-single-phase trip mechanism shall be included to provide protection from single phasing due to a blown power fuse.]***
15. A viewing window shall be located in the medium-voltage compartment door to allow quick and easy verification of the opened and closed positions of the non-load-break

isolation switch. Viewing non-load-break isolation switch position shall not require opening any compartment door.

16. Load cable terminations shall be front accessible.

2.6 LOAD-INTERRUPTER SWITCH

- A. When specified, the load-interrupter switch shall be a manually operated, single-throw, gang-operated load-interrupter switch, rated **[600] [1,200]** A. Quick-make, quick-break arcing blades combined with arc chutes shall provide positive, three-phase interruption of load currents. The switch shall employ a quick-make/quick-break stored-energy operator. The load-interrupter switch may be un-fused or equipped with current-limiting fuses to provide short-circuit current interrupting capacity.
 1. The door and switch operating handle shall be mechanically interlocked so that the door cannot open while the switch is closed and the switch cannot close with the door open.
 2. The switch shall be covered with a clear, polycarbonate barrier. The switch shall be fixed mounted and when specified, shall be equipped with fixed-mounted fuses.
 3. **[Optional: Provide auxiliary switch contacts (2 NO and 2 NC).]**
 4. The load-interrupter switch door shall be equipped with a self-locating adjustable door interlock.

2.7 UNITS REQUIRED

- A. **Incoming line: quantity [____].**
 1. **Three [____] kV MCOV [station] [intermediate] [distribution] class surge arresters**
 2. **Surge capacitors (three-phase set).**
 3. **Set of [____] voltage transformers, rated [2,400:120] [4,200:120] [4,800:120] [7,200:120].**
 4. **Set of [____] current transformers, rated [____]:5.**
 5. **One microprocessor-based, three-phase and ground overcurrent relay, ANSI device 50/51, 50/51N, as specified in 2.4.D.**
 6. **One microprocessor-based meter, as specified in 2.4.B.**
 7. **Space heater and thermostat.**
 8. **Note: Choose one of the next three choices:**
 - a. **[Set of cable lugs per phase: [clamp type] [compression type].]**
 - b. **[Provisions for connection to metal-enclosed bus rated [____] A.]**
 - c. **[Provisions for close-coupled bus connection to switchgear.]**
- B. **Full-voltage, non-reversing squirrel-cage motor starter (FVNR): quantity [____].**
 1. **One fixed-mounted vacuum contactor.**
 2. **[Optional: Plug-in type (400 A only).]**
 3. **Three current-limiting power fuses.**
 4. **One [0.75] [2.0] [3.0] kVA control transformer with two primary and one secondary current-limiting fuses.**
 5. **Three current transformers, or one three-phase current transformer.**
 6. **One master control relay (three NO and one NC auxiliary contacts).**
 7. **One start/stop pushbutton.**
 8. **One three-phase ambient-compensated thermal overload relay.**
 9. **One externally-mounted overload reset button.**
 10. **[Optional: One motor protective relay as specified in 2.4.C (replaces thermal overload relay and overload reset button.)]**
 11. **One integrated test circuit.**
 12. **Non-load-break isolation switch with isolating shutter system, external operating handle and interlocked to prohibit user access to an energized medium-voltage compartment.**
 13. **Cable lugs.**
- C. **Full-voltage, reversing squirrel-cage motor starter (FVR): quantity [____].**
 1. **Two fixed-mounted vacuum contactors.**
 2. **[Optional: Plug-in type (400 A only).]**

3. *Three current-limiting power fuses.*
 4. *One [0.75] [2.0] [3.0] kVA control transformer with two primary and one secondary current-limiting fuses.*
 5. *Three current transformers, or one three-phase current transformer.*
 6. *One master control relay (three NO and one NC auxiliary contacts).*
 7. *Two start/stop pushbuttons.*
 8. *One three-phase ambient-compensated thermal overload relay.*
 9. *One externally-mounted overload reset button.*
 10. *[Optional: One motor protective relay as specified in 2.4.C (replaces thermal overload relay and overload reset button.)]*
 11. *One integrated test circuit.*
 12. *Non-load-break isolation switch with isolating shutter system, external operating handle and interlocked to prohibit user access to an energized medium-voltage compartment.*
 13. *Cable lugs.*
- D. *Full-voltage, two-speed, two winding squirrel-cage motor starter (2S2W): quantity [____].*
1. *Two fixed-mounted vacuum contactors.*
 2. *Three current-limiting power fuses.*
 3. *One [0.75] [2.0] [3.0] kVA control transformer with two primary and one secondary current-limiting fuses.*
 4. *Three current transformers, or one three-phase current transformer.*
 5. *Two master control relays (three NO and one NC auxiliary contacts).*
 6. *Two start/stop pushbuttons.*
 7. *One three-phase ambient-compensated thermal overload relay.*
 8. *One externally-mounted overload reset button.*
 9. *[Optional: One motor protective relay as specified in 2.4.C (replaces thermal overload relay and overload reset button.)]*
 10. *One integrated test circuit.*
 11. *Non-load-break isolation switch with isolating shutter system, external operating handle and interlocked to prohibit user access to an energized medium-voltage compartment.*
 12. *Cable lugs.*
- E. *Full-voltage, two-speed, one winding squirrel-cage motor starter (2S1W): quantity [____].*
1. *Three fixed-mounted vacuum contactors.*
 2. *Three current-limiting power fuses.*
 3. *One [0.75] [2.0] [3.0] kVA control transformer with two primary and one secondary current-limiting fuses.*
 4. *Six current transformers, or two three-phase current transformers.*
 5. *Two master control relays (three NO and one NC auxiliary contacts).*
 6. *Two start/stop pushbuttons.*
 7. *One three-phase ambient-compensated thermal overload relay.*
 8. *One externally-mounted overload reset button.*
 9. *[Optional: One motor protective relay as specified in 2.4.C (replaces thermal overload relay and overload reset button.)]*
 10. *One integrated test circuit.*
 11. *Non-load-break isolation switch with isolating shutter system, external operating handle and interlocked to prohibit user access to an energized medium-voltage compartment.*
 12. *Cable lugs.*
- F. *Full-voltage, mechanically latched, electrically tripped contactor (FVMLNR): quantity [____].*
1. *One fixed-mounted vacuum contactor.*
 2. *[Optional: Plug-in type (400 A only).]*
 3. *Three current-limiting power fuses.*

4. *One [0.75] [2.0] [3.0] kVA control transformer with two primary and one secondary current-limiting fuses.*
5. *Three current transformers, or one three-phase current transformer.*
6. *One master control relay (three NO and one NC auxiliary contacts).*
7. *One close pushbutton.*
8. *One open pushbutton.*
9. *One three-phase overcurrent relay as specified in 2.4.D.*
10. *One integrated test circuit.*
11. *Non-load-break isolation switch with isolating shutter system, external operating handle and interlocked to prohibit user access to an energized medium-voltage compartment.*
12. *Cable lugs.*

2.8 ACCESSORIES

- A. No special accessories, such as fuse pullers, feeler gauges, etc., shall be required.
- B. Supply the followings:
 1. *[Optional: Three spare power fuses of each rating.]*
 2. *[Optional: Two spare primary fuses for VT and CPT.]*
 3. *[Optional: Spare indicating lights: One of each type installed.]*
- C. Exhaust plenum shall be shipped separately, in pre-assembled modular sections for connection at the site.
- D. Touch-up paint to match enclosure finish.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Electrical contractor or controller installer shall install controller in accordance with manufacturer's written instructions and the following specifications.

3.2 ADJUSTMENTS AND CLEANING

- A. Remove debris from controller and wipe dust and dirt from all components.
- B. Repaint marred and scratched surfaces with touch up paint to match original finish.
- C. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture's recommendations.
- D. Check all installed controllers for proper grounding, fastening and alignment.

3.3 TESTING

- A. After installing controller assembly and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 1. Perform each electrical test and visual and mechanical inspection per the manufacturer's instruction manual.
 2. Correct malfunctioning units onsite, and retest to demonstrate compliance.
- B. Prior to shipment from the factory, perform production tests in compliance with UL 347 requirements.

3.4 WARRANTY

- A. Equipment manufacturer shall warrant that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than 18 months from date of shipment, whichever occurs first.

3.5 START-UP SERVICE

- A. Controller manufacturer shall provide a factory-authorized service representative for a period of two days to train Owner's maintenance personnel in the following:
 - 1. Procedures and schedules related to startup and shutdown, troubleshooting, servicing and preventive maintenance.
 - 2. Review data in the instruction manuals. Refer to Division 1 Section ***["Contract closeout."] ["Operation and maintenance data."]***
 - B. Verify that the controller is installed and connected according to the Contract documents.
 - C. Verify that the electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
 - D. Complete installation and start-up checks according to manufacturer's written instructions.
 - E. Schedule training with Owner with at least three week's advance notice.
- 3.6 ***[FIELD SERVICE***
- A. ***Controller manufacturer's own field service office (same name as the manufacturer) shall be located not more than a three-hour drive from the installation site.]***

END OF SECTION