SECTION [26 18 39 12][16340]

MEDIUM VOLTAGE MOTOR CONTROLLERS

Square D Motorpact™ MV Starters and Contactors by Schneider Electric

Schneider Electric Editor's Note:

This guide specification is written in accordance with the Construction Specifications Institute (CSI) Master Format. This section must be carefully reviewed and edited by the architect or the engineer to meet the requirements of the project. Coordinate this section with other specification sections within the Contract Documents and Drawings.

To properly use / edit this document, show formatting and hidden text by selecting ¶ on the menu or by typing (Ctrl+*) simultaneously. Except for these introductory and closing paragraphs, green hidden text will not print. Text in red is optional. Red text in [brackets] denotes multiple options where one or more should be chosen. All red text should be edited and changed to black for final project conformation. In addition, these introductory paragraphs should be deleted or changed to hidden text. Additional guidance and specifications can be found at https://www.schneider-electric.us/e2e

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for medium voltage motor controllers (also identified as medium voltage motor control centers, MVMCC, MV starter, MV FVNR, MV FVR, MV 2S2W, 2S1W, MV RVSS, MV RVAT or MV contactor) as required for the complete performance of the Work, as shown on the Drawings and as specified herein.

B. Related Sections: Related sections include, but shall not be limited to, the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
2. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
3. The following information is typically depicted on the Drawings: control wiring, bus configuration, bus ratings, [interrupting ratings,] circuit breaker ratings, circuit breaker protective relaying, elevation and footprint, etc. Where not shown on or able to be derived from the Drawings, the minimum requirements specified herein shall be provided.
4. Refer to specification Section 26 09 17 Protective Relays and Controllers for additional requirements
5. Refer to specification Section 26 27 13.13 Power and Energy Meters for additional requirements
6. Refer to specification Section 26 27 13.16 Power Quality Meters for additional requirements
7. Refer to specification Section 26 13 09 Electrical Power Management System for additional requirements.
8. Refer to specification Section 13 34 23.11 Fabricated Electrical Houses for additional requirements

1.2 REFERENCES

A. 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.

1. Canadian Standards Association (CSA)
   a. C22.1, "Canadian Electrical Code, Part I" (CEC)
2. National Electrical Manufacturers Association (NEMA)

a. NEMA ICS 3 (Parts 1&2), “Medium Voltage Controllers Rated 2,001 to 7,200 V AC”

3. National Fire Protection Agency (NFPA)
   a. NFPA 70, “National Electrical Code (NEC)”
   b. NFPA 70E, “Standard for Electrical Safety in the Workplace”
4. Underwriters Laboratories, Inc. (UL):
   a. UL 347, “Medium Voltage AC Contactors, Controllers, and Control Centers”
5. International Electrotechnical Commission (IEC):
   a. IEC 60470, “High-voltage alternating current contactors and contactor-based motor-starters”
   b. IEC 60529, “Degrees of protection provided by enclosures”
   c. IEC 60604, “'Topflash/Flipflash' photographic lamp array”
   d. IEC 60129, “Alternating current disconnectors and earthing switches”
   e. IEC 62271-102, “Alternating current disconnectors and earthing switches”
   f. IEC 62271-200, “High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV”
6. International Organization for Standardization (ISO):
   a. ISO 9001, “Quality Management Systems - Requirements”

1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1. MV: Medium voltage
2. LV: Low voltage
3. MVMCC: Medium Voltage Motor Control Center
4. FVNR: Full Voltage Non Reversing starter
5. FVR: Full Voltage Reversing starter
6. RVSS or SSRV: Reduced Voltage Solid State starter
7. RVAT: Reduced Voltage Auto Transformer starter
8. 2S2W: Two Speed Two Winding starter
9. 2S1W: Two Speed One Winding starter

1.4 SUBMITTALS

Most submittal requirements including those for electrical equipment of all types are specified elsewhere. Additional requirements should only be listed herein if they only pertain to MV VFDs and not to electrical equipment in general.

A. General: Submittals shall be in accordance with the requirements of Section [01 33 00][01300] Submittals and Section [26 00 10][16010] Electrical Requirements, in addition to those specified herein.

1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.
3. Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information:

a. Electronic 2D dimensional drawing and 3D model CAD files for standard units shall be provided upon request if not available from the manufacturer's website.

b. Equipment assembly. Indicate dimensions, shipping section dimensions, weights, foundation requirements, required clearances, location and size of each field connection, and mounting and installation instructions.

c. Include elementary and interconnection diagrams for power, signal, control, and communications wiring. Diagrams shall provide the minimum detail as shown for drawings in the appendix of NFPA 79. All field terminals shall be identified and updated later within the O&M data to include actual field connection information. Drawings shall not be typical but be provided for each MVMCC furnished.

d. Where applicable the following additional information shall be submitted to the Engineer.

1) Bus connection

2) Connection details between close coupled assemblies.

3) Composite floor plan of close coupled assemblies.

4) Key interlock scheme drawing and sequence of operations.

4. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which, the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Required working clearances and required area above and around MVMCC's

b. Show support locations, type of support, and weight on each support

B. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified in Section [01 78 23][1780] Operation and Maintenance Data, Section [26 00 10][16010] Electrical Requirements and additional requirements specified herein.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of ten years.

1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.

2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.

B. Installer Qualifications: Installer shall be a firm that shall have a minimum of [10] years of successful installation experience with projects utilizing equipment similar in type and scope to that required for this Project [and shall be approved by the manufacturer's representative].

C. All work performed, and all materials used shall be in accordance with the [National Electrical Code], [Canadian Electrical Code] and with applicable local regulations and ordinances. Equipment assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform

temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.7 WARRANTY

A. General: Refer to [Section 01 77 00 - Closeout Procedures] [Section 01770 - Closeout Procedures].

Schneider Electric extends the warranty of most equipment by 12 months at no additional cost when their service technicians perform functional testing, commissioning, and first parameter adjusting of the installed equipment.

B. The manufacturer shall warrant products against defects in material and workmanship for [12 months from the date of commissioning or 18 months from the date of shipment – whichever comes first.][24 months from the date of commissioning or 36 months from the date of shipment, whichever comes first, provided that the manufacturer performs functional testing, commissioning and first parameter adjusting of equipment.] During the warranty period the manufacturer shall repair or replace defective products. This warranty shall be in addition to any provided by the Contractor. The warranty shall exclude normal wear and tear under normal usage and any damage caused by abuse, modification, or improper maintenance by entities other than the manufacturer or its approved representative.

C. Additional Owner Rights: 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.

1.8 SPECIAL TOOLS AND SPARE PARTS [- NOT USED]

A. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:

1. Contact information for the closest parts stocking location to the Owner.
2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.
3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the furnished equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

B. Spare parts shall be provided for each type and size of unit installed. At a minimum, the following shall be provided:

1. Provide the minimum spare parts recommended by the manufacturer.
2. [1] set of each type of control fuse installed within equipment
3. [3] sets of each type of power fuse installed within equipment
4. [1] set of each indicating pilot light, if not LED type, of each color and type installed

C. Any manufacturer specific special tool, not normally found in an electrician's toolbox, required to remove and install recommended or furnished spare parts shall be furnished. At a minimum the following shall be provided:

1. If available from manufacture, provide PC-based configuration software tool and a minimum of [one] communication interface cable for each type of cable required to connect a PC-based computer to the devices specified herein for configuration and programming.

2. Electronic configuration files, in a media format acceptable by the Owner (e.g. CD, USB stick, etc.), updated to an as-installed and commissioned state.

D. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. [Basis-of-Design Product: Subject to compliance with requirements, provide Square D Motorpact Motor Controllers by Schneider Electric.]

B. Acceptable Products: MV Motor Controllers specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:

1. Square D Motorpact Motor Controllers by Schneider Electric
2. [2nd manufacturer and model]
3. [3rd manufacturer and model]

C. Modifications or additions to existing MVMCCs shall be the same as the original manufacturer for model series still in production; otherwise the original manufacturer or an above listed acceptable manufacturer may provide these modifications and assemblies with proof of prior experience furnishing these types of modifications.

2.2 GENERAL REQUIREMENTS

A. The following MVMCC information is typically depicted on the Drawings: control wiring, bus configuration, bus ratings, [interrupting ratings,] component size and type, power line and feeder connections, application specific unit control wiring, elevation and footprint, etc. Where not shown on or able to be derived from the Drawings, the minimum requirements specified herein shall be provided.

B. The controllers shall be designed to accommodate motors of the size and type as shown on the drawings.

C. The MVMCC shall consist of a single section or multiple section line up. Close couple the MVMCC to MV SWGR as shown on the Drawings or specified elsewhere. The MVMCC enclosure shall be [indoor, NEMA 1, non-walk-in][outdoor NEMA 3R, non-walk-in][outdoor NEMA 3R, walk-in][NEMA 1 within an outdoor fabricated electrical house] type.

D. Close Coupled Multi-Section Line Ups

1. When controllers are grouped together in a line-up, the horizontal main bus shall be located in its own compartment to allow for ease of maintenance or extension of the MVMCC, the main bus shall be front, and rear accessible.

Silver plate should not be used in the presence of H2S gas (e.g. wastewater treatment plants and pump stations) due to wiskering of the metal possibly causing a fault.

2. Main power bus bars, shall be [tin-plated copper][silver-plated copper] and braced for 50 kA symmetrical for 2 seconds. The bus bar shall be continuous over the shipping split to simplify installation and reduce the number of overlaps in the equipment

3. [Bare][Tin-plated] and copper ground bus, when furnished, shall be continuous and extend from one end of the shipping split to the other through each vertical section. Minimum size ground bus to be 0.25”(6.35mm) by 2.0” (50.8mm).Motor controllers and contactors shall be modular one-high, one controller per structure of construction. Stacked or tiered controllers are not acceptable. The

equipment shall be factory-assembled (except for necessary shipping splits) and operationally checked.

E. The medium voltage motor controller shall be compartmentalized into the following distinct compartments.
   1. Main bus compartment or incoming cable compartment.
   2. Isolating disconnector compartment.
   3. Mechanism compartment
   4. Low voltage compartment
   5. Load compartment shall contain the fuses, contactor, instrument transformers and power cable terminations.

F. Isolating disconnector and contactor assemblies including current limiting fuses shall be of the component to component design. There shall be no bolted connections between the contactor and the customer load terminals.

G. The equipment shall be designed for front accessibility only, with front and rear access to be provided as a standard.

H. Cable entry or exist shall be [bottom][top][bottom and top][bottom unless shown on drawings].

I. Motor controllers shall not require ventilation opening to aid in cooling associated components.

J. Motor controllers shall maintain their full current carrying capacity in their intended enclosure.

K. A low voltage compartment to accommodate control circuit terminal blocks, control components, protective relays and metering shall be located at the top of each vertical section. The interior of the low voltage compartment shall be painted white.

L. Shipping splits shall be a maximum of [1][2][3][4][5] sections.

M. Arc Resistant Construction:
   1. The enclosure shall be arc resistant Type 2[B] construction.
   2. When arc resistant construction is specified a plenum shall be provided to divert the bi-products of an arching event.
   3. Arc resistant construction shall not derate the current carrying capacity of the controllers.

N. The MVMCC shall be rated as follows unless except where shown otherwise on Drawings:
   1. System Voltage [_____] kV, three phase [3 wire][4 wire], [solidly grounded][resistor grounded through a [____] ohm resistor][ungrounded] system.
   2. Operating Frequency [50][60] Hz
   3. Maximum Short Circuit Current : 50 kA RMS Symmetrical.
   4. Maximum Design Voltage [2.4][3.3][4.16][6.60][6.9] kV.
   5. Basic Impulse Level (BIL): 60kV
   6. Power Frequency Withstand: 20kV
   7. Short Time Current [(two seconds) 50kA][(3 seconds) 40kA] symmetrical.
   8. Medium Voltage Controllers shall have an integrated interrupting rating of 50kA with current limiting fuses.

O. The following components or equal shall be provided:
   1. Standard push buttons shall be Square D type 9001 XB4, 600 V rated.
   2. Standard pilot lights shall be Square D type 9001 XB4, 600 V rated LED long life.

3. Standard control relays shall be TeSys type CA2KN

2.3 COMPONENTS MV MOTOR CONTROLLER

A. The non-load break isolating disconnector shall be a two position externally operated manual three-pole device, such that in the open position it grounds and isolates the line side from the load compartment. The switch-operating handle shall be removable. The operating mechanism shall be rugged, simple and shall have provisions for three padlocks in the on or off position. [A Form-C contact shall be provided for remote position indication of the disconnector.][Provide key interlocks to coordinate with….]

B. Mechanical Interlocks: An interlocking system shall be provided to prevent the opening of the high voltage access door with the no-load disconnector closed. To access the medium voltage compartment, the no-load disconnector must be opened to the ground position; the operating port must be closed to allow padlocking the disconnector open. The interlock shall be directly attached to the operating mechanism and should not rely on long cables and linkages.

C. A viewing port shall be installed in the disconnector enclosure to enable visible verification of the blade position. LED light with pushbutton operation for ease of viewing shall be provided.

D. A cable ground switch (LDA Load Discharge Assembly) shall be provided. The LDA shall be used to ground the load cables. It is shall be mechanically interlocked with the Isolation Switch (disconnector) and be operated using the same handle. The LDA shall have a spring-operated quick make device capable of making 5kA sym. current at 7.2kV up to five times. The LDA shall not be used as a system grounding switch. The LDA shall be mounted in the load box at the motor lead terminals. The LDA shall be a maintenance free device.

E. Current limiting fuses shall be type “R” for motor loads or type “E” for non-motor loads. A blown fuse indicator shall be provided. The blown fuse indicator shall be an “Extended Travel” type with a minimum of 1 inch of travel. Fuses shall have a 50,000 Amperes interrupting capability. The type “R” fuses shall incorporate time/current characteristics for motor service allowing proper coordination with the contactor and overload relay for maximum protection. This coordination shall be such that under a low fault condition the interrupting rating and dropout time of the contactor shall be properly coordinated with all possible fuse sizes to eliminate contactor racing. The power fuses shall be vertically mounted permitting easy inspection and replacement without the need for removing the contactor.

F. Fuse shunt trip, single phase protection system using din style fuses [(FuseLogic™ or equal)] shall be provided to automatically open the vacuum contactor when a fuse blows and shall function as backup protection only to the motor overload relay. The system shall further prevent potential single phasing conditions by blocking the closing of the contactor when a fuse is blown. [Contact for trip indication (1NO/1NC) shall be provided.]

G. The vacuum contactor shall be [magnetically held][latched design], with single-break high-pressure type main contacts. The vacuum contactor contact wear shall be easily checked with the use of a “go / no-go” feeler gauge, included with each contactor. A built-in test circuit shall be included within each controller to permit checking the control and pilot circuits, with the contactor in open position. The test circuit shall be capable of being energized through a polarized plug connector from an external 120-volt supply while in the test mode. The plug connector shall be electrically interlocked with the disconnector. A viewing window shall be provided to view the contactor status.

H. The contactor shall withdraw on a rail system. When the contactor is lowered it shall disconnect the contactor and when raised, it shall connect the contactor and lock it in position.

I. The controller mounted control power transformer (CPT) shall be [300VA], [500VA], [750VA], [2kVA], [5kVA] and be 60kV BIL rated. CPTs below 2kVA shall be urethane encapsulated.

J. Live Line Indicators (LLI) lights connected by a capacitive circuit to motor lead terminals shall be provided. LLI lights shall indicate voltage when the equipment is energized

2.4 FULL VOLTAGE MOTOR STARTERS AND REDUCED VOLTAGE AUTO-TRANSFORMER MOTOR STARTERS [- NOT USED]

A. Each Induction Motor Controller (full or reduced voltage) shall include.

1. Medium Voltage Compartment containing.
   a. one - three-pole non-load break isolating disconnector.
   b. three - Current limiting power fuses.
   c. one - Draw-out three-pole vacuum contactor assembly for Full Voltage Non Reversing Motor Starters.
   d. Two - Draw-out three-pole vacuum contactor assembly for Full Voltage Reversing Motor Starters.
   e. one – 3 pole Draw-out main contactor assembly for Reduced Voltage Auto Transformer Motor Starters.
   f. one – 3 pole Draw-out Start/Run contactor and AT section. Mechanically interlocked contactor to AT doors for Reduced Voltage Auto Transformer Motor Starters.
   g. One – Medium duty three coil auto transformer (with 50-65-80% voltage taps) for Reduced Voltage Auto Transformer Motor Starters
   h. one - Control circuit transformer [300VA][500VA][750VA][2kVA][5kVA].
   i. two - Control circuit primary current limiting fuses.
   j. set - Electrical and Mechanical interlocks.
   k. three - Load terminals
   l. Current Transformer Options: (Max 3)
      1) Each section containing a contactor shall include the following as shown on the drawings:
      2) [one][three] phase donut Type Low Power Current Transformer use with SEPAM relay
      3) [one][two] three phase donut type current transformers [ ]: 5A. or [_____]: 1A
      4) [one] Zero Sequence CT [2000:1][50:5]
2. Low-Voltage Compartment Door:
   a. one - Motor protection relay (MPR) Sepam Series [20][40][80]where specified.
   b. one - Microprocessor Square D PowerLogic® circuit monitor metering package where specified.
   c. Mounting space for any additional low voltage control, protection, or metering specified
3. Low-Voltage Compartment
   a. Two - Control relay's.
   b. one - Control circuit secondary fuse.
   c. Set of control circuit terminal blocks.
   d. Customer terminal blocks with screw compression type connections.
   e. Mounting space for any additional low voltage control, protection, or metering specified.
   f. One Test circuit receptacle requiring no access to the MV components.
4. Operator Panel
   a. Disconnector operator mechanism
   b. Mechanical open-close indication
   c. Disconnector Viewing Window
   d. two – 22 mm pushbuttons
   e. two 22 mm indicating lights
   f. Elapsed time meter

g. Key Interlocks: shall be provided for the disconnector operating mechanism as indicated on the drawings.

h. Provide [compression lugs] for terminating cables onto the motor controller terminal pads.

i. Indoor anti-condensation space heaters rated 120 VAC, 125W shall be supplied in each section. Control power shall be supplied [by internal controller mounted CPT][supplied by owner] and shall be supplied with [thermostats][humidistat.]

j. Cable ground switch – LDA

2.5 REDUCED VOLTAGE SOFT STARTER (RVSS) [- NOT USED]

A. Solid state reduced voltage motor starters shall be Square D type RVSS (sized as indicated), or pre-approved equal modified to meet the requirements of this specification. The starter shall be complete with the following standard features and adjustments.

B. Motor and Load Protection shall be integral to the starter assembly. Motor protection shall be based upon modeling of the thermal characteristics of the motor as programmed by the user and measured by the starter. All current referenced protection features shall be calculated from the motor nameplate FLA, and automatically adjusted for the Service Factor, NEMA Design, Insulation Class, Line Voltage and Line Frequency as entered by the user. All time-based protection features shall be based on a Real Time Clock, remaining active through any power loss. Starter shall provide the following functions:

1. Thermal Overload shall be provided by the on-board microprocessor control. Basic protection shall be inverse time-current trip curves as defined by NEMA trip curve Classes. The trip curve classes shall be programmable from between Class 5 and Class 30 and the starter shall be UL listed to provide each individual class. The overload protection shall be based on a Dynamic Thermal Register retained in memory and provide the following features:

2. Retentive Thermal Memory shall be used to ensure that the Dynamic Thermal Register does not lose track of motor temperature after the power is lost or shut down. Upon reapplication of power, the microprocessor shall be automatically updated as to the motor temperature and adjusted for real time cooling while the power is off.

C. Dynamic Reset Capacity shall retain a snapshot of the thermal capacity necessary to restart the motor. The starter shall determine these requirements by recording and averaging the previous 3 successful start-ups. After an overload trip has occurred the protection shall prevent resetting until enough cooling time has passed and sufficient motor thermal capacity is available.

D. True Thermal Modeling shall be a feature of the overload and reset calculations. Once established at setup, the Dynamic Thermal Register shall be biased according to the following input information when available: Cold Stall Time, Hot Stall Time, Stopped Cool Down Time, Running Cool Down Time, and all of the real time information from the RTD Option if ordered.

E. Separate Trip Curves shall be provided for Start and Run, allowing a higher level curve to avoid nuisance tripping during acceleration, but dropping to another level for accurate motor protection while at full speed. To maximize flexibility, each trip curve shall be programmable as follows:

1. Basic, using the NEMA Class ranges described above.

2. Locked Rotor programmable between 400 – 800% of FLA, and a trip time from 1 – 30 seconds.

3. Measured Start Capacity (I^2t curve area) taken from the previous successful start (only applicable to the Start Curve).

F. Overload Alarm shall be provided to warn users of an impending overload trip. The Alarm level shall be programmable between 40 – 95% of the Dynamic Thermal Register value. It shall provide an adjustable delay of 1 – 20 seconds.

G. Manual or Automatic Reset shall be selectable in programming to provide for automatic reset in unattended remote applications.

H. Phase Monitoring shall be standard and based on motor current. In order to protect against disconnected motor leads, this feature will function even if the line voltage remains normal. All features shall be as follows and capable of being disabled if not needed:

1. Phase Loss shall shut down the starter if current through any leg drops to 20% of unit FLA or less. This protection shall be implemented via hardware and shall be non-adjustable. It shall provide an adjustable trip delay of 1 – 20 seconds.

2. Phase Imbalance Protection shall be provided with programmable sensitivity to provide both Alarm and Trip points. The sensitivity shall be adjustable for phase-to-phase imbalances of between 5% and 30%. Each point shall provide an adjustable delay of 1 – 20 seconds.

3. Phase Rotation protection shall be self-learning and field programmable. If phase rotation varies from the initial set pattern, the starter shall trip immediately. If phase rotation is correct, the starter can be re-taught to recognize the new rotation.

I. Short Circuit Detection with dual mode protection for starting and running operation shall be standard. This circuit MUST be provided to protect the starter from load failures. This protection shall be implemented via hardware and shall be non-adjustable.

1. In the starting mode the starter shall employ a ¼ second pre-check routine to determine if the load circuit has a fault condition and disable the ramping prior to reaching the Initial Voltage setting. This is to avoid additional equipment damage after a fault that may have occurred while the starter was off.

2. In the running mode, the starter shall be shut down if current through any leg exceeds 10 times unit FLA for 12.5 milliseconds.

J. Over Current Protection shall be provided separate from the above to be used as a Shear Pin trip. It shall be adjustable at lower levels for protecting mechanical components from undue shock when rapid unexpected load changes occur.

1. Adjustment level shall be from 100% to 300% of the programmed motor FLA.

2. A time delay of up to 20 seconds shall avoid nuisance tripping from short duration transients.

K. Under Current Protection shall alarm the starter on an adjustable condition. This Load Loss sensor shall be programmable from 10% to 90% of the programmed motor FLA, and, with a time delay of up to 20 seconds shall avoid nuisance tripping from short duration transients.

L. Ground Fault protection shall be provided to protect the motor from damage using the Residual Current method. An Alarm and 2 trip levels, each adjustable from 5 – 90% shall be available with separate trip times as follows:

1. ALARM level preset at 5% with a 0.5 – 20 second delay.
2. LOSET Trip level preset at 7% with a 1 – 20 second delay.
3. HISET Trip level preset at 10% with an 8 – 250 millisecond delay.

M. Line Frequency Window shall be programmable from a 1 – 6Hz variance from the nominal line frequency as entered by the user. It shall provide an adjustable trip delay of 1 – 20 seconds.

N. Coast Down Lockout shall be provided to prevent restarting of the motor during backspin or other dangerous mechanical conditions after shutting off. The coast down lockout time shall be programmable between 0 and 60 minutes following a Stop command.

O. Starts-per-Hour Lockout shall be provided to prevent damage to the motor from rapid cycling of start commands for any reason. The maximum starts-per-hour shall be programmable between 1 and 10 starts.

1. Time Between Starts Lockout shall also be programmable to work with the above. A minimum time of between 0 and 60 minutes between start attempts shall prevent restarting too rapidly for the motor and load conditions as determined by the user.

P. Acceleration Control shall be fully adjustable in programming to match any application. As a minimum, starter shall come complete with the following settings:

1. Ramp Type: To ensure maximum flexibility in matching the load conditions in the field, the starter shall provide all of the following methods of closed loop acceleration ramp control: Voltage Ramp, Voltage Ramp with Current Limit, Current Limit Only (Current Step), Current Ramp (Torque Ramp) or up to 3 Custom Ramp profiles that can be programmed by the user.
2. Starting Torque: Initial torque output shall be programmable as either Current or Voltage output, and adjustable between 0-100% of maximum Locked Rotor Torque (600% current) available from the motor.
3. Maximum Current Limit: To ensure reliability of starting under any circumstance that the motor can function in, Current Limit shall be adjustable between 200 and 600% of the unit rating. This will allow locked rotor current to be delivered to the motor if necessary. Lighter duty starters with lower current limit settings will not be acceptable.
4. Ramp Time: The time between Initial Torque and Full Output shall be adjustable between 1 and 120 seconds.
5. Dual Ramps: To accommodate changing load conditions, the starter shall provide 2 separately adjustable ramp profiles, selectable via a dry contact closure. Each ramp shall provide all of the above features.
6. Custom Ramp Curves shall be available that can be configured by the user to match any load or starting condition. Each of the 3 available custom curves can be profiled by entering 8 torque and time points. The starter shall create a smooth acceleration curve from these plotted axis points.
7. Kick Start: To provide for starting difficult loads, the starter shall include a Kick Start feature that will apply a high output for a short time on initial start command. The Kick-Start voltage level shall be adjustable from 10 – 100% voltage, for 0.1-2 seconds max.
8. Jog: For checking rotation at start-up or other testing procedures, the starter shall provide a programmable Jog feature, adjustable from 5 – 75% of line voltage.

Q. Deceleration Control (Ramp Down) shall be completely independent of any Accel Ramp settings and provide a fully adjustable Decel profile in order to avoid possible motor damage. Pre-programmed decel “algorithm” systems that do not allow contouring to match load conditions are not acceptable.

1. Step Down Voltage: adjustable from 100 to 0% of line voltage. Allowing the motor torque to drop off immediately to a level that affects output without waiting for a linear ramp.
2. Deceleration Ramp Time: adjustable from 0 – 60 seconds. To allow gentle controlled deceleration in excess of the natural coast-to-stop time of the load.
3. Stop Voltage Level: adjustable from 100 – 0% of line voltage to automatically turn off the starter when the output torque has reached a desired level. Programming shall not allow the Stop level to be set higher than the Step Down Level. External timers shall not be needed to turn off the starter.
4. Selectable Operation During Overload shall be available to allow the user to decide if the motor shall turn off or continue to Decelerate when an overload condition is detected.

R. Starter Protection shall be provided with the following features. To maintain reliability of both the equipment and the circuit components.

1. Shorted SCR Detection shall be standard. This function must automatically prevent a “start” sequence when at least one SCR is shorted. A means of having qualified service personnel defeat the lockout of this circuit MUST be provided to allow for “Must Run” situations.
2. Shunt Trip Circuit shall be standard. This feature shall instantly energize a dry relay contact that can be wired to a “Shunt Trip” coil of the circuit breaker in order to protect the motor from damage. This protection shall only operate if there is current flowing through any phase of the starter when in the “Off” condition, such as when there are multiple shorted SCRs or a bypass contactor stuck on. This feature shall be independent of the above Shorted SCR protection so that it cannot be defeated.

3. Starter Over-temperature Trip shall be built-in and protect the SCRs from excessive heat build-up in the enclosure or heat sinks. Thermal sensors on the heat sinks shall be pre-wired to one of the programmable inputs that has been factory preset as the Over Temp input.

S. Inputs shall be provided for the control and option selection of the starter as follows.

1. Digital Inputs: All input and control devices shall be rated for 120VAC control or shall require dry contact closures without the need for external power supplies or interposing relays.

a. On-Off Control shall be 120VAC to avoid potential problems with voltage drop in long control wire runs. The starter shall provide for 2-wire or 3-wire control schemes. Seal-In relay contact for the 3-wire control scheme shall be internal, dedicated to that use and not counted as an output contact. Terminals shall be provided for use in interlocking with programmable output relays or external devices.

b. User Inputs: 4 programmable digital inputs shall be provided. Each input shall accept dry contact closures from external user supplied devices, and can be named for display on the DCU when energized. 2 of these inputs shall be preset as Temperature and Dual Ramp Select, but can be changed by the user. Inputs shall be programmable as N.O. or N.C., and programmed with a de-bounce timer of 0 – 60 seconds. Each input can be assigned to operate any of the Programmable Outputs.

c. Analog Input shall be provided for optional Tach Feedback Starting. This input shall accept 4-20ma with adjustable offset and gain.

T. Outputs shall be provided for the following functions in addition to the seal-in relay used in 3-wire control schemes as mentioned above.

1. Digital Outputs shall be eight (8) Form “C” contact relay outputs, rated for 240VAC, 5AMPS, 1200VA max., with each relay being programmable for any one of the following functions;

a. Indicator Relay programmable to change state on any of the following conditions:

b. Run / Stop, Start / End of Decel, Timed Output, At Speed / Stop, At Speed / End of Decel, Dual Ramp Selected, Self Test Fail.

2. Fault Trip Relay programmable for each of the following fault conditions: Overload, Phase Imbalance / Loss / Reversal, Lock Out Inhibits, External Inputs, Short Circuit, Over Current / Shear Pin, Ground Fault HISET / LOSET, Over / Under Frequency, I^2t Start Curve, Shorted SCR, Shunt Trip, Over Temp, Under Current / Load Loss.

3. Alarm Relay including the following conditions:

a. Overload Warning, Overcurrent Warning, Ground Fault Warning, Under Current Warning, Imbalance Warning, Thermal Register Warning.

4. RTD Relay (when RTD Input option is ordered) including Stator or Non-Stator Trip and/or Warning, and RTD Failure.

5. Analog Outputs (2) shall be included for providing information to external controls and be programmable as RMS Current or Percentage of Motor FLA.

a. If the Tachometer Feedback Starting option is used, the Analog outputs can be programmed as RPM.

b. If the RTD input option is used, the Analog outputs can be programmed as Hottest RTD Temperature for Stator or Non-Stator RTDs.

U. Operator Interface Panel that provides simple to use adjustment and status indication on a dead-front shroud of the starter shall be provided.

1. Adjustments shall be made by keypad with tactile feedback keys for high noise environments. To prevent confusion, no binary coded dip switches shall be used for programming. Pass code protection shall be available to prevent unauthorized changes to the programming.

2. Alpha-Numeric Display shall be Backlit LCD with 2 lines by 20 characters.

3. Indicators using long life LED devices shall provide additional quick annunciation of Power, Run Alarm and Trip operation, as well as the status of the eight output relays.

4. Password Protection shall be provided, allowing 3 levels of access to program information, 2 of these levels requiring separate Passwords.

V. Available control or protection options shall include the following:

1. Tach Feedback Starting. An optional input card shall be available to allow linear speed acceleration based on closed loop feedback from a tachometer.

2. RTD Inputs. Allowing biasing and adjustment of the Dynamic Thermal Register based on real-world temperature readings from up to 12 RTDs, with the following features:

a. Programmable RTD Type, shall accept 100 ohm platinum, 100 ohm nickel, 120 ohm nickel and/or 10 ohm copper RTDs

b. Configurable RTDs allowing for up to 6 RTDs to be used for the Stator. All RTDs shall have names assigned in programming for clear indication on the display.

c. RTD Voting providing for the requirement of at least 2 RTDs to be exceeding the setpoints for Trip or Alarm. This feature shall be programmable as Enabled or Disabled..

W. Serial Communications shall be built-in as a standard feature without the need for separate modules.

1. Communications protocol shall be RS-232 to a windows based program for data entry, and/or Modbus RTU protocol via RS485 signals.

2. Units shall be capable of being connected to an intelligent communication device in a network of up to 247 devices with unique addresses.

X. SCR Modules

1. PIV Ratings: SCRs shall be connected as inverse parallel pairs in series circuits to attain the following Peak Inverse Voltage ratings as a minimum for each phase:

a. System Voltage: 1500 / 2300V Pairs: 1 PIV Rating. 6500V

b. System Voltage: 3300 / 4160V Series Pairs: 2 PIV Rating. 13000V

2. Protection: RC snubber network circuits on each phase assembly. To avoid possible component damage, MOV protective devices shall be used only on the gate firing circuitry.

3. Efficiency: 99.7% through SCRs, 99.97% in bypass mode.

4. Control Method: To ensure reliable gate firing even when powered with on-site generators, firing circuits shall use individual phase transformer coupling method for maximum isolation and rapid rise of firing pulse.

5. Noise Immunity: The gate firing circuitry shall be protected from electrical noise and transients to ensure reliable starting and firing of the SCRs under all power conditions, regardless of the available fault current or motor lead length.

a. They shall be amplified and isolated from the control voltages by means of rugged encapsulated ring transformers that provide separate power sources for each set of SCR gate drives. The design shall allow for a “back-porch” DC carry-over of the firing pulse to prevent the SCRs from falsely turning off due to ringing of the output current or line notching caused by other connected equipment. The gate drive shall be maintained for 240 electrical degrees from the zero cross point to avoid motor switching transients.

b. For additional reliability and to protect against EMI/RFI interface generated by the internal components, connections to the Digital Control Unit shall be fiber optic.

c. When at all possible, the starter shall not require line reactors in the Medium Voltage power section. Those that do shall include them within the same enclosure as the starter and shall be UL listed in this configuration.

6. Ambient Conditions
   a. Temperature: As a standard of unit design quality, starter shall be documented to show the design has been tested for 0 – 50° C (-32 to 122° F) operation, and Overload Capacity shall be rated at this temperature.
   b. Altitude: 3300 ft (1000 m) maximum without de-rating.
   c. Humidity: 0 – 95% RH, non-condensing.
   d. Thermal: Heat sink temperature switches designed to trip at 85° C.
7. Electronics
   a. Non-Volatile Memory shall be used throughout the control and protection systems. To prevent the possibility of loosing protection values, stored programs or statistical data, battery back-up memory systems shall not be allowed.
   b. The starter shall store all factory defaults in a preset replaceable EPROM memory chip.
   c. User Programming and statistical data shall be stored in EEPROM memory for ready alteration. Loss of power shall not affect memory status.
   d. For fast updates and operation, running programs shall use DRAM memory. The starter shall store the DRAM memory contents to the EEPROM upon power failure, and restore it upon return to normal.
8. Data Sampling
   a. Critical operating data such as instantaneous current for Short Circuit, Ground Fault and Immediate Overload calculations shall be sampled every 2 milliseconds to prevent lagging operation.
   b. Non-Critical data shall be obtained from a true RMS calculation circuit, and sampled in a 350 millisecond moving window of individual phase currents.
9. Real Time Clock with automatic leap-year updating shall be provided. This clock alone shall use a battery back-up with a Lithium-Ion battery rated for at least 10 years of continuous operation without power applied. The clock shall be capable of being reset in the field after changing the battery, without affecting any other stored information.

2.6 MECHANICALLY-LATCHED CONTACTOR [- NOT USED]

A. Mechanically-latched contactor shall be provided when specified for transformer disconnect circuits, and other uses when it is required to have contactor remain closed, regardless of system and/or controller voltage condition.

B. Latched controllers shall have all the same features as a Full voltage Non-reversing Controllers except shall be closed electrically from a standard local or remote “close” push-button, and be tripped by a solenoid from a local or remote “open” push-button. An easily accessible, door mounted mechanical trip device shall be provided to allow the contactor to be opened when control power is not present.

2.7 VOLTAGE TRANSFORMER SECTION [- NOT USED]

A. A. The voltage transformer section shall contain [one (1) VT and be an open delta connection][(2) VT’s and be an open delta connection][(3) VT’s and be a wye connection][(3) VT’s and be a delta connection]. VT primaries shall have disconnect fuses and be connected directly to a source.
   1. The width of the unit shall be 20” wide.
   2. The voltage transformer shall have a secondary of 120 VAC. Primary will be determined by the system.
   3. (Option 1) 1 VT arrangements shall have a rating of 700 VA.

4. (Option 2) 2 VT arrangements shall have a combined rating of [750 VA][1500 VA].
5. (Option 3) 3 VT arrangements shall have a rating of [750 VA][1500 VA].
6. The Voltage transformer shall have a no-load disconnector to disconnect and ground the primary of the VT from the source.
7. Key Interlocks: shall be provided for the disconnector operating mechanism as indicated on the drawings

2.8 INCOMING LINE SECTIONS TO MCC

A. Each incoming line section shall be [20" wide bottom entry only][29.5" wide top or bottom entry] and shall be connected to an adjacent controller or VT section.

1. Terminations shall accommodate up to quantity and size or ratings of cables as indicated on the drawings.
2. Incoming Line section shall have a rating of [600A][1200A][2000A][3000A].
3. Section shall have a set of three (3) phase CT's to be used for main metering of lineup. Ratio :5 A
4. Provide Live Line Indicators (LLI) lights connected by a capacitive circuit to the main bus. LLI lights will indicate voltage when the equipment is energized.
5. Surge Arresters (metal-oxide type): [Distribution][Intermediate][Station] class, rated [3][6][9] kV,one per phase. See specification Section 16412 for specifications on surge arresters.
6. The section shall contain a top mounted pull box [10" high {max 500 kcmil}][17" high {1000 kcmil}] to ease in cable pulling and for additional shielded cable bending space.

2.9 PROTECTIVE RELAYS

A. Provide a protective relay for each circuit breaker as specified in Section 26 09 17 Protective Relays and Controllers and as indicated on Drawings. Protective relays shall meet the minimum requirements for the circuit breaker application (main, feeder, busbar, capacitor, transformer, generator, etc.) with the protection types (ANSI/IEEE C37.2 device numbers) and protection levels (basic, standard, advanced) specified or shown.

2.10 POWER METERING [- NOT USED]

Metering functionality is inherent in protective relays. If additional metering capabilities are needed use a separate power meter as suggested below.

A. Provide a power meter for each circuit breaker application as follows:

1. MV Mains: The metering device used to monitor the medium voltage mains for network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be an Advanced Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.
2. MV Feeders: The metering device used to monitor the medium voltage feeders for network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be a Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.

2.11 CONSTRUCTION

A. Construction: [Indoor.] Each equipment section shall be a separately constructed cubicle assembled to form a rigid freestanding unit. Minimum sheet metal thickness shall be 11-gauge steel on all exterior surfaces, with the exception of the Low Voltage door, which shall be 14-gauge steel minimum. Adjacent sections shall be securely bolted together to form an integrated rigid structure. Each individual unit shall be braced to prevent distortion. [Arc resistant enclosure as defined by C37.20.7 or EEMAC G14-1.1987]

B. All bus joints shall use Belleville washers. Torqued bolts that are used for bus joints or for insulators and direct support of any current carrying parts shall be marked with a bead of highly visible bright orange “torque seal”, that will readily show when a bolt has loosened.

C. Main bus shall be tin-plated copper, [non-insulated][insulated] rated [600][1200][2000][3000] amps, and shall be supported directly by the switch.

For single sections…

D. Include a ground pad with lug.

For multiple section lineups…

E. Include continuous ground bus through the motor controller assembly, securely connected to the steel frame of each cubicle. Ground connection points shall be available at each end of the lineup.

F. Main bus and ground bus connections shall be designed for easy for future extensions. Cutout areas with removable bolted on covers shall allow for future extension of the main bus and ground bus

2.12 FACTORY FINISHING

A. All non-painted steel parts shall be zinc plated.

B. All painted steel parts shall be cleaned and an iron phosphate pre-treatment applied prior to paint application.

C. Paint Color shall be [ANSI-61 (light gray)][ANSI-49 (Dark Gray)] TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

D. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.3-1987. Salt spray withstand tests in accordance with paragraph 5.2.8.4 shall be performed on a periodic basis to provide conformance to this corrosion resistance standard of at least 600 hours minimum (indoor equipment).

A close-coupled mounted transformer has several advantages over an integrally mounted transformer since it may be mounted away from the power unit of the VFD. The transformer could then be located outside of the air conditioned space of the power unit lowering the heat load and removal requirements of the space. It could also be located outdoors where additional savings can be achieved through the conservation of building layout space.

2.13 MARKINGS AND LABELING

A. All identification and warning labels and nameplates exterior to the MVMCC shall be resistant to weather, UV, and their intended installation environment.

B. Each MVMCC shall be provided with an engraved nameplate identifying the project specific equipment tag and service description.

C. Warning labels and nameplates shall be present at access locations to advise personnel of possible hazards. The MVMCC shall be marked in accordance with UL, NFPA 70 NEC, NFPA 70E, and other applicable standards.

2.14 ELECTRICAL POWER MANAGEMENT SYSTEM [- NOT USED]

EPMS systems, such as Schneider Electric EcoStruxure™ Power, provide many benefits throughout the lifecycle of an electrical distribution system through the connection, monitoring and analysis of the system and its connected equipment. Equipment connectivity and application support are critical to achieving the benefits of a safe, reliable, efficient and compliant system architecture.

A. The equipment specified herein shall provide the necessary communications connectivity and functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:

1. Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected devices and equipment necessary to provide functionality. Devices may be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment. Equipment sections with multiple connected devices and assemblies of bolted adjacent bays shall include an internal inter-wired communications network for a singular connection to the EPMS network for power monitoring, equipment status and alarms.
2. Compliance with Cyber security requirements.
3. Remote EPMS application functionality for equipment configuration [and operational control]; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.
4. Refer to the Electrical Power Management System specification section for additional requirements.

B. Native software compatibility shall be fully factory-tested, and shall include the following characteristics.

1. Capability for pre-engineered, interactive graphical display screens to view and analyze real-time device data. Data displayed shall include the following:
2. Pre-mapping of registers to standard measurement names without the need for additional configuration or internal device registers.
3. Automatic collection and logging of device data by EPMS software without additional configuration. Historical data logged shall include the following.

PART 3 - EXECUTION

3.1 GENERAL

A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of specifications Section [26 00 10][16010], Section [26 08 00][16080] and Drawings.

B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

C. 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 Engineer, 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.

D. Pre-Installation Conference: Prior to commencing the installation, an onsite pre-installation conference shall review the material selections, installation procedures, and coordination with other trades. Attendees 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 Engineer

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

F. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.

G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 FACTORY ACCEPTANCE TESTING [- NOT USED]

3.3 FIELD QUALITY CONTROL [- NOT USED]

Schneider Electric extends the warranty of most equipment by 12 months at no additional cost when their service technicians perform functional testing, commissioning and first parameter adjusting of the installed equipment.

A. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory-trained manufacturer's field service representative. This manufacturer's field service technician shall provide all material, equipment, labor and technical supervision to perform inspection, testing and adjustments to ensure equipment is installed, adjusted, and tested in accordance with the manufacturer's recommendations and is ready for operation. The manufacturer's field service technician shall replace damaged or malfunctioning equipment and report to the Engineer any discrepancies or issues with the installation.

B. The manufacturer's representative shall, upon satisfactory completion of inspection and testing, attach a label to all serviced devices indicating the date serviced and testing company responsible.

3.4 INSTALLATION

A. Connect the primary surge arresters if not connected. If required, use jumper cables, as provided by the motor controller manufacturer.

B. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer

C. Perform mechanical operator tests in accordance with manufacturer's instructions.

D. Check torque of all bolted connections, including cable terminations, either by observing the bead of indicating compound to confirm that it is still intact, or with a torque wrench to confirm the joint is tightened to the manufacturer's specifications.

E. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with Owner.

F. Verify key interlock operation if applicable.

G. Perform insulation resistance test on each phase to ground and each phase to each other phase. Record results.

H. Perform low frequency withstand tests according to ANSI/IEEE C37.20.3, paragraph 5.5.

I. Perform contact resistance test across each switchblade; report any contact resistance in excess of 50 micro-ohms.

3.5 FIELD TESTING AND COMMISSIONING [- NOT USED]

A. Operational Readiness Testing

1. The Contractor shall inspect and test furnished equipment and associated systems for conformance to the contract documents, including equipment manufacture's recommendations, and readiness for operation. The test shall include the following as a minimum:

    a. Visually inspect for physical damage and proper installation

    b. Perform tests in accordance with manufacturer's instructions

    c. Perform tests to ensure compliance with Contract Documents

    d. Perform tests that equipment is ready for operation

e. Touch-up paint all chips and scratches with manufacturer-supplied paint and transfer remaining paint to Owner

2. Contractor shall submit an operational readiness test report documenting all test results, including all assumptions, conditions, allowances and corrections made during the test. The report shall provide a listing of all modifications and adjustments made onsite to include any settings / parameters not identified as factory defaults within the equipment's O&M documentation. The test report shall include a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

B. Functional Demonstration Testing

1. Prior to scheduling functional demonstration testing the Contractor shall submit a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

2. The Contractor shall completely demonstrate the functionality and performance of the equipment and associated systems in the presence of Owner and Engineer, observing and documenting complete compliance with the Contract Documents.

3. The Contractor shall submit a written report documenting successful completion of functional demonstrating testing including all assumptions, conditions, allowances and corrections made during the test.

3.6 TRAINING [- NOT USED]

A. O&M Training: Onsite training specific to the equipment furnished shall be provided to the Owner's staff by a factory trained manufacturer's representative. Training duration shall be sufficiently adequate to cover the operation and maintenance of the equipment and shall consist of not less than [1][2 repeated] session(s) with [4] hours of onsite classroom and hands-on instruction for a minimum of [4] attendees per session.

1. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:

a. Theory of operation

b. Major components of equipment

c. Operation of equipment

d. Configurations of equipment

e. Maintenance, troubleshooting and repair

f. Replacement of component level parts

2. [The submitted O&M manuals shall be used for training.][Manuals and documentation shall be provided to each participant for training.]

END OF SECTION [26 18 39.26][16340]

This guide specification has been written and is intended to be used by a professionally qualified specifier and/or design professional. The use of this guide specification requires the professional judgment and expertise of the qualified specifier and/or design professional to adapt or revise the information to the specific needs for the Project and is not intended to be used verbatim as a project specification section without appropriate modifications for the specific use intended. The guide specification must be used and coordinated in accordance with the procedures of each design firm, and the requirements of the specific project. This guide specification is subject to change without written notice by the manufacturer and the manufacturer expressly disclaims any warranty, expressed or implied.