Specification Guide

Allen-Bradley

Medium Voltage Smart Motor Controllers (SMC)

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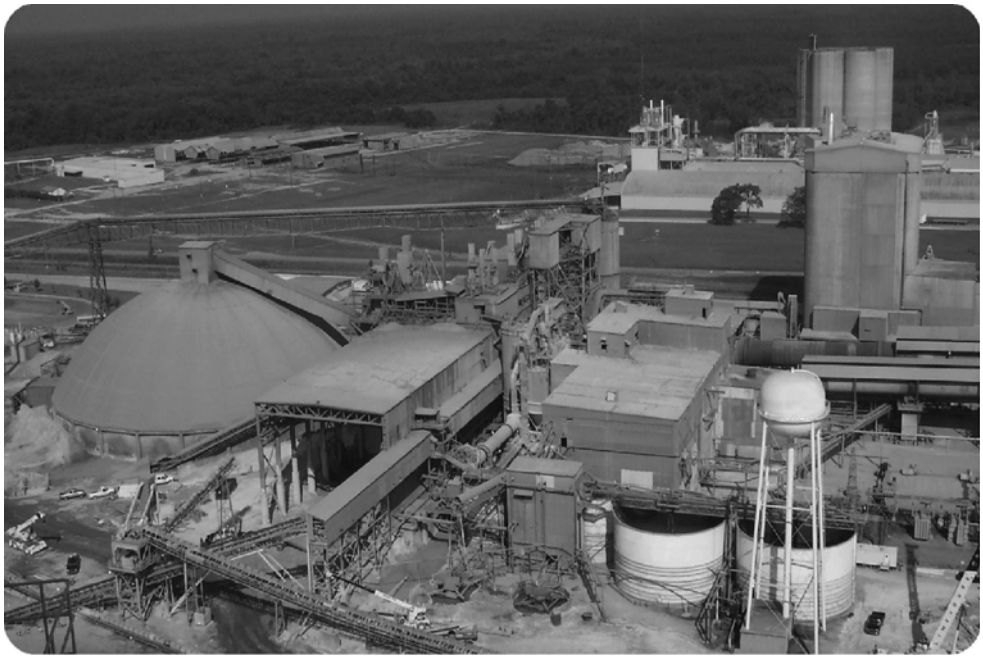

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

	**WARNING:** Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	**ATTENTION:** Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

	**SHOCK HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	**BURN HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
	**ARC FLASH HAZARD:** Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

This manual contains new and updated information.

New and Updated Information

This table contains the changes made to this revision.

Topic	Page
Edited environmental conditions voltage ratings	11
Added printed circuit board detail	15
Changed Type 2 to Type 2B Accessibility	20
Edited Ground Bus plating dimensions	22
Added Arc Resistant to Enclosure Type	20
Updated Low Voltage Control section	24
Updated SCR firing circuitry section	29
Added EtherNet/IP information to Equipment Design and Selection chapter	31
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Added 50 kA notation to Electrical Ratings table	42
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Overview

General

Introduction

Rockwell Automation has produced quality medium voltage products to meet the requirements of all types of industries for well over six decades.

From the original oil-immersed contactor, to air break and vacuum contactors, to solid-state controllers such as Smart Motor Controllers and AC Variable Frequency Drives, Rockwell Automation has developed and built a medium voltage product line that satisfies those industries demanding more safety, less maintenance, longer life and reliability in motor control equipment.

Added to those demands is the need for smaller and more flexible medium voltage products that are more efficient and that enable a reduction in building and expansion costs.

MV SMC-Flex Solid-State Motor Controllers

Rockwell Automation meets and exceeds industry demands with the medium voltage smart motor controller (MV SMC-Flex) line of solid-state, reduced-voltage motor controllers. The MV SMC controller is available for soft starting motors rated up to 600 Amps full load current, 2300...6900V AC, 50 and 60 Hz. Higher motor currents are possible under certain conditions (consult factory).The MV SMC-Flex control module provides closed-loop microprocessor control to start and stop three-phase medium voltage and low voltage motors. Several standard modes of operation are available within a single controller:

- Soft Start with Selectable Kickstart
- Current Limit Start with Selectable Kickstart
- Linear Acceleration with Selectable Kickstart(1)
- Linear Deceleration(1)
- Soft Stop
- Dual Ramp Start
- Full Voltage Start
- Pump Control (optional), including start and stop control

(1) Requires motor tachometer

Additional Features:

- Solid-state motor protection
- Metering
- Drive Programming Interface (DPI) communication
- LCD display
- Keypad programming
- Fiber optic control of medium voltage silicon controlled rectifiers (SCRs) (for isolation)
- Current loop gate driver boards
- Vacuum bypass contactor
- Starting optimized power stacks
- CENTERLINE™ power bus

The Bulletin 1503E, 1560E, and 1562E are solid-state reduced voltage controllers which utilize the same SMC-Flex digital control module as the 480/600 V Bulletin 150 SMC-Flex controllers.

MV SMC-Flex Motor Controllers	Bulletin Number
OEM Components	1503E
Retrofit Controller	1560E
Combination Controller, non-reversing	1562E

Custom engineered units available upon request (for example, reversing or multi-motor).

Scope

This specification outlines the overall fabrication, performance, and functional requirements for a medium voltage solid-state, reduced-voltage motor controller for use with polyphase motors. The complete controller must meet the overall design requirements as specified herein.

The solid state reduced voltage starter must be _____ V, 3 phase, _____ hp or _____ kW rated, and used for the controlled starting and/or stopping of AC induction motors.

Codes and Standards

The seller's equipment must be designed, manufactured, and tested to meet or exceed the applicable requirements of the latest standards published by the following organizations:

- Canadian Standards Association (CSA) Industrial Control Equipment C22.2 No. 253
- American National Standards Institute (ANSI) Instrument Transformers C57.13
- Institute of Electrical & Electronic Engineers (IEEE)
- National Electrical Code (NEC)
- Occupational Safety & Health Act (OSHA)
- National Electrical Manufacturers Association (NEMA) Medium Voltage Controllers Rated 1501...7200V AC ICS 3-2 (formerly ICS 2-324)
- Underwriters Laboratories, Inc. (UL) High Voltage Industrial Control Equipment 347
- European Directives for Safety and EMC

IMPORTANT It must be the responsibility of the user and/or installer to know and meet all local codes, standards, and OSHA requirements.

Environmental Conditions

The controller must be offered in versions that accept nominal plant power of 2400V AC, 3300V AC, 4200V AC, 4200V AC, 4800V AC, 5500V AC, 6600V AC, 6900V AC (+5/-10%) or 7200V AC (+0/-10%), 3 phase 50/60 Hz (± 3%).

The standard controller must operate in an ambient temperature range of 0...40 °C (32...104 °F) with a relative humidity of up to 95% (non-condensing). Higher ambient temperature conditions are supported with factory assistance.

Rockwell Automation products are built using materials that comply with Class 1: Industrial Clean Air Sulphur Environments as defined in IEC Standard 60654-4 (Operating Conditions for Industrial-Process Measurement and Control Equipment), and G1 as defined in ISA-S71.04-1985 (Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants).

The equipment must be capable of being stored in an environment with an ambient temperature range of -30...65 °C (-22...149 °F).

The equipment must operate at altitudes from 0...1000 m (0...3300 ft) above sea level, without derating. For applications above 1000 m (3300 ft), the maximum current and basic impulse levels (BIL) of the controllers must be derated, and vacuum contactors may be compensated for operation at the specified altitude (Refer to Table 2 - Environmental Ratings).

Seismic Qualifications

The controller can be provided such that it must withstand certain horizontal and vertical accelerations (seismic zones 1, 2, 3, and 4) without overturning or lateral movement when bolted down (mounted) per the seller's recommended installation instructions.

IMPORTANT	The above seismic qualification does not indicate that the equipment operates properly during or after a seismic event.

Obligations of Seller

Deviations

Any exceptions or deviations must be defined in writing at the time of bid.

Drawings and Manuals

Information Drawings

Orders must include a submittal of three bond paper prints of the dimension drawing and electrical drawings (two for customer and one for seller's local representative), at the time engineering is finalized. These drawings must be suitable for photo copying.

Approval Drawings

If requested at the time of order entry, approval drawings must be available at no charge. The approval submittal must include three bond paper prints of the dimension drawing and electrical drawings supplied at the published lead time after order receipt by the seller. Submittal of approval drawings requires an additional _____ weeks. Approval drawings can be sent electronically via the Internet, as an alternative to sending them by mail.

IMPORTANT	Seller must allow the customer two weeks to review the drawings. This period starts on the date that the drawings are shipped to the customer and ends on the date that the drawings must be back to the seller. If drawings are returned earlier than two weeks, then lead-time may be adjusted accordingly.

Final Drawings and Manuals

Certified drawings, instruction, and maintenance manuals must be provided on CD (three copies) and sent within 30 days of final product shipment. Final drawings must be available in DXF format at no charge.

Spare Parts

Recommended spare parts list and prices must be supplied with the bid. Also, the address of the manufacturer's closest parts stocking location to the user can be provided on request.

Critical Spares

Critical spare parts are those associated with long lead times and/or are critical to the unit's operation. These spares should be held in reserve by the customer to limit unforeseen downtime.

Maintenance Spares

Maintenance spare parts are those required by customers to regularly perform scheduled maintenance on their equipment. These spares include, but are not limited to, consumable spares that are required to be exchanged during scheduled customer maintenance periods.

Seller must assist in determining an appropriate level of spare parts in conjunction with the customer's bill of material (which may include circuit breakers, full voltage starters, load break switches and other auxiliary equipment) and the customer's current installed base.

On-site Inventory Agreement (Optional)

Seller must offer an on-site inventory agreement, in which the seller stocks and supplies, as needed, all of the spare parts required by the user in the closest stocking location. The user must have a controlled/immediate access to this inventory 365 days a year.

Notes:

Quality Assurance

Introduction

All inspection and testing procedures must be developed and controlled under the guidelines of the seller's quality system. This system must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.

All incoming material must be inspected and/or tested for conformance to quality assurance specifications.

All sub-assemblies must be inspected and/or tested for conformance to the vendor's engineering and quality assurance specifications.

All printed circuit boards with active components must be burned-in (either 100% or on a sampling basis) for a minimum of two hours at 65 °C (149 °F).

Standard Testing

The following tests must be carried out in accordance with applicable requirements and/or specifications of:

- Canadian Standards Association (CSA)
- Underwriters Laboratories (UL)
- National Electrical Manufacturers Association (NEMA)
- European Standard (EN)
- International Electrotechnical Commission (IEC).

Functional checks must be performed wherever possible; otherwise, inspection and continuity checks must be made.

A "HI-POT" dielectric withstand test must be performed on all buswork and cables from phase-to-phase and phase-to-ground (except solid-state components, low voltage controls, and instrument transformers). The voltage level used for this test depends on the product's nominal AC voltage.

Component devices must be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.

Instruments, meters, protective devices, and associated controls must be functionally tested by applying the specified control signals, current, and/or voltages.

Medium voltage solid-state controllers must be inspected for the following:

- Electrical interlocking
- Motor protection and ground fault
- Motor start tests (under medium voltage load conditions)

Physical Inspection

The product must meet all applicable engineering and workmanship standards and specifications. All components must be verified against engineering documentation to be present and correctly installed.

Warning plates, isolation barriers, and mechanical interlocks must provide sufficient safety/isolation for personnel and equipment.

- Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
- Isolation barriers must be in place within the cabinet. These barriers protect personnel from touching live medium voltage components in an area that otherwise does not have power supplied to it.
- Operation of isolation switch handle, if supplied, and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full on position.

All bus and bus connections must be checked for proper clearance, creepage, phasing, and tightness (torque).

Factory Inspections (Optional)

Visual Inspection of Equipment

If requested, a review of the electrical and mechanical drawings for the purchased equipment is done with the Applications Specialist or Project Manager prior to commencing the inspection.

The visual inspection consists of a customer visit to the factory, with prior notification and coordination with the Customer Service Coordinator or the Project Manager, with the intent to view the customer-specific equipment at the various stages of build. There is no special preparation of the equipment for this inspection. It is a means for the customer to verify the progress of the order without any disruption to the manufacturing cycle.

Witness Testing

A review of the electrical and mechanical drawings for the purchased equipment is done with the Applications Specialist or Project Manager prior to commencing the tests. Any questions or clarifications prior to commencing the test is addressed at this time. The test facility then hosts the customer for the duration of the actual testing. At the conclusion of the test, the customer reconvenes with the Applications Specialist or Project Manager to discuss any concerns and/or issues that arose during the test. The Applications Specialist or Project Manager responds back to the customer at the earliest possible time with an outline of the financial and/or schedule impact of the changes.

The medium voltage solid-state, reduced-voltage testing consists of:

- Demonstrating an AC high pot test to the customer.
- Applying control power at the rated voltage to the equipment.
- A functional demonstration of customer-purchased options and control devices is completed with the starter in the test position.
- Operation of the vacuum contactor.
- Connection of equipment to a medium voltage input source and the test motor in the manufacturing facility. The motor starting functionality is demonstrated by starting and stopping the test motor.

Custom Testing

The seller must be prepared to provide custom testing of the equipment. The customer specifications for the customer test must be provided to the seller at least two months prior to the testing date at which time the seller provides a cost and schedule impact for completing the testing requirements.

Notes:

Equipment Design and Selection

General

The controller must be manufactured by a single vendor.

The medium voltage, solid-state controller must consist of a metal-enclosed, free-standing, dead front, vertical steel structure, available in either standard NEMA type 1 with optional type 12 and Arc Resistant enclosures.

Each structure must be suitable for future expansion at each end. Each structure must also have two non-removable base sill channels and removable lifting angles or brackets for ease of handling and installation.

The controller must be of modular design to provide for ease and speed of maintenance. The modules are to be manufactured by one supplier, designed to allow ease of maintenance, including removal of medium voltage components and power electronic components.

The structure must be divided into isolated compartments as follows:

- Main power bus and ground bus compartment
- Power cell compartment
- Low voltage compartment

Metal or glass polyester barriers must be provided between the low voltage compartment and the power cell and/or main power bus compartment, and between the power cell and main power bus compartment. Personnel must have access to the low voltage compartment, with the controller energized, without being exposed to any medium voltage.

Structure and Controller

Each structure must contain the following items:

Retrofit Controller

Note: For use with existing isolating or full voltage controller.

- Tin-plated copper horizontal power bus (optional)
- A continuous bare copper ground bus
- Power electronics
- A vacuum bypass contactor
- An LV control panel complete with microprocessor-based control module
- Three current transformers
- Top and bottom plates to accommodate cable entry/exit

Combination Starters

Note: Includes isolating controller.

- Tin-plated copper horizontal power bus (optional)
- A continuous bare copper ground bus
- Power electronics
- A non-load-break isolation switch and operating handle, complete with ground connection, when open
- A vacuum isolation contactor
- A vacuum bypass contactor
- Three current limiting power fuses for NEMA Class E2 operation
- Three current transformers
- A control power transformer
- A low voltage control panel complete with microprocessor-based control module
- Space for necessary auxiliary control and metering devices
- Top and bottom plates to accommodate cable entry/exit

Enclosure Types

The medium voltage product line must be available in a NEMA Type 1 (IEC IP10) general purpose enclosure as standard. Optional enclosures are:

- NEMA Type 1 with door gasketing (IEC IP21)
- NEMA Type 12 dust tight and drip proof (IEC IP52)
- NEMA Type 3R outdoor (IEC IP34) non-walk-in
- Arc Resistant

Each enclosure must be properly sized to dissipate the heat generated by the controller within the limits of the specified environmental operating conditions.

Arc Resistant Enclosure (optional for selected units)

The medium voltage solid-state motor controller must be provided with an arc resistant enclosure design (select units – consult factory for availability).

The arc resistant units must be tested per IEEE C37.20.7, Type 2B Accessibility, and provide the following benefits:

- Reinforced structure, to contain arc flash material, and arc faults up to 40 kA, 0.5 s
- Arc vent to exhaust arc flash material
- Plenum to redirect arc flash material
- Reinforced low voltage panel, sealed to prevent entry of arc flash material, providing type 2B accessibility in the area of the low voltage control panel.
- Full arc protection is also maintained when the low voltage door is open for maintenance purposes

Structure Finish

As standard, all exterior and interior metal parts (except for the power cell back plates and low voltage panel) must be painted ANSI 49 medium light gray (3R must be ANSI 61). All metal back plates in the power cell and low voltage compartments must be painted high gloss white for high visibility. Optional field touch-up spray cans, matching the enclosure color, must be supplied when requested.

Description	Hybrid epoxy powder paint
Standard color	ANSI 49 medium light gray (optional ANSI 61 light gray)
Procedure	Continuous paint line. All parts are painted before assembly
Preparation	Alkaline wash/rinse/iron phosphate rinse/iron-chrome sealer rinse/recirculated de-ionized water rinse and virgin de-ionized water rinse
Painting	Air-atomized electrostatic spray. Total paint thickness - 0.002 in. (0.051 mm) minimum
Baking	Natural gas oven at 179 °C (355 °F) minimum.

IMPORTANT When optional custom paint color is specified (including ANSI 61), all external surfaces must be painted to the custom color requirement, except for the external isolating switch handle assembly, lifting angles and lifting brackets.

All unpainted steel parts must be plated with a zinc plate/bronze chromate process for corrosion resistance.

Main Power Bus (Optional)

The main horizontal power bus must be located at the center rear of the structure to provide optimum heat distribution, ease of maintenance, and splicing. The power bus must be mounted on edge to a molded bus support insulator in a common vertical plane. This provides better short circuit withstand capability and protection against tracking between phases and the accumulation of dust. The power bus must be made of tin-plated copper and be available in one of the following continuous current ratings: 1200 A, 2000 A, or 3000 A. Optional silver-plated power bus must be available.

Access must be provided to the bus compartment from the front or the rear of the structure to allow for installation and regular maintenance of the power and ground bus splice connections.

The horizontal buswork, the cabling/bus from the main power cell must be braced and tested in accordance with NEMA ICS 3-2 and UL 347 (paragraph 30).

When optional insulated power bus is specified for the main horizontal bus, a sleeve-type, heat shrink insulating material with good flame resistance and self-extinguishing properties, must be used. This material must have a minimum wall thickness of 1.4 mm (0.055 in.).

Vertical Bus (Combination Controller only)

Vertical power bus risers must be provided from the main horizontal power bus to the unit isolating switch line terminals. It must be made of tin-plated copper and rated according to the unit size.

Bus Bracing

The horizontal/vertical buswork and the cabling/bus in the main power cells must be braced and tested in accordance with NEMA ICS 3-2 and UL 347.

The buswork and cabling must be braced to withstand the let-through energy allowed by the largest fuse during a short circuit fault.

Ground Bus

A continuous copper ground bus must be provided along the entire length of the controller line-up. A mechanical lug for 8...1/0 AWG or 6...250 MCM cable must be supplied at the incoming end of the line-up. The ground bus must be 9.5 x 51 mm (3/8 x 2 in.) bare copper. Optional tin plating must be available.

Vacuum Contactor Specifications (Input and Bypass)

The electrically held medium voltage contactor must be the Allen-Bradley Bulletin 1502 vacuum type.

The following current ratings must be available:

- 400 A
- 800 A

The contactor must have visual contact wear indicators. No special tools are required for checking contact wear.

Vacuum bottle and coil maintenance must be performed on the contactor while it is mounted. Removal of contactor is not required.

Vacuum Input Contactor (Combination Controller Only)

The vacuum input contactor must be fixed mounted inside the power cell. Fixed mounting provides solid, continuous contact, lowering maintenance requirements considerably. The contactor must be interlocked with the non-load-break isolating switch, both electrically and mechanically, which must provide the following safety features:

- Prevent the isolating switch from being opened or closed when the contactor is in the closed position.
- Prevent the opening of the medium voltage door when the isolating switch is in the closed position.
- Prevent the closing of the isolating switch when the medium voltage door of the controller is open.
- Remove control power from the control power transformer, power transformers, or external power source to the control circuit when the isolating switch and contactor are in the open position.

Vacuum Bypass Contactor

A contactor must be provided to bypass the silicon controlled rectifiers (SCRs) once the motor is at full speed. When a stop option is selected, the bypass contactor opens, bringing the SCRs back into the power circuit. It must be fixed mounted in the main power cell.

The bypass contactor must be capable of providing a full voltage start in case of emergency bypass.

Control Wire Specification

The control wire must be an insulated (with a flame retarding thermoplastic compound), flexible stranded, tinned copper wire supported and neatly bundled. A red wire must indicate AC power, a blue wire must indicate DC power and a green wire must indicate ground. Other colors or combinations may be used for specific applications. Whenever possible, the control wire must be isolated from high voltage components in the power cell and wire markers which are numbered according to the electrical diagram, must be provided at each end of the wire.

All of the control wire terminations must be a screw-type, copper-compression-type terminal block or connector which firmly grips the conductor. Non-insulated, locking-type, fork tongue lugs must be provided on the control wire terminating on the control power transformers and current transformers.

Low Voltage Wireway

An optional low voltage wireway must be available across the top of the structure. There are two sizes of low voltage wireway available:

- 51 x 102 mm (2 x 4 in.)
- 152 x 152 mm (6 x 6 in.)

The low voltage wireway must allow a convenient method of interconnecting control wire from one controller to another, when interfacing with a master panel or with programmable controller circuits.

Low Voltage Control Panel

Each controller must have a separate, front accessible, low voltage control compartment. The compartment must be completely isolated, using metal barriers between the low voltage compartment and the power cell and/or main power bus compartments for utmost safety.

Optional meters, motor protection relays, selector switches, operators, indicating lights, for example, must be mounted on the front of the low voltage control panel, and arranged in a logical and symmetrical manner. The low voltage panel must provide the following features:

- Space must be provided for low voltage control devices, transducers and metering.
- Necessary terminal blocks must be supplied. Extra terminal blocks can be supplied as an option.
- There must be low voltage control panel access from the front, without turning the controller off.
- All remote low voltage cables must be able to enter the low voltage control panel from the top or bottom of the structure. Access must be by means of removable entry plates on the top and bottom of the structure.
- As standard, the combination controllers must incorporate a swing-out low voltage panel which provides easier access to the power cell to make bus splicing and load cable connections. All products must have a swing-out low voltage panel, which is interlocked with the power cell compartment to allow easy access to medium voltage equipment, for example, power stacks, power bus, power factor correction capacitor, or other similar equipment.

WARNING: The panel must not have the ability to swing open until the power cell is off and isolated from the main power bus.

- Pilot control relays must be used to operate and economize the vacuum contactor. Pilot relays are used only with relay-controlled contactors. IntelliVAC controlled contactors do not use relays to economize the contactor.
- The control panel supply voltage must be 120V AC or 240V AC, 50/60 Hz. It must be rectified to provide a DC operating voltage for the vacuum contactor coils and economizing relay. The control voltage is rectified in the control circuit only for relay controlled contactors. The IntelliVAC controller has the AC to DC conversion done within the module. There is no economizing relay for IntelliVAC control.
- There must be a two-pole, three-conductor (with a grounding prong) male plug to provide a means for connecting a two-pole, three-conductor receptacle from a remote 120V AC, 50/60 Hz supply to operate the control circuit when it is in the test position (combination controllers only). 240V AC and all DC control circuits will have segregated terminal blocks provided for test power from a remote source in lieu of the receptacle.
- The low voltage control panel door must have a viewing window, allowing the user to monitor the MV SMC-Flex controller operation via the built-in display.

IntelliVAC Control (Optional)

- Optional IntelliVAC contactor control must be available with the following features:
  - Universal input voltage (110...240V AC, 50/60 Hz or 110...250V DC)
  - Consistent vacuum contactor pick-up time
  - Selectable and repeatable vacuum contactor drop-out time (eight settings)
  - Altitude compensation
  - Power loss ride-through (TDUV) for up to two seconds
  - Temporary motor jog function
  - Delayed motor re-start
  - Anti-kiss and anti-plugging protection
  - Status indication (LEDs and relay outputs)

Main Isolating Switch (Combination Controller Only)

The main power cell must have an externally operated, three-pole, gang-operated, fixed-mounted, non-load-break isolating switch providing the following features:

- The isolating switch must isolate the power bus compartment from the power cell by means of a positively-driven shutter mechanism to prevent accidental contact with line terminals in the power bus compartment.
- The main power cell door must have a viewing window through which the operator can verify that the isolating switch is open.
- The isolating switch must only have the ability to interrupt the no-load (magnetizing) current of the control power transformers and/or potential transformers supplied inside the controller power cell.
- While in the off position, the isolating switch must provide a means of grounding appropriate medium voltage power cell components, discharging stored energy, thus providing safer operation and maintenance.
- Three rating sizes must be available: 400 A, 600 A, and 800 A.
- One or more normally open (N.O.) and normally closed (N.C.) auxiliary contacts must be arranged to open the secondary circuit of the control power transformer (CPT) and/or potential transformers (PT), to de-energize the control circuit. This is to ensure there is no load on the isolating switch when it is opened or closed. The contacts must also prevent backfeeding through the CPT and/or PT and isolate the power cell when the control circuit is in the test mode. It must only be possible to operate the test control circuit when the isolating switch is in the open position. The auxiliary contacts must have NEMA contact ratings of A600 (quantity two) and P600.
- The isolating switch must remain connected to the external operating handle at all times.
- The isolating switch must be mechanically and electrically interlocked with the main contactor.

- The external isolating switch operating handle must have provisions to be padlocked, with up to three padlocks in the open position and one padlock in the closed position. The closed position must be located and marked, but must be drilled out by the user to allow insertion of the padlock.
- The power cell door on each controller must be interlocked with the isolating switch such that the doors cannot be opened when the isolating switch is fully closed, and the isolating switch cannot be closed with the doors open without circumventing the interlock using a tool.

Interlocking

Mechanical interlocking, including cable interlocks, horizontal, and vertical ram interlocks, must be provided to prevent the opening of any power cell door or medium voltage compartment until the non-load-break isolating switch is fully in the open position and power is removed (the external operating handle must be in the off position).

Optional key interlocks configured to operate with the operating handle or power cell door must be available when interlocking is required with another specified device, for example, main breaker, load-break switch, and starter.

Power Fuses and Fuse Holders (Combination Controller Only)

R-rated current limiting power fuses must be provided. R-rated fuses must be used for the short circuit protection of medium voltage motors and motor controllers.

The medium voltage controller must have fixed power fuse holders that are separately mounted in the power cell, not on the contactor, and be located to allow easy inspection and replacement without any disassembly. The power fuses must have a spring-actuated blown fuse indicator. The power fuse size must be selected when motor data and the protective device characteristics are known.

Control Power Transformer (Combination Controller Only)

The control power must be 110/120V AC or 220/240V AC, and must be obtained from a control power transformer (CPT) located in each controller power cell, or from a separate control source. As standard, the dry-type CPT must be 500 VA in size with approximately 350 VA extra capacity for the customer's use when the standard control circuit is supplied. Appropriately sized primary and secondary fuses are supplied. Optional sizes of 1000 VA, 2000 VA, and 3000 VA CPTs must also be available.

The secondary circuit of the transformer must be disconnected from the control circuit by means of the isolating switch auxiliary contacts. This is to prevent backfeeding through the transformer and to isolate the power cell when the control circuit is in the test mode.

The standard CPTs used in the controller must be a compensated type with an output accuracy of approximately 4% over nominal at no load. They must be designed to maintain voltage at in-rushes of up to 600%, which results in a 2% overvoltage at full load.

Control Power Transformer Primary Fuses

The primary side of the CPTs and/or potential transformers must be protected by current limiting fuses sized according to requirements. The interrupting rating of the primary fuses must be 50 kA symmetrical.

Control Power Transformer Secondary Fuses

The secondary side of the CPT and/or potential transformers must be fused appropriately to protect the transformers from overloads. The standard control circuit must have one leg of the secondary grounded.

Primary Current Transformer

The medium voltage power cell must include three current transformers of sufficient VA capacity to meet the requirements of all the devices connected to them.

Each current transformer must have the primary rating sized appropriately in relation to the full load current rating of the motor or feeder. The secondary of the current transformers must have a 5 A output and an accuracy suitable for the type and quantity of protection or metering devices connected to it. All current transformer control wiring must be terminated on the current transformer with locking type, fork tongue lugs.

An appropriate load termination location must be provided to accommodate lugs with single or two-hole mounting, for connection of the load cables, when either bar or donut type current transformers are supplied.

The power cell must have provisions to locate a toroid (donut) style, ground-fault sensing current transformer, when the zero sequence ground fault protection feature is required (Combination Controller only). The secondary of the ground fault current transformers may have either a 5 Amp or 1 Amp output, depending on protection type and style.

Control Module - Logic Design Feature

Mechanical

The control module must be designed for mounting within the low voltage panel (for safety reasons) and must be compatible with the full range of current and voltage ratings.

The control module must consist of a power supply, logic control circuitry, silicon controlled rectifier (SCR) firing circuitry, I/O circuitry, a digital programming keypad, a backlit LCD display, and a serial communication port.

Programming and Display

Digital parameter adjustment must be provided through a standard built-in keypad. Analog potentiometer adjustments are not acceptable. A built-in backlit LCD display must be provided for controller set-up, diagnostics, status, and monitoring. The display must be three-line, 16-characters minimum.

The display must be capable of depicting alphanumeric characters in any of the following languages, by adjustment of a single parameter:

- English
- French
- Spanish
- German
- Portuguese
- Mandarin

Communications

A serial communications port drive programming interface (DPI) must be provided as standard. Optional communications protocol interface modules must be available for connection to Remote I/O, DeviceNet™, ControlNet™, Ethernet, RS-485, ModBus RTU and Profibus-DP.

Electrical

The control module must provide closed-loop digital microprocessor control and supervision of all controller operations, including silicon controlled rectifier (SCR) pulse firing control.

The control module must be the same as used for the SMC-Flex low voltage product family.

The control module must offer the following functions:

- Soft Start – with Selectable Kickstart
- Soft Stop
- Current Limit Start – with Selectable Kickstart
- Linear Speed Acceleration(1) – with Selectable Kickstart
- Linear Speed Deceleration(1)
- Dual Ramp – with Selectable Kickstart
- Full Voltage
- Preset Slow Speed
- Pump Control (Optional)

(1) Requires motor tachometer

The standard start ramp time must be programmable from 0...30 seconds.

The standard stop time must be programmable from 0...30 seconds. Extended start or stop times may be made available, upon consultation with qualified factory personnel.

Kick-start, selectable with soft start, current limit, and linear acceleration, must provide an adjustable time pulse of current prior to the normal start mode. The current must be controlled to provide 0...90% of locked rotor torque for a time between 0...2 seconds. This feature must be field selectable.

Silicon Controlled Rectifier (SCR) Pulse Firing Control

The silicon controlled rectifier (SCR) must be protected from voltage transients with an R-C snubber network to prevent false SCR firing.

The SCRs must be protected from overvoltage with voltage threshold gating circuitry.

The SCR firing circuitry must be fully isolated from the control circuits. Fiber optic cables must be used for isolation from the logic circuits. The circuits must be self-powered by deriving operational voltage from the snubber circuits.

Monitoring

The controller must provide the following monitoring functions indicated though the built-in LCD display; or remotely via the communication port:

- Phase-to-phase supply voltage
- Three-phase line current
- Three-phase power (MW, MWh, power factor)
- Elapsed time
- Motor thermal capacity usage
- Motor speed (with optional use of tachometer input)

Protection and Diagnostics

The following protection and diagnostics must be provided as standard with the controller:

- Power loss (with phase indication; pre-start)
- Line fault (with phase indication; pre-start) advising:
  - Shorted silicon controlled rectifier (SCR)
  - Missing load connection
- Line fault (running protection) advising:
  - Power loss
  - Shorted SCR
  - Missing load connection
- Voltage unbalance(1)
- Phase reversal(1)
- Undervoltage(1)
- Overvoltage(1)
- Stall(1)
- Jam(1)
- Overload(1)
- Underload(1)
- Excessive starts/hour(1)
- Open gate (with phase indication)
- Overtemperature (power stack, with phase indication)
- Communication loss
- Motor temperature (via PTC input)
- Ground fault (with GFCT option)

Overload Protection

- The control module must meet applicable standards as a motor overload protective device
- Three-phase current sensing must be utilized; the use of two current transformers must be unacceptable.
- Overload trip classes of 10, 15, 20, and 30 must be provided and user-programmable.
- Electronic thermal memory must be provided for enhanced motor protection
- Protection must be available through the controller while in bypass configuration
- Separate overload relay must be provided for emergency bypass operation

(1) These protective features must be defeatable.

Pump Control (Optional)

- The pump control option must be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This must aid in eliminating the phenomena commonly referred to as water hammer. Methods utilizing Soft Start with Soft Stop must not be acceptable.
- Closed loop control must be achieved without using external sensors or feedback devices.
- Pump Stop must be initiated by a dedicated Pump Stop input. A coast-to-rest stop must still be possible with a separate stop input.
- The Pump Stop time must be user adjustable from 0...30 seconds.

Tachometer Signal Conditioner (Optional)

- A panel-mounted tachometer signal conditioner (TSC) must be made available for use with acceleration/deceleration applications.
- A suitable power supply must be provided with the TSC.
- The TSC must be used to convert the motor speed feedback signal (in pulse format) to a 0...4.5V DC level.

Ethernet/IP, DeviceNet, and IntelliCENTER Options

General

The medium voltage motor controller (MV MCC) must have Ethernet/IP or DeviceNet cabling integrated throughout the sections.

Each motor starter and soft starter in the MV MCC line-up must be supplied with a means to communicate via Ethernet/IP or DeviceNet, and have the capability of monitoring at least two devices in each starter.

Cable

Ethernet/IP

The Ethernet/IP cable used must be 600V shielded UL listed Ethernet cable.

The addition or removal of a unit from the Ethernet/IP network must not interrupt the operation of other units in the network.

DeviceNet

The DeviceNet cable used for the trunk line and drop lines must be a flat cable rated 8 A, 600V, Class 1.

The DeviceNet cable used to connect a DeviceNet unit to a DeviceNet port must be a round cable rated 8 A, 600V, Class 1.

The addition or removal of a unit from the DeviceNet system must not interrupt the operation of other units within the system.

Cable Layout

Ethernet/IP

A Etherent/IP cable must be routed through the low voltage wireway, located on the top of each MV MCC section to prevent accidental mechanical damage during MV MCC installation.

A Ethernet/IP cable must be routed into the low voltage control panel of each MV MCC unit. The EtherNet/IP device within each plug-in unit shall be factory connected to one of the EtherNet/IP ports in the LV compartment with the 600V UL PLTC rated cable outlined above in the EtherNet/IP Cable section.

DeviceNet

A DeviceNet trunkline must be routed through the low voltage wireway, located on the top of each MV MCC section to prevent accidental mechanical damage during MV MCC installation.

A DeviceNet dropline must be routed into the low voltage control panel of each MV MCC unit.

Two DeviceNet ports must be provided in the low voltage control panel of each unit to simplify installation of DeviceNet products.

Power Supplies

EtherNet/IP

The EtherNet/IP system in the MCC shall provide a built-in 24V power supply and power distribution network. All the EtherNet/IP switches, as well as some of the components in various units, are powered from this 24V DC supply. There are several configuration options for this power supply including the following:

- User-supplied 115V source
- Power supply output shall be rated 8 A, 24V DC

DeviceNet

The MV MCC manufacturer must check the user's design to ensure adequate power supplies have been specified to conform to DeviceNet requirements. The power supply must provide 24V DC for the DeviceNet system and be rated no less than 8 A.

Programming and Testing

EtherNet/IP

- The MCC manufacturer shall load the IP Address into each unit.
- The IP Address shall be as indicated on the contract drawings or as provided by the contractor.
- The MCC manufacturer shall test the MCC to ensure that each unit communicates properly prior to shipment.
- Each unit shall have a label showing the IP Address for the devices within it.
- The MCC manufacturer shall provide a disk containing applicable electronic data sheet (EDS) files for the EtherNet/IP devices.

DeviceNet

- The MCC manufacturer shall load the DeviceNet MAC ID number (node address) into each unit.
- The DeviceNet MAC ID number shall be as indicated on the contract drawings or as provided by the contractor.
- The DeviceNet network shall be designed and programmed for use at 250 kB or 500 kB.
- The MCC manufacturer shall test the MCC to ensure that each unit communicates properly prior to shipment.
- Each DeviceNet device shall have a label showing the unit location, node address, and communication rate.
- The MCC manufacturer shall provide a disk containing applicable electronic data sheet (EDS) files for the DeviceNet devices.

Unit Monitoring

EtherNet/IP

Each unit shall be supplied with the IntelliVAC for vacuum contactor control. The IntellVAC shall also come with the 1734-AENT Point I/O Ethernet/IP Adapter.

DeviceNet

Each unit must be supplied with IntelliVAC Plus for vacuum contactor control and unit monitoring. The eight digital inputs must be used to monitor the status of the isolation switch as well as other non-intelligent devices. The two digital outputs are available for use in the control system (customer to program and additional control hardware).

DeviceNet System Performance

The DeviceNet system must be designed to operate at 500 kBaud to maximize the system performance, unless precluded by the cumulative length of the trunk and drop lines.

The DeviceNet system is to be qualified to communicate and perform under normal and adverse MVMC electrical environments, for example, vacuum contactor electrical operation and unit short circuit fault.

Solid-State Controllers

Each solid-state controller (SMC Flex) unit must have an EtherNet/IP/DeviceNet communication module to communicate the status over EtherNet/IP/DeviceNet. The DeviceNet communication module must have four input points.

Unit Protection

EtherNet/IP

Available options for protection include:

- Bulletin 857 Motor/Feeder protection relay
- E3 Plus
- E1 (equiped with Ethernet/IP module)

DeviceNet

Available options for protection include:

- 857 Motor/Feeder Protection System
- 825P modular
- E3 Plus
- E1 (equipped with optional DeviceNet module)

Programming of Parameters

EtherNet/IP

The MCC manufacturer shall load the IP address into each unit. The IP address shall be as indicated on the contract drawings or as provided by the contractor.

The MCC manufacturer shall test the MCC to ensure that each unit communicates properly prior to shipment. Each unit shall have a label showing the IP address for the devices within it. The MCC manufacturer shall provide a disk containing applicable electronic data sheet (EDS) files for the EtherNet/IP devices.

DeviceNet

The DeviceNet MAC ID number (node address) must be loaded into each unit per the drawings. All other parameters must be left at the factory default setting.

The DeviceNet System components must be preconfigured to operate at the appropriate baud rate.

Software

The DeviceNet MVMC must be provided with pre-configured software. The software must be capable of viewing multiple MVMC line-ups. The software communication driver must allow the software to be installed and located on Ethernet, ControlNet, or DeviceNet. The software must be capable of displaying the following:

System View

- Dynamically configured based on reading data from devices in MVMC line-up
- Sizeable view to allow ease of viewing multiple MVMC line-ups
- Unit nameplate information
- Unit status indicators (ready, running, warning, fault, no communication)

Unit Monitor View

- Pre-configured for specific unit
- Real time monitoring via analog dials and trending
- Data configurable for customized monitoring
- Modifying device parameters

Spreadsheet View

- User configurable for customized monitoring
- Sorting and cascading functions
- Custom user fields

Event Log

- Track history of MVMC unit
- Automatic logging of trips, alarms, and changes
- Manual entry of events

Documentation

- Front elevation drawings
- One-line drawings
- Unit wiring diagrams
- User manuals
- Spare parts lists

Testing

The interwired EtherNet/IP/DeviceNet MV MCC must be powered up, configured, and tested in an ISO 9001 facility to ensure each unit communicates properly prior to shipment.

Transportation and Equipment

Delivery Times

Estimated drawing and shipment delivery times are based on receipt of all information at time of order.

The shipment of equipment commences approximately _____ weeks after the seller receives a written purchase order. The actual on-site delivery depends on the site location.

Unless specified, transportation is determined by the seller based on shipment by the lowest cost carrier, and charged to buyer.

Loading Equipment

As standard, the seller must utilize tractors and trailers equipped with air-ride features, reducing the chance of damage and the need for extra packaging. All trailers must have logistic posts allowing the most secure loading.

Special Packaging Requirements (Optional)

The seller must use custom-designed crates to reduce the possibility of air or sea transit damage, and offer vacuum shrink-wrap to eliminate moisture or humidity damages.

Notes:

Commissioning

Start-Up Commissioning Services (Optional)

Start-up is performed at the user's site.

The seller provides the following:

- A pre-installation meeting with the user to review:
  - The start-up plan
  - The start-up schedule
  - The controller's installation requirements
- Inspect the starter's mechanical and electrical devices enclosed.
- Perform a tug test on all internal connections within the controller and verify wiring.
- Verify critical mechanical connections for proper torque requirements.
- Verify and adjust mechanical interlocks for permanent location.
- Confirm all sectional wiring is connected properly.
- Re-verify control wiring from any external control devices.
- Set up auxiliary equipment with customer supplied parameters.
- Exercise the controller in test mode (combination controllers).
- Confirm cabling of controller to motor and line feed.
- Apply medium voltage to the controller and perform operational checks.
- Run the controller motor system throughout the operational range to verify proper performance.
- User's personnel must be required on-site to participate in the start-up of the system.

Start-up service is to be quoted at a per diem rate with an estimate of time required for commissioning.

On-Site Training (Optional)

The seller must provide a qualified instructor to provide the user's personnel with training that is specific to the medium voltage (MV) controller system installed at the user's facility. The training session is one day in duration and is customized for the user's needs. Manuals and documentation are provided for each participant, to a maximum of eight participants per class.

The training covers the following topics:

- Basic motor theory
- Starter hardware
- Contactor hardware

- Hardware replacement procedures
- Power device replacement procedures
- Fault analysis and troubleshooting
- Preventative maintenance procedures

Time is spent on lecture and hands-on training if user's equipment is available. Demos are not provided.

Basic Data Sheets

Basic Data Sheets

Table 1 - Electrical Ratings

Electrical Ratings	UL/CSA/NEMA	IEC
Power Circuit		
Method of Connection	Motor in delta or star; SCRs between windings and supply	
Number of Poles	Equipment designed for three phase loads only	
Rated Voltage (Ur)	2400V AC (-15%, +10%) 3300V AC (-15%, +10%) 4200V AC (-15%, +10%) 6900V AC (-15%, +5%)	3.6 kV 7.2 kV
Rated Insulation Voltage (Ui)	2500V 5000V 7200V	3.6 kV 7.2 kV
Rated Impulse Voltage (Uimp)	60 kV	(3.6 kV) 40 kV (7.2 kV) 60 kV
Dielectric Withstand	(2500V) 7625V AC (5000V) 13,250V AC (7200V) 18,200V AC	(3.6 kV) 10 kV (7.2 kV) 20 kV
Repetitive Peak Inverse Voltage Rating	2500V max 6500 V (2 SCRs per phase) 5000V max 13,000 V (4 SCRs per phase) 7200V max 19,500 V (6 SCRs per phase)	
Output Rating	100…7500 hp	75…5600 kW
Semi-Conductor Isolation	Fiber optic	
Operating Frequency	50/60 Hz	50/60 Hz
dv/dt Protection	RC Snubber Network	
Transient Protection	Integrated overvoltage trigger circuit	
Rated Current	180 A 360 A 600 A	
dv/dt	180 A 1000V/µs 360/600 A 2000V/µs	
di/dt	180/360/600 A 200 A/µs	
Voltage Drop (Line to Output Terminals)	2.5V per SCR without bypass; Less than 1.0 V with bypass, total	
Overall Efficiency	99.95% with bypass	
Initial Torque	0…90% of motor locked rotor torque	
Thermal Capacity	600%, 10 s 450%, 30 s	
Ramp Time	0…30 s (consult factory for longer time)	
Kickstart	0…90% of motor locked rotor torque for 0…2 s	
Approvals	UL E102991 CSA LR12235	Safety: 92/59/EEC (Directive) Ref: BSEN 61010-1: 1993 BSEN 60204-1: 1997 EMC: 89/336/EEC, 92/31/EEC, 93/68/EEC (Directives) Ref: EN 61000-6.4:2001 EN 61000-6.2:2001

Table 1 - Electrical Ratings (continued)

Electrical Ratings	UL/CSA/NEMA	IEC
Short Circuit Protection		
The power electronics unit must be protected by current-limiting fuses (to be included by customer in existing starter with 1560E). The combination controller includes appropriate fusing (coordinated with motor).		
Fault Level Withstand as a Fused (E2) Controller according to NEMA at 50 kA	5000V 430 MVA Sym 7200V 620 MVA Sym	
Control Circuit		
Rated Operation Voltage	120/240V AC (10…-15%)	110/230V ~ (10…-15%)
Dielectric Withstand	1600V AC	2000V ~
Operating Frequency	50/60 Hz	50/60 Hz
Enclosure		
Enclosure Type	NEMA Type 1, 1G, 12, 3R, and arc resistant accessibility 2B (IEEE C37.20.7)	IP 10, 21, 52 and 34
Overload Characteristics (Control Module)		
Type	Solid-state thermal overload with phase loss	
Current Range	1…1000 A	
Trip Classes	10, 15, 20, and 30	
Trip Current Rating	120% of Motor FLC	
Number of Poles	3	
Power Requirements		
Control Module	75 VA	
Gate Driver Boards(1)	30 VA (total)	
Contactor	See Contactor Specifications (page 47)	
Auxiliary Contacts (Control Module)		
Rated Operation Voltage (Max.)	20…265V AC 5…30V DC (resistive)	20…265V ~ 5…30V DC (resistive)
Rated Insulation Voltage	N/A	277V ~
Operating Frequency	50/60 Hz, DC	
Utilization Category	AC-15/DC-12	
Mechanical Ratings (Control Module)		
Terminals	Control Terminals: M 3.5 x 0.6 Pozidriv screw with self-lifting clamp plate	
SCPD Performance	Type 2	
SCPD List	Class CC 8 A @ 1000 A Available Fault Current	
DPI Communication (Control Module)		
Maximum Output Current	280 mA	
Metering Functionality (Control Module)		
Voltage, Current, MW, MWh, Displacement Power Factor	Yes	
Tachometer Input (Control Module)		
Voltage	0…4.5V DC	
Current	1.0 mA	

(1) Power requirements for the gate driver boards are the same for all voltages.

Table 2 - Environmental Ratings

Environmental Ratings	UL/CSA/NEMA	IEC
Operating Temperature Range	0…40 °C (32…104 °F)	
Storage and Transportation Temperature Range	-30…65 °C (-22…149 °F)	
Altitude	0…1000 m (0…3300 ft) without derating	
Humidity	5…95% (non condensing)	
Pollution Degree	2	
Seismic (UBC Rating) (1)	1, 2, 3, 4	

(1) Some units may require special bracing. Contact factory for more information.

Table 3 - Controller Deratings

Altitude Range	Power Cell Rating			Reduce BIL Withstand Rating By:
	180 A	360 A	600 A	
1000 …2000 m (3300…6600 ft)	Reduce Max. Continuous Current Rating By:(1)			6.0 kV
	5 A	10 A	15 A	
2001…3000 m (6601…9900 ft)	10 A	20 A	30 A	12.0 kV
3001…4000 m (9901…13,200 ft)	15 A	30 A	45 A	18.0 kV
4001…5000 m (13,201…16,500 ft)	20 A	40 A	60 A	24.0 kV

(1) Current deratings shown are the minimum levels. Additional derating may be required due to power fuse limitations. Please consult factory for additional details.

Table 4 - Area Available for Cable Entry/Exit(1)

Structure Code	Voltage	Top		Bottom	
		Line	Load	Line	Load
14.60	2300…4160V	5.68 x 9.00 (144 x 229)	Combined with line	5.68 x 9.00 (144 x 229)	Combined with line
14.62	6900V	5.68 x 12.55 (144 x 319)	Combined with line	5.68 x 12.55 (144 x 319)	5.68 x 12.55 (144 x 319)
14.64	All	5.68 x 12.55 (144 x 319)	Combined with line	NA	NA
14.66	All	5.68 x 12.55 (144 x 319)	Combined with line	15.00 x 15.00 (381 x 381)	Combined with line
14.70	2300…4160V	5.68 x 5.68 (144 x 144)	5.68 X 9.00 (144 X 229)	5.68 x 9.00 (144 x 229)	5.68 x 9.00 (144 x 229)
14.70XP	2300…4160V	5.68 x 5.68 (144 x 144)	5.00 x 9.00 (144 x 229)	5.68 x 9.00 (144 x 229)	5.68 x 9.00 (144 x 229)
14.72	6900 V	5.68 x 9.00 (144 x 229)	5.68 X 9.00 (144 X 229)	5.68 x 5.68 (144 x 144)	5.68 x 9.00 (144 x 229)
14.74	2300…4160V	5.68 x 9.00 (144 x 229)	5.68 X 9.00 (144 X 229)	5.68 x 9.00 (144 x 229)	5.68 x 9.00 (144 x 229)
14.76	All	5.68 x 9.00 (144 x 229)	7.25 X 15.88 (184 X 403)	5.68 x 9.00 (144 x 229)	7.25 x 15.88 (184 x 403)

(1) Dimensions are in inches (mm).

Table 5 - Shipping Weights and Dimensions(1)

Current Rating	Horsepower (kW)					Dimensions			Shipping Weight	
	2400V	3300V	4200V	6600V	6900V	Width	Depth	Height	lb	kg
Bulletin 1560E										
200 A	800 (600)	1000 (746)	1250 (933)	–	–	26 (660)	36 (915)	91 (2315)	800	363
400 A	1500 (1119)	2250 (1679)	2750 (2051)	–	–					
Bulletin 1560E										
200 A	–	–	–	2250 (1678)	2500 (1865)	36 (915)	36 (915)	91 (2315)	1220	554
400 A	–	–	–	4500 (3357)	5000 (3730)					
600 A (top exit)	2750 (2051)	4000 (2984)	4500 (3357)	7500 (5595)	7500 (5595)	44 (1117)	36 (915)	36 (915)	1330	590
600 A (bottom exit)	2750 (2051)	4000 (2984)	4500 (3357)	7500 (5595)	7500 (5595)	70 (1778)	36 (915)	91 (2315)	2100	951
Bulletin 1562E										
200 A	800 (600)	1000 (746)	1250 (932)	–	–	36 (915)	36 (915) or 462 (1168)	91 (2315) or 128.52 (3264)	1400 or 1950 (2)	636 or 886(2)
400 A	1500 (1119)	2250 (1679)	2750 (2051)	–	–					
Bulletin 1562E										
200 A	–	–	–	2250 (1676)	2500 (1865)	62 (1575)	36 (915)	91 (2315)	2325	1056
400 A	–	–	–	4500 (3357)	5000 (3730)					
Bulletin 1562E										
600 A	2750 (2051)	4000 (2984)	4500 (3357)	7500 (5600)	7500 (5600)	80 (2032)	36 (915)	91 (2315)	2700	1227
	>2750 (2051)	>4000 (2984)	>4500 (3357)	>7500 (5600)	>7500 (5600)	100 (2540)	36 (915)	91 (2315)	4000	1816

(1) Weights and dimensions are approximate. Certain options (such as PFCC) changes weight and dimensions. Contact factory for certified dimensions and weights.

(2) Additional dimensions/weights shown are for arc resistant version.

Table 6 - Power Bus Specifications

Description	Specifications	
Main Horizontal Power Bus		
Bus Bar Material	Tin-plated copper	
Optional Bus Bar Material	Silver-plated copper	
Continuous Current Rating at 40 °C (104 °F)	1200, 2000, and 3000 A	
Maximum Full Load Temperature Rise	65 °C (149 °F)	
Maximum Full Load Temperature	105 °C (221 °F)	
Fault Withstand Current Rating (10 cycles)(0.5 s)	50 kA RMS SYM (80 kA ASYM)	
Type of Bus Bracing	Molded glass polyester Anti-hygroscopic	
Dimensions per Phase	1200 A 2000 A 3000 A	Qty 1 – 6 x 100 mm (1/4 x 4 in.) Qty 2 – 6 x 100 mm (1/4 x 4 in.) Qty 2 – 9.5 x 127 mm (3/8 x 5 in.)
Cross Sectional Area per Phase	1200 A 2000 A 3000 A	65 mm^2 (1.0 in^2) total 129 mm^2 (2.0 in^2) total 242 mm^2 (3.75 in^2) total
Insulating Material Between Phases and Ground	Air (Standard)	
Optional Insulation Material for Main Horizontal Bus	Type:	Sleeve, heat shrink
	Material:	Polyolefin
	Thickness:	1.4 mm (0.055 in./55 mils)
	Anti-hygroscopic:	0.5…1%
	Electrical Strength:	900 V/mil (49.5 kV total)
Vertical Power Bus		
Bus Bar Material	Tin-plated copper	
Continuous Current Rating at 40 °C (104 °F)	400, 600 and 800 A	
Fault Withstand Current Rating (½ cycle)	50 kA RMS SYM (80 kA ASYM)	
Insulation Material for Vertical Bus	Type:	Sleeve, heat shrink
	Material:	Polyolefin
	Thickness:	1.14 mm (0.045 in./45 mils)
	Anti-hygroscopic:	0.5…1%
	Electrical Strength:	900 V/mil (40.5 kV total)
Ground Bus		
Ground Bus Material	Bare copper	
Optional Ground Bus Material	Tin-plated copper	
Continuous Current Rating at 40°C (104°F)	600 A	
Dimensions per Phase	600 A	9.5 x 51 mm (3/8 x 2 in.)
Cross Sectional Area	600 A	485 mm^2 (0.75 $in.^2$) total

Table 7 - Power Fuse Specifications

Description	Specifications				
Power Fuses and Fuse Holders					
This section details the power fuse and fuse holder technical information that each medium voltage product conforms to. It includes information on R-rated fuses, as well as mounting dimensions.					
Fuse Types					
R Rated : 2…12R 19…38R, 48X, 57X 2…38R, 48X, 57X	Mersen A480R – 5.0 kV Mersen A051B – 5.0 kV Mersen A072 – 7.2 kV				
Mounting (Center) Dimensions					
Clip-On	304.8 mm (2.0 in.)				
Bolt-On	454.2 mm (7.88 in) *or* 511.6 mm (20.14 in.)				
Maximum Heat Dissipation (kW) (Convection)					
Controller Rating	**Start or Stop Cycle (@ 450% Starting Duty)**				**Continuous**
		180 A	360 A	600 A	
	2500V	13.5	19.2	45.3	0.250
	5000V	27.0	38.5	90.5	0.250
	7200V	40.5	57.7	136.0	0.250
Power Losses					
Power Cell Losses	**Current (A)**		**Fuse Size**		**Losses (kW) ± 10%**
	90		6R		0.125
	180		12R		0.350
	240		18R		0.510
	360		24R		1.000
	600		48X		1.500
Power Bus Losses	**Bus Rating (A)**			**Fully Loaded Bus Losses per 915 mm (36 in.) Section (Watts) ±%**	
	1200			150	
	2000			200	
	3000			200	
Control Power Transformer Losses	The losses from a 500 VA control power transformer fully loaded is approximately 50 W per controller.				
Low Voltage Panel Losses	The losses from the standard control circuit is approximately 25 W per controller.				

Table 8 - Bulletin 1502 Medium Voltage 400 Amp Contactor Ratings

Description			Specification
Voltage Ratings[1]			
Maximum Rated Voltage			7200
System Voltages			2400 3300 4160 4800 6600 6900
Dielectric Voltage Withstand Rating		For 60 s (kV)	18.2 / 20 (IEC)
Basic Impulse Level (BIL) Withstand		Phase-to-Ground, Phase-to-Phase (kV)	60
Frequency Ratings		Hz	50/60
Current Ratings[1]			
Rated Continuous Current (Amps)			400
Maximum Interrupting Current Rating		2400V (RMS Sym Amps)	6300
		5000V (RMS Sym Amps)	6300
		7200V (RMS Sym Amps)[2]	6000
Maximum Interrupting MVA Rating		2400V (Sym MVA)	25
		5000V (Sym MVA)	50
		7200V (Sym MVA)[2]	75
Short-Circuit Withstand at Rated Voltage		Current Peak ½ cycle (kA)	60
Short Time Current Rating Capability		For 1 second (kA)	6.0
		For 30 seconds (kA)	2.4
Chop Current (Average RMS Amps)			0.5
Make and Break Capability at Rated Voltage (kA)			4.0
Ambient Temperature		°C	40
Contactor Coil Data (Series E)			
Control Voltage (V_{CTL})	Coil Voltage (V_{CL})		
Electro-Mechanical (Relay) Control (Mechanical Latch Only)			
120V AC	110V DC	Close Current (A_{DC})	5.6
		Trip Current (A_{DC})	6.0
		Pick-up Voltage	102
		Trip Voltage	84
IntelliVAC Control (Electrically Held & Mechanical Latch)			
110…240V AC or 110…250V DC[3]	V AC: $V_{CL} = \sqrt{2} \times V_{CTL}$ (Max.) V DC: $V_{CL} = V_{CTL}$	Close Current (A_{DC}, 200 ms)	4.3
		Hold Current (A_{DC})	0.48
		Pick-up Voltage[3]	95
		Drop-out Voltage[3]	75
		Trip Current (A_{DC}, 200 ms)	5.5
		Trip Voltage[3]	70

(1) The voltage and current ratings listed are valid up to 1000 m (3300 ft). Please refer to Table 2 - Environmental Ratings for ratings above this altitude.

(2) The IEC rating at 7200V (RMS Sym.) is 5300 A / 66 MVA.

(3) Control voltage, as measured at the input of the IntelliVAC control module.

Table 8 - Bulletin 1502 Medium Voltage 400 Amp Contactor Ratings (continued)

Description			Specifications
Contactor Coil Data (Series D)			
Control and Coil Voltage	120V AC / 110V DC	Coil Inrush Current (A) – Electrically Held	7.3
		Coil Inrush Current (A) – Mechanical Latch	11.5
		Coil Inrush Current (A) – Mechanical Latch Trip	5.1
		Coil Continuous Current (A)	0.13
		Coil Pick-up Voltage (V AC)	102
		Coil Drop-out Voltage (V AC)	75
	230V AC / 210V DC	Coil Inrush Current (A) – Electrically Held	8.3
		Coil Inrush Current (A) – Mechanical Latch	NA
		Coil Inrush Current (A) – Mechanical Latch Trip	NA
		Coil Continuous Current (A)	0.11
		Coil Pick-up Voltage (V AC)	190
		Coil Drop-out Voltage (V AC)	140
Operational Characteristics			
Mechanical Life (Operations) x 1000[1]		Electrically Held	2500
		Mechanical Latch	100
Electrical Life (Operations) x 1000[1]			1000
Switching Frequency (Operations per hour)		Electrically Held	600
		Mechanical Latch	150
Opening and Closing Times (Series E)			
Electro-Mechanical (Relay) Control (Mechanical Latch Only)			
Maximum Closing Time (120V AC)		50 or 60 Hz (ms)	160
Maximum Opening Time (120V AC)		50 or 60 Hz (ms)	50
IntelliVAC Control (Electrically Held & Mechanical Latch)			
Maximum Closing Time		50/60 Hz or DC (ms)	100 / 70
Maximum Opening Time (without delay)[2]		50/60 Hz or DC (ms)	60
Opening and Closing Times (Series D)			
Maximum Closing Time		50 or 60 Hz (ms)	160
Maximum Opening Time (Normal Drop Out)		50 or 60 Hz (ms)	130
Maximum Opening Time (Fast Drop Out and Mechanical Latch)		50 or 60 Hz (ms)	50
Capacitor Switching (max. KVAR)			
System Voltage		2400V	800
		4160V	1400
		6900V	2000
General			
Standard Altitude Capability (m/ft)[3] [4]			-1000…5000 -3300…16,500
Contactor Weight (kg/lb)			21.8 / 48
Auxiliary Contact Rating			A600
Auxiliary Contacts on the Vacuum Contactor (Max.)[5]			3 N.O. / 3 N.C.

(1) Provided that regular maintenance is performed.

(2) A contactor drop-out delay may be configured with the IntelliVAC control module (refer to publication 1503-UM051 -EN-P).

(3) The voltage and current ratings listed are valid up to 1000 m (3300 ft). See Table 3 for ratings above this altitude.

(4) The full Altitude range is available with the IntelliVAC control module only, and the IntelliVAC is to be configured accordingly (refer to publication 1503-UM051 -EN-P). The standard mechanical latch contactors, if used with electro-mechanical control, are designed for -1000 …1000 meters (-3300…3300 ft). Higher altitudes are possible by changing the contactor return springs.

(5) The number of contactor auxiliary contacts depends on the contactor type. Some of the contacts are used in the typical control schemes used.

Table 9 - Bulletin 1502 Medium Voltage 800 Amp Contactor Ratings

Description		Specification
Voltage Ratings(1)		
Maximum Rated Voltage		7200
System Voltages		2400 3300 4160 4800 6600 6900
Dielectric Voltage Withstand Rating	For 60 s (kV)	18.2/20 (IEC)
Basic Impulse Level (BIL) Withstand	Phase-to-Ground, Phase-to-Phase (kV)	60
Frequency Ratings	Hertz	50/60
Current Ratings(1)		
Rated Continuous Current (A)		800
Maximum Interrupting Current Rating	2400V (RMS Sym Amps)	12,500
	5000V (RMS Sym Amps)	12,500
	7200V (RMS Sym Amps)	12,500
Maximum Interrupting MVA Rating	2400V (Sym MVA)	50
	5000V (Sym MVA)	100
	7200V (Sym MVA)	150
Short-Circuit Withstand at Rated Voltage	Current Peak ½ cycle (kA)	85
Short Time Current Rating Capability	For 1 s (kA)	12.0
	For 30 s (kA)	4.8
Chop Current (Average RMS A)		0.5
Make and Break Capability at Rated Voltage (kA)		8.0
Ambient Temperature	°C	40
Contactor Coil Data (Series E)		
Control Voltage (V_{CTL})	Coil Voltage (V_{CL})	
110…240V AC or 110…250 V DC(2)	V AC: $V_{CL} = \sqrt{2} \times V_{CTL}$ (Max.) V DC: $V_{CL} = V_{CTL}$	Close Current (A DC, 200 ms) 12
		Hold Current (A DC) 0.7
		Pick-up Voltage(2) 95
		Drop-out Voltage(2) 75
		Trip Current (A DC, 200 ms) 5.2
		Trip Voltage(2) 70
Contactor Coil Data (Series D)		
Control Voltage (V_{CTL})	Coil Voltage (V_{CL})	
120V AC	110V DC	Coil Inrush Current (A) – Electrically Held 13.1
		Coil Inrush Current (A) – Mechanical Latch 13.1
		Coil Inrush Current (A) – Mechanical Latch Trip 5.6
		Coil Continuous Current (A) 0.24
		Coil Pick-up Voltage (VAC) 102
		Coil Drop-out Voltage (VAC) 75

(1) The voltage and current ratings listed are valid up to 1000 m (3300 feet). Please refer to Table 2 - Environmental Ratings for ratings above this altitude.

(2) Control voltage, as measured at the input of the IntelliVAC control module.

Table 9 - Bulletin 1502 Medium Voltage 800 Amp Contactor Ratings (continued)

Description		Specifications
Operational Characteristics		
Mechanical Life (Operations) x 1000(1)	Electrically Held	250
	Mechanical Latch	100
Electrical Life (Operations) x 1000(1)		250
Switching Frequency (Operations per hour)	Electrically Held	600
	Mechanical Latch	150
Opening and Closing Times (Series E)		
Maximum Closing Time	50/60 Hz or DC (ms)	150
Maximum Opening Time (without delay)(2)	50/60 Hz or DC (ms)	60
Opening and Closing Times (Series D)		
Maximum Closing Time	50 or 60 Hz (ms)	200
Maximum Opening Time (Normal Drop Out)	50 or 60 Hz (ms)	240
Maximum Opening Time (Fast Drop Out and Mechanical Latch)	50 or 60 Hz (ms)	60
Capacitor Switching (max. KVAR)		
System Voltage	2400V	2000
	4160V	3000
	6900V	4000
General		
Standard Altitude Capability (m/ft)(3)		0…1000 / 0…3300
Contactor Weight (kg / lb)		45/100
Auxiliary Contact Rating		A600
Auxiliary Contacts on the Vacuum Contactor (Max.)(4)		3 N.O. / 3 N.C.

(1) Provided that regular maintenance is performed.

(2) A contactor drop-out delay may be configured with the IntelliVAC control module (refer to publication 1503-UM051).

(3) The voltage and current ratings listed are valid up to 1000 m (3300 ft). Please refer to Table 2 - Environmental Ratings for ratings above this altitude.

(4) The number of contactor auxiliary contacts depends on the contactor type. Some of the contacts are used in the typical control schemes used.

Table 10 - Control and Power Wire Specifications

Description	Specifications
Control Wire	
All Medium Voltage structures must be equipped with control wire which meets the following specifications:	
Type	TEW, Stranded Copper Wire (Tinned)
AWG Size (Control Circuit)	14 AWG – 1.5 mm^2
AWG Size (Current Transformer Circuit)	12 AWG – 2.5 mm^2
Number of Strands	19
Maximum Voltage Rating	600V
Maximum Rated Temperature	105 °C (221 °F)
Power Wire	
Power wire used to feed the primary of the control power transformer or potential transformers is as follows:	
AWG Size	PT – 8 AWG / CPT – 12 AWG
Type	Belden EPDM 37508
Insulation Rating	8.0 kV
Maximum Temperature Rating	150 °C (302 °F)

The controller must be wired with the following non-shielded, stranded wire type, based on the current ratings:

Controller Rating (Amps)	AWG Size	Type	Insulation Rating	Maximum Temperature Rating
200	2	EP-CSPE MV90	8.0 kV	90 °C (194 °F)
400	4/0	EP-CSPE MV90	8.0 kV	90 °C (194 °F)
600	(2) x 4/0	EP-CSPE MV90	8.0 kV	90 °C (194 °F)
800	(2) x 350 MCM	EP-CSPE MV90	8.0 kV	90 °C (194 °F)

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