Cutler-Hammer

Motor Starter (Ampgard) — Medium Voltage

Technical Data

New Information

General Description

Application

The Cutler-Hammer® Ampgard® medium voltage metal-enclosed control family from Eaton's Electrical business provides control and protection of medium voltage motors and equipment rated 2300 to 6600 volts nominal/7200 volts maximum.

Ampgard control has a complete metal-enclosed offering:

- Full and reduced voltage starting of medium voltage motors up to 8000 hp.
- Main breaker metal-enclosed switchgear, a smaller footprint, single integrated assembly direct coupled to the Ampgard control.
- LBS load break switch direct coupled main or feeder disconnect.

Features

Personnel safety: Positive mechanical isolating switch with visible disconnect completely grounds and isolates the starter from the line connectors with a mechanically driven isolating shutter, leaving no exposed high voltage. Medium voltage door is mechanically locked closed with the disconnect; low voltage section has separate door and is segregated from the medium voltage section.

Ease of installation: Current limiting fuses, contactor assembly and isolating switch assembly are easily removed from the enclosure; line and load terminals are completely accessible from the front.

Ease of maintenance: All components are front accessible, facilitating routine inspection and/or parts replacement.

Simplicity of design: Component-to-component design eliminates half of the electrical connections.

Two vacuum contactor ratings are utilized, 400 ampere and 800 ampere. The 400 ampere is available as rollout, slide-out or narrow design. The 800 ampere is available as rollout only.

Ampgard Motor Control Assembly

Starter catalog types are available for the following applications:

- Squirrel cage, full voltage.
- Narrow design, full voltage.
- Squirrel cage, primary reactor.
- Squirrel cage, autotransformer.
- Reduced voltage solid-state (consult factory).
- Synchronous full voltage.
- Synchronous primary reactor.
- Synchronous autotransformer (reversing and non-reversing).

Personnel Safety Features

One of the most important considerations in designing the Cutler-Hammer Ampgard Starter was personnel safety. The result is an extensive system of interlocks and other safety features.

Interlocks

Interlocking on Ampgard Starters includes:

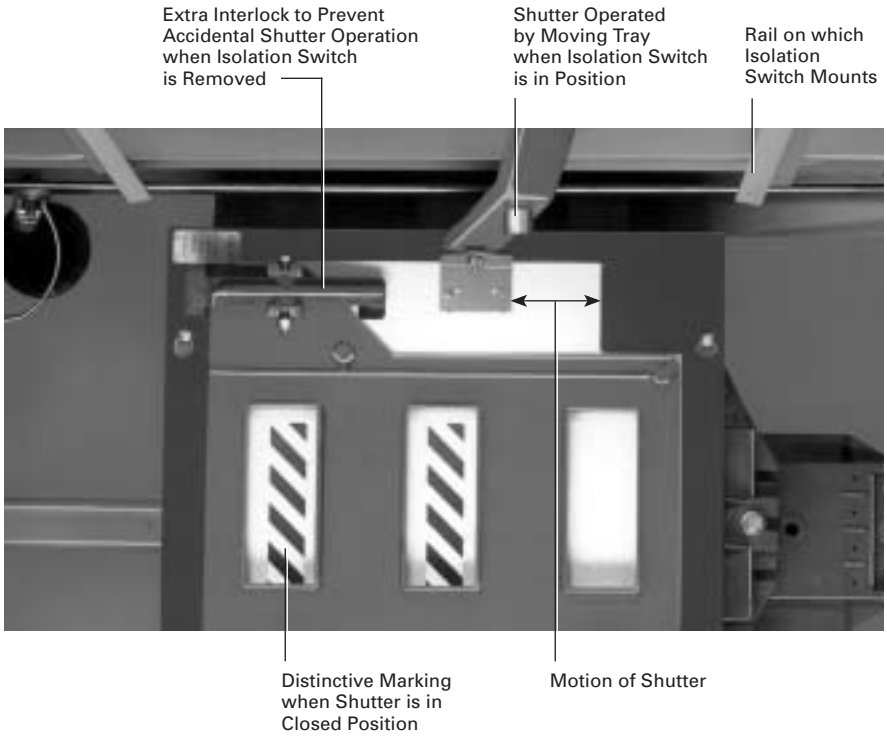
- Isolating switch handle housing extends over medium voltage door when handle is in ON or OFF position, preventing door from being opened.
- Provision for optional key interlocks.
- When door is open, detent prevents operating handle from being moved inadvertently to OFF or ON position.
- When contactor is energized, isolating switch cannot be opened or closed.

Other Safety Features

Ampgard Starters include many additional features designed to protect operating personnel. These features include:

- Provision for three padlocks on isolating switch handle in OFF position.
- Operating handle must be rotated 90° to the horizontal service position in order to open main door, ensuring complete isolation from the main power source.
- Shutter barrier between line terminals and fuse stabs are mechanically driven in both directions (see photo).
- Distinctive marking on back of switch assembly appears when shutter barrier is in position and starter is completely isolated from the line.
- Visible grounding clips provide a positive grounding of the starter and main fuses to a grounding bus when the isolating switch is opened.
- High and low voltage circuits are compartmentalized and isolated from each other.
- Illustrated selected safety features, operating instructions and renewal parts information are permanently mounted inside main enclosure door.
- The drawout isolation switch is easily removed by loosening two bolts in the front casting. The shutter is mechanically interlocked when the switch is withdrawn (400 amperes only).

Isolation Switch Handle



Shutter Mechanism and Finger Barrier Isolation of Incoming Line Bus (Shown with Isolation Switch Removed)

Component-to-Component Circuitry

All major components of Cutler-Hammer Ampgard Starters — mechanical isolating switch, vacuum contactor, current transformers and control transformer — were designed specifically to function together as an integrated starter unit.

One of the most important design features, however, is the component-to-component circuit concept employed to eliminate 50% of the current carrying junctions.

The flow of current through a vacuum-breaker controller (starter) can be traced by referring to the lower portion of **Figure 1**, where the controller is shown in the energized position. The line stab assembly mounted at the back of the enclosure also serves as the controller line terminals (1). The stabs themselves are engaged by the fuse jaws (2) of the isolating switch which is mounted on the rails at the top of the cell compartment. The line ferrules (3) of the current-limiting motor starting power circuit fuses (4) clip into the fuse jaws, and the load ferrules (5) fit into the fuse holders (6) which are part of the contactor line terminals. Current flow through the contactor is from the load ferrules of the power circuit fuses, through the contactor line bus (7), and the vacuum interrupters (bottles) of the contactor (8), to the contactor load terminals (9). The contactor is mounted on rails in the lower part of the cell, immediately adjacent to the current transformers, which are bolted to a panel on the side of the enclosure. Spring loaded contact jaws mounted on the contactor load terminals plug into the lower stab assembly (10), providing a convenient connection through the current transformers to the motor (load) terminals mounted on the left-hand side wall of the enclosure. Instrument quality potential transformers (when furnished) are mounted to the right side sheet of contactor.

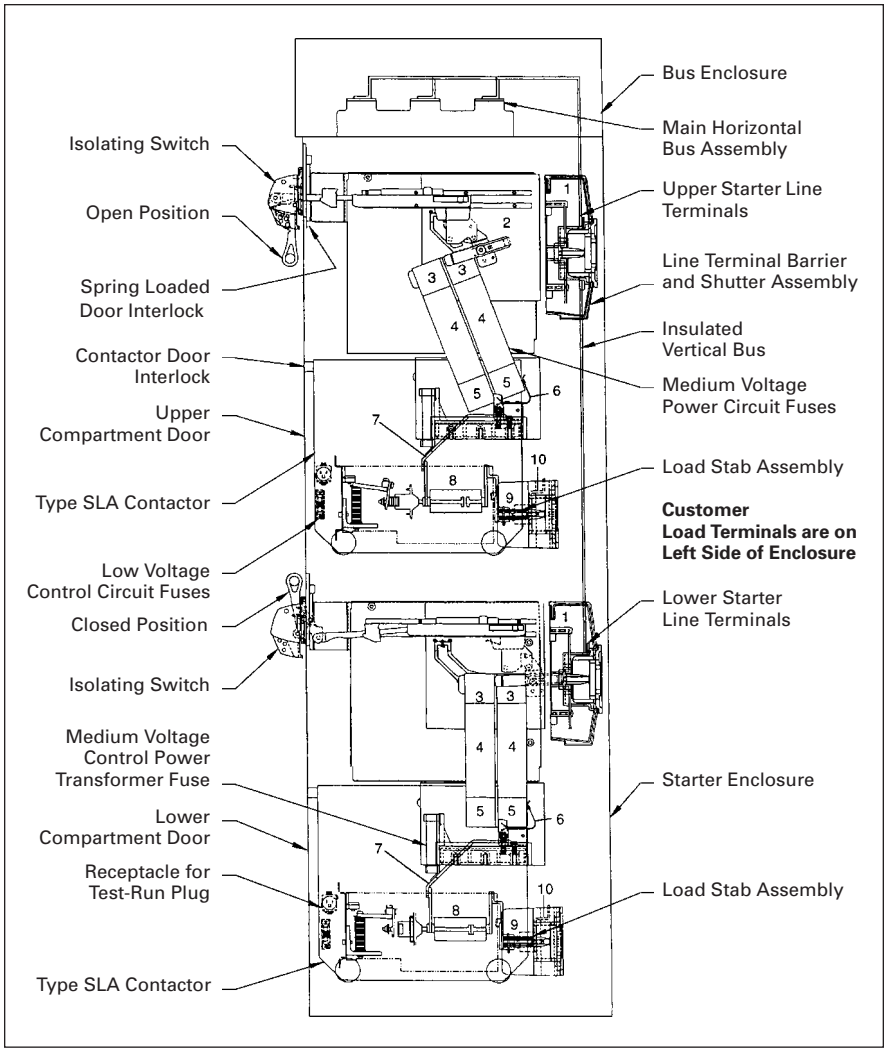
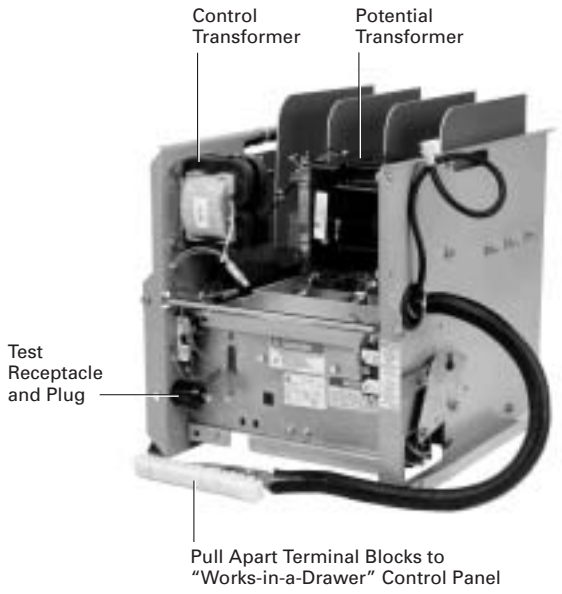
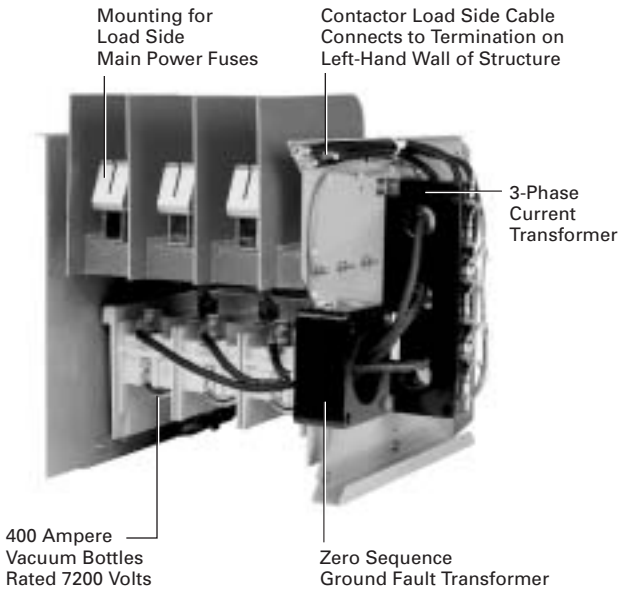


Figure 1. Section View of 400 Ampere Two-High Rollout Starters

Type SL 400 Ampere Vacuum Contactor Slide-Out



Front View



Rear View

SL 200 Ampere and 400 Ampere Vacuum Contactors

Cutler-Hammer Type SL Vacuum Contactors were designed and engineered specifically for use in Ampgard Starters. They are self-supporting, compact, drawout, 3-pole, dc magnet closed contactors. To permit application matching of the starter to the motor rating, the SL Contactor is available in 200 and 400 ampere ratings.

SL Contactors are available in the standard slide-out configuration and optional rollout or narrow designs. Slide-out and rollout designs can be supplied in a 2-high configuration, with both the upper and lower contactors fully rated up to 400 amperes enclosed. The narrow design is available as 1-high only and is fully rated at up to 400 amperes enclosed.

Design

Cutler-Hammer Vacuum Contactors are highly versatile, low-surge contactors that have been designed to meet all applicable NEMA® standards and are UL® recognized components. The contactors accommodate mechanical interlocks which function with the starter isolation switch and with other contactors. These interlocks provide unmatched safety and service protection.

The contactors consist of a molded frame with moving armature, magnet and vacuum interrupters. The contactor is easily positioned into the starter and long-life vacuum interrupters provide many operations with a minimal maintenance program. The contactor design incorporates fuse holders for the load side of the current limiting main power fuses and provides for connection to the medium voltage side of the control power transformer (CPT). CPTs of up to 2 kVA capacity are mounted on the contactor. The SL operating coils are energized by a control board which provides a pulse-width-modulated dc output. Control voltages and contactor dropout times are programmed using a DIP switch located on the control board. The control board is mounted in a protected cavity in the molded contactor frame to prevent inadvertent access to the voltage and dropout DIP switch. Four auxiliary contacts (2NO, 2NC) are supplied with each contactor and are wired to terminal blocks on the starter control panel.

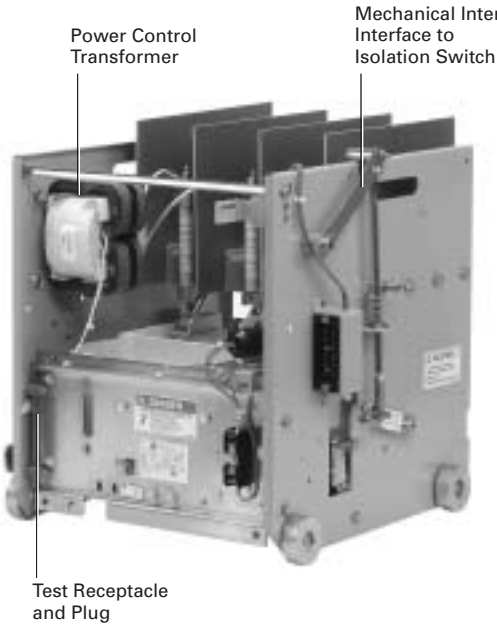
The vacuum interrupters employ special main contact materials that exhibit a low chop current and have a limited ability to interrupt high frequency currents. Ampgard contactors thus minimize switching surges. Surge protection is therefore not required due to the use of the vacuum contactor. Surge protection may be required for other reasons such as the high probability of lightning strike, etc.

Maintenance

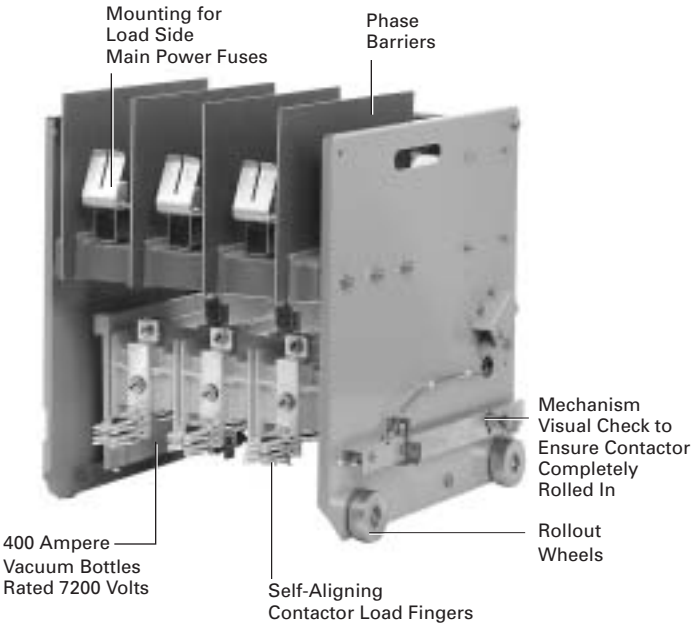
Reduced maintenance is one of the outstanding features of the Cutler-Hammer Vacuum Contactor line. The special contact material in the vacuum interrupters provides long life even under severe operating conditions. The main coils operate with a very low temperature rise to maximize insulation life. Steel bearings on the main shaft provide long, trouble-free operation.

A simple go/no-go gauge for checking contact wear is included with each contactor. Wear can be checked without removing the contactor from the starter. The vacuum contactor is much lighter than previous generation airbreak contactors, which allows for easier insertion and removal from the starter structure.

Type SL 400 Ampere Vacuum Contactor Rollout with Wheels and Load Fingers



400 Ampere Contactor Features — Front View



400 Ampere Contactor Features — Rear View

200/400 Ampere Slide-out

The slide-out version of the Cutler-Hammer SL Contactor is supplied as standard for those applications requiring a 200 or 400 ampere contactor. The contactor slides into the Ampgard structure on steel rails. Medium voltage cables connect the contactor load terminals to the lug landings for the motor load cables. A 3-phase current transformer, 3-phase potential transformer and ground fault current transformer are mounted on the contactor when required. A set of pull-apart terminal blocks connects the contactor to the low voltage control panel.

The contactor is easily removed from the structure by removing three bolts securing the contactor load cables, one bolt in each of the two mounting rails, and one bolt connecting the isolating switch interlock arm.

Note: Each contactor supplied with a feeler gauge to check contact wear from front of starter.

200/400 Ampere Rollout

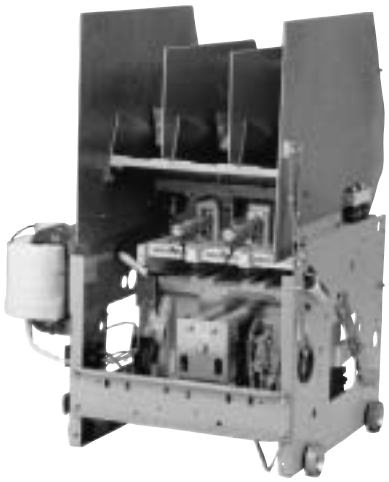
A rollout version of the SL Contactor is an available option. The rollout contactor is mounted on wheels and simply rolls into the Ampgard structure. Contactor load fingers engage a load stab as the contactor is inserted into the starter cell. The contactor is held in position by a detent latch and can be easily removed by releasing the latch mechanism. The contactor can be removed from the starter without disconnecting any medium voltage cables or interlock mechanisms.

200/400 Ampere Narrow Design

A special 1-high narrow design is an available option. The contactor slides into the starter compartment and has pull-apart terminal blocks and isolation switch-to-contactor interlocks similar to the slide-out design. The contactor includes load fingers like those on the rollout contactor. Current transformers are mounted in a special CT compartment above the contactor.

SJ 800 Ampere Vacuum Contactors

The 800 ampere contactor is a Cutler-Hammer Type SJ and is available in rollout design only. It is a 1-high configuration and is rated at 720 amperes enclosed. The dc main coil for the SJ is controlled in a conventional manner with an economizing circuit mechanically actuated by an auxiliary contact. Control voltages and dropout times are not DIP switch selectable. Other features are similar to the Cutler-Hammer SL 400 ampere rollout.



Front View

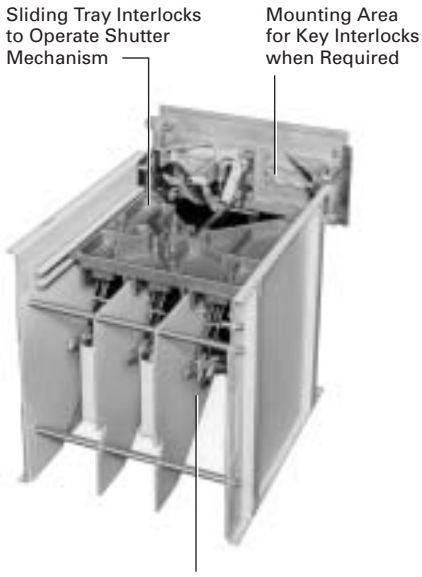
800 Ampere Vacuum Break Contactor 7200 Volt Maximum Rollout with Wheels and Load Fingers

Type LFR Mechanical Non-Loadbreak Isolating Switch

Mechanical Interlock Between Isolation Switch and Contactor Slide-Out Design

400 Ampere Isolation Switch — Side View

400 Ampere Isolation Switch — Front View



400 Ampere Isolation Switch — Rear View

LFR Isolation Switch

The Cutler-Hammer LFR drawout, lightweight, 3-pole, manually operated isolating switch is mounted on slide rails in the top of the enclosure. It may be easily removed by loosening two bolts in the front casting.

The component-to-component circuitry concept utilizes the current limiting fuses as part of the isolating switch. The switch fuse jaw is constructed so that firm pressure is applied to the fuse ferrule when the switch is in the ON position, yet also allows the fuse to be easily removed or inserted when the switch is open.

A positive mechanical interlock between the isolating switch and contactor prevents the isolating switch from being opened when the contactor is closed, and from being closed if the contactor is closed.

The isolating switch handle is designed to break off if the operator uses too much force in trying to open the non-loadbreak isolating switch when the contactor is closed.

To operate the isolating switch, the operating handle is moved through a 180° vertical arc from the ON to the OFF position. In the ON and OFF position, a portion of the handle housing extends over the starter high voltage door, preventing the door from being opened. From the OFF position, the handle must be rotated 90° counterclockwise to a horizontal service position which allows the high voltage door to be opened. When the high voltage door is open, a door interlock prevents the handle from being inadvertently returned to the OFF position. From the horizontal service position, the handle cannot be moved to the ON position without first moving to the vertical OFF position.

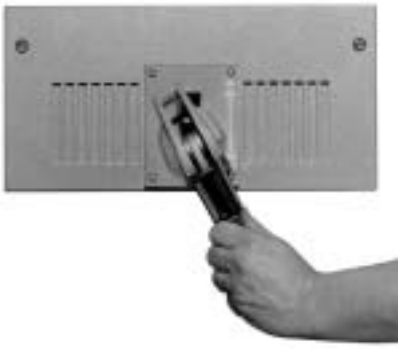
When the operating handle is moved from ON to OFF, copper fingers are withdrawn from incoming line stabs. As the fingers withdraw, they automatically tilt up so they are visible above the top of the fuses when viewed from the front, and simultaneously grounded. At the same time as the fingers are withdrawn, a mechanically-driven insulating shutter moves across the back barrier to prevent front access to the line connections. As the shutter slides into position, distinctive markings appear on the back barrier, making it easier to check the position of the fuses and barriers. Refer to **Page 3**.

800 Ampere Isolation Switch

Isolation Switch

ON Position

OFF Position



Handle Being Moved to Horizontal Service Position

Handle in Horizontal Service Position

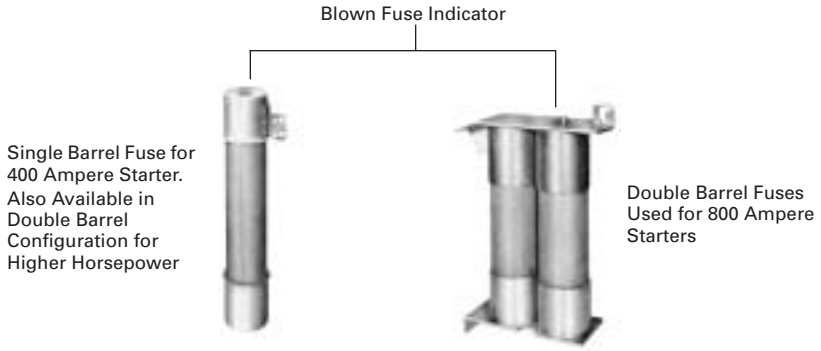
Current Limiting Fuses

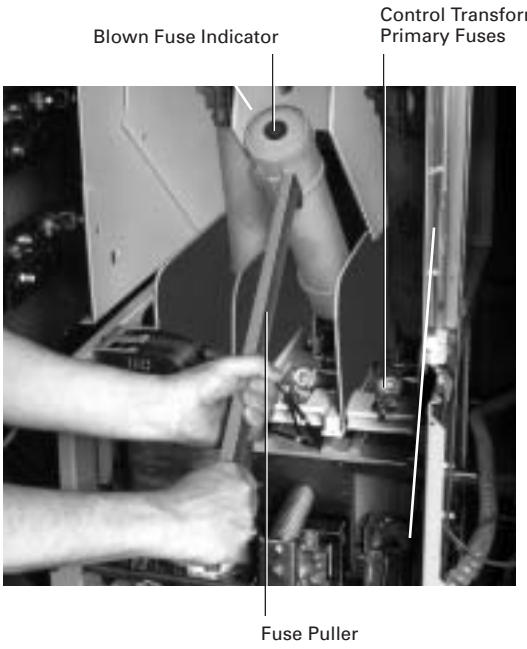
All Ampgard Starters use Cutler-Hammer Type CLS power fuses with time/current characteristics for motor service. Type CLE power fuses are applied when the starter is used to feed a transformer. This characteristic is coordinated with the contactor and overload relay characteristics to provide maximum motor/transformer utilization and protection.

Interruption is accomplished without expulsion of gases, noise or moving parts. Type CLS/CLE fuses are mounted in a vertical position to ensure maximum rating reliability, proper operation and to eliminate the possibility of dust and dirt collecting, causing a short circuit. When a fault has been cleared, a plastic indicator in the top of the fuse, normally depressed, pops up to give visible blown fuse indication.

The control circuit primary fuses are also current limiting.

Blown fuses may be removed and replaced without removing or drawing out the contactor by using the fuse puller supplied with the lineup.





Starter Fuse Removal

Contactor-Fuse Coordination

The Ampgard Starter provides ensured coordination between its fuses, contactor, current transformers, protective relays, and the motor it is controlling.

One of the most critical coordination issues is between the contactor and its starter fuses. The fuses must interrupt faults greater than the interrupting rating of the contactor. The Ampgard 400 ampere contactor has an 8-cycle dropout time factory setting as standard and will interrupt 8500 amperes. The maximum size fuse used in a 400 ampere starter is a 450-24R. By comparing the fuse curve with the contactor rating it can be observed that for faults greater than 8500 amperes, the fuse will open before the contactor. With faults less than 8500 amperes, the contactor may clear the fault before the fuse blows, depending on the settings of the protective relays. Refer to **Figure 2** for an illustration of Ampgard coordination.

Other vacuum contactors available today may have lower interrupting ratings than the Ampgard Type SL vacuum contactors. Dropout times also vary, and may be as short as two cycles on other starter designs. Lower interrupting ratings and shorter dropout times can result in fault current levels where the contactor may be required to interrupt a fault greater than its rating. This can result in severe equipment failure. Refer to **Figure 3** for an illustration of an improperly coordinated starter.

Ampgard Starters also ensure coordination between other starter components. The current transformers and protective relays are selected to work properly with each other, and to protect the motor. Protective relays like the Cutler-Hammer MP-3000 provide optimal motor protection, while also rapidly opening the contactor during fault conditions. This rapid opening signal cannot open the contactor in less than its set dropout time, but it will take the motor off-line in the shortest possible time. This will help minimize mechanical damage to the motor and may prevent the starter fuses from blowing by allowing the contactor to clear the fault (only if the fault is less than the contactor interrupting rating).

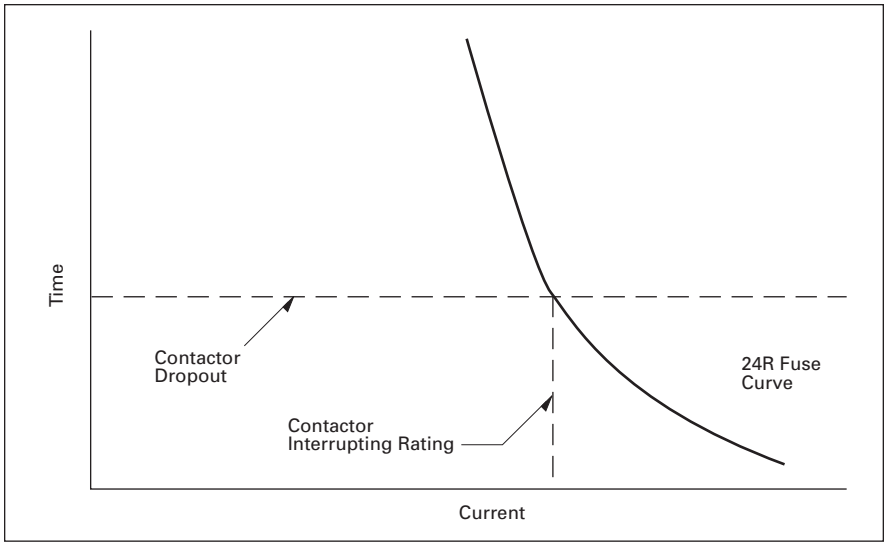


Figure 2. Proper Contactor Fuse Coordination Found in Ampgard Starter

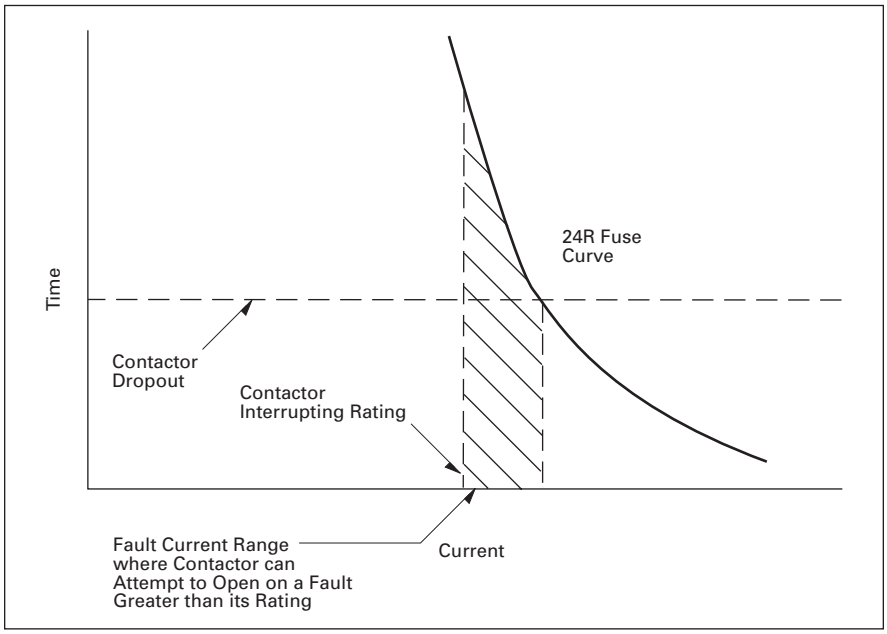


Figure 3. Contactor Fuses that are not Properly Coordinated

Protection Considerations

Coordinated with the motor's characteristics, the protective devices in the Cutler-Hammer Ampgard Starter provide motor protection from overload to full system capacity faults.

The industry standard, bi-metallic overload relay provides motor protection against sustained overloads. The relay's inverse time characteristic curve normally falls within the motor's safe allowable stall heating curve. However, the particular application/ motor requirements should be reviewed to ensure both full utilization and proper protection of the motor. To be considered are excessive accelerating time, locked rotor stalled conditions, and varying load conditions. Additional motor protection considerations are overtemperature, instantaneous overcurrent, ground fault and phase unbalance. Also, the load protection functions should also be reviewed.

Such relays as Groundgard, Resistance Temperature Detector, SVM-3, MP-3000, and IQ Meters can easily be factory installed. The use of multi-function relays that can be easily adjusted for each motor application ensures maximum motor utilization.

MP-3000 Motor Protective Relay

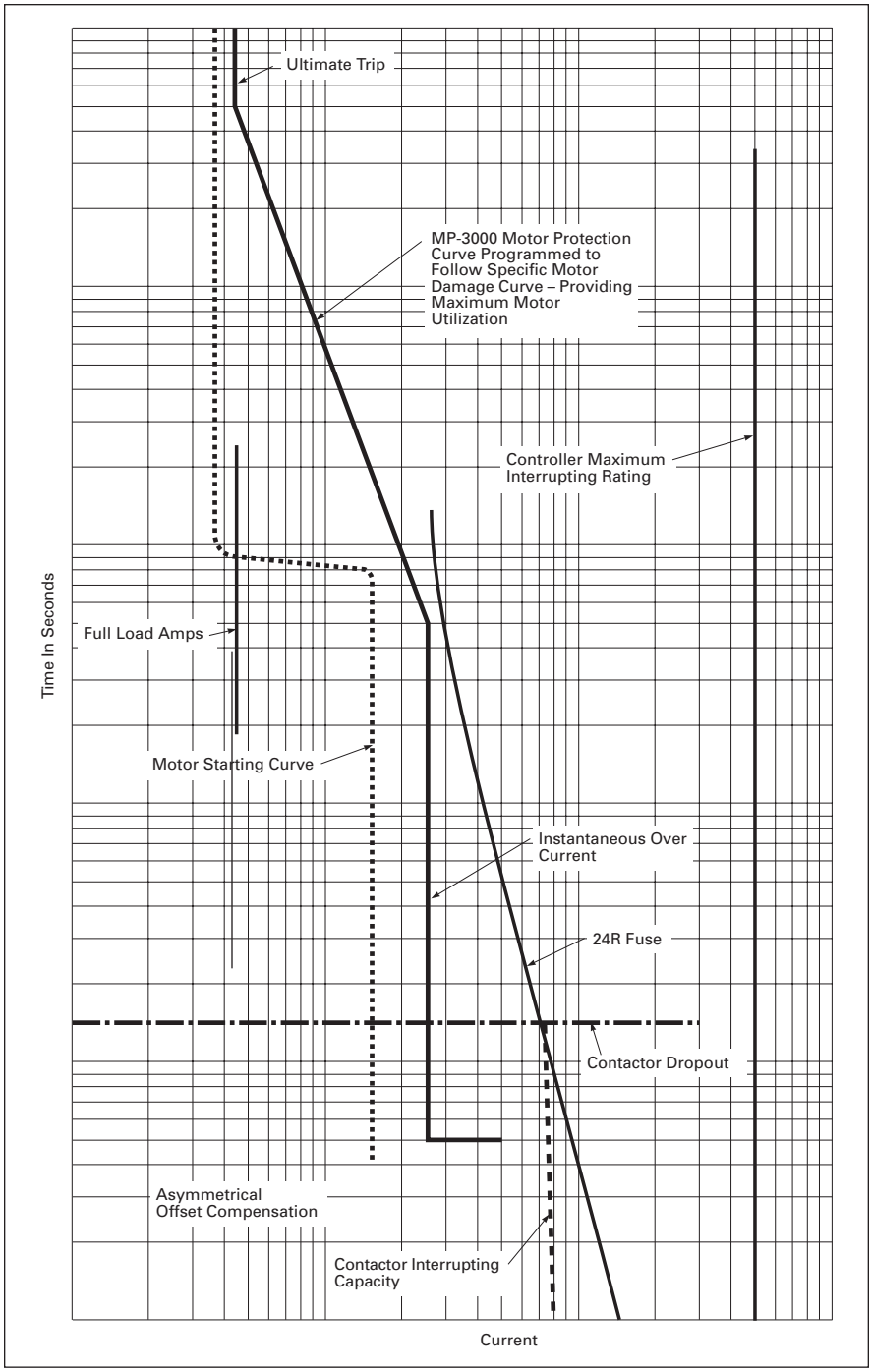
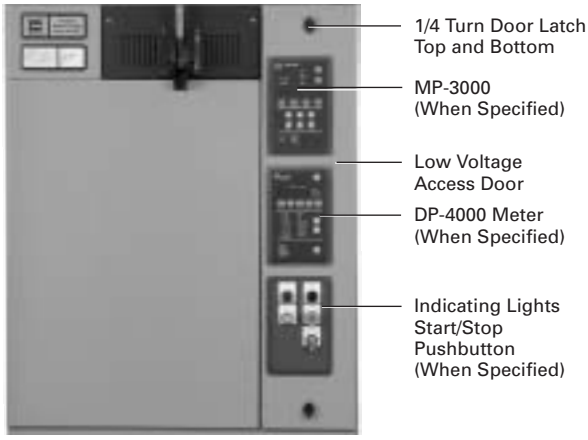


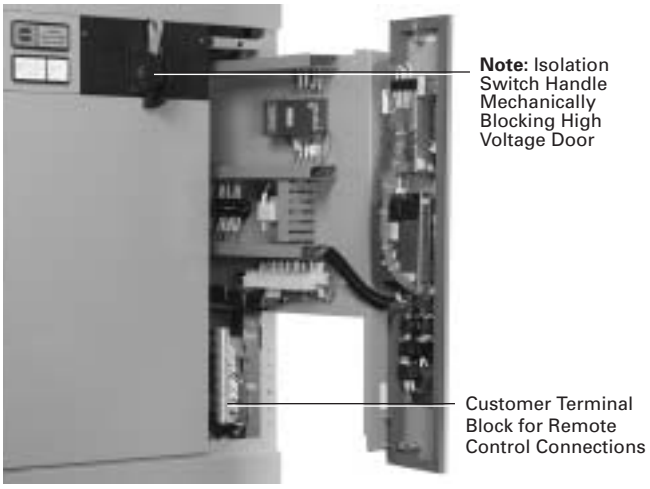
Figure 4. Full Range Coordinated Protection Between Current Limiting Type CLS Fuses, Vacuum Contactor and Motor Protection Relay

Isolated Low Voltage Control (Works-in-the-Drawer)

Mounted on the right side of the enclosure, the low voltage control panel is completely isolated and barriered from high voltage and has a separate low voltage access door.



Low Voltage and High Voltage Compartments

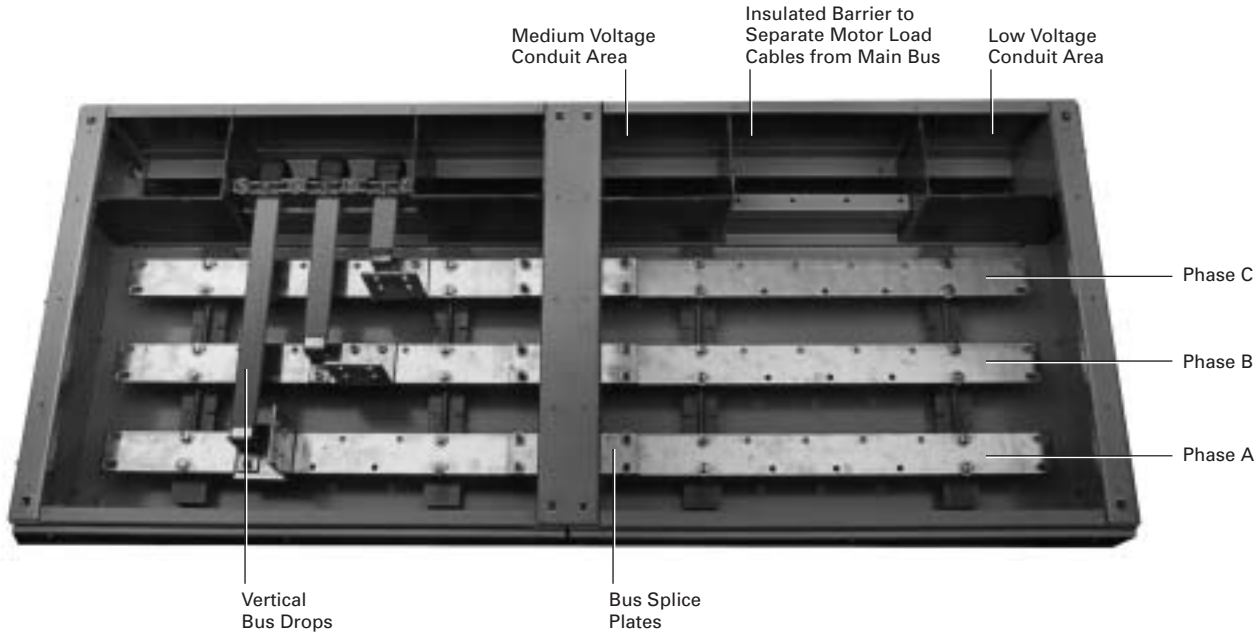


Isolated Low Voltage Control Panel

The Device Panel, MP-3000 and DP-4000 all fit in this same size low voltage door cutout.

Low Voltage Panel Completely Extended

Bus and Optional Features



Top View Main Horizontal Bus

Main Bus

When starters are grouped together in a lineup, a typical option is the main bus. The Cutler-Hammer Ampgard main bus is mounted in its own 10-inch (254.0 mm) high enclosure, which isolates it from the starter. The connection from the main bus to the starter is done with rigid vertical bus. Insulated barriers are provided for separate top entry of power and control cables. The main bus is top, side and front accessible, which allows for ease of maintenance or extension of lineup without disassembling the starters.

Main bus is available for 1000, 1200, 2000 and 3000 amperes. Crossover bus, busway entry, and pull boxes are not available for the 3000 ampere design.

UL and CSA Certification

Ampgard Starters are designed, assembled and tested to meet all applicable standards: NEMA/ANSI ICS3, EEMAC E14-1, UL 347 and CSA® C22.2 No. 14. The major components i.e., contactor, isolating switch, fuses, MP-3000, IQ DP-4000, and IQ Analyzer are UL recognized.

UL or CSA labeling of a specific starter requires review to ensure that all requested modifications and auxiliary devices meet the appropriate standards. Refer to factory when specified.

Seismic Certification

Ampgard Starters are seismically tested, seismically qualified, and exceed requirements of both the Uniform Building Code® (UBC) and California Building Code Title 24.

ABS Certification

Cutler-Hammer Ampgard Medium Voltage Control assemblies have been certified under the ABS type approval program. ABS (American Bureau of Shipping) develops and verifies standards for design, construction and operational maintenance of marine-related facilities. ABS Type Approval is a means of demonstrating compliance with specifications and recording the compliance in the ABS Web site. Ampgard is listed in the ABS publications and Web site. Ampgard may be used on board a vessel, MODU (mobile offshore drilling unit) or facility classed by ABS with two conditions:

1. The Ampgard assembly may not be used in the propulsion system.
2. The Ampgard assembly may not be placed on deck.

The standard Ampgard assembly will be modified with grab rails, drip shields, insulated bus and wind latches for the doors to meet all the ABS requirements.

Other Optional Features

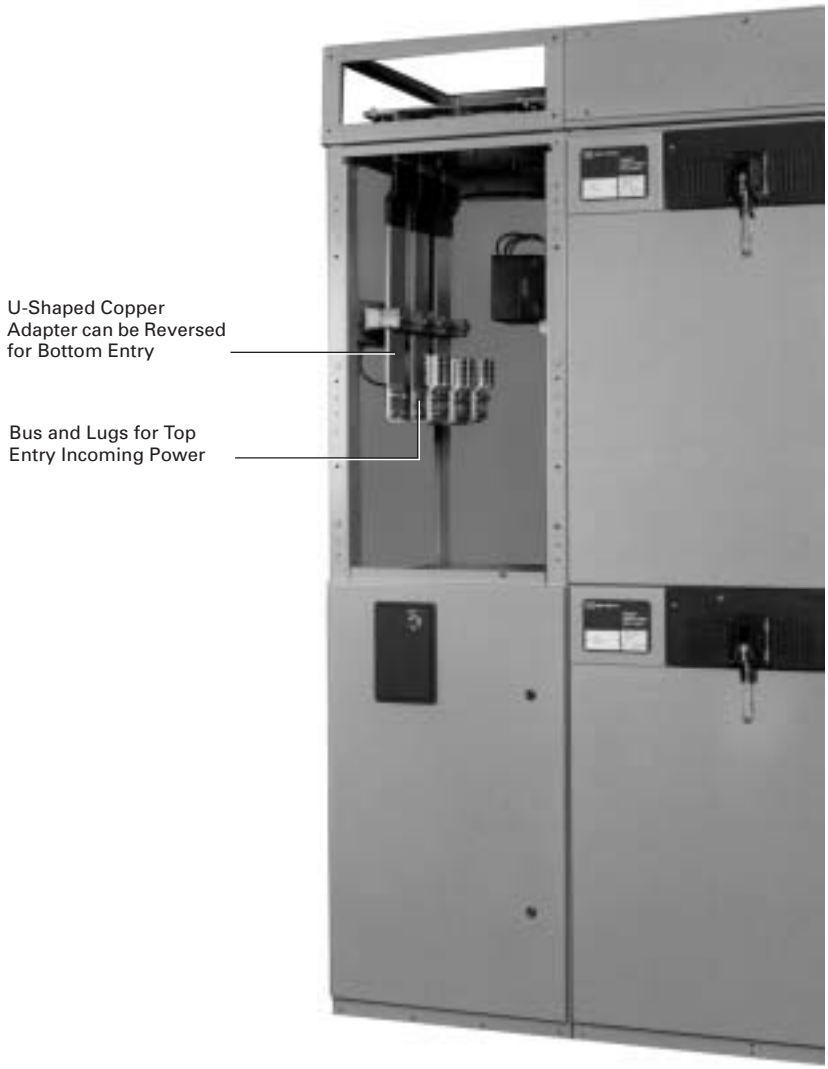
Ampgard Starters are available with a variety of accessories and modifications to satisfy a wide range of application requirements. Some of the broad areas covered include:

- Bus and cable entrance enclosures (see photos).
- Transformers.
- Power factor correction capacitors.
- Operators and pilot devices.
- Instruments and meters.
- Control relays and timers.
- Solid-state or selected electro-mechanical protection devices.

Incoming Line

Depending on the size and number of incoming cables, an incoming line enclosure may be necessary. Different designs are available for incoming power for top or bottom entry.

The addition of incoming line metering requires a 36-inch (914.4 mm) wide structure in lieu of a 26-inch (660.4 mm) wide structure.



Typical 26-Inch (660.4 mm) Wide Incoming Line Structure

Drawout Potential Transformers and Fuses

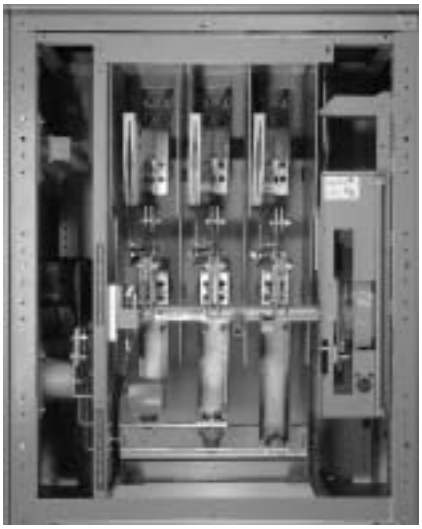
Drawout trunnion-mounted potential transformer design with fuses is available to meet specific application requirements or code regulations.

Drawout Potential Transformer and Fuses Mounted in a 36-Inch (914.4 mm) Wide Structure, Height 15 Inches (381.0 mm)

Type LBS Loadbreak Switch

For application needs with loads rated 600 or 1200 amperes at 2500, 5000 and 7200 volts, Ampgard is available with the Type LBS loadbreak switch. This device, a 3-pole, manually operated, quick-make, quick-break switch, is used primarily as a disconnect switch in ac power systems. This switch is fixed mounted and will fit in one-half of a standard 90-inch (2286.0 mm) high, 36-inch (914.4 mm) wide vertical structure. Power fuses up to 450E amperes can be mounted within the half-high structure. Mechanical interlocks are incorporated so that the door cannot be opened when the switch is on, and when the door is open the switch cannot be closed. A safety screen is supplied behind the switch door. The Type LBS switch can be supplied with a total of four electrical interlocks.

Type LBS Load Break Switch Shown in Upper or Lower Half of 36-Inch (914.4 mm) Wide Structure, Height 45 Inches (1143.0 mm)



Type LBS Load Break Switch Shown with Safety Screen Removed

Description

The Cutler-Hammer Main Breaker Ampgard (MBA) is a fully integrated metal-enclosed medium voltage Type VCP-W Drawout Vacuum Circuit Breaker that is bus connected (close-coupled) to Ampgard Medium Voltage Starters in a single integrated assembly.

Incoming Line Options

- **Cable:** Maximum of six per phase, 750 kcmil maximum, top or bottom entry.
- **Bus Duct:** Top only, 1200, 2000 or 3000 amperes. Standard Cutler-Hammer 3-wire designs only.
- **Transformer Throat:** Must be the standard design used by Eaton.

Standards

Main Breaker Ampgard is service entrance rated and is designed and built to meet the following standards where applicable:

- NEMA ICS-1 and NEMA ICS-3, Part 2.
- ANSI/IEEE C37.20.3.
- UL 347 and UL 869A.
- CSA C22.2, No. 31 and No.14.
- EEMAC G8.2 and E14.1.

Listing/Certification

UL listing and CSA certification is available, depending on the specific bill of material.

Ratings

- 2300 – 6900 Vac systems (7200 Vac maximum), 3-phase.
- 60 kV BIL impulse withstand rating.
- ANSI interrupting ratings — 250, 350 and 500 MVA.
- Continuous current — 1200, 2000 and 3000 amperes.

Main Breaker Ampgard — Breaker Connected

Main Breaker Ampgard — Breaker Withdrawn

Requires Less Floor Space

- Only 60 inches (1524.0 mm) deep, the integrated MBA design provides a bus system that directly connects to Ampgard Motor Starters, eliminating space-consuming transition sections. The reduced floor space requirements yield significant cost savings, particularly when installation in a prefabricated electrical house is required.
- Back-to-back design provides for an increase in the number of starters without an increase in floor space.

Front/Side Accessible Connections

- All connections requiring maintenance are front or side accessible.
- Rear access space is not required.
- An MBA (excluding back-to-back design) can be installed flush against the wall.

Circuit Breaker Rating Chart

Table 1. ANSI Standards — Type VCP-W Circuit Breakers Rated on Symmetrical Current Rating Basis

ANSI Interrupting Rating MVA	Nominal Voltage Class kV	Impulse Withstand Rating kV Peak	Short Circuit Current at Rated Maximum kV kA rms	Continuous Current at 60 Hz Amperes
250	4.16	60 kV BIL	29	1200 2000 3000
350	4.16	60 kV BIL	41	1200 2000 3000
500	7.2	60 kV BIL	33	1200 2000 3000

Microprocessor-Based Devices

- Cutler-Hammer FP-5000 and Digitrip® 3000 Overcurrent Protective Relays provide programmable circuit protection, information and operator conducted testing.

Protection/Metering

- Traditional 50/51/87 relays.
- Ammeter/voltmeter (1%).

Communications

- Cutler-Hammer PowerNet™ communications provides for monitoring and controlling complete electrical distribution systems of those parts of a system selected by the operator.

Enclosures

- The MBA is available in NEMA/EEMAC 1, NEMA/EEMAC 1G/1A, and NEMA/EEMAC 12 enclosures.

Seismic Qualified

- The Main Breaker Ampgard is seismically tested, seismically qualified, and exceeds requirements of the Uniform Building Code (UBC), the California Building Code (CBC) and BOCA® National Building Code.

Top View of Front Aligned Integrated MBA. From Left to Right: Incoming Line, Main Breaker and Ampgard Starter Bus Compartments. The MBA Assembly Employs an Integrated Common Main Bus

Low Voltage Equipment Cell Compartment for Metering and Protection Devices

Side Panel Removed to Show Incoming Cable Connections

Synchronous Motor, Brush Type Solid-State Soft Sync Field Control

The synchronous motor starter includes the basic induction motor control in the bottom half of the structure. The synchronous control and protection function fit easily in the upper compartment.

The step down static excitation transformer is connected to the load side of the main contactor and is protected by its own current-limiting fuses.

The static exciter is an SCR type. Its dc voltage output is adjustable via door mounted potentiometer. Minimum setting is 50% of rated voltage.

The synchronous control board monitors the induced field during acceleration and energizes the dc rotor field at the optimum speed and rotor-stator pole relationship.

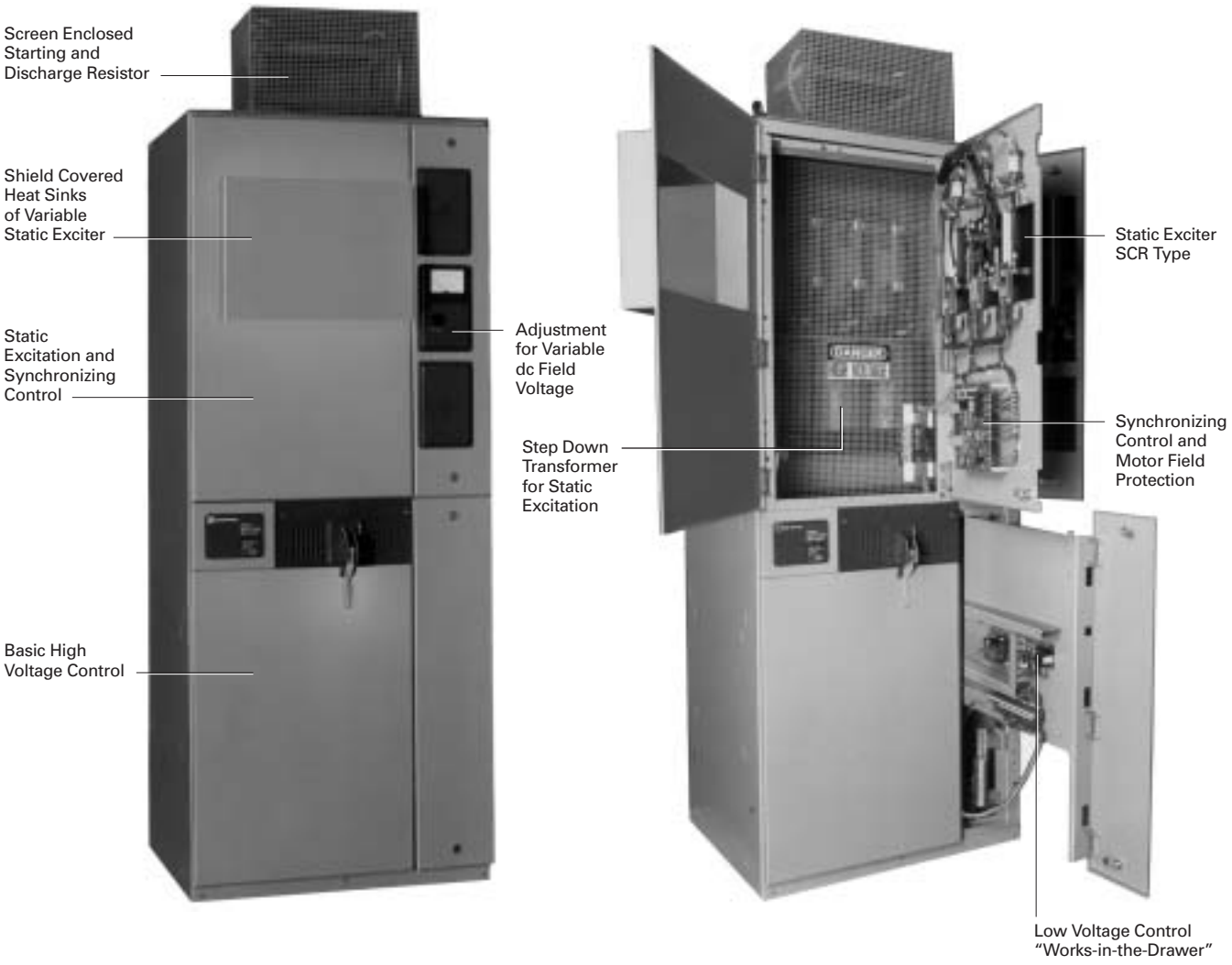
Solid-state, brush-type synchronous motor control includes the following protective features:

- Locked rotor protection.
- Incomplete sequence.
- Failure to synchronize.
- Fuse failure.
- Pullout protection.
- Field loss protection.

The motor windings are protected by the conventional induction motor control protection (thermal, MP-3000).

When ordering you must specify:

- dc field amperes.
- dc field volts.
- Maximum induced field current rms at start (starting and discharge resistor amperes).
- Starting and discharge resistor ohms.



Synchronous Motor Brush-Type Across-the-Line Starter

Typical Wiring Diagram for Full Voltage FVNR Starter

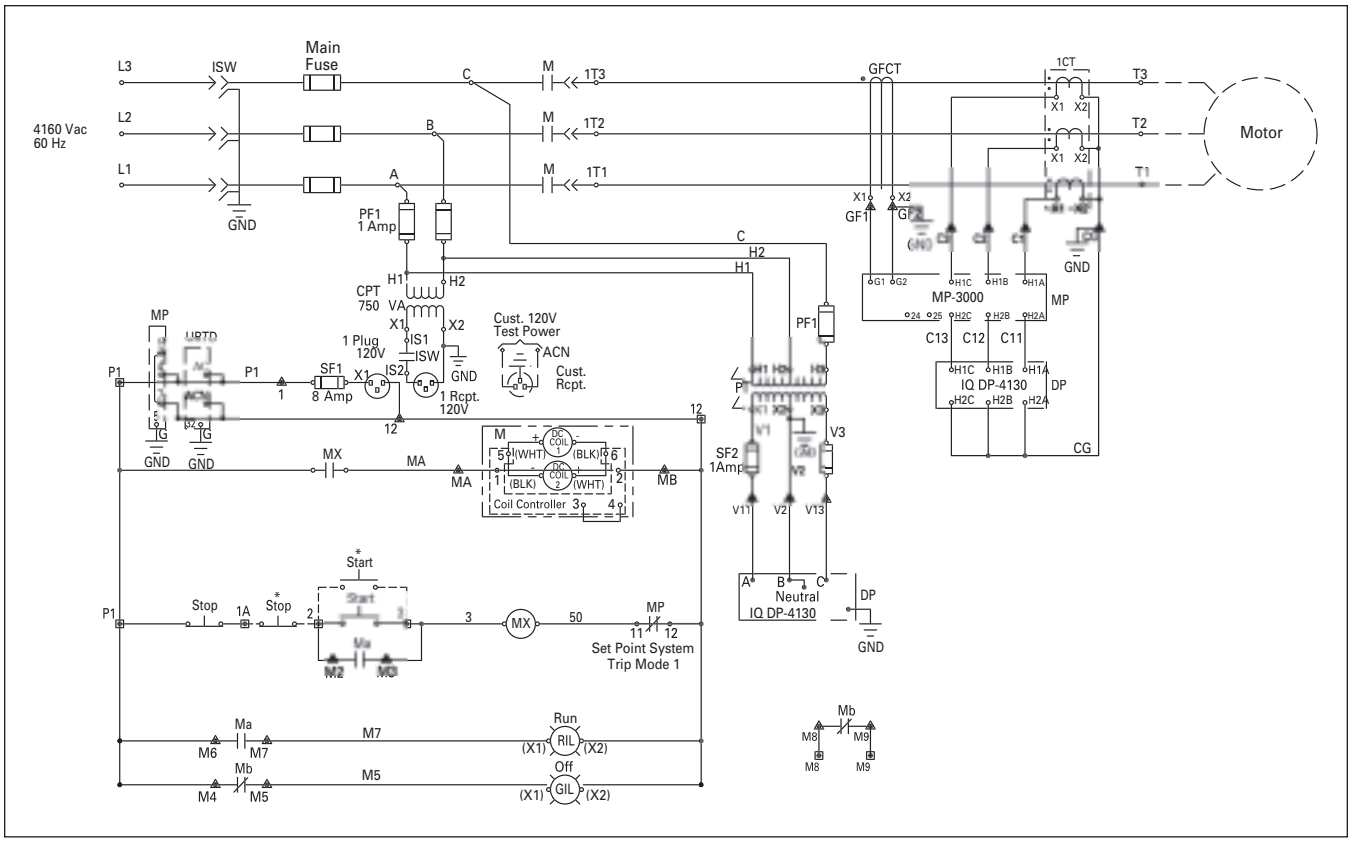


Figure 5. Induction Motor Across-the-Line Starter Vacuum Contactor with MP-3000 Motor Protection with Optional Universal RTD Module and Optional IQ Metering, Local and Remote Start-Stop Pushbuttons, and Local and Remote Red and Green Indicating Lights

Typical Wiring Diagram for Reduced Voltage Autotransformer RVAT Starter

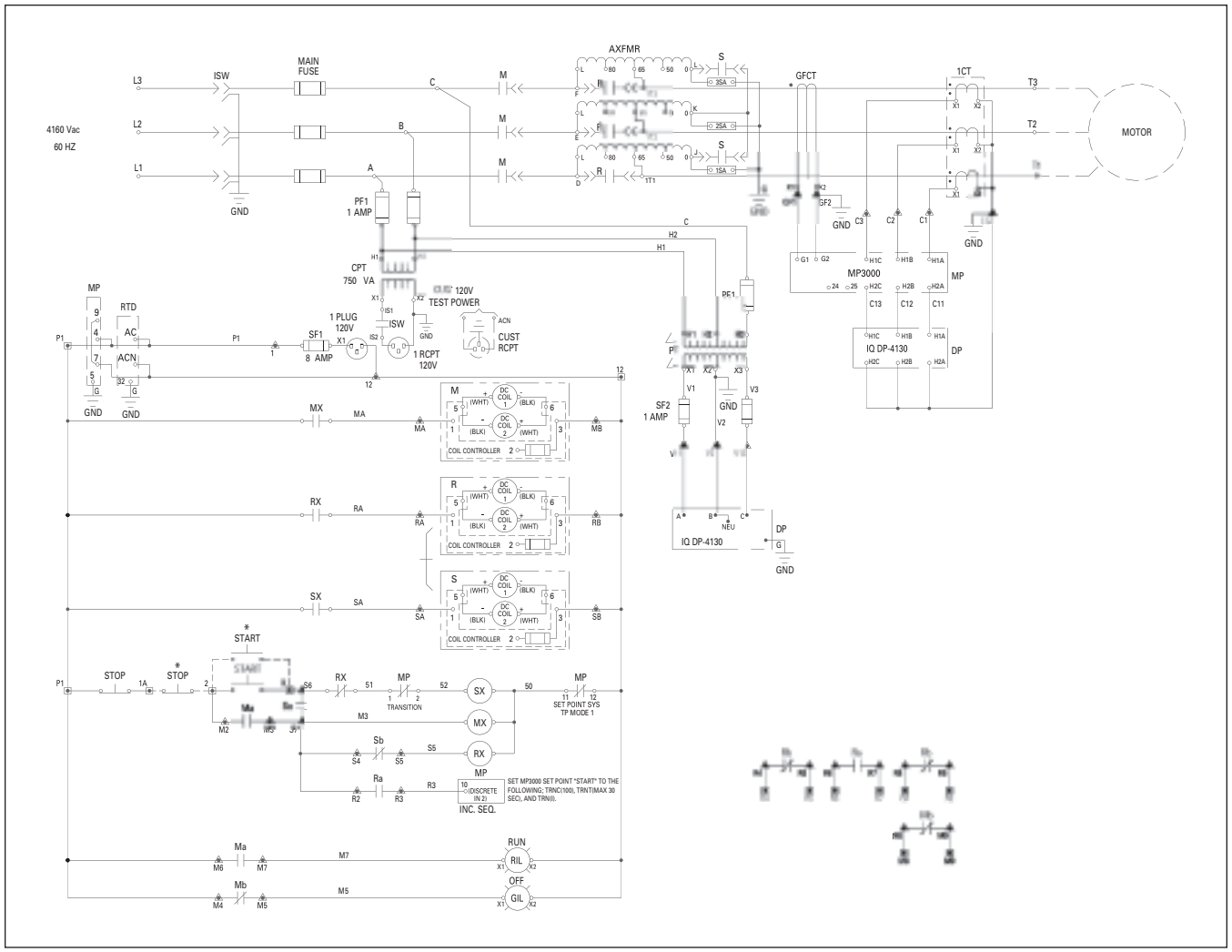


Figure 6. Induction Motor Reduced Voltage Autotransformer Starter, Vacuum Contactor with MP-3000 Motor Protection with Optional Universal RTD Module and Optional IQ Metering, Local and Remote Start-Stop Pushbuttons, and Local and Remote Red and Green Indicating Lights

Typical Wiring Diagram for Ampgard *IT.* Soft Start

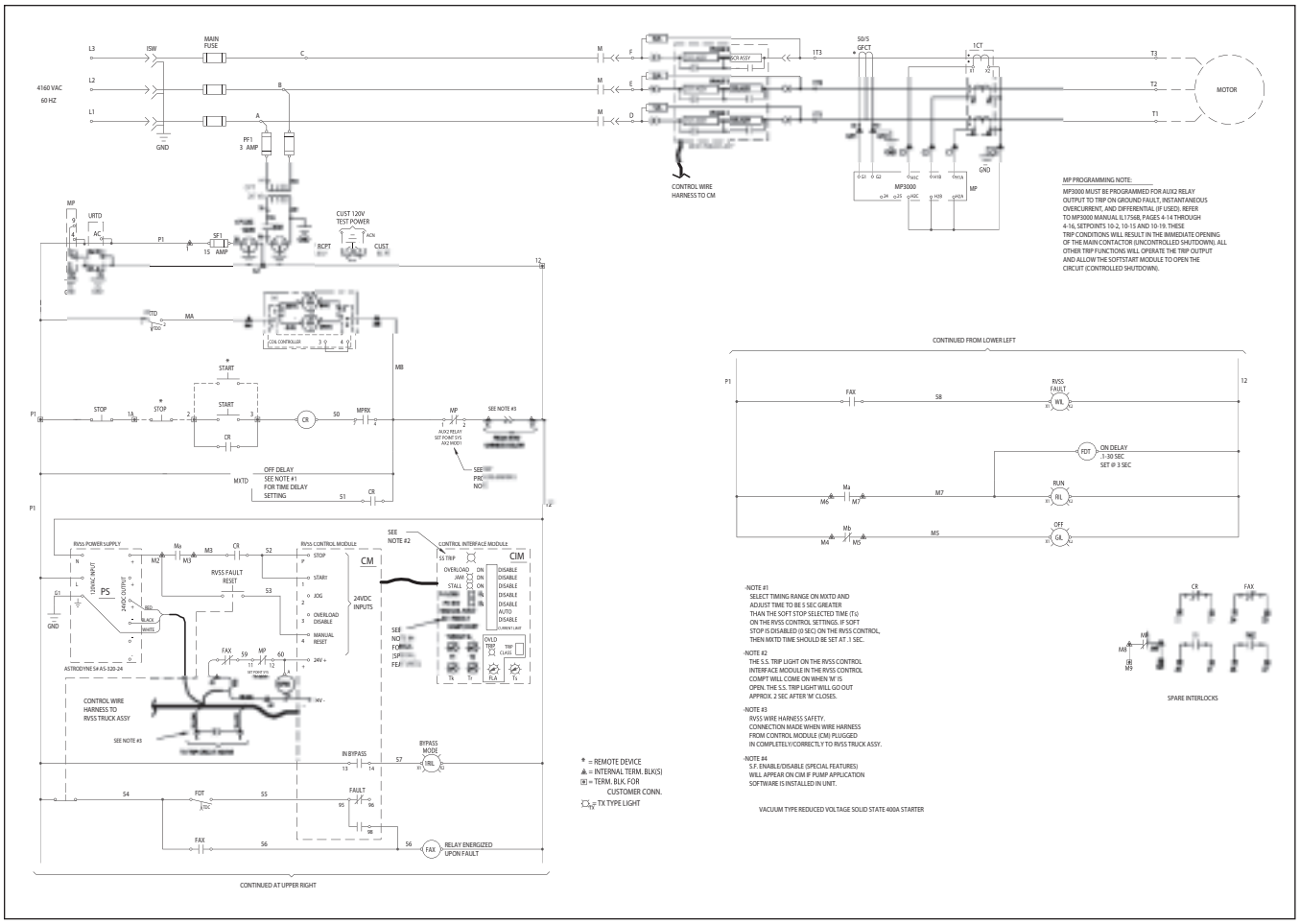


Figure 7. Induction Motor Reduced Voltage Solid-State Starter, Vacuum Contactor with MP-3000 Motor Protection with Optional Universal RTD Module and Optional IQ Metering, Local and Remote Start-Stop Pushbuttons, and Local and Remote Red and Green Indicating Lights

Technical Data

Type SL 200 Ampere Vacuum Contactor Ratings

Table 2. Type SL 200 Ampere Vacuum Contactor Ratings

Rated Utilization Voltage	2200 to 2500 Volts	3000 to 3600 Volts	3800 to 4800 Volts	6000 to 6900 Volts
Interrupting Rating				
NEMA Unfused (E1)	4.5 kA	4.5 kA	4.5 kA	4.5 kA
NEMA Fused (E2)	50 kA	50 kA	50 kA	50 kA
	200 MVA at 2400 Volts	285 MVA at 3300 Volts	400 MVA at 4600 Volts	570 MVA at 6600 Volts
Application Table				
Induction Motor	800 hp	1100 hp	1500 hp	2250 hp
Synchronous Motor (0.8 PF)	800 hp	1100 hp	1500 hp	2250 hp
(1.0 PF)	1000 hp	1250 hp	1750 hp	2750 hp
Transformer	750 kVA	1000 kVA	1500 kVA	2000 kVA
Capacitor 3-Phase	600 kvar	825 kvar	1050 kvar	1650 kvar

Maximum Insulation Voltage: 7200 Volts

Maximum Interrupting Current (3 Operations)	4500 Amperes	**Arcing Time**	12 Milliseconds (3/4 Cycle) or Less
Rated Current	200 Amperes Enclosed	**Pickup Voltage**	80% Rated Coil Voltage
IEC Make-Break Capability-AC4		**Dropout Voltage**	60% Rated Coil Voltage
Make	4000 Amperes	**Control Voltages**	
Break	3200 Amperes	**ac**	110/120/220/240 (50/60 Hz)
Short-Time Current		**dc**	125
30 Seconds	2400 Amperes	**Control Circuit Burden**	
1 Second	6000 Amperes	Closing (ac)/(dc)	—
8.7 Milliseconds (.5 Cycle) ①	63 kA Peak	Holding (ac)/(dc)	30 VA
Standard Service Altitude	-1000 to +2000 Meters	**Auxiliary Contact Rating**	
Optional Service Altitudes	-3500 to -1001 Meters	Voltage (Maximum)	600 Volts
	+2001 to +5000 Meters	Continuous Current	10 Amperes
Mechanical Life	2.5 Million Operations	Making Capacity (ac)	7200 VA
Electrical Life	300,000 Operations	(dc)	125 VA
BIL	60 kV (1.2 x 50 Microseconds)	Breaking Capacity (ac)	720 VA
Dielectric Strength (60 Hz)	20 kV (1 Minute)	(dc)	125 VA
Closing Time (Energization to Contact Touch)	80 Milliseconds	**Latch (When Specified)**	
		Mechanical Life	250,000 Operations
Opening Time	30 to 250 Milliseconds (selectable)	Trip Voltages (dc)	24 Volts
		(dc)	125 Volts
		(ac)	110/120 Volts
		Minimum Trip Voltage	80% Rated Coil Voltage
		Trip Burden	
		(24 Vdc)	—
		(125 Vdc)	—
		(110/120 Vac)	—
		Trip Time	30 Milliseconds
		Weight	150 Lbs. (68 kg) (Rollout)

① Time stated in cycles on 60 Hz base.

Type SL 400 Ampere Vacuum Contactor Ratings

Table 3. Type SL 400 Ampere Vacuum Contactor Ratings

Rated Utilization Voltage	2200 to 2500 Volts	3000 to 3600 Volts	3800 to 4800 Volts	6000 to 6900 Volts
Interrupting Rating				
NEMA Unfused (E1)	8.5 kA	8.5 kA	8.5 kA	8.5 kA
NEMA Fused (E2)	50 kA	50 kA	50 kA	50 kA
	200 MVA at 2400 Volts	285 MVA at 3300 Volts	400 MVA at 4600 Volts	570 MVA at 6600 Volts
Application Table				
Induction Motor	1750 hp	2250 hp	3000 hp	4500 hp
Synchronous Motor (0.8 PF)	1750 hp	2250 hp	3000 hp	4500 hp
(1.0 PF)	2000 hp	2500 hp	3500 hp	5500 hp
Transformer	1500 kVA	2000 kVA	3000 kVA	4000 kVA
Capacitor 3-Phase	1200 kvar	1650 kvar	2100 kvar	3300 kvar

Maximum Insulation Voltage: 7200 Volts

Maximum Interrupting Current (3 Operations)	8500 Amperes	**Arcing Time**	12 Milliseconds (3/4 Cycle) or Less
Rated Current	400 Amperes Enclosed	**Pickup Voltage**	80% Rated Coil Voltage
IEC Make-Break Capability-AC4		**Dropout Voltage**	60% Rated Coil Voltage
Make	4000 Amperes	**Control Voltages**	
Break	3200 Amperes	**ac**	110/120/220/240 (50/60 Hz)
Short-Time Current		**dc**	125
30 Seconds	2400 Amperes	**Control Circuit Burden**	
1 Second	6000 Amperes	Closing (ac)/(dc)	—
8.7 Milliseconds (.5 Cycle) ①	63 kA Peak	Holding (ac)/(dc)	30 VA
Standard Service Altitude	-1000 to +2000 Meters	**Auxiliary Contact Rating**	
Optional Service Altitudes	-3500 to -1001 Meters +2001 to +5000 Meters	Voltage (Maximum)	600 Volts
		Continuous Current	10 Amperes
Mechanical Life	2.5 Million Operations	Making Capacity (ac)	7200 VA
Electrical Life	300,000 Operations	(dc)	125 VA
BIL	60 kV (1.2 x 50 Microseconds)	Breaking Capacity (ac)	720 VA
Dielectric Strength (60 Hz)	20 kV (1 Minute)	(dc)	125 VA
Closing Time (Energization to Contact Touch)	80 Milliseconds	**Latch (When Specified)**	
		Mechanical Life	250,000 Operations
Opening Time	30 to 250 Milliseconds (selectable)	Trip Voltages (dc)	24 Volts
		(dc)	125 Volts
		(ac)	110/120 Volts
		Minimum Trip Voltage	80% Rated Coil Voltage
		Trip Burden	
		(24 Vdc)	—
		(125 Vdc)	—
		(110/120 Vac)	—
		Trip Time	30 Milliseconds
		Weight	150 Lbs. (68 kg) (Rollout)

① Time stated in cycles on 60 Hz base.

Type SJ 800 Ampere Vacuum Contactor Ratings

Table 4. Type SJ 800 Ampere Vacuum Contactor Ratings

Description	SJ 25V830	SJ 33V830	SJ 50V830	SJ 72V830
Rated Utilization Voltage	2200 to 2500 Volts	3000 to 3300 Volts	3800 to 5000 Volts	6000 to 7200 Volts
Interrupting Rating				
NEMA Unfused (E1)	50 MVA	50 MVA	75 MVA	100 MVA
NEMA Fused (E2)	200 MVA at 2300 Volts	285 MVA at 3300 Volts	408 MVA at 4600 Volts	570 MVA at 6600 Volts
Interrupting Rating				
Induction Motor	800 hp	4000 hp	5000 hp	8000 hp
Synchronous Motor (0.8 PF)	800 hp	4000 hp	5000 hp	8000 hp
(1.0 PF)	1000 hp	5000 hp	6000 hp	10,000 hp
Transformer	2500 kVA	3500 kVA	4500 kVA	6000 kVA
Capacitor 3-Phase	2400 kVAC	3200 kVAC	4000 kVAC	4800 kVAC
Maximum Insulation Voltage: 7200 Volts				

Maximum Interrupting Current (3 Operations)	13200 Amperes	**Arcing Time**	12 Milliseconds (3/4 Cycle) or Less
Rated Current	720 Amperes Enclosed 800 Amperes Open	**Pickup Voltage**	80% Rated Coil Voltage
		Dropout Voltage	60% Rated Coil Voltage
IEC Make-Break Capability-AC4 Class 3		**Control Voltages**	
Make	8000 Amperes	(ac)/(dc)	110/120 Volts (50/60 Hz) 125 Volts (dc)
Break	6400 Amperes		
Short Time Current		**Control Circuit Burden (Rated Volt)**	
30 Seconds	4320 Amperes	Closing (ac)/(dc)	2600 VA/3000 VA
1 Second	10,800 Amperes	Holding (ac)/(dc)	50 VA/56 VA
8.75 Milliseconds (.5 Cycle) ①	86 kA Peak	**Auxiliary Contact Rating (L-64)**	
Switching Frequency	1200/Hour	Voltage (Maximum)	600 Volts
Mechanical Life	1 Million Operations	Continuous Current	10 Amperes
Electrical Life	250,000 Operations At Rated Current	Making Capacity (ac)	7200 VA
		(dc)	200 VA
BIL	60 kV (1.2 x 50 Microseconds)	Breaking Capacity (ac)	720 VA
Dielectric Strength (60 Hz)	18.2 kV (1 Minute)	(dc)	200 VA
Closing Time (Energization to Contact Touch)	50 Milliseconds (3.0 Cycles)	**Latch (When Specified)**	
		Mechanical Life	250,000 Operations
Closing Time (Energization to Armature Seal) ①	65 Milliseconds (3.5 Cycles)	Trip Voltages (dc)	24 Volts
		(dc)	48 Volts
Opening Time (De-energization to Contacts Separate)	115 Milliseconds (7.0 Cycles)	(dc)	96 Volts
		(ac)	110 Volts (50/60 Hz)
Opening Time (De-energization to Full Open) ①	130 Milliseconds (8.0 Cycles)	(ac)	220 Volts (50/60 Hz)
		Tripping Voltage	80% Rated Coil Voltage
		Tripping Burden	
		(24 Vdc)	1200 VA
		(48 Vdc and 96 Vdc)	400 VA
		(110 Vac and 220 Vac)	500 VA
		Weight	210 Lbs. (95 kg)

① Time stated in cycles on 60 Hz base.

LBS Switch

Table 5. LBS Switch Ratings

Description	Continuous and Break Current Amperes	Fault-Close (Unfused) kA	Short-Time (2 Second) Current kA	Fused Interrupting Rating (kA Symmetrical)
Switch with Internal Fuses (450E Maximum at 5 kV, 350E Maximum at 7.2 kV)	600	40	25	50
Switch with 600E and 750E Fuses (5 kV Maximum)	1200	61	38	40
Switch with 1100E and 1350E Fuses (5 kV Maximum)	1200 ②	61	38	31.5
Unfused (7.2 kV Maximum)	1200	61	38	N/A

① 1200 ampere rating is for NEMA 1 enclosure with vented covers. NEMA 3/12 rating (without vents) is 1000 amperes.

Main Breaker

Table 6. Available VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards

Identification			Rated Values											Related Required Capabilities ②					Asymmetry Factor for VCP-W Breakers
Circuit Breaker Type	Nom. Volt. Class	Nom. 3-Phase MVA Class	Voltage		Insulation Level		Current		Rated Transient Recovery Voltage		Rated Interrupting Time	Rated Permissible Tripping Delay	Rated Reclosing Time	Rated Maximum Voltage Divided By K	Current Values				
			Rated Maximum Voltage	Rated Volt. Range Factor	Rated Withstand Test Voltage		Rated Continuous Current at 60 Hz	Rated Short Circuit Current (at Rated Max. kV)	Rated Crest Volt.	Rated Time to Crest					Maximum Sym. Interrupting Capability	3 Second Short-Time Current Carrying Capability	Closing and Latching Capability (Momentary) ⑦		
					Normal Frequency	1.2 x 50 µsec. Impulse									K Times Rated Short Circuit Current ④ KI		1.6 K Times Rated Short Circuit Current	1.6 K Times Rated Short Circuit Current	
	kV Class	MVA Class	V kV rms	③ K	kV rms	kV Crest	④ Amps	③ I kA rms	E2 kV Crest	T2 mS	⑤ Cycles	⑥ Y Sec	Cycles	V/K kV rms	kA rms	kA rms	kA Crest	⑧ kA rms Assy.	⑨ S
50 VCP-WND 250	4.16	250	4.76	1.24	19	60	1200	29	8.9	50	5	2	30	3.85	36	36	97	58	1.2
50 VCP-W 250	4.16	250	4.76	1.24	19	60	1200 2000 3000	29	8.9	50	5	2	30	3.85	36	36	97 132 ⑦	58 78 ⑦	1.2
50 VCP-W 350	4.16	350	4.76	1.19	19	60	1200 2000 3000	41	8.9	50	5	2	30	4.0	49	49	132	78	1.2
75 VCP-W 500	7.2	500	8.25	1.25	36	95	1200 2000 3000	33	15.5	60	5	2	30	6.6	41	41	111	66	1.2

② For reclosing service, there is **No De-Rating** necessary for the Cutler-Hammer type VCP-W family of circuit breakers. **R = 100%.** Type VCP-W breaker can perform the O-C-O per ANSI C37.09; O-0.3s-CO-15s-CO per IEC 56; and some VCP-Ws have performed O-0.3s-CO-15s-CO-15s-CO-15s-CO; **all with no derating**. Contact Eaton for special reclosing requirements.

③ For 3-phase and line-to-line faults, the symmetrical interrupting capability at an operating voltage, $V_O = \frac{V}{V_O}$ (Rated Short Circuit Current)
But not to exceed KI.
Single line-to-ground fault capability at an operating voltage, $V_O = 1.15 \frac{V}{V_O}$ (Rated Short Circuit Current)
But not to exceed KI.
The above apply on predominately inductive or resistive 3-phase circuits with normal-frequency line-to-line recovery voltage equal to the operating voltage.

④ 4000 ampere continuous rating is available for 5/15 kV. Contact Eaton for details.

⑤ 3-cycle rating available.

⑥ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:

$$T \text{ (seconds)} = Y \left[\frac{\text{(K Times Rated Short Circuit current)}}{\text{Short Circuit Current Through Breaker}}\right]^2$$

The aggregate tripping delay on all operations within any 30-minute period must not exceed the time obtained from the above formula.

⑦ Non-standard breakers with high momentary rating available for special applications.

⑧ Included for reference only.

⑨ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

Note: Contact Eaton for capacitor switching, low inductive switching, and cable charging ratings.

Table 7. VCP-W Breaker Stored Energy Mechanism Control Power Requirements

Rated Control Voltage	Spring Charge Motor			UV Trip mA (Maximum)	Voltage Range		Ind. Light Amperes
	Run Amperes	Time (Seconds)	Close or Trip Amperes		Close	Trip	
48 Vdc	9.0	6	16	200	38 – 56	28 – 56	.35
125 Vdc	4.0	6	7	80	100 – 140	70 – 140	.35
250 Vdc	2.0	6	4	40	200 – 280	140 – 280	.35
120 Vac	4.0	6	6	—	104 – 127	104 – 127	.35
240 Vac	2.0	6	3	—	208 – 254	208 – 254	.35

Table 8. Main Breaker Relays

ANSI Number	Relay Type	Function
50/51 50/51N 50/51G	Digitrip 3000	Microprocessor overcurrent Multi-function, long, short, flat, It, I^2t, I^4t, phase and ground
27/47	—	Undervoltage, phase sequence and unbalanced voltage
86	—	Lockout

Starter Fuse Information

Table 9. Fuse Coordination Recommendations — 400 Ampere Contactor

Minimum FLA	Maximum FLA	Fuse Rating	CT Ratio
10.0	22.9	70-2R	25:5
23.0	31.1	70-2R	50:5
31.2	41.9	100-3R	50:5
42.0	46.7	100-3R	75:5
46.8	62.9	130-4R	75:5
63.0	74.7	150-5R	100:5
74.8	82.9	170-6R	100:5
83.0	93.5	170-6R	150:5
93.6	123.9	200-9R	150:5
124.0	137.0	200-9R	200:5
137.1	165.9	230-12R	200:5
166.0	187.0	230-12R	300:5
187.1	246.9	390-18R	300:5
247.0	328.9	450-24R	400:5
329.0	360.0	450-24R	600:5
360.1	400.0	450-24R	600:5

Table 10. Fuse Coordination Recommendations — 800 Ampere Contactor

Minimum FLA	Maximum FLA	Fuse Rating	CT Ratio
200.0	250.0	450-24R	300:5
250.1	330.0	450-24R	400:5
330.1	499.0	650-36R	600:5
500.0	650.1	700-44R	800:5
650.1	720.0	700-44R	1000:5

Layout Dimensions

Full Voltage Squirrel Cage Starters Catalog S/R/E210 Non-Reversing Catalog S/R/E310 Reversing

Equipment Details

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- Drawout 3-pole gang-operated line isolating switch assembly with two-direction driven isolating shutter, external operating handle interlocked to prevent opening the medium voltage compartment door until the isolating switch is open and grounded.
- Vertically mounted current limiting power fuses with pop-up blown fuse indicators.
- One magnetic 3-pole vacuum contactor with dc operating coils and mechanical interlock to prevent opening the isolating switch when contactor is closed.
- One control power transformer (115-volt secondary).
- Two CPT primary current limiting fuses.
- One control circuit secondary fuse.
- One run-test circuit.
- Four electrical interlocks (2NO, 2NC).
- Three current transformers.
- Three screw-type load connectors.

Reversing Starter

- One additional magnetic 3-pole vacuum contactor (duplicate of above), both contactors are mechanically and electrically interlocked.

Mounted on Inside of Medium Voltage Door

- One set of operating and maintenance instructions.
- Two renewal parts nameplates.

Mounted in the Low Voltage Section

- Control panel on slide rails with:
  - ❑ One adjustable thermal overload relay, temperature compensated, 3-pole, hand reset
  - ❑ One interposing control relay
- Set of control circuit terminal blocks.

Specifications

Table 11. Starter Selection Information — Dimensions in Inches (mm)

Horsepower ①	Volts	Contactor Ampere Rating (Enclosed)	Starter Int. Rating (kVA)	Equip. Arrgt. Figure No.	Dimensions			Add. Starter Spaces	Weight Lbs. (kg)
					Height ②	Width	Depth		
2200 – 2400 Volts Non-Reversing									
700/800 ③	2300	200	200,000	1	90 (2286)	36 (914.4)	30 (762)	1	1350 (613)
1500/1750 ④	2300	400	200,000	1	90 (2286)	36 (914.4)	30 (762)	1	1350 (613)
3000	2300	720	200,000	2	90 (2286)	40 (1016.0)	30 (762)	0	1700 (772)
2200 – 2400 Volts Reversing									
700/800 ③	2300	200	200,000	3	90 (2286)	36 (914.4)	30 (762)	1	1800 (817)
1500/1750 ④	2300	400	200,000	3	90 (2286)	36 (914.4)	30 (762)	1	1800 (817)
3000	2300	720	200,000	4	90 (2286)	40 (1016.0)	30 (762)	0	2400 (1090)
4000 – 4800 Volts Non-Reversing									
1250/1500 ③	4600	200	400,000	1	90 (2286)	36 (914.4)	30 (762)	1	1350 (613)
2500/3000 ④	4600	400	400,000	1	90 (2286)	36 (914.4)	30 (762)	1	1350 (613)
5500	4600	720	400,000	2	90 (2286)	40 (1016.0)	30 (762)	0	1700 (772)
4000 – 4800 Volts Reversing									
1250/1500 ③	4600	200	400,000	3	90 (2286)	36 (914.4)	30 (762)	0	1800 (817)
2500/3000 ④	4600	400	400,000	3	90 (2286)	36 (914.4)	30 (762)	0	1800 (817)
5500	4600	720	400,000	4	90 (2286)	40 (1016.0)	30 (762)	0	2400 (1090)
7200 Volts Non-Reversing									
2000/2250 ③	7200	200	570,000	1	90 (2286)	36 (914.4)	30 (762)	1	1500 (681)
4000/4500 ④	7200	400	570,000	1	90 (2286)	36 (914.4)	30 (762)	1	1500 (681)
8000	7200	720	570,000	2	90 (2286)	40 (1016.0)	30 (762)	0	1800 (817)
7200 Volts Reversing									
2000/2250 ③	7200	200	570,000	3	90 (2286)	36 (914.4)	30 (762)	0	1800 (817)
4000/4500 ④	7200	400	570,000	3	90 (2286)	36 (914.4)	30 (762)	0	1800 (817)
8000	7200	720	570,000	4	90 (2286)	40 (1016.0)	30 (762)	0	2400 (1090)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 100 inches (2540.0 mm).
③ At higher hp rating, maximum acceleration time is 3.5 seconds.
④ At higher hp rating, maximum acceleration time is 6 seconds.

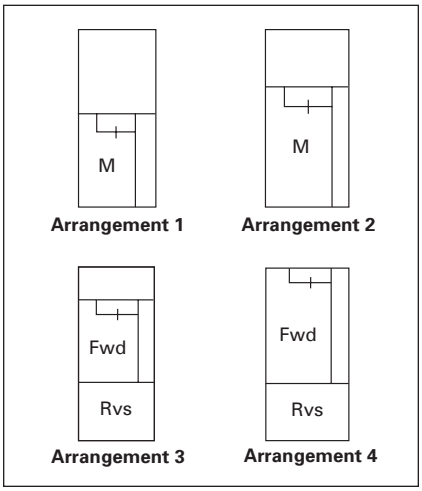


Figure 8. Starter Arrangements

Dimensions for estimating purposes only.

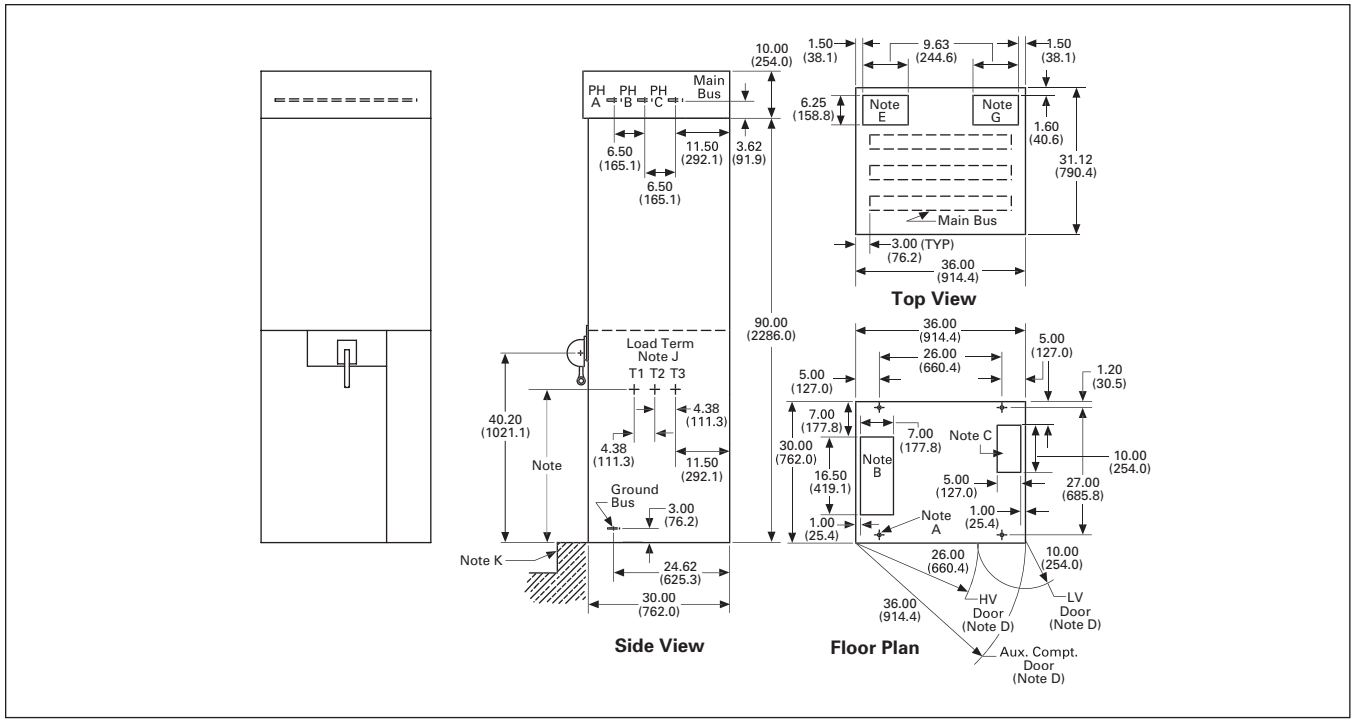


Figure 9. Arrangement 1 Detail (Full Voltage 400 Amperes) — See Table 12 for Notes

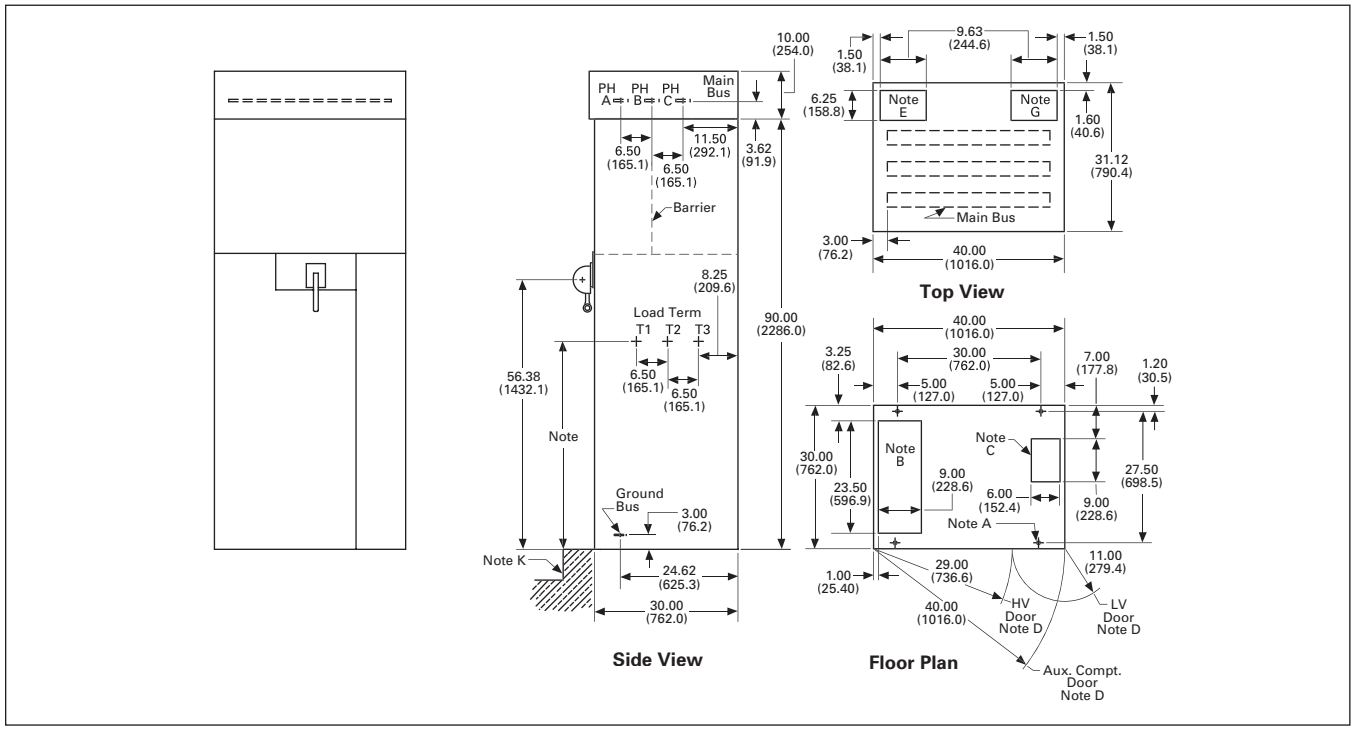


Figure 10. Arrangement 2 Detail (Full Voltage 800 Amperes) — See Table 12 for Notes

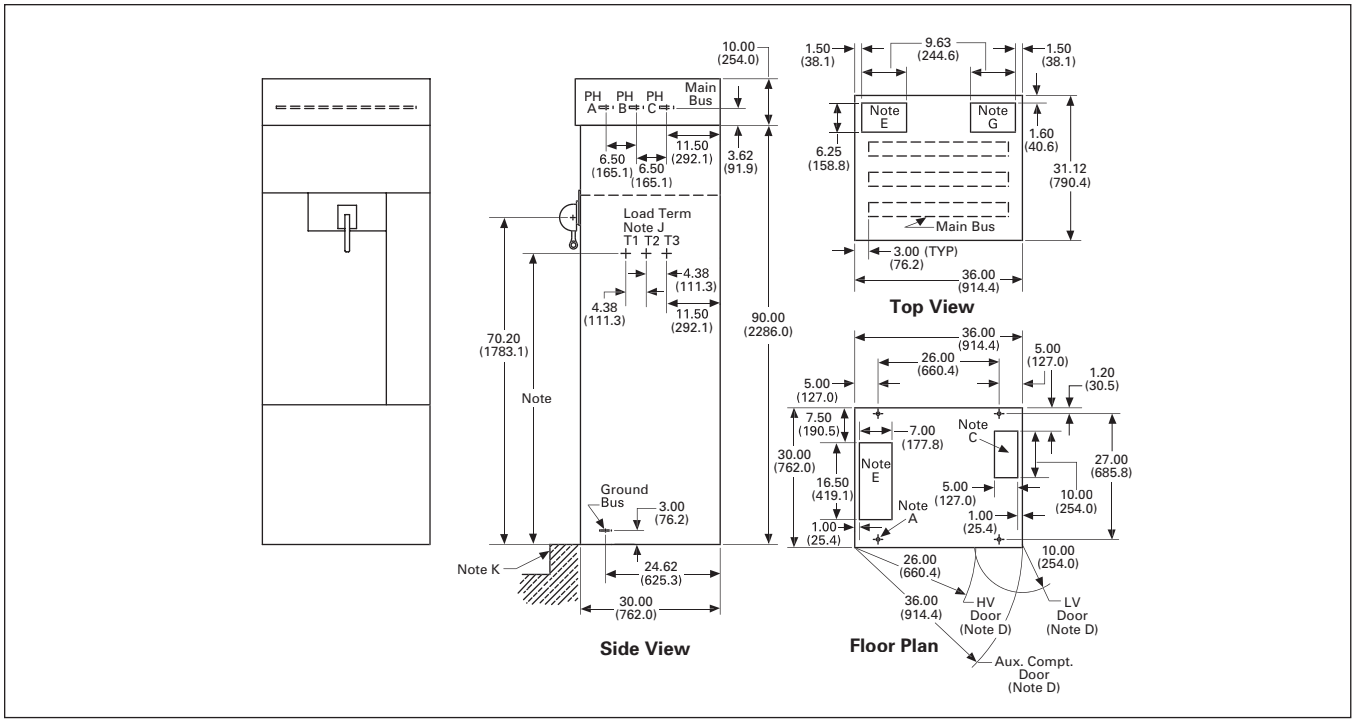


Figure 11. Arrangement 3 Detail (Full Voltage Reversing 400 Amperes) — See Table 12 for Notes

Table 12. Arrangement Detail Notes

Cable Notes

1	Line connection is designed for maximum of one 4/0 cable.
2	Line connection is designed for maximum of two 500 kcmil.
3	Load connection is designed for maximum of one 350 kcmil.
4	Load connection is designed for maximum of one 750 kcmil.

Arrangement Notes

A	.875 diameter typical 4 holes. Mounting studs must extend a minimum of 2.50" above grade.
B	High voltage conduit space, line and load for two-high starters, upper starter cable should enter in rear half of conduit space and lower starter should enter in front half of conduit space.
B1	High voltage conduit space, (line without main bus).
B2	High voltage conduit space, (incoming line connection).
C	Low voltage conduit space for two-high starters control wiring for upper starter should enter in rear half of conduit space and lower starter control wiring should enter in front half of conduit space.
D	Door dim's to open doors 90°. Auxiliary compartment door not applicable for two-high starters.
E	High voltage conduit space, load.
F	High voltage conduit space, line only.
G	Low voltage conduit space only.
H	For top entry load terminals located 32.50" from bottom of enclosure; for bottom entry load terminals located 18.00" from bottom of enclosure.
H1	For top entry load terminals located 76.00" from bottom of enclosure; for bottom entry 61.00" from bottom of enclosure.
H2	For top entry load terminals located 53.00" from bottom of enclosure; for bottom entry load terminals located 40.50" from bottom of enclosure.
H3	For top entry load terminals located 62.50" from bottom of enclosure; for bottom entry load terminals located 48.00" from bottom of enclosure.
H4	For top entry load terminals located 43.00" from bottom of enclosure; for bottom entry load terminals located 50.00" from bottom of enclosure.
J	Load terminals located on left-hand side of enclosure.
J1	Load terminals located in reduced voltage enclosure on left-hand side.
K	Maximum sill height 6.00" and maximum sill extension 3.00" for removal of contactor without lifting device.
L	Line terminal for top cable entry.
M	Line terminal for bottom cable entry.
X	Steel bottom with removable lead plates.
Y	Tolerances -0.0" +.25" per structure.
Z	Conduits to extend a maximum of 2.00" into structure.

Primary Reactor, Reduced Voltage Starters
Catalog S/R/E510 Non-Reversing
Catalog S/R/E710 Reversing

Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with two-direction driven isolating shutter, external operating handle interlocked to prevent opening the medium voltage compartment door until the isolating switch is open and grounded.
- One vertically mounted current limiting power fuse with pop-up blown fuse indicators.
- One magnetic 3-pole vacuum contactor with dc operating coils and mechanical interlock to prevent opening the isolation switch when the contactor is closed.
- One control power transformer (115-volt secondary).
- Two CPT primary current limiting fuses.
- One control circuit secondary fuse.
- One run-test circuit.
- Four electrical interlocks (2NO, 2NC).

Reversing Starter

- One additional magnetic contactor (duplicate of above), both contactors are mechanically and electrically interlocked.

Mounted on Inside of Medium Voltage Door

- One set of operating and maintenance instructions.
- One renewal parts nameplate.

Mounted in the Low Voltage Section

- One control panel on slide rails with:
  - ❑ One adjustable thermal overload relay, temperature compensated, 3-pole, hand reset
  - ❑ One adjustable pneumatic timing relay
  - ❑ Two interposing relays
  - ❑ One current transition relay
  - ❑ Incomplete sequence timer
- One set of control circuit terminal blocks.

Reduced Voltage Structure

- One magnetic 3-pole vacuum run contactor with dc operating coil and electrical interlocks.
- Three current transformers.
- Three screw-type load connectors.
- One 3-phase starting reactor with 50 – 65 – 80% taps.

Starting Characteristics

Table 14. Starting Characteristics

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
502 Reactor				
80% Tap	80	80	80	64
65% Tap ⑤	65	65	65	42
50% Tap	50	50	50	25

⑤ Factory set on 65% tap.

Specifications

Table 13. Starter Selection Information — Dimensions in Inches (mm)

Horsepower ①	Volts	Contactor Ampere Rating (Enclosed)	Starter Int. Rating (kVA)	Equip. Arrgt. Figure No.	Dimensions			Weight Lbs. (kg)
					Height ②	Width	Depth	
2200 – 2400 Volts Non-Reversing								
700/800 ③	2300	200	200,000	1	90 (2286)	72 (1828.8)	30 (762)	2800 (1271)
1500/1750 ④	2300	400	200,000	1	90 (2286)	72 (1828.8)	30 (762)	2800 (1271)
3000	2300	720	200,000	2	90 (2286)	80 (2032.0)	30 (762)	4000 (1816)
2200 – 2400 Volts Reversing								
700/800 ③	2300	200	200,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
1500/1750 ④	2300	400	200,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
3000	2300	720	200,000	4	90 (2286)	80 (2032.0)	30 (762)	4650 (2111)
4000 – 4800 Volts Non-Reversing								
1250/1500 ③	4600	200	400,000	1	90 (2286)	72 (1828.8)	30 (762)	2800 (1271)
2500/3000 ④	4600	400	400,000	1	90 (2286)	72 (1828.8)	30 (762)	2800 (1271)
5500	4600	720	400,000	2	90 (2286)	80 (2032.0)	30 (762)	4000 (1816)
4000 – 4800 Volts Reversing								
1250/1500 ③	4600	200	400,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
2500/3000 ④	4600	400	400,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
5500	4600	720	400,000	4	90 (2286)	80 (2032.0)	30 (762)	4650 (2111)
7200 Volts Non-Reversing								
2000/2250 ③	7200	200	570,000	1	90 (2286)	72 (1828.8)	30 (762)	3300 (1498)
4000/4500 ④	7200	400	570,000	1	90 (2286)	72 (1828.8)	30 (762)	3300 (1498)
8000	7200	720	570,000	2	90 (2286)	80 (2032.0)	30 (762)	4650 (2111)
7200 Volts Reversing								
2000/2250 ③	7200	200	570,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
4000/4500 ④	7200	400	570,000	3	90 (2286)	72 (1828.8)	30 (762)	3250 (1476)
8000	7200	720	570,000	4	90 (2286)	80 (2032.0)	30 (762)	4650 (2111)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 100 inches (2540.0 mm).
③ At higher hp rating maximum acceleration time is 3.5 seconds.
④ At higher hp rating maximum acceleration time is 6 seconds.

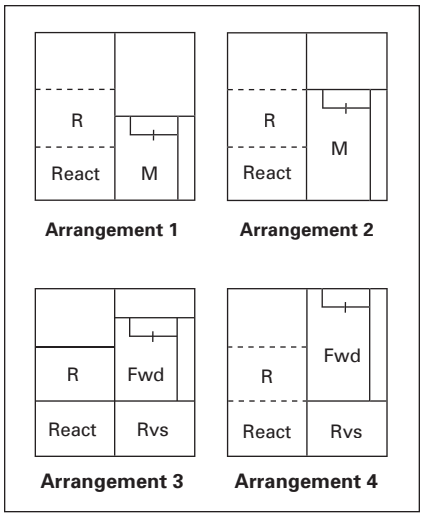


Figure 12. Starter Arrangements

Dimensions for estimating purposes only.

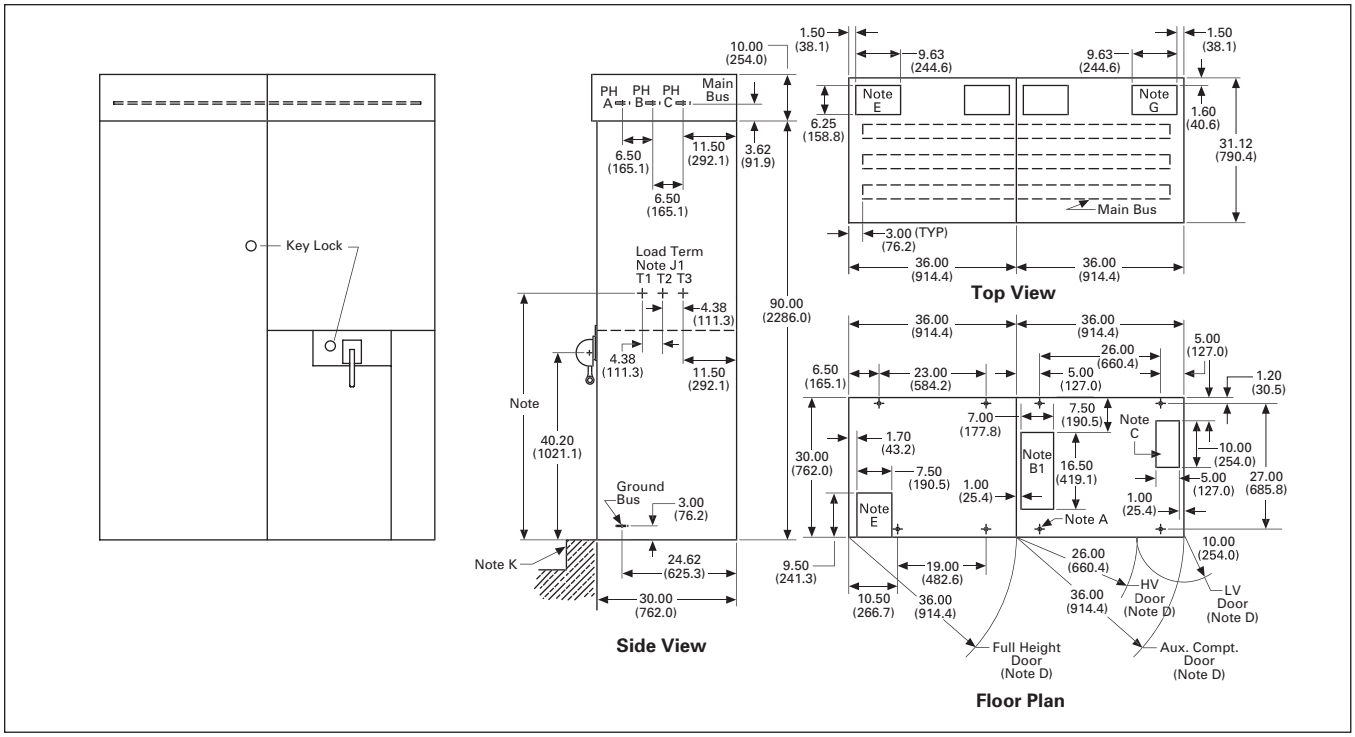


Figure 13. Arrangement 1 Detail (Reduced Voltage, 400 Amperes) — See Table 12 for Notes

Reduced Voltage Autotransformer Starters Catalog S/R/E610 Non-Reversing Catalog S/R/E810 Reversing

Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with two-direction driven isolating shutter, external operating handle interlocked to prevent opening the medium voltage compartment door until the isolating switch is open and grounded.
- Three vertically mounted current limiting power fuses with pop-up blown fuse indicators.
- One magnetic 3-pole vacuum contactor with dc operating coils and mechanical interlock to prevent opening the isolation switch when the contactor is closed.
- One control power transformer (115-volt secondary).
- Two CPT primary current limiting fuses.
- One control circuit secondary fuse.
- One run-test circuit.
- Four electrical interlocks (2NO, 2NC).

Reversing Starter

- One additional magnetic contactor (duplicate of above), both contactors are mechanically and electrically interlocked.

Mounted on Inside of Medium Voltage Door

- One set of operating and maintenance instructions.
- One renewal parts nameplate.

Mounted in the Low Voltage Section

- One control relay panel on slide rails with:
  - ❑ One adjustable thermal overload relay, temperature compensated, 3-pole, hand reset
  - ❑ One current transition relay
  - ❑ One incomplete sequence relay
  - ❑ Three interposing relays
- One set of control circuit terminal blocks.

Reduced Voltage Structure(s)

- One magnetic 3-pole vacuum run contactor with dc operating coil and electrically and mechanically interlocked with the starting contactor.
- One magnetic 2-pole vacuum start contactor with dc operating coil and electrical interlocks.
- Three current transformers.
- Three screw-type load connectors.
- One open delta starting autotransformer with 50 – 65 – 80% taps.
- Three distribution class lightning arresters for high voltage stress protection on the transformer zero tap.

Specifications

Table 15. Starter Selection Information — Dimensions in Inches (mm)

Horsepower ①	Volts	Contactor Ampere Rating (Enclosed)	Starter Int. Rating (kVA)	Equip. Arrgt. Figure No.	Dimensions Height ②	Width	Depth	No. of Structures	Weight Lbs. (kg)
2200 – 2400 Volts Non-Reversing									
700/800 ③	2300	200	200,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
1500/1750 ④	2300	400	200,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
3000	2300	720	200,000	2	90 (2286)	120 (3048.0)	30 (762)	3	4800 (2179)
2200 – 2400 Volts Reversing									
700/800 ③	2300	200	200,000	3	90 (2286)	72 (1828.8)	30 (762)	2	3650 (1657)
1500/1750 ④	2300	400	200,000	3	90 (2286)	72 (1828.8)	30 (762)	2	3650 (1657)
3000	2300	720	200,000	4	90 (2286)	120 (3048.0)	30 (762)	3	5650 (2565)
4000 – 4800 Volts Non-Reversing									
1250/1500 ③	4600	200	400,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
2500/3000 ④	4600	400	400,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
5500	4600	720	400,000	2	90 (2286)	120 (3048.0)	30 (762)	3	4800 (2179)
4000 – 4800 Volts Reversing									
1250/1500 ③	4600	200	400,000	3	90 (2286)	72 (1828.8)	30 (762)	2	3650 (1657)
2500/3000 ④	4600	400	400,000	3	90 (2286)	72 (1828.8)	30 (762)	2	3650 (1657)
5500	4600	720	400,000	4	90 (2286)	120 (3048.0)	30 (762)	3	5650 (2565)
7200 Volts Non-Reversing									
2000/2250 ③	7200	200	570,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
4000/4500 ④	7200	400	570,000	1	90 (2286)	72 (1828.8)	30 (762)	2	3100 (1407)
8000	7200	720	570,000	2	90 (2286)	120 (3048.0)	30 (762)	3	4800 (2179)
7200 Volts Reversing									
2000/2250 ③	7200	200	570,000	3	90 (2286)	72 (1828.8)	30 (762)	3	3650 (1657)
4000/4500 ④	7200	400	570,000	3	90 (2286)	72 (1828.8)	30 (762)	3	3650 (1657)
8000	7200	720	570,000	4	90 (2286)	120 (3048.0)	30 (762)	4	5650 (2565)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 100 inches (2540.0 mm).
③ At higher hp rating, maximum acceleration time is 3.5 seconds.
④ At higher hp rating, maximum acceleration time is 6 seconds.

Dimensions for estimating purposes only.

Starting Characteristics

Table 16. Starting Characteristics

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
602 Autotransformer				
80% Tap	80	80	67	64
65% Tap ⑤	65	65	45	42
50% Tap	50	50	28	25

⑤ Factory set on 65% tap.

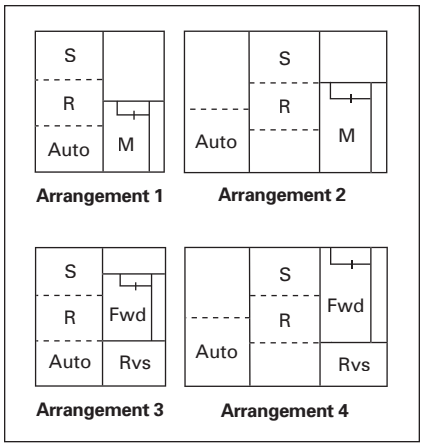


Figure 14. Starter Arrangements

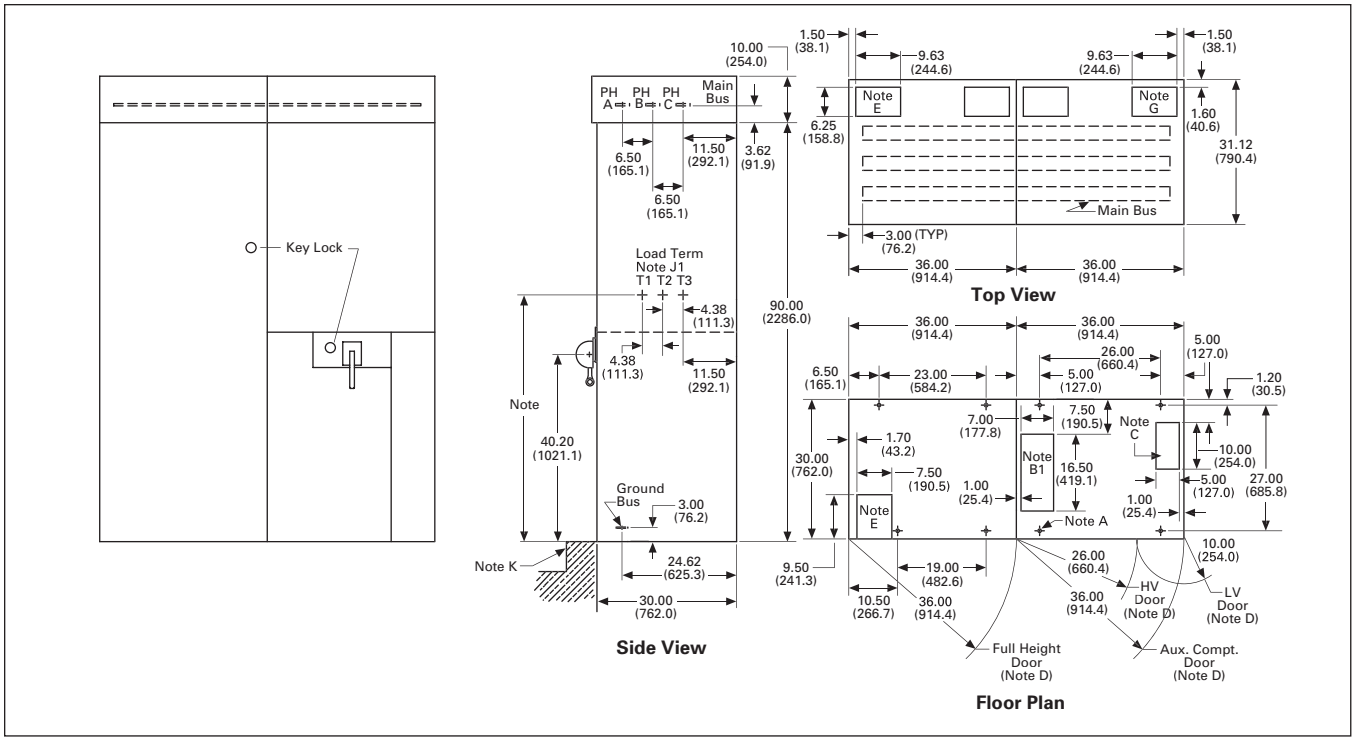


Figure 15. Arrangement 1 Detail (Reduced Voltage, 400 Amperes) — See Table 12 for Notes

Full Voltage Synchronous Starters Brush Type Mark V Solid-State Catalog S/R/E241 Non-Reversing Catalog S/R/E341 Reversing

Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with two-direction driven isolating shutter. External operating handle interlocked to prevent opening the medium voltage compartment door until the isolating switch is open and grounded.
- Three vertically mounted current limiting power fuses with pop-up blown fuse indicators.
- One magnetic 3-pole vacuum contactor with dc operating coils and mechanical interlock to prevent opening the isolation switch when the contactor is closed.
- One control power transformer (115-volt secondary).
- Two CPT primary current limiting fuses.
- One control circuit secondary fuse.
- One run-test circuit.
- Four electrical interlocks (2NO, 2NC).
- Three current transformers.
- Three screw-type load connectors reversing starter.

Reversing Starter

- One additional magnetic contactor (duplicate of above), both contactors are mechanically and electrically interlocked.

Mounted on Inside of Medium Voltage Door

- One set of operating and maintenance instructions.
- One renewal parts nameplate.

Mounted in the Low Voltage Section

- One control panel on slide rails with:
  - ❑ One adjustable thermal overload relay, temperature compensated 3-pole, hand reset
  - ❑ One interposing relay
  - ❑ One set of control circuit terminal blocks

Mounted in the Upper Compartment or Auxiliary Structure

- One brush-type solid-state Mark V field panel with:

Mounted on Door

- ❑ One ac line ammeter, panel type
- ❑ One dc field ammeter, panel type
- ❑ One exciter field potentiometer
- ❑ One set of externally ventilated heatsinks

Mounted on Inside Compartment

- ❑ One step-down exciter transformer 3-phase
- ❑ One "SCR" power supply panel
- ❑ One synchronous control board
- ❑ Three "MOV" surge protection
- ❑ One field loss current relay
- ❑ One ammeter shunt
- ❑ One set of control circuit blocks
- ❑ Three primary fuses
- ❑ Three secondary fuses

Mounted on Top of Starter

- ❑ One starting and field discharge resistor

Specifications

Table 17. Starter Selection Information — Dimensions in Inches (mm)

Horsepower at .8 PF ①	Horsepower at 1.0 PF	Volts	Contactor Amp. Rating (Encl.)	Starter Int. Rating (kVA)	Equip. Arrgt. Figure No.	Dimensions Height ②③	Width	Depth	No. of Structures	Weight Lbs. (kg)
2200 – 2400 Volts Non-Reversing										
700/800 ④	900/1000 ④	2300	200	200,000	1	90 (2286)	36 (914.4)	30 (762)	1	1500 (681)
1500/1750 ⑤	1750/2000 ⑤	2300	400	200,000	1	90 (2286)	36 (914.4)	30 (762)	1	1500 (681)
3000	3500	2300	720	200,000	2	90 (2286)	76 (1930.4)	30 (762)	1	2350 (1067)
2200 – 2400 Volts Reversing										
700/800 ④	900/1000 ④	2300	200	200,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
1500/1750 ⑤	1750/2000 ⑤	2300	400	200,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
3000	3500	2300	720	200,000	4	90 (2286)	76 (1930.4)	30 (762)	2	2900 (1317)
4000 – 4800 Volts Non-Reversing										
1250/1500 ④	1500/1750 ④	4600	200	400,000	1	90 (2286)	36 (914.4)	30 (762)	1	1550 (704)
2500/3000 ⑤	3000/3500 ⑤	4600	400	400,000	1	90 (2286)	36 (914.4)	30 (762)	1	1550 (704)
5500	6000	4600	720	400,000	2	90 (2286)	76 (1930.4)	30 (762)	1	2350 (1067)
4000 – 4800 Volts Reversing										
1250/1500 ④	1500/1750 ④	4600	200	400,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
2500/3000 ⑤	3000/3500 ⑤	4600	400	400,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
5500	6000	4600	720	400,000	4	90 (2286)	76 (1930.4)	30 (762)	2	2900 (1317)
7200 Volts Non-Reversing										
2000/2250 ④	2500/2750 ④	7200	200	570,000	1	90 (2286)	36 (914.4)	30 (762)	1	1700 (772)
4000/4500 ⑤	5000/5500 ⑤	7200	400	570,000	1	90 (2286)	36 (914.4)	30 (762)	1	1700 (772)
8000	10,000	7200	720	570,000	2	90 (2286)	76 (1930.4)	30 (762)	1	2500 (1135)
7200 Volts Reversing										
2000/2250 ④	2500/2750 ④	7200	200	570,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
4000/4500 ⑤	5000/5500 ⑤	7200	400	570,000	3	90 (2286)	72 (1828.8)	30 (762)	2	2100 (953)
8000	10,000	7200	720	570,000	4	90 (2286)	76 (1930.4)	30 (762)	2	2900 (1317)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 100 inches (2540.0 mm).
③ Starting and discharge resistors are mounted on top, add 13 inches (330.2 mm) to the height.
④ At higher hp rating maximum acceleration time is 3.5 seconds.
⑤ At higher hp rating maximum acceleration time is 6 seconds.

Dimensions for estimating purposes only.

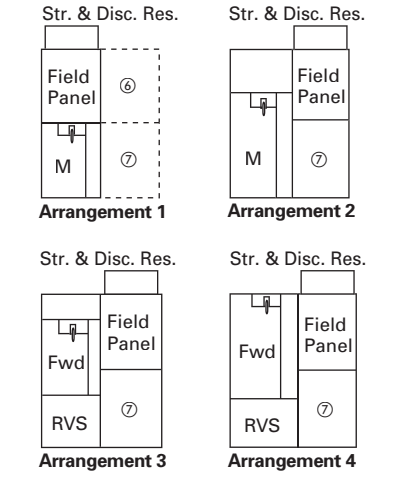


Figure 16. Starter Arrangements

⑥ When the field panel requirement exceeds 88 amperes at 125 Vdc or 44 amperes at 250 Vdc, an auxiliary structure 36 inches (914.4 mm) wide is required.
⑦ Mounting location of exciter transformer when field panel requirement exceeds 88 amperes at 125 Vdc or 44 amperes at 250 Vdc. Otherwise compartment is blank.

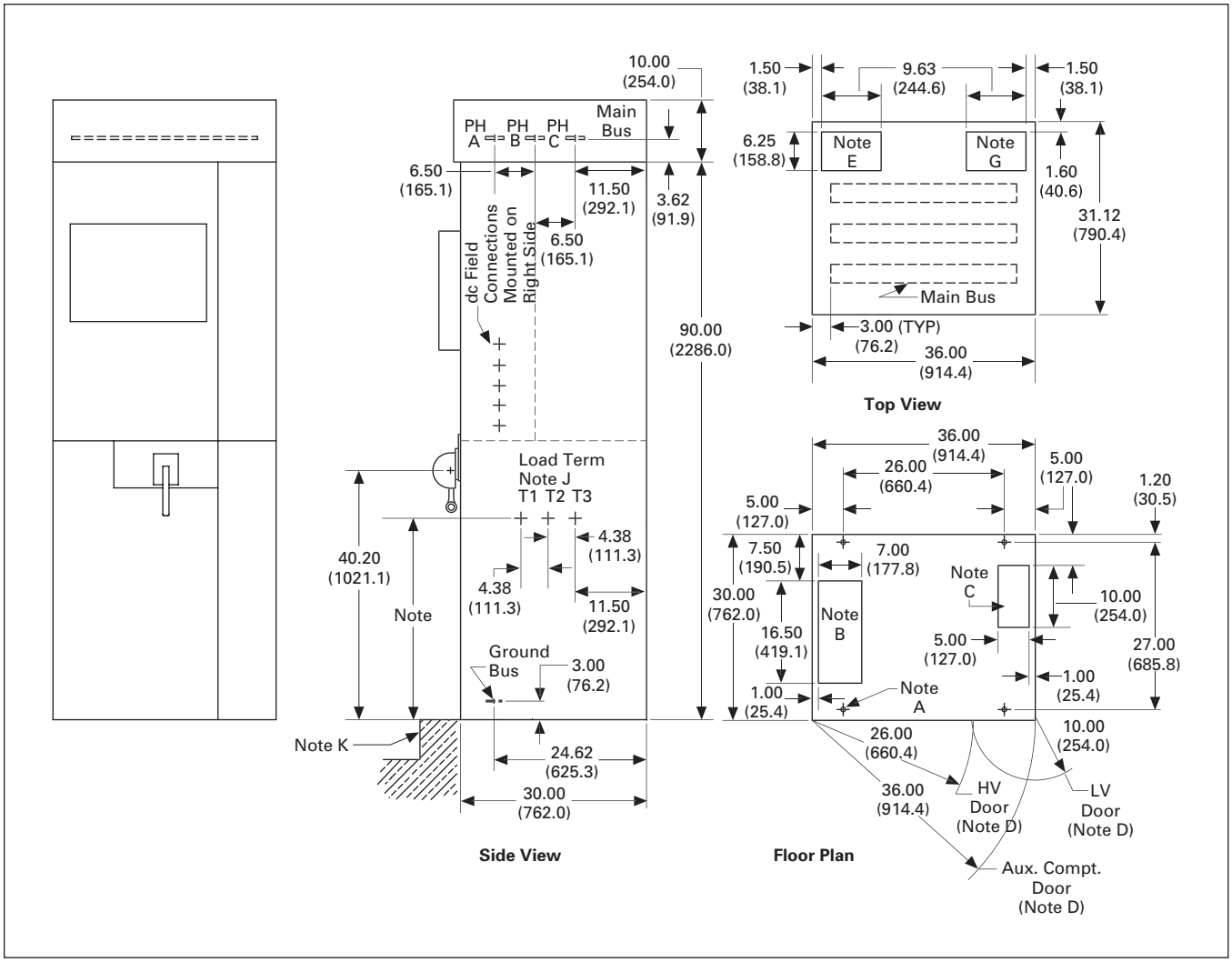


Figure 17. Arrangement 1 Detail (400 Amperes, Synchronous) — See Table 12 for Notes

Ampgard *IT.* Soft Start

The 400 ampere Ampgard ***IT.*** Soft Start requires one full height structure with a full voltage starter in the upper compartment bus connected to a soft start truck assembly in the lower compartment. The soft starter includes internal fault protection and some built-in basic motor protection. The standard assembly includes an MP-3000 motor relay for motor protection.

Why is soft starting desirable?

- Eliminate water hammer in hydraulic systems.
- Eliminate shock to your mechanical components.
- Avoid coupling and shaft damage.
- Prevent rotor and winding failure.
- Stop drive belt squeal and breakage.
- Prevent water hammer in pipes.
- Soft stop the pump motors.
- Reduce pressure so valves close gently.
- Avoid the surge wave.
- Reduce peak starting currents.
- Eliminate voltage drop on motor start.

Ratings

- 2300 – 4800 Vac grounded systems.
- 60 kV BIL impulse rating.
- Continuous current: 200 and 400 amperes.

The Ampgard ***IT.*** Soft Start is recommended for application only on power systems that are solidly grounded or resistance grounded. Ungrounded systems are not recommended.

Industry Standards

The Ampgard ***IT.*** Soft Start is designed and built to meet all applicable industry standards including UL listing as a complete assembly.

- NEMA ICS3 – 93.
- UL 347.
- CSA.
- EEMAC E14-1.
- Manufactured in an ISO® 9001 and ISO 14001 certified facility.

Starting Characteristics

The soft start controller provides a number of selectable starting characteristics as standard:

Kick Start

Provides an initial boost of current to overcome motor and system inertia.

Ramp Start

Operator sets the initial starting torque value then raises the torque to full voltage.

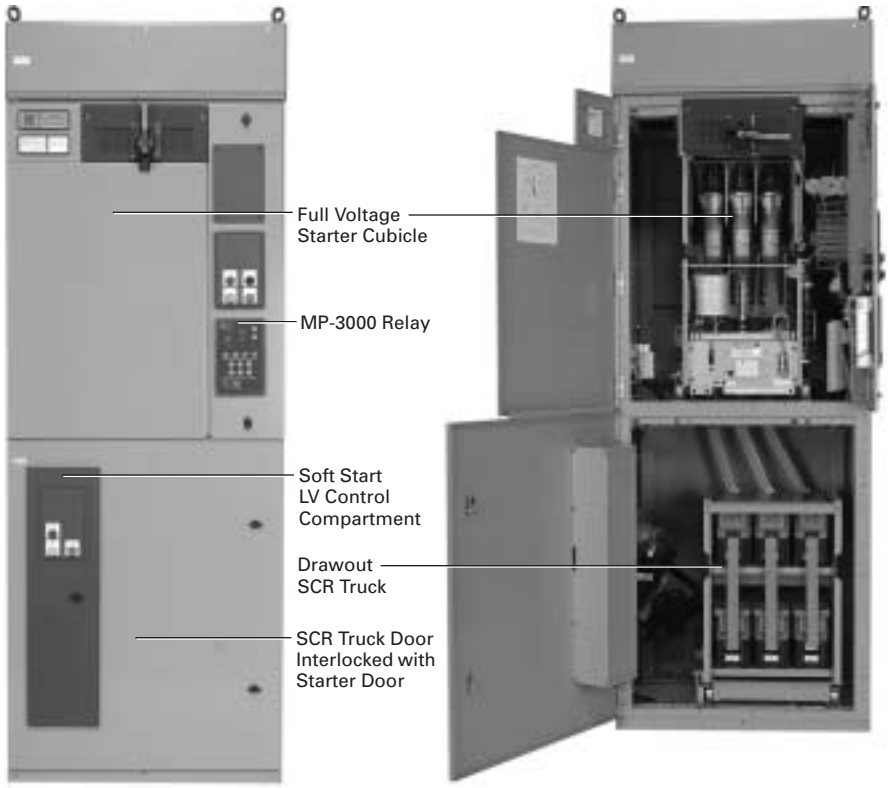
Current Limit

Limits the maximum starting current. Used in long start time applications and motor protection applications.

Soft Stop

Provides extended coast to rest time. Used in high friction load applications where a sudden stop may cause system damage.

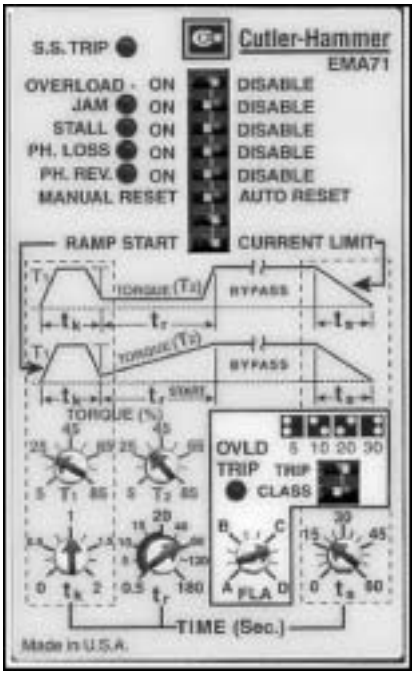
An optional pump control algorithm provides a special S shaped torque curve that can eliminate water hammer in hydraulic systems.



Ampgard IT. Soft Start

Settings are selected via DIP switches on the operator interface located behind the low voltage door on the lower compartment.

Lower Compartment Low Voltage Door



CIM Operator Interface

The pole units include an integrated run contactor and are rated 2500 volts per set. One set is required for systems up to 2500 volts and two sets in series are required for systems up to 5000 volts.

2500 Volt Pole Unit

Pole units are mounted in a easy to remove rollout truck assembly. Maintenance can be performed with the truck on a bench away from the starter cubicle.

SCR Truck Removal

Rollout SCR Truck

How *IT.* Works

1. Industry exclusive integral run contactor dramatically reduces overall size of starter.
2. Run contactor is open, all current passes through the SCRs and voltage is reduced per program requirements.
3. After full start is complete, the run contactor closes then the SCRs are turned off (closed transition).
4. The SCRs are on only a short time therefore no MCC venting or cooling is required.
5. Because the run contactor never sees the in-rush current, it is sized only for full load amperes.

An optional bypass truck is available that will allow full voltage starting in case of emergency.

Bypass Truck

Reduced Voltage Solid-State Squirrel Cage Starters Non-Reversing

Equipment Details

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- Drawout 3-pole gang-operated line isolating switch assembly with two-direction driven isolating shutter, ex-ternal operating handle interlocked to prevent opening the medium voltage compartment door until the isolating switch is open and grounded.
- Vertically mounted current limiting power fuses with pop-up blown fuse indicators.
- One magnetic 3-pole vacuum contactor with dc operating coils and mechanical interlock to prevent opening the isolating switch when contactor is closed.
- One control power transformer (115-volt secondary).
- Two CPT primary current limiting fuses.
- One control circuit secondary fuse.
- One run-test circuit.
- Four electrical interlocks (2NO, 2NC).
- Three current transformers.
- Three screw-type load connectors.
- Withdrawable SCR truck with integral bypass contactor.

Mounted on Inside of Medium Voltage Door

- One set of operating and maintenance instructions.
- Two renewal parts nameplates.

Mounted in the Low Voltage Section

- Control panel on slide rails with:
  - One MP-3000 motor protection relay
  - One interposing control relay
- Set of control circuit terminal blocks.

Mounted in Lower Door

- 24 Vdc power supply.
- Soft start control module and CIM.
- Status lights for soft starter fault and bypass mode.
- Fault reset button.

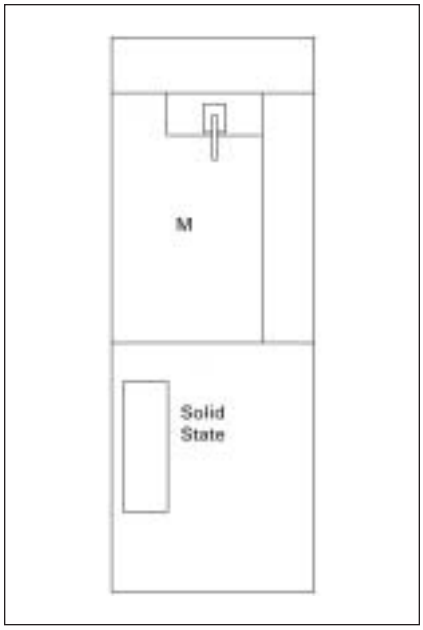


Figure 18. Starter Arrangement

Specifications

Table 18. Starter Selection Information — Dimensions in Inches (mm)

Horsepower ①	Volts	SCR/ Contactor Ampere Rating (Enclosed)	Starter Int. Rating (kVA)	Equip. Arrgt. Figure No.	Dimensions			Add. Starter Spaces	Weight Lbs. (kg)
					Height	Width	Depth		
2200 – 2400 Volts Non-Reversing									
1500/1750 ②	2300	400	200,000	1	100 (2540)	36 (914.4)	30 (762)	1	2000 (908)
4000 – 4800 Volts Non-Reversing									
2500/3000 ②	4600	400	400,000	1	100 (2540)	36 (914.4)	30 (762)	1	2000 (908)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② Maximum acceleration time is 180 seconds. Consult factory for times beyond 180 seconds.

Dimensions for estimating purposes only.

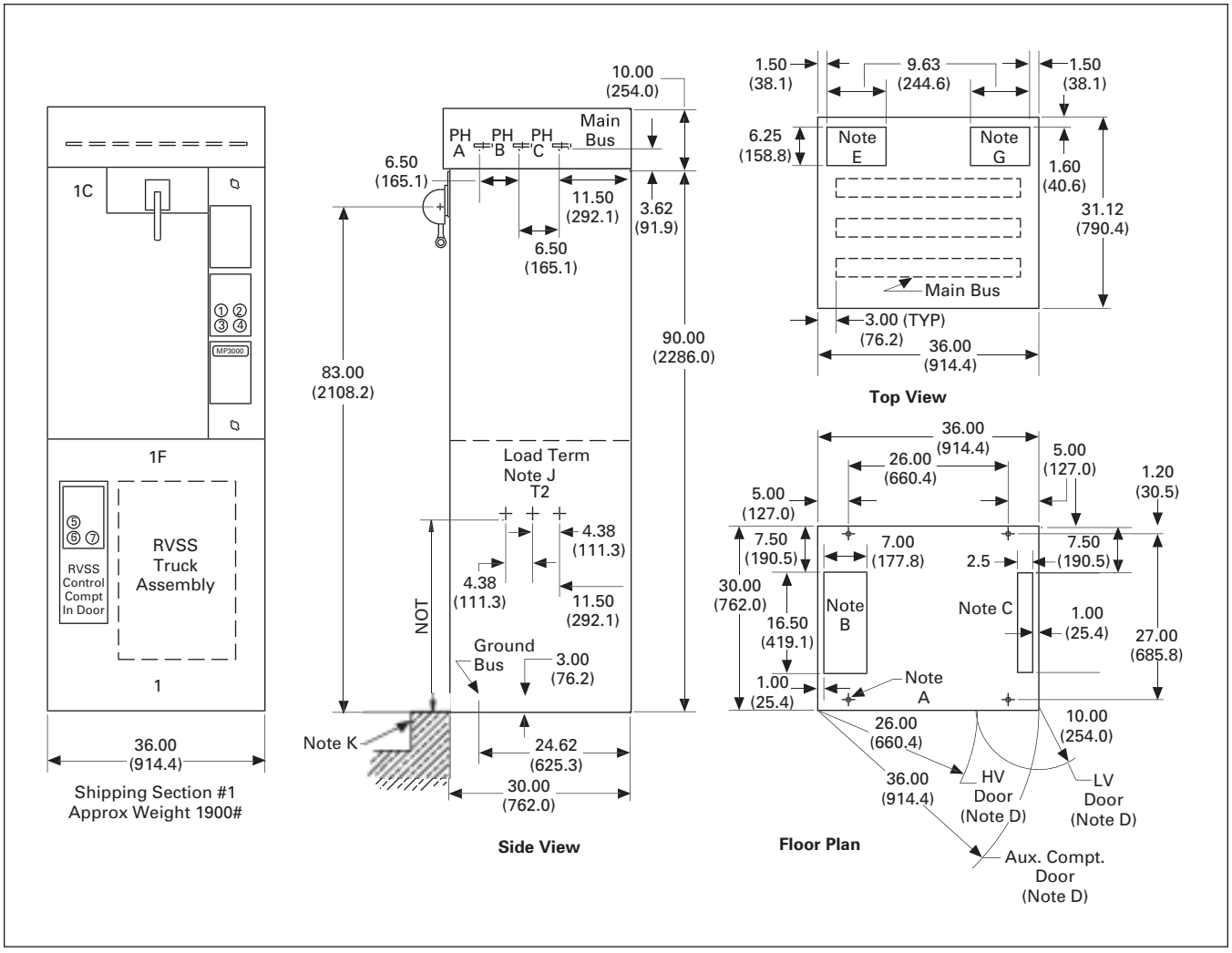


Figure 19. Arrangement Detail (400 Amperes Reduced Voltage Solid State) — See Table 12 for Notes

Incoming Line/PT Layouts — Dimensions in Inches (mm)

When ordering you must specify:

- Field data.
- dc field amperes.
- dc field voltage.
- Starting and discharge resistor ohms and amperes.
- Options.
- dc voltmeter.
- Other modifications.

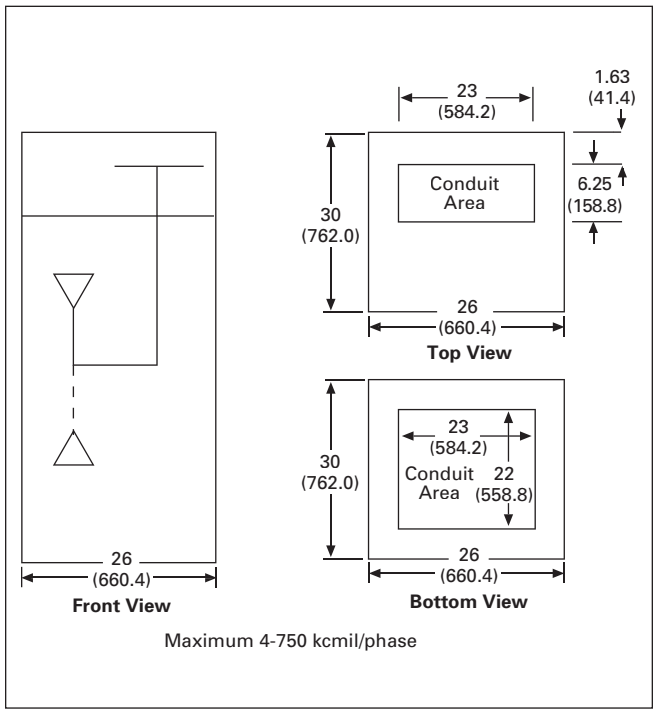


Figure 20. Incoming Line — 26-Inch (660.4 mm) Wide

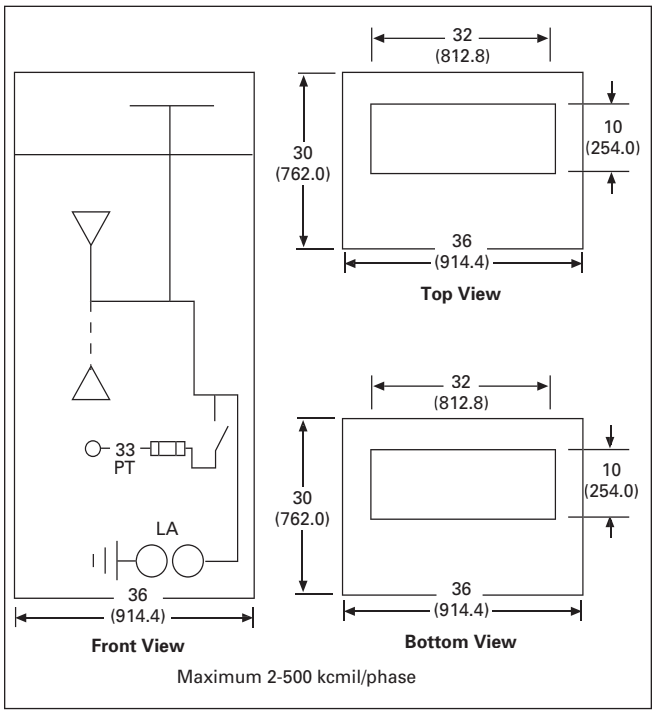


Figure 22. Incoming Line with PTs — 36-Inch (914.4 mm) Wide

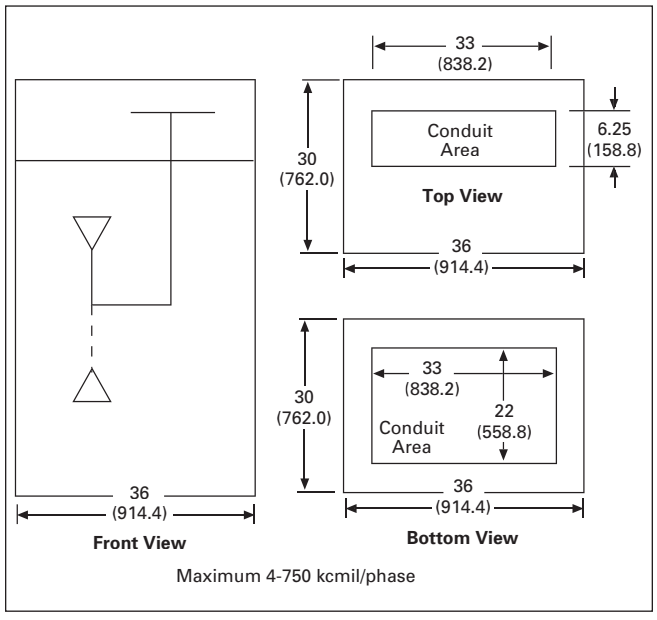


Figure 21. Incoming Line — 36-Inch (914.4 mm) Wide

Main and Tie LBS Switch Layouts — Dimensions in Inches (mm)

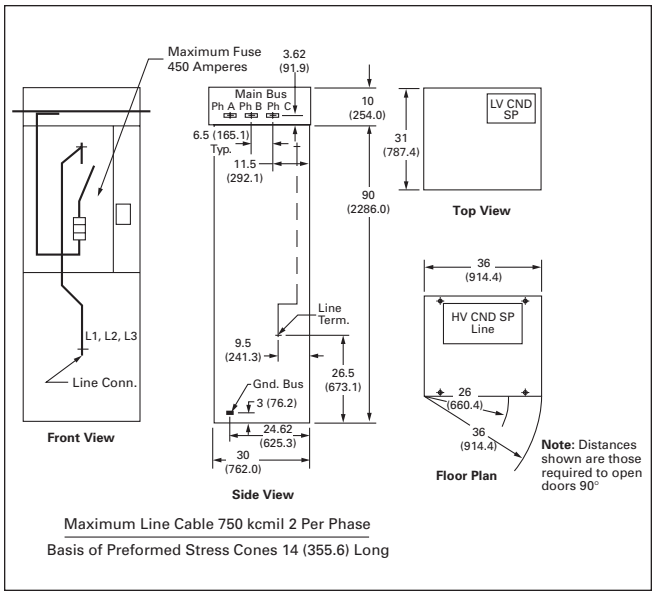


Figure 23. Incoming Line from Bottom, Lineup Either Direction

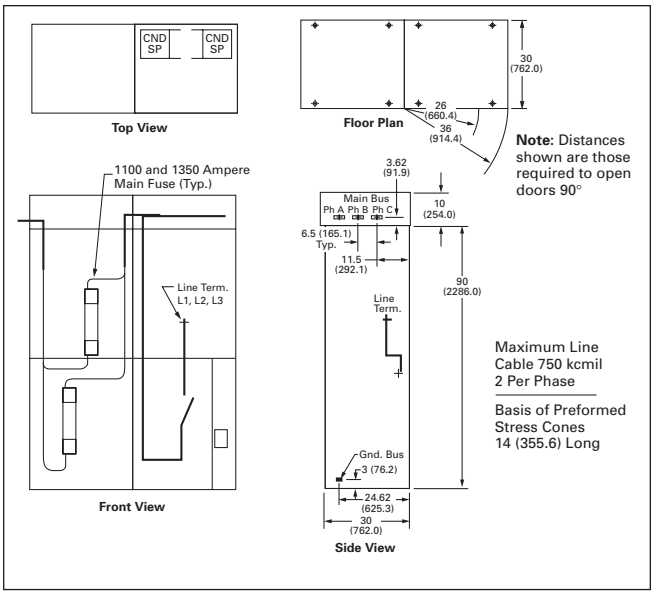


Figure 24. Incoming Line from Top, Lineup to the Left

Main and Tie LBS Switch Layouts (Continued) — Dimensions in Inches (mm)

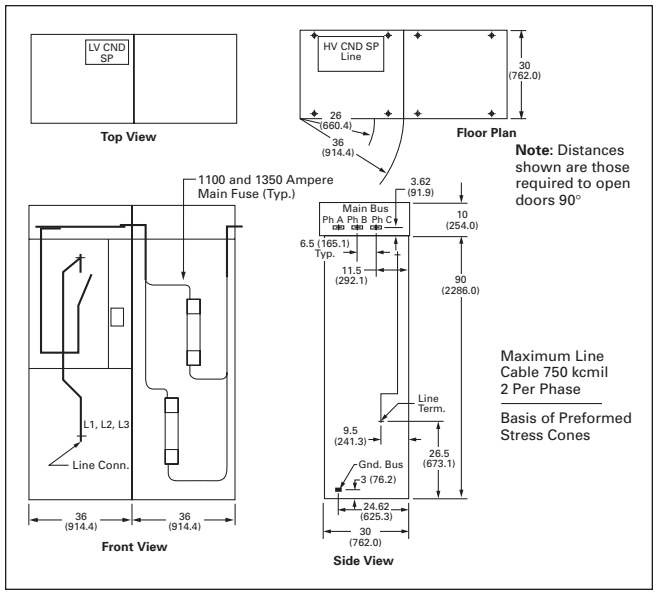


Figure 25. Incoming Line from Bottom, Lineup to the Right

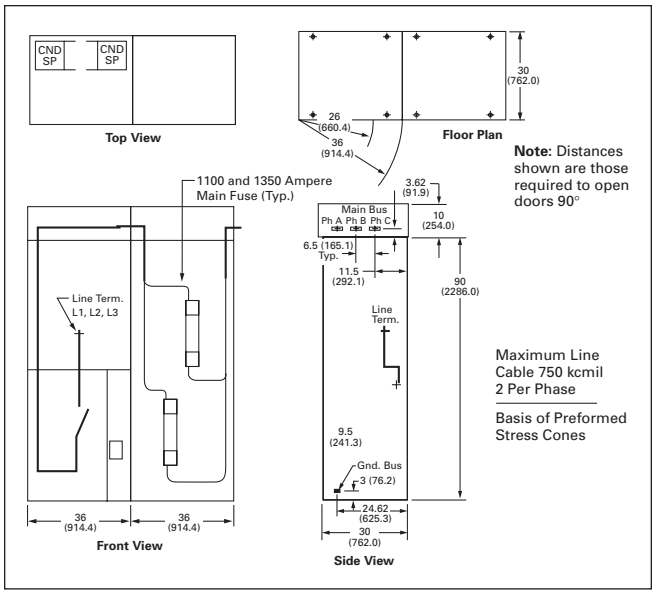


Figure 27. Incoming Line from Top, Lineup to the Right

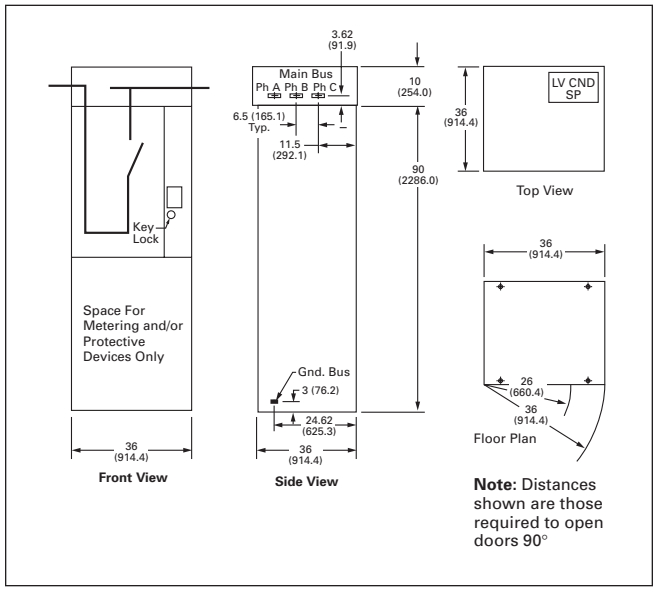


Figure 26. Tie Switch

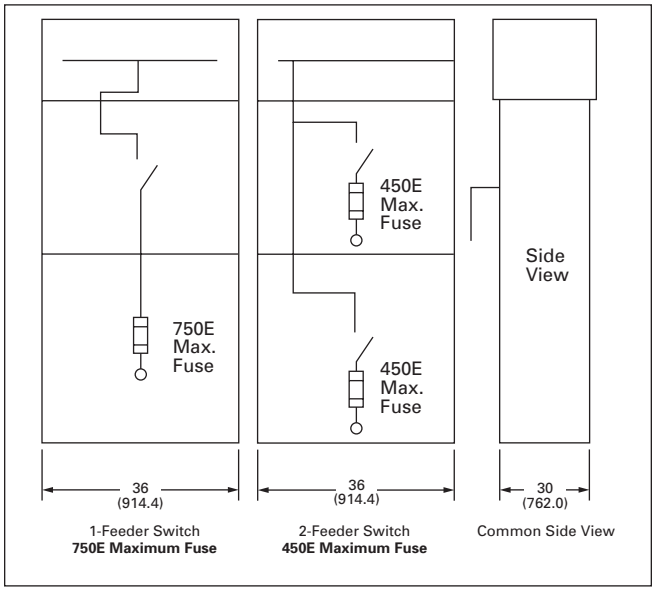


Figure 28. 1- and 2-Feeder Switches

Main Breaker Ampgard — Dimensions in Inches (mm)

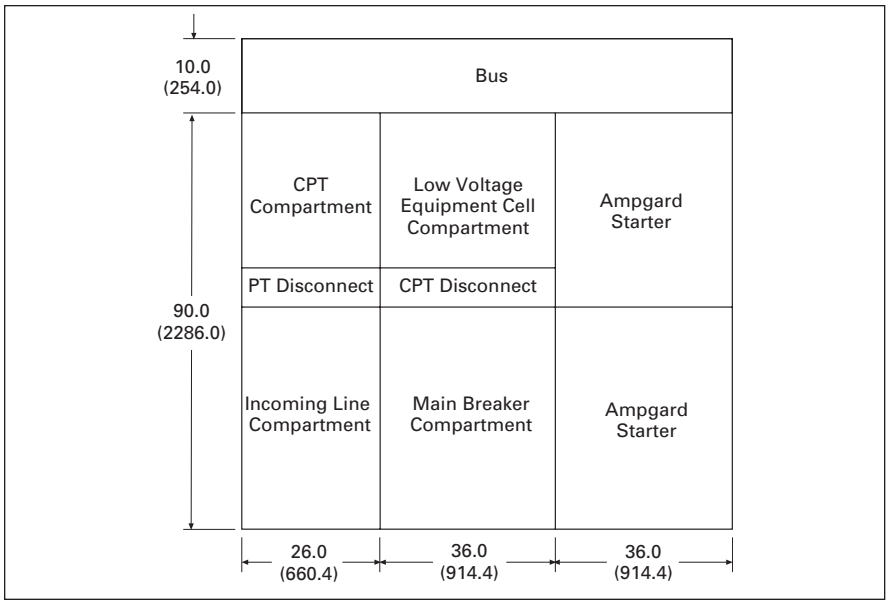


Figure 29. Front View — Main Breaker Ampgard

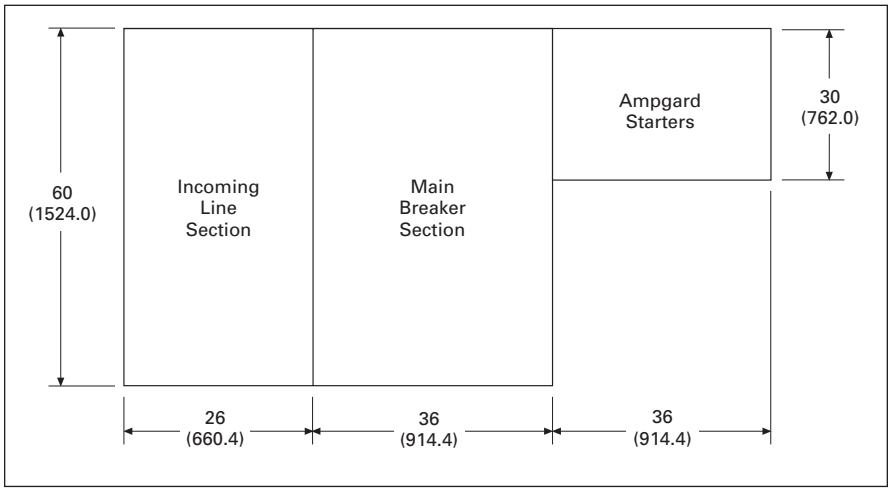


Figure 30. Plan View — Main Breaker Ampgard

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