EATON | Cutler-Hammer

Motor Starter (AMPGARD) — Medium Voltage

Technical Data TD02003001E

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.
- Integral LBS load break available as main, tie or feeder. The LBS can be supplied as fused or un-fused.

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. The low voltage compartment is painted white as standard to maximize serviceability.

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

Time-proven contactor technology: Two vacuum contactor ratings are utilized, 400 ampere and 800 ampere. 400 ampere contactors are available as stab-in or bolt-in design. 800 ampere contactors are available as stab-in design only.

High degree of isolation: Main bus is located in separate compartment on top of lineup. Vertical bus is barriered in rear of starter and auxiliary compartments. Load cables are isolated from adjacent starter in two-high sections. A vertical low voltage wireway is provided for isolation of customer control wiring. The low voltage control compartment is isolated from medium voltage by steel barriers.

AMPGARD Motor Control Assembly

Starter catalog types are available for the following applications:

- Squirrel cage, full voltage (reversing and non-reversing).
- Squirrel cage, primary reactor.
- Squirrel cage, autotransformer.
- Reduced voltage solid-state.
- Synchronous full voltage.
- Synchronous primary reactor.
- Synchronous auto-transformer (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

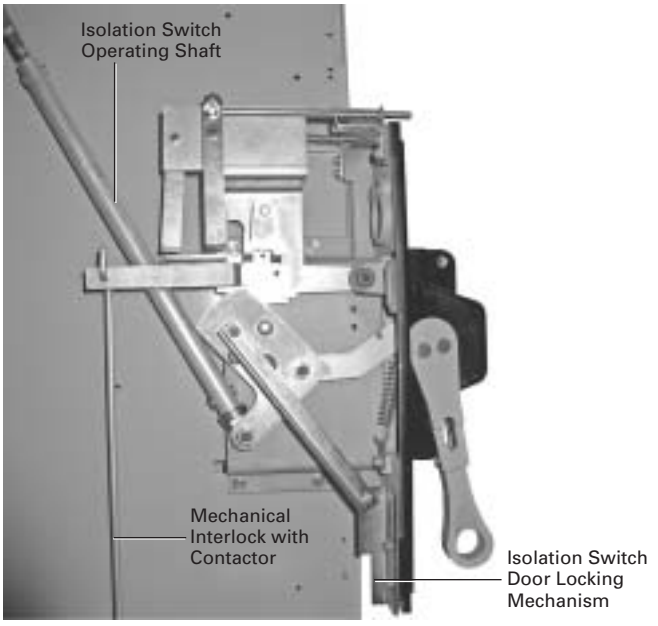
Interlocking on AMPGARD starters includes:

- Isolating switch mechanism locks the medium voltage door closed when the switch is in the ON position.
- Provision for optional key interlocks.
- When door is open, interlock prevents operating handle from being moved inadvertently to ON position.
- When contactor is energized, isolating switch cannot be opened or closed.

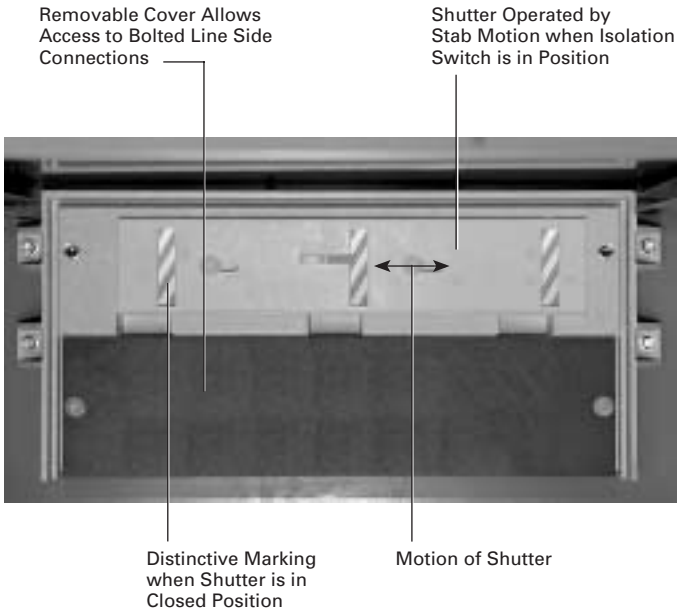
Other Safety Features

AMPGARD starters include many additional features designed to protect operating personnel. These features include:

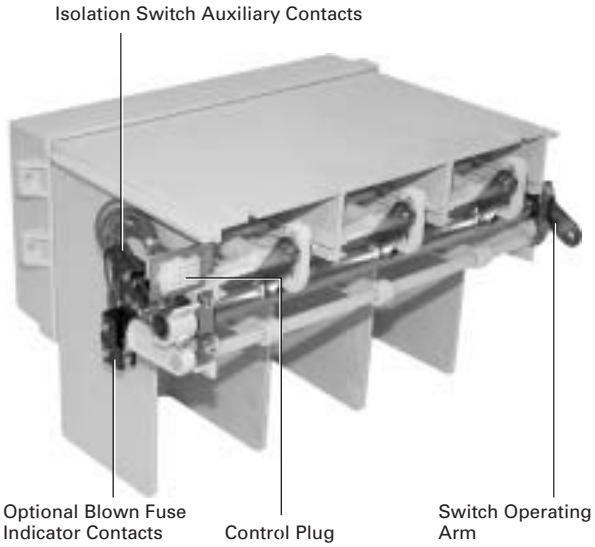
- Provision for a padlock on the isolating switch handle in OFF position.
- Shutter barrier between line terminals and isolation switch stabs is mechanically driven.
- Distinctive marking on back of switch assembly appears when shutter barrier is in position and starter is completely isolated from the line.
- Grounding clips provide a positive grounding of the starter and main fuses when the isolating switch is opened.
- High and low voltage circuits are compartmentalized and isolated from each other.
- The drawout isolation switch is easily removed by loosening two bolts in the back of the switch. The shutter remains in place when the switch is withdrawn.



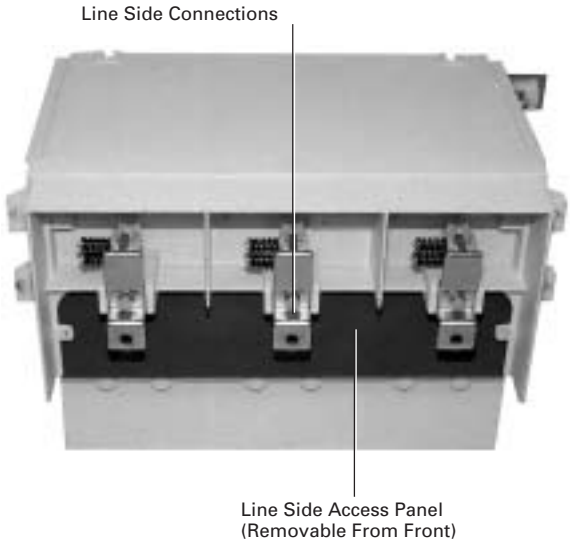
Isolation Switch Handle



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



400/800 Ampere Isolation Switch Front View



400/800 Ampere Isolation Switch Rear View

Isolation Switch

The Cutler-Hammer Type JMT-4/8, is a drawout, lightweight, 3-pole, manually operated isolating switch mounted in the top of the starter enclosure. It may be easily removed by loosening two bolts in the rear of the switch. The JRM-4 is rated 400 amperes continuous while the JRM-8 is rated 800 amperes continuous. The switches are identical in features and differ only in the current carrying components of the switch.

The component-to-component circuitry concept includes the mountings for the current limiting fuses as part of the isolating switch.

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

An operating lever in the isolating switch handle mechanism is designed to shear off if the operator uses too much force in trying to open the non-loadbreak isolating switch when the contactor is closed. This feature ensures that the operator cannot open the switch with the main contactor closed, even if excessive force is used on the operating handle.

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 position, an operator on the back of the handle housing extends through a bracket on the rear of the starter high voltage door, preventing the door from being opened with the switch closed. When the high voltage door is open, a door interlock prevents the handle from being inadvertently returned to the ON position.

When the operating handle is moved from ON to OFF, copper stabs are withdrawn from incoming line fingers. As the stabs withdraw, they are visible above the top of the fuses when viewed from the front, and simultaneously grounded. As the fingers are withdrawn, a spring-driven isolating 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 shutter. Refer to **Page 3** for an illustration of this feature.

Switch Handle Closed

Switch Handle Open

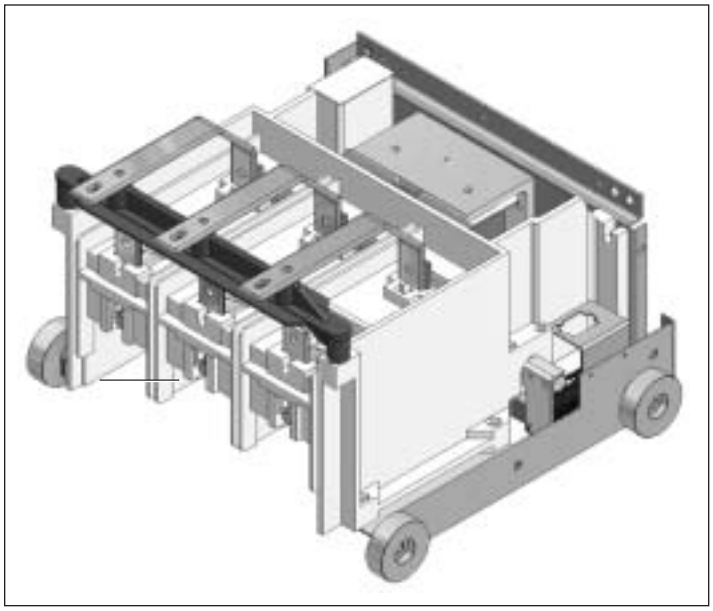


FIGURE 1. BOLT-IN CONTACTOR REAR/SIDE VIEW

SL 400 Ampere Vacuum Contactor

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 400 ampere standard and high interrupting ratings.

SL Contactors are available in the standard bolt-in configuration and optional stab-in design. Either bolt-in or stab-in designs can be supplied in a two-high configuration, with a starter maximum of 400 full load amperes. The total structure rating cannot exceed 720 amperes for a combination of two starters.

Design

Cutler-Hammer Vacuum Contactors are highly versatile, low-chop 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 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.

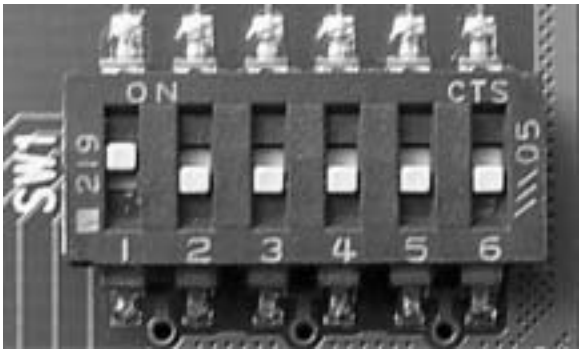
The vacuum interrupters employ special main contact materials that exhibit a low chop current plus other specially engineered characteristics that minimize switching surges. Surge protection is therefore not required due to the use of the vacuum contactor. Surge protection may be required for other reasons 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 is used for checking contact wear. Wear can be checked without removing the contactor from the starter. The vacuum contactor is much lighter than previous generation air-break or vacuum contactors, which allows for easier insertion and removal from the starter structure.

Contactor Control Board



DIP Switch on Contactor Control Board

Type SL 400 Ampere Vacuum Contactor Stab-in with Wheels, and Line and Load Fingers

400 Ampere Stab-in Contactor

400 Ampere Bolt-in

The bolt-in version of the Cutler-Hammer SL Contactor is supplied as standard for those applications requiring a 400 ampere contactor. The contactor is mounted on wheels and rolls into the AMPGARD structure on steel rails. Bolted bus bars connect the contactor line and load terminals to the power components in the starter cell. A 3-phase current transformer, 3-phase potential transformer and ground fault current transformer are mounted in the cell when required. A plug on the side of the contactor connects the contactor to the low voltage control panel.

The contactor is easily removed from the structure by removing the six bolts securing the contactor line and load terminals, and the pin connecting the isolating switch interlock arm. The contactor can be removed from the starter without disconnecting any medium voltage cables.

400 Ampere Stab-in

A stab-in version of the SL Contactor is an available option. The stab-in contactor is mounted on wheels and rolls into the AMPGARD structure. Contactor line and load fingers engage cell-mounted stabs as the contactor is inserted into the starter cell. The contactor is held in position by a bolt and bracket combination. It can be easily withdrawn from the starter cell by removing the bolt holding the contactor against the bracket and disconnecting the isolation switch interlock. The contactor can be removed from the starter without disconnecting any medium voltage cables.

800 Ampere Vacuum Contactors

The 800 ampere SL Contactor is available in a one-high configuration and is rated at 720 amperes enclosed. The 800 ampere contactor is available with a stab-in type connection only. The 800 ampere contactor is mounted on wheels and has similar features to the stab-in 400 ampere contactor.

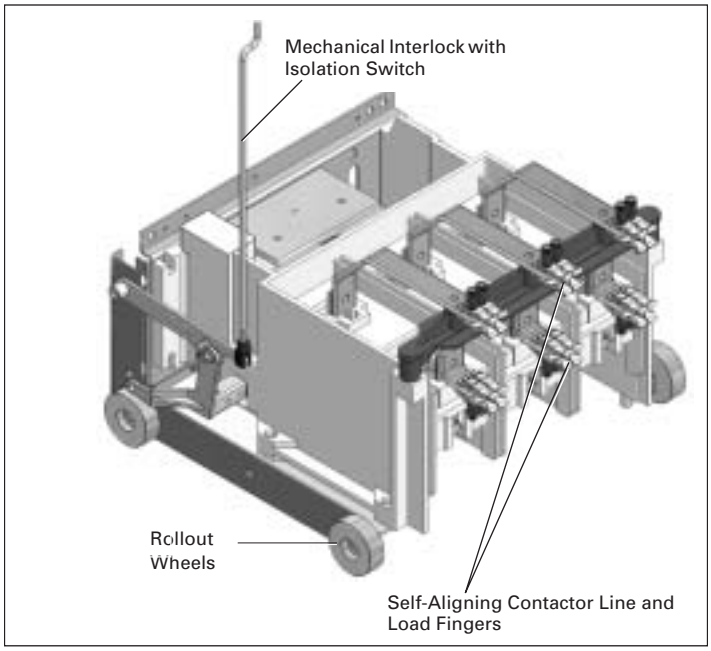


FIGURE 2. STAB-IN CONTACTOR MECHANICAL INTERLOCK

800 Ampere Vacuum Break Contactor 7200 Volt Maximum Stab-in with Wheels, and Line and Load Fingers

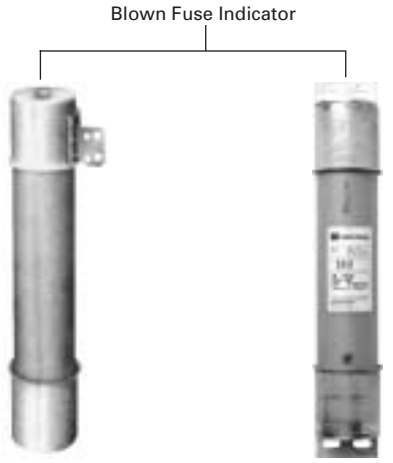
Current Limiting Fuses

AMPGARD starters use Cutler-Hammer Type CLS power fuses with special time/current characteristics for motor service. Type CLE or Type HLE power fuses are applied when the starter is used to feed a transformer. The fuse is coordinated with the contactor and overload relay characteristics to provide maximum motor/transformer utilization and protection. The standard mounting method for power fuses is bolted with an option for fuse clips in the 400 ampere starter. 800 ampere fuses are supplied as bolted only.

Interruption is accomplished without expulsion of gases, noise or moving parts. Type CLS/CLE/HLE fuses are mounted in a vertical position to ensure maximum rating reliability, proper operation and to eliminate the possibility of dust and dirt collecting, resulting in a deterioration of dielectric properties. 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. This indicator also operates the optional blown fuse mechanism (available with bolted fuses only) on the isolation switch that gives a contact closure to allow use in the starter control circuit.

The control circuit primary fuses are also current limiting.

Blown fuses may be removed and replaced without removing or drawing out the contactor.



Standard Fuse Mounting is Bolted with Optional Clip Mounting

Blown Fuse Indicating Device

Contactor-Fuse Coordination

The AMGARD 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 the starter fuses. The fuses must interrupt faults greater than the interrupting rating of the contactor. The AMPGARD 400 ampere high interrupting contactor (SL400A-HI) has an 8-cycle dropout time factory setting as standard and will interrupt at 8500 amperes. The maximum size fuse used with an SL400A-HI contactor 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 3** 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 equipment failure. Refer to **Figure 4** 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).

AMPGARD starters utilize 400 ampere standard interrupting contactors (SL400-SI) when the contactor is not required to coordinate with the starter main fuse. An example of this application is the run contactor of a reduced voltage starter.

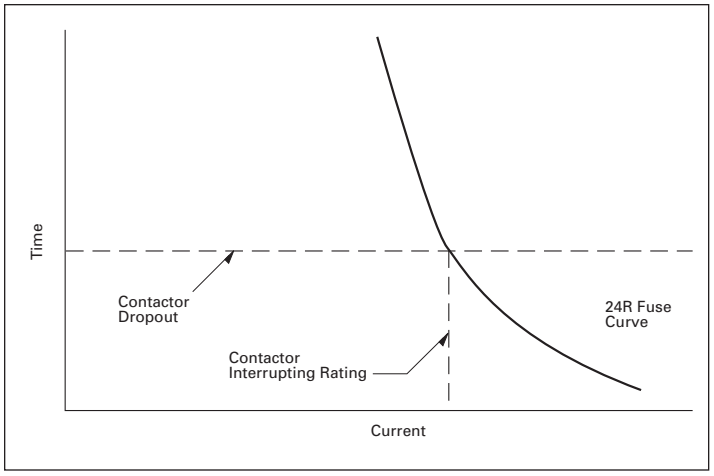


FIGURE 3. PROPER CONTACTOR FUSE COORDINATION FOUND IN AMPGARD STARTER

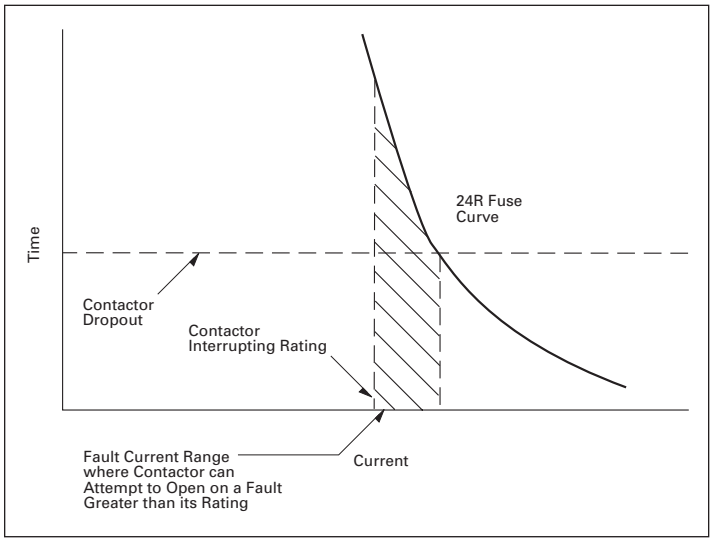


FIGURE 4. CONTACTOR FUSES THAT ARE NOT PROPERLY COORDINATED

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.

AMPGARD starters are supplied with an adjustable thermal overload relay as standard. The overload relay is designed to protect the motor from sustained overloads. A Cutler-Hammer GroundGard relay is an available option for protection from ground faults. The factory setting for the GroundGard will initiate a starter trip at approximately 7 amperes ground current.

Multi-function solid-state motor protection relays are a common option on AMPGARD starters. The Cutler-Hammer MP-3000 is typically provided when a multi-function relay is specified. The MP-3000 provides many types of protection including overload, locked rotor, ground fault and phase loss/phase unbalance. The MP-3000 also provides start control logic to protect the motor against excessive starting. The relay may be applied to either across-the-line or reduced voltage starters. On reduced voltage starters, the MP-3000 can control the transition from reduced to full voltage, offering the greatest protection for the motor and starter. An optional RTD module can be supplied for motors with built-in RTDs.

MP-3000 Motor Protective Relay

InsulGard relays are an available option on AMPGARD starters. The InsulGard provides early warning of increasing partial discharge levels in the starting equipment, cables and motor. This early warning will help the user to better schedule maintenance and avoid unplanned downtime.

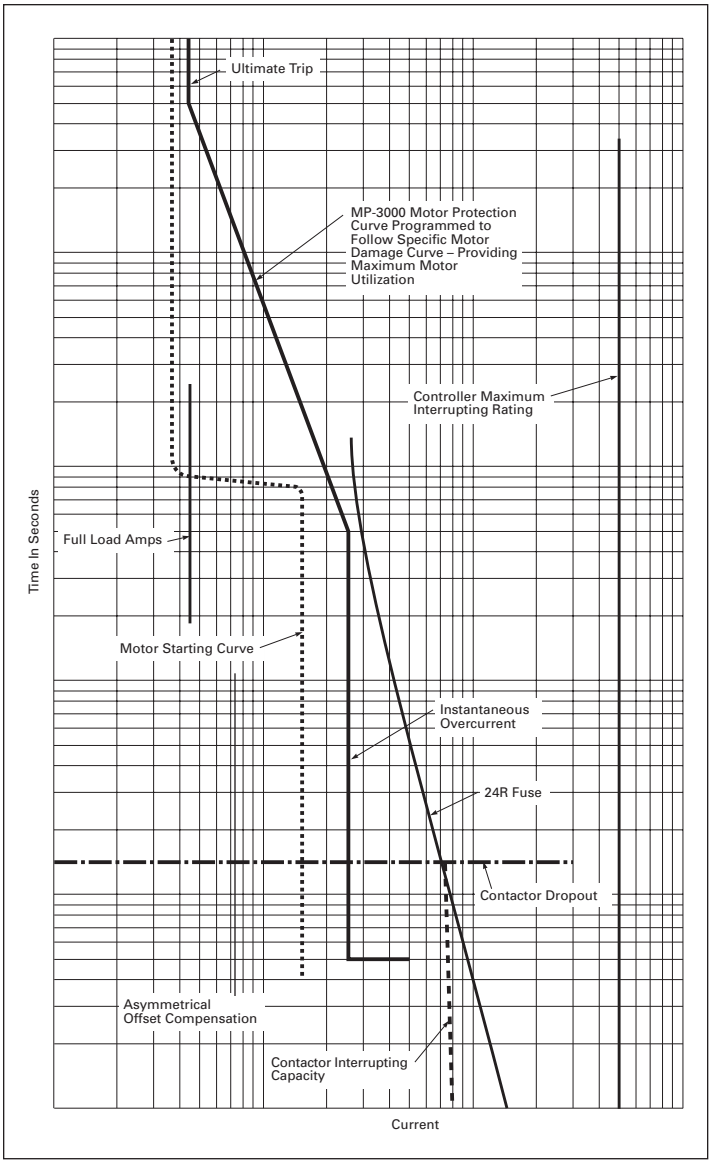
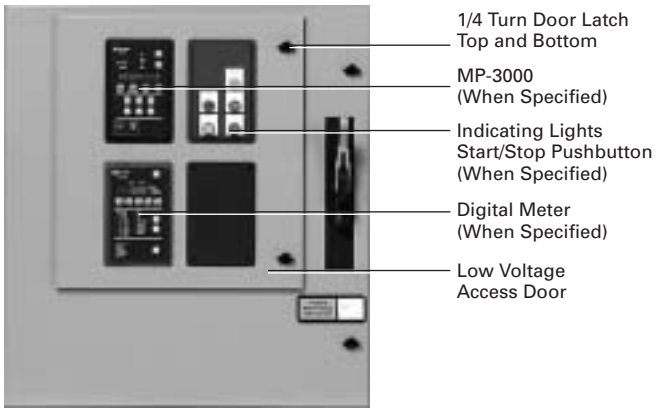


FIGURE 5. FULL RANGE COORDINATED PROTECTION BETWEEN CURRENT LIMITING TYPE CLS FUSES, VACUUM CONTACTOR AND MOTOR PROTECTION RELAY

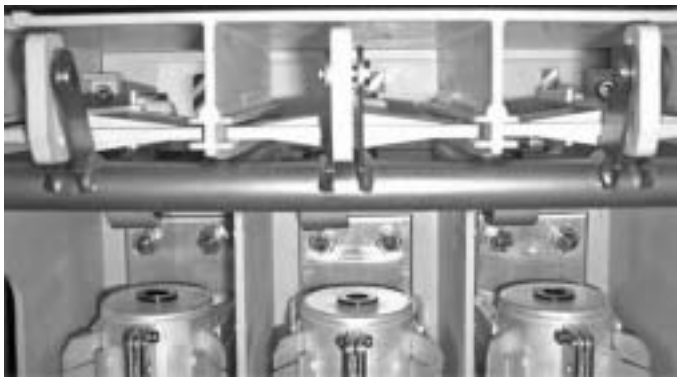
Isolated Low Voltage Control

The low voltage door has four cutouts as standard.

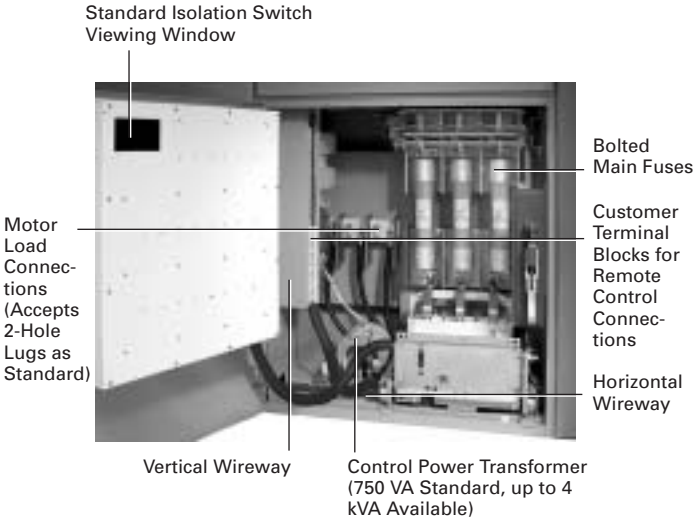


AMPGARD 400 Ampere Starter Door Closed

Distinctive Markings on Isolation Switch Shutter Indicate Shutter is Closed and Switch is Open

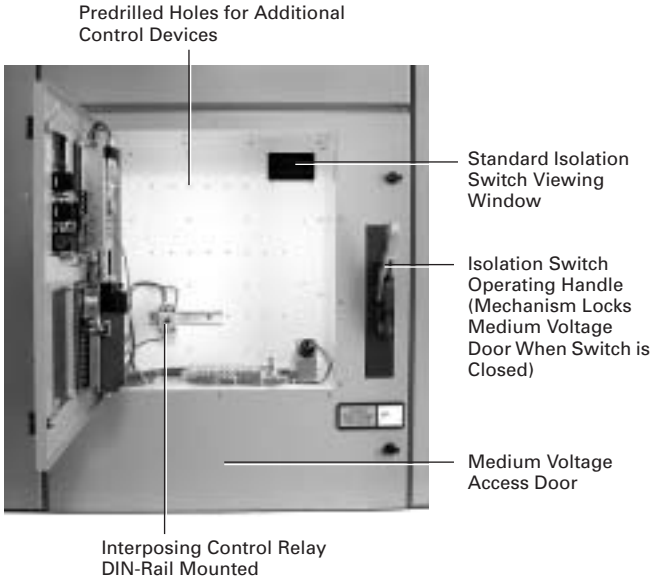


View of Isolation Switch Through Viewing Window



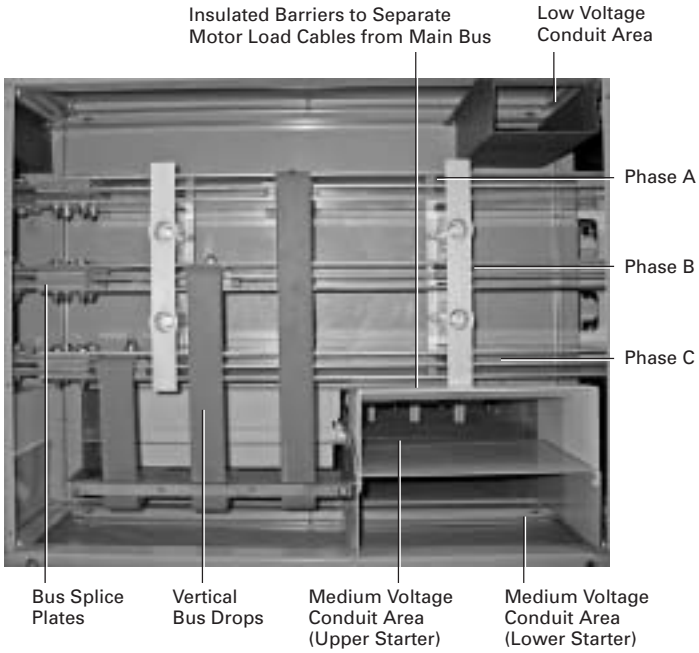
AMPGARD 400 Ampere Starter —— Medium Voltage Door Open

The Device Panel, MP-3000 and DP-4000 all fit in this same size low voltage door cutout. The low voltage control panel is behind the low voltage door and is completely isolated from the medium voltage compartment. A standard viewing window allows visual verification of the isolation switch status before attempting to open the medium voltage door. The medium voltage door is locked closed whenever the isolation switch is closed.



AMPGARD 400 Ampere Starter — Low Voltage Door Open

Bus and Optional Features



Bus Compartment Top View 3000 A 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 12-inch (305 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. Main bus is uninsulated as standard. Fully insulated bus is an available option. Bus may be supplied with either tin or silver plating. Crossover bus, busway entry, and pull boxes are not available for the 3000 ampere design (3000 ampere bus duct provisions are available with the Main Breaker AMPGARD, see **Page 17**).

The standard bus short circuit rating is per NEMA standards and is based on the let-through current of the largest fuse used in any starter. An optional 50 kA, 1-second bus rating is available for customers that require a higher rating for the main bus.

Vertical Bus

Vertical bus is located behind a fixed barrier in the rear of the enclosure. It is fully insulated as standard, with plating to match that of the main bus.

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. AMPGARD starters meet the requirements of IEC standards 60694, 60298 and 60470.

Seismic Certification

AMPGARD starters are seismically tested, seismically qualified, and exceed requirements of both the International Building Code® (IBC) and California Building Code Title 24. Seismic certified starters require the use of special keyed door latches on the medium voltage doors to ensure that the doors do not open during a seismic event. No other special modifications are required.

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 onboard a vessel, MODU (mobile offshore drilling unit) or facility classed by ABS with two conditions:

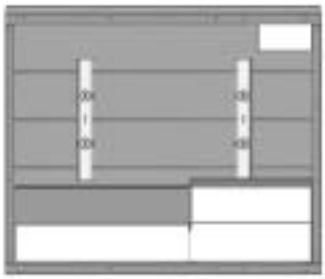
1. The AMPGARD assembly may not be used in the propulsion system.
2. The AMPGARD assembly may not be placed on deck.

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.
- Transformers.
- Power factor correction capacitors.
- Operators and pilot devices.
- Instruments and meters.
- Control relays and timers.
- Solid-state or selected electromechanical protection devices.



1000 and 1200 A Bus Arrangement

Vertical Bus, Rear View (2-High 400 A)

Reduced Voltage Starters

Eaton offers traditional electromechanical reduced voltage starters in addition to the AMPGARD ***IT.*** solid-state starter. Unless otherwise specified, reactors and autotransformers are NEMA medium duty rated. They are designed for three 30-second starters per hour. Heavy-duty reactors and transformers can be supplied when specified. Locked rotor current must be specified when ordering reduced voltage starters to ensure that the reactors or autotransformers are properly sized.

Reduced Voltage Reactor Starter

TABLE 1. TYPE 502 REACTOR STARTING CHARACTERISTICS

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
80% Tap	80	80	80	64
65% Tap ①	65	65	65	42
50% Tap	50	50	50	25

① Factory set on 65% tap.

Reactor Starter

Advantages

- Reduces starting currents.
- Least costly reduced voltage starting method.

Disadvantages

- Large footprint: 1-1/2 structures at 400 amperes.
- "Bump" on transition to full voltage.
- Not as efficient as autotransformer.
- Due to reduced torque during starting, motor must typically be unloaded during the start sequence.

Sequence of Operation

- Main contactor (M) closes.
- Current flows through reactor reducing voltage to motor (based on tap setting).
- When motor current reaches ~125%, the run contactor (R) closes providing full voltage to the motor.

Reduced Voltage Autotransformer Starter

TABLE 2. TYPE 602 AUTO-TRANSFORMER STARTING CHARACTERISTICS

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
80% Tap	80	80	67	64
65% Tap ②	65	65	45	42
50% Tap	50	50	28	25

② Factory set on 65% tap.

Auto Transformer Starter

Advantages

- Produces the most torque per incoming line ampere of any reduced voltage starting method.
- Less costly than RVSS.

Disadvantages

- Large footprint: 1-1/2 structures at 400 amperes.
- More costly than reactor.
- "Bump" on transition to full voltage.
- Due to reduced torque during starting, motor must typically be unloaded during the start sequence.

Sequence of Operation

- Shorting contactor (S) closes.
- Main contactor (M) closes.
- Current flows through autotransformer reducing voltage to motor (based on tap setting).
- When motor current reaches ~125%, the shorting contactor (S) opens and the run contactor (R) closes providing full voltage to the motor.

Note: Since the motor is never disconnected from the supply voltage, the starting is closed transition.

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 built-in basic motor protection. The standard assembly includes an MP-3000 motor relay for advanced motor protection.

Why is Soft Starting Desirable?

- 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.
- Reduce voltage drop on motor start.

Ratings

- 2300 – 4800 Vac grounded systems.
- 60 kV BIL impulse rating.
- Continuous current: to 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 – 1993
- 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.

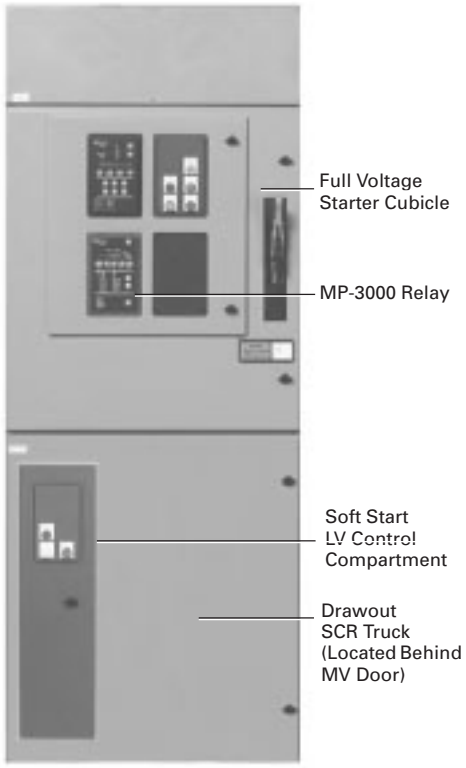
Current Limit

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.

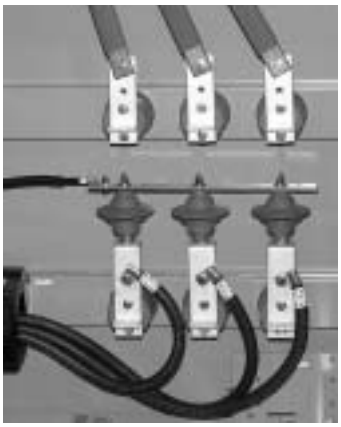


AMPGARD IT. Soft Start

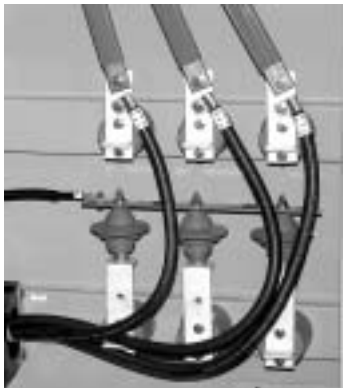
AMPGARD *IT.* Soft Start (Continued)

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

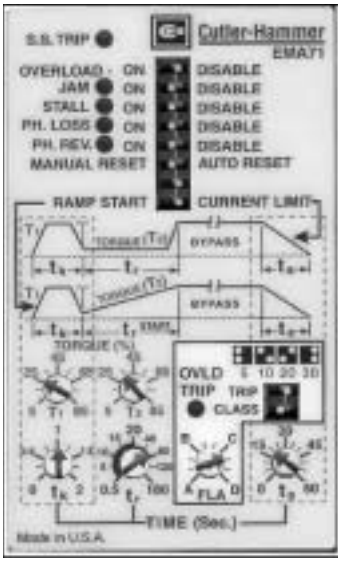
Lower Compartment Low Voltage Door



Load Cables — Normal



Load Cables — Moved for Full Voltage Start



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.

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 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.

If maintenance or repair of the SCR truck is required, it can be quickly removed and the motor can be started at full voltage by two methods. Method one is to move the lower compartment load cables from the load stabs to the line stabs (see photo). Method two is to install the optional bypass truck.

Bypass Truck

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.

Note: Maximum induced field current multiplied by starting and discharge resistor ohms must be less than 1500 volts to prevent damage to starting equipment and motor.

Synchronous Motor, Brushless ECS/VR Field Controller

The brushless synchronous motor starter includes the basic induction motor control in the bottom half of the structure. The ECS/VR synchronous control and protection module fits easily into the upper compartment.

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

The ECS/VR uses IGBT technology to control the dc output. The field voltage level can be adjusted from the HMI. The output is adjustable across the full range 0 – 150 Vdc.

The ECS/VR applies field voltage after an adjustable time delay. The controller monitors the stator current and voltage levels for metering and protection purposes. Automatic power factor regulation is an available option.

The ECS/VR brushless motor control includes the following protective features:

- Incomplete sequence.
- Failure to synchronize.
- Pullout protection.
- Field loss protection.
- Over excitation.

The motor windings are protected by a motor protection relay such as the MP-3000.

When ordering you must specify:

- dc field amperes.
- dc field voltage.
- Complete motor data sheet is preferred.

Brushless ECS/VR Field Controller

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 mm) wide structure in lieu of a 24-inch (610 mm) wide structure.

Typical 24-Inch (610 mm) Wide Incoming Line Structure

Potential Transformers, Control Power Transformer Disconnect and Fuses

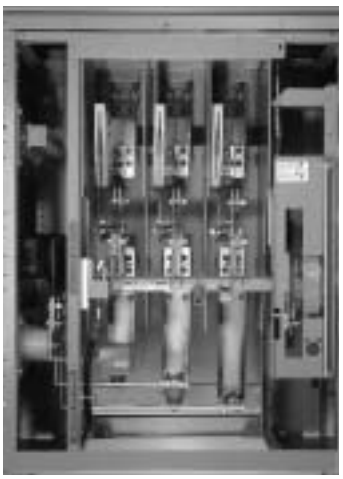
Bus connected potential transformers and/or control power transformers are mounted in a 20 inch (508 mm) high assembly that includes a disconnect and primary fuses. The assembly can be mounted in a 24 inch (610 mm) or 36 inch (914 mm) wide structure.

Potential Transformers, Control Power Transformer and Fuses Mounted in a disconnect assembly, Height 20 Inches (508 mm)

Type LBS Loadbreak Switch

For application needs with loads rated 600 or 1200 amperes at 2300 to 6600 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 80-inch (2032 mm) high, 36-inch (914 mm) wide vertical structure. Power fuses up to 450E amperes can be mounted within the half-high structure. 600E or 750E fuses require an additional half-structure, 1100E or 1350E fuses require an additional full 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 mm) Wide Structure, Height 40 Inches (1016 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.

Note: MBA sections are 100 inches (2540 mm) high.

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 suitable for service entrance 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 – 6600 Vac systems (7200 Vac maximum), 3-phase.
- 60 kV BIL impulse withstand rating.
- ANSI interrupting ratings — 250, 350 and 500 MVA. 500 MVA rating available for 6600 V systems only.
- Continuous current — 1200, 2000 and 3000 amperes.

Main Breaker AMPGARD

Main Breaker AMPGARD — Doors Open

Requires Less Floor Space

- Only 60 inches (1524 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 3. 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 at 4760 V	1200 2000 3000
350	4.16	60 kV BIL	41at 4760 V	1200 2000 3000
500	7.2	60 kV BIL	33 at 8250 V	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.

Metering

- IQ DP-4000 meter.
- IQ Analyzer meter.

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 International Building Code (IBC) and the California Building Code (CBC).

AMPGARD 2-High Structure Bus Connected to Main Breaker Section

Low Voltage Equipment Cell Compartment for Metering and Protection Devices

Side Panel Removed to Show Incoming Cable Connections

Typical Wiring Diagram for Full Voltage FVNR Starter

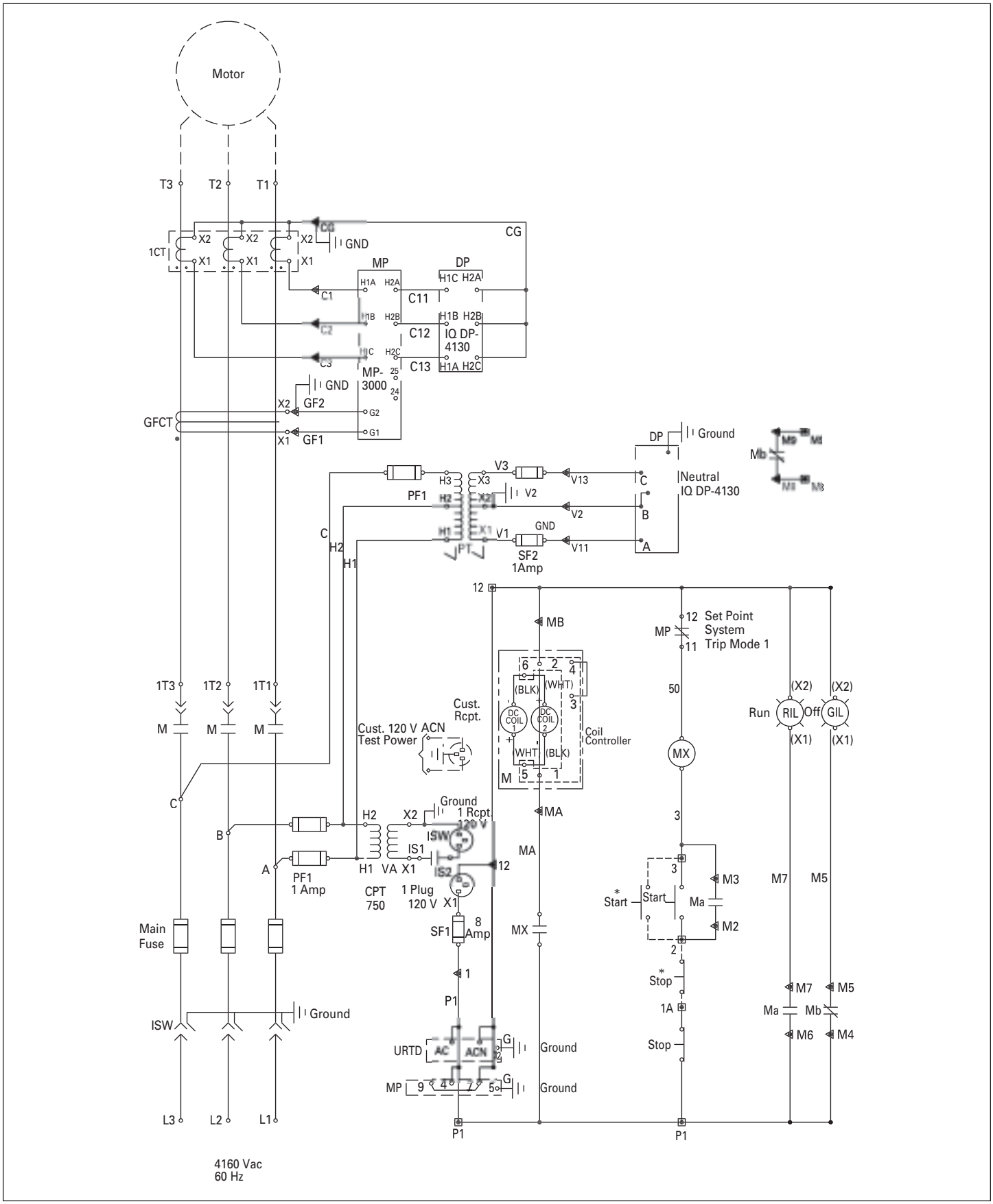


FIGURE 6. INDUCTION MOTOR ACROSS-THE-LINE STARTER VACUUM CONTACTOR WITH OPTIONAL MP-3000 MOTOR PROTECTION AND IQ METERING, START-STOP PUSHBUTTONS, AND RED AND GREEN INDICATING LIGHTS

Typical Wiring Diagram for Reduced Voltage Autotransformer RVAT Starter

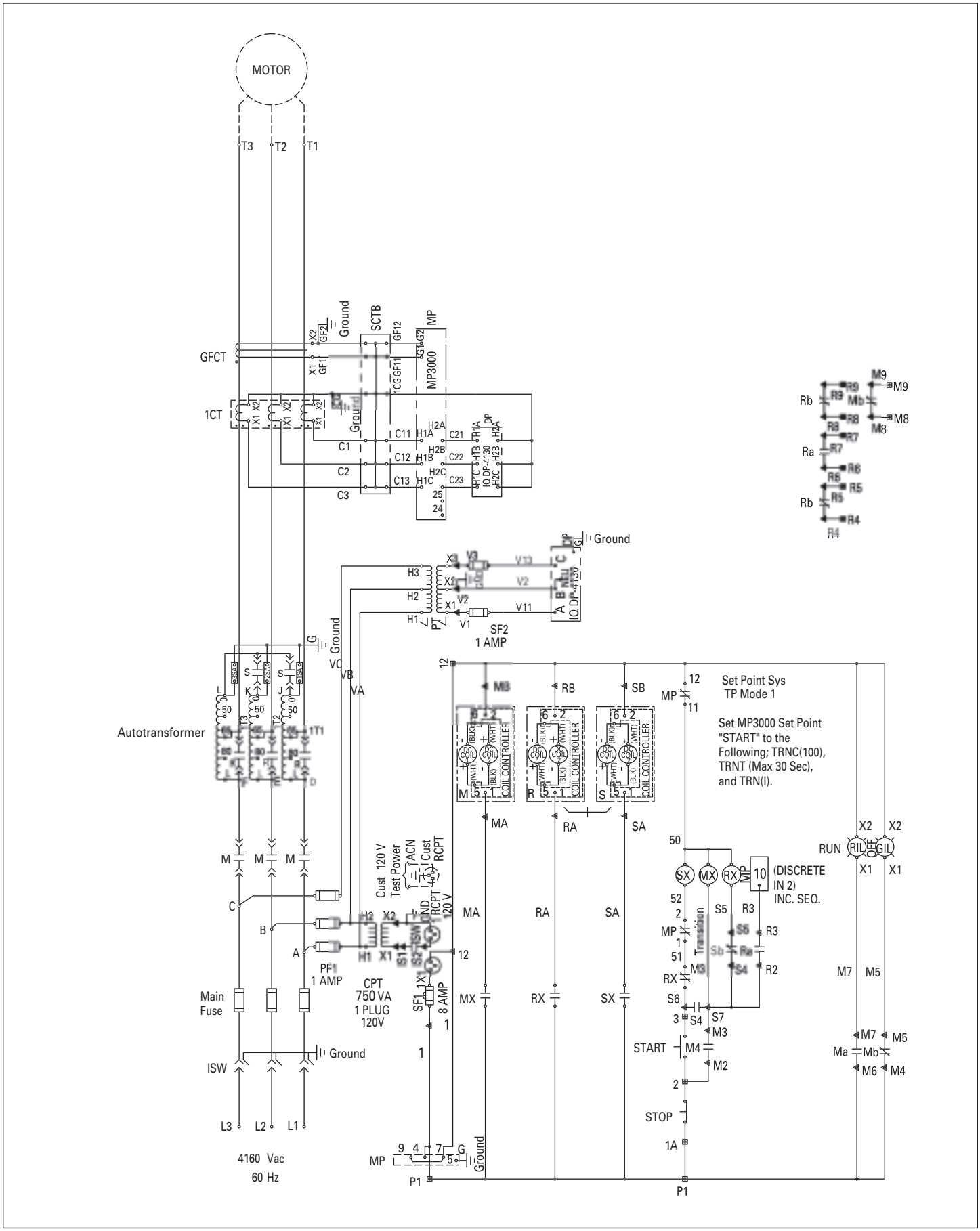


FIGURE 7. INDUCTION MOTOR REDUCED VOLTAGE AUTOTRANSFORMER STARTER, VACUUM CONTACTOR WITH OPTIONAL MP-3000 MOTOR PROTECTION AND IQ METERING, START-STOP PUSHBUTTONS, AND RED AND GREEN INDICATING LIGHTS

Typical Wiring Diagram for AMPGARD *IT.* Soft Start

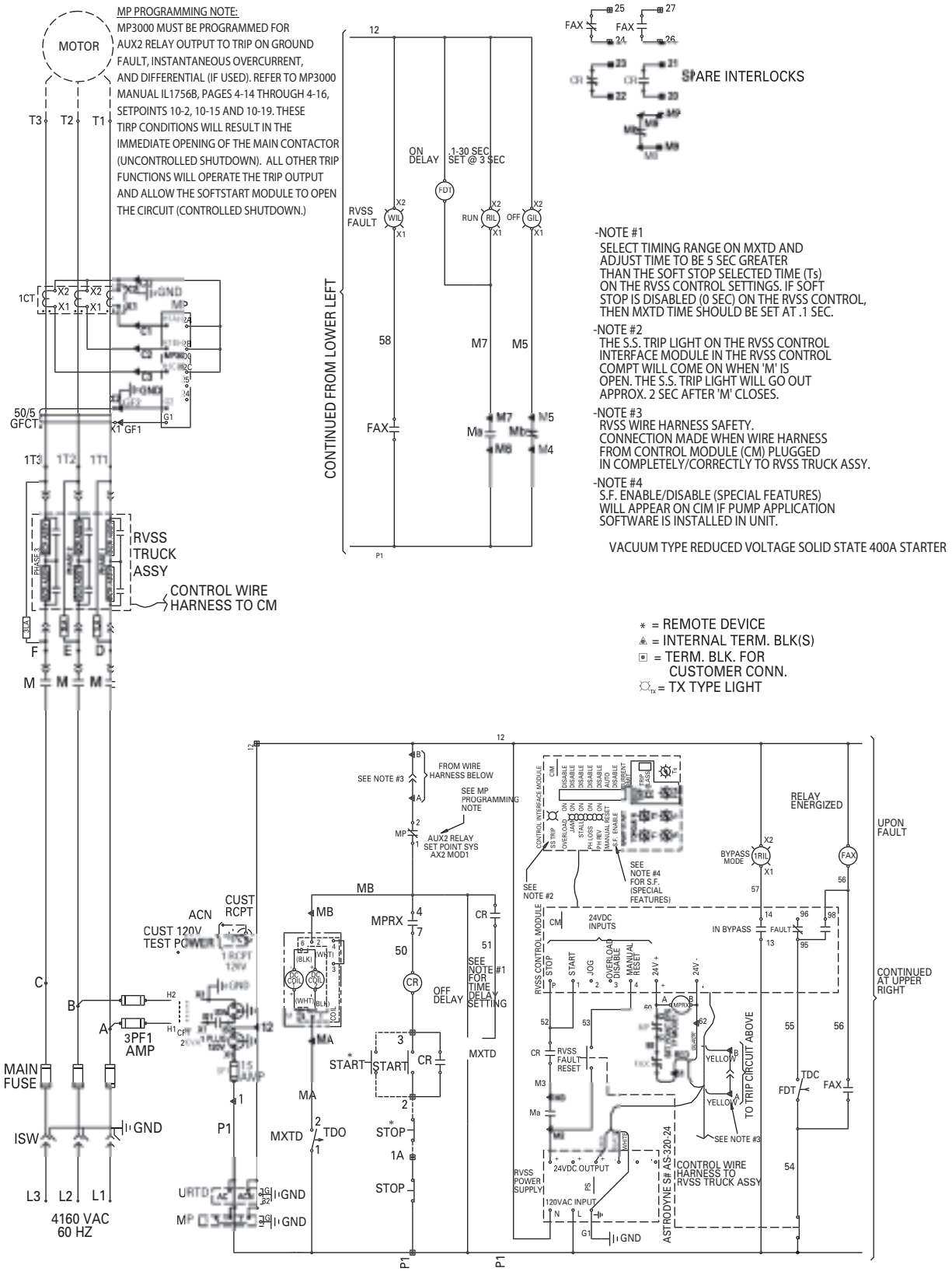


FIGURE 8. INDUCTION MOTOR REDUCED VOLTAGE SOLID-STATE STARTER, VACUUM CONTACTOR WITH MP-3000 MOTOR PROTECTION WITH OPTIONAL UNIVERSAL RTD MODULE LOCAL AND REMOTE START-STOP PUSHBUTTONS, AND LOCAL AND REMOTE RED AND GREEN INDICATING LIGHTS

Type SL 400 Ampere Vacuum Contactor Ratings

TABLE 4. TYPE SL 400 AMPERE VACUUM CONTACTOR RATINGS

Rated Utilization Voltage	2200 to 2500 Volts	3000 to 3600 Volts	3800 to 4800 Volts	6000 to 6600 Volts
Interrupting Rating (With 400 A High Interrupting Contactor)				
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 V	285 MVA at 3300 V	400 MVA at 4600 V	570 MVA at 6600 V
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 (High Interrupting) 4500 Amperes (Standard Interrupting)	Arcing Time	12 Milliseconds (3/4 Cycle) or Less	
		Pickup Voltage	80% Rated Coil Voltage	
		Dropout Voltage	60% Rated Coil Voltage	
Rated Current	400 Amperes Enclosed	Control Voltages		
IEC Make-Break Capability-AC4		ac	110/120/220/240 (50/60 Hz)	
Make	4000 Amperes	dc	125	
Break	3200 Amperes	Control Circuit Burden		
Short-Time Current		Closing (ac)/(dc)	100 V – 125 V, 1 kVA/200 V – 250 V, 1.8 kVA	
30 Seconds	2400 Amperes	Holding (ac)/(dc)	100 V – 125 V, 40 VA/200 V – 250 V, 50 VA	
1 Second	6000 Amperes	Auxiliary Contact Rating		
8.7 Milliseconds (.5 Cycle) ①	63 kA Peak	Voltage (Maximum)	600 Volts	
Standard Service Altitude	-1000 to +2000 Meters	Continuous Current	10 Amperes	
Optional Service Altitudes	-3500 to -1001 Meters +2001 to +5000 Meters	Making Capacity (ac)	7200 VA	
		Making Capacity (dc)	125 VA	
Mechanical Life	2.5 Million Operations	Breaking Capacity (ac)	720 VA	
Electrical Life	300,000 Operations	Breaking Capacity (dc)	125 VA	
BIL	60 kV (1.2 x 50 Microseconds)	Latch (When Specified)		
Dielectric Strength (60 Hz)	20 kV (1 Minute)	Mechanical Life	250,000 Operations	
Closing Time (Energization to Contact Touch)	80 Milliseconds	Trip Voltages (dc)	24 Volts/125 Volts	
		Trip Voltages (ac)	110/120 Volts	
Opening Time	30 to 330 Milliseconds (Selectable)	Minimum Trip Voltage	80% Rated Coil Voltage	
		Trip Burden		
		24 Vdc	400 VA	
		125 Vdc	400 VA	
		110/120 Vac	400 VA	
		Trip Time	30 Milliseconds	
		Weight	60 lbs. (27 kg) (Stab-in/bolt-in)	

① Time stated in cycles on 60 Hz base.

Type SJ 800 Ampere Vacuum Contactor Ratings

TABLE 5. 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)		12.5 kA	12.5 kA	12.5 kA	12.5 kA
NEMA Fused (E2)		200 MVA at 2300 V	285 MVA at 3300 V	408 MVA at 4600 V	570 MVA at 6600 V
NEMA Fused (E2)		50 kA	50 kA	50 kA	50 kA
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 kvar	3200 kvar	4000 kvar	4800 kvar
Maximum Insulation Voltage: 7200 Volts					
Maximum Interrupting Current (3 Operations)		12,500 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 (ac)/(dc)		110/120/220/240 Volts (50/60 Hz) 125 Volts (dc)
Make		8000 Amperes			
Break		6400 Amperes	Control Circuit Burden (Rated Volt)		
Short Time Current			Closing (ac)/(dc)		2600 VA
30 Seconds		4320 Amperes	Holding (ac)/(dc)		80 VA
1 Second		10,800 Amperes	Auxiliary Contact Rating (L-64)		
8.75 Milliseconds (.5 Cycle)		86 kA Peak	Voltage (Maximum)		600 Volts
			Continuous Current		10 Amperes
Mechanical Life		1 Million Operations	Making Capacity (ac)		7200 VA
Electrical Life		250,000 Operations At Rated Current	Making Capacity (dc)		200 VA
			Breaking Capacity (ac)		720 VA
BIL		60 kV (1.2 x 50 Microseconds)	Breaking Capacity (dc)		200 VA
Dielectric Strength (60 Hz)		18.2 kV (1 Minute)	Latch (When Specified)		
Closing Time (Energization to Contact Touch)		80 Milliseconds	Mechanical Life		250,000 Operations
			Trip Voltages (dc)		24 Volts/48 Volts/96 Volts
			Trip Voltages (ac)		110 Volts/220 Volts (50/60 Hz)
Opening Time		130 to 330 Milliseconds (Selectable)	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		95 lbs. (43 kg)

LBS Switch

TABLE 6. LBS SWITCH RATINGS

Description	Continuous and Break Current Amperes	Fault-Close (Unfused) kA	Short-Time (2 Seconds) 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 ①	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 7. AVAILABLE VCP-W VACUUM CIRCUIT BREAKER TYPES RATED ON SYMMETRICAL CURRENT RATING BASIS, PER ANSI STANDARDS

Identification			Rated Values											Related Required Capabilities ②					
			Voltage		Insulation Level		Current		Rated Transient Recovery Voltage						Current Values				
					Rated Withstand Test Voltage										Maximum Sym. Interrupting Capability	3-Second Short Time Current Carrying Capability	Closing and Latching Capability (Momentary) ⑨		
	Nominal Voltage Class	Nominal 3-Phase MVA Class	Rated Maximum Voltage	Rated Voltage Range Factor	Normal Frequency	1.2 x 50 µsec. Impulse	Rated Continuous Current at 60 Hz	Rated Short Circuit Current (at Rated Maximum kV)	Rated Crest Voltage	Rated Time to Crest	Rated Interrupting Time	Rated Permissible Tripping Delay	Rated Reclosing Time	Rated Maximum Voltage Divided By K	K Times Rated Short Circuit Current ④ KI		1.6 K Times Rated Short Circuit Current	1.6 K Times Rated Short Circuit Current	Asymmetry Factor for VCP-W Breakers
Circuit Breaker Type	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	⑦ kA rms Assy.	⑧ S
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 ⑨	58 78 ⑨	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 Included for reference only.

⑧ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

⑨ Non-standard breakers with high momentary rating available for special applications.

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

Main Breaker (Continued)

TABLE 8. VCP-W BREAKER STORED ENERGY MECHANISM CONTROL POWER REQUIREMENTS

Rated Control Voltage	Spring Charge Motor			UV Trip mA (Maximum)	Voltage Range		Indicating 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

Starter Fuse Information

TABLE 9. FUSE COORDINATION RECOMMENDATIONS

Minimum FLA	Maximum FLA	Fuse Rating	CT Ratio
400 Ampere Contactor			
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 ①	450-24R	600:5
800 Ampere Contactor			
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	800-44R	800:5
650.1	720.0	800-44R	1000:5

① Specific motor acceleration time and locked rotor current must be reviewed to ensure fuse 24R fuse has sufficient capacity for start cycle.

Layout Dimensions

Full Voltage Squirrel Cage Starters Catalog S210 Non-Reversing Catalog S310 Reversing

Equipment Details

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- Drawout 3-pole gang-operated line isolating switch assembly with 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.

Reversing Starter

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

Mounted in the Low Voltage Compartment

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

Specifications

TABLE 10. STARTER SELECTION INFORMATION — DIMENSIONS IN INCHES (MM)

Horsepower ①	Volts	Contactor Ampere Rating (Enclosed)	Starter Interrupting Rating (kVA)	Equipment Arrangement Number	Dimensions			Add. Starter Spaces	Weight Lbs. (kg)
					Height ②	Width	Depth		
2200 – 2400 Volts Non-Reversing									
700/800 ③	2300	400	200,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1350 (613)
1500/1750 ④	2300	400	200,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1350 (613)
3000	2300	720	200,000	2	80 (2032)	36 (914)	30 (762)	0	1700 (772)
2200 – 2400 Volts Reversing									
700/800 ③	2300	400	200,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
1500/1750 ④	2300	400	200,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
3000	2300	720	200,000	4	80 (2032)	36 (914)	30 (762)	0	2400 (1090)
4000 – 4800 Volts Non-Reversing									
1250/1500 ③	4600	400	400,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1350 (613)
2500/3000 ④	4600	400	400,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1350 (613)
5500	4600	720	400,000	2	80 (2032)	36 (914)	30 (762)	0	1700 (772)
4000 – 4800 Volts Reversing									
1250/1500 ③	4600	400	400,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
2500/3000 ④	4600	400	400,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
5500	4600	720	400,000	4	80 (2032)	36 (914)	30 (762)	0	2400 (1090)
6600 Volts Non-Reversing									
2000/2250 ③	6600 ⑥	400	570,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1500 (681)
4000/4500 ④	6600 ⑥	400	570,000	1	80 (2032)	36 (914)	30 (762)	1 ⑤	1500 (681)
8000	6600 ⑥	720	570,000	2	80 (2032)	36 (914)	30 (762)	0	1800 (817)
6600 Volts Reversing									
2000/2250 ③	6600 ⑥	400	570,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
4000/4500 ④	6600 ⑥	400	570,000	3	80 (2032)	36 (914)	30 (762)	0	1800 (817)
8000	6600 ⑥	720	570,000	4	80 (2032)	36 (914)	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 92 inches (2337 mm).
③ At higher hp rating, maximum acceleration time is 3.5 seconds.
④ At higher hp rating, maximum acceleration time is 6 seconds.
⑤ Maximum current for 2 starters in a single structure is 720 amperes.
⑥ May be applied on 6900 volt systems where maximum voltage does not exceed 7200 volts.

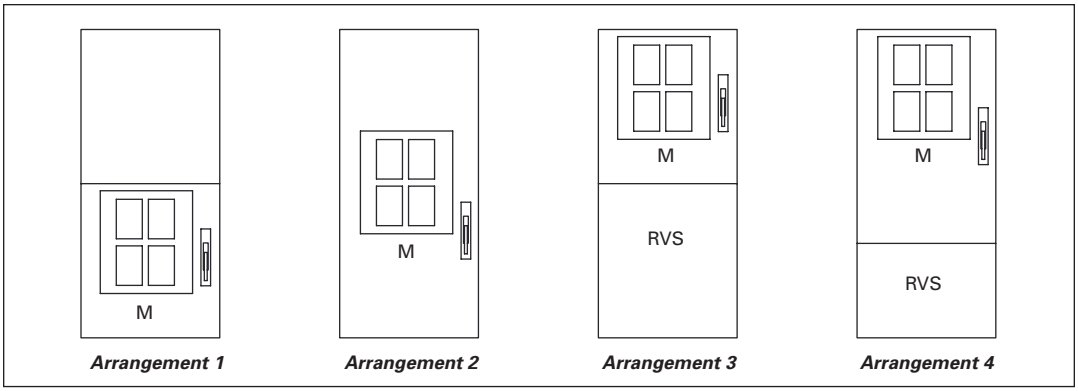


FIGURE 9. STARTER ARRANGEMENTS

Dimensions for estimating purposes only.

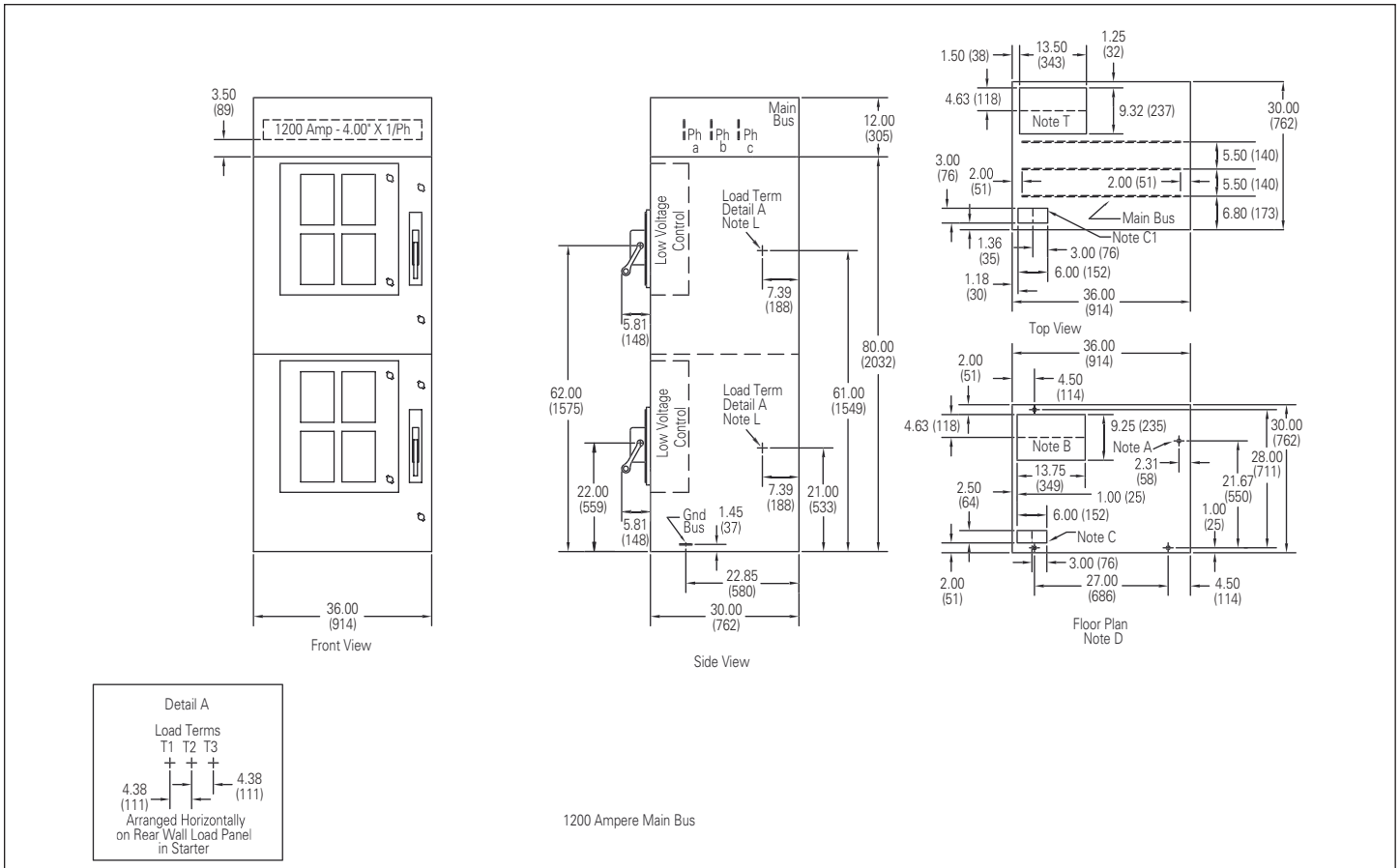


FIGURE 10. ARRANGEMENT 1 DETAIL (FULL VOLTAGE 400 AMPERES) — SEE TABLE 17 ON PAGE 36 FOR NOTES

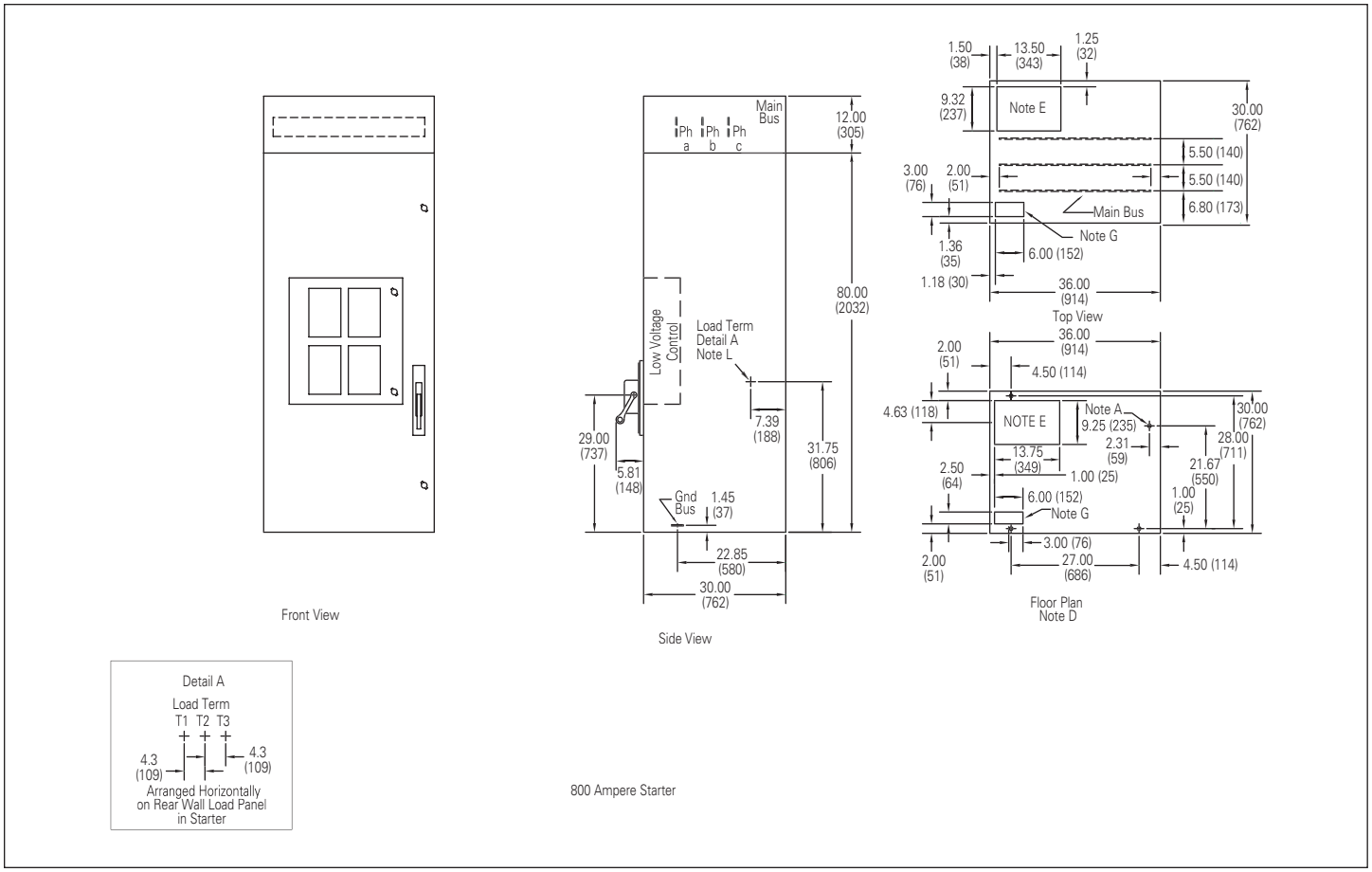


FIGURE 11. ARRANGEMENT 2 DETAIL (FULL VOLTAGE 800 AMPERES) — SEE TABLE 17 ON PAGE 36 FOR NOTES

Primary Reactor, Reduced Voltage Starters Catalog S510 Non-Reversing Catalog S710 Reversing — Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with 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 in the Low Voltage Compartment

- One control panel with:
  - One MP-3000 motor protection relay
  - Two interposing relays
- 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.
- One medium-duty starting reactor with 50 – 65 – 80% taps.

Starting Characteristics

TABLE 11. TYPE 502 REACTOR STARTING CHARACTERISTICS

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
80% Tap	80	80	80	64
65% Tap ①	65	65	65	42
50% Tap	50	50	50	25

① Factory set on 65% tap.

Specifications

TABLE 12. STARTER SELECTION INFORMATION — DIMENSIONS IN INCHES (MM)

Horsepower ②	Volts	Contactor Ampere Rating (Enclosed)	Starter Interrupting Rating (kVA)	Equipment Arrangement Number	Dimensions Height ③	Width	Depth	Weight Lbs. (kg)
2200 – 2400 Volts Non-Reversing								
700/800 ④	2300	400	200,000	1	80 (2032)	72 (1829)	30 (762)	2800 (1271)
1500/1750 ⑤	2300	400	200,000	1	80 (2032)	72 (1829)	30 (762)	2800 (1271)
3000	2300	720	200,000	2	80 (2032)	72 (1829)	30 (762)	4000 (1816)
2200 – 2400 Volts Reversing								
700/800 ④	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
1500/1750 ⑤	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
3000	2300	720	200,000	4	80 (2032)	72 (1829)	30 (762)	4650 (2111)
4000 – 4800 Volts Non-Reversing								
1250/1500 ④	4600	400	400,000	1	80 (2032)	72 (1829)	30 (762)	2800 (1271)
2500/3000 ⑤	4600	400	400,000	1	80 (2032)	72 (1829)	30 (762)	2800 (1271)
5500	4600	720	400,000	2	80 (2032)	72 (1829)	30 (762)	4000 (1816)
4000 – 4800 Volts Reversing								
1250/1500 ④	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
2500/3000 ⑤	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
5500	4600	720	400,000	4	80 (2032)	72 (1829)	30 (762)	4650 (2111)
6600 Volts Non-Reversing								
2000/2250 ④	6600	400	570,000	1	80 (2032)	72 (1829)	30 (762)	3300 (1498)
4000/4500 ⑤	6600	400	570,000	1	80 (2032)	72 (1829)	30 (762)	3300 (1498)
8000	6600	720	570,000	2	80 (2032)	72 (1829)	30 (762)	4650 (2111)
6600 Volts Reversing								
2000/2250 ④	6600	400	570,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
4000/4500 ⑤	6600	400	570,000	3	80 (2032)	72 (1829)	30 (762)	3250 (1476)
8000	6600	720	570,000	4	80 (2032)	72 (1829)	30 (762)	4650 (2111)

② Horsepower based on NEMA standard design B motor at 1800 rpm.
③ When horizontal bus is added, height becomes 92 inches (2337 mm).
④ At higher hp rating maximum acceleration time is 3.5 seconds.
⑤ At higher hp rating maximum acceleration time is 6 seconds.

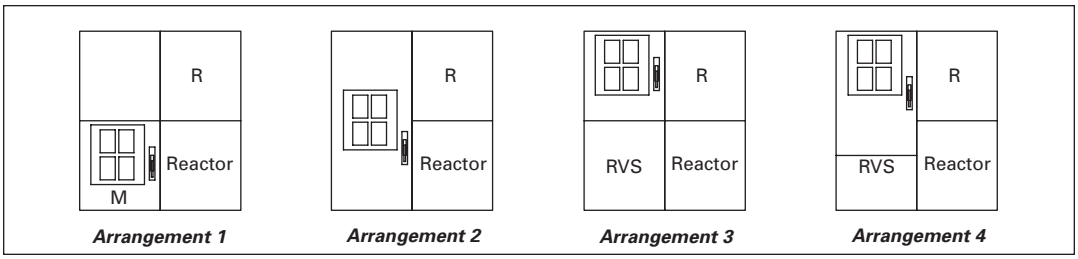


FIGURE 12. STARTER ARRANGEMENTS

Dimensions for estimating purposes only.

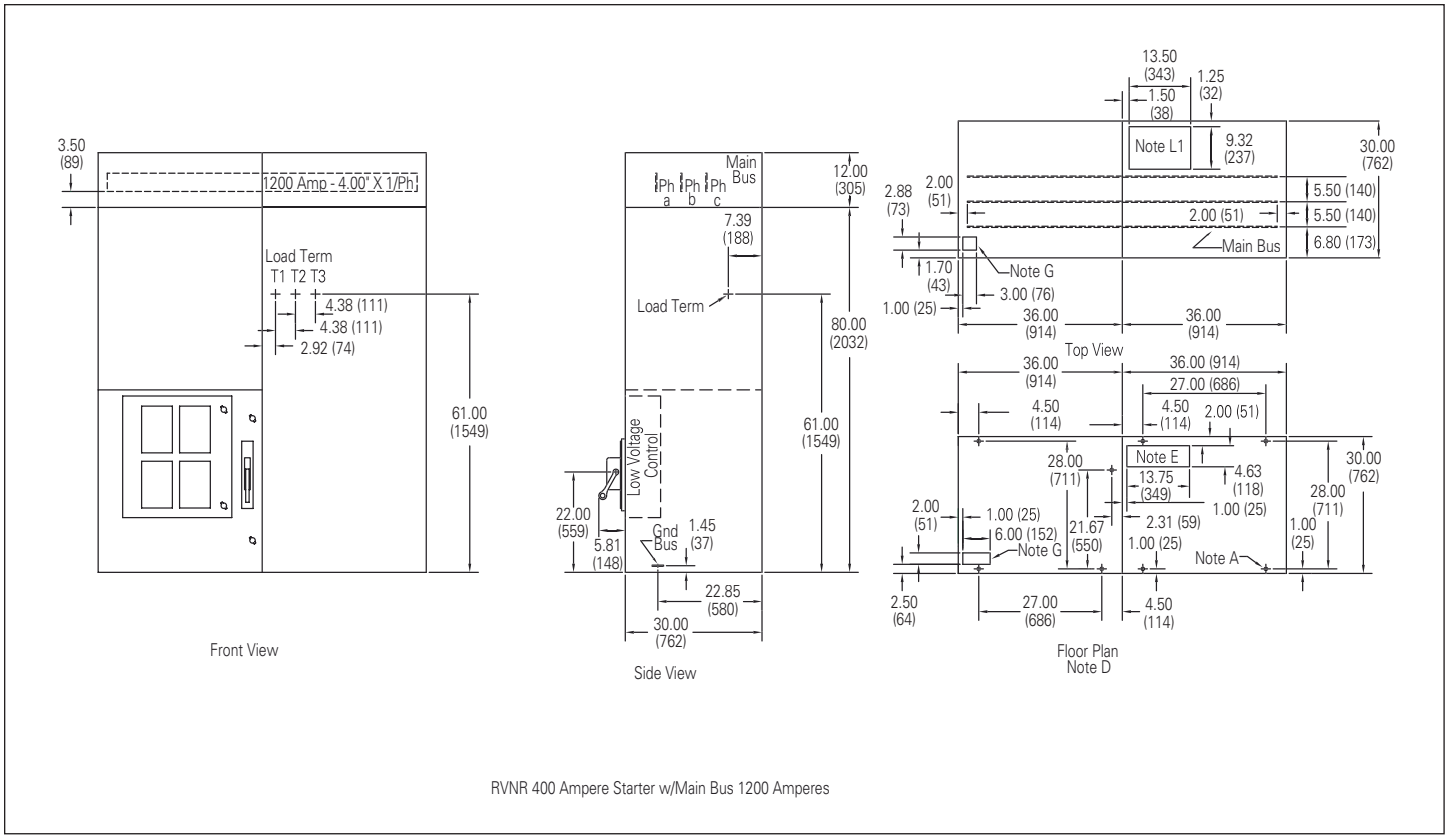


FIGURE 13. ARRANGEMENT 1 DETAIL (REDUCED VOLTAGE, 400 AMPERES) — SEE TABLE 17 ON PAGE 36 FOR NOTES

Reduced Voltage Autotransformer Starters Catalog S610 Non-Reversing Catalog S810 Reversing — Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with 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 in the Low Voltage Compartment

- One control panel with:
  - One MP-3000 motor protection 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 and mechanical interlocks.
- Three current transformers.
- One medium-duty starting autotransformer with 50 – 65 – 80% taps.
- Three distribution class lightning arresters for high voltage stress protection on the transformer zero tap.

Starting Characteristics

TABLE 13. TYPE 602 AUTO-TRANSFORMER STARTING CHARACTERISTICS

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
80% Tap	80	80	67	64
65% Tap ①	65	65	45	42
50% Tap	50	50	28	25

① Factory set on 65% tap.

Specifications

TABLE 14. STARTER SELECTION INFORMATION — DIMENSIONS IN INCHES (MM)

Horsepower ②	Volts	Contactor Ampere Rating (Enclosed)	Starter Interrupting Rating (kVA)	Equipment Arrangement Number	Dimensions Height ③	Width	Depth	Number of Structures	Weight Lbs. (kg)
2200 – 2400 Volts Non-Reversing									
700/800 ④	2300	400	200,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
1500/1750 ⑤	2300	400	200,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
3000	2300	720	200,000	2	80 (2032)	108 (2743)	30 (762)	3	4800 (2179)
2200 – 2400 Volts Reversing									
700/800 ④	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	2	3650 (1657)
1500/1750 ⑤	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	2	3650 (1657)
3000	2300	720	200,000	4	80 (2032)	108 (2743)	30 (762)	3	5650 (2565)
4000 – 4800 Volts Non-Reversing									
1250/1500 ④	4600	400	400,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
2500/3000 ⑤	4600	400	400,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
5500	4600	720	400,000	2	80 (2032)	108 (2743)	30 (762)	3	4800 (2179)
4000 – 4800 Volts Reversing									
1250/1500 ④	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	2	3650 (1657)
2500/3000 ⑤	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	2	3650 (1657)
5500	4600	720	400,000	4	80 (2032)	108 (2743)	30 (762)	3	5650 (2565)
6600 Volts Non-Reversing									
2000/2250 ④	6600	400	570,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
4000/4500 ⑤	6600	400	570,000	1	80 (2032)	72 (1829)	30 (762)	2	3100 (1407)
8000	6600	720	570,000	2	80 (2032)	108 (2743)	30 (762)	3	4800 (2179)
6600 Volts Reversing									
2000/2250 ④	6600	400	570,000	3	80 (2032)	72 (1829)	30 (762)	3	3650 (1657)
4000/4500 ⑤	6600	400	570,000	3	80 (2032)	72 (1829)	30 (762)	3	3650 (1657)
8000	6600	720	570,000	4	80 (2032)	108 (2743)	30 (762)	4	5650 (2565)

② Horsepower based on NEMA standard design B motor at 1800 rpm.
③ When horizontal bus is added, height becomes 92 inches (2337 mm).
④ At higher hp rating, maximum acceleration time is 3.5 seconds.
⑤ At higher hp rating, maximum acceleration time is 6 seconds.

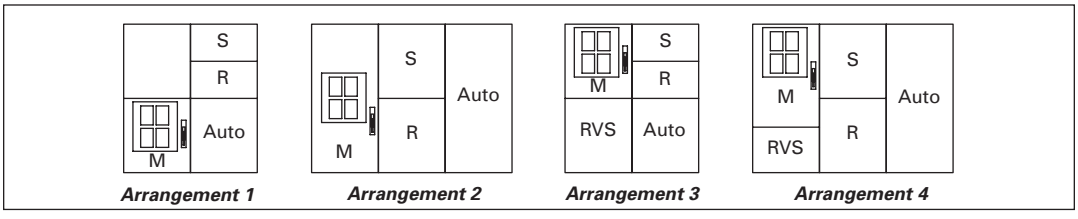


FIGURE 14. STARTER ARRANGEMENTS
Dimensions for estimating purposes only.

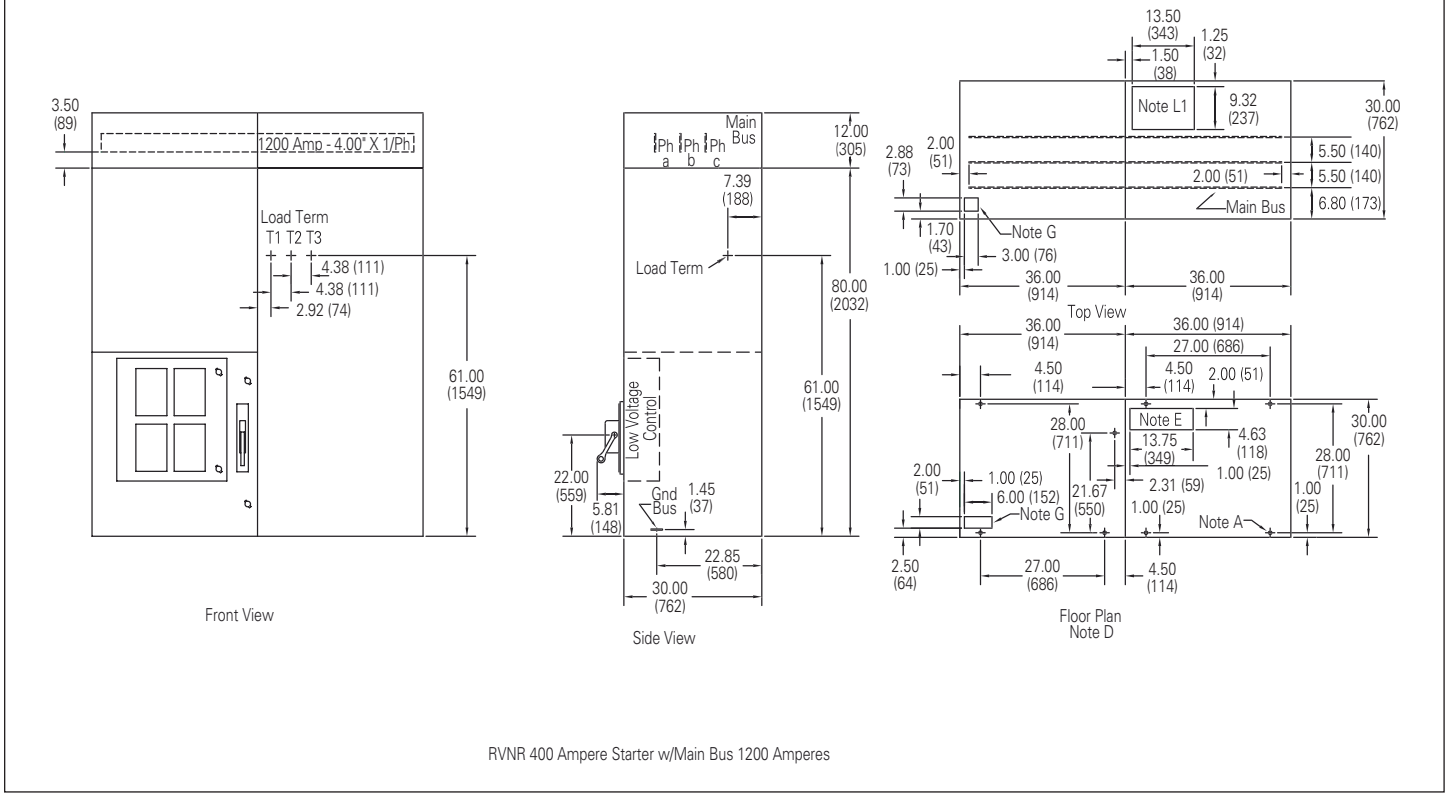


FIGURE 15. ARRANGEMENT 1 DETAIL (REDUCED VOLTAGE, 400 AMPERES) — SEE TABLE 17 ON PAGE 36 FOR NOTES

Full Voltage Synchronous Starters Brush Type Mark V Solid-State Catalog S241 Non-Reversing Catalog S341 Reversing — Main Structure

Mounted in the Medium Voltage Section

- Three incoming line connectors.
- One drawout 3-pole gang-operated line isolation switch assembly with 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.

Reversing Starter

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

Mounted in the Low Voltage Compartment

- One control panel with:
  - One MP-3000 motor protection relay
  - 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
  - "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

TABLE 15. STARTER SELECTION INFORMATION — DIMENSIONS IN INCHES (MM)

Horsepower at .8 PF ①	Horsepower at 1.0 PF	Volts	Contactor Ampere Rating (Enclosed)	Starter Interrupting Rating (kVA)	Equipment Arrangement Number	Dimensions Height ②③	Dimensions Width	Dimensions Depth	Weight Lbs. (kg)
2200 – 2400 Volts Non-Reversing									
700/800 ④	900/1000 ④	2300	400	200,000	1	80 (2032)	36 (914)	30 (762)	1500 (681)
1500/1750 ⑤	1750/2000 ⑤	2300	400	200,000	1	80 (2032)	36 (914)	30 (762)	1500 (681)
3000	3500	2300	720	200,000	2	80 (2032)	72 (1829)	30 (762)	2350 (1067)
2200 – 2400 Volts Reversing									
700/800 ④	900/1000 ④	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
1500/1750 ⑤	1750/2000 ⑤	2300	400	200,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
3000	3500	2300	720	200,000	4	80 (2032)	72 (1829)	30 (762)	2900 (1317)
4000 – 4800 Volts Non-Reversing									
1250/1500 ④	1500/1750 ④	4600	400	400,000	1	80 (2032)	36 (914)	30 (762)	1550 (704)
2500/3000 ⑤	3000/3500 ⑤	4600	400	400,000	1	80 (2032)	36 (914)	30 (762)	1550 (704)
5500	6000	4600	720	400,000	2	80 (2032)	72 (1829)	30 (762)	2350 (1067)
4000 – 4800 Volts Reversing									
1250/1500 ④	1500/1750 ④	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
2500/3000 ⑤	3000/3500 ⑤	4600	400	400,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
5500	6000	4600	720	400,000	4	80 (2032)	72 (1829)	30 (762)	2900 (1317)
6600 Volts Non-Reversing									
2000/2250 ④	2500/2750 ④	7200	400	570,000	1	80 (2032)	36 (914)	30 (762)	1700 (772)
4000/4500 ⑤	5000/5500 ⑤	7200	400	570,000	1	80 (2032)	36 (914)	30 (762)	1700 (772)
8000	10,000	7200	720	570,000	2	80 (2032)	72 (1829)	30 (762)	2500 (1135)
6600 Volts Reversing									
2000/2250 ④	2500/2750 ④	7200	400	570,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
4000/4500 ⑤	5000/5500 ⑤	7200	400	570,000	3	80 (2032)	72 (1829)	30 (762)	2100 (953)
8000	10,000	7200	720	570,000	4	80 (2032)	72 (1829)	30 (762)	2900 (1317)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 92 inches (2337 mm).
③ Starting and discharge resistors are mounted on top, add 13 inches (330 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.

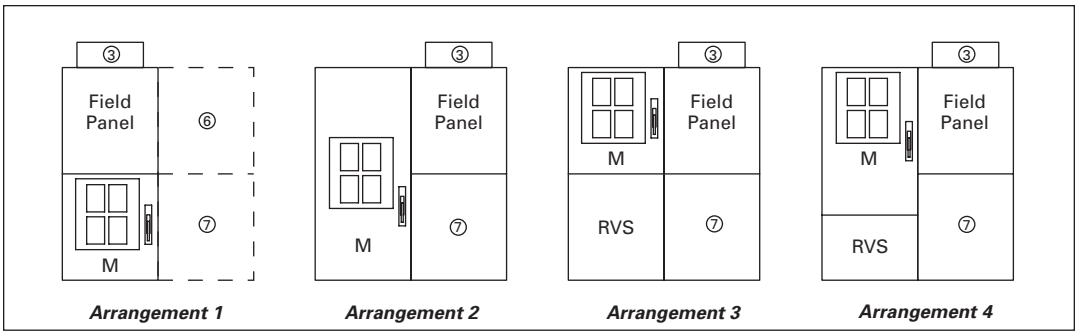


FIGURE 16. STARTER ARRANGEMENTS

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.

Dimensions for estimating purposes only.

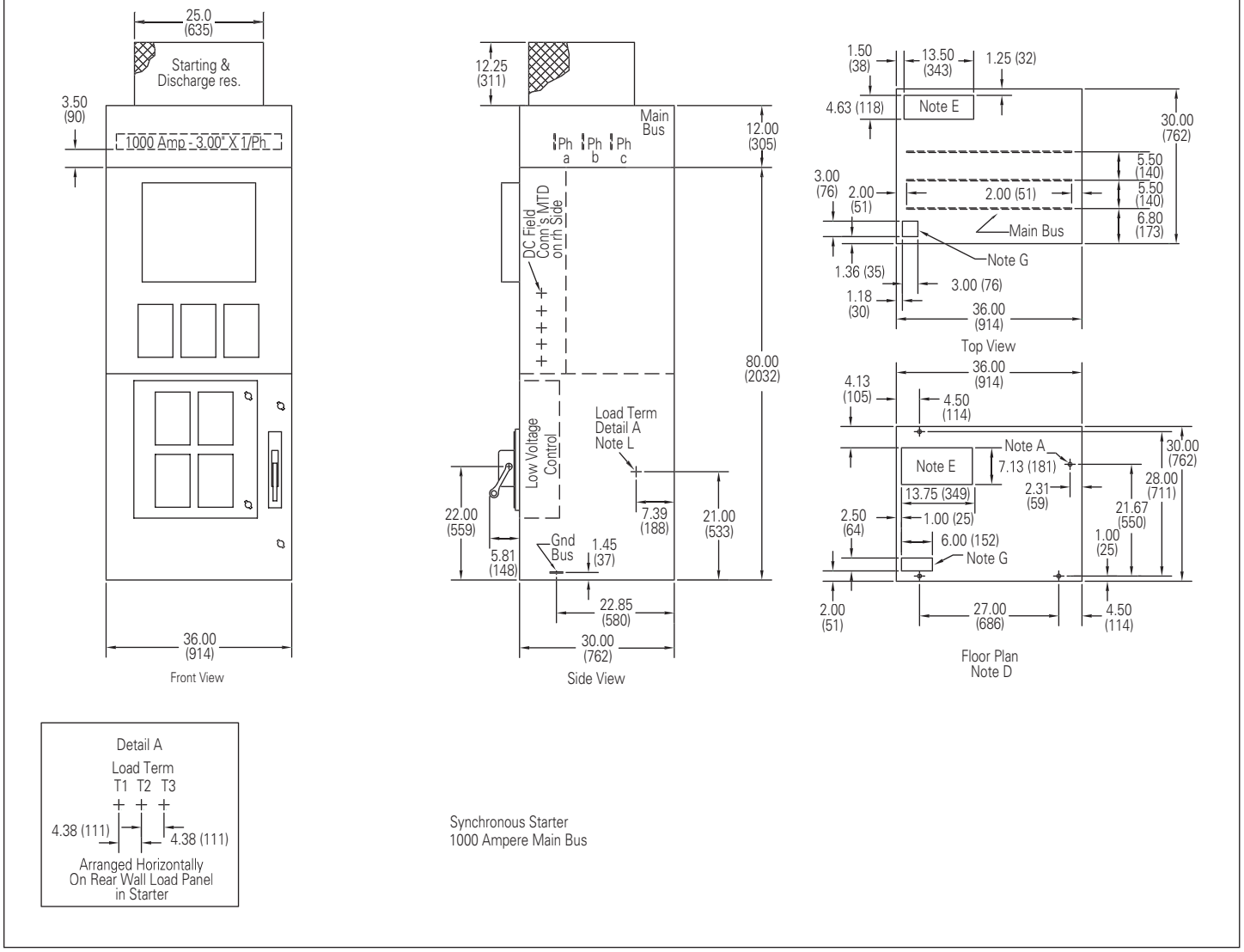


FIGURE 17. ARRANGEMENT 1 DETAIL (400 AMPERES, SYNCHRONOUS) — SEE TABLE 17 ON PAGE 36 FOR NOTES

Reduced Voltage Solid-State Squirrel Cage Starters Non-Reversing — Equipment Details

Mounted in the Medium Voltage Sections

- Three incoming line connectors.
- Drawout 3-pole gang-operated line isolating switch assembly with 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.
- Withdrawable SCR truck with integral bypass contactor.

Mounted in the Low Voltage Compartment

- Control panel 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.

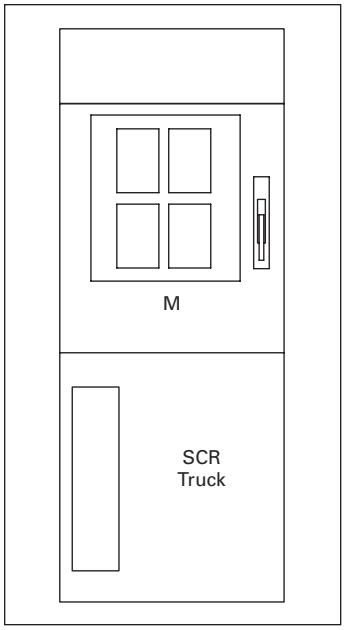


FIGURE 18. STARTER ARRANGEMENT 1

Specifications

TABLE 16. STARTER SELECTION INFORMATION — DIMENSIONS IN INCHES (MM)

Horsepower ①	Volts	SCR/Contactor Ampere Rating (Enclosed)	Starter Interrupting Rating (kVA)	Equipment Arrangement Number	Dimensions			Add. Starter Spaces	Weight Lbs. (kg)
					Height ②	Width	Depth		
2200 – 2400 Volts Non-Reversing									
1500/1750 ③	2300	400	200,000	1	80 (2032)	36 (914)	30 (762)	1	2000 (908)
4000 – 4800 Volts Non-Reversing									
2500/3000 ③	4600	400	400,000	1	80 (2032)	36 (914)	30 (762)	1	2000 (908)

① Horsepower based on NEMA standard design B motor at 1800 rpm.
② When horizontal bus is added, height becomes 92 inches (2337 mm).
③ Maximum acceleration time is 180 seconds. Consult factory for times beyond 180 seconds.

Dimensions for estimating purposes only.

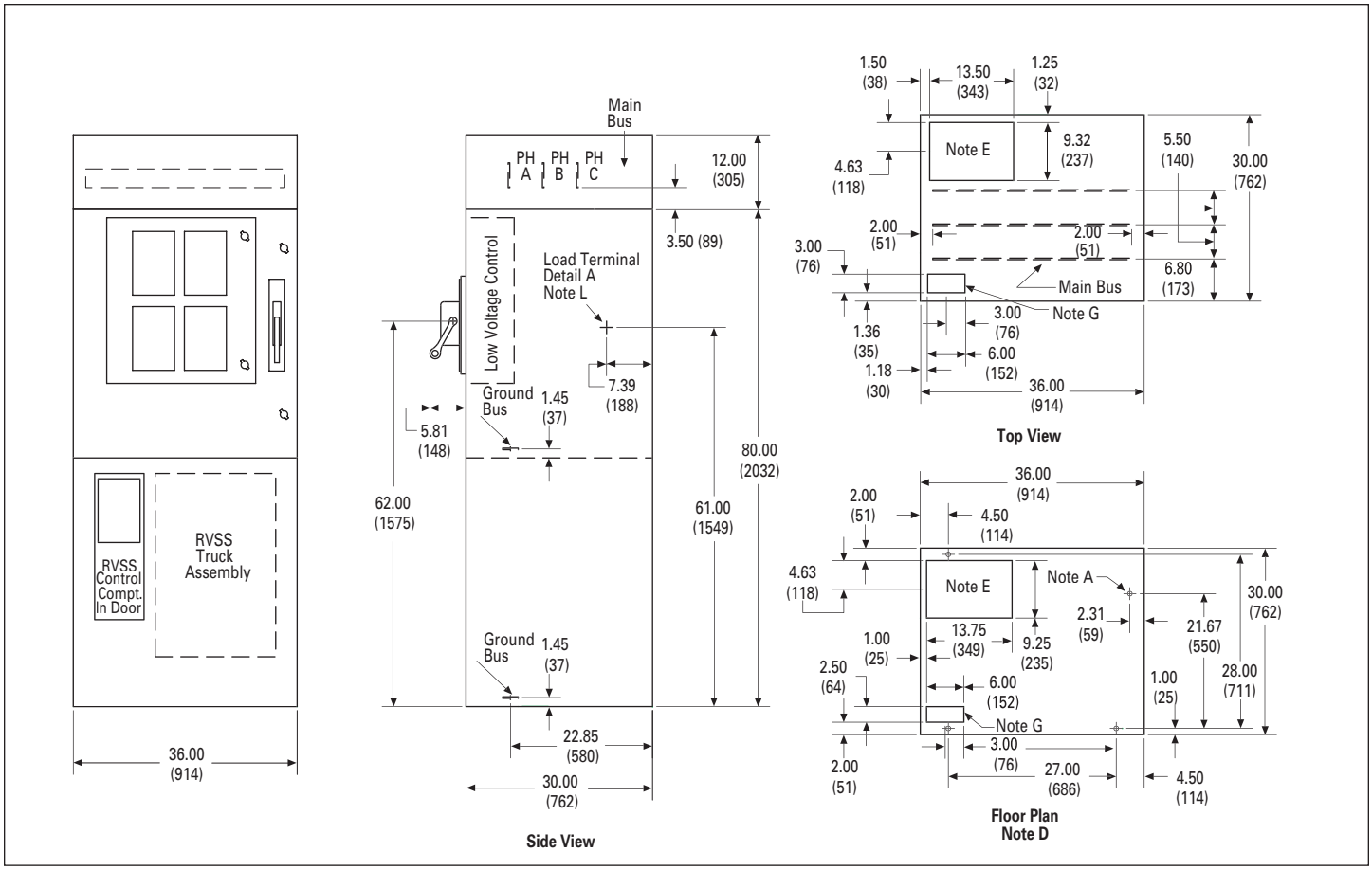


FIGURE 19. ARRANGEMENT DETAIL (400 AMPERES REDUCED VOLTAGE SOLID-STATE) — SEE TABLE 17 ON PAGE 36 FOR NOTES

TABLE 17. 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 dia. typical 4 holes. Mounting studs to extend a maximum of 2.00 inches (51 mm) above grade.
B	HV conduit space, load cables for two-high starters. Cables for lower starter enter in front half of conduit space, and cables for upper starter enter in rear half.
B1	HV conduit space, line and load cables for bottom entry stand-alone starters. Line cables should enter in rear half of conduit space, and load cables should enter in front half of conduit space.
C	LV conduit space for two-high starters with bottom entry control conduit. Control wiring for upper starter should enter in left half of conduit space, and lower starter control wiring should enter in right half of conduit space.
C1	LV conduit space for two-high starters with top entry control conduit. Control wiring for upper starter should enter in right half of conduit space, and lower starter control wiring should enter in left half of conduit space.
D	90° door swing requires 12 inches (305 mm) for 12-inch (305 mm) wide structure, 18 inches (457 mm) for 18-inch (457 mm) wide structure, 24 inches (610 mm) for 24-inch (610 mm) wide structure, 36 inches (914 mm) for 36-inch (914 mm) wide structure and 40 inches (1016 mm) for 40-inch (1016 mm) wide structure.
E	HV conduit space, load.
F	HV conduit space, line only.
F1	HV conduit space, line only. Line cables to enter in rear half of conduit space only.
G	LV conduit space only.
L	Load terminations located on rear wall of starter mounted on a load panel. Terminations are arranged horizontally from left to right. T1, T2, T3 left to right at 4.38 inch (111 mm) centers.
L1	Load terminations located on rear wall of reduced voltage enclosure mounted on a load panel. Terminations are arranged horizontally from left to right. T1, T2, T3 left to right at 4.38 inch (111 mm) centers.
T	HV conduit space, load cables for two-high starters. Cables for lower starter enter in rear half of conduit space, and cables for upper starter enter in front half.
Y	Tolerances -0.0" +.25" per structure.
Z	Conduits to extend a maximum of 2 inches (51 mm) into structure.

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

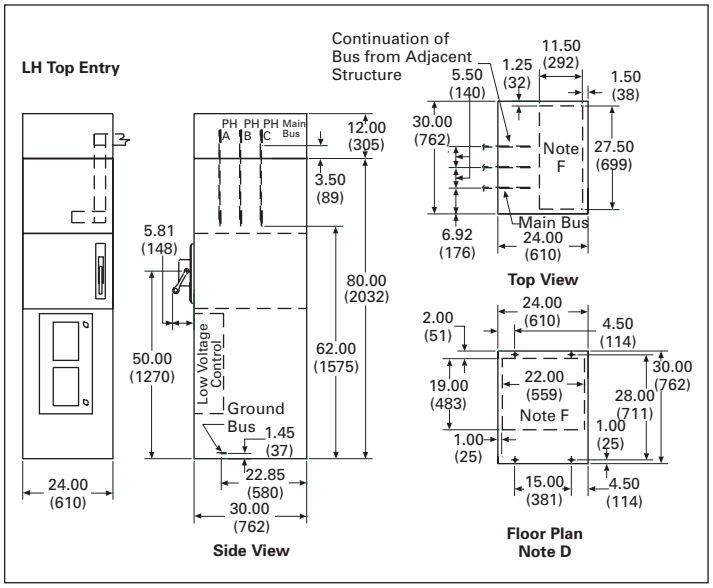


FIGURE 20. INCOMING LINE — 24-INCH (610 MM) WIDE

Note: 24-inch (610 mm) incoming line with 1200 A main bus, PT/CPT disconnect and LV compartment for left-hand end of lineup. Righthand end of lineup is mirror image. As shown for top entry of incoming cable. For bottom entry, PT/CPT disconnect must be deleted. Maximum of 4 – 750 kcmil/phase.

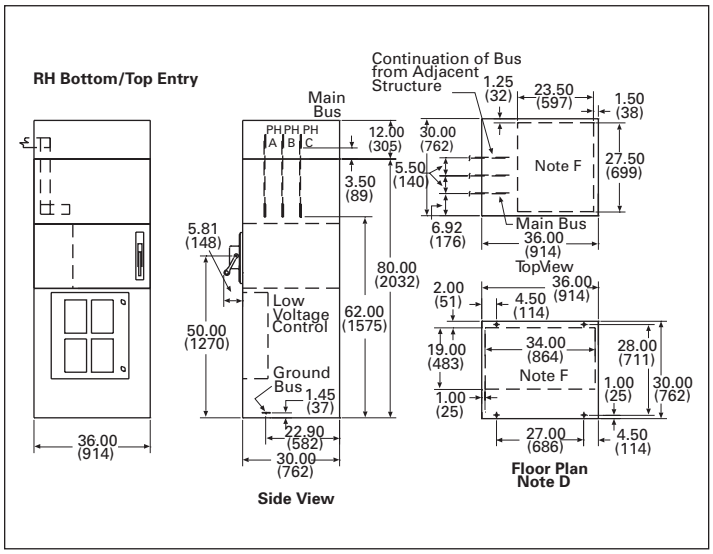


FIGURE 21. INCOMING LINE — 36-INCH (914 MM) WIDE, RIGHT END OF LINEUP

Note: 36-inch (914 mm) incoming line with 1200 A main bus, PT/CPT disconnect and LV compartment for right-hand end of lineup. Top or bottom entry of incoming cable. Maximum of 4 – 750 kcmil/phase.

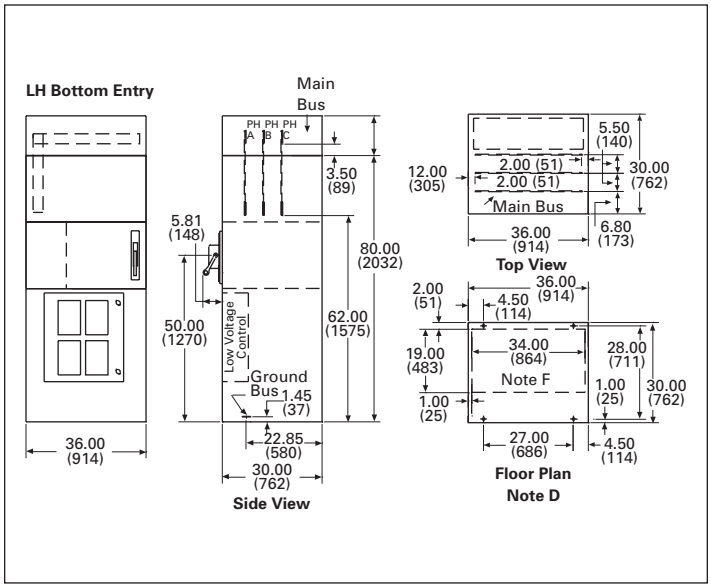


FIGURE 22. INCOMING LINE — 36-INCH (914 MM) WIDE

Note: 36-inch (914 mm) incoming line with 1200 A main bus, PT/CPT disconnect and LV compartment for lefthand end of lineup. Bottom entry of incoming cable. Maximum of 4 – 750 kcmil/phase.

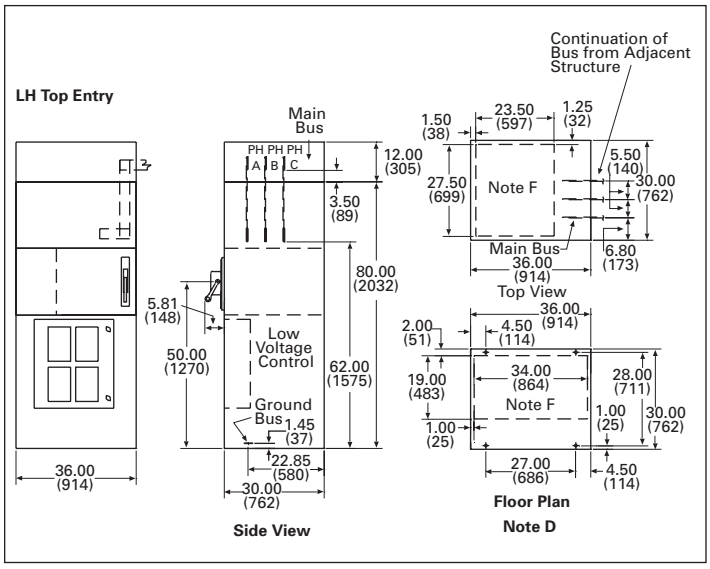


FIGURE 23. INCOMING LINE WITH PTS — 36-INCH (914 MM) WIDE

Note: 36-inch (914 mm) incoming line with 1200 A main bus, PT/CPT disconnect and LV compartment for left-hand end of lineup. Top entry of incoming cable. Maximum of 4 – 750 kcmil/phase.

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

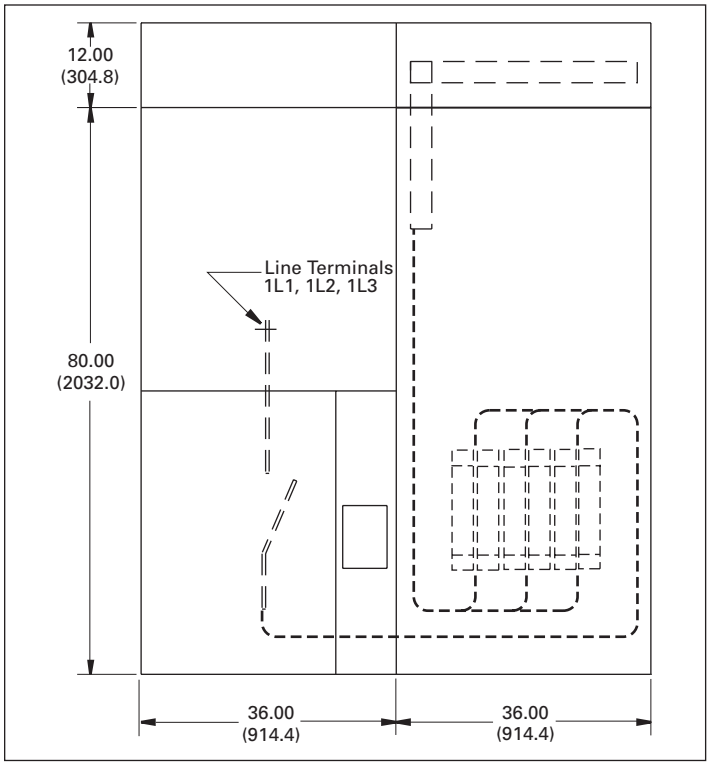


FIGURE 24. INCOMING LBS SWITCH WITH 600E/750E FUSES

Note: Left-hand end of lineup, bottom cable entry. Maximum 4 – 750 kcmil/phase.

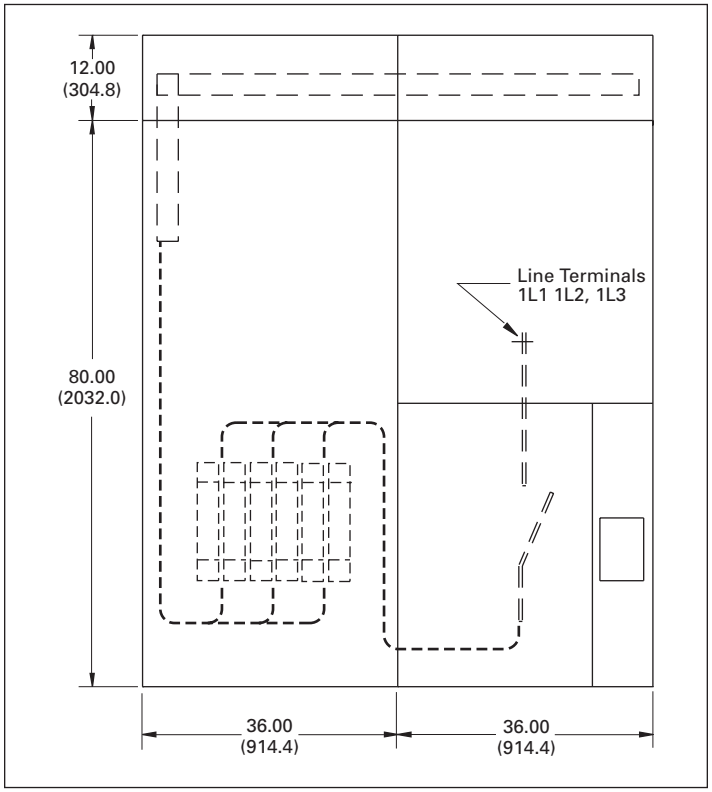


FIGURE 25. INCOMING LBS SWITCH WITH 600E/750E FUSES

Note: Right-hand end of lineup, bottom cable entry. Maximum 4 – 750 kcmil/phase.

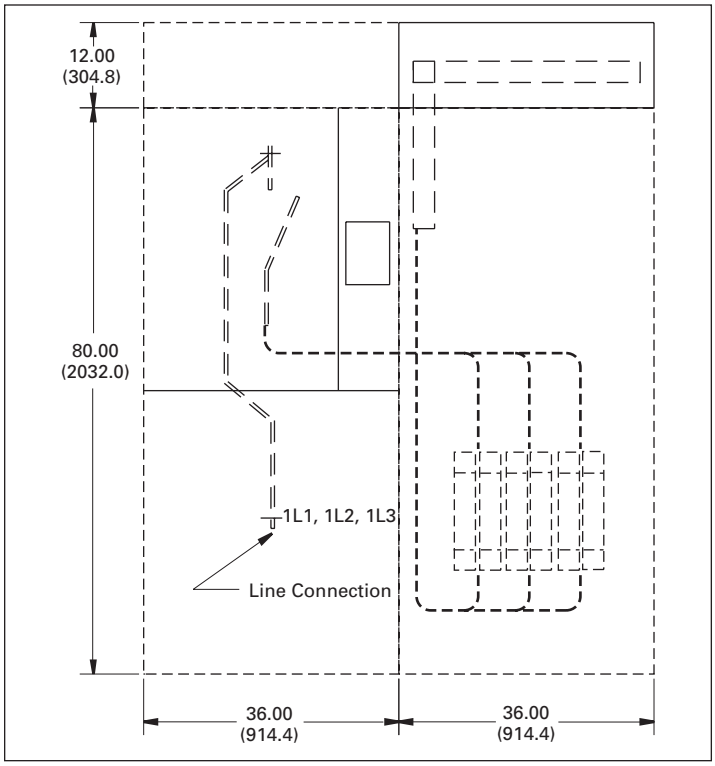


FIGURE 26. INCOMING LBS SWITCH WITH 600E/750E FUSES

Note: Left-hand end of lineup, top cable entry. Maximum 4 – 750 kcmil/phase.

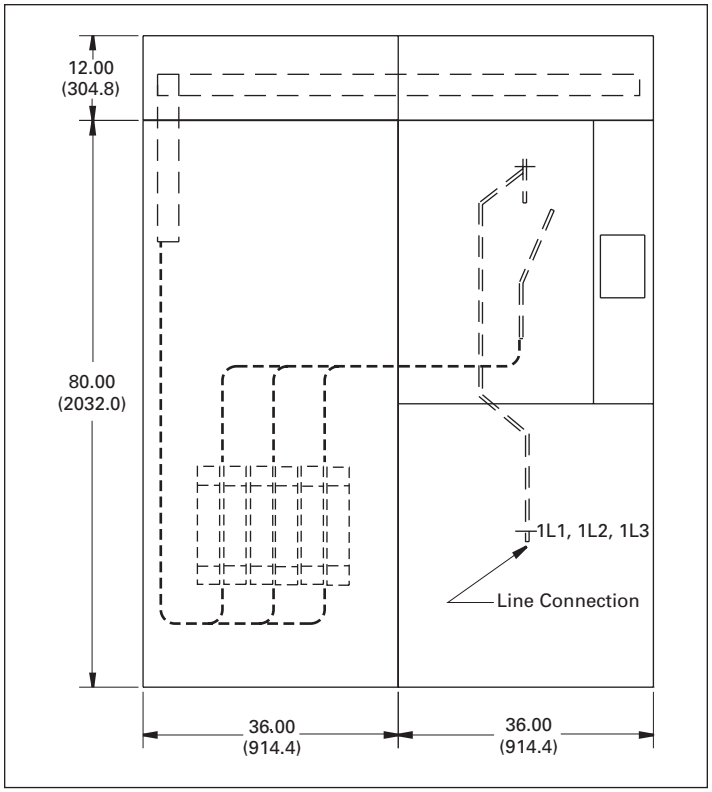


FIGURE 27. INCOMING LBS SWITCH WITH 600E/750E FUSES

Note: Right-hand end of lineup, top cable entry. Maximum 4 – 750 kcmil/phase.

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

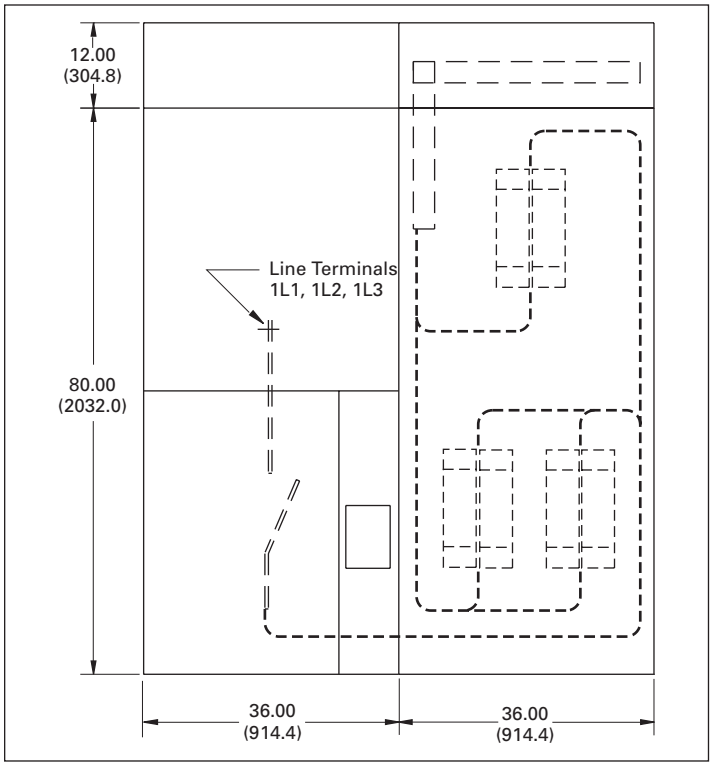


FIGURE 28. INCOMING LBS SWITCH WITH 1100E/1350E FUSES

Note: Left-hand end of lineup, bottom cable entry. Maximum 4 – 750 kcmil/phase.

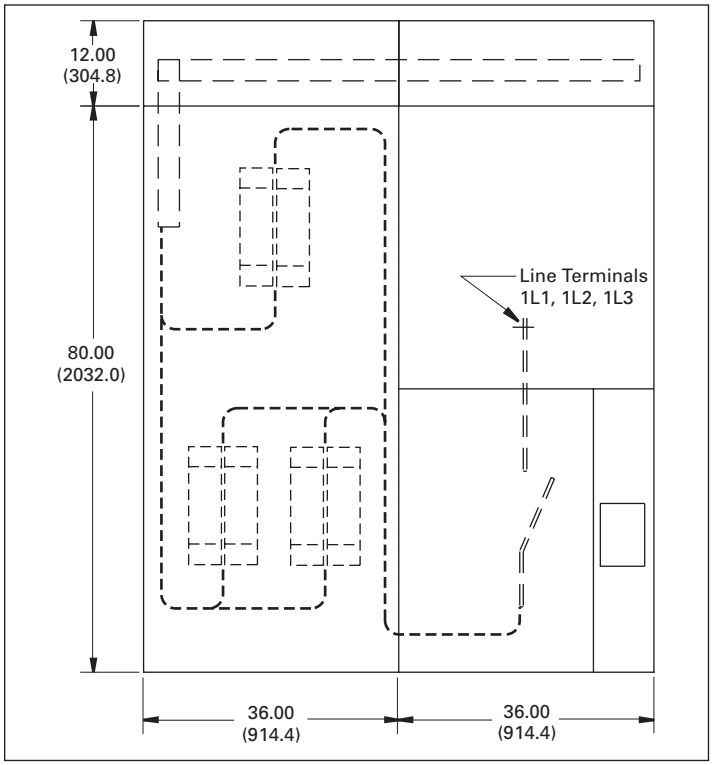


FIGURE 29. INCOMING LBS SWITCH WITH 1100E/1350E FUSES

Note: Right-hand end of lineup, bottom cable entry. Maximum 4 – 750 kcmil/phase.

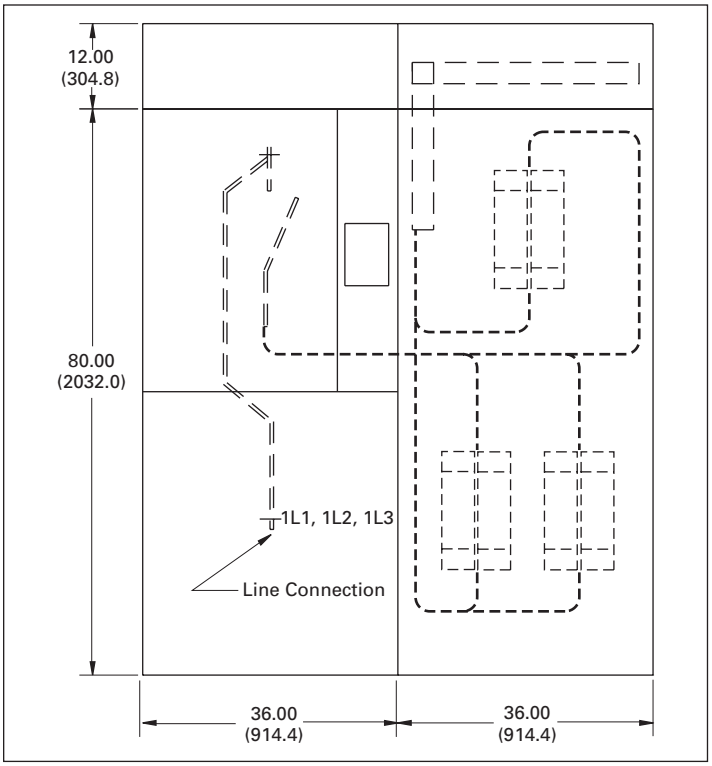


FIGURE 30. INCOMING LBS SWITCH WITH 1100E/1350E FUSES

Note: Left-hand end of lineup, top cable entry. Maximum 4 – 750 kcmil/phase.

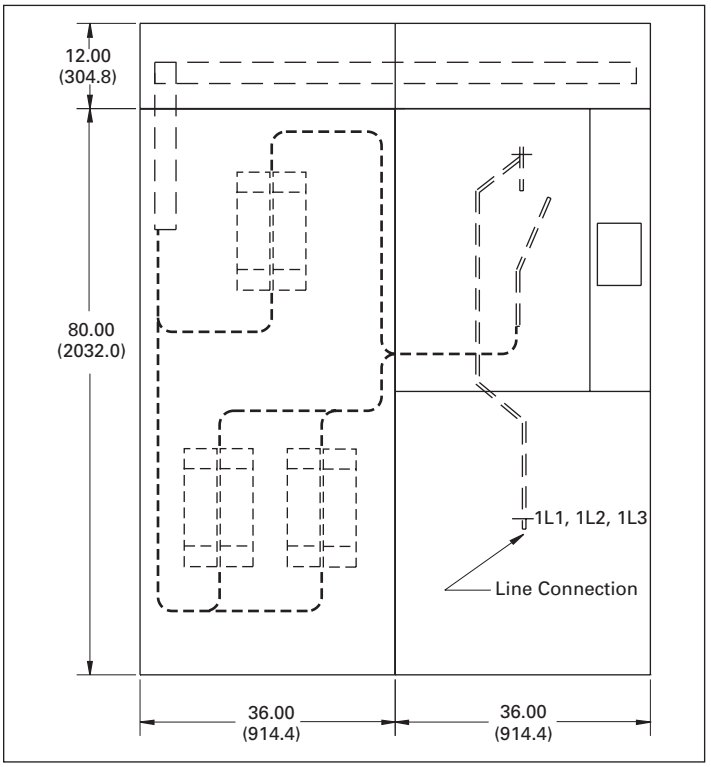


FIGURE 31. INCOMING LBS SWITCH WITH 1100E/1350E FUSES

Note: Right-hand end of lineup, top cable entry. Maximum 4 – 750 kcmil/phase.

Main Breaker AMPGARD — Dimensions in Inches (mm)

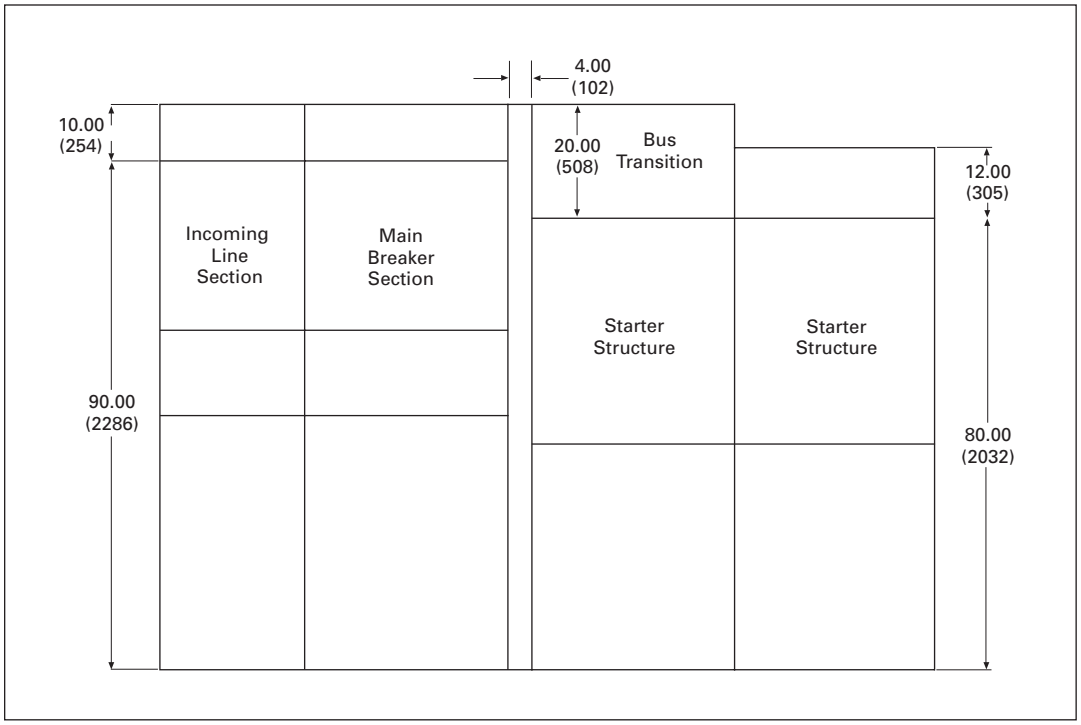


FIGURE 32. TYPICAL FRONT VIEW — MAIN BREAKER AMPGARD

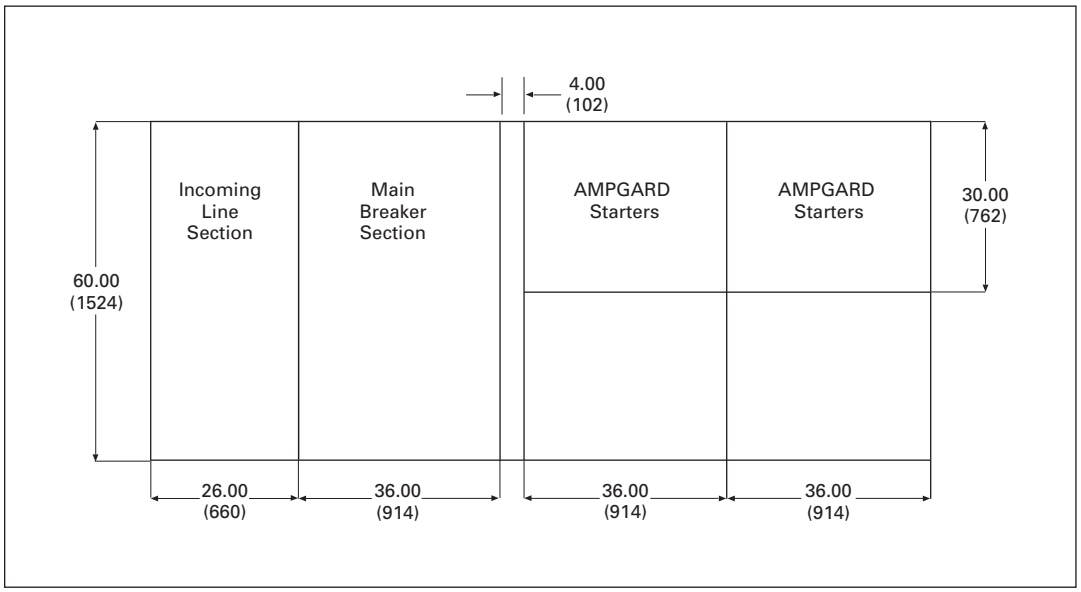


FIGURE 33. TYPICAL PLAN VIEW — MAIN BREAKER AMPGARD (REAR ALIGNED)

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Printed in USA
Publication No. TD02003001E / Z4036
December 2005

EATON | Cutler-Hammer