

GE Consumer & Industrial  
Electrical Distribution





# Spectra RMS™ Molded Case Circuit Breakers



imagination at work

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# Spectra RMS™ at a glance

Characteristics																
			Spectra E Frame				Spectra F Frame			Spectra G Frame				Spectra K Frame		
			SED	SEH	SEL	SEP	SFH	SFL	SFP	SGD	SGH	SGL	SGP	SKH	SKL	SKP
<b>Poles</b>			2, 3 <sup>①</sup>				2, 3 <sup>①</sup>			2, 3 <sup>①</sup>				2, 3 <sup>①</sup>		
<b>Frame Rating (amperes)</b>			150				250			600				1200		
<b>Current Range (amperes)</b>			15 - 150 <sup>②</sup>				70 - 250			125 - 600				300 - 1200		
<b>Interrupting Ratings</b>	UL/CSA Rating (kA RMS) (50/60 Hz AC)	240Vac	18	65	100	200	65	100	200	65	65	100	200	65	100	200
		480Vac	18	25	65	100	35	65	100	-	35	65	100	50	65	100
		600Vac	14	18	25	25	22	25	25	-	25	65	65	25	42	65
	IEC 947-2 Rating (50/60 Hz AC)	220-240Vac (Icu/Ics)	18/9 <sup>③</sup>	65/33 <sup>③</sup>	100/50 <sup>③</sup>	200/100 <sup>③</sup>	65/33	100/50	200/100	-	65/33	100/50	200/100	65/16	100/25	140/35
		380-415Vac (Icu/Ics)	14/7 <sup>③</sup>	35/17 <sup>③</sup>	65/33 <sup>③</sup>	100/50 <sup>③</sup>	35/17	65/33	100/50	-	25/13	65/33	100/50	50/13	65/16 <sup>④</sup>	85/25 <sup>⑥</sup>
	500Vac (Icu/Ics)	14/7 <sup>③</sup>	25/12 <sup>③</sup>	40/20 <sup>③</sup>	50/25 <sup>③</sup>	25/12	40/20	65/33	-	18/9	35/18	50/25	25/13	42/21 <sup>⑤</sup>	50/25	
	690Vac (Icu/Ics)	-	-	5/5 <sup>③</sup>	10/5 <sup>③</sup>	-	14/7	18/9	-	-	14/7	18/9	-	14/14	18/18	
<b>Ratings/ Markings</b>	CE		✓				✓			✓				✓		
	HACR		✓				✓			✓				✓		
	Reverse Feed		✓				✓			✓				✓		
	SWD (15 - 20A)		✓													
	HID (15 - 50A)		✓													
	Current Limiting		SEL, SEP				SFL, SFP			SGL, SGP						
	100% Rated									SGH, SGL, SGP				SKH, SKL, SKP		
<b>Enclosures</b>	General Purpose (NEMA Type 1)		✓				✓			✓				✓		
	Rain-Tight (NEMA Type 3R)		✓				✓			✓				✓		
	Dust-Tight (NEMA Type 12)		✓				✓			✓				✓		
	Water-Tight (NEMA Type 4/4X)		✓				✓			✓				✓		
<b>Panel Connections</b>	A-Series (Main)		✓				✓			✓				✓		
	A-Series (Branch) (AD)		✓													
	A-Series (Subfeed) (AD, AE)		✓				✓									
	Spectra (Main)						✓			✓				✓		
	Spectra (Branch)		✓				✓			✓				✓		
	SCP Plus (Branch)		✓							✓						
	CCB (Branch)						✓							✓		
<b>Envelope</b>	Dimensions (inch/mm)	H	6.31 (160)				10.12 (257)			10.09 (256)				15.50 (394)		
		W	4.12 (105)				4.12 (105)			5.50 (140)				8.25 (210)		
		D	3.38 (86)				3.81 (97)			3.81 (97)				5.50 (140)		
	Weight (3 pole - max frame rating) (lbs)		5.65				9.15			15.85				47.6		

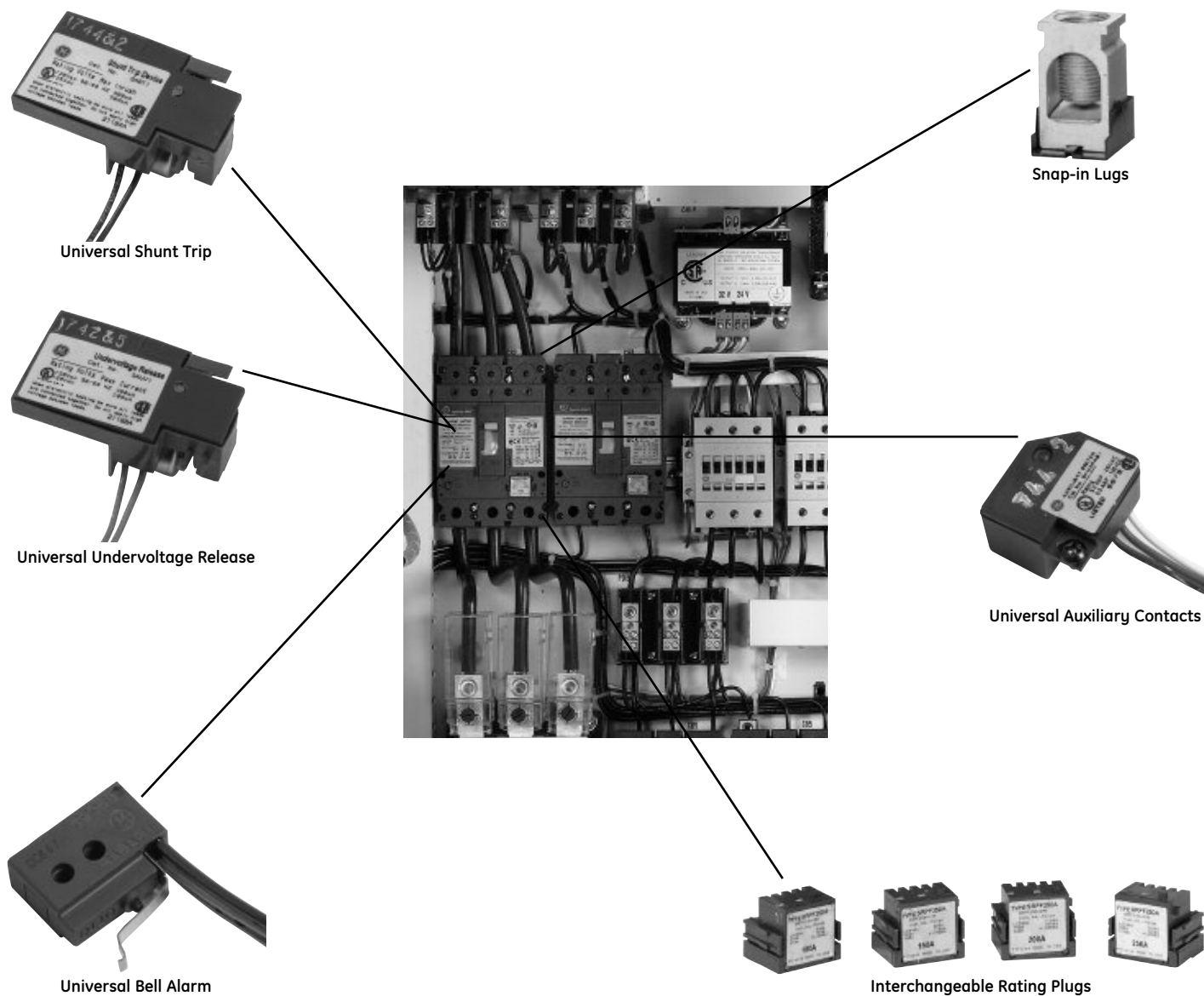
- ① 2 Pole Device in 3 Pole Frame
- ② SE MCP avail w/ 3 & 7 amp rating plugs
- ③ Spectra E Frame IEC ratings vary by ampere rating - consult table 31.1 for detail
- ④ 65/21 for SKL12
- ⑤ 42/16 for SKL12
- ⑥ 70/25 for SKP12

All frames are available as molded case circuit breakers, motor circuit protectors and molded case switches.

All frames accept the following common accessories and modifications:

- Shunt Trip
- Undervoltage Trip
- Auxiliary Switches
- Bell Alarm Switch
- Motor Operator
- Handle Operators
- Mechanical Interlocks (3-pole)
- Handle Padlock Attachment
- Plug-in Base
- Standard Lugs
- Optional Lugs

GE's Spectra RMS™ circuit breaker line pioneered the use of interchangeable rating plugs and universal internal accessories. With the superior performance characteristics needed to meet your most demanding applications, rounded out by a complete line of OEM accessories, we are confident that the Spectra RMS line of circuit breakers, motor circuit protectors and molded case switches will be the preferred product for most of your commercial, industrial and OEM applications.



- True RMS current sensing technology provides superior circuit protection. The electronic trip unit accurately monitors and responds to overcurrent conditions without the hassle of nuisance trips, even for non-sinusoidal loads such as SCR drives, welders, arc furnaces, computer power supplies and HID lighting.
- Higher IC ratings. Ratings to 100kA@480V without fuses – and without changing from traditional GE breaker sizes.

- Current limiting by design. Spectra SE, SF and SG frames provide exceptional equipment protection with less system stressing.
- Front-mounted internal accessories and rating plugs make reverse feeding possible on all frames.
- Better packaging density delivers more amps per cubic inch. The Spectra SF Frame offers up to 250A protection and the Spectra G Frame up to 600A protection in a 4X wide frame, compared to the 6X wide J Frame.

# Spectra RMS™

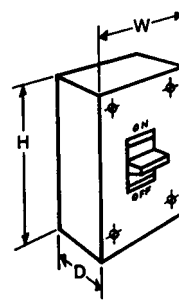
## Features and benefits overview

### Interchangeable rating plugs

The ampere rating of the Spectra RMS™ family of circuit breakers and MagBreak® motor circuit protectors is established via an interchangeable rating plug located on the face of the frame. To change the ampere rating, simply remove the existing rating plug and “snap in” a new one (up to the maximum ampere rating of the frame). The unique accept/reject feature prevents installing an incompatible rating plug. The rating plugs are a fraction of the size of traditional thermal magnetic replaceable trip units. A wide array of rating plugs is offered for each frame size (see Table 5.1).

### Field-installed breaker accessories

Each Spectra RMS circuit breaker accepts a full range of internal accessories, including a wide array of shunt trip and undervoltage release devices as well as bell alarm and auxiliary switches. These accessories are UL Listed for field installation and install in minutes without the need to remove the breaker cover. The best feature is that these internal accessories are common across all frame sizes – a simplified design approach that saves you time and money.



**Table 3.1** Spectra RMS frame dimensions

Frame	Maximum Ampere	Dimensions (in.) <sup>②</sup>		
		H	W	D
SE	7, 30, 60, 100 & 150	6.31	4.12	3.38
SF	250	10.12	4.12	3.81
SG	400 & 600	13.62 <sup>①</sup>	5.50	3.81
SK	800 & 1200	15.50	8.25	5.50

<sup>①</sup> 10.49 without lugs.

<sup>②</sup> For detailed outlines, refer to pages 36-39.

Important space savings are built into each Spectra RMS circuit breaker. Envelope dimensions for each frame are shown in Table 3.1. Accessory leads exit from the right and



**Fig. 3.1** Typical range of rating plugs SF Frame, 70-250 amps shown



**Fig. 3.2** View of SG Frame breaker with accessory pouches open, accessories displayed

left sides of the breakers (see Figure 4.1). Each Spectra RMS breaker has built-in channels along the sides and rear of the frame to allow the accessory leads to lie below the surface of the frames (see Figure 4.2). No additional space is required between adjacent breakers to accommodate accessory leads in group-mounted applications. The rear channel also allows accessory leads to be routed behind a panel-mounted unit without the need for stand-off hardware.

**Application focused time-current characteristics**

The tracking short-time function provided by Spectra RMS circuit breakers is shown in Figure 4.3. Long-time and instantaneous-trip points establish the breaker’s full load and severe overcurrent trip characteristics.

In feeder circuit applications, the tracking short-time function backs up downstream devices such as fuses or starter overloads with time for them to clear before the breaker opens. For branch circuit applications, the Spectra RMS breaker provides added, tighter protection not available in any other standard 150-amp frame breaker.

**Higher interrupting capacities**

Modern power distribution systems require protective devices with higher interrupting capacities. Each Spectra RMS circuit breaker is available in multiple IC ranges with 100 kA rms symmetrical @ 480Vac being the maximum interrupting tier. Complete UL489, CSA C22.2, and IEC 947-2 interrupting ratings are detailed in Tables 28.1 and 29.1.



Fig. 4.1 View of typical breaker with undervoltage release leads brought out on left side and auxiliary switch leads brought out on right side

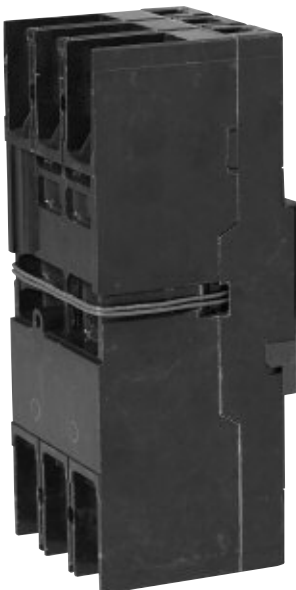


Fig. 4.2 Undervoltage release leads run behind back of breaker

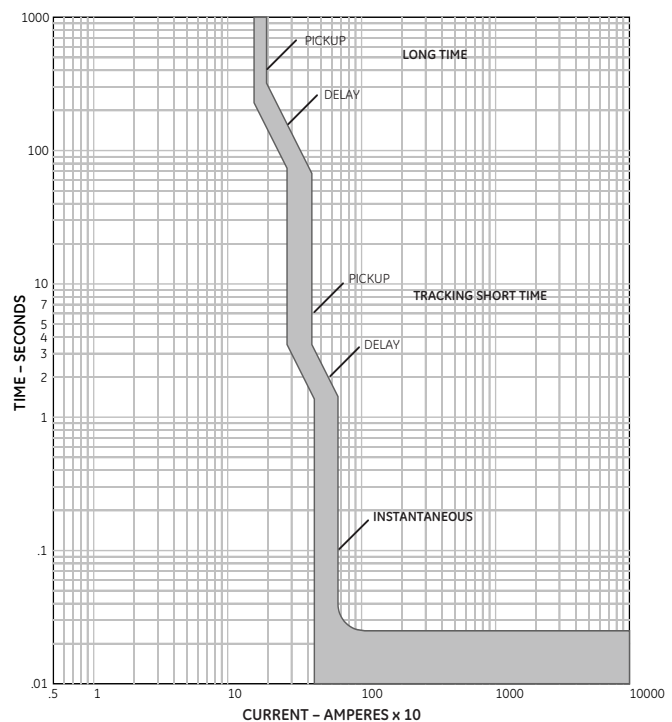


Fig. 4.3 Typical time-current curve for Spectra RMS circuit breaker

### Spectra RMS Mag-Break product line

The Spectra RMS Mag-Break motor circuit protector offers the precision and ambient insensitivity of GE's solid-state tripping system in a highly cost-effective motor circuit protective device. The same interchangeable rating plugs are used to define the instantaneous setting ranges of each unit. The instantaneous-trip point and tracking short-time characteristic is adjustable over approximately a 5-to-1 range. Figure 5.1 illustrates time current curve features of the typical Mag-Break unit shown in Figure 8.1.

As an example of the flexibility of the Spectra RMS Mag-Break line, consider a 250A SF frame with 70A and 250A rating plugs, the nominal instantaneous pickup range is 205 (min. setting) to 700A (max. setting) with a 70A plug to a range of 740A – 2500A with a 250A plug. (See Table 21.2 for details.)

### Spectra RMS molded-case switch product line

The Spectra RMS circuit breaker family also has a full line of compact, economical circuit disconnect devices. Spectra RMS molded case switches have seven current ratings from 100 amps to 1200 amps. In the event of mis-application or severe overcurrent, the contacts of these devices will open on a non-adjustable, high-set, instantaneous basis, preventing damage to the molded case switch (see Table 10.1 for values). Downstream conductor and load protection must be provided by other devices with adequate interrupting capacity.

Molded case switches, by definition, do not provide any over current protection. The short circuit withstand ratings are listed in Table 29.2.

**Table 5.1** Spectra RMS Circuit Breaker and Mag-Break motor circuit protector rating plug current ratings

Frame	Maximum Amperes	Available Rating Plugs, Amperes
SE-Frame	7 <sup>①</sup>	3 & 7
	30	15, 20, 25 & 30
	60	40, 50 & 60
	100	70, 80, 90 & 100
	150	110, 125 & 150
SF-Frame	250	70, 90, 100, 110, 125, 150, 175, 200, 225 & 250
SG-Frame	400	125, 150, 175, 200, 225, 250, 300, 350 & 400
	600	250, 300, 350, 400, 450, 500 & 600
SK-Frame	800	300, 400, 500, 600, 700 & 800
	1,200	600, 700, 800, 900, 1000 & 1200

<sup>①</sup> The 7-amp frame and the 3A and 7A rating plugs are used only with the Spectra RMS Mag-Break motor circuit protector.

### Spectra RMS circuit breaker, Mag-Break and molded case switch product line

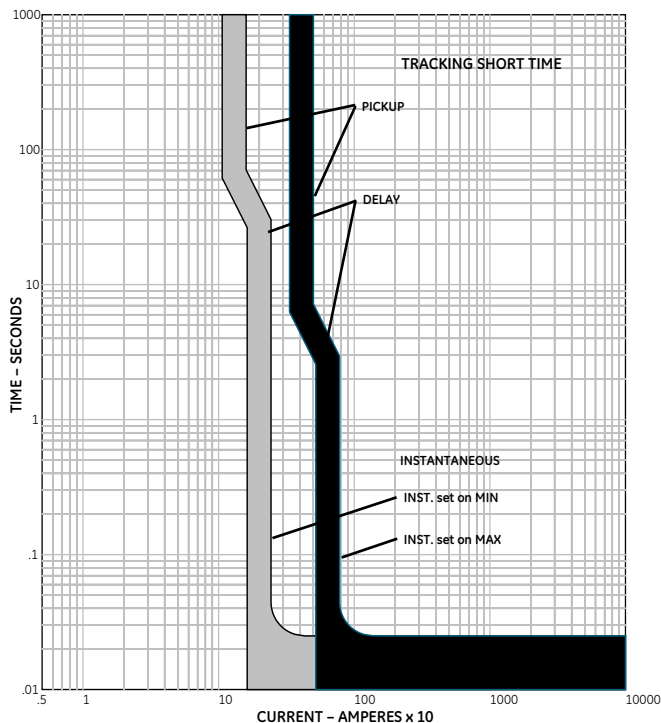
**Table 5.2** Spectra RMS maximum frame ratings (amperes) & construction summary

Frame	Circuit Breaker <sup>①</sup> (2 & 3 Pole)	Motor Circuit Protector <sup>②</sup> (3 Pole Only)	Molded Case Switch <sup>③</sup> (3 Pole Only)
SE-Frame	-	7	-
	30	30	-
	60	60	-
	100	100	100
	150	150	150
SF-Frame	250	250	250
SG-Frame	400	400	400
	600	600	600
SK-Frame	800	800	800
	1,200	1,200	1,200

<sup>①</sup> Adjustable instantaneous/short-time with changeable long-time (via rating plug)

<sup>②</sup> Adjustable instantaneous/short-time

<sup>③</sup> Fixed high-set instantaneous override



**Fig. 5.1** Typical adjustability range for Spectra RMS Mag-Break motor circuit protector

# Spectra RMS™ molded case circuit breakers

## Universal rating plug concept

All Spectra RMS circuit breakers incorporate a UL Listed interchangeable rating plug that establishes the circuit breaker's ampere rating. The key advantages of the rating plug concept are the speed and flexibility of selecting or changing the ampere rating of the circuit breaker. Each circuit breaker frame and sensor have multiple rating plugs that offer a wide range of standard ampere ratings from which to select.

Since the installed rating plug establishes the ampere rating of the breaker, the installer must verify the adequacy of the connected cable and/or bus bar ampacity. The National Electrical Code allows cable size to be matched to the ampere rating established by the rating plug.

All rating plugs have built-in accept/reject features to assure that they are applied correctly. For example, SE-Frame Spectra RMS circuit breakers are offered in four frame ratings: 30, 60, 100 and 150 amp. The 60-amp frame has three rating plugs (40-, 50- and 60-amp). Rating plugs for the 60-amp SE-Frame circuit breaker can only be used on that family of units. Conversely, rating plugs for other frames or current ratings are not accepted by the 60-amp SE-Frame rating plug cavity.

## Trip unit characteristics

Spectra RMS circuit breakers offer the application flexibility and accurate measurement of current waveforms with harmonic content. In addition, SE-, SF- and SG-Frame circuit breakers incorporate true current limiting construction. All Spectra RMS circuit breakers offer IC (Interrupting Capacity) ratings up to, and including 100,000 amps, rms, symmetrical, at 480 Vac and up to 200 kA at 240 Vac.

## Application flexibility

Application flexibility is provided by adding short-time and instantaneous trip characteristics to the long-time, time current curve of the solid-state trip system.

## Long time

The rating plug determines the long-time trip performance of the Spectra RMS circuit breaker. Spectra RMS circuit breakers are designed to carry 100% of the rating plug ampere rating continuously, in open air without exceeding a 50°C temperature rise at the circuit breaker terminals. At 105% to 130% of the rating plug ampere rating (the long-time pick-up tolerances of the trip circuit), the circuit breaker will trip in the event of a long-term overload downstream from the circuit breaker.

## Short time

The inverse-time short-time delay trip characteristic of Spectra RMS circuit breakers provides an increase in protection by



Fig. 6.1 Removal of rating plug

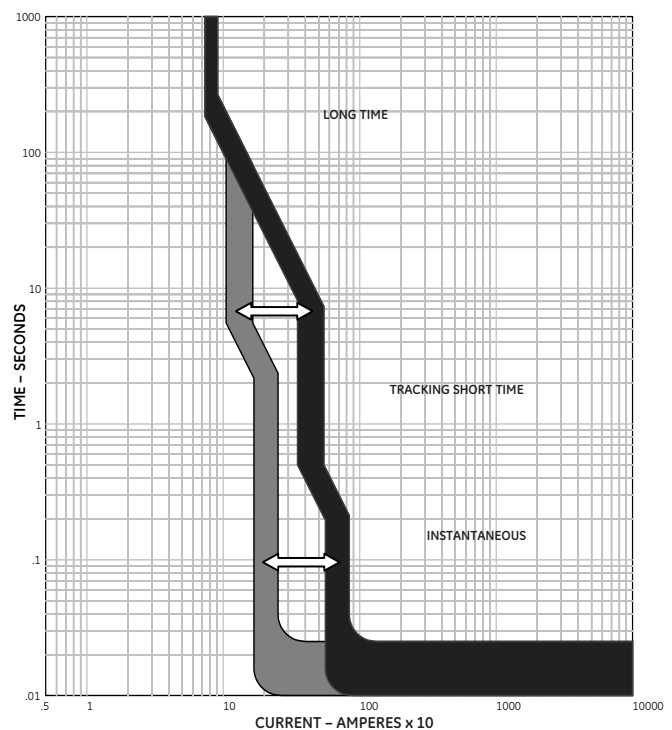


Fig. 6.2 Typical adjustability range for Spectra RMS circuit breaker



providing closer tracking of load-operating conditions. The short-time pickup function tracks the instantaneous pickup by a factor of 0.5 to 0.8, depending upon specific frame and rating plug.

**Instantaneous**

The trip setting adjustment knob controls the settings of both short-time and instantaneous-trip characteristics. When the adjustment knob is set in the “Max” position, the breaker will trip instantaneously between 10 to 13 times (depending upon breaker frame) the long-time trip rating (i.e., rating plug amp rating). This provides sufficient margin to avoid nuisance tripping when energizing inductive loads such as motors or transformers.

The nominal instantaneous pickup values, in amps, are listed on each rating plug as shown in Figure 7.1.

**Spectra RMS current limiting construction**

Spectra RMS circuit breakers continue the GE standard of rugged construction and the use of heavy silver-alloy contacts. The low physical mass of the contact arms in the SE, SF and SG Frame Spectra RMS circuit breakers, coupled with a reverse current loop, result in true current limiting performance without compromising breaker life.

When short circuit current flows through the lower and upper contact arms of the circuit breaker, a strong magnetic field is produced by the fault current. Since the fields are opposing, forces proportional to the square of the current act to “blow-open” the movable contact arms. The higher the fault current, the higher the contact separation forces. During maximum fault conditions, contact separation typically occurs within a quarter of one cycle, and the arc is fully quenched within eight milliseconds.

Peak let-through current, illustrated in Figure 7.2, is held to less than 45% of the maximum available peak fault current, resulting in a tremendous reduction in the amount of energy that the fault delivers to the conductors and the connected load.

If current limiting performance is required, choose between Spectra SEL, SEP, SFL, SFP, SGL and SGP catalog numbers.



Fig. 7.1 Rating plug label

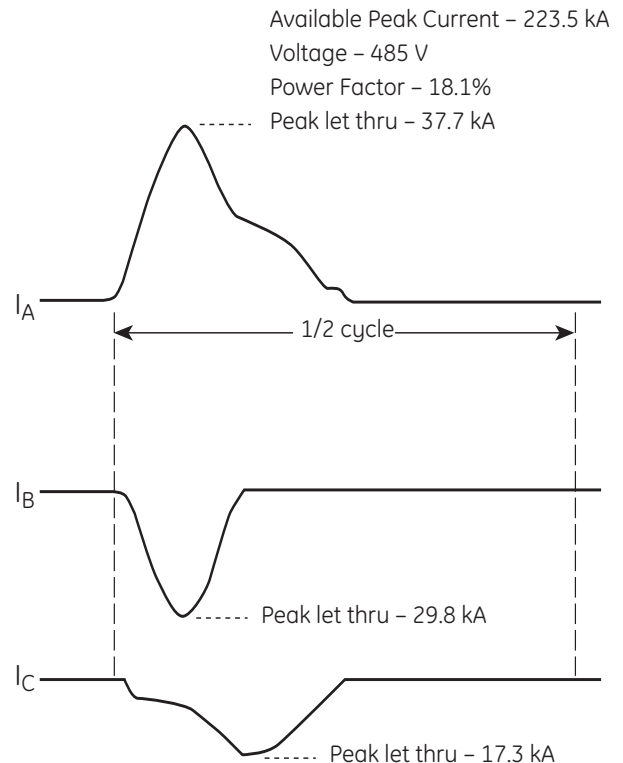


Fig. 7.2 Typical current limiting performance

# Spectra RMS™ Mag-Break® motor circuit protectors

## Interchangeable rating plug

Spectra RMS Mag-Break motor circuit protectors use the same snap-in rating plugs as fully configured (long-time trip function) Spectra RMS circuit breakers. Each rating plug defines the range of instantaneous-trip settings available to the circuit breaker through its trip setting adjustment.

## Trip setting adjustment

The solid-state instantaneous-trip circuitry of the Spectra RMS Mag-break motor circuit protectors has a single, multi-position adjustment at the front of each breaker. Changes in settings vary the instantaneous-trip and tracking short-time characteristics. The Mag-Break motor circuit protectors differ from a fully configured circuit breaker by only providing an instantaneous and tracking short-time trip function.

## Accessory pockets

Spectra RMS Mag-Break motor circuit protectors have the same accessory pockets and use the same internal accessories as Spectra RMS circuit breakers. This important capability allows field modification of Mag-Break units with shunt trip, undervoltage release, bell alarm or auxiliary switch accessories, in any combination, without affecting the UL Listing status.

## Spectra RMS rating plugs

Use of the same UL Listed interchangeable rating plugs for both Mag-Break and fully configured Spectra RMS circuit breakers expands the flexibility of the entire Spectra RMS family of products. The advantages of interchangeable rating plugs with Spectra RMS circuit breakers are inherent to Spectra RMS Mag-Break units, which permit wider ranges of motor ratings to be protected by a given breaker frame size.



Fig. 8.1 SE150 Spectra RMS Mag-Break motor circuit protector

## Spectra RMS Mag-Break trip unit characteristics

Spectra RMS Mag-Break motor circuit protectors provide positive, reliable and cost-effective instantaneous, with tracking short-time overcurrent protection to those circuits where long-time overload protection is supplied by thermal or solid-state overload devices.

## Motor circuit short circuit protection

When a squirrel-cage induction motor is energized, a high value of magnetizing inrush current flows for the first few cycles, followed by a substantial reduction in current flow while the motor accelerates to its rated speed. When plotted on a time current curve, the motor current has three distinct regions – for the first five to eight cycles, typical magnetizing inrush currents are approximately ten times the full-load motor current (but can be much greater for high efficiency motors). Between 0.10 and 10 seconds, the magnetizing inrush current drops to approximately five to six times the full-load motor current. After approximately 10 seconds, the motor reaches its full speed and the current quickly decreases to the full-load current of the motor.

Optimum motor protection for the first two regions of the motor time current plot would involve a two-tiered protection scheme with a high value of current tolerated for a few cycles, followed by a lower, sustained trip setting.

This is exactly the protection that is offered by the Mag-Break motor circuit protector. This two tiered protection scheme prevents nuisance tripping due to magnetizing inrush current, without compromising superior short circuit protection during motor acceleration. Protection for the third region of the motor time current plot is accomplished via the motor starter's overload relay.

Figure 8.2 illustrates this motor protection scheme. Curve A and the shaded area directly above it represents the region

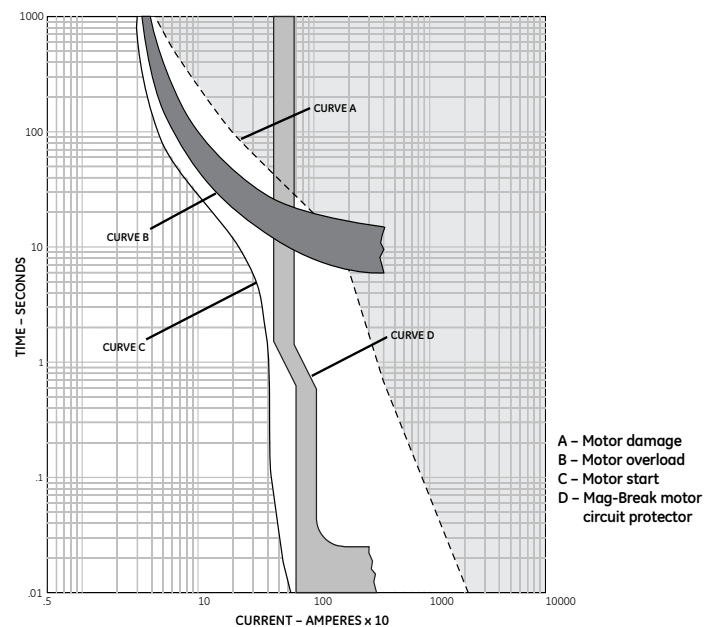


Fig. 8.2 Motor circuit protection using Mag-Break motor circuit protectors

of operation that will produce permanent damage to either the motor, its feeder conductors or both. Curve B represents the trip characteristics of the motor starter's overload relay, which provides both long-term overload and stall protection but does not protect the system from short circuits in either the motor or its feeder conductors. Curve C is a plot of the motor current during a worst-case start (e.g., low line voltage, highest load torque, etc.). Curve D represents the trip characteristics of the Mag-Break motor circuit protector — with this addition, the motor and its feeder conductors are now fully protected against short circuits.

**Spectra RMS Mag-Break motor circuit protector ratings**

Table 9.1 lists rating plugs available for each Mag-Break motor circuit protector frame size. Instantaneous trip settings are listed under electrical data on page 21 and UL interrupting ratings are shown on page 28 (per UL 489, motor circuit protectors are not marked with interrupt ratings). Except for 3 amp and 7 amp plugs, all other rating plugs are used in both circuit breaker and Mag-Break motor circuit protectors.

**Table. 9.1** Spectra RMS Mag-Break motor circuit protector and rating plug current ratings

Frame	Maximum Amperes	Available Rating Plugs, Amperes
SE-Frame	7 <sup>①</sup>	3 & 7
	30	15, 20, 25 & 30
	60	40, 50 & 60
	100	70, 80, 90 & 100
	150	110, 125 & 150
SF-Frame	250	70, 90, 100, 110, 125, 150, 175, 200, 225 & 250
SG-Frame	400	125, 150, 175, 200, 225, 250, 300, 350 & 400
	600	250, 300, 350, 400, 450, 500 & 600
SK-Frame	800	300, 400, 500, 600, 700 & 800
	1,200	600, 700, 800, 900, 1000 & 1200

① The 7-amp frame and the 3A and 7A rating plugs are used only with the Spectra RMS Mag-Break motor circuit protector.

# Spectra RMS™ molded case switches

## Construction

The family traditions of ruggedness and dependability are continued in the Spectra RMS molded case switch line. These units provide a circuit disconnect function using the compactness of molded case circuit breaker construction. The operating handle actuates all three poles of the switch using the same internal components as the Spectra RMS circuit breakers and Mag-Break units.

## Termination lugs

Snap-in termination lugs used with SE- and SF-Frame Spectra RMS circuit breakers are used interchangeably in Spectra RMS molded case switches. SG- and SK-Frame molded case switches use the same bolt-on termination lugs used with Spectra RMS circuit breakers.

## External accessories

The full range of external circuit breaker accessories offered for use with Spectra RMS circuit breakers and Mag-Break motor circuit protectors, are available for molded case switches. Figure 10.1 shows a Spectra RMS molded case switch. In addition, plug-in bases, motor-operated mechanisms, mechanical interlocks and the full complement of external handle operators (STDA, TDR and TDM) are available for use with Spectra RMS molded case switches.

## Fixed-trip setting

The Spectra RMS molded case switches are equipped with a fixed Hi-set instantaneous trip setting whose values are shown in Table 10.1.

Table 10.1 Spectra RMS molded case switch fixed trip setting

Molded Case Switch Frame	Maximum Amperes	Fixed Trip Setting RMS Amperes Nominal ±20%
SE-Frame	100	2,100
	150	
SF-Frame	250	2,450
SG-Frame	400	5,600
	600	6,000
SK-Frame	800	12,600
	1,200	12,700

The 7-amp frame and the 3A and 7A rating plugs are used only with the Spectra RMS Mag-Break motor circuit protector.

## Spectra RMS molded case switch applications

Molded case switches are inherently horsepower-rated. By virtue of the UL489 six-times-rated current overload test, they can be used as motor circuit disconnects where overload and short circuit protection are provided by other protective devices.

A common application of Spectra RMS molded case switches is illustrated in Figure 10.2, which shows a system containing three branch circuits.

Branch Circuit 1 uses a Spectra RMS Mag-Break motor circuit protector, in conjunction with the overload devices of the motor starter, to protect the motor and the conductors of that branch circuit. Branch Circuits 2 and 3 use fully configured Spectra RMS circuit breakers to provide instantaneous, short-time and long-time protection for both branch-circuit conductors and loads.



Fig. 10.1 Spectra RMS molded case switch

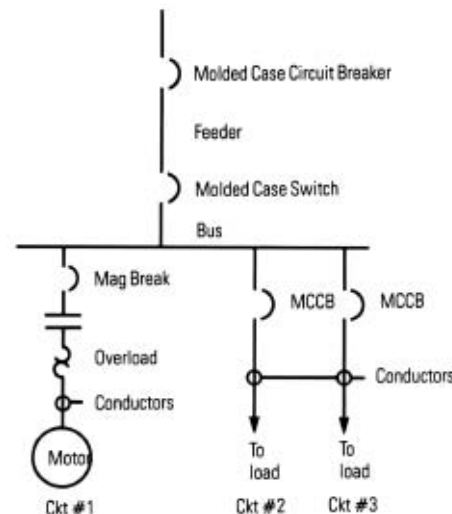


Fig. 10.2 Spectra RMS molded case application

Protection of the short bus and feeder between the Spectra RMS molded case switch and the bus in this figure is provided by a properly rated breaker.

Spectra RMS molded case switches are excellent circuit disconnect devices for those applications where both the advantages of molded case switch construction are desired, and where the available short circuit current is less than the switch withstand rating as defined in Table 29.2.

All Spectra RMS molded case switches are UL Listed and tested per UL Standard 1087 for molded case switches. The short circuit withstand ratings are based upon three cycle tests. Thus the UL Listed upstream overcurrent protective devices (i.e., low-voltage power circuit breakers equipped with instantaneous-trip functions, insulated-case circuit breakers, molded case circuit breakers or fuses) can be used in conjunction with molded case switches.

**Table. 11.1** Spectra RMS molded case switch current ratings  
Three-pole, 600-Vac

Switch Frame	Type	Maximum Frame Ampere
SE-Frame	SEDA	100 & 150
SF-Frame	SFDA	250
SG-Frame	SGDA	400 & 600
SK-Frame	SKDA	800 & 1200

## Accessories

### Internal accessories

Spectra RMS™ internal accessories are common to all products in the Spectra RMS product family, including circuit breakers, Mag-Break motor circuit protectors and molded case switches. They are interchangeable between frame sizes, i.e., the 24 Vdc/24 Vac shunt trip – SAST3 – can be installed in any of the four basic frames from the type SE150 to the type SK1200. In addition, Spectra RMS internal accessories are designed to be installed in pockets accessible from the front of the circuit breaker.

### No disassembly of the circuit breaker case is required.

These unique characteristics – interchangeability, commonality and installation without violation of case integrity – provide the user with the optimum combination of reliability, standardization and parts reduction. **All Spectra RMS accessories are UL Listed for field installation.**

The left-hand circuit breaker accessory pocket accepts an actuator, shunt trip or undervoltage release plus a bell alarm switch. The right-hand pocket is used for auxiliary switches. All accessories are supplied with 36-inch long, #18AWG 105°C 300V minimum insulated leads. Side and rear wire channels allow accessory leads to be led to the left, right or back of the breaker within the dimensions of the breaker envelope.

### Shunt trip



The shunt trip is used to trip (open) the circuit breaker by remote control. Spectra RMS shunt trips are UL Listed for field installation, meeting UL requirements for operation at 55% of rated ac voltage and 75% of rated dc voltage for use on ground fault systems.

A momentary application of control power is recommended to activate the shunt trip coil. An integral pulsing circuit is used within the shunt trip's electronics to prevent the coil from being damaged from maintained control power. If maintained control power (latching relay) is used in lieu of momentary application of control power, use a bell alarm contact in series with the shunt trip's control power for the SE/SF breakers or an auxiliary switch in series with the shunt trip's control power for the SG/SK breakers. Failure to wire

the bell alarm or aux switch in series could result in a 1 to 2 second delayed response if the breaker is re-closed while the shunt trip is continuously energized.

### Electrical data

Table 12.1 Shunt trip device electrical characteristics

Catalog Number	Rated Nominal Voltage		Current, mA	
	AC	DC	Inrush	Cont.
SAST1	120	125	500	6
SAST2	240	250	400	5
SAST5	—	12	1000	800
SAST3	24	24	300	10
SAST4	48	48	300	1

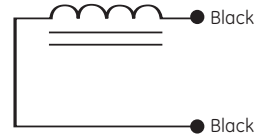


Fig. 12.1 Wiring diagram, shunt trip

### Undervoltage release



The undervoltage release trips the circuit breaker when control voltage drops to less than 35% to 70% of its rated voltage. Optional time delay units from 100 to 1,000 milliseconds allow the user to minimize nuisance tripping. The time delay may be switched off to provide an instantaneous undervoltage trip. In the event an attempt is made to reclose the circuit breaker while the undervoltage condition is still present, the undervoltage release device will prevent breaker contact closure; i.e., it's a "kiss-free" design.

The "kiss-free" feature requires that if a breaker is in the OFF position and the toggle handle is being held in the off position, such as by a motor operated mechanism, and a trip command from a shunt trip or undervoltage release (UVR) causes the breaker mechanism to trip, the following steps must be completed to turn on the breaker:

1. restore control power to UVR if applicable
2. move toggle handle to ON position (breaker will not close)
3. move handle back to reset (OFF) position
4. move handle to ON to close

## Electrical data

Table 13.1 Undervoltage release electrical characteristics

Catalog Number	Rated Nominal Voltage		Peak Current, mA
	AC	DC	
SAUV1	120	125	200
SAUV2	240	250	200
SAUV3	24	24	100
SAUV4	48	48	100

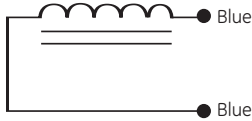
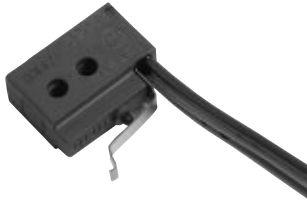


Fig. 13.1 Wiring diagram, undervoltage release

## Actuator

All Spectra circuit breakers are supplied with a factory installed actuator in the left-side accessory pocket. The actuator is removed when installing either a shunt trip or undervoltage release. The catalog number for a replacement actuator is SACTUATOR.

## Bell alarm switch



The bell alarm switch is used to signal breaker trip status to other accessories (e.g., external alarm devices, indicating lights, relays or logic circuits) for remote indication and interlocking applications. It is installed on the actuator or shunt trip or undervoltage release. The switch operates when the breaker is tripped as a result of its protective functions, or as the result of the operation of a shunt trip or undervoltage release. The switch is *not* actuated as a result of normal breaker “On-Off” operation.

The bell alarm switch is available with one single-pole double-throw (SPDT) element in either of two ratings: with control power duty contacts suitable for 120-240 Vac and 48-125 Vdc application, or low-impedance contacts for signal-level circuits such as dc pilot circuits and programmable logic controllers. Signal-level contacts are gold-plated and are suitable for 5-30 Vac or Vdc.

## Electrical data

Table 13.2 Alarm switch electrical characteristics

Catalog Number	Contact Configuration	Contact Ratings				
		AC		DC		
		Volts	Amps	Volts	Amps - Res.	Amps - Ind.
SABAP1	1 AB element	120-240	5	48-125	0.50	0.25
SABAG1	1 AB element, gold-plated	5-30	1	5-30	1.0	0.50

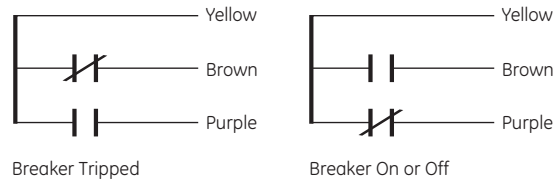


Fig. 13.2 Wiring diagram, bell alarm switch

## Auxiliary switch



The auxiliary switch signals primary contact position (open or closed) to other accessories (e.g., indicating lights, relays or logic circuits) for remote indication, interlocking and control applications. Switch operation is independent of the method used to open or close the breaker. Auxiliary switches do not distinguish between a trip or open condition.

The auxiliary switch is available with either one or two single-pole double-throw (SPDT) elements in either of two contact ratings: control power duty contacts suitable for 120-240 Vac and 48-125 Vdc application, or low-impedance contacts for signal-level circuits such as dc pilot circuits and programmable logic controllers. Signal-level contacts are gold-plated and are suitable for 5-30 Vac or Vdc.

## Electrical data

Table 13.3 Auxiliary switch electrical characteristics

Catalog Number	Contact Configuration	Contact Ratings				
		AC		DC		
		Volts	Amps	Volts	Amps - Res.	Amps - Ind.
SAUXPAB1	1 AB Element	120-240	5	48-125	0.50	0.25
SAUXPAB2	2 AB Elements	120-240	5	48-125	0.50	0.25
SAUXGAB1	1 AB Element, gold-plated	5-30	1	5-30	1.0	0.50
SAUXGAB2	2 AB Elements, gold-plated	5-30	1	5-30	1.0	0.50

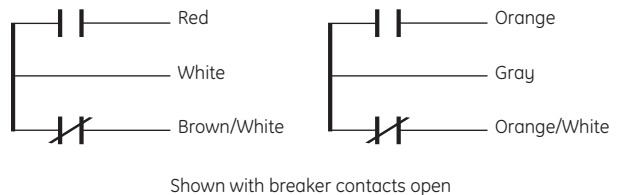


Fig. 13.3 Wiring diagram for SAUXPAB2

## External accessories

### Termination lugs

Termination lugs permit easy front connection of either copper or aluminum-insulated conductors to the terminals of Spectra RMS circuit breakers and molded case switches.

Figure 14.1 illustrates the snap-in lugs that are installed without tools in SE- and SF-Frame Spectra RMS circuit breakers and molded case switches.

### Sizes and ratings

Termination lugs are designed and tested for use with conductors sized on 75°C ampacity and insulated with 75°C insulation (or higher). Table 14.1 lists the conductor ranges for these tinplated extruded-aluminum lugs and copper lugs.

**Table 14.1** Lug sizes and ratings for circuit breakers (including Mag-Break) and molded case switches

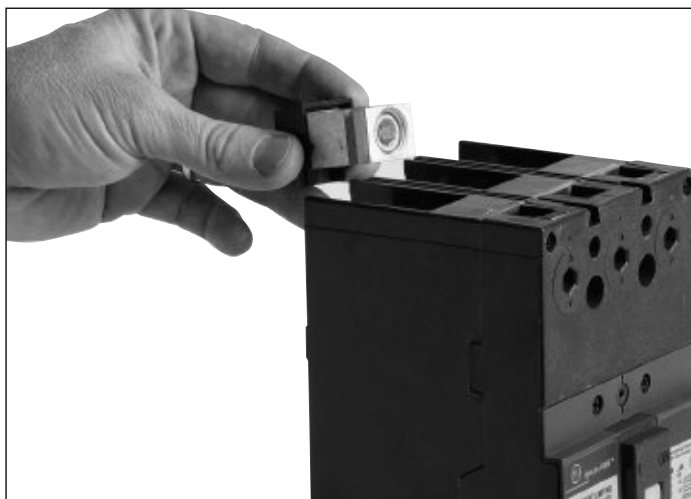
Device	Frame Amps	Catalog No.	(Qty) Wire Range (75°C Insulated Conductor)	
			Copper	Aluminum & Copper Clad
SE	All Frames (7A to 150A)	TCAL18 & TCAL18LV①	(1) #12 - 3/0 AWG	(1) #12 - 3/0 AWG
SF	250	TCAL29 & TCAL29LV①	(1) #8 AWG - 350 kcmil	(1) #8 AWG - 350 kcmil
SG	400, 600	TCLK265② & TCLK365③	(2) 2/0 - 500 kcmil or (1) #8 AWG - 600 kcmil	(2) 2/0 - 500 kcmil or (1) #6 AWG - 600 kcmil
SK	800	TCAL81	(3) 3/0 - 500 kcmil	(3) 3/0 - 500 kcmil
	1200④	TCAL125	(4) 250 - 500 kcmil	(4) 250 - 500 kcmil
SE	All Frames (7A to 150A)	TC018	(1) #12 - 3/0 AWG	—
SF	250	TC029	(1) #8 AWG - 350 kcmil	—
SG	400, 600	TCOK265②, TCOK365	(2) 2/0 - 500 kcmil or (1) #8 - 600 kcmil	—
SK	800	TC081A	(3) 250 - 500 kcmil	—
	1,200	TC0125	(4) 350 - 500 kcmil	—

① Includes 1/4" male spade terminal for control wire termination using UL Listed 250 Series fully insulated receptacle connector

② TCLK265 & TCOK265 included qty (2) lugs

③ TCLK365 & TCOK365 included qty (3) lugs

④ Alternate 1200A lug for SK; TCAL124 (3) 350-700 kcmil CU/AL, and TC0124 (3) 350-700 kcmil CU



**Fig. 14.1** Typical Snap-in Lug

### Back-connected studs

Back-connected studs are used in applications where cabling or bussing behind the panel is required. A mounting sub-base is provided that mates with the Spectra RMS circuit breaker or molded case switch and the studs. Each stud is of sufficient length to accommodate panel thicknesses from 0.25 inches (6mm) to one inch (25mm).



**Fig. 14.2** Back-connected studs

### Sizes and ratings

Table 14.2 lists the back-connected studs available for the complete line of Spectra RMS circuit breakers, including Mag-Break devices and molded case switches. These studs are field-installed.

**Table 14.2** Back-connected line and load studs

Frame	Max. Amps	Length, Back of Device		Short/Long	Catalog Number
		Inches	Millimeters		
SE	50	2 25/32	70.6	Short	TEF1
		4 13/32	112.0	Long	TEF2
	150	3 13/32	86.5	Short	TEF3
		5 25/32	147.0	Long	TEF4
SF	250	2 23/32	69.0	Short	TFK1
		5 31/32	151.5	Long	TFK2
SG	600	2 13/16	71.4	Short	SGBCS1
		6 1/16	153.7	Long	SGBCS2
SK	800	5 1/2	139.7	—	TKM11
	1,200	8	203.0	—	TKM12



**Fig. 14.2** Spectra RMS lugs



## Plug-in mounting bases

Plug-in mounting bases provide the user with another option for quick changeout of breaker and switch assemblies without disturbing power connections. Two plug-in bases (one for each terminal end) are required for each protective device.

An optional mounting plate is supplied at no additional charge when ordered with a pair of mounting bases, and provides three important functions. The plate locates and supports the line and load base assemblies, provides a convenient means to mount the entire assembly to a metal structure and serves as a deadfront barrier.

Each plug-in base assembly contains all of the mounting hardware necessary to mount the base to either end of the circuit breaker or molded case switch. Electrical spacing between adjacent terminals is provided by alternate long-short-long (LSL) or short-long-short (SLS) terminal assemblies. Fully configured Spectra RMS circuit breakers are available in two-pole configurations— with the center pole missing. Consequently, base assemblies for two-pole breakers are either short-open-short (SOS) or long-open-long (LOL). SE-, SF- and SK-Frames use horizontal studs (suffix PD1 or PD2), while SG-Frames use vertical studs (suffix PC1 or PC2). Table 15.1 lists the sizes and ratings of the plug-in base assemblies.

When breakers or switches are mounted side by side, it is important to plan for adjacent outside poles of the two devices to have a long-short or short-long configuration, so that adequate electrical spacing is provided between adjacent devices.



Fig. 15.1 Plug-in mounting base

Table. 15.1 Plug-in mounting base

Amp Rating	Breaker Type	No. of Poles	Horizontal Stud Configurations		Catalog Number	Optional Mounting Plate
			PD1	PD2		Catalog Number
			150	SE150	3	SLS
250	SF250	2	SOS	LOL	TF22PD1,2	TMP2
		3	SLS	LSL	TF23PD1,2	
600	SG400	3	SLS	LSL	SGPC1,2①	SMP3
	SG600					
800	SK1200	3	SLS	LSL	TK83PD1A,2A	TMP4
1,200	SK1200	3	SLS	LSL	TK123PD1A,2A	TMP4

① Vertical stud orientation.

## Motor-operated mechanisms (MOM)

The MOM function uses an ac or dc motor-driven mechanism to produce rapid closing or opening. No physical modification of the breaker or switch is needed to add the MOM. The MOM operator slips over the operating handle of the circuit breaker or molded case switch. The MOM cover can be lifted to manually open or close the breaker or switch. Visual indication of the “On-Off” status appears on the mechanism cover.

## Face-mounted mechanical interlocks

Mechanical interlocks are available for all Spectra RMS circuit breakers and molded case switches. The function of the mechanical interlock is to positively assure that two adjacent devices in an assembly cannot both be in their “On” (i.e., closed) position at the same time. However, both devices can be “Off” (i.e., open or tripped) at the same time.

These interlocks are useful whenever control or safety requirements dictate an either-or energized condition downstream of the two protective devices.



Fig. 15.2 Motor-operated mechanism for an SF-Frame Spectra RMS circuit breaker

**Table. 16.1** Mechanical interlock (face mounted)

Spectra RMS Breaker Type	Face-mounted Interlock Cat. No.	Adapter Kit Required when using handle operator (TDM) or motor operator (order separately)
SE150, SF250	SEFFMI	SEFFMIAK
SG600	SGFMI	SGFMIAK <sup>①</sup>
SK1200	SKFMI	SKFMIAK

① Compatible with motor operator only. SGFMI cannot be used with handle operator.

**Table. 16.2** Motor-operated mechanisms, rating and electrical data

Device Frame	Catalog Number	Control Power			Operating Time Seconds		Recommended Fuse
		Voltage <sup>①</sup>	Amps		Closing	Opening Reset	
			Inrush	Running			
SE	SEMOM1	120 Vac	10.5	5	0.15	0.13	1 Amp Time Delay
		125 Vdc	13.5	4			
	SEMOM2	240 Vac	6.5	3			
	SEMOM8	24 Vdc	31	15.5			
	SEMOM9	48 Vdc	20	7			2 Amp Time Delay
SF	SFMOM1	120 Vac	10.5	5	0.15	0.13	1 Amp Time Delay
		125 Vdc	13.5	4			
	SFMOM2	240 Vac	6.5	3			
	SFMOM8	24 Vdc	31	15.5			
	SFMOM9	48 Vdc	20	7			
SG	SGMOM1	120 Vac	13.5	8.5	0.25	0.20	
		125 Vdc	13.5	4.5			
	SGMOM2	240 Vac	6.5	3			
		250 Vac	8	2.5			
	SGMOM8	24 Vdc	33	19.5			
	SGMOM9	48 Vdc	22	8.5			
SK	SKMOM1	120 Vac	14	7.5	0.30	0.20	3 Amp Time Delay
		125 Vdc	18	5			
	SKMOM2	240 Vac	7	3.5			
		250 Vac	8.5	2.5			
	SKMOM8	24 Vdc	50	30			
	SKMOM9	48 Vdc	32.5	15			

① All ac control power may be either 50 Hz or 60 Hz.

## Handle operators

Three different operating handles are available for use with Spectra RMS circuit breakers and molded case switches: STDA, TDM and TDR. Each provides its own unique function. Types STDA and TDM are adjustable-depth operating handles. Type TDR operating handles are rotary handles that connect directly to the protective device and the operating handle projects directly through the enclosure door.

### Type STDA flange handles, variable depth operating mechanisms and accessories

Type STDA handles (Figure 16.1) are designed to meet automotive-duty specifications. They are NEMA 12/13 and NEMA 4/4X UL recognized components. These handles can be located on either the right-hand or left-hand flange of an enclosure and they are field-convertible for either position.

Handle mounting dimensions fit standard flanged enclosures with depths from eight inches to 24 inches (203mm to 609mm).



**Fig. 16.1** Type STDA1 flange handle

Two different handle lengths are provided. Type STDA1, 1X handles have a nominal length of 6 inches (152mm) and Types STDA2, 2X handles have a nominal length of 10 inches (254mm). Both flange handles are interchangeable and are satisfactory for use with all operating mechanisms.

The advantage to using the longer Type STDA2 handle is the reduction in the operating forces provided by the longer lever arm. Both handles permit use of up to three 3/16 to 5/16 inch (4.75mm to 7.94mm) diameter padlocks. Both handles are equipped with O-ring seals for oil-tight/dust-tight duty.

### Variable depth operating mechanisms

The operating mechanism consists of two primary components: a combination mounting plate and yoke, and a drive rod that connects the handle to the yoke mechanism.

The protective device is mounted on the plate, and the device's operating handle slips into a slot on the front of the yoke. The mounting plates have a spring-assist feature to assure positive "On-Off" operation. Yoke stops are included to prevent excessive wear of the operating handle of the circuit breaker or molded case switch.

The standard drive rod is 3/8 inch (9.5mm) in diameter for SE and SF and 1/2 inch for SG and SK frames.

The SK frame operating mechanism (SD0M6) requires a unique flange handle, Cat. No. STDA3 pr STDA3X which cannot be used with any other operating mechanism.

### Type STDA handle accessories

Four accessories are available for use with the STDA handle

operator. They are auxiliary contacts, a flange stiffener (and an extended drive rod), an extended drive stud and special NEMA 12 vault-type sealing and interlocking door hardware.

#### **Auxiliary contacts**

Auxiliary single-pole, double-throw (SPDT) and double-pole, double-throw (DPDT) auxiliary contact kits are available for either left-flange or right-flange mounting. These contacts are actuated by the operating mechanism yoke.

#### **Flange stiffener and extended drive rod**

When either the enclosure needs stiffening behind the operating handle, or a drive rod longer than 16 inches is required, a special flange stiffener kit is available. The kit contains a 3/8-inch (9.5mm) drive rod 22 inches (559mm) long which is threaded and may be cut to any convenient length.

#### **Extended drive stud**

Extended drive stud provides additional room inside the enclosure by allowing a 1 5/16-inch (33mm) displacement of the operating mechanism with respect to the handle. Specifically, when the handle is mounted on the right-hand side of the enclosure, the operating mechanism is displaced to the left by 1 5/16-inches with the extended drive stud installed. Conversely, when the handle is installed on the left-hand side, the operating mechanism is displaced 1 5/16-inches to the right. (Note: not suitable with SK frame operating mechanisms, SDOM6.)

#### **Vault-type interlocking door hardware**

Type TDV door hardware kits are available to permit interlocking with a STDA handle. Kits are designed for doors having a nominal depth of 3/4 inch (19mm). The interlocking function requires use of a screwdriver to release interlocking and permit door opening. Normally, the flange handle and operating mechanism cannot be placed in the “ON” (energized) position unless the enclosure door and door hardware is closed. Kits are available for both NEMA 12/13 and NEMA 4/4X applications.

When enclosure doors are 40 inches (1,016mm) long or longer, a third point latch is recommended and available.

#### **Type TDM door-mounted handles and variable depth operating mechanisms**

Type TDM handles and mechanisms are designed for door-mounting of a rotary operating handle. Shafts of various lengths connect directly to a sliding plate assembly that fits over the “On-Off” handle of the Spectra RMS circuit breaker or molded case switch. The rotary motion of the TDM handle opens or closes the protective device.

#### **Handles**

TDM door-mounted handles accommodate up to three padlocks. There are two basic handle styles. Both TH1 and TH2 handles are designed for NEMA 1, 3R and 12 enclosures. TH2 handles are longer than TH1 to provide more torque for SG- and SK-Frame devices. When NEMA 4 or 4X enclosures are required, handle Cat. No. THCH45 is available (for all size devices).

#### **Operating mechanisms, including shafts**

The Type TDM operating mechanism attaches to the face of the Spectra RMS circuit breaker or molded case switch. As mentioned earlier, the protective device may be mounted either vertically or horizontally. Shafts are cut by the user to the length required for the specific application.

#### **Replacement handle gaskets**

Replacement neoprene gaskets are available for the TDM handle operators. Order part number 788A742P3 for the TH1 operator (SE/SF breakers) and 788A742P4 for the TH2 operator (SG/SK breakers).

#### **Type TDR integral handle mechanism**

Type TDR handles are designed for direct mounting to the Spectra RMS circuit breaker or molded case switch operating handle. A door ring on the handle projects through a mating hole on the front of the enclosure door. Type TDR handles are suitable for use with shallow depth NEMA 1, NEMA 12 or NEMA 12K enclosures. Rotary motion of the handle opens or closes the protective device.

Figure 17.1 shows a Type TDR handle operator. Different handles are used for vertical and horizontal mounting of the protective device. An interlock kit is available to mate with the door ring of the type TDR handle and provides an interlock function between protective device and enclosure door. Gasket kits are available to limit the intrusion of dust and dirt into the enclosure through the space between the door ring on the protective device and the hole in the enclosure door. A gasket kit is required for NEMA 12 and NEMA 12K applications. Order part number SEFRGSK for SE/SF breakers, SGRGSK for SG breakers and SKRGSK for SK breakers.



Fig. 17.1 Type TDR integral handle mechanism



Fig. 18.1 The Spectra RMS circuit breaker family

Table. 18.1 Internal and external accessories available for the Spectra RMS product line

	Product	Circuit Breakers	Mag-Break CBs	Molded Case Switches	
Internal Accessories	Shunt Trip	Yes	Yes	Yes	
	UV Release	Yes	Yes	Yes	
	Bell Alarm Switch	Yes	Yes	Yes	
	Auxiliary Switch	Yes	Yes	Yes	
External Accessories	Line & Load Lugs	Yes	Yes	Yes	
	Back-Connected Studs	Yes	Yes	Yes	
	Plug-in Bases	Yes	Yes	Yes	
	Motor-Operated Mechanism	Yes	Yes	Yes	
	Mechanical Interlock	Yes	Yes	Yes	
	External Handles	Type TDA	Yes	Yes	Yes
		Type TDR	Yes	Yes	Yes
		Type TDM	Yes	Yes	Yes
Handle Blocking Device ①	Yes	Yes	Yes		
Padlock Device	Yes	Yes	Yes		

① SE and SF frames only.

# Electrical data

## Introduction

The Electrical Data section of this manual is intended to assist those responsible for the selection and application of circuit protective devices in making the proper choices of Spectra RMS™ circuit breakers and molded case switches. Because Spectra RMS devices are true international products, attention is given to the selection procedures associated with American, Canadian and IEC Standards.

Electrical Data is presented in a sequence that follows the steps necessary to make the selection of the protective device that matches system and equipment requirements.

## General

### **Molded case circuit breakers**

Molded case circuit breakers are circuit protective devices that perform two primary functions: 1) manual switching to open and close a circuit by means of a toggle handle; and 2) automatic opening of the circuit under short circuit and/or sustained overload conditions.

### **Functions**

A circuit breaker inherently protects circuits during short circuit and overload conditions by automatically opening its protected electrical circuit without the use of fuses. When the circuit breaker opens to clear a short circuit or a sustained overload condition, its “toggle” handle moves to the “Tripped” position (midway between “On” and “Off” positions), indicating the circuit breaker has automatically opened. Once the overload or short circuit has been corrected, the circuit breaker can be closed by simply moving the toggle handle first into the “Reset” (fully “Off”) position and then into the “On” position.

### **Circuit breaker advantages**

There are several advantages to using circuit breakers as protective devices. One key advantage to circuit breakers over fusible elements is that an overcurrent on one pole of a multipole device actuates a common trip bar that trips all poles simultaneously. Consequently, “single phasing” a three-phase load is not possible when a circuit breaker opens, while it is possible with fusible devices. Molded case circuit breakers utilize “trip-free” construction. A trip-free device is one that cannot be forced into the closed or “On” position when a tripping action is present as the result of an abnormal condition. If an attempt is made to manually close a circuit breaker’s toggle handle while an overcurrent condition exists in the protected circuit, the circuit breaker will open, even if the toggle handle is held in the “On” position.

### **Protective function – circuit breakers**

Spectra RMS circuit breakers are not intended to replace running overload, unbalanced voltage or special-purpose protection provided by other motor-protective equipment such as overload relays and motor-temperature sensing

devices. However, Spectra RMS circuit breakers can be used to provide motor overload and overcurrent protection for branch circuits containing infrequently started induction or synchronous motors.

Spectra RMS molded case circuit breakers meet UL Standard 489 covering “Branch Circuit and Service Circuit Breakers”; NEMA Standard AB-1 – Molded Case Circuit Breakers; IEC Standard 947-2, Circuit Breakers (Low-voltage Switchgear and Controlgear) and applicable Canadian and Japanese standards. All Spectra RMS molded case circuit breakers are marked HACR Type.

### **UL Standard vs. 100% rated**

Spectra RMS circuit breakers are classified as “standard-rated” devices with optional 100% rated versions available in the SG and SK frames. UL Standard 489 makes provisions for two categories of circuit breakers. “UL Standard-rated” and “UL 100% rated”. The basis for UL Standard-rated circuit breakers is as follows:

Mounted in free air. Circuit breakers are tested to carry 100% of nameplate current rating, continuously, when mounted in free air at 25°C (77°F) and cabled per Table 22.1. However, they are not applied in this manner.

Mounted in an enclosure. Spectra RMS enclosed circuit breakers are rated to carry 100% of nameplate current rating, intermittently (three hours, maximum) and 80% continuously with the enclosure in a 25°C ambient and cabled per Table 22.1.

Group-mounted. Group-mounted circuit breakers may require derating of the circuit breakers and cable in room ambients other than 25°C and with cable other than listed in Table 22.1.

“100%” breakers will carry full rated current **continuously**, enclosed, provided the enclosure meets minimum size and ventilation requirements (if specified).

### **IEC equivalent to UL Standard rated circuit breakers**

IEC Standard 947-2 lists three current ratings: “conventional free air thermal current ( $I_{th}$ )”; “conventional enclosed thermal current ( $I_{the}$ )”; and “rated current ( $I_n$ ).” IEC procedures call for an eight-hour test. Consequently, when a standard-rated circuit breaker is mounted in free air at 25°C and with the cabling of Table 22.1, the breaker’s conventional free air thermal current may be considered to be 100% of nameplate current. Enclosed circuit breakers cabled per Table 22.1 and mounted in 25°C room ambient may be considered to have a conventional enclosed thermal current of 80% of nameplate current. Group-mounted circuit breakers may require additional derating to reflect actual room ambient and cabling.

Rated current ( $I_n$ ) is equal to the free air thermal current ( $I_{th}$ ) and is the same as the rated current for circuit breakers described in the technical data of this publication. Specifically, rated current per UL489 and rated current per IEC947-2 are equivalent terms.

## **Molded case switches**

Molded case switches are used as circuit-disconnect devices where overload and short circuit protection for the relevant circuit is provided by other devices. Because these switches are tested to meet a size-times rated current overload requirement they are useful as disconnects in motor circuits and are horsepower rated.

Spectra RMS molded case switches are designed to meet and are tested in accordance with UL Standard 1087, specifically covering molded case switches.

## **Standards and references**

### **Underwriters' Laboratories**

*Branch Circuit and Service Circuit Breakers*; and UL Standard 1087, *Molded Case Switches*. Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062.

### **National Electrical Manufacturers Association (NEMA)**

NEMA Standard AB-1, *Molded Case Circuit Breakers*. NEMA, 1300 North 17th Street, Suite 1752, Rosslyn, VA 22209.

### **Institute of Electrical and Electronics Engineers (IEEE)**

IEEE Standard No. 45, *Recommended Practices for Electrical Installation on Shipboard*. IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

### **National Electrical Code (NEC) NFPA 70**

NFPA Headquarters, 1 Battery March Park, Quincy, MA 02169.

### **International Electrotechnical Commission (IEC)**

IEC Standard 947-2, *Low-Voltage Switchgear and Controlgear, Part 2, Circuit Breakers*. Bureau Central de la Commission Electrotechnique Internationale, 3, Rue de Varembe, 1211 Geneva 20, Switzerland.

### **Canadian Standards Association (CSA)**

CSA Standard 22.2 No. 5, *Service Entrance and Branch Circuit Breakers*. CSA International, 178 Rexdale Blvd., Toronto, ON, M9W 1R3 Canada.

### **Japanese Industries Standard (JISC)**

JISC Standard 8370, *Low Voltage Switchgear and Controlgear, Circuit Breakers*.

### **Verband Deutscher Elektrotechniker (VDE)**

(Association of German Electrical Engineers)  
VDE Specification 0660, *Low Voltage Switchgear and Controlgear, Circuit Breakers*.

Approved by the city of New York, Bureau of Electrical Control

# Current ratings of circuit breakers and Mag-Break motor circuit protectors

**Table 21.1** Spectra RMS circuit breaker current ratings  
SE-Frame circuit breakers

Frame	Max. Frame Amps	Rating Plug Amps	Instantaneous Trip Settings, Nominal RMS Sym, Amps						
			Trip Setting Adjustment Position						
			Min.	2	3	4	5	6	Max.
SE	7 <sup>①</sup>	3	11	13	16	19	24	31	39
		7	22	27	35	43	56	71	90
	30	15	43	55	69	86	111	143	182
		20	58	74	93	116	151	196	254
		25	73	93	117	147	193	253	332
		30	87	112	142	179	237	314	415
	60	40	118	150	188	237	308	394	501
		50	148	187	236	296	386	498	637
		60	178	224	284	355	464	604	777
	100	70	206	261	329	411	534	684	863
		80	236	299	377	472	614	787	999
		90	267	338	426	532	694	892	1,138
		100	297	376	475	593	775	998	1,280
	150	110	328	415	524	654	857	1,105	1,426
		125	374	474	598	745	979	1,265	1,640
		150	450	570	720	897	1,181	1,528	1,991

① The 7 Amp frame and the 3A and 7A rating plugs are used only with the Spectra RMS Mag-Break motor circuit protector.

**Table 21.2** Spectra RMS circuit breaker current ratings  
SF-, SG- and SK-Frame breakers

Frame	Max. Frame Amps	Rating Plug Amps	Instantaneous Trip Settings, Nominal RMS Sym, Amps							
			Trip Setting Adjustment Position							
			Min.	2	3	4	5	Max.		
SF	250	70	205	260	330	410	535	700		
		90	265	335	425	530	690	900		
		100	295	375	470	590	765	1,000		
		110	325	410	520	650	845	1,100		
		125	370	465	570	740	960	1,250		
		150	440	560	705	885	1,150	1,500		
		175	515	655	825	1,035	1,345	1,750		
		200	590	750	940	1,180	1,535	2,000		
		225	665	840	1,050	1,330	1,730	2,250		
		250	740	935	1,180	1,480	1,920	2,500		
		SG	400	125	380	480	620	765	990	1,275
				150	455	575	740	920	1,185	1,530
175	530			670	865	1,070	1,385	1,785		
200	605			765	990	1,225	1,580	2,040		
225	680			860	1,115	1,375	1,780	2,295		
250	755			955	1,235	1,530	1,975	2,550		
300	905			1,145	1,480	1,835	2,370	3,060		
350	1,060			1,340	1,730	2,140	2,765	3,570		
400	1,210			1,530	1,980	2,445	3,160	4,080		
600	250		765	965	1,215	1,500	1,960	2,530		
	300		915	1,155	1,455	1,800	2,355	3,035		
	350		1,070	1,350	1,700	2,100	2,745	3,545		
	400		1,220	1,540	1,940	2,400	3,135	4,050		
	450		1,375	1,735	2,185	2,695	3,530	4,555		
	500		1,525	1,925	2,425	2,995	3,920	5,060		
	600		1,830	2,310	2,910	3,595	4,705	6,075		
	SK		800	300	940	1,150	1,445	1,795	2,375	3,015
				400	1,255	1,535	1,930	2,395	3,165	4,015
500		1,570		1,915	2,410	2,990	3,955	5,020		
600		1,875		2,290	2,895	3,610	4,740	6,195		
700		2,155		2,665	3,375	4,240	5,525	7,420		
800		2,440		3,035	3,860	4,875	6,305	8,705		
1,200		600	1,825	2,310	2,905	3,685	4,730	6,110		
		700	2,125	2,695	3,390	4,300	5,515	7,125		
		800	2,430	3,080	3,870	4,910	6,305	8,145		
		900	2,735	3,465	4,355	5,525	7,090	9,160		
		1,000	3,040	3,850	4,840	6,140	8,880	10,180		
		1,200	3,650	4,620	5,805	7,370	9,455	12,215		

## Factors affecting current ratings of installed devices

There are seven application factors that should be considered when selecting the frame and ampere rating of molded case circuit breakers and switches. These are: 1) the size of the cable used in the line and load connections, 2) the actual installed ambient temperature, 3) the system operating frequency, 4) the altitude of the installation, 5) the type of loading of the protected circuit, 6) the design safety factor, and 7) derating for continuous loading, if applicable.

The following simple relationship combines these seven application factors into one equation:

$$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$$

Where

$I_p$  = Circuit Breaker Frame Rating (amps)

$I_a$  = Actual Load Current (amps)

A = Cable Size Factor

B = Ambient Temperature Rating Factor

C = Operating Frequency Rating Factor

D = Altitude Rating Factor

E = Load Class Rating Factor

F = Safety Factor

G = Duty Rating Factor

Examples of how these selection factors are used are shown on pages 25-26.

### Cable size

The thermal design of a circuit breaker takes into account the ability of line and load cables to act as heat sinks. UL Standard 489 has assigned specific cable sizes for each current rating. Generally, these assignments are coordinated with specific conductor temperature ratings. Increasing a conductor's temperature rating has the same effect as decreasing both the cross sectional area of the conductor and its ability to conduct heat. Figure 22.1 illustrates the effect of changing cable size upon the current-carrying ability of the circuit breaker or molded case switch.

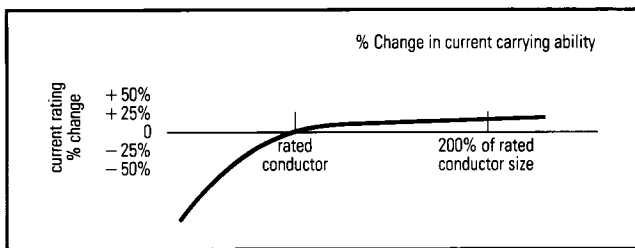


Fig. 22.1 Effects of changing load and line conductor sizes

Table. 22.1 Cable size by circuit breaker or switch amp rating

Device Ampere Rating	Copper Conductor		Aluminum or Copper Clad Aluminum Conductor	
	Paralleled	Size	Paralleled	Size
15 or less	—	14 AWG <sup>ⓐ</sup>	—	12 AWG
20	—	12 AWG	—	10 AWG
25	—	10 AWG	—	10 AWG
30	—	10 AWG	—	8 AWG
35	—	8 AWG	—	8 AWG
40	—	8 AWG	—	8 AWG
45	—	8 AWG	—	6 AWG
50	—	8 AWG	—	6 AWG
60	—	6 AWG	—	4 AWG
70	—	4 AWG	—	3 AWG
80	—	4 AWG	—	2 AWG
90	—	3 AWG	—	2 AWG
100	—	3 AWG	—	1 AWG
110	—	2 AWG	—	1/0 AWG
125	—	1 AWG	—	2/0 AWG
150	—	1/0 AWG	—	3/0 AWG
175	—	2/0 AWG	—	4/0 AWG
200	—	3/0 AWG	—	250 kcmil
225	—	4/0 AWG	—	300 kcmil
250	—	250 kcmil	—	350 kcmil
275	—	300 kcmil	—	500 kcmil
300	—	350 kcmil	—	500 kcmil
325	—	400 kcmil	Two	4/0 AWG
350	—	500 kcmil	Two	4/0 AWG
400	Two	3/0 AWG	Two	250 kcmil
450	Two	4/0 AWG	Two	300 kcmil
500	Two	250 kcmil	Two	350 kcmil
550	Two	300 kcmil	Two	500 kcmil
600	Two	350 kcmil	Two	500 kcmil
700	Two	500 kcmil	Three	350 kcmil
800	Three	300 kcmil	Three	400 kcmil
1,000	Three	400 kcmil	Either Four or Three	350 kcmil 600 kcmil
1,200	Either Four or Three	350 kcmil 600 kcmil	Four	600 kcmil

<sup>ⓐ</sup> SE 30A frame with 15A rating plug requires #12AWG minimum.

Table. 22.2 Approximate correlation, standard cross sections of round copper conductors AWG and kcmil versus ISO metric cable sizes

AWG or kcmil Size	Equivalent Cross-Section (mm) <sup>2</sup>	ISO Metric Cable Size (mm) <sup>2</sup>
18	0.82	0.75
—	—	1
16	1.3	1.5
14	2.1	2.5
12	3.3	4
10	5.3	6
8	8.4	10
6	13.3	16
4	21.2	25
2	33.6	35
1/0	53.5	50
2/0	67.4	70
3/0	85	95
4/0	107.2	—
250	127	120
300	152	150
350	177	185
500	253	240
600	304	300



### Factor "A" – Cable Size

Determine any difference between the cross-sectional area of the cable size assigned to the breaker or switch current rating shown in Table 22.1 and the cross-sectional area of the cable actually used in the installation. Then select the cable size selection factor (Item "A" in the equation on page 22) from Table 23.1.

**Table 23.1** Factor "A" – Cable or bus size multiplying factor

Percentage of Rated (Required) Cross-Sectional Area (%)	Factor A
50	1.40
60	1.25
70	1.15
80	1.07
90	1.02
100	1.00
125	0.99
150	0.97
200	0.97

### Ambient temperature

Ambient temperature has a wider effect on the rating of the circuit breaker/cable system than making an exact match of actual versus rated cable sizes. While the accuracy of the internal sensing and tripping circuitry within Spectra RMS circuit breakers is ambient insensitive, high ambient may cause internal temperatures to exceed allowable temperature limits. Low temperatures substantially increase the current carrying capability of the circuit breaker/cable system however other limiting factors come into play (e.g., lubrication problems or mechanical binding due to differential contraction of internal parts). The minimum acceptable breaker ambient temperature for storage or operation is -40°C (-40°F).

When using cable with insulation temperature ratings above 75°C, ensure that the cable is sized to 75°C ampacity per the NEC or other applicable electrical code.

**Table 23.2** Properties of conductors rated for use with molded case circuit breakers

AWG or kcmil Size	Area Cir. Mils	Concentric Lay Stranded Cond.		Bare Conductors		DC Resistance, Ohms per 1000 ft. @ 25C (77°F)		
		No. of Wires	Diameter Each Wire (Inches)	Diameter (Inches)	Area <sup>①</sup> (Square Inches)	Copper		Aluminum
						Bare Conductor	Tinned Conductor	
18	1,620	Solid	0.0403	0.0403	0.0013	6.51	6.79	10.7
16	2,580	Solid	0.0508	0.0508	0.0020	4.10	4.26	6.72
14	4,110	Solid	0.0641	0.0641	0.0032	2.57	2.68	4.22
12	6,530	Solid	0.0808	0.0808	0.0051	1.62	1.68	2.66
10	10,380	Solid	0.1019	0.1019	0.0081	1.018	1.06	1.67
8	16,510	Solid	0.1285	0.1285	0.0130	0.6404	0.659	1.05
6	26,240	7	0.0612	0.184	0.027	0.410	0.427	0.674
4	41,740	7	0.0772	0.232	0.042	0.259	0.269	0.424
3	52,620	7	0.0867	0.260	0.053	0.205	0.213	0.336
2	66,360	7	0.0974	0.292	0.067	0.162	0.169	0.266
1	83,690	19	0.0664	0.332	0.087	0.129	0.134	0.211
1/0	105,600	19	0.0745	0.372	0.109	0.102	0.106	0.168
2/0	133,100	19	0.0837	0.418	0.137	0.0811	0.0843	0.133
3/0	167,800	19	0.0940	0.470	0.173	0.0642	0.0668	0.105
4/0	211,600	19	0.1055	0.528	0.219	0.0509	0.0525	0.0836
250	250,000	37	0.0822	0.575	0.260	0.0431	0.0449	0.0708
300	300,000	37	0.0900	0.630	0.312	0.0360	0.0374	0.0590
350	350,000	37	0.0973	0.681	0.364	0.0308	0.0320	0.0505
400	400,000	37	0.1040	0.728	0.416	0.0270	0.0278	0.0442
500	500,000	37	0.1162	0.813	0.519	0.0216	0.0222	0.0354
600	600,000	61	0.0992	0.893	0.626	0.0180	0.0187	0.0295
700	700,000	61	0.1071	0.964	0.730	0.0154	0.0159	0.0253
750	750,000	61	0.1109	0.998	0.782	0.0144	0.0148	0.0236

① Area shown is that of a circle having a diameter equal to the diameter of the stranded conductor.

The term "ambient" temperature always refers to the temperature of the air immediately surrounding the protective device itself, and never the temperature of the air outside the device's enclosure. Room or outside air temperature only establishes the thermal floor to which all other heating is added.

To convert breaker ambient temperature to room ambient, it is necessary to know the temperature rise within the equipment housing the circuit breaker (or switch). This temperature rise is a function of several variables, including heating caused by other equipment, ventilation, solar heating, factors relating to group mounting and free surface area of the breaker's enclosure.

### Factor "B" – Ambient Temperature Rating

Once the device ambient temperature is determined, select the ambient temperature selection factor from Table 23.3 (Factor "B" in the equation on page 22). SE, SF and SG breakers can be used where the breaker ambient is 70°C max. (temperature of the air surrounding the breaker); SK is limited to 60°C max.

**Table 23.3** Factor "B" - Ambient Temperature Factor

Ambient Temperature (°C)	Minimum Wire Insulating Rating (°C)	Factor B			
		SE	SF	SG	SK
25	75 <sup>①</sup>	1.00	1.00	1.00	1.00
40	90	1.00	1.00	1.00	1.00
50	105	1.00	1.00	1.00	1.00
60	110	1.10	1.14	1.17	1.10
70	120	1.30	1.59	1.57	-

① Minimum Wire Insulating Rating for SE at 25°C ambient is 60°C

## Operating frequency

All Spectra RMS circuit breakers and molded case switches may be applied at their published ratings on 50 Hz and 60 Hz systems. Operation at other system frequencies such as 380 Hz, 400 Hz and 415 Hz requires thermal and short circuit derating. See Tables 24.1 and 30.2. Spectra RMS circuit breakers and molded case switches are not suitable for direct current applications.

System operating frequencies above 60 Hz may change the performance and rating of molded case circuit breakers by increasing heating of metallic parts and significantly reducing interrupting capacity. System operating frequencies below 50 Hz may saturate the current sensors and adversely affect their accuracy.

### “Factor C” – Operating Frequency Rating

Determine the system-operating frequency. The operating frequency selection factor (Factor “C” in the equation on page 22) for both 50 Hz and 60 Hz systems is 1.0. If the operating frequency is higher than 60 Hz, use derating factor from Table 24.1.

**Table 24.1** Factor “C” – Operating Frequency Factor

Frequency (Hz)	Factor C							
	Max. Rating Plug Amperes							
	SE		SF		SG		SK	
	100	150	200	250	400	600	800	1200
dc <sup>①</sup>	-	-	-	-	-	-	-	-
50 – 60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100 – 120	1.00	1.00	1.00	1.02	1.00	1.02	1.00	1.02
150 – 180	1.00	1.02	1.00	1.05	1.00	1.04	1.00	1.04
200 – 240	1.00	1.05	1.00	1.10	1.00	1.06	1.00	1.15
300 – 360	1.00	1.08	1.00	1.20	1.00	1.08	1.00	1.35
400 – 415	1.00	1.10	1.00	1.20	1.00	1.08	1.00	1.35

<sup>①</sup> Spectra circuit breakers are not suitable for use on dc circuits

## Altitude

Spectra RMS circuit breakers do not require any derating for altitudes below 6,000 feet. Reduced air density at altitudes above 6,000 feet affects the ability of the circuit breaker to transfer heat and interrupt short circuits.

### Factor “D” – Altitude Rating

Determine the altitude of the installation. Determine the altitude selector factor (Factor “D” in the equation on page 22) using the altitude rating in Table 24.2.

**Table 24.2** Factor “D” – Altitude Rating

Installation Altitude		Factor “D”
Feet	Meters	
From -100 to 6,000	From -30 to 1,800	1.00
From 6,001 to 10,000	From 1,801 to 3,000	1.04
Above 10,000	Above 3,000	1.08

## Load type and duty cycles

Both the type of loading and its duty cycle must be considered in the application of a molded case circuit breaker. For example, both capacitors and electromagnets require a significant continuous current derating if a circuit breaker is

used to switch the load. Group-mounted devices may require additional derating due to the lack of free air circulation around the devices.

The minimum continuous current rating for resistance welder loads is 125% of the welder’s 100% duty-cycle rating.

### IEC 947-2 considerations

IEC uses a number of different terms to quantify rated duties of circuit breakers. These include:

*Eight-hour duty:* The circuit breaker carries a steady continuous current (conventional thermal current,  $I_{th}$  and  $I_{the}$ ) for eight hours.

*Uninterrupted duty:* The circuit breaker carries a steady, continuous current for periods in excess of eight hours – essentially no time limit.

*Intermittent periodic duty and intermittent duty:* A relationship involving the value of current flow, the ratio of “On Time” to total time within the defined time period, and a “class” definition of the number of load cycles per hour. For example, an intermittent duty consisting of a current flow of 100A for two minutes in every five minutes (or 12 cycles per hour) would be stated as “100A, class 12, 40%.”

As a general rule, refer all eight-hour and intermittent duty applications using IEC rules to GE for assistance and concurrence with rating selection.

### Factor “E” – Load Class Rating

Table 24.3 lists six different load class factors. A specific load may involve more than one of these factors. For example, a group-mounted circuit breaker may be responsible for the branch circuit protection of a single-motor (with normal duty). In this type of application, the load class selection factors in Table 24.3 would be multiplied (i.e., group-mount factor x single-motor (normal duty) factor =  $1.1 \times 1.5$  or 1.65). The total load class selection factor is Factor E in the equation on page 22.

It is important to emphasize here that molded case circuit breakers are intended to act as protection for insulated cable. When a circuit breaker will be applied to protect equipment, prudent engineering practices call for obtaining factory review and concurrence with the selection of the specific protective device.

**Table 24.3** Factor “E” - Load Class or Type

Load Type	Factor E
Group Mounted (12 or more breakers)	1.10
Switching Capacitors	1.50
Switching Electromagnets	1.50
Single Motor Branch Circuit Protection (Normal Duty)	1.25
Single Motor Branch Circuit Protection (Heavy Duty) <sup>①</sup>	1.75
All other Load Types (Normal Duty)	1.00

**Note:** the total load class factor is the product of all the load class factors that apply to the circuit under consideration.

<sup>①</sup> For plugging duty or when starting more than 25 times per hour. Consult NEC article 430 regarding protection of motor circuits.

## Safety factor

A safety factor is used to provide a design margin between the rating limit of a circuit breaker and the derived operating current calculated using all of the selection factors described in the equation on page 22.

A safety factor of 10% is recommended to prevent nuisance tripping.

### Factor "F" – Safety

A safety factor of 10% is equivalent to a current rating multiplier of 1.10.

## Intermittent/continuous duty rating factor

In those applications governed by UL rules and the National Electrical Code (NEC), an additional rating factor is necessary for standard-rated circuit breakers. This factor differentiates between continuous and intermittent duty.

When a circuit breaker is installed in an intermittent duty application, the duty rating factor is 1.00. Intermittent duty is defined as operation under rated load for a period of not more than three hours, followed by a period of no-load operation, followed by a period of rest. The time periods of no load and rest are undefined by the NEC. Some authorities suggest that the use of a three-hour period of no-load operation after the three-hour, full-load operation meets the intent of the term "intermittent."

Continuous duty generally means operation without any time limit whatsoever, however, for purposes of rated molded-case circuit breakers, operation at rated loads for periods of time in excess of three hours is considered continuous duty. The duty rating factor for Spectra RMS circuit breakers, as standard-rated devices, in continuous duty applications, is 1.25.

### Factor "G" – Duty Rating

Table 25.1 lists the duty rating factor (Factor G in the equation on page 22).

**Table 25.1** Factor "G" - Duty Rating Factor

Duty Type	Factor G
Continuous (operation at constant load for greater than 3 hours)	1.25
Intermittent (operation at constant load for 3 hours or less)	1.00

## Selection of circuit breaker current rating

There are basically two different situations present in making the selection of circuit breaker current rating. The first is where the circuit breaker is assigned to protect insulated cable that has been selected by a competent authority. The second is where a number of factors, such as altitude, motor loads, high-ambient temperatures, etc., are involved.

### Wire and cable protection

One of the primary functions of molded case circuit breakers is to protect insulated wire and cable from sustained overloads and short circuits. The National Electrical Code (NEC) requires

that conductors be protected in accordance with their ampacities. A series of tables found in Article 310 defines ampacities for a number of different conditions. Exceptions are listed in Article 310 for specific applications, including protection of motor-circuit conductors.

When the size and type of conductors are specified by a competent authority (e.g., an electrical consulting engineer), it is only necessary to select a standard rating matching the ampacity of the conductor; the NEC permits the use of the next higher standard rating – with some specific exceptions.

### Equipment protection and other special conditions

When only load current is known, or where one or more special conditions exist (e.g., use of smaller-than-assigned cable, group mounting, high-ambient temperatures, special-duty cycles, equipment protection, etc.), use of the equation on page 22 is required to determine the frame rating of the suitable circuit breaker. This equation is repeated here for ease of use.

$$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$$

Where

$I_p$  = Circuit Breaker Frame Rating (amps)

$I_a$  = Actual Load Current (amps)

A = Cable Size Factor

B = Ambient Temperature Rating Factor

C = Operating Frequency Rating Factor

D = Altitude Rating Factor

E = Load Class Rating Factor

F = Safety Factor

G = Duty Rating Factor

### Example:

*Step 1. Determine actual load current*

Determine the actual current of the circuit by adding the continuous load current for each load component of the total circuit to be protected by the circuit breaker.

When an intermittent load is involved, a derived rms load current is used as the actual load current. The time period to be used in calculating rms current is a function of circuit breaker frame amps. The assigned time period is equal to one-tenth of the breaker frame ampere rating, in minutes. For example, an SE100 breaker would have a time period of 10 minutes and an SF250 breaker would have a time period of 25 minutes.

Example data: An air-conditioning compressor cycles on and off at a maximum rate of four times per hour and has the following load characteristics:

1. Full load current	62A
2. Locked rotor (starting) current	248A
3. Acceleration (starting) time	6 sec. (0.1 min.)
4. Off time between starts	5 min
5. Duty cycle	0.1 min. start, 9.9 min. run, 5 min. off, cycle repeats

Using an SE100 breaker, calculate rms current during the worst 10-minute period. This would be one Start and Run period for this example.

$$I_{rms} = \sqrt{\frac{I_{start}^2 \times T_{start} + I_{run}^2 \times T_{run}}{T_{total}}}$$

$$I_{rms} = \sqrt{\frac{248^2 \times 0.1 + 62^2 \times 9.9}{10}}$$

$$I_{rms} = 66.5A$$

Using an SF250 breaker, calculate rms current during a 25-minute period. This consists of two starts, one 5-minute off period and two 9.9-minute run periods.

$$I_{rms} = \sqrt{\frac{2 \times 248^2 \times 0.1 + 2 \times 62^2 \times 9.9}{25}}$$

$$I_{rms} = 59.6A$$

*Step 2. Estimate breaker frame size (I<sub>p</sub>)*

Using either the actual current or the calculated rms current, whichever is greater, estimate the frame size required for the application. Record the estimate for use in completing Step 3.

*Step 3. Determine breaker Selection Factors A through F*

Determine the selection factors described on pages 23 through 25 and substitute in the formula for determination of I<sub>p</sub>, circuit breaker current rating. For those applications under the jurisdiction of the NEC, the product of Factors B through F must be equal to or greater than 1.25 for standard-rated devices (such as Spectra RMS circuit breaker).

*Step 4. Select circuit breaker frame and rating plug*

Compute the circuit breaker frame amp rating for the application by multiplying the actual current by each of the factors determined in Step 3. Select the circuit breaker frame. Size the rating plug to the actual load current, I<sub>a</sub>, not the calculated circuit breaker frame rating, I<sub>p</sub>.

**Second example:**

Example data:

- |                                     |                                              |
|-------------------------------------|----------------------------------------------|
| 1. Circuit voltage                  | 480 Vac                                      |
| 2. Loading (computer power supply)  | 120 amp, rms, continuous                     |
| 3. Available short circuit current  | 23kA, rms symmetrical                        |
| 4. Mounting                         | Group-mounted, anel-board, 30 circuits total |
| 5. Conductor equal to device rating |                                              |
| 6. Ambient inside box               | 40°C or less                                 |
| 7. No appreciable harmonics         |                                              |
| 8. Altitude                         | 7,200 ft.                                    |

Calculation:

$$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$$

$$= 120 \text{ amps} \times 1.0 \times 1.0 \times 1.0 \times 1.04 \times 1.1 \times 1.1 \times 1.25$$

$$= 188.76 \text{ ams}$$

I<sub>p</sub> = Calculated circuit breaker frame rating = 188.76 amps.  
Select 250A frame.

Selection: Select an SF-Frame Spectra RMS circuit breaker frame. Select a 125 amp rating plug. The catalog number of the circuit breaker is SFHA36AT0250 and rating plug would be SRPF250A125 which is the next higher standard ampere rating for the actual 120 amp load. Note: Since this is a continuous load, cables should be sized to 1.25 times the load or 150A which requires (1) 1/0 75°C copper per phase.

## Interrupting ratings

In addition to full load considerations, circuit breakers (not Mag-Break® motor circuit protectors or molded case switches) must automatically trip – or open – the protected circuit under overload conditions. Further, the device must have either sufficient interrupting capacity (circuit breakers) or withstand capability (molded case switches) to either interrupt or withstand the maximum short circuit current that can flow under worst-case conditions.

The following pages describe the interrupting ratings of Spectra RMS™ circuit breakers and withstand ratings of Spectra RMS molded case switches.

### Basis of interrupting ratings

#### Short Circuit Current

Interrupting ratings depend upon knowing the magnitude of the short circuit current that may flow through the circuit breaker or molded case switch. Devices rated in accordance with UL Standard 489 list their interrupting rating in terms of rms symmetrical amps. Devices rated in accordance with the IEC Standard 947-2 list both a “rated ultimate short circuit breaking capacity ( $I_{cu}$ )” and a “rated service short circuit breaking capacity ( $I_{cs}$ )” both in terms of rms symmetrical amps.

Differences between the IEC 947-2 values of  $I_{cu}$  (ultimate) and  $I_{cs}$  (service) breaking capacities are based upon specific ratios of  $I_{cs}$  to  $I_{cu}$ , depending upon a number of factors, including whether the protective device is intentionally designed to incorporate time delay to provide selectivity to the protection system.

The procedures for calculating short circuit current and the X/R ratios are described in detail in GE Publication GET-3550.

Generally, electrical power system engineers calculate the X/R ratios rather than the power factors of protected circuits during their short circuit studies. The magnitude of the momentary peak current to be interrupted is a function of the maximum peak current displacement from the zero current axis. That displacement is a function of the X/R ratio, the

lower the power factor, the greater the magnitude of peak displacement.

Listed interrupting ratings are subject to derating where circuit power factors are below listed values. A table of rating factors versus X/R ratios and power factors allows the user to compensate the interrupting rating of a Spectra RMS circuit breaker for circuit power factor where necessary (see Table 30.1).

#### Frequency

Frequency has an effect on the interrupting capability of a molded case circuit breaker. Exhaustive testing has been conducted at the two worldwide standard frequencies, 50 Hz and 60 Hz. Less testing has been conducted on industrial circuit breakers at 25 Hz and 400 Hz. Table 30.2 lists suggested application guidelines for Spectra RMS circuit breakers in 400 Hz circuits.

The data shown takes into account the lack of world test facilities to verify 400 Hz performance but does represent the existing best engineering judgment of General Electric.

#### Power factor or X/R ratio

Interrupting ratings of molded case circuit breakers are based upon a specific ratio of reactance-to-resistance, or a specific power factor. Since practical ac circuits contain some reactance, there is some displacement between current and voltage waveforms. Because a short circuit can literally occur during any point of the voltage wave, an actual trace of short circuit current may display considerable initial displacement from the zero axis.

Figure 27.1 shows a symmetrical ac current waveform that would occur if a purely resistive circuit was short circuited (or even a circuit containing reactance if the short circuit occurred at a precisely the right point in the voltage waveform – which is unlikely.)

Figure 27.2 shows the current trace of a short circuited ac circuit where displacement about the zero axis exists as a consequence of when the short circuit is applied and the amount of reactance in the short circuited circuit, compared to its resistance.

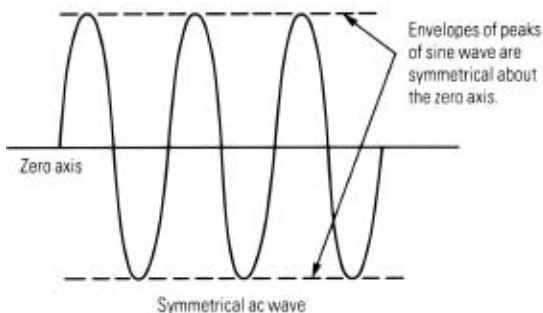


Fig. 27.1 Symmetrical ac waveform

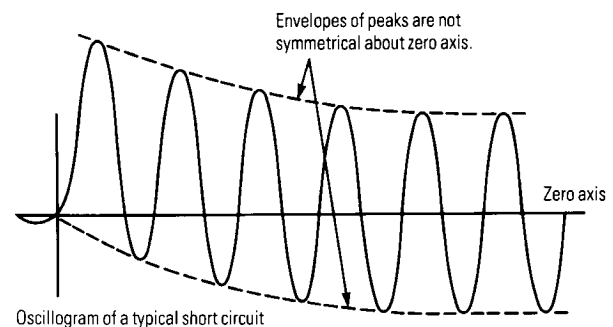


Fig. 27.2 Asymmetrical ac waveform

## Interrupting ratings

There is a simple relationship between the power factor of a short circuited circuit and its X/R ratio.

$$\text{It is: Power factor (in \%)} = \frac{R}{Z} \times 100$$

and:

$$Z = \sqrt{R^2 + X^2}$$

therefore:

$$\text{PF} = \frac{R}{\sqrt{R^2 + X^2}} \times 100$$

**Table. 28.1** Spectra RMS Circuit Breaker UL/CSA Interrupting Ratings (kA) (50/60 Hz)

Frame	Type	240 Vac	480 Vac	600 Vac
SE <sup>①</sup>	SED	18	18	14
	SEH	65	25	18
	SEL <sup>②</sup>	100	65	25
	SEP <sup>②</sup>	200	100	25
SF <sup>①</sup>	SFH	65	35	22
	SFL <sup>②</sup>	100	65	25
	SFP <sup>②</sup>	200	100	25
SG	SGD	65	-	-
	SGH	65	35	25
	SGL <sup>②</sup>	100	65	65
	SGP <sup>②</sup>	200	100	65
SK	SKH	65	50	25
	SKL	100	65	42
	SKP	200	100	65

① Two Pole SE and SF circuit breakers rated 480Vac.

② UL Listed current limiting circuit breakers. Refer to Table 32.1 for I<sub>p</sub> and I<sup>2</sup>T let-through curve numbers.

**Table. 29.1** Spectra RMS™ Circuit Breaker IEC 947-2 Interrupting Ratings (kA) (50/60 Hz)

Type	Ampere Rating	Poles	220 - 240 Vac		380 - 415 Vac		500 Vac		690 Vac		
			I <sub>cu</sub>	I <sub>cs</sub>	I <sub>cu</sub>	I <sub>cs</sub>	I <sub>cu</sub>	I <sub>cs</sub>	I <sub>cu</sub>	I <sub>cs</sub>	
SED	15 - 32	2	18	9	10	5	-	-	-	-	
		3					4	4			
SEH		2	65	33	15	10	-	-	-	-	
		3					6	6			
SEL		2	100	50	20	15	-	-	-	-	
		3					8	8			3
SEP		2	200	100	20	20	-	-	-	-	
		3					10	10			5
SED		40 - 160	2	18	9	14	7	-	-	-	-
			3					14	7		
SEH			2	65	33	35	17	-	-	-	-
			3					25	12		
SEL	2		100	50	65	33	-	-	-	-	
	3						40	20			5
SEP	2		200	100	100	50	-	-	-	-	
	3						50	25			10
SFH	70 - 250		2	65	33	35	17	-	-	-	-
			3					25	12		
SFL			2	100	50	65	33	-	-	-	-
			3					40	20		
SFP		2	200	100	100	50	-	-	-	-	
		3					65	33			18
SGH		125 - 600	2	65	33	25	13	-	-	-	-
			3					18	9		
SGL			2	100	50	65	33	-	-	-	-
			3					35	18		
SGP			2	200	100	100	50	-	-	-	-
			3					50	25		
SKH	300 - 1250		2	65	16	50	13	25	13	-	-
			3								
SKL			2	100	25	65	16 <sup>①</sup>	42	21 <sup>②</sup>	14	14
			3								
SKP			2	140	35	85 <sup>③</sup>	25	50	25	18	18
			3								

① I<sub>CS</sub> = 21 with 1200A sensors.  
 ② I<sub>CS</sub> = 16 with 1200A sensors.  
 ③ I<sub>CU</sub> = 70 with 1200A sensors.

**Table. 29.2** Spectra RMS molded case switch withstand ratings, UL 1087

Molded Case Switch			Protective Device				Withstand Rating RMS Symmetrical Amps (in kA)		
Frame	Type	Rated Amperes	Fuse		Circuit Breaker		240 Vac	480 Vac	600 Vac
			Type	Max. Rating Amperes	Type ①	Max. Rating Amperes			
SE	SED	100	RK5, J, T or L		MCCB, ICCB or LVPCB	100	200	100	25
		150				150			
SF	SFD	250				250			
		400				400			
SG	SGD	600				600			
		800				800			
SK	SKD	1,200				1,200	100	65	42

① MCCB = molded case circuit breaker, ICCB = insulated-base circuit breaker,  
 LVPCB = low-voltage power circuit breaker – must have instantaneous trip function.  
 Note: Withstand ratings are based upon the use of the proper protective device located on the *Line* side of the molded case switch.

**Table 30.1** Interrupting rating multiplying factors for power factors lower than (or X/R ratios higher than) test values

Power Factor (%)	X/R Ratio	Rated Maximum Interrupting Rating		
		1 to 10 kA <sup>①</sup>	11 to 20 kA	21 kA and Higher
		Multiplier	Multiplier	Multiplier
4	24.980	0.60	0.72	0.81
5	19.974	0.62	0.74	0.82
6	16.637	0.63	0.75	0.83
7	14.251	0.64	0.76	0.84
8	12.460	0.65	0.77	0.85
9	11.066	0.66	0.78	0.87
10	9.950	0.67	0.79	0.88
11	9.036	0.68	0.80	0.89
12	8.273	0.69	0.81	0.90
13	7.627	0.69	0.82	0.91
14	7.072	0.70	0.83	0.93
15	6.591	0.71	0.84	0.94
16	6.169	0.72	0.85	0.95
17	5.797	0.73	0.85	0.96
18	5.465	0.74	0.87	0.97
19	5.167	0.75	0.88	0.98
20	4.899	0.76	0.89	1.000
21	4.656	0.77	0.90	1.000
22	4.434	0.77	0.91	1.000
23	4.231	0.78	0.92	1.000
24	4.045	0.79	0.94	1.000
25	3.873	0.80	0.95	1.000
26	3.714	0.81	0.96	1.000
27	3.566	0.82	0.97	1.000
28	3.429	0.83	0.98	1.000
29	3.300	0.83	0.99	1.000
30	3.180	0.84	1.000	1.000
31	3.067	0.85	1.000	1.000
32	2.961	0.86	1.000	1.000
33	2.861	0.87	1.000	1.000
34	2.766	0.88	1.000	1.000
35	2.676	0.88	1.000	1.000
36	2.592	0.89	1.000	1.000
37	2.511	0.90	1.000	1.000
38	2.434	0.91	1.000	1.000
39	2.361	0.91	1.000	1.000
40	2.291	0.92	1.000	1.000
41	2.225	0.93	1.000	1.000
42	2.161	0.94	1.000	1.000
43	2.100	0.95	1.000	1.000
44	2.041	0.95	1.000	1.000
45	1.984	0.96	1.000	1.000
46	1.930	0.97	1.000	1.000
47	1.878	0.97	1.000	1.000
48	1.828	0.98	1.000	1.000
49	1.779	0.99	1.000	1.000
50	1.732	1.000	1.000	1.000

① kA = Kiloamps (1 kA is 1,000 amps) rms, symmetrical.

**Example:**

An SE-Frame Spectra RMS type SEHA circuit breaker has a 480 Vac short circuit interrupting rating of 25,000 rms symmetrical amps when used in a circuit whose X/R ratio at the point of breaker application is 4.899 or lower (or equivalent circuit power factor is 20%, or higher).

Assume that the calculated system X/R ratio at the point of breaker application is 6.591. Using Table 30.1, the adjusted interrupting rating for the SEHA circuit breaker for this circuit at 480 Vac is 23,500 rms symmetrical trips (0.94 x 25,000 = 23,500).

**Table 30.2** Estimated 380 Hz to 415 Hz interrupting ratings of Spectra RMS circuit breakers amps, rms, symmetrical — not listed

Frame	Type	Rating Amperes	240Vac	480Vac	600Vac <sup>①</sup>
SE	SEDA	150	1,800	1,400	1,400
	SEHA	150	2,500	2,500	1,800
	SELA	150	2,500	2,500	1,800
	SEPA	150	2,500	2,500	1,800
SF	SFHA	250	6,500	2,500	1,800
	SFLA	250	6,500	2,500	1,800
	SFPA	250	6,500	2,500	1,800
SG	SGDA	600	6,500	—	—
	SGHA	600	6,500	5,000	1,800
	SGLA	600	6,500	5,000	1,800
	SGPA	600	6,500	5,000	1,800
SK	SKHA	1,200	6,500	5,000	2,500
	SKLA	1,200	6,500	5,000	2,500
	SKPA	1,200	6,500	5,000	2,500

① Two-pole SE- and SF-Frames rated 480 volts maximum.

**Humidity and Fungus**

Spectra RMS circuit breakers and molded case switches contain no fungus nutrients on any of their functional parts. Consequently, all Spectra RMS circuit breakers and molded case switches are considered inherently fungus-proof.

Spectra RMS circuit breakers and molded case switches may be applied in applications with relative humidities up to 95%, non-condensing.



# Spectra RMS™ trip unit

## Solid-state sensing

The advent of cost-effective microprocessors has enabled manufacturers of molded case circuit breakers to offer products containing solid-state trip units. There are a number of advantages to using solid-state circuitry in the trip circuitry of a circuit breaker. These advantages include:

- Higher levels of accuracy in establishing specific tripping points
- Ability to shape instantaneous, short-time and long-time tripping current versus time curves to obtain better protection, better selectivity or both
- Ability to provide better user adjustment of tripping points
- Ability to provide sensing and tripping circuitry that is ambient-insensitive

These advantages are essentially generic to any well-engineered molded case circuit breaker with a solid-state tripping system. They apply to all Spectra RMS circuit breakers. Figure 31.1 shows the typical time current curves for a circuit breaker with a thermal-magnetic trip system. Figure 31.2 shows the time current curves for a 150 amp, SE-Frame Spectra RMS circuit breaker.

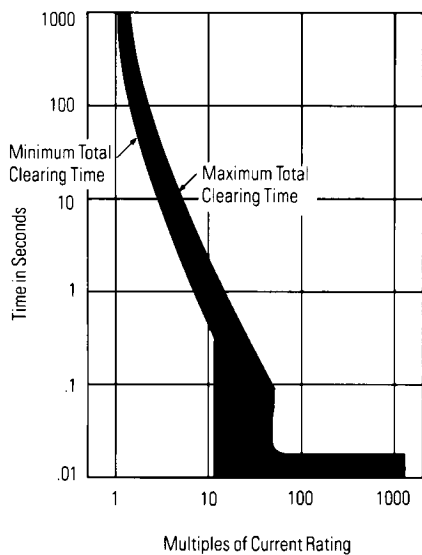


Fig. 31.1 Time current curve typical thermal-magnetic trip

Differences in flexibility and accuracy are visible and obvious.

## True RMS sensing versus peak sensing

Many modern electrical loads use static power conversion units that produce a high level of harmonics that cause the steady state current to become non-sinusoidal. Peak or rms sensing solid-state trip systems can provide accurate overload and overcurrent protection for sinusoidal currents. However, peak-sensing units will overprotect or underprotect as the steady state current becomes increasingly non-sinusoidal, since they measure peak current and then compute the rms current.

Figure 31.3 shows a distorted current waveform with about 10% fifth harmonic.

In Figure 31.3 the peak current is 110 amps and the true rms current is 71.1 amps. However, a peak-sensing circuit, calibrated to produce rms equivalent outputs, would measure 77.8 amps. If, for example, the peak-sensing breaker were set to trip at 72 amps, the breaker would “overprotect” its loads and produce a nuisance trip.

Conversely, “underprotection” occurs when a peak-sensing circuit calculates a rms current lower than actual. Figure 31.4

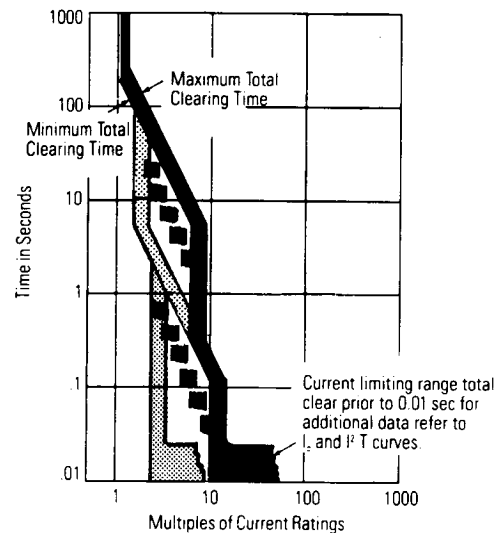


Fig. 31.2 Time current curve Spectra RMS 150 amp, SE-Frame circuit breaker

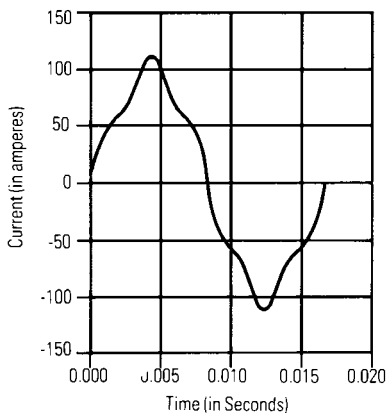


Fig. 31.3 Distorted current waveform with 10% fifth harmonic

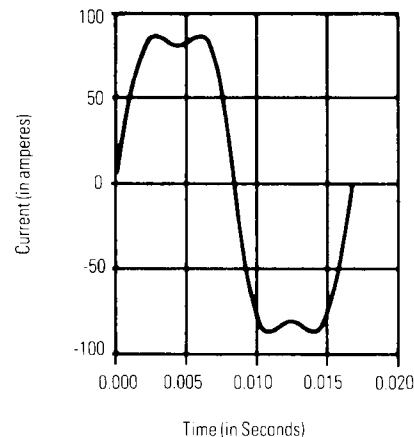


Fig. 31.4 Distorted current waveform with 20% third harmonic

shows a current waveform with 20% third harmonic. The peak current is 85 amps, which the rms calculator will output at 60.1 amps. The true rms current is 71.1 amps, a difference of more than 15%.

The use of accurate current sensors, fast analog to digital converters and microprocessors, enables GE to produce a rugged and cost-efficient trip circuit to meet the requirements of a true rms current measuring system. The trip unit continuously samples each phase throughout every cycle at a sampling frequency greatly exceeding 1620 HZ, which provides superior accuracy in determining true rms current. The Spectra RMS true rms-sensing circuit is an ideal design solution for protective devices used in modern power distribution systems. Literature describing GE's true rms-sensing circuitry is documented in an IEEE paper presented at the 35th Petroleum and Chemical Industry Conference, Dallas, Texas and recorded in the conference record dated September 12-14, 1988, pages 157-163. Order GER-3698 which is a reprint of the IEEE paper.

Other current waveform measuring techniques involve either measuring average current, or sub-cyclical measurements of the current wave for several cycles within a longer sampling period. Both methods introduce significant errors when the loads involve solid-state controllable output power conversion equipment.

### Spectra RMS true rms sensing circuitry

The magnitude of any harmonic is inversely proportional to its harmonic order. Consequently, harmonics above the 13th will not cause significant distortion of the current waveform. Sampling theory indicates if the current is measured at least 27 times during each cycle (1,620 measurements per second), rms current can be computed with a resulting error of one percent, or less, between calculated and true rms. For multiple-phase systems this sampling must be done for each phase.

### Electrical time current tripping characteristics

Time current curves are a graphic representation of how a molded case circuit breaker responds to overcurrent conditions. The test parameters creating these curves are as follows:

- A. Circuit breaker connected with a minimum of four feet of rated conductor per terminal.
- B. Circuit breaker in open air at ambient temperature indicated.
- C. All tests initiated from the no-current condition (cold start).

Information provided on the time current curve includes the following:

1. Product family type
2. Specific device type
3. Amp ratings covered on curve
4. Overcurrent characteristics – long-time, short-time, instantaneous, etc.
5. Maximum total clearing time
6. Maximum and minimum temperature limits
7. Frequency ratings
8. Voltage ratings
9. Specific trip unit ratings
10. Trip unit adjustment ranges
11. Tolerances

On the time current curve, current (in multiples of rating plug amperes) is represented on the horizontal axis, and time (in seconds) is represented on the vertical axis. The circuit breaker's range of clearing times for overcurrent conditions is visually determined from the curves. As an example (refer to curve K215-171), consider an SELA, 3-phase, 480V breaker with a 125 amp rating plug installed with the instantaneous set on MAX under a sustained load of 250 amps. The 250-amp load represents two times (2X) the rating plug amps. Reading up from the "2" on the horizontal axis, the range of clearing times is between 55 and 120 seconds. This curve also shows that the SEHA breaker will trip instantaneously at a nominal current between approximately 10 and 15 times the rating plug value (between 1,250 and 1,875 amps). The instantaneous clearing time with no intentionally introduced time delay is 0.025 seconds as shown on the curve. The total clearing time is reduced to 0.010 seconds for current limiting Spectra E, F and G frames.

Tripping characteristics meet National Electrical Manufacturers Association (NEMA AB-1) Underwriters' Laboratories, Inc. standards (489), CSA, IEC and JIS.

Table. 32.1 Time current curve index

Breaker			Time Current Curve Number		Let Through Curve Number	
Type	Frame	Rating Plug	Circuit Breaker	Mag-Break	I <sup>2</sup> T	I <sub>p</sub>
SE	7	3, 7	—	K215-181	K215-205	K215-204
	30	15, 20	K215-165	K215-182	K215-201	K215-200
		25, 30	K215-166	K215-183		
	60	40, 50	K215-167	K215-184	K215-203	K215-202
		60	K215-168	K215-185		
	100	70, 80	K215-169	K215-186	K215-196	K215-197
		90, 100	K215-170	K215-187		
150	110, 125	K215-171	K215-188	K215-196	K215-197	
	150	K215-172	K215-189			
SF	250	70, 90, 100, 110, 125, 150, 175, 200, 225, 250	K215-173	K215-190	K215-179	K215-180
SG	400	125, 150, 175, 200, 225, 250, 300, 350, 400	K215-174	K215-191	K215-198	K215-199
	600	250, 300, 350, 400, 450, 500, 600	K215-175	K215-192	K215-198	K215-199
SK	800	300, 400, 500, 600	K215-176	K215-193	—	—
	800	700, 800	K215-177	K215-194	—	—
	1200	600, 700, 800, 1000, 1200	K215-178	K215-195	—	—

Note: Let Through Curves apply to current limiting versions of SE, SF and SG (SK is not current limiting).

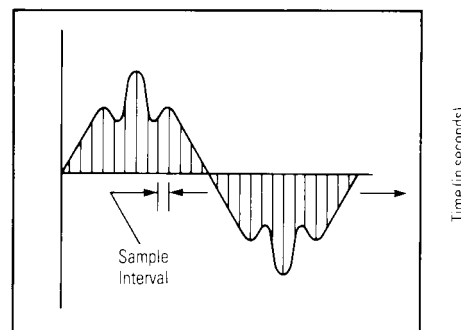


Fig. 32.1 Frequent sampling of current waveform

## Physical data

### Outline drawings

Order from:  
GE Consumer & Industrial  
P.O. Box 2913  
Bloomington, IL 61702-2913  
Attn: Distribution Services

### Installation Instructions

GEH-5591 Spectra RMS™ Circuit Breakers - SE and SF Frames  
GEH-5663 Spectra RMS Circuit Breakers - SG Frame  
GEH-5592 Spectra RMS Circuit Breakers - SK Frame  
GEH-5549 Spectra RMS Rating Plugs - SE, SF, SG and SK Frames  
  
GEH-5593 Internal Accessory - Auxiliary & Bell Alarm Switches  
GEH-5551 Internal Accessory - Shunt Trip & UVR  
GEJ-3051 External Accessory - Lug for SE Frame  
GEJ-3045 External Accessory - Lug for SF Frame  
GEJ-3052 External Accessory - Lug for SG Frame  
GEJ-4656 External Accessory - Lug for SK Frame  
GEH-5688 External Accessory - Adapter Kit (Face Mounted Interlock) for SE and SF Frames  
  
GEH-5874 External Accessory - Adapter Kit (Face Mounted Interlock) for SK Frame  
GEJ-3609 External Accessory - Back Connected Studs for SE Frame  
GEJ-3635 External Accessory - Back Connected Studs for SF Frame  
GEH-5665 External Accessory - Back Connected Studs for SG Frame  
GEJ-3619 External Accessory - Back Connected Studs for SK Frame  
GEH-6290 External Accessory - Cable Operated Mechanism for SE, SF and SG Frames  
GEH-6291 External Accessory - Cable Operated Mechanism for SK Frame  
GEH-5881 External Accessory - Control Wire Terminal for SE Frame  
GEH-5882 External Accessory - Control Wire Terminal for SF Frame  
GEH-5615 External Accessory - Face Mounted Interlock for SE and SF Frames  
GEH-5697 External Accessory - Face Mounted Interlock for SG Frame  
GEH-5698 External Accessory - Face Mounted Interlock for SK Frame  
GEH-5699 External Accessory - Lug Cover for SK Frame  
GEH-5613 External Accessory - Motor Operated Mechanism for SE and SF Frames  
GEH-5657 External Accessory - Motor Operated Mechanism for SG Frame  
GEH-5614 External Accessory - Motor Operated Mechanism for SK Frame  
GEJ-3056 External Accessory - Padlocking Device for SE and SF Frames  
GEH-5877 External Accessory - Padlocking Device for SK Frame  
GEH-4610 External Accessory - Plug In Base for SE and SF Frames  
GEH-5655 External Accessory - Plug In Base for SG Frame  
GEH-4342 External Accessory - Plug In Base for SK Frame  
GEH-5609 External Accessory - Rotary Handle Operator (TDR) for SE and SF Frames

GEH-5654 External Accessory - Rotary Handle Operator (TDR) for SG Frame  
GEH-5610 External Accessory - Rotary Handle Operator (TDR) for SK Frame  
GEH-5314 External Accessory - STDA Flange Handle for SE and SF Frames  
GEH-5684 External Accessory - STDA Variable Depth Operating Mechanisms for SE, SF, SG and SK Frames  
GEH-5611 External Accessory - TDM Operating Mechanism and handle for SE and SF Frames  
GEH-5653 External Accessory - TDM Operating Mechanism and handle for SG Frame  
GEH-5612 External Accessory - TDM Operating Mechanism and handle for SK Frame

### Other reference publications

GEA-11884 Spectra RMS Circuit Breakers  
GEP-1100 BuyLog Catalog  
GET-3550 Short Circuit Calculations

### Outline drawings

168D1109SH1 SE150 Frame  
168D1103SH1 SF250 Frame  
208C1549SH1, 2, 3 SG600 Frame  
208C1757SH1 SK1200 Frame  
168D1678SH2 SK1200 Frame (100% Rated 1200A)

### Procurement drawings

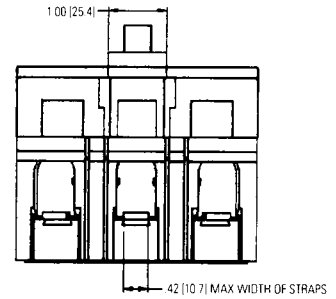
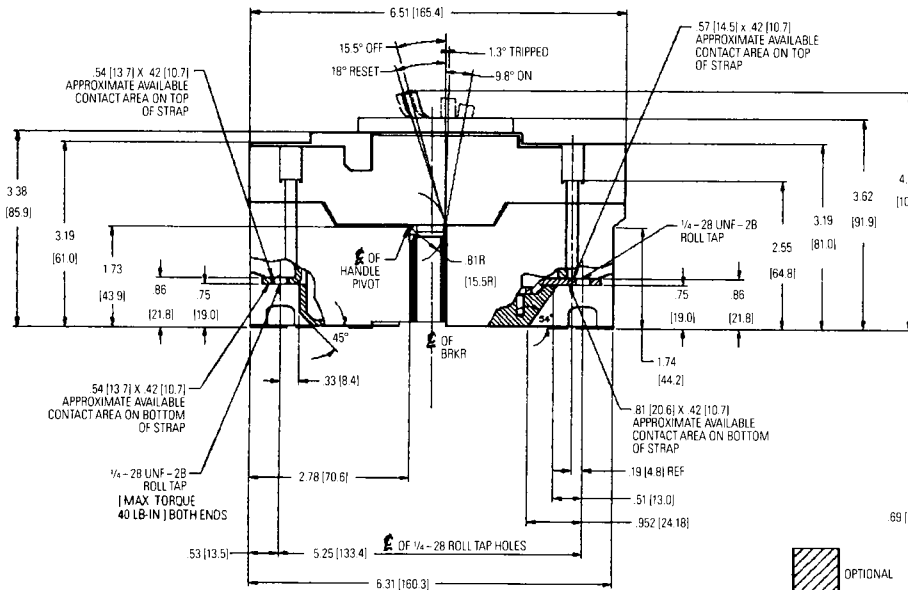
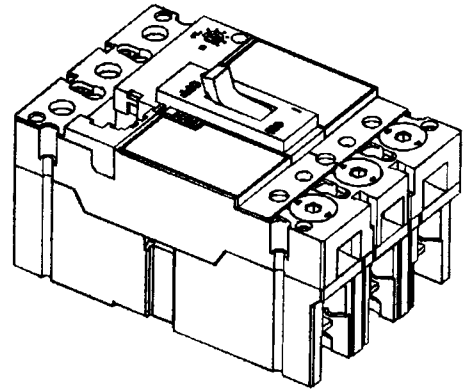
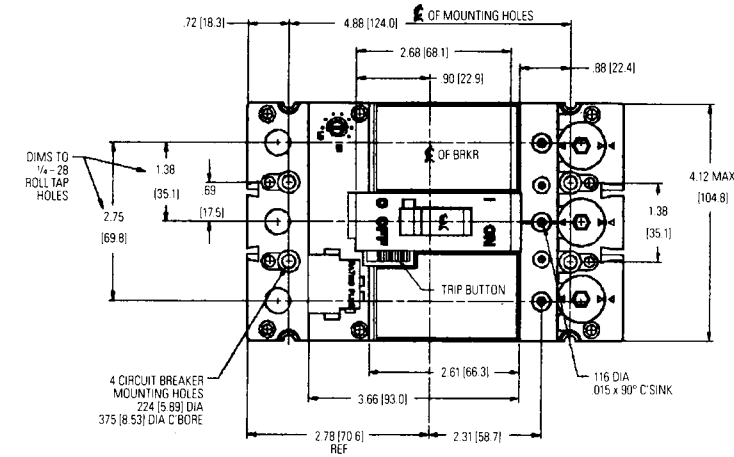
Order from:  
GE Consumer & Industrial  
P.O. Box 2913  
Bloomington, IL 61702-2913  
Attn: Distribution Services

These are 11 x 17 inch outline drawings with a blank title block suitable for OEM use as a purchased part drawing.

GEM-2877 SE150 frame  
GEM-2878 SF250 frame  
GEM-2879 SG600 frame  
GEM-2880 SK1200 frame

# Outline drawings

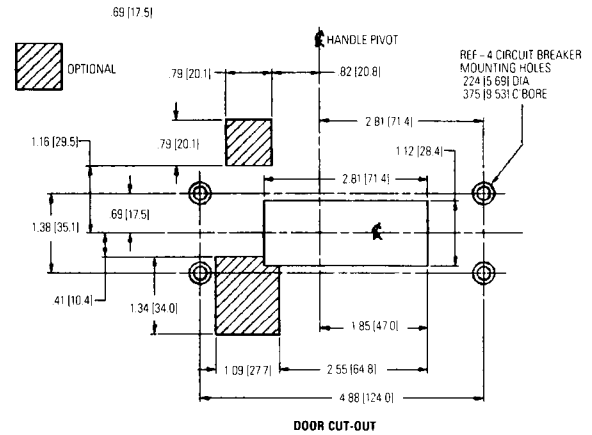
## SE150 Frame



NOTE: 1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

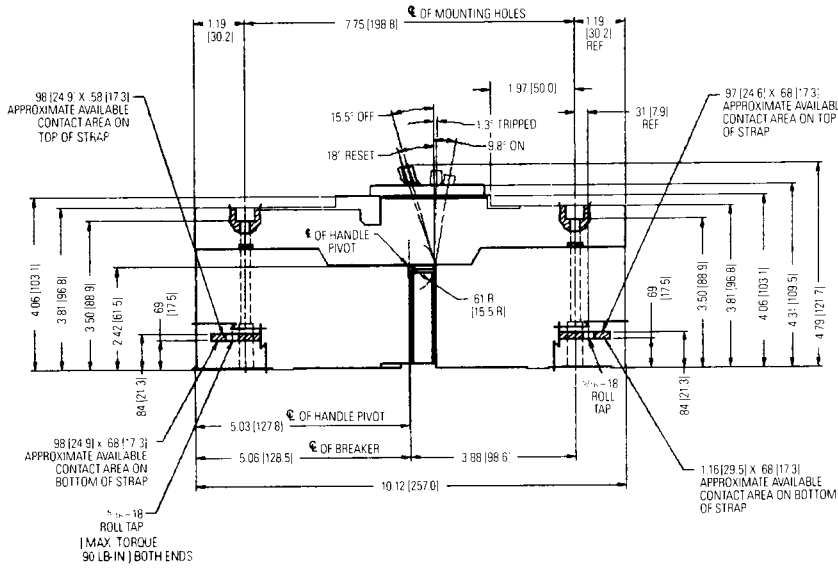
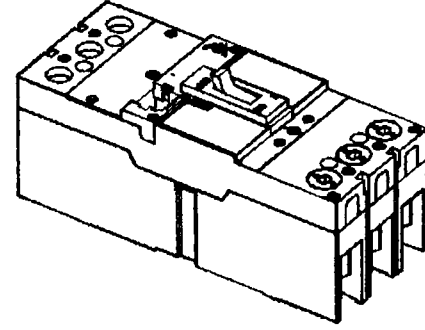
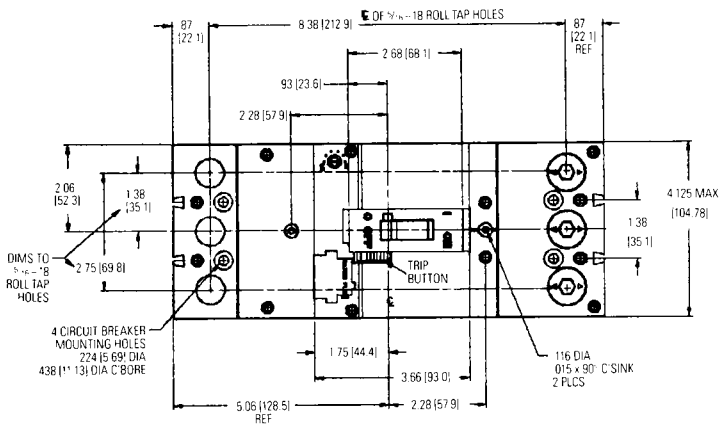
LUG DATA	
CATALOG NUMBER	TCAL1B, TCAL1BV
WIRE RANGE	#12 - 3/0 CU / AL
TORQUE	#12, #10 35 LB-IN
	#8 - #3 100 LB-IN
	#2 - 3/0 150 LB-IN

OPERATING FORCES	
TRIPPED TO MAX RESET	28 LB (12.7 Kg)
OFF TO ON	13 LB (5.9 Kg)
ON TO OFF	14 LB (6.4 Kg)



DOOR CUT-OUT

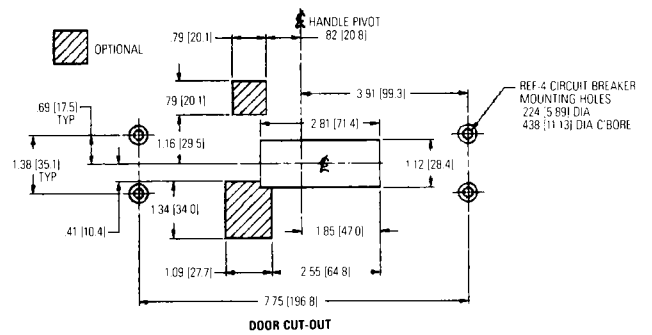
# SF250 Frame



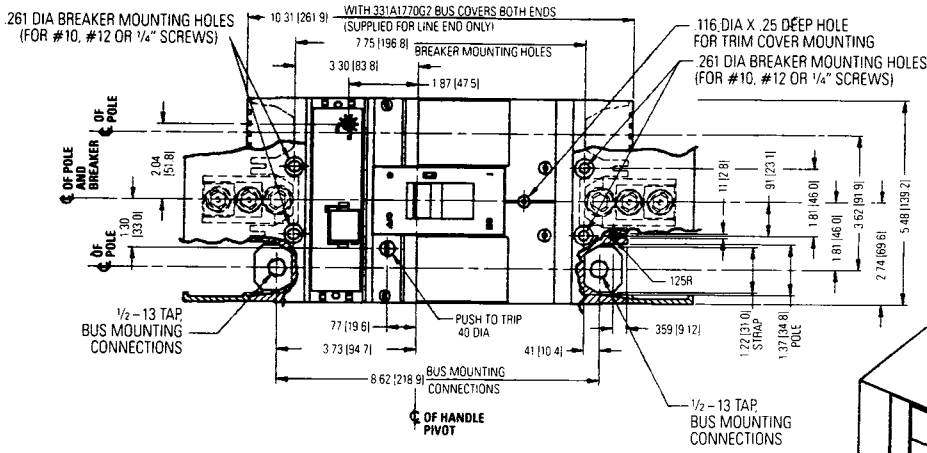
NOTE: 1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

OPERATING FORCES	
TRIPPED TO MAX RESET	28 LB (12.7 Kg)
OFF TO ON	13 LB (5.9 Kg)
ON TO OFF	14 LB (6.4 Kg)

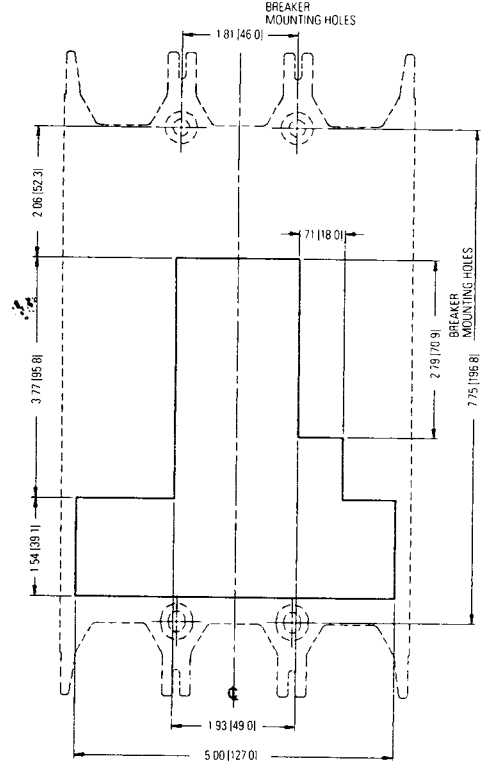
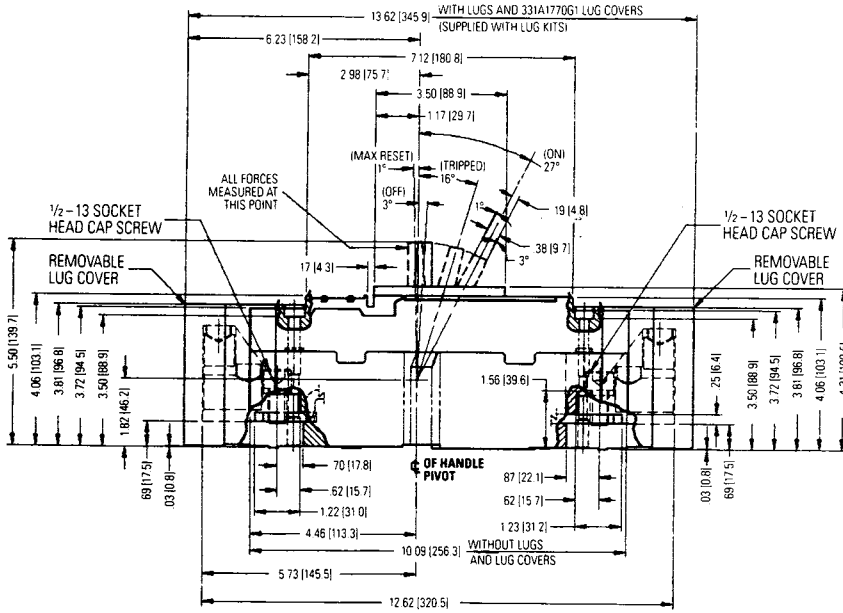
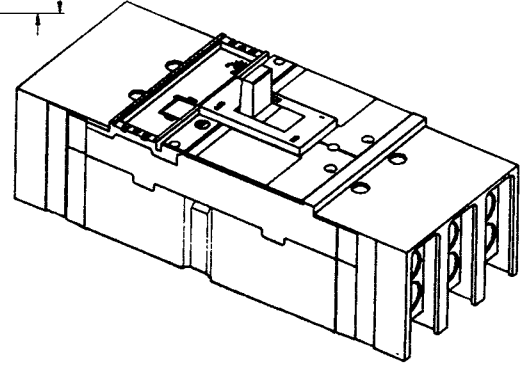
LUG DATA	
CATALOG NUMBER	TCAL29, TCAL29LV
WIRE RANGE	#8 AWG - 350 kcmil CU / AL
TORQUE	#8 - #4 150 LB-IN #3 - #1 200 LB-IN #1/0 - 350 kcmil 275 LB-IN



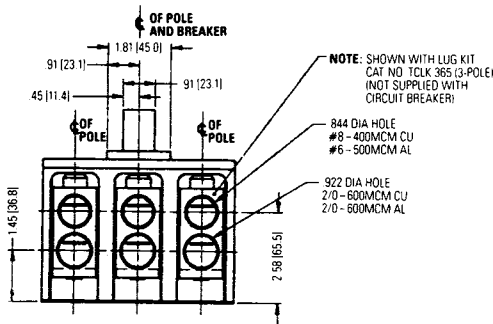
# SG600 Frame



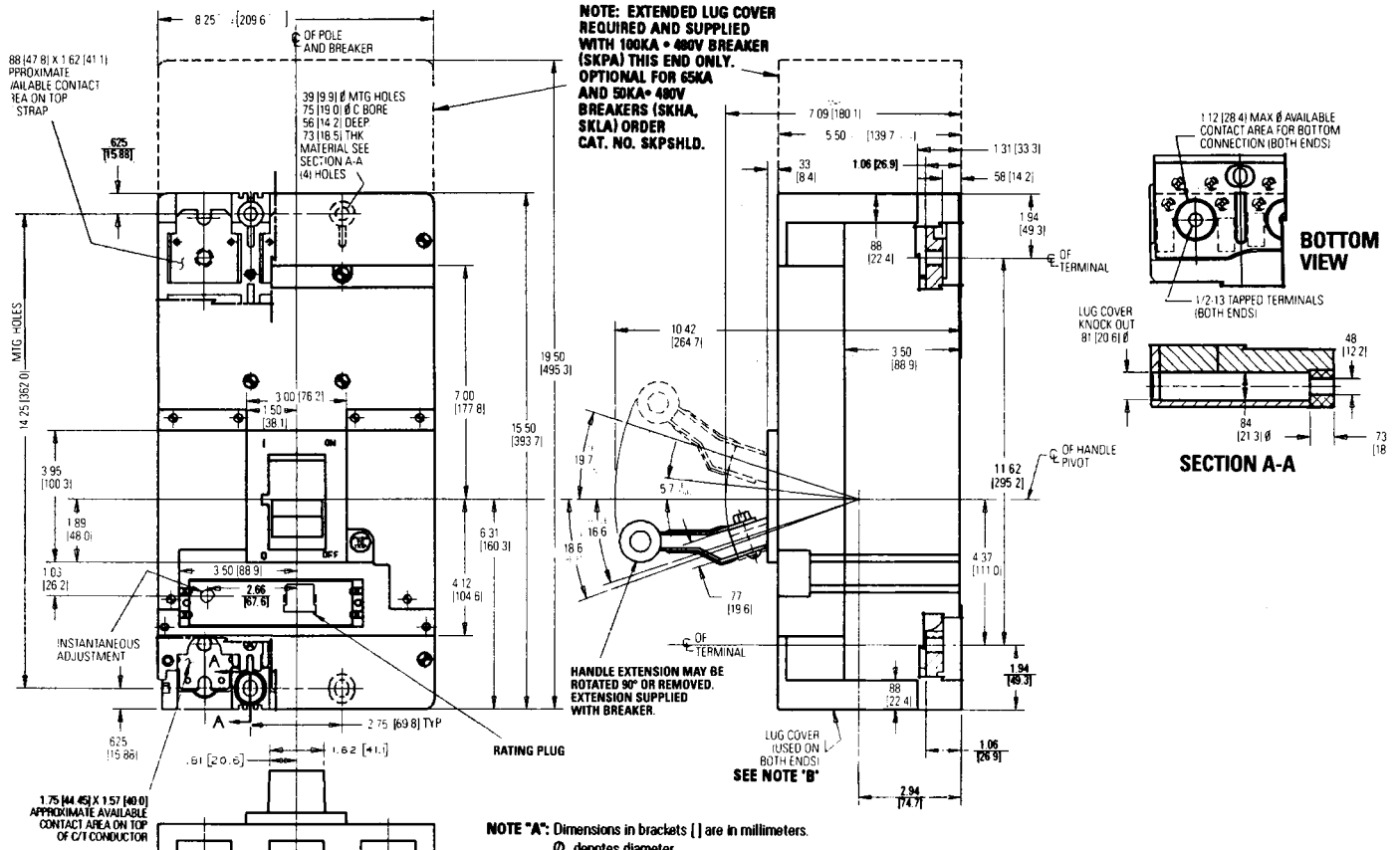
OPERATING FORCES	
TRIPPED TO MAX RESET	40 LB (18.1 Kg)
OFF TO ON	40 LB (18.1 Kg)
ON TO OFF	30 LB (13.6 Kg)
PUSH-TO-TRIP BUTTON	3 LB (1.4 Kg)



LUG DATA	
CATALOG NUMBER	TCLK265 TCLK365
WIRE RANGE	(1) #8 - 600 kcmil or (2) 2/0 - 400 kcmil CU or (1) #6 - 600 kcmil or (2) 2/0 - 500 kcmil AL
TORQUE	#8 - #3 275 LB-IN #2 - 600 kcmil 375 LB-IN



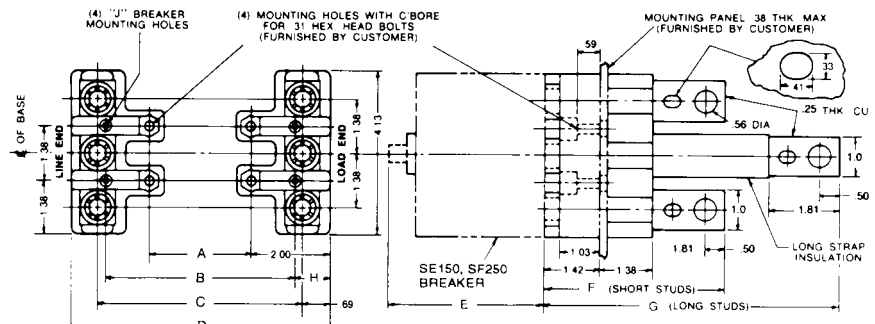
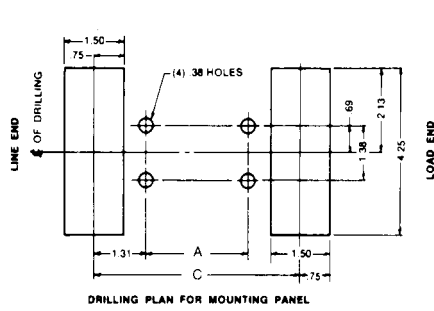
# SK1200 Frame



NOMINAL HANDLE OPERATING FORCES (LBS)		
	WITHOUT EXTENSION	WITH EXTENSION
ON TO OFF	40	20
TRIP TO RESET	78	39
OFF TO ON	88	44

LUG DATA	
Catalog Number	TCAL81
Wire Range	(3) 3/0-500 kcmil CU/AL
Torque	375 LB-IN
Catalog Number	TCAL121
Wire Range	(4)-500 kcmil CU/AL 1200 A Max
Torque	375 LB-IN

# Plug-in bases

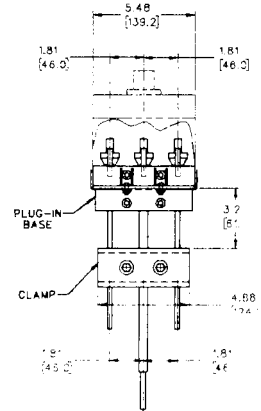
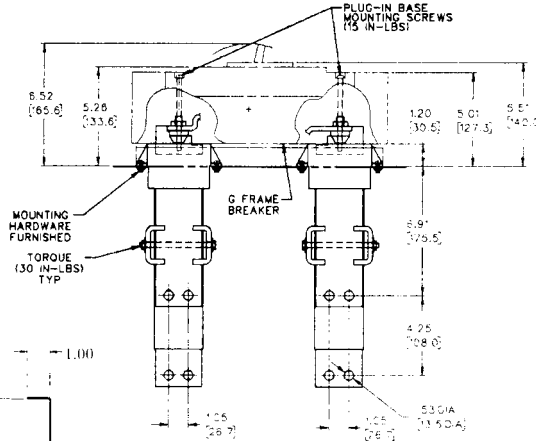
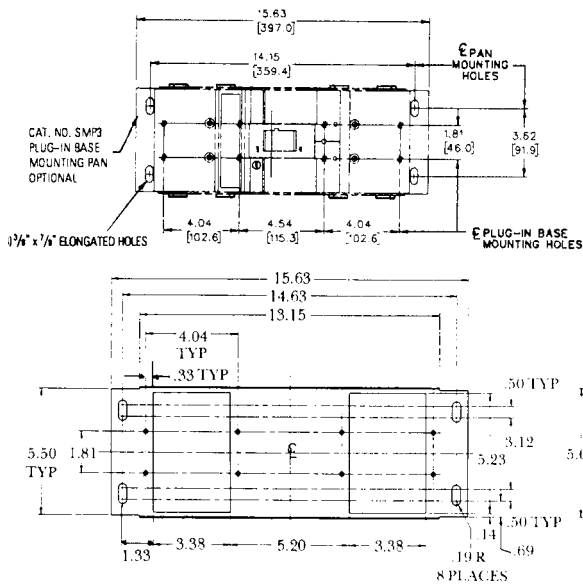


Breaker Type	Dimensions in inches									
	A	B	C	D	E	F	G	H	J	
SE150	2.63	4.88	5.25	6.63	4.09	4.16	6.84	.88	#8-32 TAP	
SF250	5.75	7.25	8.38	9.75	5.50	4.66	7.66	1.00	#10-32 TAP	

2 POLE - CENTER POLE OMITTED

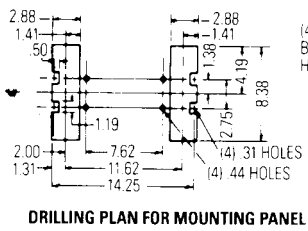
NOTE: HORIZONTAL STUDS AS SHOWN FOR VERTICAL STUDS. ROTATE CU STUDS 90° OTHERWISE SAME AS HORIZONTAL

## SE150 and SF250 Lines

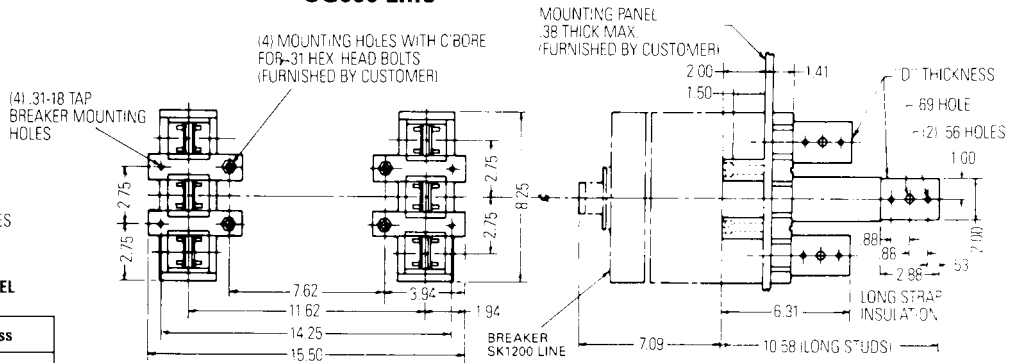


NOTE: DIMENSIONS IN BRACKETS ( ) ARE IN MILLIMETERS

## SG600 Line



Amperes	D Thickness
800A	44
1200A	62



3 POLE AS SHOWN  
2 POLE CENTER POLE OMITTED

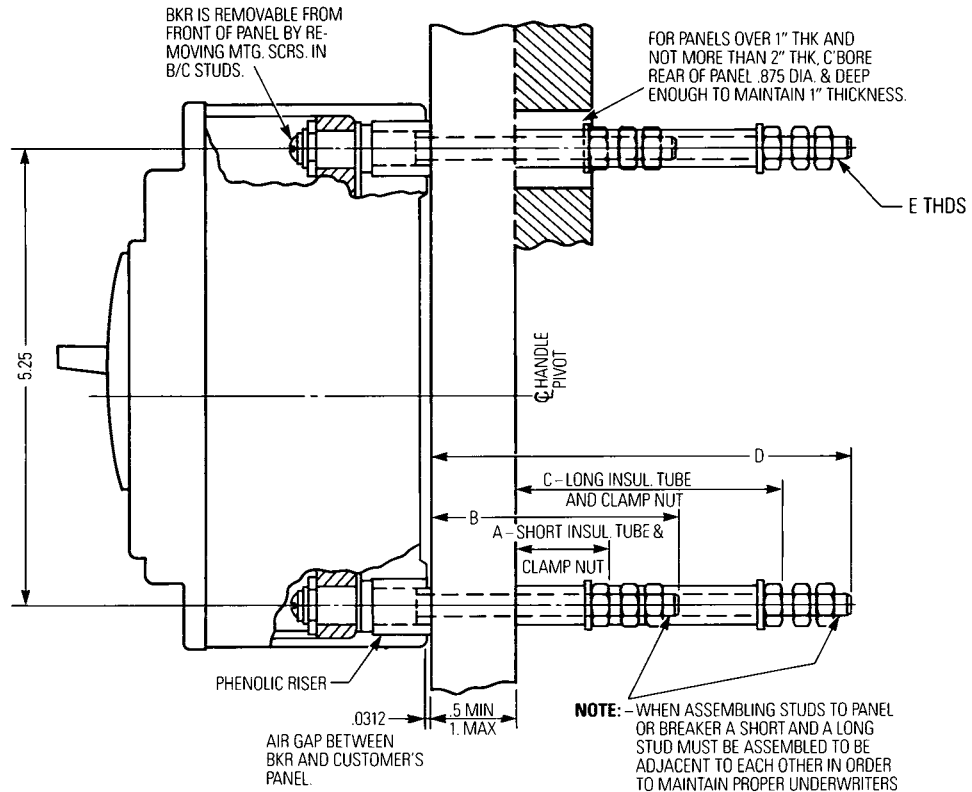
NOTE: HORIZONTAL STUDS AS SHOWN FOR VERTICAL STUDS. ROTATE CU STUDS 90° OTHERWISE SAME AS HORIZONTAL

## SK1200 Line



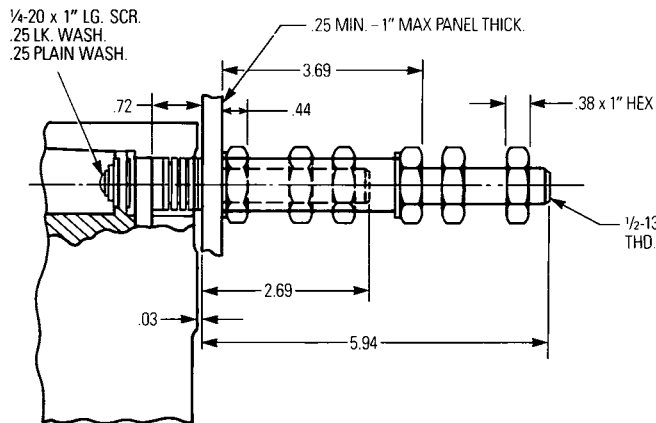
# Back-connected studs

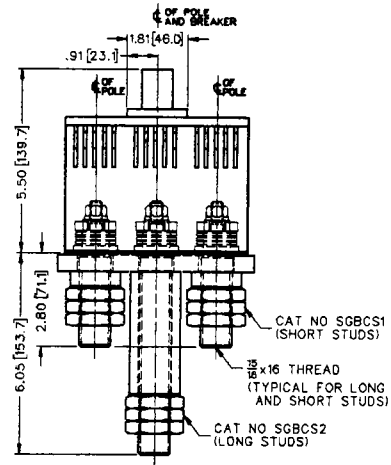
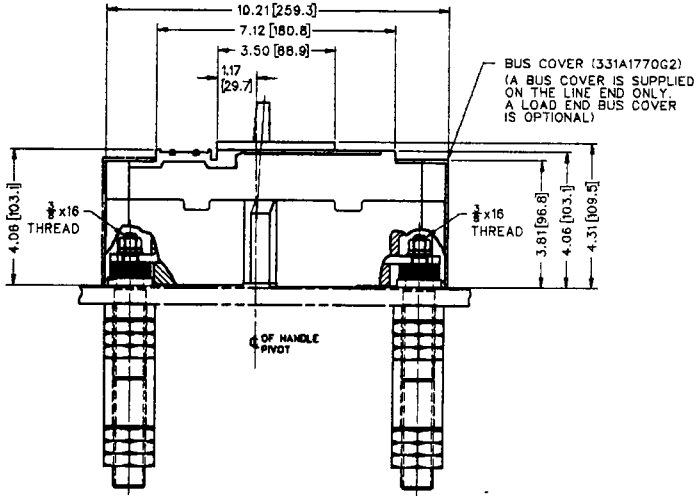
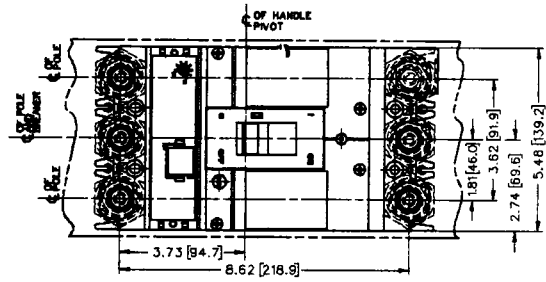
## SE150 Line



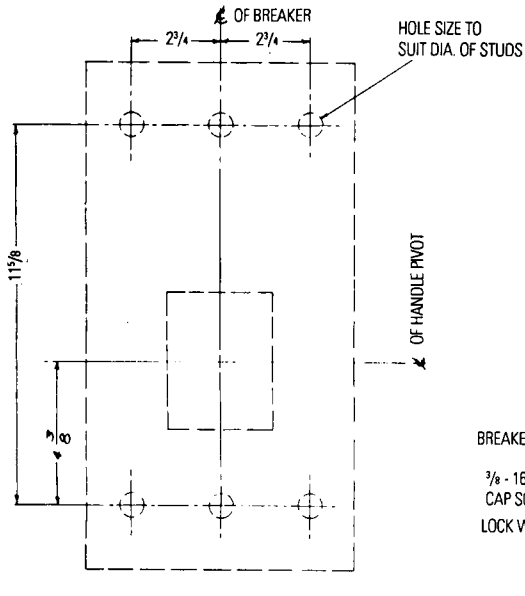
STUD. CAT.	RATING & LENGTH	A	B	C	D	E
TEF1	15-50A SHORT	1.06	2.75	—	—	1/4-20
TEF2	15-50A LONG	—	—	2.56	4.38	1/4-20
TEF3	60-150A SHORT	1.25	3.375	—	—	3/8-16
TEF4	60-150A LONG	—	—	3.62	5.75	3/8-16

## SF250 Line

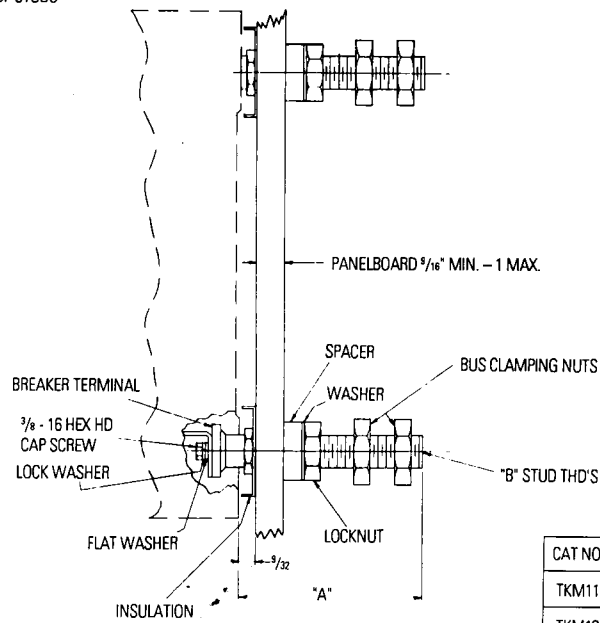




### SG600 Line



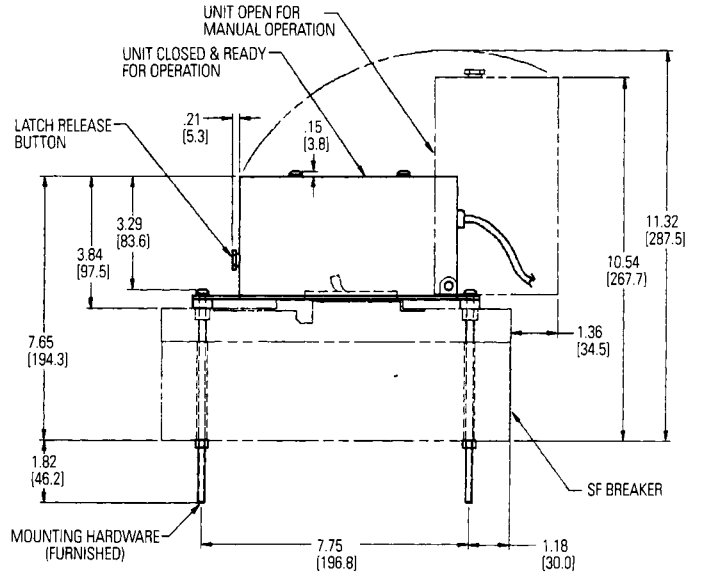
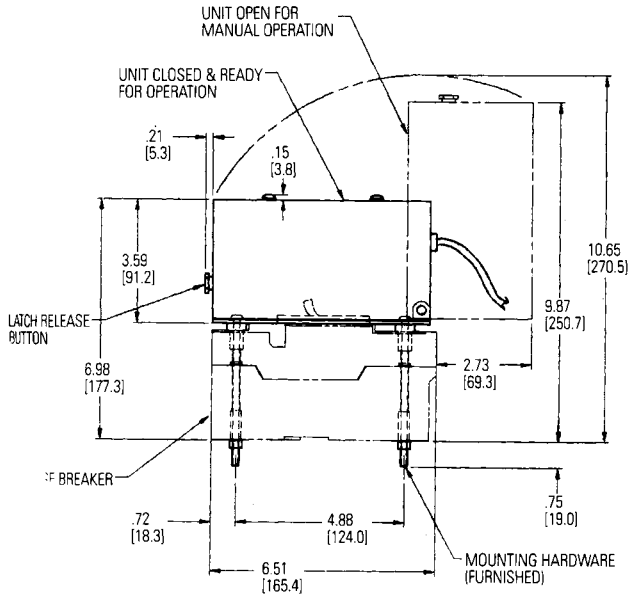
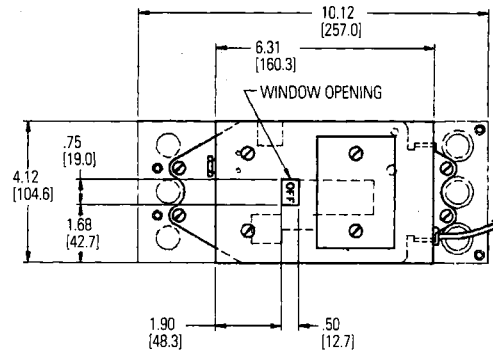
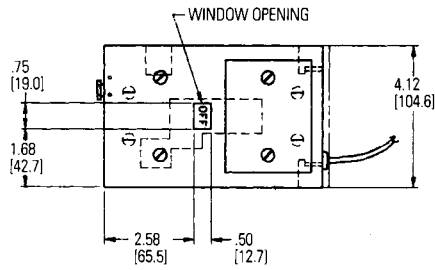
DRILLING PLAN FOR BACK CONNECTED STUDS, 2 & 3 POLE. (FRONT VIEW) OMIT CENTER HOLES FOR 2 POLE BREAKER.



CAT NO.	AMP. MAX.	"A"	"B" STUD THD'S
TKM11	800 TO	5 1/2	1 1/8 x 16
TKM12	1200	8	1 1/8 x 16

### SK1200 Line

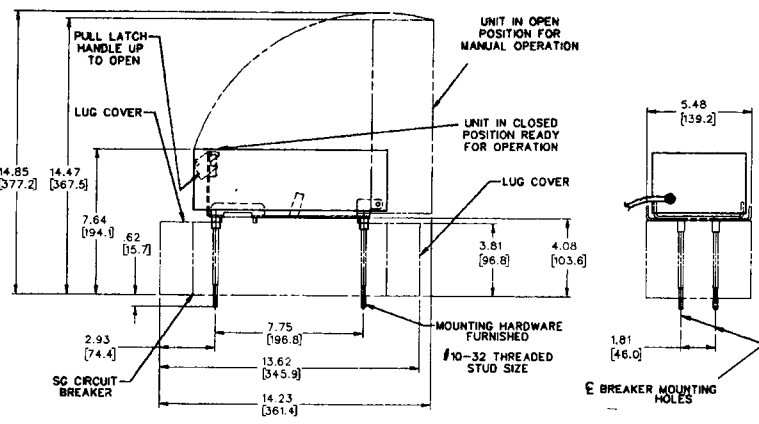
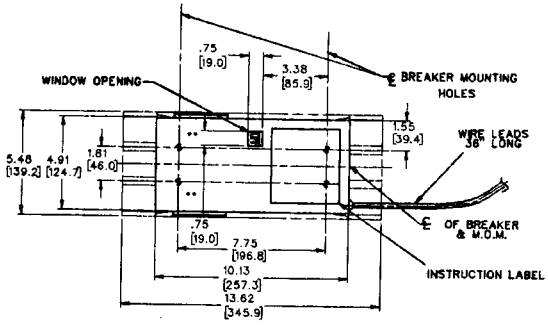
# Motor-operated mechanisms



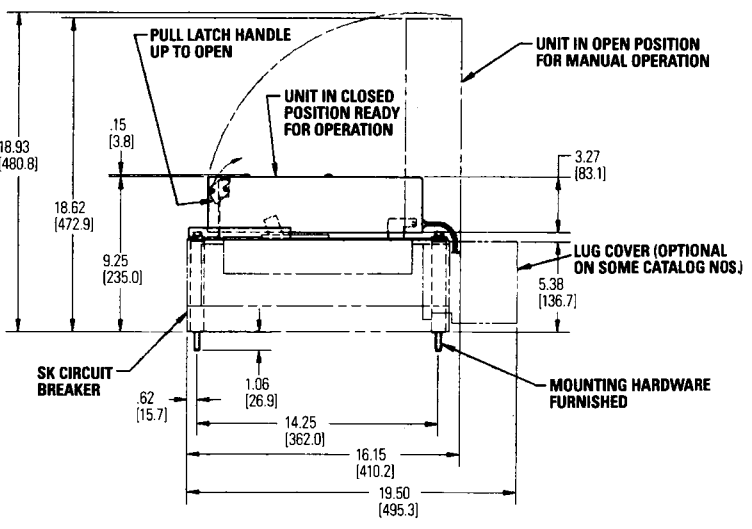
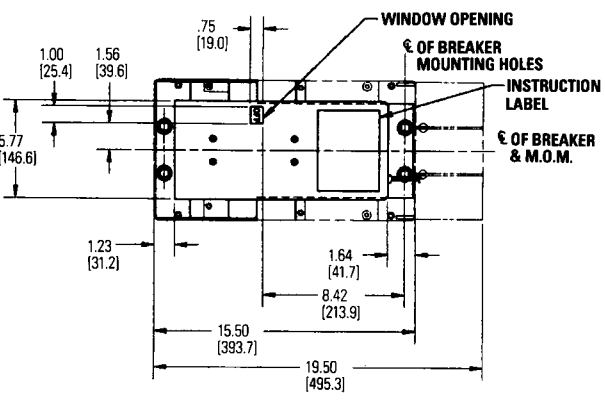
**NOTE:** DIMENSIONS IN BRACKETS  
{ } ARE IN MILLIMETERS

SE150 Line

SF250 Line



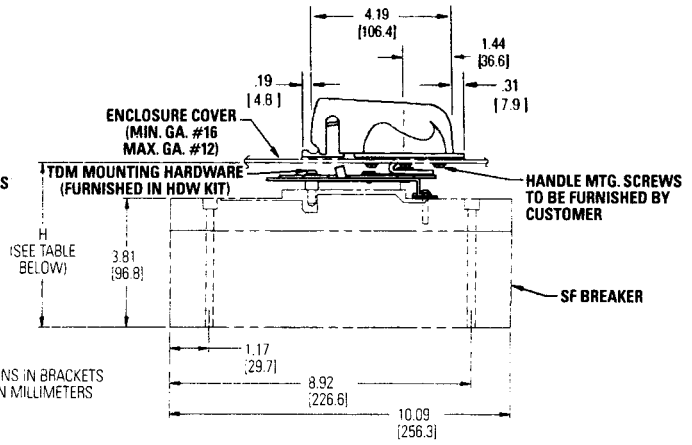
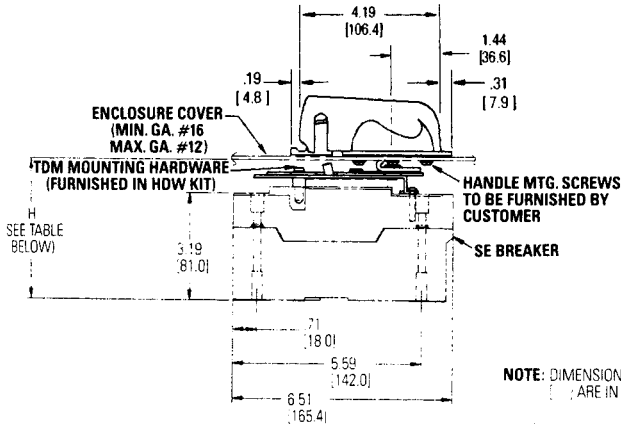
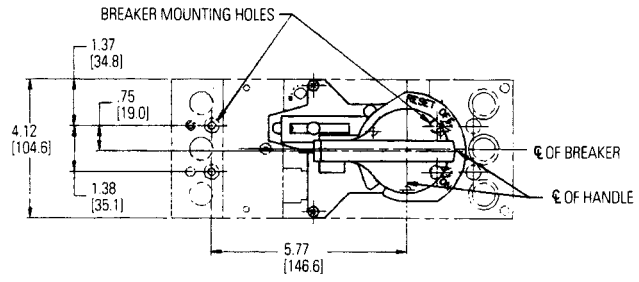
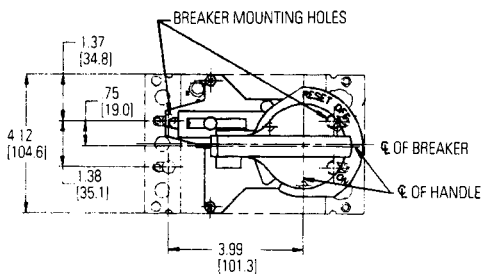
**SG600 Line**



**SK1200 Line**

NOTE: DIMENSIONS IN BRACKETS [ ] ARE IN MILLIMETERS

# TDM handle operators

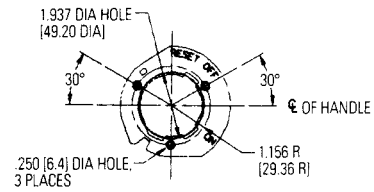


NOTE: DIMENSIONS IN BRACKETS ARE IN MILLIMETERS

**SE150 Line**

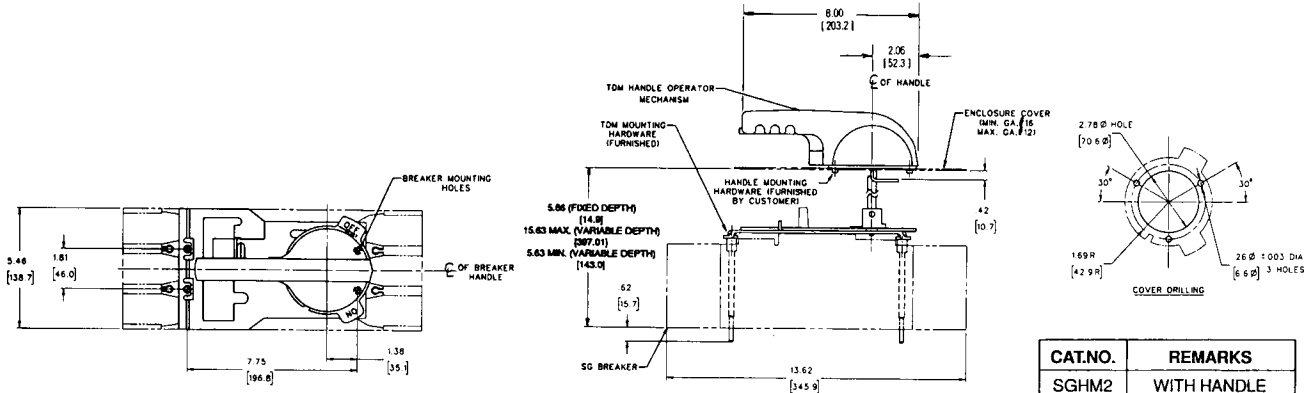
**SF250 Line**

Breaker Line	Handle Operator Catalog No.	H	
		Inch	mm
SE150	SEFHM1 SEFDM1	4.19	106.4
	SEFHM2 SEFDM2	5.13 min 15.0 max	130.3 min 381.0 max
SF250	SEFHM1 SEFDM1	4.87	123.7
	SEFHM2 SEFGM2	5.88 min 15.50 max	149.4 min 393.7 max

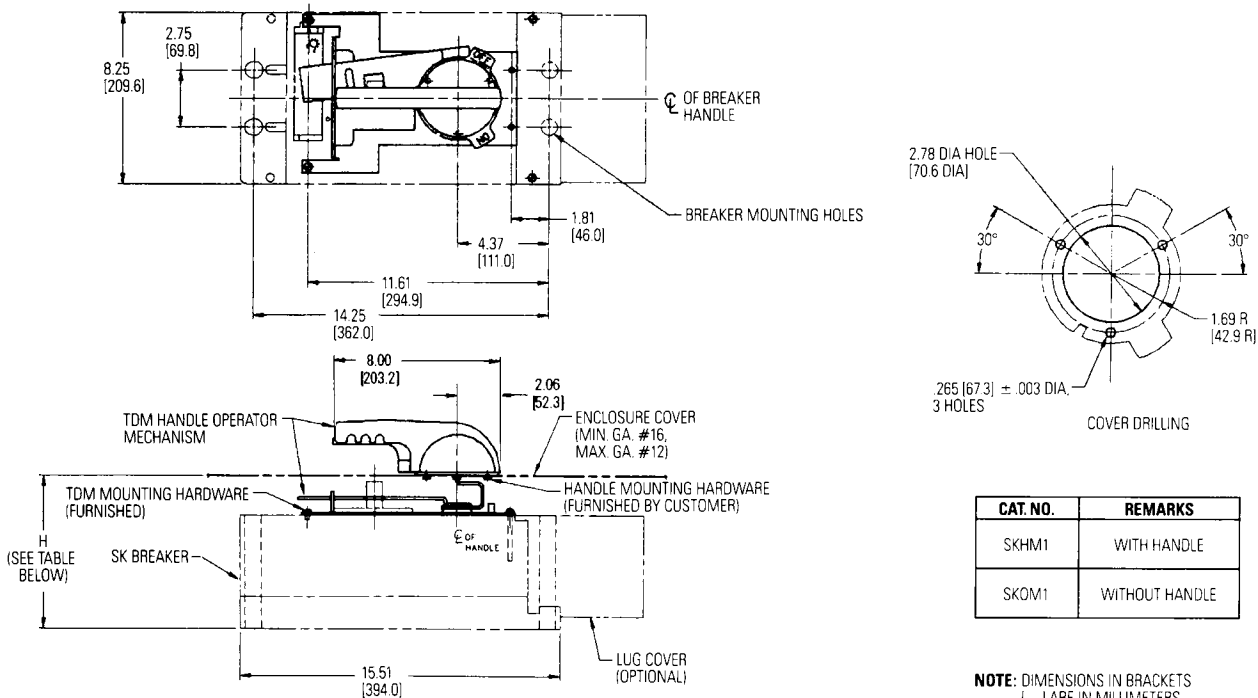


**COVER DRILLING  
COMMON TO SE-150 & SF-250 LINE**

\*SHAFT FURNISHED TO MAX. DEPTH. CUSTOMER TO CUT WHEN DIMENSION IS LESS.



**SG600 Line**



**SK1200 Line**

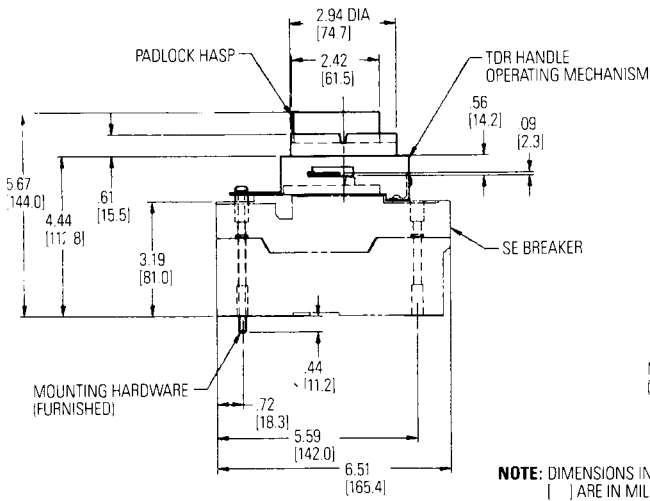
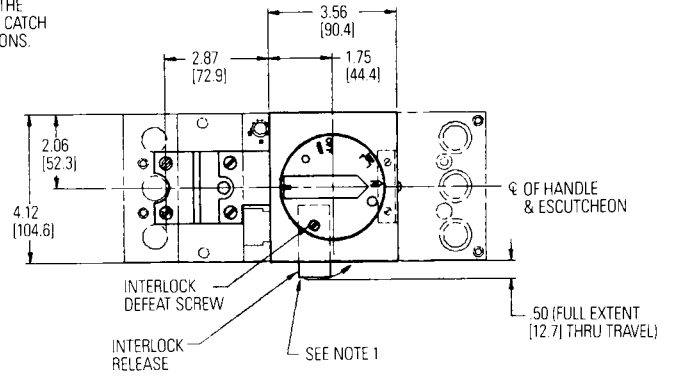
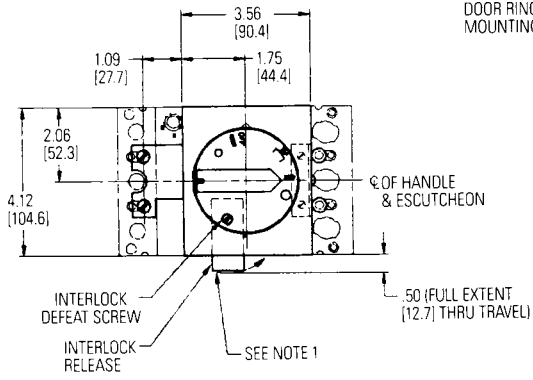
NOTE: DIMENSIONS IN BRACKETS [ ] ARE IN MILLIMETERS

Breaker Line	Handle Operator Catalog No.	H	
		Inch	mm
SK1200	SKHM1	7.38	187.5
	SKOM1		
	SKHM2	7.19 min	182.6 min
	SKOM2		

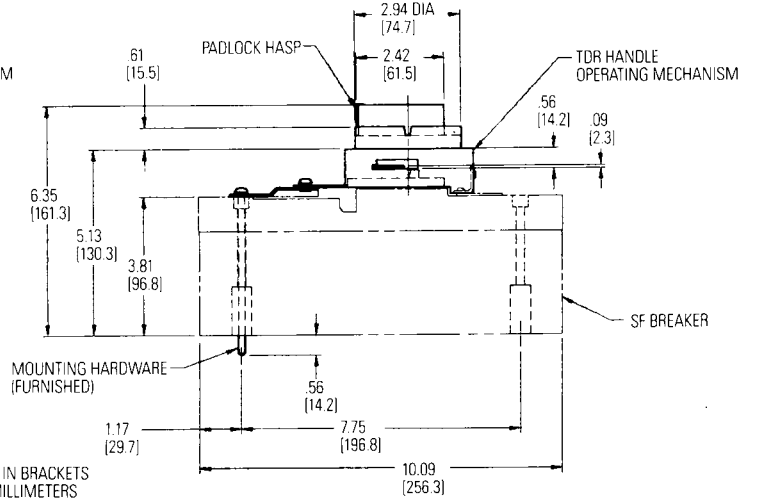
\*SHAFT FURNISHED TO MAX. DEPTH. CUSTOMER TO CUT WHEN DIMENSION IS LESS

# TDR handle operators

**NOTE: 1** REFER TO OUTLINE DRAWING 792A499, SHEET 4 FOR THE DOOR RING INTERLOCK CATCH MOUNTING INSTRUCTIONS.

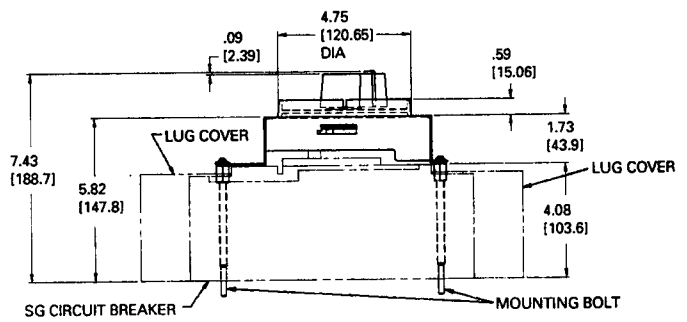
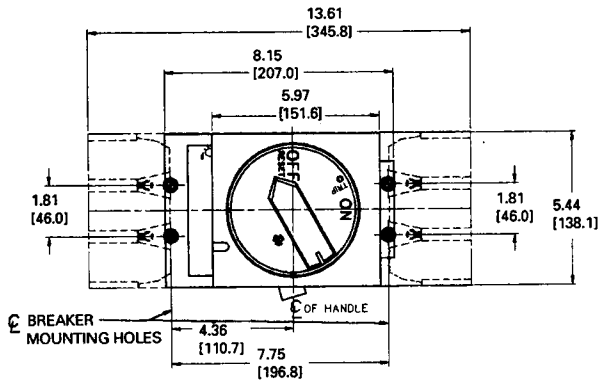


**SE150 Line**

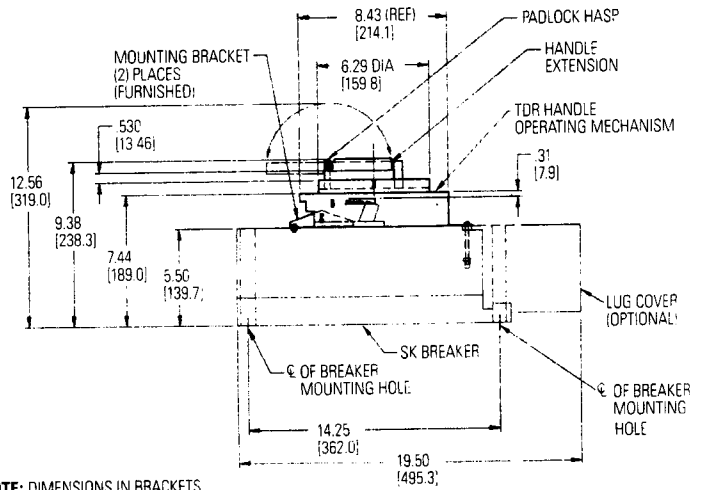
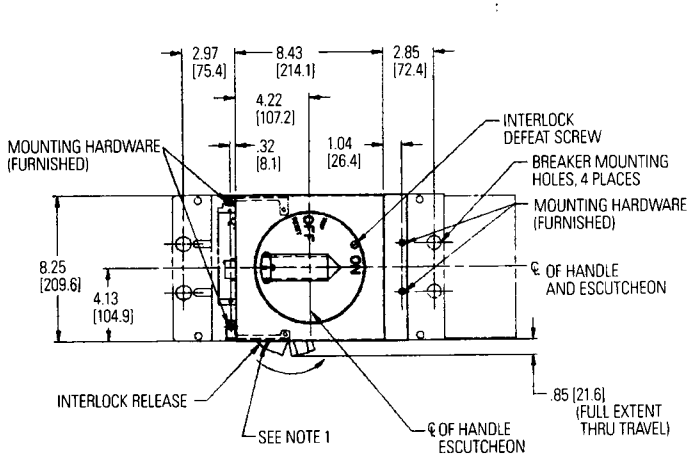


**SF250 Line**

**NOTE:** DIMENSIONS IN BRACKETS [ ] ARE IN MILLIMETERS



### SG600 Line

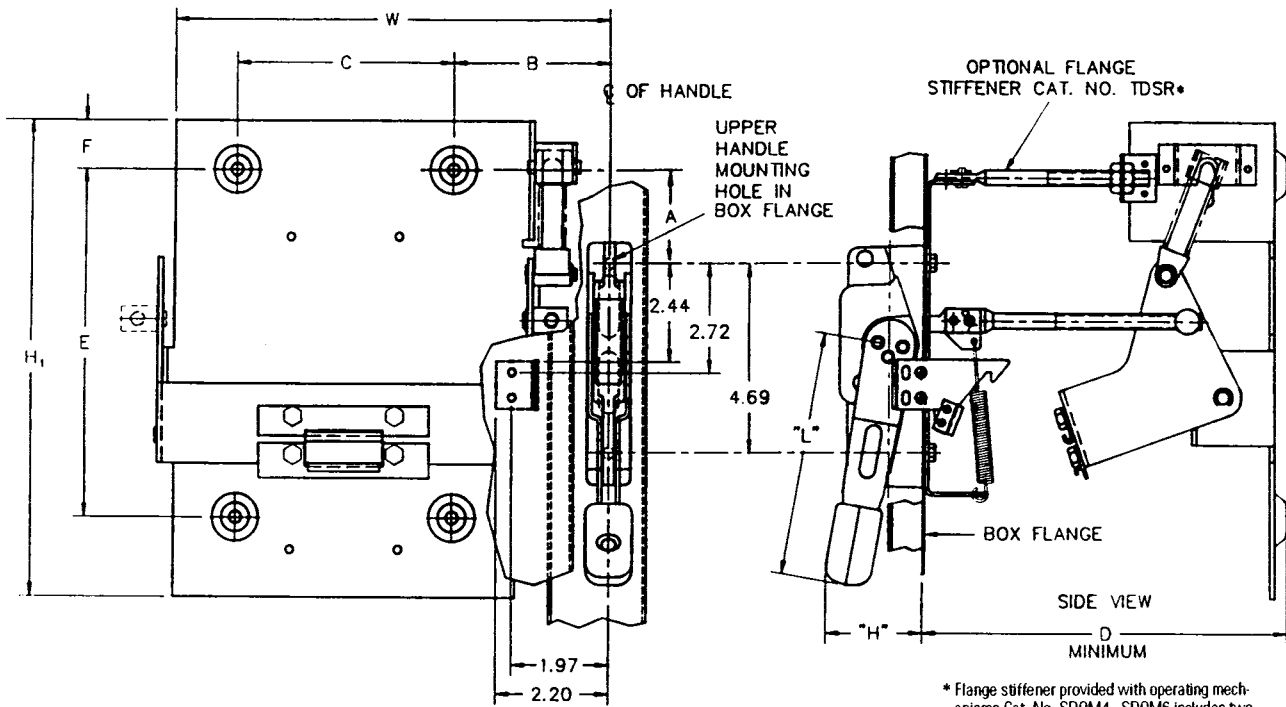


NOTE: DIMENSIONS IN BRACKETS [ ] ARE IN MILLIMETERS

### SK1200 Line



# STDA flange handles & operating mechanisms



\* Flange stiffener provided with operating mechanisms Cat. No. SDOM4. SDOM6 includes two flange stiffeners.

BREAKER TYPE	MECHANISM CAT. NO.	DIMENSIONS IN INCHES							
		A	B	C	D	E	F	H <sub>1</sub>	W
SE150	SDOM1A	1.62	1.78	3.00	6.50	6.75	1.20	9.69	6.25
SF250	SDOM3	1.22	2.72	2.75	6.50	10.88	1.38	13.38	6.75
SG600	SDOM4	3.22	2.38	3.35	8.00	5.51	1.56	15.32	7.59
SK1200	SDOM6*	6.00	2.66	5.50	9.00	16.75	1.00	18.75	10.33

HANDLE CAT. NO.	"L"	"H"
STDA1, STDA1X	6.04	2.38
STDA2, STDA2X STDA3** STDA3X**	9.38	3.00

\*\* STDA3, 3X for use only with SDOM6.  
SDOM6 to be used only with STDA3, 3X.

## Guide Form Specifications

All molded case circuit breakers shall have an over-center, toggle handle-operated, trip-free mechanism with quick-make, quick-break action independent of the speed of the toggle handle operation. The designs shall provide common tripping of all poles. The escutcheon area of the breaker cover shall have molded-in "ON" and "OFF" markings and corresponding "I" and "O" (for "ON" and "OFF" respectively) international markings.

All molded case circuit breakers shall be GE Spectra RMS or equal with digital solid-state, ambient insensitive tripping. All frames from 30A to 1200A shall use field-installed, UL Listed rating plugs to establish (or change) the ampere rating and shall be suitable for reverse feed (i.e., no line/load markings). The digital microprocessor trip system shall be applicable for 50 Hz through 400 Hz systems. It shall accurately sense sinusoidal and non-sinusoidal current waveforms (fundamental through the thirteenth harmonic order on a 60 Hz base) by continuously sampling each phase throughout every cycle.

All breaker frame sizes (SE150, SF250, SG600 and SK1200) shall have a single, customer-adjustable, instantaneous pickup knob to set the instantaneous response for all poles. In addition, there shall be a short time pickup setting at approximately 50 to 80% of the instantaneous pickup.

(Where) (If) required, instantaneous-only breakers shall be Spectra RMS Mag-Break motor circuit protectors or equal employing the same features as the molded case breakers, except with the long-time (thermal) response omitted. The tracking short-time function and common rating plugs shall be provided on the instantaneous-only breakers.

Molded case switches (where) (if) required, shall have a fixed, high-set instantaneous pickup set below the popping level of the contacts. The short circuit withstand ratings shall be 100kA @ 480 Vac and 25k (minimum) @ 600 Vac when protected by any UL Listed circuit breaker or fuse of equal or lesser ampere rating.

Circuit breakers and instantaneous-only breakers shall have frame sizes as follows: 30A, 60A, 100A, 150A, 250A, 400A, 600A and 1200A. In addition, a 7A instantaneous-only frame shall be available. Rating plugs shall cover all standard ampere ratings from one frame's maximum ampere rating down to the next lower frame ampere rating. A frame shall reject a rating plug not intended for use in it. Mag-Break or equal breakers shall use the same rating plugs for 15A through 1200A ratings as the Spectra RMS circuit breakers and shall additionally have 3A and 7A plugs for the 7A frame.

The circuit breaker frames shall employ high-strength, molded-polyester, glass-reinforced cases and covers. The breaker frame shall have legible, tamper-proof nameplates containing catalog number; maximum frame ampere rating; maximum voltage ratings and interrupting ratings in accordance with UL Standard 489, International Electrotechnical Commission (IEC) Standard 947.2 and Japanese Industrial Standard (JIS) No. C8370; terminal lug catalog number, torque requirements and cable insulation rating and wire ranges; the rating plug type; and Underwriters' Laboratories, Inc. Listing mark (or Component Recognition symbol in the case of Mag-Break instantaneous-only breakers). The IEC short circuit ratings shall contain both service ( $I_{cs}$ ) and ultimate ( $I_{cu}$ ) values.

All breaker frame sizes shall have a Verifier™ or equal to provide an external means for manually tripping the breaker and exercising the mechanism and trip latch member.

Internal accessories shall be UL Listed for field installation and shall not require circuit breaker cover removal. All internal accessories shall be common to the SE150, SF250, SG600 and SK1200 frame size. Shunt trips, undervoltage releases, auxiliary switches and bell alarms shall be available and shall install from the front of the circuit breaker, instantaneous-only breaker or molded case switch.

External accessories, such as motor-operated mechanisms, various handle operators, plug-in base assemblies, back-connected studs, shall be UL Listed for field installation on circuit breakers (including instantaneous-only circuit breakers) and molded case switches.

**GE Consumer & Industrial**  
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imagination at work