Molded Case Circuit Breaker Types

This catalog discusses the following types of molded case circuit breakers:

— Thermal-magnetic, including current limiting circuit breakers

— Magnetic only (Mag-Gard™) circuit breakers

— Molded case switches

- Thermal-Magnetic Molded Case Circuit Breakers

Thermal-magnetic molded case circuit breakers are the most common overcurrent protection devices. Their primary functions are to provide a means to manually open a circuit and automatically open a circuit under overload or short circuit conditions. Thermal-magnetic circuit breakers use bimetals and electromagnetic assemblies to provide overcurrent protection. Their characteristic inverse time tripping under overload conditions is ideally suited for many applications varying from residential to heavy industrial loads. For higher level (short circuit) overcurrents, instantaneous trip characteristics allow molded case circuit breakers to interrupt with no intentional delay.

- Current Limiting Circuit Breakers

Current limiting circuit breakers are used for overcurrent protection and switching on ac systems where high fault currents may be encountered. They have permanent trip units containing individual thermal and magnetic trip elements in each pole like thermal-magnetic circuit breakers. But they go one step further by limiting the amount of current that normally passes through a circuit breaker during a severe fault on the circuit being protected. Schneider Electric™ brand current limiting circuit breakers are designed to take advantage of the electromagnetic repulsion created by closely spaced, parallel contact arms carrying current in opposite directions. This repulsion, intensified by an “O” shaped magnet surrounding the contact arms, causes the contacts to blow open in less than one millisecond under fault conditions above 10 to 15 times the handle rating of the circuit breaker. This high speed contact separation enhances the ability of the I-Limiter™ circuit breakers to limit both peak current and I^2t let-through energy. UL® requires that peak current and I^2t let-through curves be available for current limiting circuit breakers.

FIL
Current Limiting
Circuit Breaker

The following steps describe the short circuit interrupting process of current limiting circuit breakers at fault levels within the current limiting range:

1. Contacts Part—The electromagnetic repulsion between the contact arms exceeds the spring force that holds the contact arms together. The repulsion blows the contact open.
2. Limited Peak Current Reached—The intense magnetic field inside the “O” shaped magnet forces the arc (between the opening contacts) into the stack plates.
3. Limiter Latch Holds Contacts Open—After Ip has been reached, the current must then be driven to zero. At the same time this occurs, a specially designed limiter latch holds the contacts open until interruption is complete.
4. Interruption Complete—To complete interruption, the arc voltage is sustained at a high enough level to overcome source voltage and thereby drive the current to zero (complete interruption). This requires a rapid rise in arc resistance and is accomplished by maintaining arc length while quickly cooling the arc. Cooling the arc causes a loss of ionization which increases arc resistance.

FAL
Magnetic Only
Circuit Breaker

- Magnetic Only Circuit Breakers

Mag-Gard magnetic only circuit breakers comply with National Electrical Code (NEC) requirements for providing motor circuit protection when installed as part of a listed combination controller having motor overload protection.

Mag-Gard instantaneous trip circuit breakers (often referred to as motor circuit protectors) are similar in construction to thermal-magnetic circuit breakers. They are designed as disconnect devices for use in combination with motor starters. Mag-Gard circuit breakers are built without thermal detection elements (bimetals), therefore, they provide short circuit protection only. Mag-Gard circuit breakers have an adjustable amperage pick up so they can be set to open instantaneously at current values slightly above the motor starting inrush current. This setting coordinates the pick-up time-current response of the Mag-Gard with the overload relay of the starter to give the best possible motor protection. According to the 2002 NEC®, "Where the setting specified in Table 430.52 is not sufficient for the starting current of the motor, the setting of an instantaneous trip circuit breaker shall be permitted to be increased but shall in no case exceed 1300 percent of the motor full-load current for other than Design E motors or Design B energy efficient motors and no more than 1700 percent of full-load motor current for Design E motors or Design B energy efficient motors. Trip settings above 800 percent for other than Design E motors or Design B energy efficient motors and above 1100 percent for Design E motors or Design B energy efficient motors shall be permitted where the need has been demonstrated by engineering evaluation. In such cases, it shall not be necessary to first apply an instantaneous-trip circuit breaker at 800 percent or 1100 percent." Current interrupting ratings for these UL recognized components are established in combination with motor starters and properly sized overload relays and contactors. Mag-Gard circuit breakers are tested in combination with Schneider Electric starters per UL Standard 845.

- Molded Case Switches

KHL
Automatic Molded
Case Switch

Molded case switches are intended for use as disconnect devices only. UL Standard 489 requires molded case switches to be protected by a thermal-magnetic circuit breaker (or fuse) of equivalent rating. Molded case switches are labeled with their appropriate withstand ratings. Withstand rating is defined as the maximum current, at rated voltage, that the molded case switch will withstand, without damage, when protected by a circuit breaker (or fuse) with an equal continuous current rating.

Automatic molded case switches are similar in construction to thermal-magnetic circuit breakers, except that the thermal detection element is not present. These switches open instantaneously at a non-adjustable, factory preset, magnetic trip point calibrated to protect only the molded case construction, they are more compact than conventional disconnect switches and accept electrical accessories for added flexibility.

The following molded case switches are available from Schneider Electric:

Table 1: Molded Case Switches

Circuit Breaker	Frame Type
FH	100 A Frame
QB, QD, QG, QJ [1]	70–250 A Frame
KH	250 A Frame
LH	400 A Frame
MH	600-1000 A Frame
NC	1200 A Frame
PH	2000 A Frame
PC	2500 A Frame

[1] See Class 612, 613, and 734 catalogs for other PowerPacT and MasterPacT™ circuit breakers.

Internal Operating Mechanisms

The following mechanisms allow the circuit breaker to operate:

— Thermal trip

— Magnetic trip

— Push-to-trip button

— Shunt trip

— Undervoltage trip

Note: Shunt trip and undervoltage trip are described in the Accessories section.

- Tripping Mechanism

The tripping mechanism is an assembly within the circuit breaker frame that causes the circuit breaker to open automatically under sustained overload, short circuit, or high level ground fault conditions.

The tripping mechanisms in two and three-pole circuit breakers operate such that an overcurrent on any given pole of the circuit breaker will cause all poles of the circuit breaker to open simultaneously. A thermal and magnetic factory calibration test (with current) is performed on each pole of every circuit breaker manufactured by Schneider Electric.

The sensing system of a thermal-magnetic circuit breaker is an integral part of the circuit breaker that continually monitors the current flowing through the circuit breaker. It detects abnormal current conditions and, depending on the magnitude of the current, initiates an inverse-time or an instantaneous tripping response. This action causes the tripping mechanism to open the circuit breaker contacts and interrupt current flow. The speed of the tripping process must be controllable and inversely matched to the severity of the overcurrent. The ability of a particular circuit breaker to interrupt a given level of overcurrent depends on the sensitivity of the circuit breaker.

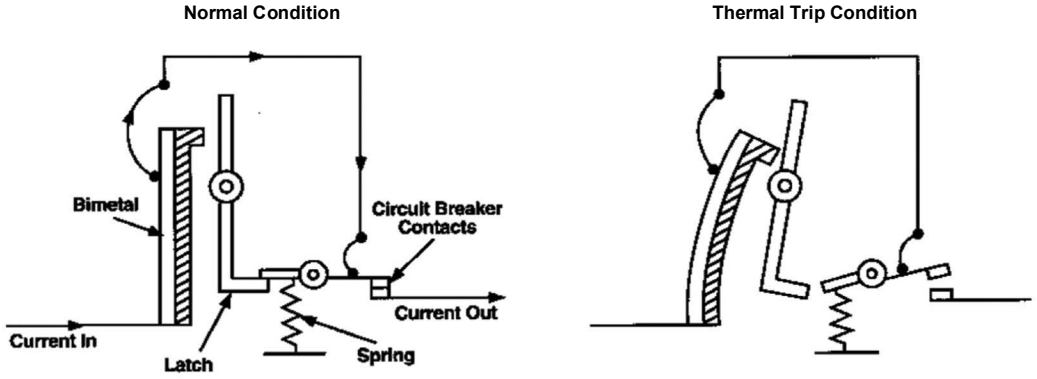
Thermal-magnetic circuit breakers have two tripping elements.

- Thermal Trip

The molded case circuit breaker thermal trip element is a root means squared (RMS) sensing device. The bimetal thermal element is constructed from metals of dissimilar rates of expansion bonded together. The thermal portion responds to overloads by reacting to the heat generated both by the current flowing through the circuit breaker and by the heat contribution from the ambient conditions. The bending force of the bimetal causes the circuit breaker to trip. The deflection of the bimetal is predictable as a function of current and time. This is the inverse time tripping characteristics of the thermal element (i.e., the tripping time decreases as the magnitude of the current increases).

Schneider Electric calibrates the thermal elements for a specific amperage rating, and they are not field adjustable. The thermal trip elements are calibrated for 104 °F (40 °C) ambient temperature per UL Standard 489.

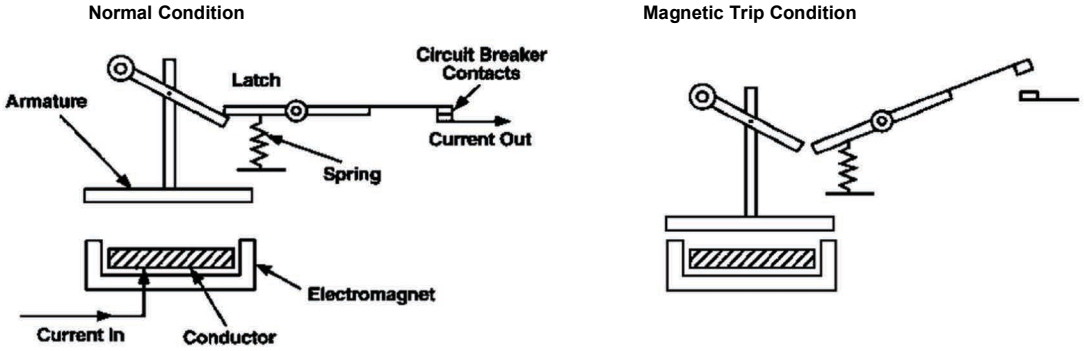
Figure 1: Thermal Trip Condition



- Magnetic Trip

The magnetic (instantaneous) trip element uses an electromagnetic assembly, in series with the load current, to trip the circuit breaker instantaneously (with no intentional delay) at or above a predetermined current value. During a short circuit of significant magnitude, the high level current passing through the conductor rapidly increases the magnetic field of the electromagnet which attracts the armature. As the armature is drawn toward the electromagnet, it initiates an unlatching action and opens the circuit breaker contacts.

Figure 2: Magnetic Tip Condition



- Line and Load Connections

Thermal-magnetic circuit breakers, magnetic only circuit breakers, and molded case switches are provided with factory installed UL listed mechanical-type aluminum alloy lugs suitable for either aluminum or copper wire. In addition to mechanical lugs, Schneider Electric can supply copper mechanical lugs, aluminum or copper Versa-Crimp™ compression lugs, and power distribution connectors. Circuit breakers can be ordered without lugs to accept bus connections.

Figure 3: Mechanical and Versa-Crimp Lugs

Schneider Electric also offers I-Line circuit breakers, which feature plug-on connectors. They are designed for easy installation and removal of the circuit breakers in our exclusive I-Line panelboards. I-Line circuit breakers use “blow-on” type connectors. In case of a short circuit, in the circuit being protected, the increased magnetic flux causes the plug-on connectors to grasp the panelboard bus bars even tighter. These connectors are an integral part of the I-Line circuit breakers, as is the circuit breaker mounting bracket.

- Push-To-Trip Button

Push-to-Trip is a standard feature of Schneider Electric molded case circuit breakers that allows the circuit breaker to be manually tripped without exposure to live parts. The Push-to-Trip button is located on the face of each molded case circuit breaker for ease of periodic operation.

International I/O (ON/OFF) markings appear on the face of each Schneider Electric molded case circuit breaker and molded case switch in addition to the standard ON/OFF markings to indicate handle position. When tripped, the handle assumes a center position. To reset the breaker, the handle is moved to the OFF position and then to the ON position. During normal on/off operation, the handle opens and closes the circuit breaker contacts but does not exercise the tripping mechanism. Schneider Electric suggests that the circuit breaker's tripping mechanism be exercised at least annually. Use of the Push-to-Trip system will also check:

— Alarm circuits

— Emergency circuits

— Motor sequencing operations

For maintenance information, application and field testing guides, contact the local Schneider Electric Customer Information Center at 1-888-778-2733.

Circuit Breaker Tripping Characteristics

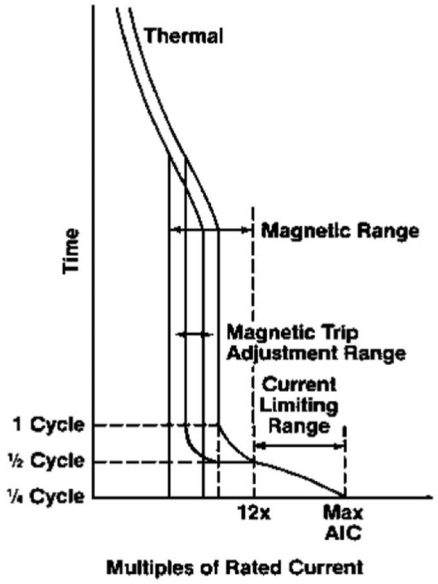
The tripping characteristics of thermal-magnetic molded case circuit breakers can be represented by a characteristic tripping curve that plots tripping time versus current level. The curve shows the amount of time required for a circuit breaker to trip for currents ranging from minor overloads to maximum interrupting capacity.

- Thermal Tripping Characteristics

The left-hand portion of a tripping curve displays the circuit breaker's thermal response. On low level overcurrents, up to the magnetic tripping level, thermal tripping occurs when a bimetal in the circuit breaker responds to heat associated with overcurrent. The bimetal deflects, unlatching the mechanism, which causes the circuit breaker contacts to open. The larger the overcurrent, the faster the circuit breaker operates to open the circuit (inverse time).

- Magnetic Tripping Characteristics

Figure 4: FI Characteristic Tripping Curve



The right hand portion of a tripping curve displays the magnetic tripping response of the circuit breaker. This takes place when overcurrents of sufficient magnitude operate an internal magnetic armature that unlatches the tripping mechanism. Magnetic tripping occurs with no intentional delay.

For example, the FI circuit breaker time current characteristic tripping curve shows the tripping response of the circuit breaker for currents ranging from minor overloads to maximum interrupting capacity.

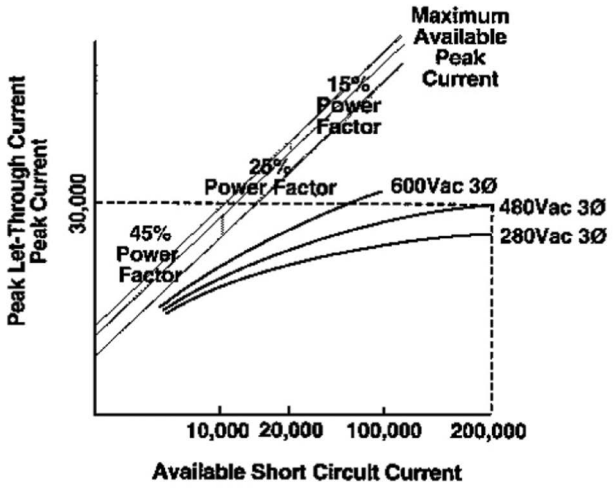
- Circuit Breaker Coordination

To determine what level of coordination exists between molded case circuit breakers, a comparison of circuit breaker characteristic tripping curves is necessary.

A coordination study is an organized effort to achieve optimum electrical distribution system protection by determining the appropriate frame sizes, ampere ratings, and settings of overcurrent protective devices. When an overcurrent within the coordination limits occurs in a distribution system, only the protective device nearest the overload or fault opens. Lack of coordination between overcurrent devices can result in upstream devices opening and interrupting electrical distribution in other parts of the system.

- Let-through Current Curves

Figure 5: Maximum Instantaneous Let-through Current



Let-through current curves show the extent to which a current limiting circuit breaker limits the peak current that could flow during a short circuit. On these curves, the slanting straight lines marked 15%, 25% and 45% power factor show the maximum theoretical peak currents that could flow in a faulted circuit having that particular short circuit power factory—with NO current limiting device in the circuit.

Short circuits which produce high fault currents typically are associated with low short circuit power factors; that is, high X/R ratios. Since different portions of a system will exhibit various available fault levels and power factors associated with those levels, UL has established that the following power factors be used in short circuit testing:

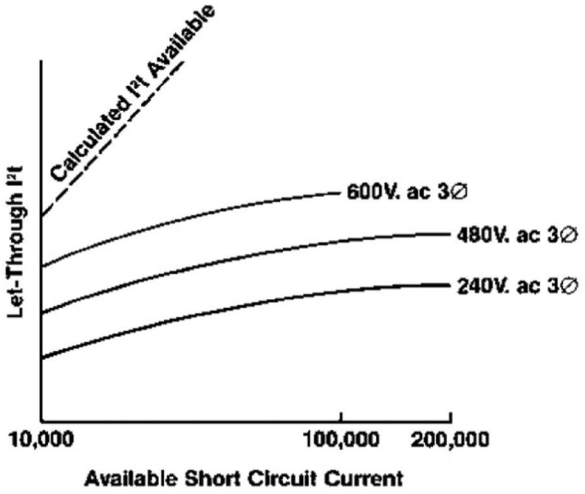
Table 2: Power Factors in Short Circuit Testing

Test Current RMS Symmetrical (Amperes)	Power Factor (%)
10,000 or Less	45–50
10,000–20,000	25–30
Over 20,000	15–20

Since the peak current let-through curves for the I-Limiter current limiting circuit breakers were derived from tests at the current levels and power factors indicated, the degree of current limitation is expressed by the differential between the maximum available peak current and the actual test let-through peak current.

The curves extend from the threshold of current limitation through the maximum interrupting rating of the current limiting circuit breaker.

Figure 6: Maximum Let-through I^2t Energy



Let-through I^2t curves show the extent to which the current limiting circuit breaker limits energy let-through under short circuit conditions. The theoretical I^2t let-through of symmetrical sinusoidal current can be calculated. At 100,000 A rms, this would be 83 x 10^6 A^2 seconds for ½ cycle if NO CURRENT LIMITING DEVICE WERE IN THE CIRCUIT. In contrast, the curves show that with the same level of 100,000 rms symmetrical short circuit amperes available, the 100 A current limiting circuit breaker would limit the energy flow 0.62 x 10^6 A^2 seconds at 480 volts or 0.27 x 10^6 A^2 seconds at 240 volts.

Construction

Thermal-magnetic circuit breakers are manufactured and tested according to the following standards and files:

- Underwriters Laboratories Inc. (UL) Listed to UL489 Standard, File E10027,
- National Electrical Manufacturers Association (NEMA) AB-1 Standard,
- Canadian Standards Association (CSA) Certified to CSA C22.2 No. 5-02 Standard, File LR7551,
- International Electrotechnical Commission (IEC) 60947-2 Standard,
- Federal Specification W-C-375B/GEN as Class 11a, 11b; 12a, 12b; and 13a, 13b.

Magnetic only circuit breakers are manufactured and tested according to the following standards and files:

- Underwriters Laboratories Inc. (UL) Recognized to UL489 Standard, File E10027,
- Canadian Standards Association (CSA) Certified to CSA C22.2 No. 5-02 Standard, File LR32390.

Molded case switches are manufactured and tested according to the following standards and files:

- Underwriters Laboratories Inc. (UL) Listed to UL489 Standard, File E33117 or E87159,
- Canadian Standards Association (CSA) Certified to CSA C22.2 No. 5-02 Standard, File LR32390 or LR40970.

Note: Circuit breakers are to be applied by guidelines detailed in the NEC and other local electrical codes.

- Specifications

Cases for molded case circuit breakers are constructed of a glass-reinforced insulating material that provides high dielectric strength. Current carrying components are isolated from the handle and accessory mounting area. The handle position indicates whether the circuit breaker is OFF, ON or tripped.

Schneider Electric molded case circuit breakers:

- Have common tripping of all poles,
- Are equipped with a Push-To-Trip button to manually trip the circuit breaker,
- Can be mounted and operated in any position,
- Are fully tested, UL listed, CSA certified, and IEC rated for reverse connection without restrictive “LINE” or “LOAD” markings.

- Tripping System

Schneider Electric thermal-magnetic molded case circuit breakers have a permanent trip unit that contains a factory preset thermal trip element and a magnetic trip element in each pole. The thermal trip element is rms sensing. In circuit breakers with frame sizes greater than 100 A, the magnetic trip element is field adjustable. A single adjustment simultaneously adjusts the instantaneous trip point in each pole.

- Terminations

All factory installed mechanical type lugs are UL listed to accept solid or stranded conductors and can be used with wire rated at 60° C (sized according to the NEC 140 °F (60 °C) temperature rating). 167 °F (75 °C) and 90° C (sized according to the NEC 167 °F (75 °C) temperature rating). Most molded case circuit breakers are UL listed to accept field installable mechanical type and compression type lugs.

- UL Requirements

A UL label on a Schneider Electric molded case circuit breaker indicates that the circuit breaker meets the requirements of UL Standard 489 for circuit breakers.

A UL label also means the production procedure is monitored by UL inspectors for continuing conformance to UL performance requirements. These requirements are based on sound engineering principles, research, records of test and field experience, and information gathered from users and inspection authorities. These requirements are subject to revision as necessary.

- UL HACR Type

All UL 489 listed molded case circuit breakers are HACR type.

UL 489 Test Procedures

- Limited Available Fault Current Tests

UL requires a series of tests on a single set of sample circuit breakers for compliance with UL Standard 489. The tests for thermal-magnetic circuit breakers are described below.

Since molded case switches are derivatives of molded case circuit breakers, some testing of switches is identical to that for circuit breakers. These tests include a 600% overload performance test:

— 200% Thermal Calibration

Each pole of the circuit breaker must trip within a specified time limit when carrying 200% of its continuous current rating.

— 135% Thermal Calibration

With all poles connected in series, the circuit breaker must trip within a specified time limit when carrying 135% of its continuous current rating.

— Magnetic Calibration

If the circuit breaker has an adjustable magnetic tripping means, then it must trip within a specified percentage of the marked tripping current.

— Overload

The circuit breaker is operated making and breaking 600% of its continuous current rating, but not less than 150 A.

For circuit breakers through 1600 A, the number of 600% operations is 50. For larger circuit breakers to 4000 A, the number of operations is 25.

— Temperature Rise

While carrying 100% of rated current at a 104 °F (40 °C) ambient temperature and mounted in open air, the circuit breaker is checked for temperature rise on a wring terminal. The temperature on the terminal shall not exceed a 122 °F (50 °C) rise above ambient temperature and must be within specified limits.

— Endurance

The circuit ibreaker must successfully complete the following number of switching operations.

Table 3: Circuit Breaker Endurance

Frame Size Amperes	Full Load Operations	No Load Operations
0–100	6,000	4,000
101–225	4,000	4,000
226–600	1,000	5,000
601–800	500	3,000
801–2500	500	2,000
2501–4000	400	1,100

— Calibration Retest

Both the 200% and 135% thermal calibration tests are repeated.

- Short Circuit

  For circuit breakers rated 240 Vac and higher, two short circuit tests per pole and one test with all poles connected in series is performed. For example, a three-pole circuit breaker receives seven short circuit tests.

  For circuit breakers rated 120/240 Vac, three tests are made with all poles connected in series.

  The circuit breaker is connected to the test circuit using wire correctly sized for the rating of the circuit breakers. The line leads are not more than four feet in length and the load leads are not more than 10 inches in length.

  Note: Successful testing requires that the current be interrupted while monitoring the integrity of the line-end load connection.

- Trip Out

  The 200% thermal calibration test is repeated following the short circuit tests:

  — Dielectric

  The circuit breaker must withstand, for one minute, twice its rated voltage plus 1000 Vac:

  — between line and load terminals with the circuit breaker open, that is, with the circuit breaker in the tripped and off positions,

  — between terminals of opposite polarity with the circuit breaker closed, and

  — between live parts and the overall enclosure with the circuit breaker both open and closed.

  No conditioning of the circuit breaker can take place during or between these tests. There also can be no failure of functional parts at the conclusion of the sequences.

- High Available Fault Current Tests

After qualifying a set of circuit breakers to the standard tests, a manufacturer can have additional circuit breaker samples tested on higher than standard available fault currents.

The following performance requirements apply:

— 200% Thermal Calibration

Each pole of the circuit breaker must trip within a specified time limit when carrying 200% of its continuous current rating.

— Short Circuit

With the load side terminals connected by 10-inch lengths of specified cable, the circuit breaker is exposed to a short circuit current for a set time interval. After safe interruption, the circuit breaker is reset and closed again on the short circuit.

— 250% Thermal Calibration

Each pole of the circuit breaker must trip within a specified time limit when carrying 250% of its continuous current rating.

— Dielectric Withstand

The circuit breaker is subjected to twice its rated voltage, but not less than 900 Vac.

When the sample circuit breaker passes these tests, circuit breakers of the same construction can be marked or labeled with the higher current interrupting rating.

- Switching Duty

The switching duty (SWD) listing applies only to 15 A and 20 A circuit breakers rated at 277 Vac or less. The circuit breakers are subjected to specified temperature rise tests at predetermined periods during the endurance operations.

- Performance Requirements for Magnetic Trip Only Circuit Breakers

Design performance verification is tested as follows:

1. Verification of calibration
2. Overload
3. Temperature rise
4. Mechanical and electrical endurance
5. Limited fault current
6. Re-verification of calibration
7. Dielectric

Ratings for Molded Case Circuit Breakers

Molded case circuit breakers are selected by their ratings. The ratings must meet or exceed the parameters of the electrical system on which they are used.

- Voltage Rating

A circuit breaker may be rated either for alternating current (ac) or direct current (dc) system applications. The established voltage rating of a circuit breaker is based on design parameters such as clearance of current carrying parts and dielectric withstand tests both through air and over surfaces. Voltage ratings indicate the maximum voltage for the electrical system on which the circuit breaker can be applied. UL Standard 489 recognizes the following ratings:

Table 4: UL Standard 489 Recognized Voltage Ratings

Volts for Alternating Current (ac)	Volts for Direct Current (dc)
120	125
120/240	125/250
240	250
277	600
480Y/277	—
480	—
600	—

A circuit breaker can be rated for either ac or dc system applications or both. Circuit breaker voltage ratings must be equal to or greater than the nominal voltage of the electrical system on which they are used.

Paragraph 240.85 of the 2002 NEC states that a circuit breaker must be applied in the following manner:

> **240.85**—A circuit breaker with a straight voltage rating, such as 240 V or 480 V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker's voltage rating. A two-pole circuit breaker shall not be used for protecting a three-phase, corner-grounded delta circuit unless the circuit breaker is marked 1Ø–3Ø to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240 V or 480Y/277 V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

FPN: Proper application of molded case circuit breakers on 3-phrase systems, other than solidly grounded WYE, particularly on corner grounded delta systems, considers the circuit breakers' individual pole-interrupting capability.

- Continuous Current Rating

The continuous current rating (or handle rating) of a circuit breaker is defined by NEMA as: "The maximum direct current or rms current, in amperes, at rated frequency which a device or assembly will carry continuously without exceeding the specified limits of observable temperature rise." Continuous current amperage ratings established by the 2002 NEC, paragraph 240.6 are: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 A.

Paragraph 210.20 (A) and 215.3 of the 2002 NEC states:

210.20 (A)—Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

Exception: Where the assembly, including the overcurrent devices protecting the branch circuit(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.

215.3—Feeders shall be protected against overcurrent in accordance with the provisions of Part I of Article 240. Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

Exception No. 1: Where the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to not less than the sum of the continuous load plus the noncontinuous load.

Exception No. 2: Overcurrent protection for feeders over 600 volts, nominal, shall comply with Prt IX of Article 240.

NEC defines a continuous load as: "A load where the maximum current is expected to continue for three hours or more."

UL Standard 489 states that circuit breakers must carry 100% of their continuous current rating indefinitely (without tripping) at 104 °F (40 °C) in free air. Thermal-magnetic circuit breakers are sized per the NEC for 80% continuous current ratings in the intended enclosure. The continuous current rating is indicated on the front of each circuit breaker.

- Interrupting Ratings

Schneider Electric thermal-magnetic molded case circuit breakers can be standard interrupting, high interrupting, extra high interrupting, and time current limiting in construction and are UL listed for the interrupting ratings as shown below.

UL recognizes component combinations (circuit breaker / circuit breaker and fuse / circuit breaker) for series connected interrupting ratings. All series rated combinations are marked on the end use equipment along with the statement, "Caution—Series Rated System."

For 100% rated applications, see Class 602, 611, 612, and 613 catalogs for more information.

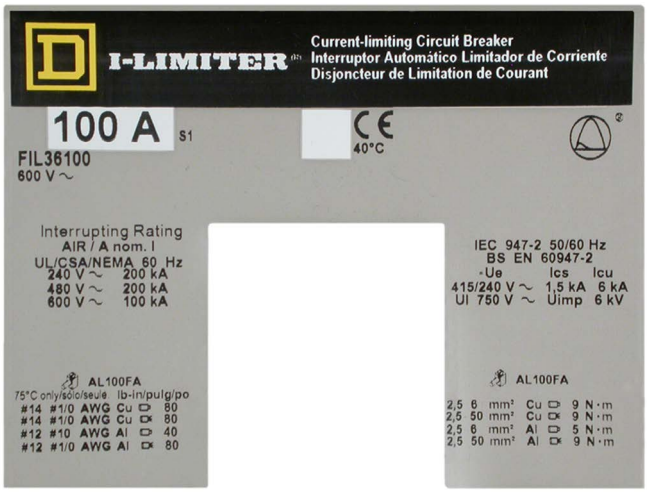
Table 5: UL Listed Interrupting Ratings in kA (RMS Symmetrical Amperes)

Ampacity	Catalog Prefix	Maximum Voltage	UL Listed Interrupting ratings (in kA)					
			240 Vac	480 Vac	600 Vac	125 Vdc	250 Vdc	500 Vdc
Standard Interrupting								
15–100	FA	600 Vac	25	18	14	10	10	—
		480 Vac	25	18	—	10	10	—
		240 Vac	10	—	—	5	5	—
70–250	KA	600 Vac	42	25	22	10	10	—
125–600	LA	600 Vac	42	30	22	10	10	—
300–1000	MA	600 Vac	42	30	22	10	10	—
600–1200	NA	600 Vac	100	50	25	—	—	—
600–2000	PA	600 Vac	65	50	42	—	—	—
High Interrupting								
15–100	FH	600 Vac	65	25	18	50	50	—
70–250	KH	600 Vac	65	35	25	50	50	—
125–400	LH	600 Vac	65	35	25	50	50	—
300–1000	MH	600 Vac	65	65	25	50	50	—
600–2000	PH	600 Vac	125	100	65	—	—	—
15–100	FH-DC	500 Vdc	—	—	—	—	—	20
70–250	KH-DC	500 Vdc	—	—	—	—	—	20
125–400	LH-DC	500 Vdc	—	—	—	—	—	20
300–1000	MH-DC	500 Vdc	—	—	—	—	—	20
600–2500	PA-DC	500 Vdc	—	—	—	—	—	25
Extra High Interrupting								
15–100	FC	480 Vac	100	65	—	—	—	—
110–250	KC	480 Vac	100	65	—	—	—	—
300–600	LC	600 Vac	100	65	35	—	—	—
600–1200	NC	600 Vac	125	100	65	—	—	—
1600–2500	PC	600 Vac	125	100	65	—	—	—
Current Limiting								
20–100	FI	600 Vac	200	200	100	—	—	—
110–250	KI	600 Vac	200	200	100	—	—	—
300–600	LI	600 Vac	200	200	100	—	—	—

Note: These ratings apply to I-Line circuit breakers and circuit breakers with or without lugs.

The ampere interrupting rating (AIR) of a circuit breaker is the highest current at rated voltage that the circuit breaker is intended to interrupt under standard test conditions. The interrupting rating is shown on the faceplate of the circuit breaker for each voltage level that the circuit breaker can use. Circuit breakers are selected with interrupting ratings equal to or greater than the available short circuit current at the point where the circuit breaker is applied in the system. Circuit breaker interrupting ratings are commonly expressed in rms symmetrical amperes. The industry standardization on rms symmetrical ampere ratings takes into account asymmetrical current conditions by specifying a power factor in the test circuit.

Figure 7: Circuit Breaker Faceplate Label



- Ambient Temperature Rating

To meet the requirements of UL Standard 489, CSA, and IEC, molded case circuit breakers are designed, built and calibrated for use on 50/60 Hertz (Hz) ac systems in a 104 °F (40 °C) ambient temperature.

The ambient temperature is the temperature of the air surrounding a circuit breaker. Thermal-magnetic circuit breakers are temperature sensitive devices, and their rated continuous current carrying capacity is based on a UL specified 104 °F (40 °C) calibration temperature. The ambient temperature can affect the thermal (overload) tripping characteristics of thermal-magnetic circuit breakers. When applying the circuit breaker at a temperature other than 104 °F (40 °C) , it may be necessary to rerate the circuit breaker to compensate for ambient conditions. Conductors are sized using the ampacity rerating factors shown in NEC Table 310-16 when designating systems for ambient temperatures other than 104 °F (40 °C).

Thermal-magnetic circuit breakers use bimetal strips that bend in response to temperature changes. Current flowing through the circuit breaker creates most of the heat that causes the tripping action. The ambient temperature surrounding the circuit breaker either adds to or subtracts from this available heat.

- Re-rating of Thermal-Magnetic Circuit Breakers for Ambient Conditions

Schneider Electric thermal-magnetic circuit breakers are to be applied in ambient temperatures within a range of 14 to 104 °F (-10 °C to 60 °C). These re-rating guidelines should be followed:

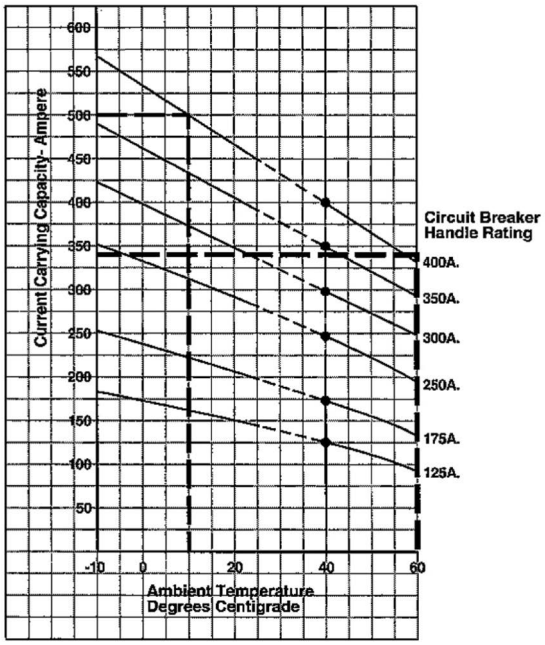
1. At ambient temperatures between 77—104 °F (25—40 °C), no rerating is necessary.
2. At ambient temperatures between 14—75 °F (-10—24 °C), thermal-magnetic circuit breakers carry more than their continuous current rating without tripping. Wire and equipment damage can result if they are not in the same low ambient environment as the circuit breaker.

   If closer protection of the equipment and wire is required, the increased current carrying capacity of the circuit breaker at the lower ambient temperature should be taken into consideration.
3. At ambient temperatures between 106—140 °F (41—60 °C) thermal-magnetic circuit breakers carry less than their continuous current rating and must be carefully selected to prevent nuisance tripping.

The following procedure is used to determine the continuous current carrying capacity of a thermal-magnetic circuit breaker at ambient temperature other than 104 °F (40 °C) (see data bulletin Determining Current Carrying Capacity in Special Applications for more information):

1. Refer to the ambient rerating curves for the circuit breaker type.
2. Select the curve for the specific amperage rating of the circuit breaker involved. Note in the figure, below, that the curve crosses the 104 °F (40 °C) ambient temperature line at the circuit breaker's UL listed continuous current rating (handle rating).
3. Follow this curve to the ambient temperature in which the circuit breaker is to be installed.
4. Read the continuous current carrying capacity at this left axis point.
5. Apply any other applicable factors, such as 80% loading per the NEC.

Figure 8: LA Circuit Breaker Ambient Rerating Curves



For example, this figure shows the ambient rerating curves for the LA thermal-magnetic circuit breaker. Determine the continuous current carrying capacity of a 400 A LA circuit breaker applied at 104 °F (40 °C) by finding 40 on the horizontal axis and reading up to the 400 A curve. The circuit breaker carries 400 A, which is its rated capacity. If the circuit breaker is used on a continuous load (3 hours or more). Paragraph 220-10b of the NEC requires that loading not exceed 80% of the rating
(400 A x 80 = 320 A).

- Frequency Rating

The standard rated frequency for circuit breakers is 60 Hz, but Schneider Electric circuit breakers can be applied on 50 Hz systems without thermal or magnetic re-rating. Other frequencies can affect the thermal, magnetic and short circuit tripping characteristics of circuit breakers.

Applying thermal-magnetic circuit breakers at frequencies above 50/60 Hz requires special consideration of the effects of high frequency on circuit breaker tripping characteristics. Thermal and magnetic operations must be treated separately.

- Thermal Tripping Performance

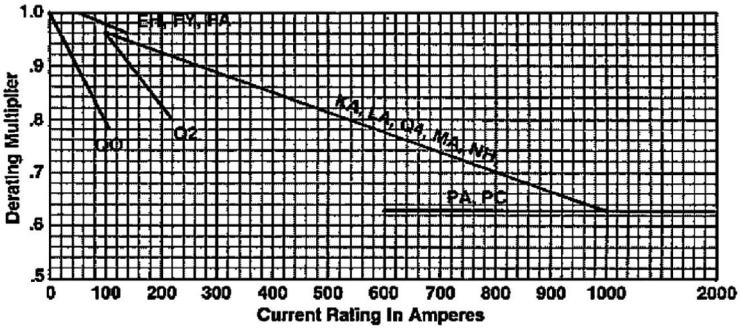
At frequencies below 60 Hz, the thermal rerating of thermal-magnetic circuit breakers is negligible. However, at frequencies above 60 Hz, thermal rerating is required. High frequency operation causes abnormal heat rise in the current carrying parts because of the skin effect. One of the most common frequency applications is at 400 Hz.

For example, when applying a 200 A kA circuit breaker on a 400 Hz system, the circuit breaker's current carrying capacity is as follows:

- Non-continuous loads (less than three hours): The kA circuit breaker may be applied at 0.92 of its rating, or 184 A.
- Continuous loads (3 hours or more): Paragraph 220-10b of the NEC requires that circuit breaker's loading does not exceed 80% of its rating when used for continuous loads.

(Unless the circuit breaker is rated for operation at 100% of its rating). Therefore, the current carrying capacity of a 200 A kA circuit breaker operating under continuous load at 400 Hz would be 200 x 0.92 x 0.80 = 147 A.

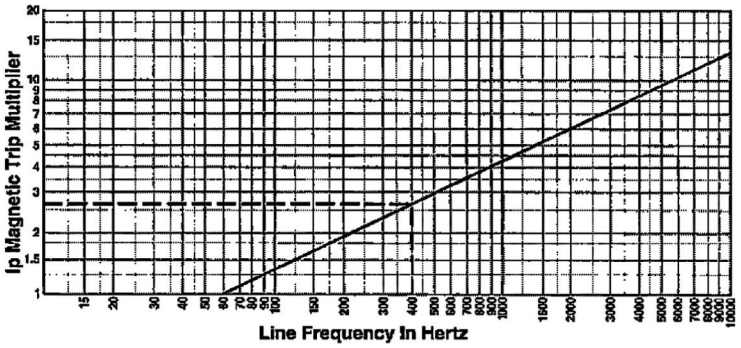
Figure 9: 400 Hz Thermal Rerating Multiplier



At frequencies above 60 Hz, the interrupting capacity of thermal-magnetic circuit breakers is less than the 60 Hz interrupting capacity. Unless specifically marked on 400 Hz systems, the interrupting capacity of Schneider Electric circuit breakers is reduced to 1/10th of the 60 Hz interrupting capacity.

- Magnetic Tripping Performance

Figure 10: 60 Hz Current Multipliers



At frequencies above 60 Hz, more current is necessary to magnetically trip a circuit breaker than at 60 Hz. The figure below shows the multipliers of 60 Hz current that it takes to magnetically trip a circuit breaker when applied at various frequencies. For example, at 60 Hz it takes 1000 A to magnetically trip a 200 A KA circuit breaker at its low setting. At 400 Hz it takes 2600 A (2.6 multiplier) to magnetically trip the same circuit breaker.

- Rerating for Direct Current

Trip curves provide complete time-current characteristics of circuit breakers when applied on ac systems only. Thermal-magnetic circuit breakers (1000 A frame or less) on dc systems retain their thermal tripping characteristics, but a multiplier must be applied to the ac magnetic trip level to determine an equivalent dc trip level.

Below is a list of multipliers for the dc magnetic trip level of each type of thermal-magnetic circuit breaker:

Table 6: Rerating Multipliers for Direct Current

Circuit Breaker	Magnetic Trip Level Multiplier
FA/FH/FC	1.15
KA/KH/KC	Hi Setting 1.15
	Lo Setting 1.3
LA/LH	Hi Setting 1.2
	Lo Setting 1.3
MA/MH	Hi Setting 1.1
	Lo Setting 1.2

For example, the equivalent dc magnetic trip levels for a 200 A kA circuit breaker would be:

1. ac Hi Setting = 2000 A + 20%.
2. dc Hi Setting = 2000 A x 1.15 = 2300 A + 20%.
3. ac Lo Setting = 1000 A + 25%.
4. dc Lo Setting = 1000 A x 1.3 = 1300 A + 25%.

UL Listed 500 Vdc Rated Circuit Breakers

Schneider Electric has UL listed dc thermal-magnetic circuit breakers specifically designed for use on ungrounded dc systems having a maximum short circuit (loaded) voltage of 500 Vdc or a maximum floating (unloaded) voltage of 600 Vdc.

This UL listed dc rating is available on FH. KH, LH, MH and PA molded case circuit breakers. Specific time current characteristic tripping curves are available for these applications.

Return and Exchange Policy

Molded case circuit breakers are factory sealed and no internal inspection or maintenance is required under normal conditions. **Important: DO NOT OPEN THE SEALED CASE.** Opening of the sealed case voids the UL label and the Schneider Electric warranty.

All damaged or used circuit breakers should be replaced as a unit and returned to the factory for inspection. Upon receipt of the circuit breaker, Schneider Electric performs a thorough inspection of the circuit breaker and issues a test report (on request). Unused circuit breakers and circuit breakers returned for inspection must be returned as instructed by the local Schneider Electric Customer Care Center.

Circuit breakers sent to the factory for inspection or testing are not returned. Schneider Electric offers a new circuit breaker and allows a credit for the circuit breaker that was returned. Price and credit allowances for all replacements of molded case circuit breakers and trip units are determined by Class, as follows.

- Class I

New circuit breakers that have been broken by handling or assembling, by other than Schneider Electric, or in transit and have not been in service.

  — Allowance

  A replacement circuit breaker is furnished and billed at list price minus the regular discount. When the circuit breaker in need of repair is returned, a credit allowance (42% of the billing price minus any transportation paid by Schneider Electric) is issued against the invoice of the replacing order.

- Class II

New circuit breakers that meet factory inspection standards and are interchangeable electrically and physically with standard units of current manufacture.

  — Allowance

  A replacement circuit breaker is furnished at the list price minus the regular discount. When the unused circuit breaker is returned, a credit (in the amount of the billing price minus 20% restocking charge and any transportation paid by Schneider Electric) is issued.

- Class III

Inoperative circuit breakers.

  — Allowance

  A replacement circuit breaker is furnished at the list price minus the regular discount. Upon return of the circuit breaker claimed inoperative, full credit is issued on the basis of the replacement cost plus any transportation costs paid by the customer.

  Examination by Customer Care must substantiate the claimed inoperative nature of the material returned.

- Class IV

Exchange of permanent trip circuit breakers (KA, LA, MA or NA) furnished in lieu of circuit breakers specified with interchangeable trip. These circuit breakers can be identified by a label stating they are subject to this exchange policy.

  — Allowance

  A replacement circuit breaker within the same frame size, but of a different trip rating than that exchanged, is furnished at the lowest recognized competitive list price for a trip unit of the same frame size and trip rating minus the regular discount. This exchange arrangement requires that the replaced circuit breaker be returned to Schneider Electric.

Catalog Numbers

Square D brand circuit breakers by Schneider Electric are ordered by a catalog number that includes the breaker family, description, poles, voltage rating, amperage rating and suffix.

The table below shows a typical catalog number broken down by components. For example, FAL36050V2100, can be broken down as follows:

Table 7: Catalog Numbers

Components	Description
FA	100 A frame circuit breaker
L	Circuit breaker with lugs on both ends
3	Number of poles
6	Voltage rating
050	Continuous current amperage rating (handle rating)
V and 2100	V indicates the Visi-Blade feature and the 2100 indicates a factory installed contact alarm. These two components are the suffix

Table 8: Breakdown of Typical Catalog Number

	FA	L	3	6	050	V	2100

Circuit Breaker Family

FY - 30 A Frame
FA - 100 A Frame
KA - 250 A Frame
LA - 400 A Frame
MA 1000 A Frame
NA - 1200 A Frame

Note:
"A" is replaced by letter "H" for High Interrupting
"A" is replaced by letter "C" for Extra High Interrupting
"A" is replaced by letter "I" for Current Limiting. (FA, KA. LA circuit breakers only)

Description

NO LETTER - (I-Line) Plug-on Circuit Breaker
B - (I-Line) Bolt-on Circuit Breaker (400 A frame maximum)
F - Terminal Pads Only (No Lugs)
L - Lugs on Both Ends (Merchandised - Universal Circuit Breaker)
P - Lugs OFF End Only
R - Plug-on Circuit Breaker (I-Line Type DO with Plug-on Line and Load connectors)

Poles

1 - One-Pole
2 - Two-pole
3 - Three-Pole

Voltage Rating

2 - 240 Vac
4 - 480 Vac
6 - 600 Vac

Ampere Rating

015–090 - 15–90 A Rating
100–900 - 100–900 A Rating
1000–1200 - 1000–1200 A Rating
000 or 0000 - Molded Case Switch
000X or 000XX - Molded Case Switch

Suffix

The suffix indicates a special feature of the circuit breaker.
A, B, C - indicated I-Line Phase Connections
CV - Indicates Visi-Blade
M - Indicates Automatic Molded Case Switch
XXM - Indicated Instantaneous Trip Only (Mag-Gard) (i.e., 18M is 300-1100 A adjustable trip range)
XXT - Indicates adjustable magnetic trip with responsive thermal (mining circuit breakers)
G - Indicates Ground Fault Shunt Trip accessory
XXXX - I.e., 2100 Indicates a factory installed accessory

Table 9: PowerPacT Q-frame Catalog Numbering System [1]

Number Segment	Character	Description	Q	B	L	3	2	250	4 [2]	L W [3]
Circuit Breaker Family	Q									
Circuit Breaker Type (Interrupting Rating)	B	10 kA								
	D	25 kA								
	G	65 kA								
	J	100 kA								
Connection Type	A	I-Line								
	E	Bolt-on I-Line								
	F	No lugs (Bus Connection)								
	L	Lugs on both ends								
	M	Lugs on ON (I) end only								
	P	Lugs on OFF (O) end only								
Poles	2	Two-pole								
	3	Three-pole								
240 Volts Only	2									
Continuous Current Rating (Amperes)	70									
	80									
	90									
	100									
	110									
	125									
	150									
	175									
	200									
	225									
	250									
	000 S 22 = Switch (QB only)									
I-Line Phasing	Two-pole	1 = AB								
		2 = AC								
		3 = BA								
		4 = BC								
		5 = CA								
		6 = CB								
	Three-pole	None = ABC								
		6 = CBA								
Special Ambient	C	A = 50 C								
Control Taps	L	U = Control taps applied to ON (I) end								
		V = Control taps applied to OFF (O) end								
		W = Control taps applied to both ends								
Termination Options	T	M = Lugs applied to OFF (O) end; studs with nuts and washers threaded onto ON (I) end								
		N = Lugs applied to ON (I) end; studs applied to OFF (O) end (nuts/washers in bag, supplied)								
		P = Studs applied to ON (I) end; Lugs applied to OFF (O) end (nuts/washers in bag, supplied)								
		S = Studs on BOTH ends (nuts/ washers in bag, supplied)								
Special Features	Y	D = Calibration test report supplied								
		F =Fungus treatment								
		P = Handle Padlock Attachment, ON (I) or OFF (O) position								
		Q = Handle Padlock Attachment, OFF (O) position only								

1 See Class 611, 612, 613, and 734 catalogs for other PowerPacT and MasterPacT circuit breakers.

2 May be collapsed if none.

3 May be collapsed if none. May be multiple options.

100 Ampere Frame

This section provides specific information on Schneider Electric 100 A frame thermal-magnetic molded case circuit breakers. For more information, see the “Introduction” in this catalog.

Description

Table 10: Description of 100 A Frame Circuit Breakers

Circuit Breaker	Description
FA/FH	15–100 A, 600 Vac, 50/60 Hz, 250 Vdc, One-, two- and three-pole
FC	15–100 A, 480 Vac, 50/60 Hz, two- and three-pole
FI	20–100 A, 600 Vac 50/60 Hz, two- and three-pole
FY	15–30 A, 277 Vac, 50/60 Hz, one-pole

Applications

- FI current limiting circuit breakers are used for electrical systems where high fault currents can occur.
- FA/FH, FC, and FI circuit breakers are used in industrial enclosures, panelboards, switchboards, busway plug-in units, combination starters, or motor control centers.
- FY thermal-magnetic circuit breakers are used in I-Line panelboards and switchboards.

Table 11: 100 A Frame Interrupting Ratings

Catalog Number Prefix		No. of Poles	Cont. Ampere Rating	UL Listed Interrupting Rating (kA)								Federal Specs. W-C-375B/GEN	IEC 60947-2 Icu/Ics (kA) AC Voltage
				AC Volts - RMS Symmetrical Amperes					DC Volts				
Unit Mount	I-Line			120	240	480Y/ 277	480	600	125	250	500		415/240
	FY	1	15–30	18	14	14	—	—	—	—	—	11a, 13b	10/2.5
FAL 240 Vac	FA 240 Vac	1	15–100	10	—	—	—	—	5	—	—	11a	10/2.5
		2	15–100	10	10	—	—	—	5	5	—	11b, 12b	
		3	15–100	10	10	—	—	—	5	5	—	11b, 12b	
FAL 480 Vac	FA 480 Vac	1	15–100	25	18	18	—	—	10	—	—	11a, 12a, 13a	10/2.5
		2	15–100	25	25	18	18	—	10	10	—	13b	
		3	15–100	25	25	18	18	—	10	10	—	13b	
FAL 600 Vac	FA 600 Vac	2	15–100	25	25	18	18	14	10	10	—	18a	10/2.5
		3	15–100	25	25	18	18	14	10	10	—	18a	
FHL [1]	FH [1]	1	15–30	65	65	65	—	—	10	—	—	13a	10/2.5
		1	35–100	65	25	25	—	—	10	10	—	13a	
		2, 3	15–100	65	65	25	25	18	50	50	—	22a	
FHL-DC [2]	—	3	—	—	—	—	—	—	—	—	20K	—	—
FCL	FC	2, 3	20–100	100	100	65	65	—	—	—	—	22a	10/2.5
FIL	FI	2, 3	20–100	200	200	200	200	100	—	—	—	16a	6/1.5

[1] Separate UL rating available for 240 Vac and 480 Vac grounded B single phase systems. Circuit breakers must be ordered with 5861 suffix.

[2] UL listed 500 Vdc rating for use on ungrounded systems. Must be connected three-poles in series. Consult the Schneider Electric Customer Care Center for additional information 1-888-778-2733.

Note: For IEC 60947-2 rated S-line ratings, not UL listed, see Supplemental Digest.