101 BASICS SERIES

LEARNING MODULE 9: MINIATURE CIRCUIT BREAKERS AND SUPPLEMENTARY PROTECTORS

Cutler-Hammer

EATON

WELCOME

Welcome to Module 9, which is about miniature circuit breakers and supplementary protectors.

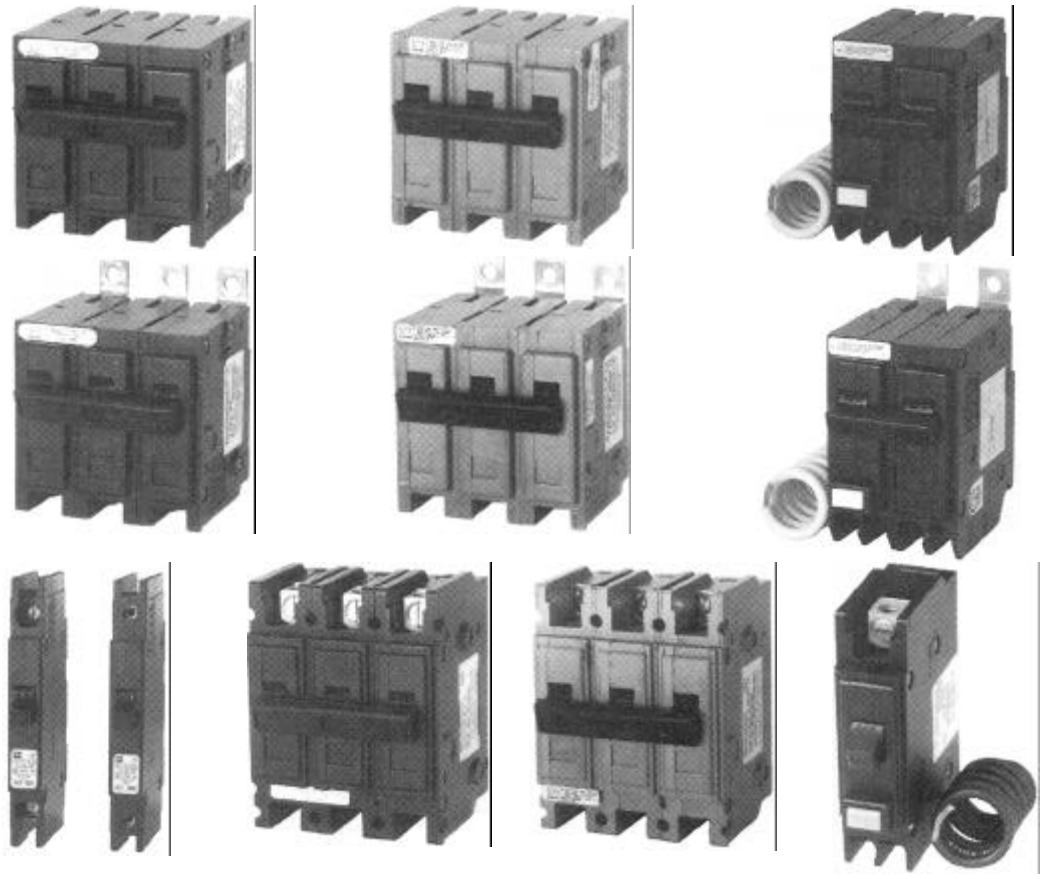


FIGURE 1. TYPICAL MINIATURE MOLDED CASE CIRCUIT BREAKERS

Like the other modules in this series, this one presents small, manageable sections of new material followed by a series of questions about that material. Study the material carefully, and then answer the questions without referring back to what you've just read.

You are the best judge of how well you grasp the material. Review the material as often as you think necessary. The most important thing is establishing a solid foundation to build on as you move from topic to topic and module to module.

A Note on Font Styles

Key points are in bold.

Glossary terms are underlined and italicized the first time they appear.

Viewing the Glossary

You may view definitions of glossary items by clicking on terms and words that are underlined and italicized in the text. You may also browse the Glossary by clicking on the Glossary bookmark in the left-hand margin.

WHAT YOU WILL LEARN

We'll **step through each of these topics** in detail:

INTRO-DUCTION

We will discuss two types of products in this module. These are the *miniature circuit breaker* and the *supplementary protector*.

We group these products together because they perform the same function. **They both switch and protect the lowest common distribution voltage in an electrical system.**

Some other similarities include:

- Both have molded case enclosures
- Both are used in low voltage (under 600 volts) systems
- Both devices are small: Typically 1" wide

The big difference between the two is that the supplementary protector is not *UL* (Underwriters Laboratory) approved. For this reason, it can not be used as a *branch circuit overcurrent protective device*, or in the place of the branch circuit protector. A miniature circuit protector protects the whole branch circuit, but the protector is only used to protect a particular device.

Figure 2 shows the difference between using just a miniature circuit breaker (shown on the left) and using a supplementary protector.

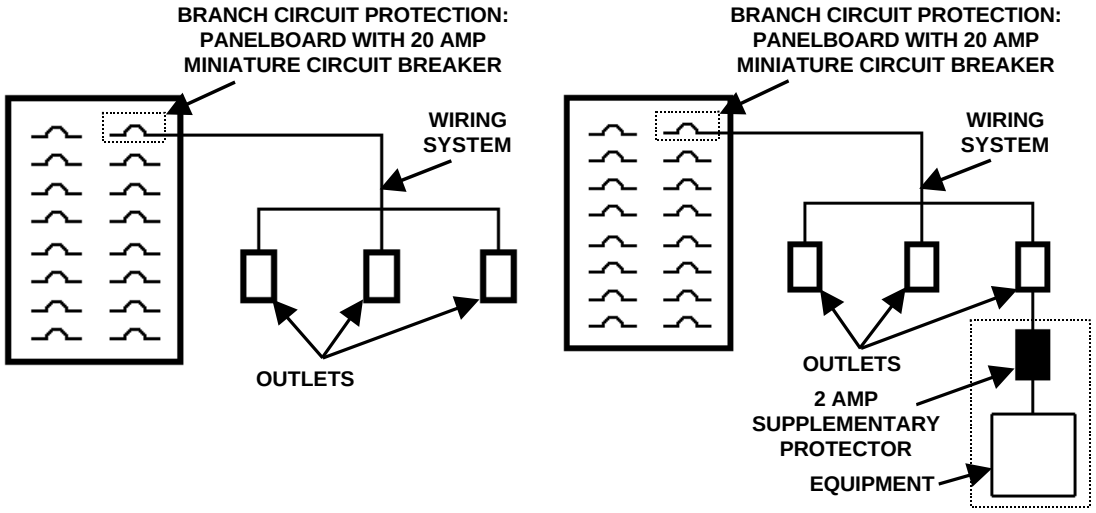


FIGURE 2. BRANCH CIRCUIT OVERCURRENT PROTECTION (ON LEFT) VS. SUPPLEMENTARY PROTECTOR (ON RIGHT)

Therefore, this module will concentrate on miniature circuit breakers. Supplementary protectors will be discussed only briefly.

MINIATURE CIRCUIT BREAKERS

As previously stated, a miniature circuit breaker is a device that switches and/or protects the lowest common distributed voltage in an electrical system. It is designed to protect conductors and insulation from damage due to *overload* and *short circuit*.

For most people, the easiest way to visualize this application picture is to think in terms of a *loadcenter* in a home (Figure 3). The *circuit breakers* inside the loadcenter are miniature circuit breakers.

Think about the electrical utility and where the electricity is generated. The residential loadcenter is certainly at the end of the distribution system. It is here that the voltages are the lowest of the distributed voltages in the electric utility's system.

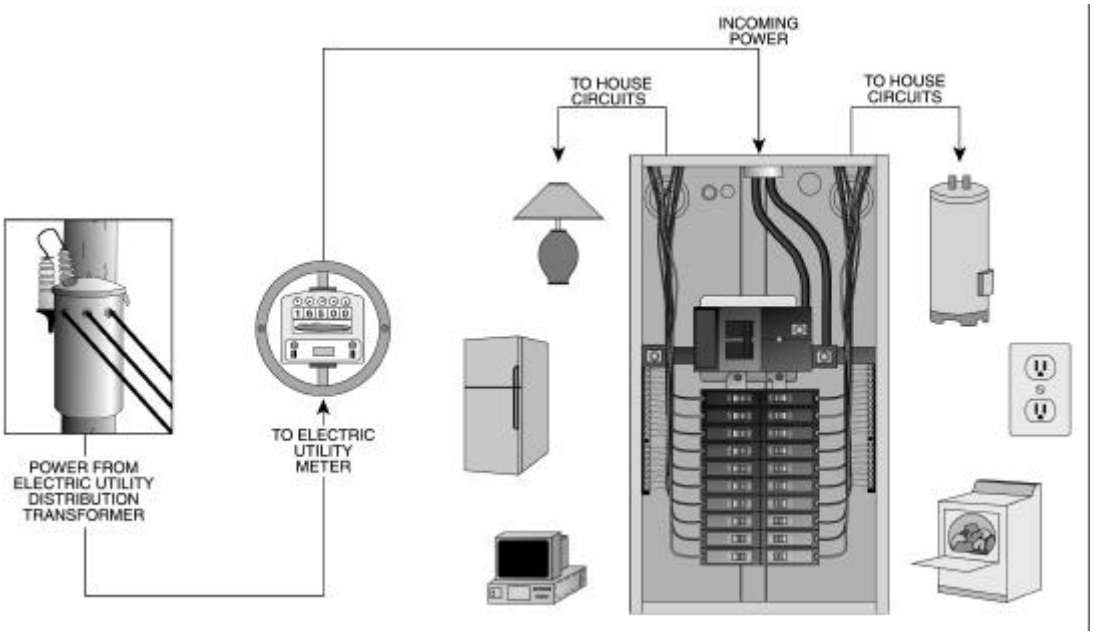


FIGURE 3. END OF THE LINE DISTRIBUTION SYSTEM (LOADCENTER)

Miniature circuit breakers are not just for residential applications only. They are used in residential, commercial and industrial applications.

In an industrial or commercial application, miniature circuit breakers can be found in loadcenters, lighting *panelboards* and individual mountings.

Applications

Miniature circuit breakers fall into two categories. These are:

- **Residential**
  Residential miniature breakers are only of the *plug-in* type. These are designed for residential loadcenters, commercial units, and light industrial applications. They typically range from 10 to 125 amps, with an *interrupting rating* of 10 or 22 KAIC.

- **Industrial**
  These breakers are designed for three types of mounting applications: plug-in, *bolt-on,* and *cable-in/cable-out*. (We will look at mounting methods shortly.)

  Industrial miniature breakers are designed to protect small branch circuits in commercial or industrial electrical distribution systems. They are applied in loadcenters, lighting panelboards or individual mounting applications. They typically range from 6 to 125 amps, with an interrupting ratings as high as 65 KAIC.

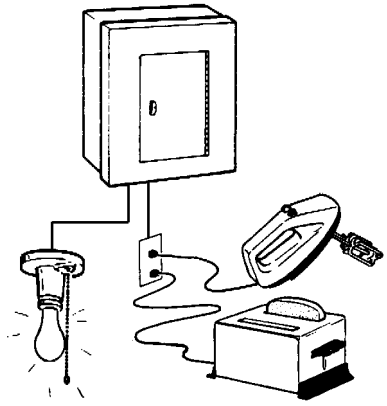
  Some potential customers are original equipment manufacturers (OEMs) involved in industrial control panels and electrical machinery, such as machine tool equipment, material handling and packaging systems. In addition, look for involvement with printing machines, food-processing systems, uninterruptable power supplies (UPS) and HVAC (heating, ventilation and air conditioning).

IN THE WORKPLACE

Pictured here is a typical residential loadcenter. Each miniature circuit breaker in the loadcenter protects a branch circuit.

Two branch circuits are shown here, each providing power to common residential loads.

Each miniature breaker is rated to handle a specific load. For example, a circuit breaker protecting a branch used with kitchen appliances has a higher rating than a circuit breaker protecting a branch with an overhead lighting fixture on it.



MINIATURE CIRCUIT BREAKERS AT WORK

COMP-ONENTS

Miniature circuit breaker construction is simple, yet very precise. In fact, a miniature circuit breaker has no replacement parts. It is not designed to be maintained. When a unit goes bad, it is simply replaced.

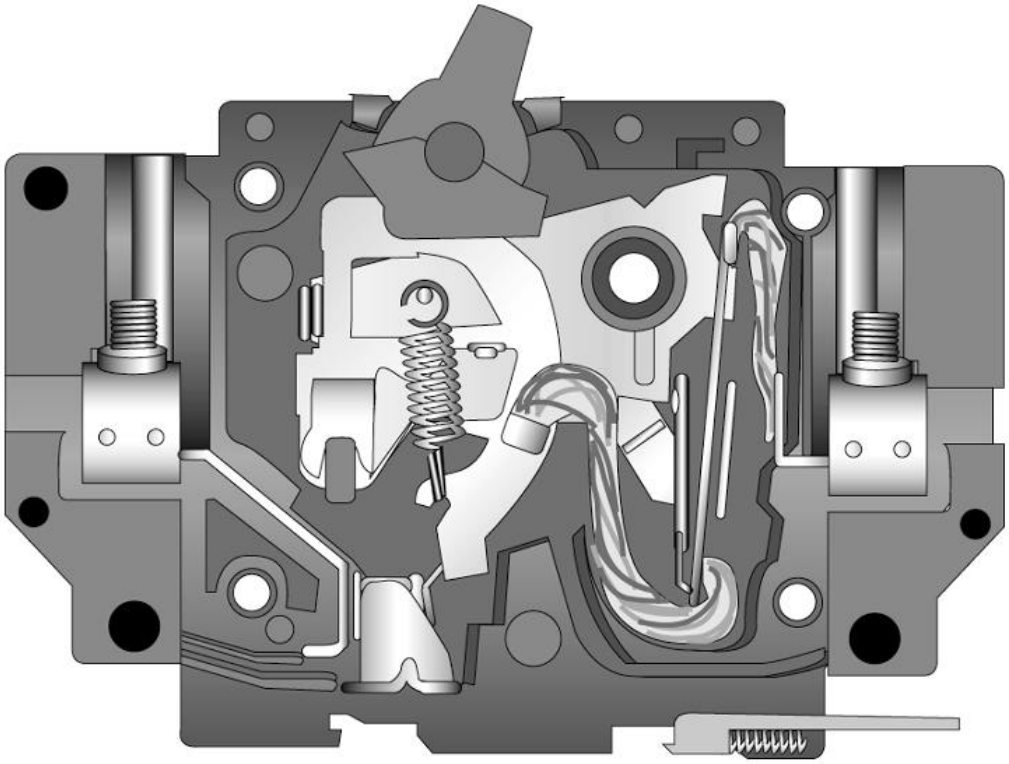


FIGURE 4. QUICKLAG THERMAL MAGNETIC CONSTRUCTION

A typical miniature circuit breaker has four main components. These are:

Frame

The *frame* has a molded case exterior. Its primary function is to provide a rigid, mechanically strong, insulated housing in which the other components are mounted.

Operating Mechanism

The *operating mechanism* provides the means of opening and closing the circuit. It has a three-position switch (“on,” “off,” and “tripped”). It can only be in the “tripped” position as a result of an overcurrent. When power is removed manually, it can only be switched to the “off” position. This makes it is easy for a maintenance person to determine why power has been cut.

Trip Unit

The *trip unit* is the brain of the miniature circuit breaker. It activates the operating mechanism in the event of a prolonged overload or short circuit. This type of circuit breaker uses a *thermal magnetic* mechanism. This is the predominant trip unit technology used in the domestic market. A bimetal and an electromagnet work together to provide overload and short-circuit protection. (The principles of how this works can be found in Module 5, Fundamentals of Circuit Breakers.)

Contacts

When an overload or short circuit situation occurs, the contacts open to break the current flow. When this happens, an electrical *arc* is formed. The arc continues until the first possible *zero point* in the AC cycle. The zero point is the weakest point in the AC cyclw and will not support the continuance of an arc. By breaking the arc, current flow is stopped. This is called *zero point construction*.

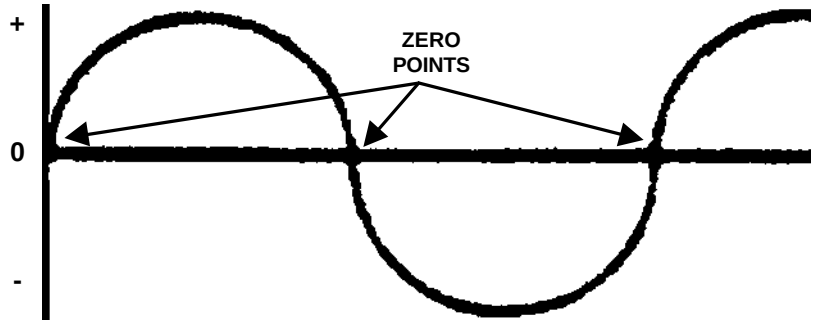


FIGURE 5. ZERO POINTS IN AN AC CYCLE

CATEGORIZING MINIATURE CIRCUIT BREAKERS

Specifications for miniature circuit breakers vary widely. As such, there is a miniature circuit breaker to fit virtually any application, standard, and local code requirement. In general, miniature circuit breakers are often categorized by the following:

- Ratings
- Number of poles
- Mounting methods

Ratings

Every circuit breaker has specific ampere, voltage, and interrupting ratings.

The *ampere rating* is the breaker's continuous current-carrying capability. In most cases, **the ampere rating should not exceed the current-carrying capacity of the circuit**. For example, if a conductor is rated at 10 amps, select a circuit breaker no larger than 10 amps. Ampere ratings for miniature circuit breakers range from 10 to 150 amps.

There are some specific circumstances when the ampere rating is permitted to be greater than the current-carrying capacity of the circuit. For example, motor and welder circuits can exceed conductor ampacity. This allows for inrush currents and duty cycles. Limits are established by the *NEC* (National Electrical Code).

The *voltage rating* of a circuit breaker **must be at least equal to the circuit voltage**. It can be higher than the circuit voltage, but never lower. For example, a 480-volt breaker can be used in a 240-volt circuit. However, a 240-volt breaker could not be used in a 480-volt circuit. Voltage ratings for miniature circuit breakers are 120/240-volt and 240-volt.

A circuit breaker is also rated according to the level of fault current it can interrupt. This is referred to as *ampere interrupting capacity*, or AIC (also called "interrupting rating"). **In an application, a breaker must be able to sustain the application's largest potential short circuit current.** If this is not done, the breaker could trip. This will cause extensive damage if the fault current exceeds the breaker's interrupting rating. Interrupting ratings for miniature circuit breakers are 10, 22, 42, and 65 KAIC (thousand amps interrupting capacity).

Poles

Miniature circuit breakers are typically available in *single pole* and *double pole* types. **A pole is a hot conductor. It is a space in a loadcenter, panelboard, or similar device where a breaker can be attached.** A single pole breaker disconnects one conductor, and a double pole breaker disconnects two conductors.

Single pole breakers are associated with 120 volts, while double pole breakers are associated with 240 volts. (For more detail on this subject, refer to Module 10, Loadcenters.)

Three pole miniature circuit breakers are available, but are not as popular as the other two types. They are typically used in industrial applications.

Miniature circuit breaker poles are generally one inch in width. **However, some breaker designs allow two poles to fit in the standard one-inch space.** This breaker type is called a *duplex circuit breaker* (or "half-size branch circuit breaker"). Twice as many protective devices fit in the same amount of available space, with the same ampere rating and without sacrificing protection or features (Figure 6). However, **these narrow design configurations have current, voltage, and interrupting capacity limitations**.

FIGURE 6. 1/2 INCH PER POLE AND 1 INCH PER POLE CIRCUIT BREAKERS, SAME AMPERE RATING (1/2 INCH ON LEFT)

Interchangeable vs. Non-Interchangeable Breakers

Branch circuit breakers are available from many manufacturers and have evolved over the years. Those referred to as *interchangeable* have 1" wide frames, which means that a single pole, interchangeable breaker is 1" wide, or takes up a 1" space in the loadcenter.

While these units, in many cases, will physically fit in another interchangeable manufacturer's loadcenter, it is not approved by the NEC, UL, or the manufacturer of the panel.

Non-interchangeable branch circuit breakers typically have a 3/4" frame width for a single-pole unit and are unique to a single manufacturer's loadcenter. These units cannot be installed into another manufacturer's loadcenter because they will not physically fit.

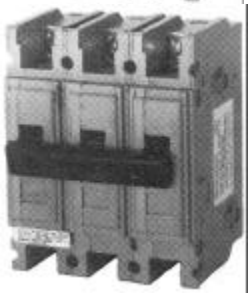
Mounting Methods

Miniature circuit breakers are considered "fixed mounted" circuit breakers. They should not be installed or removed without first removing the power. Although they are fixed mounted, a number of methods have been devised for mounting and removing them quickly and easily.

There are three main mounting methods. These are:

Plug-In
The line-side terminal is a clamp that clips onto a bus stab in a loadcenter or panelboard. The load-side terminal is cable-out. This mounting method is used in residential applications.

Bolt-On
The line-side terminal is an extended tang that is bolted onto a panelboard bus. The load-side terminal is cable-out. This mounting method is used in commercial and industrial applications.



Cable-In/Cable-Out
The line-side and load-side terminal electrical connections are by cable. This mounting method is used in industrial applications.

Mounting Methods (continued)

There are three types of cable-in/cable-out mountings. These are:

- **DIN-Rail mounted**
  A *DIN-rail* is a solidly mounted, rail-type device to which any number of circuit breakers can be mounted. Circuit breakers can be easily mounted and removed from the DIN-rail through a clip-type arrangement on the rear of the circuit breaker (Figure 7).

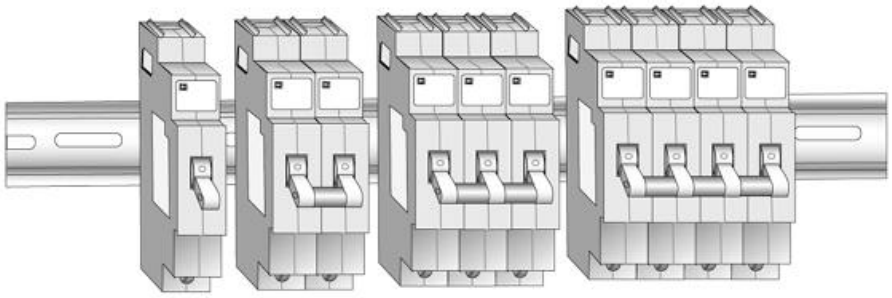


FIGURE 7. DIN RAIL MOUNTED HYDRAULIC MAGNETIC CIRCUIT BREAKER

- **Individual mounting base**
  An *individual mounting base* provides a way to rigidly mount individual circuit breakers using a rear-mounted circuit breaker clip or other device.

- **Front-Connected**
  A *front-connected* arrangement provides a method (such as front-threaded inserts) by which a circuit breaker can be rigidly mounted to a panel from the front (Figure 8). Mounting bolts are usually used to hold the circuit breaker in place.

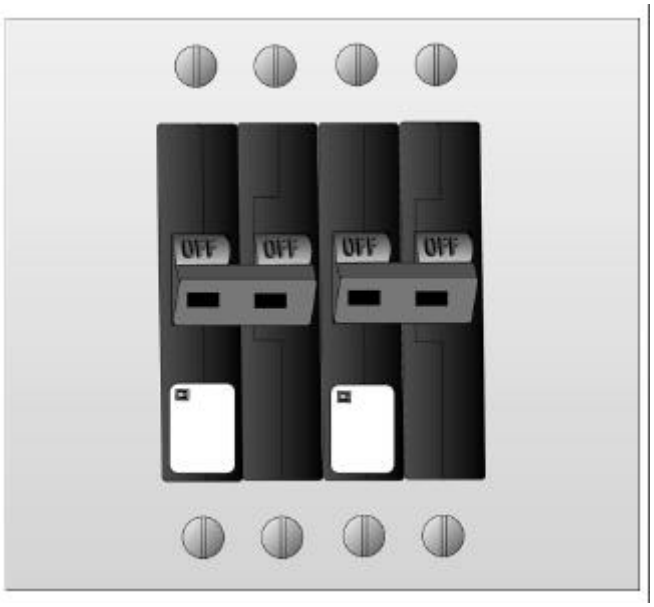


FIGURE 8. FRONT PANEL MOUNTED CIRCUIT BREAKERS

REVIEW 1

Answer the following questions without referring to the material just presented. Begin the next section when you are confident that you understand what you've already read.

1. There are several similarities between miniature circuit breakers and supplementary protectors. Name two areas of similarity.
   - _____
   - _____
2. In your own words, explain why a supplementary protector cannot be used in the place of a branch circuit protector in the United States.

   _____

   _____

   _____
3. The _____ _____ is the brain of the miniature circuit breaker.
4. Define the following ratings:

   Interrupting rating: _____

   Ampere rating: _____
5. There are three types of physical mountings for miniature circuit breakers. Name them.
   - _____
   - _____
   - _____

SPECIAL APPLICATION BREAKERS AND ACCESS-ORIES

In addition to the general use miniature circuit breaker, there are a number of breaker types that have been designed for a particular application. These include:

- **Ground Fault Circuit Interrupter (GFCI)**
  This breaker has a solid state trip unit. It detects ground currents (which are small short circuits from one phase to ground), and trips to protect both people and equipment.

Special Application Breakers

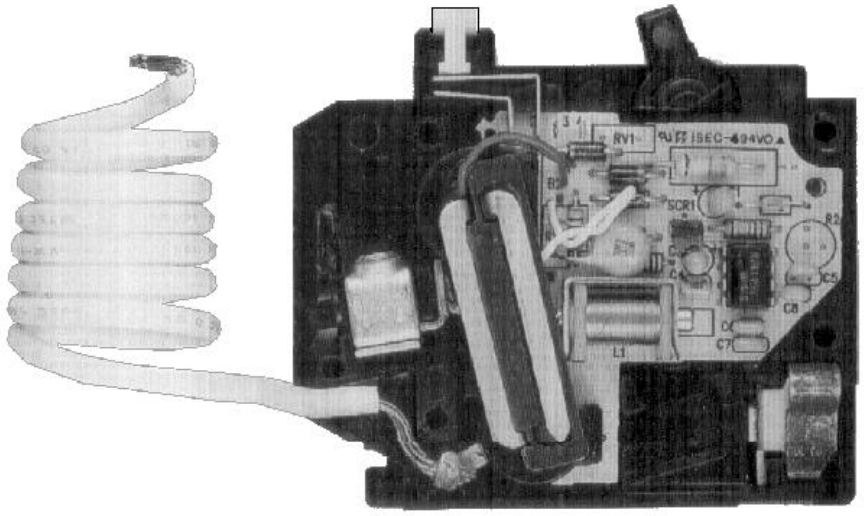


FIGURE 9. GFCI BREAKER

Two types are available in the miniature line. These are:

- **People Protection**
  This breaker type automatically senses hot wire to ground faults and trips the breaker when a ground fault exists. It is most commonly used in bathrooms, kitchens, swimming pool areas, and outdoor receptacles. It senses ground faults at 5 milliamps, a level low enough to protect people.

- **Equipment Protection**
  This breaker type is designed to protect equipment against damage from arcing ground faults. It is typically applied to computers, process control and heating equipment. The circuit breaker trips at 30 milliamps.

Special Application Breakers (continued)

- **Shunt Trip**
  This breaker type provides remote-controlled tripping of a circuit breaker. However, it is not a device for remotely operating a breaker. An intermittent rated solenoid-tripping device is mounted in the breaker. The tripping device must be energized by a control power source of AC or DC voltage.

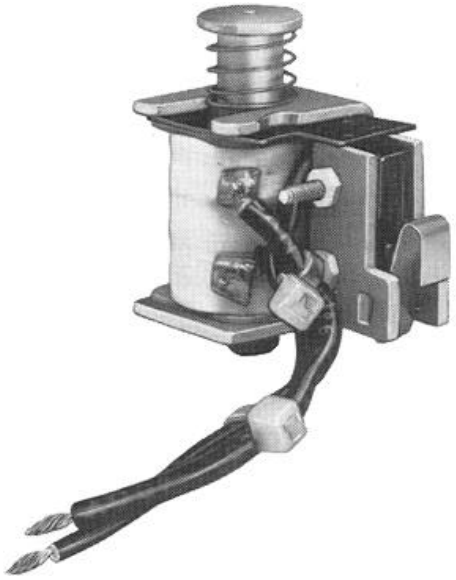


FIGURE 10. SHUNT TRIP

It is used for emergency disconnects for food service equipment such as grinders, slicers, fryers, and mixers. Other uses include pump panels, remote disconnects for UPS (uninterruptable power supply) devices, and power supply control for sequentially powering down a mainframe computer.

This breaker type requires an extra pole space in the loadcenter. It can run on 120, 208, or 240 VAC. A separate source voltage is required.

Accessories

A number of accessories are available. These include:

Undervoltage Release
For undervoltage protection, a solenoid device mounts within the breaker cover and trips the breaker within a range of 35% to 7-% of the rated coil voltage. It is reset by manually opening and closing the breaker handle.

Alarm (Signal)/Lockout Switch
For remote indication of an automatic trip operation. It does not function with manual switching. The switch automatically resets when the breaker is rest.

Auxiliary Switch
For auxiliary control circuits. Miniature switches mount within the breaker cover. Commonly used for remote indication of the breaker's open or closed status, as well as electrical interlocking functions.

Lock Dog
For non-padlockable systems using 1-, 2- and 3-pole breakers.

Padlockable Front Cover
For padlockable systems using 1-, 2- and 3-pole breakers.

DIN-Rail Adapter
For systems using 1-, 2- and 3-pole breakers. This alternate mounting method permits DIN-rail mounting of breakers.

Base Mounting Plate
Alternate mounting method for systems using up to 6-pole breakers.

SUPPLEMENTARY PROTECTORS

Supplementary protectors are used domestically and internationally. They pass several international standards as circuit breakers, but do not qualify as circuit breakers in the United States. They are not UL approved, only UL recognized.

Supplementary protectors do provide overcurrent protection, but cannot serve as the only source of protection. Supplementary protectors are available in current ratings from 0.1 to 63 amps.

There are two main types of supplementary protectors. These are:

- Hydraulic Magnetic
- Current-Limiting

Hydraulic Magnetic

Hydraulic magnetic is a technology used throughout the world in miniature circuit breakers. It is also often used in special applications.

This type of device is independent of the ambient temperature, making it well suited for use with rooftop-mounted equipment. Ambient temperature in such an appliation can vary dramatically throughout the year.

This type of device is also especially tolerant of vibration and impact, making it a good choice for shipboard applications.

Hydraulic magnetic supplementary protectors are also commonly used in the following applications:

- Sensitive equipment protection, typically below 15 amperes, like electronics or appliances
- Control circuits as a fuse substitute
- Single phase control circuit transformer protection
- Motor disconnect and protection (does not meet UL or NEC requirements)

Hydraulic Magnetic (continued)

The construction of a hydraulic magnetic supplementary protector delivers precise overcurrent protection with the following features:

- Two-position handle operating mechanism (On, Off/Tripped)
- Molded cased enclosure
- Hydraulic magnetic trip unit

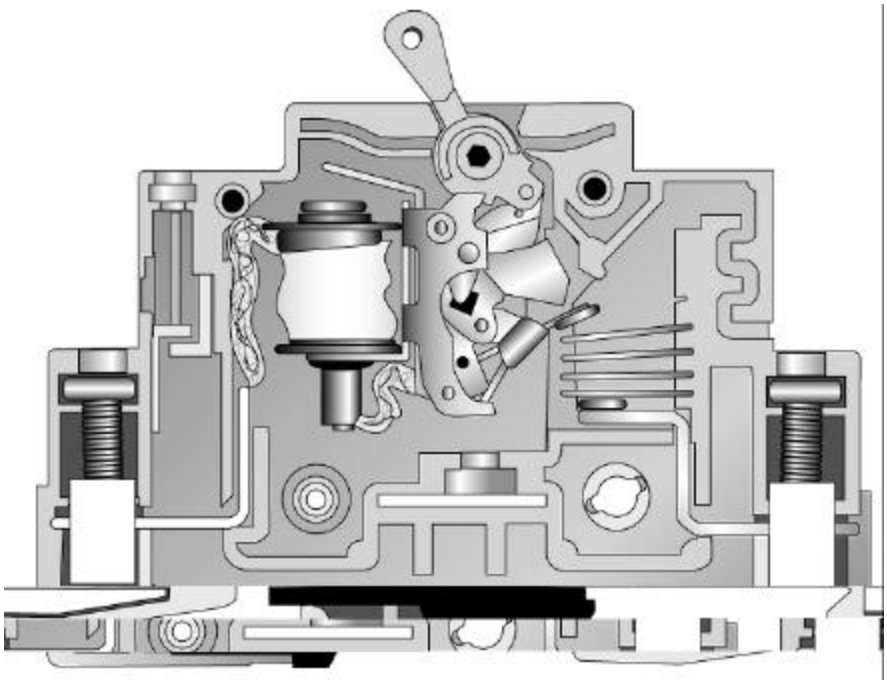


FIGURE 11. HYDRAULIC MAGNETIC CONSTRUCTION

Hydraulic Magnetic (continued)

The hydraulic magnetic design includes an iron core that moves against a spring in an oil-filled tube (Figure 12). A current-carrying magnetic coil wraps around an airtight, non-magnetic tube assembly.

If the current flowing through the coil exceeds the device's rating, the stronger magnetic field moves the iron core through the oil-filled tube enough to overcome the spring, tripping the device. The result is an overcurrent protection that is magnetic only. It is purely current-sensitive and ambient temperature-resistant.

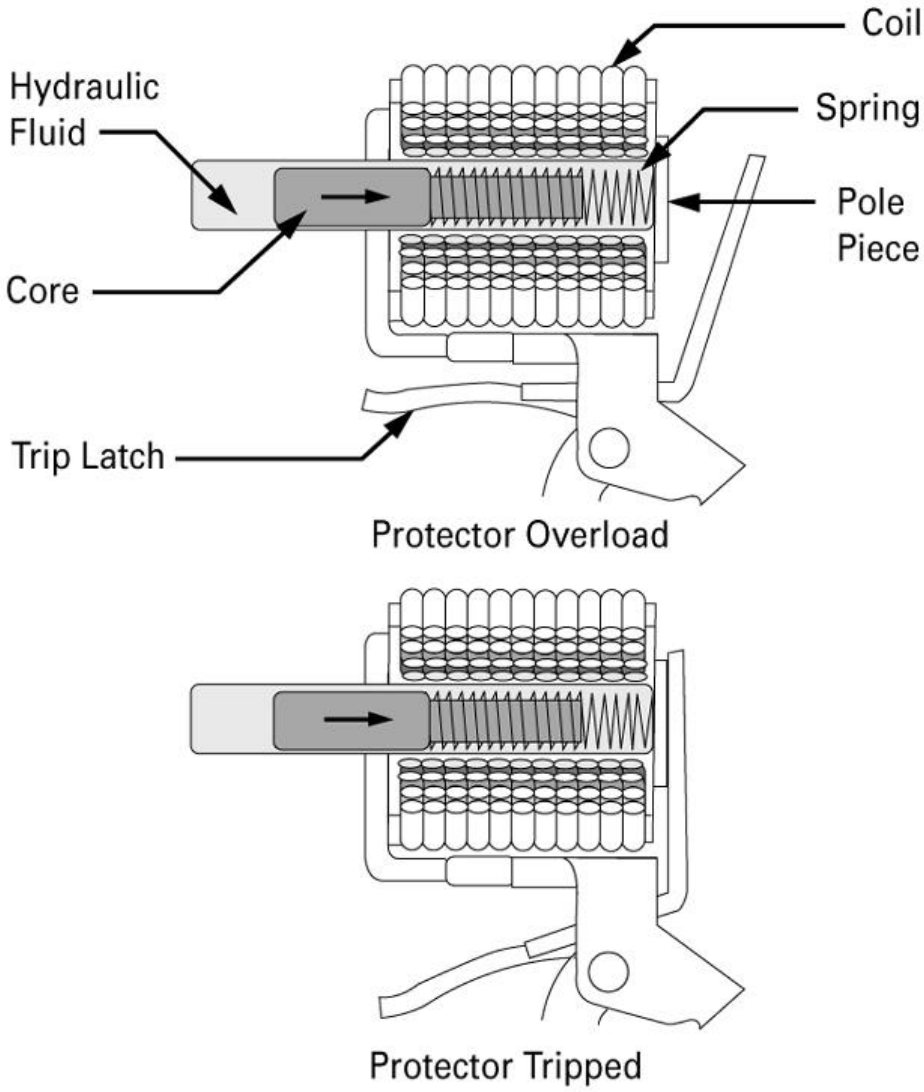


FIGURE 12. HYDRAULIC MAGNETIC BREAKER

Hydraulic Magnetic (continued)

The hydraulic magnetic design extinguishes the arc and interrupts the fault at the first possible current zero. But, **while this makes it a zero point construction circuit breaker, the industry does not normally refer to it as such**. It falls into its own category, and is just called a “hydraulic magnetic.”

Since gravity has an effect on the oil, mounting position is critical. The hydraulic magnetic may not operate properly when mounted certain mounting positions. For this reason, it is DIN-rail mounted.

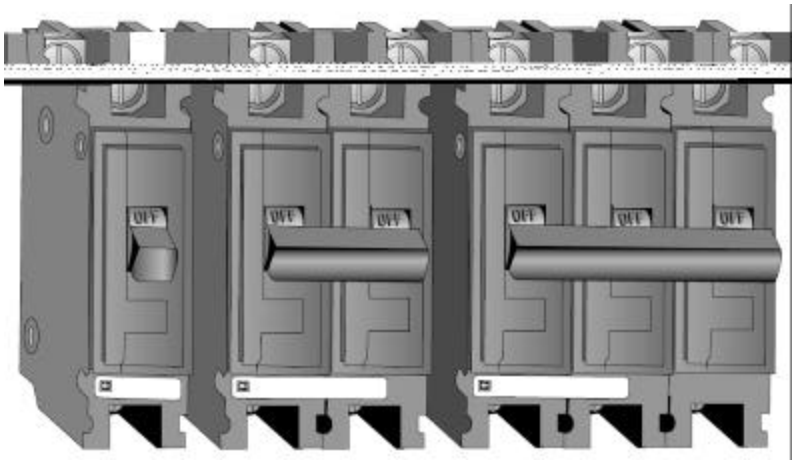


FIGURE 13. TYPICAL ONE-, TWO-, THREE- AND FOUR-POLE HYDRAULIC MAGNETIC SUPPLEMENTARY PROTECTORS

Ratings

Number of Poles	Electrical Ratings			
	Continuous Current (Amperes)	Volts AC 50/60 Hz	Volts DC	Ampere Interrupting Capacity
1-4	0.1-50	250		5 kA
1	0.1-30	277		3 kA
2-4	0.1-30	277/480		3 kA
1-4	0.1-50		12-80	5 kA
1-4	0.1-50	230/400		1.5 kA
1-4	0.1-50		12-80	2 kA

FIGURE 14. HYDRAULIC MAGNETIC AC AND DC RATINGS

Current Limiting

The *current limiting* supplementary protector **limits the amount of damaging short circuit current.** Short circuit current is limited to a value less than the maximum possible short circuit current during the first half cycle (Figure 15). This limited amounted of current is called the *let-through current*.

In short, when a fault begins and the let-through current starts to build, the circuit breaker will effectively limit the let-through current before it reaches its peak value.

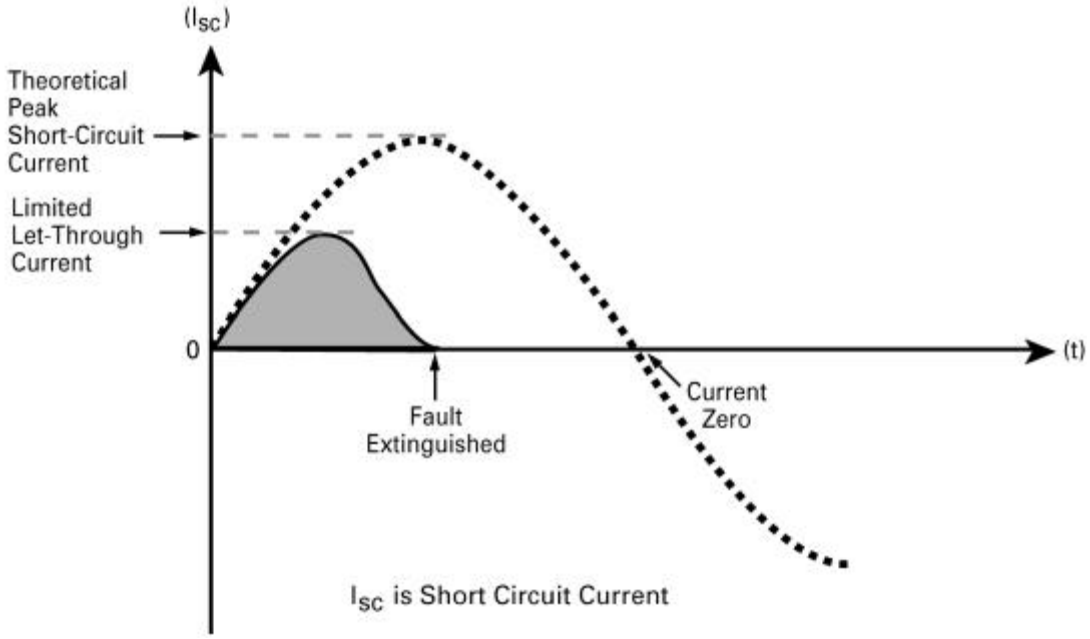


FIGURE 15. CURRENT-LIMITING INTERRUPTION PERFORMANCE

This design includes a magnetic coil and a plunger assembly, which acts quickly during short circuit conditions. Arc runners channel the arc into arc chutes, extinguishing the arc before it can reach current zero. The result is a reduction in the damaging short-circuit current that connected equipment experiences.

Supplementary protectors are applied almost exclusively in international (*IEC* – International Electro-technical Commission) markets. They are not acceptable in domestic markets because they do not meet UL standards.

It is important to note that, in an IEC-dominated market, the thermal magnetic miniature circuit breaker is typically not used. Therefore, an obvious need exists for both devices in the global market.

Current Limiting (continued)

The internal construction assures current limiting performance, as well as compliance with IEC standards (Figure 16). Construction features include:

- Visual contact position indicator window (Red = On, Green = Off)
- Three-position handle (On, Off and Tripped)
- Snap-on clip allows secure installation/easy removal from DIN-rail
- Interphase insulation barriers on multi-pole units comply with UL 1077 electrical clearance requirements

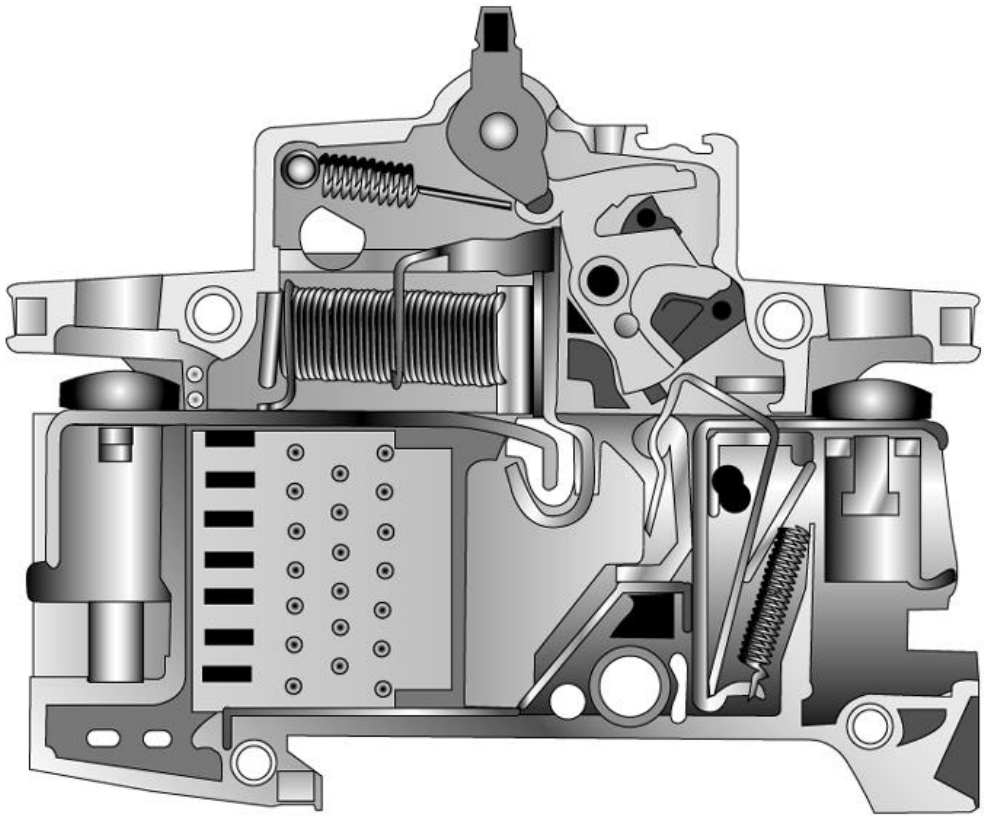


FIGURE 16. CURRENT LIMITING CONSTRUCTION

Current limiting supplementary protectors are ideal for applications such as:

- Sensitive equipment protection, typically below 15 amperes, like electronics or appliances
- Control circuits as a fuse substitute
- Single phase control circuit transformer protection
- Motor disconnect and protection (does not meet UL or NEC requirements)

Current Limiting (continued)

Now, let's consider the operating mechanism/trip unit.

In Module 5, Fundamentals of Circuit Breakers, we discussed thermal magnetic technology. We saw that protection is provided by combining a temperature-sensitive device (bimetal) with a current sensitive electromagnetic device. Both components act mechanically on the mechanism. This makes it nearly impossible to point to one device (or assembly of devices) and identify it as the trip unit or operating mechanism.

Once the circuit breaker has been called upon to trip, current limiting technology works somewhat differently than thermal magnetic technology. **The primary difference between the two centers around how each deals with the arc.**

Thermal magnetic circuit breakers manipulate the arc. When their contacts open, the circuit breaker is expected to extinguish the arc after a half cycle, or as soon as the current passes through zero the next time. This is accomplished by elongating and cooling the arc by means of the arc chute.

Current limiting devices limit the maximum possible short-circuit current to a lesser level (the let-through current). The design takes advantage of the short-circuit current. Using the increased current magnitude in conjunction with the magnetic coil, it drives the arc to the arc chute and extinguishes it before current zero.

Ratings

Number of Poles	Electrical Ratings			
	Continuous Current (Amperes)	Volts AC 50/60 Hz	Volts DC	Ampere Interrupting Capacity
1	0.5-63	120	12-65	10 kA
2	0.5-63	240	12-130 ①	10 kA
3-4	0.5-63	240		10 kA
1	0.5-63	277		6 kA
2-4	0.5-63	480		5 kA
1-4	0.5-63	240/415		10 kA

① 130 volts DC rating based on 2 poles connected in series

FIGURE 17. CURRENT LIMITING AC AND DC RATINGS

GOVERNING STANDARDS

Miniature circuit breakers and supplementary protectors are designed, built, tested, and applied in accordance with one or more specific sets of standards. Compliance with these exacting standards ensures the customer of a high quality level. Governing standards have a profound impact on the design and application of circuit breakers worldwide is profound. **There is no room for compromise when performance, quality, and safety are involved**.

Like miniature circuit breakers, ratings for supplementary protectors are usually dictated by standards for the part of the world in which the device is to be applied.

Briefly, review the world map show in Figure 18. This will give you a feel for the standards applicable to miniature circuit breakers in different parts of the world.

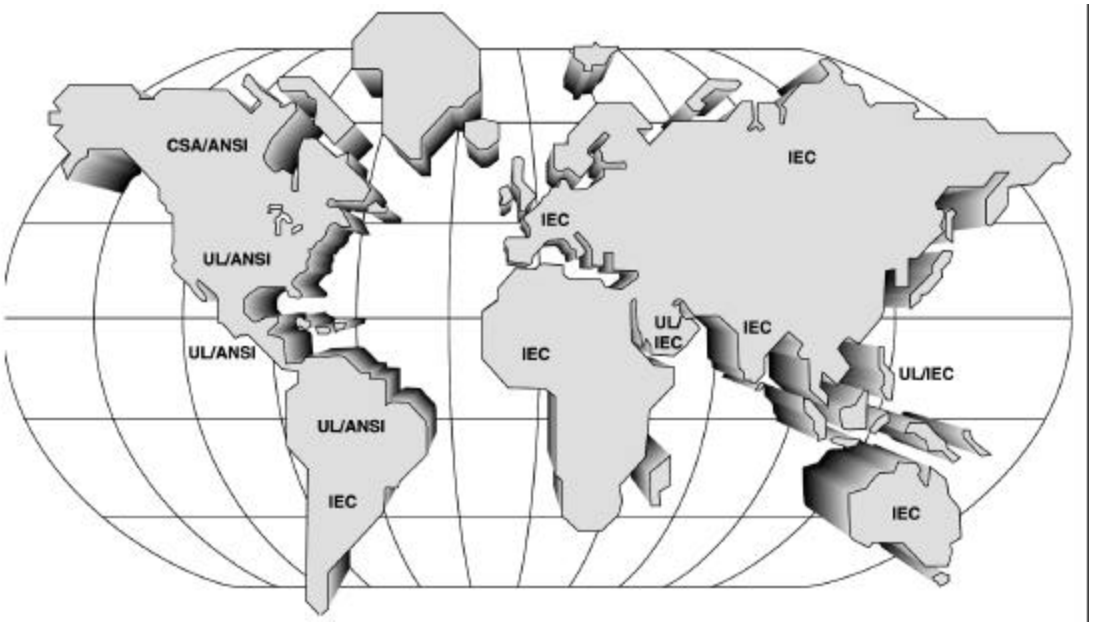


FIGURE 18. DOMINANT STANDARDS AROUND THE WORLD FOR ALL TYPES OF CIRCUIT BREAKERS

For any application, it is key to know which standards apply in the application location. The actual product selection, based on standards compliance, is left to the experts. However, it is helpful to know which specific standards your products comply with, and which areas of the world abide by those standards.

NEC or UL Compliance

When compliance with NEC and/or UL standards is required, thermal magnetic miniature circuit breakers are used. Supplementary protectors are only approved for use on circuits where branch circuit protection is already provided through some other means, or not required at all.

IEC Compliance

When compliance with IEC standards is required, both supplementary protector types are used. They have the flexibility to be used as IEC circuit breakers in assembled equipment applied in areas that require IEC compliance. Thermal magnetic miniature circuit breakers cannot normally be applied where IEC compliance is required.

HELPING THE CUSTOMER

Now you should be ready to assist a customer in matching a product to an application. When you meet with the customer, conduct a short interview to obtain the following information:

- **Standards requirements**
  In the Governing Standards section, we looked at different sets of product standards. Once you determine which standards are in force in the application location, you will know which product types can be used for the application.

- **Electrical requirements**
  Product rating information can be found in the product catalog. After selecting a product type, you can match the customer's requirements with a properly rated product in the catalog.

- **Mounting requirements**
  Determine the customer's mounting requirements. In the Mounting Methods section, we saw that miniature circuit breakers can be mounted in different ways. Some circuit breaker types offer more mounting options than others do. Go to the catalog to further refine your product selection. If the customer's first mounting choice is not offered in the catalog, offer an alternate mounting method.

- **Accessory requirements**
  Depending upon the application, miniature circuit breakers can require additional accessory items. Not all miniature circuit breakers offer all the same accessories. Determine which accessories are required, and check your catalog for availability.

  Some of the more common accessories that will be encountered are:

  - Individual circuit breaker mounting feet (plates)
  - Single phase bus bar systems
  - Auxiliary switch
  - Locking devices to lock a circuit breaker ON and/or OFF
  - Special types of terminal connectors

Once you understand the requirements, selecting the best device for the application is a simple process. Follow these steps, and soon they will be second nature to you.

REVIEW 2

Answer the following questions without referring to the material just presented.

1. The special application breaker known as a Ground Fault Circuit Interrupter comes in two types. List them, and the number of milliamps at which each will trip.
   - _____ _____ milliamps
   - _____ _____ milliamps
2. In your own words, describe how a hydraulic magnetic supplementary protector functions.

   _____

   _____

   _____

   _____

   _____
3. The current limiting supplementary protector limits the amount of damaging _____ _____ current.
4. In an area where _____ compliance is required, hydraulic magnetic and current limiting supplementary protectors are used.
5. There are four main pieces of information that are needed from a customer when attempting to match a product to an application. Name three of them.
   - _____
   - _____
   - _____

GLOSSARY

Ampere Interrupting Capacity (AIC)	Also “Interrupting Rating.” A rating of the amount of current that a protective device, such as a fuse or circuit breaker, can safely interrupt.
Ampere Rating	A rating of the amount of current a protective device will carry continuously without deteriorating or exceeding temperature rise limits.
Arc	The effect generated when electrical current bridges the air gap between two conductors that are not touching.
Bolt-On	A type of breaker which is bolted into place. More secure but less easily interchangeable than a plug-in breaker. More desirable than a plug-in breaker in industrial applications.
Branch Circuit	A circuit that supplies power to the electrical loads in a building and is terminated at a panelboard, loadcenter or similar device.
Cable-In/ Cable-Out	A circuit breaker mounting method in which the line-side and load-side terminal electrical connections are by cable. Method used in industrial applications.
Circuit Breaker	A reusable overcurrent protection device. After tripping to break the circuit, it can be reset to protect the circuit again.
Current Limiting	A type of supplementary protector which limits the amount of damaging short circuit current.
DIN-Rail	A solidly mounted, rail-type device to which any number of circuit breakers can be mounted.
Double Pole	Term used to describe a breaker that draws power from two poles of a loadcenter or similar device.
Duplex Circuit Breaker	Also, “Half-Size Branch Circuit Breaker.” A specialized reusable overcurrent protection device designed to take up only half as much space in a loadcenter as a normal branch circuit breaker. Can only be installed in loadcenters equipped with notched stabs.

Frame	A component of a miniature circuit breaker. Its primary function is to provide a rigid, mechanically strong, insulated housing in which the other components are mounted.
Front-Connected	A circuit breaker mounting method by which a circuit breaker can be rigidly mounted to a panel from the front. Mounting bolts are usually used to hold the circuit breaker in place.
Hydraulic Magnetic	A miniature circuit breaker technology also often used in special applications. It is independent of the ambient temperature, and especially tolerant of vibration and impact.
IEC	Abbreviation for International Electro-technical Commission. This organization is associated with equipment used internationally.
Individual Mounting Base	A circuit breaker mounting method which provides a way to rigidly mount individual circuit breakers using a rear-mounted circuit breaker clip or other device.
Interchangeable	A type of branch circuit breaker that is standardized in size to fit in many different manufacturers' loadcenters.
Interrupting Rating	Also "Ampere Interrupting Capacity (AIC)." A rating of the amount of current that a protective device, such as a fuse or circuit breaker, can safely interrupt.
Let-Through Current	The limited amounted of short circuit current let-through by a current limiting supplementary protector.
Loadcenter	A device that delivers electricity from a supply source to loads in light commercial or residential applications.
Miniature Circuit Breaker	A specific type of circuit breaker, used to switch and protect the lowest common distribution voltage in an electrical system. Generally used in a loadcenter, panelboard, or similar device.
NEC	Abbreviation for National Electrical Code. A standard for applying electrical equipment in the United States.

Non-Interchangeable	A type of branch circuit breaker that is unique to a single manufacturer's loadcenters. This type of breaker cannot be installed into another manufacturer's loadcenter because it will not physically fit.
Operating Mechanism	A component of a miniature circuit breaker. Its function is to provides the means of opening and closing the circuit.
Overcurrent Protective Device	A device such as a circuit breaker or fuse. In the event of an overload or short circuit, this device will quickly terminate power to the circuit.
Overload (or Overcurrent)	A condition in which current is in excess of the normal load being drawn.
Panelboard	A wall-mounted electrical power distribution device for use in commercial and industrial applications. It provides circuit control and overcurrent protection for light, heat or power circuits.
Plug-In	A style of miniature circuit breaker so named for the method of installation into the loadcenter. It is literally plugged into the bus bar stabs. Less secure but more easily interchangeable than a bolt-on breaker.
Short Circuit	An electrical fault created when two exposed conductors touch.
Single Pole	Term used to describe a breaker that draws power from one pole of a loadcenter or similar device.
Supplementary Protector	A device similar in function to a miniature circuit breaker, but not UL approved as a circuit breaker. Used in conjunction with circuit breakers.
Thermal Magnetic	The predominant trip unit technology used in the domestic market. A bimetal and an electromagnet work together to provide overload and short circuit protection.

Trip Unit	A component of a miniature circuit breaker. It is the brain of the miniature circuit breaker. It activates the operating mechanism in the event of a prolonged overload or short circuit.
UL	Underwriters Laboratory. An independent laboratory that test equipment to determine whether it meets certain safety standards when properly used.
Voltage Rating	A rating of the voltage at which a piece of equipment is designed to operate.
Zero Point	Also “Current Zero.” A point in the AC current sine wave where the value is zero.
Zero Point Construction	A term given to a circuit breaker constructed to extinguish an arc after a half cycle, or as soon as the current passes through zero point the next time.

REVIEW 1 ANSWERS

1. Any two of the following:
   - Both have molded case enclosures
   - Both are used in low voltage (under 600 volts) systems
   - Both devices are small: only 3/4” to 1” wide
2. Answer should basically say: “The supplementary protector is not UL approved for use in the place of the branch circuit protector in the U.S.”
3. Trip unit
4. current rating a protective device can safely interrupt; current a protective device will carry continuously without deteriorating or exceeding temperature rise limits

REVIEW 2 ANSWERS

1.
   - people protection; 5 milliamps
   - equipment protection; 30 milliamps
2. Answer should basically say: “The design includes an iron core that moves against a spring in an oil-filled tube. A current-carrying magnetic coil wraps around an airtight, non-magnetic tube assembly. If the current flowing through the coil exceeds the device’s rating, the stronger magnetic field moves the iron core through the oil-filled tube enough to overcome the spring, tripping the device.”
3. Short circuit
4. IEC
5. Any three of the following:
   - Standards requirements
   - Electrical requirements
   - Mounting requirements
   - Accessory requirements

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