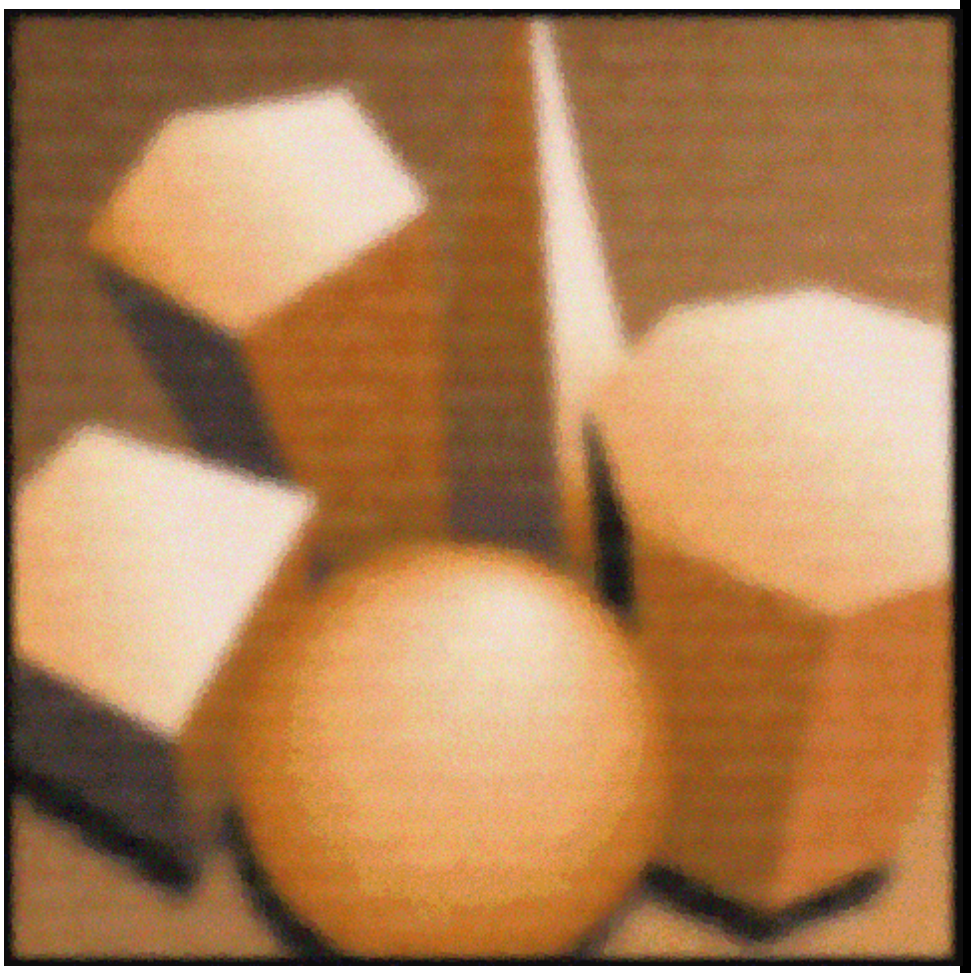
Learning Module 9:

Miniature Circuit Breakers and Supplementary Protectors

101 Basic Series



EATON | Electrical

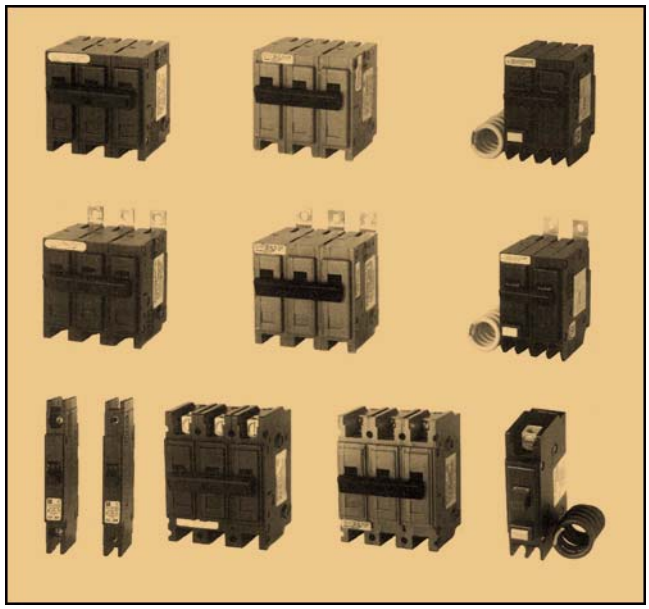
What You Will Learn

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

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 items are italicized and underlined the first time they appear.

Viewing the Glossary

Printed versions have the glossary at the end of the module. You may also browse the Glossary by clicking on the Glossary bookmark in the left-hand margin.

Miniature Circuit Breakers and Supplementary Protec-

Introduction

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.**

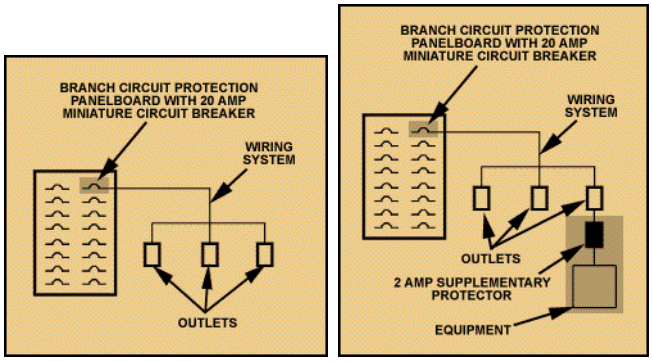
Some other similarities include:

- 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* 489 (Underwriters Laboratory) approved. For this reason, it cannot 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 supplementary 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 mainly on miniature circuit breakers. Supplementary protectors will be discussed only briefly.

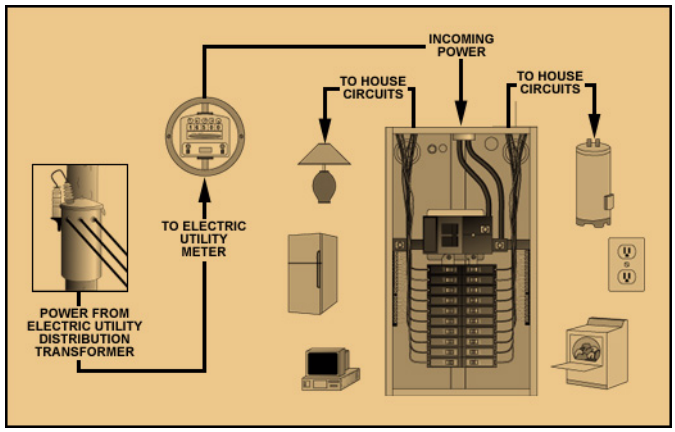
Miniature Circuit Breakers

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 Circuits*.

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:

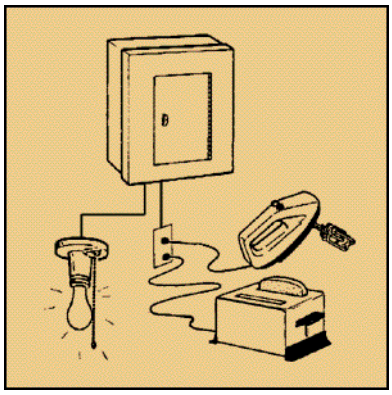
- **Residential**—Residential miniature breakers are only of the *Plug-In* type. These are designed for residential loadcenters, commercial units, and light industrial applications. They typically range from 10 to 150 amps, with an interrupting rating of 10 or 22 KAIC.
- **Industrial**—These breakers 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 building 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 Heating, Ventilation and Air Conditioning (HVAC).

In the Workplace

Pictured here is an example of a residential loadcenter. Each miniature circuit breaker in the loadcenter protects a branch circuit. Two branch circuits are shown, each providing power to common residential loads.

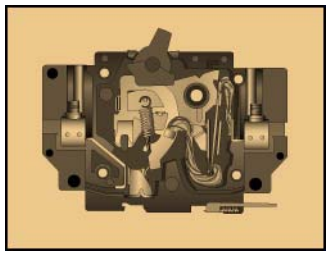


Each miniature circuit breaker is rated to handle a specific load. For example, a circuit breaker protecting a branch used with kitchen appliances has a higher rating than a circuit breaker protecting a branch with an overhead lighting fixture on it.

Components

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 repaired and when a unit goes bad, it is 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

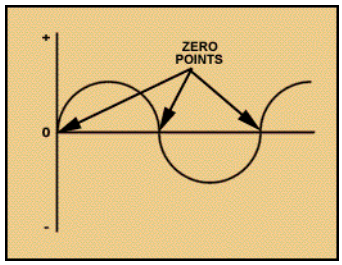
The *Trip Unit* is the brain of the miniature circuit breaker. It activates the operating mechanism in the event of a prolonged overload or short circuit. This type of circuit breaker uses a *Thermal Magnetic* mechanism. This is the predominant miniature breaker technology used in the United States. 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 cycle 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 rating.

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 (AIC)* (also called "interrupting rating"). **In an application, a breaker must be able to interrupt the circuit's maximum short circuit current (without damaging itself).** Interrupting ratings for miniature circuit breakers are 10, 22, 42, and 65 KAIC (thousand amps interrupting capacity).

Poles

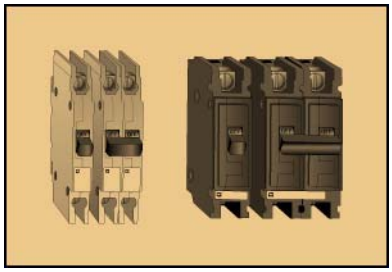
Miniature circuit breakers are typically available in *Single Pole*, *Double Pole*, and three pole types. **A pole is a hot conductor and refers to the number of conductors or wires that the circuit breaker disconnects at one time. It is a space in a loadcenter, panelboard, or similar device where a breaker can be**

attached. A single pole breaker disconnects one conductor, and a double pole breaker disconnects two conductors. A three pole breaker is typically used in industrial applications.

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.)

Miniature circuit breaker poles are generally one inch in width. **However, some residential type breaker designs allow two poles to fit in the standard one-pole 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)

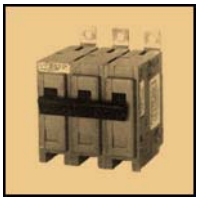


Mounting Methods

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.



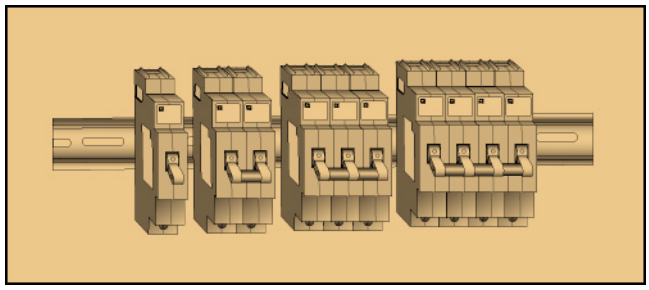
Bolt-On
The line-side terminal is an extended tang that is bolted onto a panelboard bus. The load-side terminal is cable-out. This mounting method is used in commercial and industrial applications.

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

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

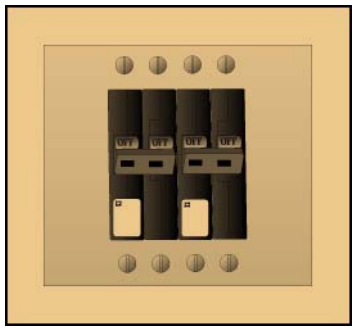
- **DIN-Rail mounted**—A *DIN-Rail* is a solidly mounted, rail-type device to which any number of circuit breakers can be mounted. Circuit breakers can be easily mounted and removed from the DIN-rail through a clip-type arrangement on the rear of the circuit breaker (Figure 7).

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.

   _____
   _____
   _____

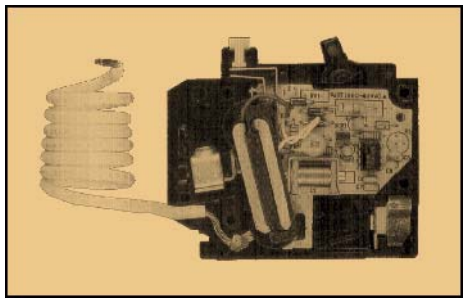
Special Application Breakers and Accessories

Special Application Breakers

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.

Figure 9. GFCI Breaker



Two types of ground fault protection are available in the miniature circuit breaker line. These are:

  - **People Protection (GFCI)**—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 (GFEP)**—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.

- **Arc Fault Circuit Interrupter (AFCI)**—An arc fault circuit interrupter is a residential circuit breaker with an integrated processor which recognizes the unique current and/or voltage signatures associated with *Arc Faults*.
  - Provides standard thermal-magnetic circuit protection along with integrated arc fault protection.
  - Acts to interrupt the current to reduce the likelihood of an electrical fire.
  - UL 1699 (AFCI) and UL 1053 (GFEP).

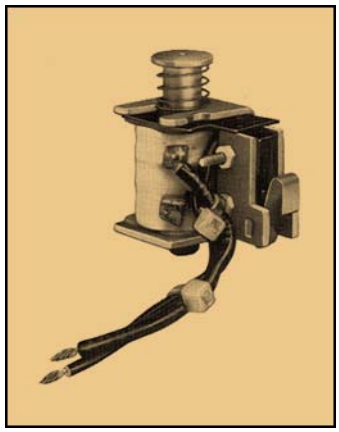
Figure 10. AFCI Breakers

Miniature Breaker Accessories

- **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 inter-

mittent 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.

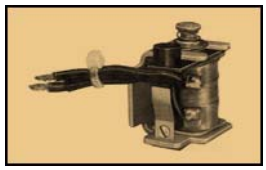
Figure 11. Shunt Trip



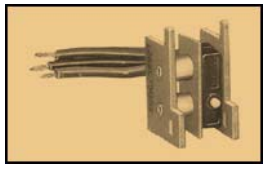
It is used for emergency disconnects for food service equipment such as grinders, slicers, fryers, and mixers. Other uses include pump panels, remote disconnects for UPS (uninterruptable power supply) devices, and power supply control for sequentially powering down a mainframe computer.

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.

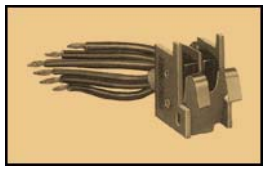
A number of accessories are available. These include:



Undervoltage Release
For undervoltage protection, a solenoid device mounts within the breaker cover and trips the breaker within a range of 35% to 70% of the rated coil voltage. It is reset by manually opening and closing the breaker handle.



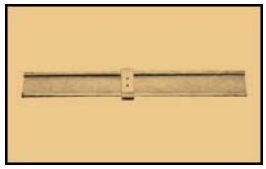
Alarm (Signal)/Lockout Switch)
For remote indication of an automatic trip operation. It does not function with manual switching. The switch automatically resets when the breaker is reset.



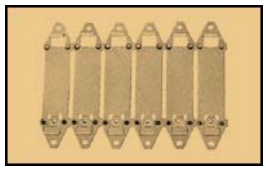
Auxiliary Switch
For auxiliary control circuits. Miniature switches mount within the breaker cover. Commonly used for remote indication of the breaker's open or closed status, as well as electrical interlocking functions.

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 in the United States 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 application can vary dramatically throughout the year.

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

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

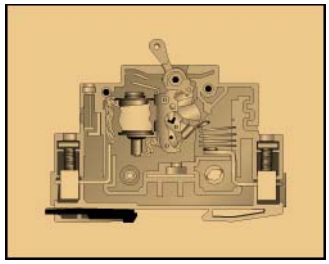
- Sensitive equipment protection, typically below 15 amperes, like electronics or appliances
- Control circuits as a fuse substitute
- Single phase control circuit transformer protection
- Motor disconnect and protection (does not meet UL or NEC requirements)

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

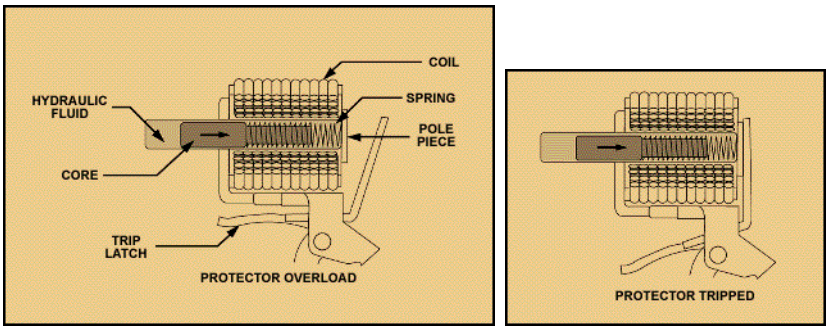
Figure 12. Hydraulic Magnetic Construction



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.

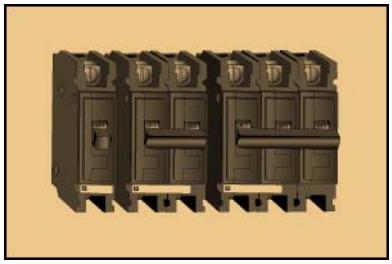
Figure 13. Hydraulic Magnetic Breakers



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."

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

Figure 14. Typical One-, Two-, and Three-Pole Hydraulic Magnetic Supplementary Protectors



Ratings

Figure 15. Short Circuit Capacity

Standards and Approvals	Ampere Rating	Volts AC 50/60 Hz	Volts DC	Interruption Capacity (I_{cu} = I_{cs})
UL 1077 CSA 22.2	0.1-30 35-50	277/480 250	— 80	3000 5000
VDE 0660 IEC-60497-2	0.1-50 0-50	230/400 —	— 80	1500 3000

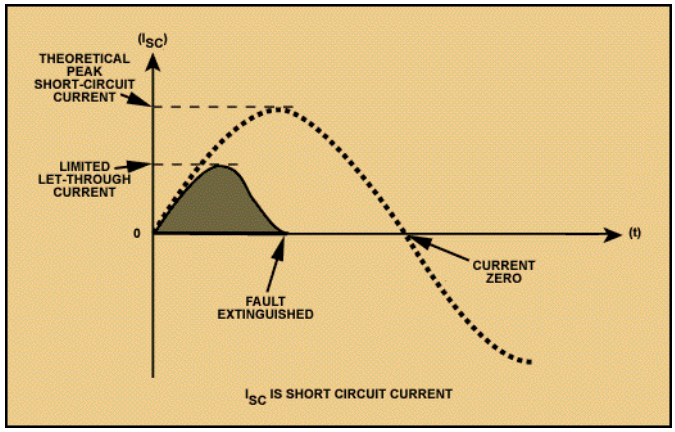
The hydraulic magnetic supplementary protector is a dual rated product for both AC and DC supplies, in accordance with UL 1077, CSA 22.2, VDE 0660, and IEC 60497-2 standards.

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 16). 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 16. 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 in both the United States and international (*IEC* –International Electro-technical Commission) markets. They meet both IEC and UL 1077 standards for supplementary overcurrent protection. As mentioned previously, supplementary protectors are not UL 489 devices and, therefore, cannot provide branch circuit protection.

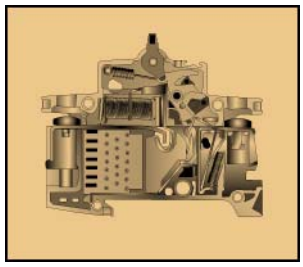
It is important to note that, in an IEC-dominated market, the thermal magnetic miniature circuit breaker is typically not used. Therefore, an obvious need exists for both devices in the global market.

The internal construction ensures current limiting performance, as well as compliance with IEC standards (Figure 17). 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 17. 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)

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

NOTE: Reference the product catalog for specific data on current limiting supplementary protectors.

Figure 18. IEC Ratings

Ampere Rating	Volts AC	Short Circuit Capacity (A)	
		IEC 898, I_{cn}	IEC 947-2, I_{cu}
0.5-5	240/415	10,000	10,000
6-40	240/415	10,000	10,000
50-60	240/415	10,000	10,000

Figure 19. UL/CSA Ratings

Ampere Rating	Poles	Volts AC	Short Circuit Capacity (A)	
			UL 1077, I_{cn}	CSA 235, I_{cu}
6-60	1	120	10,000	10,000
0.5-60	1	120	10,000	10,000
6-60	2, 3, 4	240	10,000	10,000
0.6-60	2, 3, 4	240	10,000	10,000
6-60	1	277	6,000	6,000
0.5-60	1	277	6,000	6,000
6-60	2, 3, 4	480	5,000	5,000
0.6-60	2, 3, 4	480	5,000	5,000

Figure 20. DC Ratings

Ampere Rating	Poles	Volts DC	Short Circuit Capacity (A)	
			UL 1077, I_{cn}	CSA 235, I_{cu}
0.5-63	1	65	10,000	10,000
0.5-63	2	130	10,000	10,000

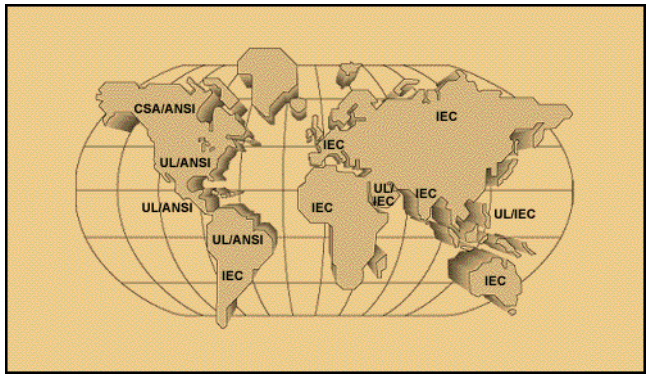
Governing Standards

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. **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 21. This will give you a feel for the standards applicable to miniature circuit breakers in different parts of the world.

Figure 21. 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 straightforward process.

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.
Arc Fault	An arc fault is an electrical fault characterized by low and erratic current that might ignite combustible materials.
Bolt-On	A type of circuit breaker that is bolted into place. Generally found in commercial and industrial applications.
Branch Circuit	A circuit that supplies power to the electrical loads in a building and is terminated at a distribution device (panelboard, loadcenter, etc.).
Cable-In/Cable-Out	A circuit breaker mounting method in which the line-side and load-side terminal electrical connections are made by cable. Method used in industrial applications.
Circuit Breaker	An 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. Double pole means that it disconnects two wires.
Duplex Circuit Breaker	A specialized overcurrent protection device designed to allow two poles to fit in a standard one-pole space. 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 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.
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 wall mounted device that delivers electricity from a supply source to loads in light commercial or residential applications.
Miniature Circuit Breaker	Also “Branch 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 set of electrical installation standards published by the National Fire Protection Agency. The NEC is the most widely adopted electrical code in the United States.
Operating Mechanism	A component of a miniature circuit breaker. Its function is to provide 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 overcurrent, this device will quickly terminate power to the circuit.
Overcurrent	A current higher than the current a conductor or electrical component can safely carry.
Overload	A temperature buildup caused by excessive loads on a circuit, causing damage to the conductor’s insulation.
Panelboard	A wall mounted device that delivers electricity from a supply source to loads in light commercial, commercial and industrial applications.
Plug-In	A type of circuit breaker that is literally plugged into the bus bar stabs. Generally found in residential applications.
Pole	Refers to the number of conductors or wires that the circuit breaker disconnects at one time.
Short Circuit	An electrical fault that is created when two exposed conductors touch or when conductor insulation fails.
Single Pole	Term used to describe a breaker that draws power from one pole of a loadcenter or similar device. Single pole means that it disconnects one wire.
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 United States 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