LEARNING MODULE 5:
FUNDAMENTALS OF CIRCUIT BREAKERS
Welcome to Module 5, Fundamentals of Circuit Breakers. This module is dedicated to the basics of circuit breakers. Once you have mastered the basics, you can move on to other modules that will focus on specific types of circuit breakers. They are as follows:

- Module 6 – Medium Voltage Power Circuit Breakers (1000V – 72.5 kV)
- Module 7 – Low Voltage Power Circuit Breakers (1000V and below) and Module 7+ – Low Voltage Power Circuit Breakers (Advanced)
- Module 8 – Industrial Molded Case Circuit Breakers (600V and below)
- Module 9 – Miniature Circuit Breakers (240V and below)

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, 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.

Key points are in bold. Glossary items are italicized the first time they appear.

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.
FUNDAMENTALS OF CIRCUIT BREAKERS

WHAT YOU WILL LEARN

We will step through each of these topics in detail:

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What is a circuit breaker? Definitions vary depending upon where you read the definition.

**NEMA** Definition: A circuit breaker is defined in NEMA standards as a device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

**ANSI** Definition: A circuit breaker is defined in ANSI standards as a mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions. Also capable of making and carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of a short circuit.

The premise is the same for both definitions and both are accurate, but the wording is quite different. The same is true with the many types of circuit breakers. Their general purpose is the same, but there are also a number of significant differences.

The circuit breaker might be applied as an individual item in its own enclosure, or be utilized in conjunction with a wide variety of other equipment in a common enclosure such as loadcenters, panelboards and switchboards.

No matter where or how it is applied, you will soon realize that the circuit breaker plays a pivotal role in the movement, distribution and use of electric power.
From a very broad perspective, all circuit breakers have the following common design and functional characteristics:

- A frame
- Contacts and operating mechanisms
- Trip units
- A method to extinguish an arc
- A method for mounting
- Compliance with specific standards

The first four characteristics are components of the circuit breaker, which can be seen in the figure below. Let's look at each component separately.

FIGURE 3: CHARACTERISTICS OF A CIRCUIT BREAKER
The rigid circuit breaker frame provides a method by which all the required components can be mounted and kept in place, ensuring the proper operation of the circuit breaker.

The circuit breaker frame provides the rigidity and strength required to successfully deal with the interruption process and achieve the desired interrupting ratings. The frame’s mechanical strength must be sufficient to withstand the forces created by the square of the current ($I^2$), which could be quite large and potentially destructive.

The frame also provides for insulation and isolation of the current path, offering personnel protection near the equipment during operation. The frame also plays a critical role in the circuit breaker’s ability to comply with applicable standards.

Historically, there are two types of frames:

- Metal Frame
- Molded Insulating Material
Metal frame circuit breakers are assembled from precise metal pieces that are bolted and welded together to form the frame. **Most older low voltage power circuit breakers and current medium voltage power circuit breakers are of the metal frame design.** Historically all power circuit breakers, both above and below 600 volts, have been referred to as metal frame circuit breakers. The metal frame design is still being used for higher voltages.

![Metal Frame Low Voltage AC Power Breaker](image-url)

**FIGURE 5: METAL FRAME LOW VOLTAGE AC POWER BREAKER**
Molded Insulated Material

Molded insulated material frames are made from a strong insulating material, such as glass-polyester or thermoset composite resins. Sizes vary according to the ampere rating size of the circuit breaker. Molded insulated material frames are primarily associated with low voltage molded case circuit breakers and insulated case circuit breakers. Because of advances in materials and technology, we are now seeing molded insulated case power circuit breakers at 600 volts and below.

FIGURE 6: POWER CIRCUIT BREAKERS
Contacts

Contacts in a circuit breaker provide a method for connecting the circuit with the system. They also provide a method for isolating a part of a circuit from the rest of the system.

![Contact and Operating Mechanism](image)

**FIGURE 7: CONTACT AND OPERATING MECHANISM**

A contact set contains a fixed and movable contact. As a circuit breaker opens or closes, the fixed contact maintains its position while the movable contact moves to close (make) or open (break) the circuit. When all is said and done, contacts perform a simple function; they open and close.

**IN THE WORKPLACE**

This typical residential light switch contains a set of contacts.

When the homeowner turns on the light, technically, he is toggling the operating mechanism. The moveable contact attached to the operating mechanism makes with the fixed contact. The circuit is made, electricity flows to the light fixture and the light turns on.

When the homeowner turns the light off, the moveable contact attached to the operating mechanism breaks from the fixed contact. The circuit is broken, electricity stops flowing to the light fixture, and the light turns off.

**FIGURE 8: CONTACTS AT WORK**
Circuit breakers require some type of operating mechanism to open and close the contacts. This operating mechanism can be mechanical or a combination of mechanical and power. Depending upon the type of circuit breaker being considered, the operating mechanism could be called upon to:

- Open and close the contacts manually
- Open and close the contacts on demand
- Open the contacts automatically

Let's consider a basic three-phase circuit breaker. It is designed such that all three sets of contacts open or close simultaneously.

This requires that all the contacts be linked together in some manner. This part of the mechanism might be connected mechanically to a common handle. The handle, when operated, puts the mechanism into motion and opens or closes the circuit breaker by opening or closing the contacts.

In reality, mechanisms are not quite as simple as just described. Circuit breakers, by virtue of their size and/or some standards requirement, need additional assistance to set the mechanism in motion to open or close the contacts.

This additional assistance takes the form of springs. Springs play a big role in the precise functioning of circuit breaker mechanisms. Springs are stretched or compressed to provide the energy necessary to assist with the proper opening or closing of the contacts.

There are two types of spring-assisted mechanisms: over-toggle and two-step stored energy. To provide the necessary background information, we will briefly discuss them here.
Over-Toggle Mechanism

A manual handle on the circuit breaker is operated to set the mechanism in motion. The handle is moved, whether opening or closing the circuit breaker, until a point is reached where the handle goes over-toggle (past the point of no return), and the spring-assisted mechanism automatically opens or closes the circuit breaker. This toggle mechanism is called the quick-make, quick-break type, which means that the speed with which the contacts open or close is independent of how fast the handle is moved. You might look at it like a gun being fired. How fast or slow the trigger is pulled will not change the speed at which the bullet leaves the barrel.

Two-Step Stored Energy Mechanism

A motor operator can be used to operate the handle automatically in lieu of manual operation. The design is such that the circuit breaker would trip open when required, even if the manual handle was held in the ON (closed) position.

The two-step stored energy mechanism uses separate opening and closing springs. This is important because it permits the closing spring to be charged independently of the opening process. This allows for an open-close-open duty cycle. The closing spring can be charged (or recharged) manually via a charging handle or electrically via a motor. The motor can be operated remotely, allowing maximum safety for the operator.
The two-step stored energy mechanism is used when a lot of energy is required to close the circuit breaker and when it needs to close rapidly. The two-step stored energy process is to charge the closing spring and release energy to close the breaker. It uses separate opening and closing springs. This is important because it permits the closing spring to be charged independently of the opening process. This allows for an open-close-open duty cycle. The closing spring can be charged (or recharged) manually via a charging handle or electrically via a motor. The motor can be operated remotely, allowing maximum safety for the operator.

Do you remember sitting in a room and suddenly have the lights flicker but not go out? Somewhere along the power distribution line, a circuit was opened and almost instantaneously closed. The action was fast enough so your lights didn’t go out. The two-step stored energy mechanism makes this possible. Once the closing spring is charged, it lies paused and ready to rapidly reclose the circuit breaker.

The major advantages of the two-step stored energy mechanism are rapid reclosing and safety. Rapid reclosing is achieved by storing charged energy in a separate closing spring. Safety is achieved by providing remote charging of the spring.

Many advances have been made in the design of circuit breaker operating mechanisms and they continue to be looked at for further improvements. A great deal of effort is invested in the operating mechanism because it is so critical to a successful circuit breaker design. It determines how fast, how strong and how precisely contacts are opened and closed. This goes a long way in determining if a circuit breaker is acceptable and where it can be applied.
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. Circuit breakers provide switching capabilities and protection against one or more overcurrent conditions.
   
   TRUE FALSE

2. Which of the following is not a common characteristic of circuit breakers.
   
   A. Compliance with specific standards
   B. Contacts and operating mechanisms
   C. A means to extinguish an arc
   D. A means to respond to transformer requests
   E. A method for mounting

3. All power circuit breakers are metal frame circuit breakers.
   
   TRUE FALSE

4. Advances in the strength of molded insulating frames have allowed them to be used for low voltage power circuit breakers.
   
   TRUE FALSE

5. A set of circuit breaker contacts is usually comprised of two parts. Which of the following terms best describes the two parts:
   
   A. Removable B. Fixed C. Non-conductive D. Movable

6. Circuit breakers utilize __________ __________ to help close and open the main contacts.

7. The two types of spring assisted mechanisms are the over-toggle mechanism and the two-step stored energy mechanism. TRUE FALSE

8. Over-toggle spring mechanisms are a quick-make, quick-break type.
   
   TRUE FALSE

9. The two steps in the two-step stored energy mechanism are charging the closing spring (storing the energy) and releasing energy to close the breaker.
   
   TRUE FALSE
TRIP UNITS

For a circuit breaker to be effective, it needs to have some intelligence to enable it to perform automatically or respond to a command. Without this capability, a circuit breaker would just be a fancy switch. A trip unit is the circuit breaker's intelligence. We will discuss the function and the types of trip units.

![Circuit Breaker Trip Units](image)

**FIGURE 12: CIRCUIT BREAKER TRIP UNITS**

The trip unit's **function is to trip the operating mechanism (open the circuit) in the event of these overcurrent conditions:**

- Thermal Overload
- *Short Circuit* Currents (*fault current*)
- Ground Fault

**Thermal Overload**

A deteriorating conductor is usually the result of an *overload* condition. When this condition exists, **a temperature buildup occurs between the insulation and the conductor.** This is called a thermal overload. Eventually, this condition will result in a short circuit. Overload conditions are predictable if the current flowing into a conductor and its flow time are monitored. As a result, a time-current curve is used to indicate the boundary between the normal and the overload condition.

![Overload Time-Current Curve](image)

**FIGURE 13: OVERLOAD TIME-CURRENT CURVE**
Short Circuit Currents

Short circuit currents (fault currents) usually occur with abnormally high current flow due to the failure of conductor insulation. When the insulation between phases breaks down, short circuit currents can be expected to flow into the fault. A typical time-current curve for a short circuit (instantaneous) element of a circuit breaker indicates that a trip will not occur until the fault current reaches or exceeds Point A in the curve.

Ground Fault

A ground fault is a particular type of short circuit current fault. It is a short circuit between one phase and the ground. The NEC requires ground fault protection on specific applications, such as a service entrance.

Now that you know the function of a trip unit, we will discuss the types of trip units. There are two types of trip units:

- Electromechanical (thermal magnetic)
- Electronic
Electromechanical Trip Unit

This type of trip unit is **generally used in low voltage circuit breakers**. It is integrally mounted into the circuit breaker and is temperature sensitive. Thermal magnetic trip units act to protect the conductors, safeguarding equipment under high ambient conditions and permitting higher safe loading under low ambient conditions.

![Electromechanical Trip Unit](image)

**FIGURE 16: ELECTROMECHANICAL TRIP UNIT**

This trip unit utilizes bimetals and electromagnets to provide overload and short circuit protection, which is referred to as “thermal magnetic”. To better understand this tripping action, the thermal and magnetic portions are explained separately and then combined.

The **thermal trip portion is used for overload protection**. Its action is achieved using a bimetal heated by the load current. **On a sustained overload, the bimetal will deflect, causing the operating mechanism to trip.**

![Thermal Trip Portion](image)

**FIGURE 17: THERMAL TRIP PORTION**
Electro-mechanical Trip Unit (continued)

Deflection is predictable as a function of current and time. This means, for example, that a typical 100A breaker might trip in 1800 seconds at 135% of rating (Point A) or ten seconds at 500% of rating (Point B).

The magnetic trip portion is used for short circuit (instantaneous) protection. Its action is achieved with an electromagnet whose winding is in series with the load current. When a short circuit occurs, the current passing through the conductor causes the electromagnet's magnetic field to rapidly increase, attracting the armature and causing the circuit breaker to trip.

This is a typical time-current curve for the magnetic portion of an electromechanical trip unit. The combination of thermal and magnetic actions protects against overloads and short circuits. Note the difference in the time-current curve. The thermal magnetic trip unit is suited for most general-purpose applications because it is temperature-sensitive, harmonics insensitive and tends to automatically follow safe cable and equipment loading that varies with ambient temperatures.
In this type of trip unit, it is difficult to detect a ground fault until it is too late, especially with motors where an internal insulation failure can result in serious damage. As a result, a separate ground fault device is needed.

The second type of trip unit is the electronic trip unit. It is generally temperature insensitive and more expensive. It is used on low voltage circuit breakers beginning at 400A and on medium voltage circuit breakers. The trip unit is integrally mounted on the low voltage and externally mounted on the medium voltage.

This unit is rapidly replacing the thermal magnetic trip because of its increased accuracy, repeatability and discrimination. It also has an optional built-in ground fault protection. In addition, it offers other capabilities such as programming, monitoring, diagnostics, communication, system coordination and testing.
In general, electronic trip units are composed of three components, which are internal to the trip unit. These components are the current transformer, circuit board and flux-transfer **shunt trip**.

The **current transformer** is used in each current phase to monitor and reduce the current to the proper input level.

The circuit board is the brains of the system. It interprets input current and makes a decision based on predetermined parameters. A decision to trip sends an output to the flux-transfer shunt trip.

The **flux-transfer shunt trip is the component that trips** the circuit breaker.

There are two types of electronic trip units: Analog and Digital.
The analog trip unit was developed first and considered the conventional approach. It functions by looking at all the points on a particular curve and responding to peak values. This can cause a problem, because peak sensing can cause false tripping. The unit is also sensitive to harmonics.

![FIGURE 25: ANALOG PEAK SENSING](image)

The digital trip unit functions by looking at selected discrete points on a particular curve and making a summation of those discrete points. The result is an RMS value that is more accurate because you are using all the values instead of just peak values. This method correlates better with the thermal characteristics of conductors and equipment.

![FIGURE 26: DIGITAL PEAK SENSING](image)

Electronic trip units vary in feature and capabilities based on system requirements. The features and capabilities of the electronic trip units will be discussed in later modules as they pertain to particular types of circuit breakers.
ARC EXTINGUISHERS

An arc extinguisher is the component of the circuit breaker that extinguishes an arc when the contacts are opened. An arc is a discharge of electric current crossing a gap between two contacts. Circuit breakers must be designed to control them, since arcs cannot be prevented. There are four techniques to extinguish an arc and there are several arc control methods. In this topic, you will be introduced to those methods.

FIGURE 27: ARC EXTINGUISHERS

What is an Arc?

Do you ever recall pulling a plug from a wall socket and seeing what appeared to be sparks? What you were observing, on a very small scale, was an attempt at arc formation between the wall contacts and the plug contacts in your hand. For the sake of this discussion, let’s define an arc as a discharge of electric current crossing a gap between two contacts.

FIGURE 28: TYPICAL ARC
Arcs are formed when the contacts of a circuit breaker are opened under a load. Arcs can be very destructive and vary greatly in size and intensity. The size of the arc depends on the amount of current present when the contacts are pulled apart. For example, an arc that forms when normal load current is broken is insignificant compared to the arc that forms when a short circuit is broken. Since arcs cannot be prevented, circuit breakers must be designed to control them.

The heat associated with an arc creates an ionized gas environment. The more ionization, the better the conditions are for an arc to be maintained and grow. The bigger the arc, the more heat created which increases ionization.

Arcing is a condition that must be dealt with quickly and effectively by a circuit breaker.

The important thing to remember here is that the ability of the circuit breaker to control the arc is the key to its short circuit interrupting capability. This is a critical factor for selecting circuit breakers.

A short circuit is the most devastating overcurrent condition.

Current zero or zero point is a very important aspect to arc extinguishing. At current zero, conditions are optimal for preventing an arc from continuing. The current is said to be “Current Zero” when the sine curve is at 0°, 180° and 360°.

Voltage is also a very important consideration because it is the pressure that keeps the current moving.

Left unchecked, voltage will keep pushing the current through current zero and give new life to the arc. Voltage does not take kindly to being stopped in its tracks during the extinguishing of an arc. If it reignites, it can damage the whole electrical system.
What is an Arc? (continued)

Circuit breakers take this process into account by simultaneously opening the contacts and extinguishing the arc. The successful extinguishing of the arc depends on the dielectric strength of the gap between the contacts. The dielectric strength is the maximum voltage a dielectric can withstand without breaking down. A dielectric is any insulating material between two conductors. In these discussions, the circuit breaker contacts are the conductors and the insulating material can be air, gas or a vacuum. If the dielectric strength is greater than the voltage trying to re-ignite the arc, the arc extinguishing will be successful.

The invention of a device called DE-ION® arc extinguisher in the early 1900s by Westinghouse was a revolutionary advance in arc interruption. Improved versions were used for years with a majority of circuit breakers and continue to be used today with low voltage circuit breakers.

![FIGURE 30: EXTINGUISHING AN ARC](image)

A number of other approaches to arc control have also been tried. One of the success stories is the use of vacuum interruption with medium voltage breakers.
Each approach has made improvements to its initial concept in an effort to extinguish arcs more efficiently. Arc control methods utilize one or more of the following general techniques:

**Stretching Arc** — The arc is produced when the contacts part. As the gap widens, the *arc is stretched and cooled* to the point where it is extinguished.

**Breaking Arc into Smaller Pieces** — The arc is produced when the contacts part. The *arc moves up into the arc divider and splits, cools* and is extinguished.
Blowing Out Arc — In this method, a high-pressure gas blows the arc into an arc divider to be extinguished.

Enclosing Contacts — In this method, the contacts are housed in an oxygen-free enclosure with a dielectric such as a vacuum, gas or cooling oil. Without oxygen, the arc cannot sustain itself and the arc is extinguished.
There are six methods used around the world today to deal with arc control. The two most commonly used methods are arc chute and vacuum interrupter. The other four methods are SF6, minimum oil, magnetic coil and puffer.

The **arc chute method** only uses the **Breaking Arc into Smaller Pieces** technique. Arc chutes are normally associated with low voltage circuit breakers due to efficiency and cost. In general, **an arc chute will confine, divide and cool an arc, resulting in the arc being unable to sustain itself**. There is one arc chute for each set of contacts.

The **vacuum interrupter method** uses the **Enclosing Contacts** technique to extinguish arcs. The vacuum enables the contacts to be smaller and eliminates the divider, making this method the most cost effective and efficient above 1000V. Arcing takes place within a sealed evacuated enclosure. The contacts are located inside and arcing occurs when the contacts are separated. Since the environment inside the interrupter envelope is a vacuum, an arc cannot be easily sustained. It will not reach the intensity possible with an arch chute. One vacuum interrupter is provided for each set of contacts.
The SF6 method also uses the Enclosing Contacts technique. It was a precursor to the vacuum interrupter and used SF6 gas as the dielectric. The heat energy created by the arc works to break apart the SF6 molecules. The larger the arc, the greater the breakdown of the gas which aids in extinguishing the arc. The technology is related more to European manufacturers of medium and higher voltage circuit breakers.

The minimum oil method also uses Enclosing Contacts with oil as the dielectric. The arc energy is absorbed as it rips hydrogen away from the oil molecule. The oil itself also helps to cool the arc. As current zero is approached, more oil is drawn into the system, further cooling and deionizing the arc. It is used today in low voltage situations and potentially explosive environments where an arc chute is not desirable.

The magnetic coil method uses the Breaking Arc into Smaller Pieces technique. It is very similar to the arc chute method. The natural movement of an arc is upward, in this instance, into an arc chute. A coil, called a blowout coil, is located in the center of the arc chute. The arc is broken into two. The arcs are lengthened and cooled as they rise higher. The cooling reduces the rate of ionization. When the ionization drops below the level necessary to sustain the arcs, they extinguish at current zero. Prior to vacuum interrupter technology becoming the method of choice with medium voltage power breakers for extinguishing arcs, the magnetic coil method served well for many years.
The **puffer method** uses the Blowing Out Arc and Enclosing Contacts techniques. It uses SF6 gas as the dielectric. It is the most efficient and cost effective method above 38 kV. This type interrupter is basically a pair of separable contacts, a piston and a cylinder, mounted in a reservoir of gas. As the contacts part, the piston moves up to drive the gas through the arc to interrupt it. It also utilizes coils and takes advantage of natural magnetic affects to create a force sufficient to extinguish the arc.

As you have seen, there are several techniques to effectively deal with extinguishing arcs and improvements continue to be made.
Methods for Mounting Circuit Breakers refers to the way a circuit breaker is used in its individual enclosure or assembly. Ease of replacement and unit cost are two factors to take into account when choosing a method for mounting circuit breakers.

Circuit breakers, depending on the type and/or the particular application, are mounted for use in one of three basic ways:

- **Fixed Mounted**
- **Removable**
- **Drawout Mounted**

**Fixed Mounted**

A circuit breaker that is bolted in its enclosure or assembly and hard-wired on to the frame is considered a fixed mounted circuit breaker.

This method has the lowest purchase cost, is very reliable and front mountable. It is appropriate for 600V and below. Power feeding the circuit breaker must be turned off in order to remove and replace this unit.
A removable circuit breaker has two parts: a base, which is bolted and hard-wired to the frame, and the actual breaker, which is plugged into the base. These allow the unit to be replaced without rewiring.

This method has a moderate purchase cost, good reliability and is front-mountable. It is appropriate for 600V and below. Power feeding the circuit breaker must be turned off in order to remove and replace the circuit breaker.

A drawout circuit breaker also has two parts: a base, which is bolted and hard wired to the frame and the actual breaker, which slides into the base. This allows the unit to be replaced without having to remove power feeding the circuit breaker.

Movement of the circuit breaker in or out could be manual or it could be accomplished by using some type of racking mechanism. This method has the highest purchase cost, is very reliable, allows for power ON testing, and is rear mounted. It is appropriate for all voltages. The load must be turned off in order to test, remove or replace the breaker. As a safety feature, it is interlocked to automatically turn the power off during removal.

A racking mechanism permits a circuit breaker to be moved, usually by turning or ratcheting a handle. By design, only the circuit breaker's load must be turned off to rack the circuit breaker from the “Connected” position. This is accomplished by built-in interlocks, which automatically open the circuit breaker before racking out begins.

The drawout feature is quite beneficial, since the power to the entire assembly does not have to be turned off to service one circuit breaker.
STANDARDS

For a circuit breaker to be used, it must comply with one or more specific sets of standards: ANSI, CSA, IEC, IEEE, NEMA, NEC and UL. The applicable standards might be domestic, international or both.

FIGURE 43: WORLDWIDE STANDARDS

As you can see, standards vary around the world. However, the impact that standards have on the design and application of circuit breakers worldwide is profound, and provides a very positive result for the users of circuit breakers.

Specific details on standards will be discussed in the module for each type of circuit breaker.
Answer the following questions without referring to the material just presented.

1. The trip unit’s function is to trip the operating mechanism in the event of an overload or short circuit.
   
   TRUE   FALSE

2. The two types of trip units are:
   
   A. current transformer
   B. flux-transfer shunt trip
   C. electromechanical
   D. electronic

3. Circuit breakers are designed to extinguish arcs.
   
   TRUE   FALSE

4. The key to a circuit breaker’s short circuit interruption capability is its ability to control an arc.
   
   TRUE   FALSE

5. Every half cycle, an alternating current waveform goes through a point called __________ __________.

6. If the dielectric strength of the contacts is greater than the voltage, the voltage will be overpowered and an arc will continue.
   
   TRUE   FALSE

7. Enclosing contacts in a vacuum for the purpose of extinguishing arcs works well because a vacuum is an excellent dielectric.
   
   TRUE   FALSE

8. The two most commonly used methods for arc control are arc chute and the magnetic coil. TRUE FALSE

9. List the three general ways to mount a circuit breaker.

   _____________________, _____________________, _____________________

10. Select which of the three circuit breaker mounting types can be in a “power on” state for servicing.

    A. Fixed
    B. Removable
    C. Drawout
GLOSSARY

Ampere Rating  A rating of the amount of current a protective device will carry continuously without deteriorating or exceeding temperature rise limits.

ANSI  American National Standards Institute.

Arc  The effect generated when electrical current bridges the air gap between two conductors that are not touching.

Arc Extinguisher  A common method used to extinguish an arc. In general, it confines, divides and cools the arc.

Circuit Breaker  A reusable overcurrent protection device. After tripping to break the circuit, it can be reset to protect the circuit again.

Contacts  Method to open and close the circuit as the contacts come together or separate.

CSA  Canadian Standards Association.

Current Zero  A point in the AC current sine wave where the value is zero. Also “Zero Point”.

Deionizing  The process of removing conduction ions, thus permitting arc extinction.

Dielectric  Any insulating material between two conductors.

Dielectric Strength  The maximum voltage a dielectric can withstand without breaking down.

Drawout Mount  A type of circuit breaker that can be moved into or out of its structure without unbolting, often on a racking mechanism.

Fault Current  The surge of amperage created during an electrical failing.

Fixed Mount  A type of circuit breaker that is bolted into a fixed position with bus or cable mechanically bolted to breaker terminations.

Harmonics  Multiples of fundamental frequency that when added together result in a distorted sine wave causing noise. Usually created by electronic equipment.

IEC  Abbreviation for International Electro-technical Commission. This organization is associated with equipment used internationally.
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IEEE  
Institute of Electrical and Electronic Engineers.

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.

Loadcenter  
A device that delivers electricity from a supply source to loads in light commercial or residential applications.

NEC  
National Electric Code — a set of electrical installation standards applicable throughout the U.S. and published by the National Fire Protection Association. The NEC works with UL requirements and usually carries mandatory compliance.

NEMA  
National Electrical Manufacturers Association — establishes manufacturing standards to meet the requirements of UL.

Overload (or Overcurrent)  
A condition in which current is in excess of the normal load being drawn.

Over-Toggle  
Handle is operated to the point of no return and the spring-assisted mechanism operates the breaker.

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.

Quick-Make, Quick-Break  
Speed with which contacts open or close, regardless of the speed of handle operation.

RMS  
Root Mean Square. RMS Current is also referred to as “effective current.” It is the square root of the average of all the instantaneous currents (current at any point on a sine wave) squared.

Short Circuit  
An electrical fault created when two exposed conductors touch or a fault in an electrical system caused by abnormally high current flow due to insulation failure.

Shunt Trip  
A device used to trip a circuit breaker remotely.

Switchboard  
Equipment in which a large block of electric power is delivered from a substation and distributed throughout a building.
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.

Three-Phase  Three streams of electricity rotated through a magnetic field and distributed on three cables.

Trip Unit  Device that trips the operating mechanism in case of a short circuit or overload condition.

Two-Step Stored Energy  Separate opening and closing springs operate the contact mechanism allowing for rapid reclosing and safety.

UL  Underwriters Laboratory. An independent laboratory that tests equipment to determine whether it meets certain safety standards when properly used.

Vacuum Interruption  This common extinguishing method encloses contacts in a vacuum where an arc can not be easily maintained.

Zero Point  Also “Current Zero.” A point in the AC current sine wave where the value is zero.
FUNDAMENTALS OF CIRCUIT BREAKERS

REVIEW 1 ANSWERS
1. True
2. D. A means to respond to transformer requests
3. False
4. True
5. B. Fixed; D. Movable
6. Operating mechanisms
7. True
8. True
9. True

REVIEW 2 ANSWERS
1. True
2. C. electromechanical; D. electronic
3. True
4. True
5. Current zero
6. False
7. True
8. False
9. Removable; Fixed mount; Drawout
10. C. Drawout