Welcome to Module 12, which is about safety switches, devices that are used to open and close a circuit.

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.

Key points are in bold.

Glossary terms are underlined and 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.
## WHAT YOU WILL LEARN

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

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SAFETY SWITCHES

INTRODUCTION

A safety switch is **a device used to open and close a circuit.** This may be done manually with an operating mechanism, or automatically with fuses.

**What is a Safety Switch?**

A safety switch will **always be found in its own enclosure.** The enclosure provides protection to personnel against incidental contact with the electrical equipment. It also provides protection to the enclosed equipment against the environment.

There are two types of safety switches:

- **Non-fusible**
- **Fusible**

**Non-Fusible**

A switch with no associated fuses is referred to as a **non-fusible** safety switch, which has no circuit protection capability. **It provides a means to manually connect and disconnect the load from its source.** External overcurrent devices (such as **circuit breakers** or **fuses**) provide circuit protection.

**Fusible**

A safety switch can be combined with fuses in a single enclosure. This is called a **fusible** safety switch. **The switch provides a means to manually open and close a circuit and the fuse provides overcurrent protection.**
SAFETY SWITCHES

Purpose of a Safety Switch

Safety switches are generally used for two main purposes:

- As a service entrance
- As a means of disconnection and fault protection for a motor circuit

Let’s take a moment to consider each purpose briefly.

Service Entrance

A service entrance is a point at which electricity first enters a building. There are times when a safety switch is used at the service entrance point to disconnect power to the whole building at one location. Consider an existing commercial building. If additional electrical service is required as a result of building expansion, an electrical contractor will usually install safety switches.

![Figure 4. Adding circuits to an existing commercial building]
SAFETY SWITCHES

Means of Disconnection

The *National Electrical Code*® (NEC) requires that a “disconnecting means shall be located in sight from the motor location and the driven machinery location” (Article 430-102b). The NEC defines “in sight” as visible and not more than 50 feet (15.24 meters) from the motor or machinery.

With the power removed, the operator can safely work on the machinery. There is no need to worry about touching live electrical components, or having the motor accidentally start.

![Safety Switch Diagram](image)

**FIGURE 5. SAFETY SWITCH USED AS POWER DISCONNECTION MEANS**

Circuit Protection

Why do we need circuit protection? **Circuit protection prevents damage that would otherwise be caused by overloads and short circuits.** Overcurrent protection devices such as fuses and circuit breakers are used for this purpose.

An overcurrent occurs when too many devices are operated on a single circuit, or a piece of electrical equipment is made to work harder than designed. For example, a motor rated for 10 amps may draw 20, 30 or more amps in an overload condition.

A package has become jammed on this conveyor, causing the motor to work harder and draw more current.

Damage will occur to the motor in a short time unless the problem is corrected or the overcurrent protection device shuts down the circuit.

Of course, motors are not the only devices that require circuit protection for an overcurrent. **Every circuit requires some form of protection against overcurrent.**
Heat is a major cause of insulation failure on any electrical component. Insulated wire exposed to high levels of heat suffers insulation breakdown, and it may even flake off, exposing the conductors.

When two bare conductors touch, a short circuit occurs and resistance drops to almost zero. **Short circuit current can be thousands of times higher than normal operating current.**

Ohm's Law gives us the relationship between current, voltage, and resistance. Consider a 240-volt motor with 24 ohms of resistance. It would normally draw 10 amps of current.

\[
I = \frac{E}{R}
\]

\[
I = \frac{240 \text{ volts}}{24 \text{ ohms}}
\]

\[
I = 10 \text{ amps}
\]

If a short circuit occurs, the resistance drops. Suppose the resistance drops to 24 milliohms, which is a reasonable figure. This means that the current will rise to 10,000 amps.

\[
I = \frac{E}{R}
\]

\[
I = \frac{240 \text{ volts}}{0.024 \text{ ohms}}
\]

\[
I = 10,000 \text{ amps}
\]

The heat generated by this high current will cause extensive damage to connected equipment and conductors. For this reason, when a short circuit occurs, this dangerous current must be interrupted immediately.
The two main types of overcurrent protective devices are the circuit breaker and the fuse. We will only look at fuses here because fuses are used in safety switches. More information about circuit breakers can be found in a number of other training modules.

A typical fuse consists of an element connected electrically to the end blades, called the ferrules. The element provides a path for current through the fuse. The element is enclosed in a tube and surrounded by a non-conductive filler material.

For this discussion, we will deal with the ferrule style fuse, but you should be aware that other types are available.
How a Fuse Works

Current flows through the element of the fuse, generating heat. During normal operation, the filler material absorbs this heat.

When an overcurrent occurs, the element temperature rises. Again, if the overcurrent is a harmless transient overload, the filler material will absorb the small amount of excess heat.

However, if a sustained overload occurs, the heat generated quickly melts a portion of the element. This forms a gap in the circuit, stopping the flow of current.

All fuses have an inverse time-current characteristic. Simply stated, the higher the overcurrent, the shorter the time required for the fuse element to melt, opening the circuit. This amount of time is called clearing time.
How a Fuse Works (continued)

For example, when an overload condition occurs in a motor, the temperature of the fuse element rises. If the condition persists, this excess heat melts a segment of the element, opening the fuse. Power stops flowing to the motor and it coasts to a stop.

![Diagram of overload condition](image1)

**FIGURE 12. HOW A FUSE PROTECTS AGAINST AN OVERCURRENT**

Short Circuit Current

As we have already stated, a short circuit current can be thousands of amps. This level of current generates extreme heat. When a short circuit occurs, several element segments can melt at the same time. This removes the load from the source very quickly. In fact, short circuit current is typically cut off in less than half a cycle, before it reaches its full value.

![Diagram of short circuit current](image2)

**FIGURE 13. HOW A FUSE PROTECTS AGAINST A SHORT CIRCUIT**
SAFETY SWITCHES

**Ampere and Voltage Ratings**

Every fuse has a specific *ampere rating*, which is the fuse’s continuous current-carrying capability. In most cases, the *ampere rating of a fuse should not exceed the current-carrying capacity of the circuit*. For example, if a conductor is rated for 20 amps, select a fuse no larger than 20 amps.

The *voltage rating* of a fuse **must be equal or greater than the circuit voltage**. It can never be lower. A 480-volt fuse could be used in a 240-volt circuit, but not vice versa.

**Ampere Interrupting Capacity**

Every fuse also has an *ampere interrupting capacity*, or AIC for short. This is the rating of the fuse’s ability to withstand its application’s large potential short circuit current.

**Nontime-Delay vs. Time-Delay**

A *nontime-delay fuse* is used in applications where the circuits are not going to be exposed to large transient surge currents. As a result, this type of fuse **is not good for use with a motor, because of the short-term overloads caused by the starting of the motor**. Using a nontime-delay fuse in a motor application may cause nuisance tripping.

This is because a *nontime-delay fuse can usually hold 500% of its rating for only about 0.25 seconds*. A motor circuit will often have starting currents in excess of 500%, lasting for much longer than 0.25 seconds.

A better choice for a motor circuit is a *time-delay fuse*, because it will allow 500% of the rated current for up to ten seconds. This is usually enough time to allow a motor to start.
Ul Fuse Classification

All fuses fall into either the “current limiting” or the “non-current limiting” class. This designation is based on a fuse’s operating and construction characteristics. A fuse, designed or sized to reject another fuse with the same ampere rating but a lower AIC rating, is termed a **current limiting fuse**.

**Underwriters’ Laboratories** (UL) has established basic standardized fuse performance and physical specifications to develop its safety test procedures. This standardization has resulted in specific characteristics of low-voltage (600 volts and below) fuses.

Below is a chart listing the various characteristics.

<table>
<thead>
<tr>
<th>FUSE TYPE</th>
<th>VOLTAGE (VAC)</th>
<th>AMPERE RATING (A)</th>
<th>INTERRUPT CAPACITY (AIC)</th>
<th>CURRENT LIMITING?</th>
<th>TIME DELAY?</th>
<th>UL STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLUG FUSE S</td>
<td>125</td>
<td>30</td>
<td>10,000</td>
<td>NO</td>
<td>YES</td>
<td>UL 198 F</td>
</tr>
<tr>
<td>PLUG FUSE T</td>
<td>125</td>
<td>30</td>
<td>10,000</td>
<td>NO</td>
<td>YES</td>
<td>UL 198 F</td>
</tr>
<tr>
<td>PLUG FUSE W</td>
<td>125</td>
<td>30</td>
<td>10,000</td>
<td>NO</td>
<td>NO</td>
<td>UL 198 F</td>
</tr>
<tr>
<td>CLASS H</td>
<td>600</td>
<td>30-600</td>
<td>100,000 OR 200,000</td>
<td>NO</td>
<td>YES</td>
<td>UL 198 B</td>
</tr>
<tr>
<td>CLASS J</td>
<td>600</td>
<td>30-600</td>
<td>200,000</td>
<td>YES</td>
<td>YES</td>
<td>UL 198 B</td>
</tr>
<tr>
<td>CLASS L</td>
<td>600</td>
<td>601-1200</td>
<td>100,000 OR 200,000</td>
<td>YES</td>
<td>YES</td>
<td>UL 248 10</td>
</tr>
<tr>
<td>CLASS R</td>
<td>600</td>
<td>30-600</td>
<td>100,000 OR 200,000</td>
<td>YES</td>
<td>YES</td>
<td>UL 248 12</td>
</tr>
<tr>
<td>CLASS T</td>
<td>600</td>
<td>200-800</td>
<td>100,000 OR 200,000</td>
<td>YES</td>
<td>YES</td>
<td>UL 248 15</td>
</tr>
</tbody>
</table>

For example, Figure 14 shows a Class R type fuse holder, equipped with a rejection clip. This clip prevents installation of a fuse with a lower AIC rating, such as a class H or K.
SAFETY SWITCH DESIGN

The safety switch is built into an enclosure. The enclosure houses the switch mechanism, wire connectors, and an operating bail. A handle is connected to the operating bail, and is used to open and close the contacts. If the switch is fusible, the enclosure also houses fuse clips for fuse installation. The enclosure door and/or handle are lockable.

Figure 15 illustrates the components of a typical safety switch.

![Diagram of a safety switch](image-url)

**FIGURE 15. THREE-POLE, THREE FUSE, SOLID NEUTRAL SAFETY SWITCH**
Enclosure Types

An enclosure is defined by NEMA as a surrounding case, constructed to provide a degree of protection to personnel against incidental contact within the enclosed equipment, and to provide a degree of protection to the enclosed equipment against specified environmental conditions. NEMA also defines enclosure types. Below are the enclosures used for safety switches.

**NEMA Type 1**
**General Purpose**
This enclosure type is for general purpose, indoor use. It is suitable for most applications where unusual service conditions do not exist. It provides protection from accidental contact with enclosed equipment. Available with either general duty safety switches or heavy duty safety switches.

**NEMA Type 3R**
**Raintight**
This enclosure type is intended for outdoor use. It provides protection against falling rain and sleet, and damage from external ice formation. It has a gasketed cover. Available with either general duty or heavy duty safety switches.

**NEMA Type 4**
**Watertight**
This enclosure type is intended for indoor or outdoor use. It provides protection from splashing or hose-directed water, wind-blown dust or rain, and damage from external ice formation. Available with heavy duty safety switches only.

**NEMA Type 4X**
**Corrosion Resistant**
This enclosure type is intended for indoor or outdoor use, where corrosion resistance is required. It is constructed of stainless steel, polymeric, or fiberglass. It also provides protection from splashing or hose-directed water, wind-blown dust or rain, and damage from external ice formation. Available with heavy duty safety switches only.

**NEMA Type 12**
**Dusttight**
This enclosure type is for indoor use. It provides protection from dripping non-corrosive liquids, falling dirt, and dust. Available with heavy duty safety switches only.

For safety switches, the NEMA Type 1 and NEMA Type 3R enclosures have two additional features

- The enclosure has an interlock that prevents it from being opened while the switch is in the “on” position.
- A latch secures the door in the closed position. A padlock can be inserted in the latch for extra security and safety.
SAFETY SWITCHES

Knife Blade Switch Principle

A switch uses contacts to make and break the circuit, controlling the flow of current. A typical switch assembly consists of a stationary contact, a hinged movable contact (called a knife blade), and an operating handle. **If the knife blade is not in contact with the stationary contact, current does not flow.**

Moving the operating handle to the “on” position closes the contacts. This provides a complete path for current to flow from the power supply to the load.

When the handle is moved to the "off" position, the contacts open, and the flow of electricity is interrupted.

**FIGURE 16. SAFETY SWITCH IN THE “ON” POSITION**

**FIGURE 17. SAFETY SWITCH IN THE “OFF” POSITION**
As the contacts begin to open, current continues to flow across the air gap between the two contacts. This is called an *arc*. Current flows across this arc until the distance between the opening contacts is great enough to interrupt it. The measurement of the distance between the contacts when the arc is extinguished is called the *break distance*.

**FIGURE 18. ARC IS CREATED AS SAFETY SWITCH IS OPENED**
SAFETY SWITCHES

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. List the two functions a safety switch serves.

__________________________________________________________________________
__________________________________________________________________________

2. Heat is a major cause of ___________ __________ on any electrical component.

3. When two bare conductors touch, a ___________ __________ occurs.

4. Explain how a fuse protects against an overload.

__________________________________________________________________________
__________________________________________________________________________

5. In your own words, explain the difference between a nontime-delay fuse and a time-delay fuse.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

6. Which NEMA type enclosure is best suited for outdoor use? In your own words, explain why.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

7. When a safety switch is opened, an arc is formed between the knife blade and the ___________ __________. When the blade moves far enough away to extinguish the arc, it is at the ___________ __________.
There are two families of safety switches: general duty and heavy duty. These two classifications are based on the safety switch’s ratings and the fuse ratings utilized in them. They are placed in a particular family based on the following ratings:

- Amperes
- Voltage
- *Dual Horsepower Rating*
- Ampere Interrupting Capacity
- Number of Poles

We have explained all the above characteristics in Section 3 except for dual horsepower rating. In motor applications, all safety switches have a standard and a maximum horsepower rating. This is called a dual horsepower rating.

Consider a safety switch with a standard rating of 5 HP and a maximum rating of 15 HP. The standard rating of 5 HP is applied when used with non-time delay fuses. Conversely, the maximum rating of 15 HP is applied when used with time-delay fuses.

This chart shows the typical available horsepower ratings for safety switches.

<table>
<thead>
<tr>
<th>Enclosed Switch Type</th>
<th>Voltage</th>
<th>Maximum Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Duty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240 AC</td>
<td></td>
<td>1.5 – 200 HP</td>
</tr>
<tr>
<td>250 DC</td>
<td></td>
<td>5 – 50 HP</td>
</tr>
<tr>
<td><strong>Heavy Duty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240 AC</td>
<td></td>
<td>1.5 – 250 HP</td>
</tr>
<tr>
<td>600 AC</td>
<td></td>
<td>3 – 500 HP</td>
</tr>
<tr>
<td>250 DC</td>
<td></td>
<td>5 – 50 HP</td>
</tr>
</tbody>
</table>
Applications and Ratings  A general duty safety switch is used primarily for residential or light commercial applications. The maximum voltage is 240 volts. Typical applications for general duty safety switches include:

- Residential service entrance
- Outdoor shut-off for residential air conditioning unit
- Temporary service at a construction site
- Outbuilding sub-feed

Below is a characteristic chart of a typical general duty single throw safety switch:

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Voltage</th>
<th>Fusible?</th>
<th>Fuse Type</th>
<th>Amp Rating</th>
<th>Poles</th>
<th>Enclosure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Duty Single Throw</td>
<td>Maximum 240 VAC Horsepower</td>
<td>Fusible</td>
<td>Plug</td>
<td>30</td>
<td>1</td>
<td>NEMA Type 1</td>
</tr>
<tr>
<td></td>
<td>Rated</td>
<td></td>
<td>Cartridge Class H</td>
<td>30, 60, 100, 200, 400, 600</td>
<td>2, 3</td>
<td>NEMA Type 1, NEMA Type 3R</td>
</tr>
<tr>
<td>Non-Fusible</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>2</td>
<td>NEMA Type 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>NEMA Type 3R</td>
</tr>
</tbody>
</table>

The maximum AIC rating below 100 amps is 10,000. In the 100-600amp range, the AIC can be 100,000 amps if Class R fuses are used.

When selecting a general duty safety switch for an application, there are many options to consider. Work with the customer to choose the safety switch that best suits the needs of the application.
SAFETY SWITCHES

Air Conditioner Disconnect

The air conditioner disconnect is a special type of general duty safety switch. It is used exclusively on air conditioners and heat pumps. Features include:

- NEMA Type 4 watertight enclosure
- Pullout block (instead of operating handle) used to make and break circuit
- Pullout is available as 30 and 60 amp fusible and 60 amp non-fusible
- Typically maximum 240 VAC

The owner of this house just had central air conditioning installed.

The box you see on the outside of the house is an air conditioner disconnect enclosure. It contains a pullout fuse block to remove power to the air conditioning unit.

A branch circuit from the house’s loadcenter, shown in the cutaway area, supplies power to the pullout fuse block and the air conditioner.

FIGURE 19. AIR CONDITIONER DISCONNECT

IN THE WORKPLACE

USING AN AIR CONDITIONER DISCONNECT
SAFETY SWITCHES

HEAVY DUTY SAFETY SWITCHES

Heavy duty safety switches are used primarily for commercial and industrial applications where they are manually operated on a repeat basis. They are built more rugged and cost more than comparable general duty safety switches. They can handle up to 600 volts.

Typical applications for heavy duty safety switches include:

- Turning on/off power to a motor
- Disconnecting power to an area of a plant, an assembly line or set of machines
- Controlling power to remote locations

When selecting a heavy duty safety switch for an application, there are many options to consider. Work with the customer to choose the safety switch that best suits the needs of the application.

Below is a characteristic chart of a typical heavy duty single throw safety switch:

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Voltage</th>
<th>Fusible?</th>
<th>Fuse Type</th>
<th>Amp Rating</th>
<th>Poles</th>
<th>Enclosure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Duty Single Throw</td>
<td>Maximum 600 VAC Horsepower Rated</td>
<td>Fusible</td>
<td>Cartridge Class H</td>
<td>30 60 100 200 400 600 800 1200</td>
<td>2 3 4</td>
<td>NEMA Type 1 NEMA Type 3R NEMA Type 12(^1) NEMA Type 4(^2) NEMA Type 4X(^3)</td>
</tr>
<tr>
<td>Non-Fusible</td>
<td></td>
<td>---</td>
<td>---</td>
<td>30 60 100 200 400 600 800 1200</td>
<td>2 3 4</td>
<td>NEMA Type 1 NEMA Type 3R NEMA Type 12(^1) NEMA Type 4(^2) NEMA Type 4X(^3)</td>
</tr>
</tbody>
</table>

\(^1\)30-800 amps only
\(^2\)400-800 amps only
\(^3\)NEMA Type 4X available in stainless steel up to 800 amps, and non-metallic up to 200 amps

Heavy duty safety switches can be used in applications where available fault current is 200,000 amps or less. The safety switch will be AIC rated at 100,000 amps when used with J or R type fuses. With applications utilizing 400-1200 amps, the safety switches can be rated at 200,000 when using J, L, or R type fuses.
The heavy duty double throw switch is a special type of heavy duty safety switch. It is used to transfer service from a normal power source to an alternate source, or to switch from one load circuit to another.

Consider the motor in Figure 20. Using a double throw switch, the motor can be connected to either power supply A or power supply B.

The handle has three positions. In the center position, the switch is off, and no power flows to the motor. In the top position, the motor connects to power supply A. In the bottom position, the motor connects to power supply B.

Below is a characteristic chart of a typical heavy duty double throw safety switch:

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Voltage</th>
<th>Fusible?</th>
<th>Fuse Type</th>
<th>Amp Rating</th>
<th>Poles</th>
<th>Enclosure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Duty Double Throw</td>
<td>Maximum 600 VAC</td>
<td>Fusible</td>
<td>Cartridge Class H</td>
<td>30 60</td>
<td>2</td>
<td>NEMA Type 1</td>
</tr>
<tr>
<td>Horsepower Rated</td>
<td>100 200</td>
<td></td>
<td></td>
<td>400</td>
<td>3</td>
<td>NEMA Type 3R</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NEMA Type 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NEMA Type 4X</td>
</tr>
<tr>
<td>Non-Fusible</td>
<td>30 60</td>
<td>---</td>
<td></td>
<td>100 200</td>
<td>2</td>
<td>NEMA Type 1</td>
</tr>
<tr>
<td></td>
<td>400 600</td>
<td></td>
<td></td>
<td>800</td>
<td>3</td>
<td>NEMA Type 3R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>NEMA Type 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>NEMA Type 4X</td>
</tr>
</tbody>
</table>

1 Up to 200amps
2 Up to 400amps
The six pole switch is a specialized type of heavy duty safety switch. This type of switch is required where an “in sight” disconnecting means is required for two-speed motors that are remote from their motor control devices.

When selecting a six-pole switch for an application, there are many options to consider. Work with the customer to choose the safety switch that best suits the needs of the application.

Below is a characteristic chart of a typical heavy duty six pole safety switch:

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Voltage</th>
<th>Fusible?</th>
<th>Fuse Type</th>
<th>Amp Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Duty Six Pole</td>
<td>Maximum 600 VAC</td>
<td>Fusible</td>
<td>Cartridge Class H</td>
<td>30, 60, 100, 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Fusible</td>
<td></td>
<td>30, 60, 100, 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NEMA Type 3R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NEMA Type 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NEMA Type 4X</td>
</tr>
</tbody>
</table>

FIGURE 21. SIX-POLE DISCONNECT
There are many different configurations for a safety switch. To understand them, the terms pole and solid neutral need to be explained. Safety switches can have 1 to 6 poles, but never any more than one neutral. A pole refers to the number of wires a safety switch disconnects at one time. The pole is a “hot” wire, meaning it has current going through it. A solid neutral, on the other hand, has no power going through it, and is tied to ground at some point in the electrical system. Depending on the application, the safety switch can provide fuse protection for the poles as well as switch them on and off.

Below are examples of two different safety switches configurations.

![Diagram of two safety switches configurations](image)

The switch on the left has two poles that are fused and can be switched on and off. This is called a two-pole, two-fuse safety switch.

The switch on the right has one pole that is fused and can be switched on and off. It also has a solid wire with a box around it. This represents a solid neutral (S/N). This switch is called a two wire safety switch.

The connected load and the power supply are used to determine the circuit configuration required. Consider a three-phase motor connected to a three-phase power supply. This arrangement requires a three-pole, three-fuse safety switch.

![Diagram of a three-phase motor](image)
SAFETY SWITCHES

The following drawings illustrate typical circuit configurations for general duty and heavy duty safety switches.

- **TWO WIRE** (GENERAL DUTY ONLY)
- **TWO-POLE, TWO -FUSE** (GENERAL AND HEAVY DUTY)
- **TWO-POLE, TWO -FUSE AND SOLID NEUTRAL** (GENERAL AND HEAVY DUTY)
- **THREE-POLE, THREE -FUSE** (GENERAL AND HEAVY DUTY)
- **THREE-POLE, THREE -FUSE AND SOLID NEUTRAL** (GENERAL AND HEAVY DUTY)
- **FOUR-POLE, FOUR-FUSE** (HEAVY DUTY ONLY)
- **TWO-POLE NON-FUSIBLE** (GENERAL DUTY ONLY)
- **THREE-POLE NON-FUSIBLE** (GENERAL DUTY ONLY)

**FIGURE 24 TYPICAL SAFETY SWITCH CIRCUIT CONFIGURATIONS**
Now you are ready to help a customer select a safety switch for an application.

Simply conduct a short interview with your customer to obtain the information you need. Follow the flowchart below as you interview the customer. It contains all the key questions to be asked and data to be gathered to assist you in making a recommendation.

**FIGURE 25. SAFETY SWITCH SELECTION FLOWCHART**
SAFETY SWITCHES

REVIEW 2

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

1. General duty switches have a maximum fault current of ________ amps.

2. In your own words, explain the difference between a two-pole, two fuse switch and a two-wire switch.

   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

3. List three typical applications for a general duty safety switch.

   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

4. An air conditioner disconnect uses a ________ ________ instead of an operating handle.

5. A double throw switch has ___ positions and is off when it is in the __________ position.

6. List the two main questions you must ask a customer about an application.

   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
**GLOSSARY**

**Ampere Interrupting Capacity (AIC)**
A fuse rating that establishes the level of fault current it can interrupt. In an application, a fuse must be able to sustain the application’s largest potential short circuit current.

**Ampere Rating**
A rating of a fuse’s continuous current-carrying capability.

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

**Break Distance**
The point at which the arc is extinguished.

**Circuit Breaker**
An electrical safety device. When the current passing through it exceeds a certain amperage, the breaker trips, breaking the circuit.

**Clearing Time**
The amount of time a fuse takes to blow. This amount of time is inversely related to the level of overcurrent.

**Current Limiting Fuse**
A type of fuse that incorporates features or dimensions for the rejection of another fuse of the same ampere rating, but with a lower interruption rating.

**Double Throw**
A safety switch type that switches two loads or power supplies.

**Dual Horsepower Rating**
A safety switch rating of its standard and maximum horsepower ratings.

**Element**
The part of a fuse that melts to break the circuit. Typically, it is a thin strip of metal.

**End Blade**
A type of cartridge fuse where the terminals resemble blades. It is meant to be installed by sliding the blade terminals into slots.

**Fault Current**
The current that may flow in any part of a circuit under specific abnormal conditions.

**Ferrule**
Another name for end blades.

**Fuse**
An electrical safety device. When the current passing through it exceeds a certain amperage, the element melts, breaking the circuit.

**Fusible**
Capable of being fused or melted by heat. A fusible safety switch uses a fuse.

**General Duty Safety Switch**
A safety switch used primarily for residential or light commercial applications.
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy Duty Safety Switch</strong></td>
<td>A safety switch used primarily for commercial and industrial applications.</td>
</tr>
<tr>
<td><strong>Knife Blade</strong></td>
<td>The hinged movable contact in a safety switch that actually makes and breaks the circuit. So named for its shape.</td>
</tr>
<tr>
<td><strong>National Electrical Code</strong></td>
<td>Abbreviated NEC. Regulations governing construction and installation of electrical wiring and components.</td>
</tr>
<tr>
<td><strong>NEMA</strong></td>
<td>Abbreviation for National Electrical Manufacturers Association. An organization of manufacturers of electrical products.</td>
</tr>
<tr>
<td><strong>Non-Fusible</strong></td>
<td>Not capable of being fused or melted by heat. A non-fusible safety switch does not use a fuse.</td>
</tr>
<tr>
<td><strong>Nontime-Delay Fuse</strong></td>
<td>A fuse type used in applications where high inrush currents do not occur. It is designed to blow as quickly as possible.</td>
</tr>
<tr>
<td><strong>Overload (or Overcurrent)</strong></td>
<td>A condition in which current is in excess of the normal load being drawn.</td>
</tr>
<tr>
<td><strong>Pole</strong></td>
<td>Refers to the number of wires that the switch disconnects at one time.</td>
</tr>
<tr>
<td><strong>Safety Switch</strong></td>
<td>A device used to open and close a circuit.</td>
</tr>
<tr>
<td><strong>Service Entrance</strong></td>
<td>The point at which electricity enters a building.</td>
</tr>
<tr>
<td><strong>Short Circuit</strong></td>
<td>An electrical fault created when two exposed conductors touch.</td>
</tr>
<tr>
<td><strong>Single Throw</strong></td>
<td>A safety switch type that switches one load.</td>
</tr>
<tr>
<td><strong>Solid Neutral</strong></td>
<td>Abbreviated S/N. A solid metal bar mounted within the safety switch enclosure, designed to accept incoming and outgoing neutral conductors. No current flows through it.</td>
</tr>
<tr>
<td><strong>Time-Delay Fuse</strong></td>
<td>Fuse type designed primarily for use in circuits containing motor loads. It has a time-delayed element to keep it from blowing under high inrush currents.</td>
</tr>
<tr>
<td><strong>Underwriters’ Laboratory</strong></td>
<td>Abbreviated UL. An independent laboratory that tests equipment to determine whether it meets certain safety standards when properly used.</td>
</tr>
<tr>
<td><strong>Voltage Rating</strong></td>
<td>A fuse rating for the level voltage it can handle. The voltage rating of a fuse must be at least equal to the circuit voltage. It can be higher than the circuit voltage, but never lower.</td>
</tr>
</tbody>
</table>
SAFETY SWITCHES

REVIEW 1
ANSWERS

1.  
   - a service entrance
   - a means of disconnection and fault protection for a motor circuit

2.  insulation failure

3.  short circuit

4.  When an overcurrent occurs, the temperature of the element rises. If the overload is sustained, the heat generated will quickly melt a segment of the element. This forms a gap in the circuit, stopping the flow of current.

5.  Answer should read something like “A nontime-delay fuse can usually hold 500% of its rating for about 0.25 seconds, making it suited for lighting and appliance applications. A time-delay fuse will allow 500% of the rated current for up to ten seconds, making it suited to accommodate the inrush of motor applications.”

6.  Answer should read something like “NEMA Type 3R Raintight. This enclosure type provides protection against falling rain and sleet, and damage from external ice formation, conditions typically found outdoors. It does not provide corrosion resistance, like the more expensive NEMA Type 4X, but this condition is not found in an outdoor setting.”

7.  stationary contact, break distance

REVIEW 2
ANSWERS

1.  100,000

2.  Answer should read something like “A two-pole, two-fuse safety switch has two poles that are fused and can be switched on and off. A two wire safety switch has one pole that is fused and can be switched on and off. It also has a solid neutral (S/N).”

3.  Any three of the following
   - Residential service entrance
   - Outdoor shut-off for residential air conditioning unit
   - Temporary service at a construction site
   - Outbuilding subfeed

4.  Pullout block

5.  3, center

6.  “Does the application require circuit protection?” and “Will the switch be used on a motor circuit?”