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Introduction

Welcome to another course in the STEP (**S**iemens **T**echnical **E**ducation **P**rogram) series, designed to prepare our distributors to sell Siemens Energy & Automation products more effectively. This course covers **Safety Switches** and related products.

Upon completion of **Basics of Safety Switches** you should be able to:

- Explain the need for circuit protection
- Identify fuse types and classes
- Explain the basic construction and operation of a Siemens safety switch
- Explain the operation and benefits of Siemens VBII Safety Switches and visible blade designs
- Identify various types of Siemens safety switches
- Explain the difference between fusible and non-fusible safety switches
- Identify circuit protection ratings for various types of Siemens safety switches
- Identify safety switch accessories

This knowledge will help you better understand customer applications. In addition, you will be better able to describe products to customers and determine important differences between products. You should complete **Basics of Electricity** before attempting **Basics of Safety Switches**. An understanding of many of the concepts covered in **Basics of Electricity** is required for **Basics of Safety Switches**.

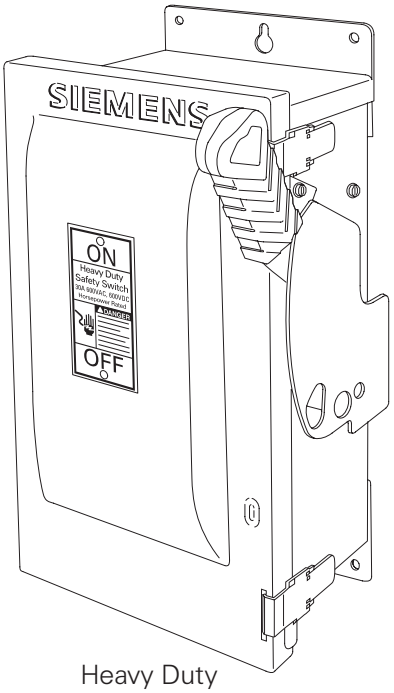
If you are an employee of a Siemens Energy & Automation authorized distributor, fill out the final exam tear-out card and mail in the card. We will mail you a certificate of completion if you score a passing grade. Good luck with your efforts.

Siemens Safety Switches

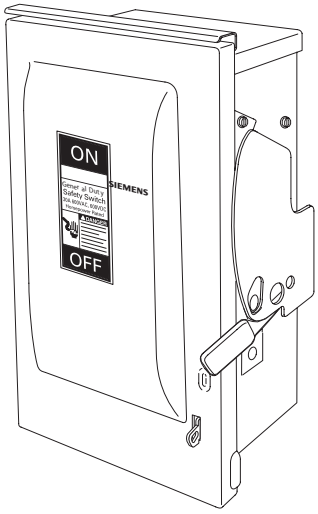
A **safety switch** is a common type of enclosed switch. Safety switches are generally used for two purposes:

1) As a disconnecting means for a service entrance
2) As a disconnecting means and fault protection for motors

The enclosure provides a degree of protection to personnel against incidental contact with live electrical equipment. It also provides protection to the enclosed equipment against specific environmental conditions. Safety switches may consist of a switch only or may consist of a switch and fuses. There are two families of Siemens safety switches: **general duty** and **heavy duty**.



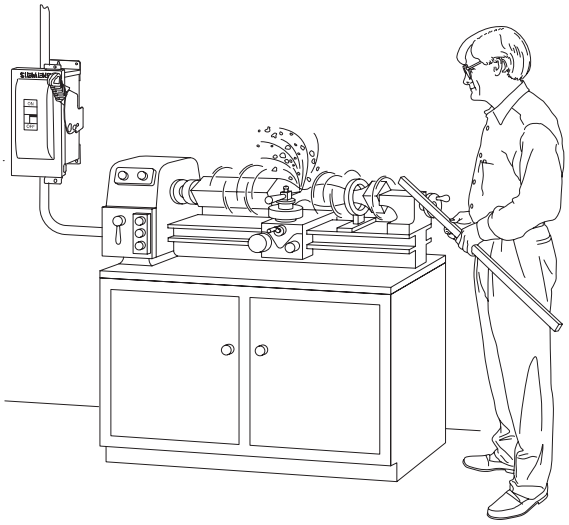
Heavy Duty



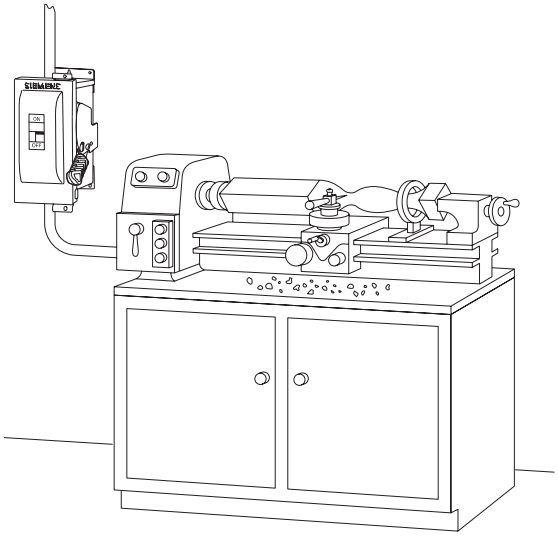
General Duty

Application

Safety switches can be used in any number of applications. The *National Electrical Code®* (*NEC®*), for example, requires that a disconnecting means shall be located in sight from the motor location and the driven machinery location (Article 430.102(B)). The *NEC®* defines "in sight" as visible and not more than 50 feet (15.24 m) distant (Article 100 - definitions). Regardless of where the safety switch is used, the function is to provide a means to connect and disconnect the load from its source of electrical power.



With power removed, the operator can safely service the machinery without coming into contact with live electrical components or having the motor accidently start.



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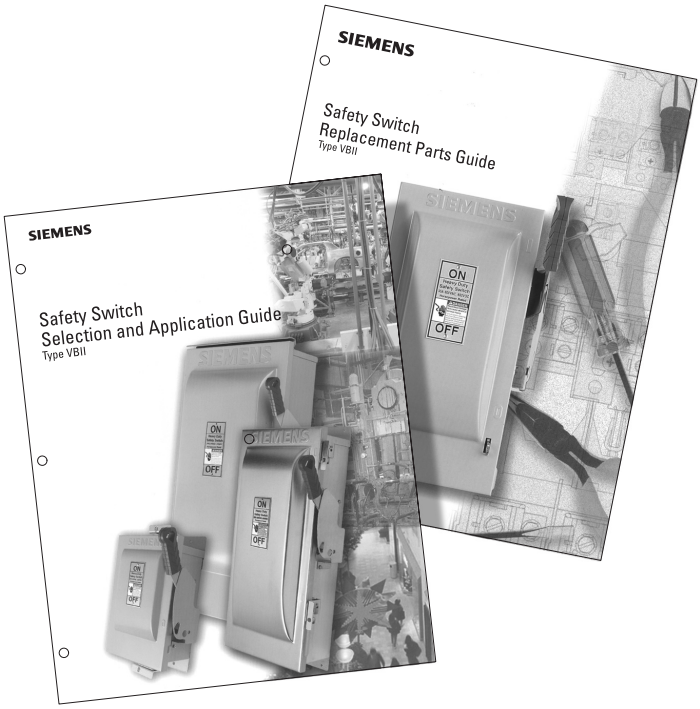
Additional Information

This book offers an introduction to Safety Switches, but more information is available from your local Siemens sales representative.



Among the booklets available are the **Safety Switch Application and Selection Guide**, the **Safety Switch Cross-Reference Guide**, and the **Safety Switch Replacement Parts Guide**.

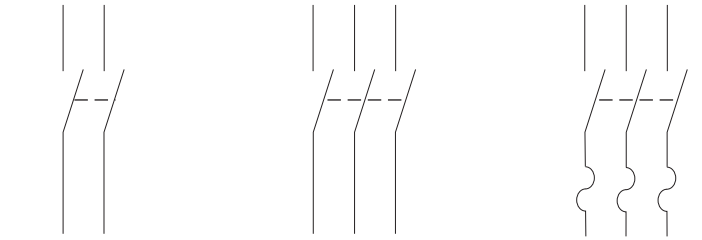
World Wide Web

Information is also available by visiting the Siemenes Energy & Automation web site, at **http://automation.usa.siemens.com**.

Switch Symbols

Switch Symbols

Symbols are used in a diagram to represent components. The symbols commonly used for a disconnect switch are shown below. The switch is normally shown in its "off" or "open" state.



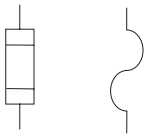
Two-Pole
Non-Fused Switch

Three-Pole
Non-Fused Switch

Three-Pole
Fused Switch

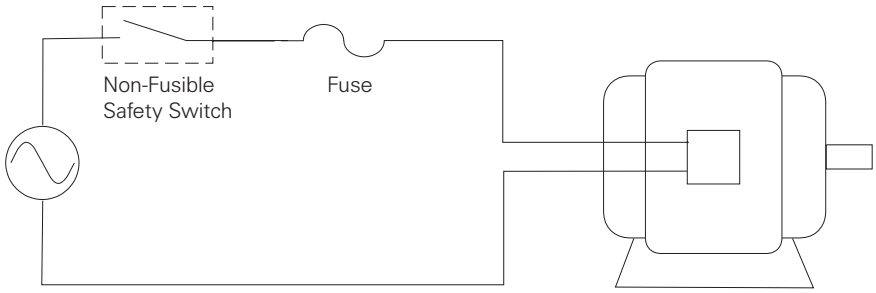
Fuse Symbols

Fuses are represented in an electrical circuit by either of the following symbols:



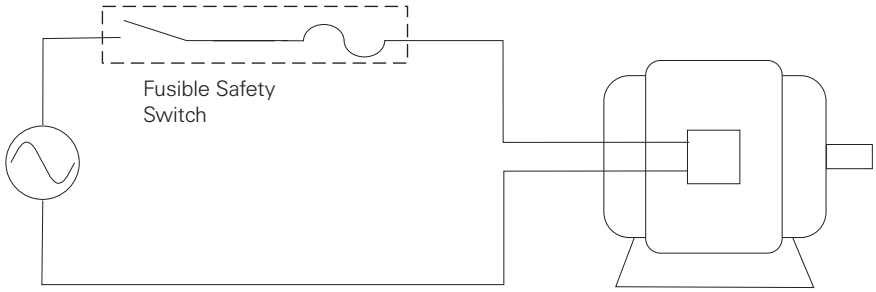
Non-Fusible Safety Switch

A safety switch with no associated fuses is referred to as a **non-fusible safety switch**. A non-fusible safety switch has no circuit protection capability. It simply provides a convenient means to open and close a circuit. Opening the circuit disconnects the load from its source of electrical power, and closing the circuit connects the load. Circuit protection must be provided by external overcurrent devices such as circuit breakers or fuses. In the following illustration, power is supplied to a motor through a non-fusible safety switch and a separate fuse.



Fusible Safety Switch

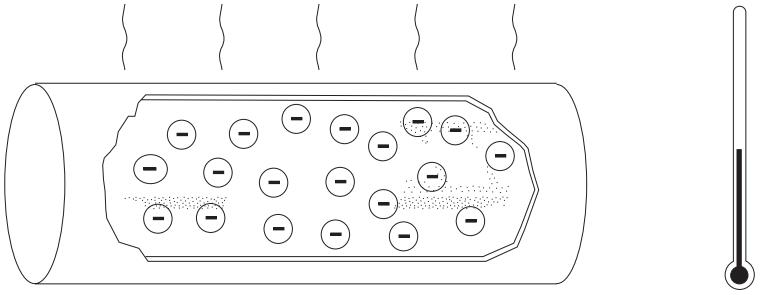
A safety switch can be combined with fuses in a single enclosure. This is referred to as a **fusible safety switch**. The switch provides a convenient means to manually open and close the circuit, and the fuse provides overcurrent protection.



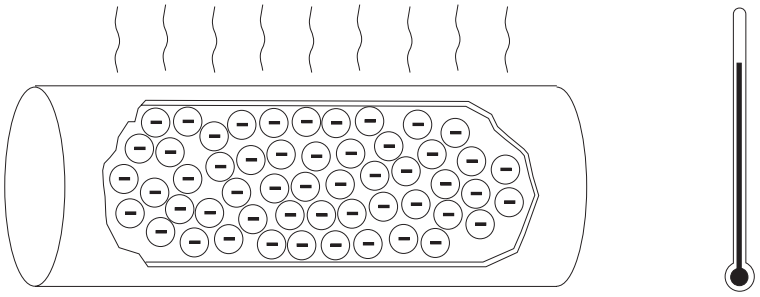
Need for Circuit Protection

Current and Temperature

Current flow in a conductor always generates heat. The greater the current flow in a given size conductor, the hotter the conductor. Excess heat is damaging to electrical components and conductor insulation. For this reason conductors have a rated continuous current carrying capacity, or ampacity. Overcurrent protection devices, such as fuses, are used to protect conductors from excessive current flow. Fuses are designed to keep the flow of current in a circuit at a safe level to prevent the circuit conductors from overheating.



Normal Current Flow

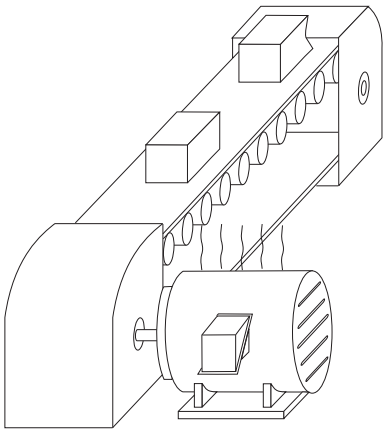


Excessive Current Flow

Excessive current is referred to as **overcurrent**. The *National Electrical Code®* defines overcurrent as *any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault* (Article 100-definitions).

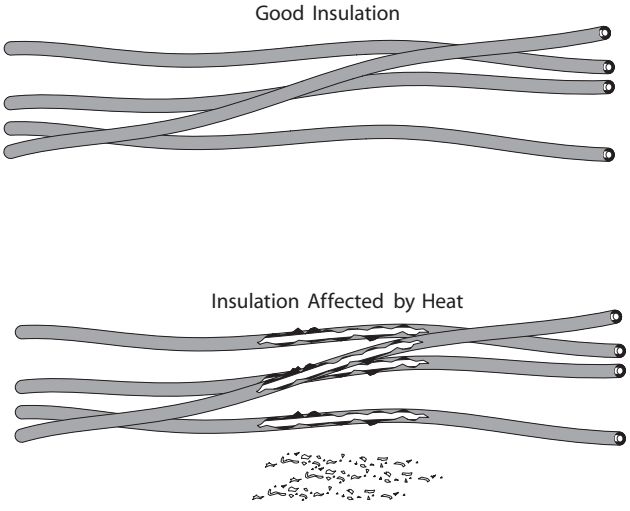
Overloads

An **overload** occurs when too many devices are operated on a single circuit, or when a piece of electrical equipment is made to work harder than it is designed to work. For example, a motor rated for 10 amperes may draw 20, 30, or more amperes in an overload condition. In the following illustration, a package has become jammed on a conveyor, causing the motor to work harder and draw more current. Because the motor is drawing more current, it heats up. Damage will occur to the motor in a short time if the problem is not corrected, or if the circuit is not shut down by the overcurrent protector.



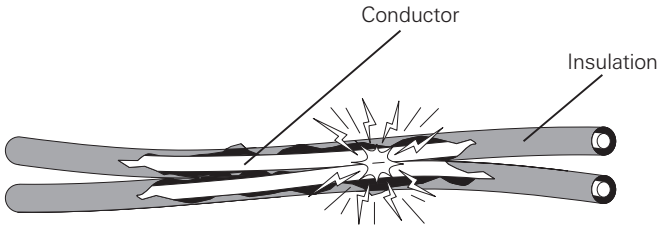
Conductor Insulation

Motors, of course, are not the only devices that require circuit protection for an overload condition. Every circuit requires some form of protection against overcurrent and the heat it produces. For example, high levels of heat to insulated wire can cause the insulation to break down and flake off, exposing the conductors.



Short Circuits

When exposed conductors touch, a **short circuit** occurs, and the circuit resistance drops to nearly zero. Because of this very low resistance, short circuit current can be thousands of times higher than normal operating current.



Ohm's Law shows the relationship of current, voltage, and resistance. For example, a 240 volt motor with 24 Ω (ohms) of resistance would normally draw 10 amperes of current.

$$I = \frac{E}{R}$$

$$I = \frac{240}{24}$$

$$I = 10\ A$$

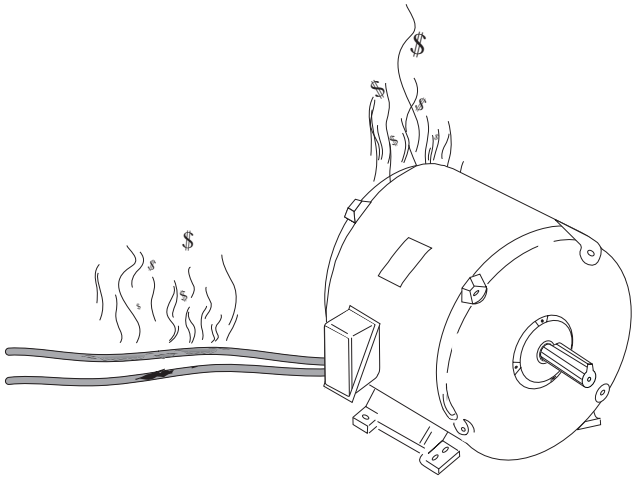
When a short circuit occurs, resistance drops dramatically. For example, if the above resistance dropped to 24 milliohms due to a short circuit, the current would increase to 10,000 amperes.

$$I = \frac{240}{.024}$$

$$I = 10{,}000\ A$$

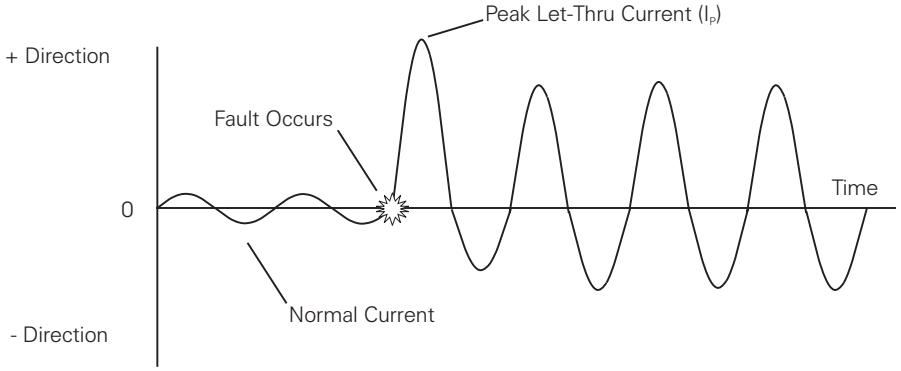
Preventing Damage

The heat generated by short-circuit current can rise to dangerous levels quickly, causing extensive damage to conductors and connected equipment. This heat-generating current must be interrupted as soon as possible after a short circuit occurs. Slight overcurrents can be allowed to continue for some period of time, but as the overcurrent magnitude increases, the protection device must act more quickly. In order to minimize costly damage, outright short circuits must be interrupted almost instantaneously.

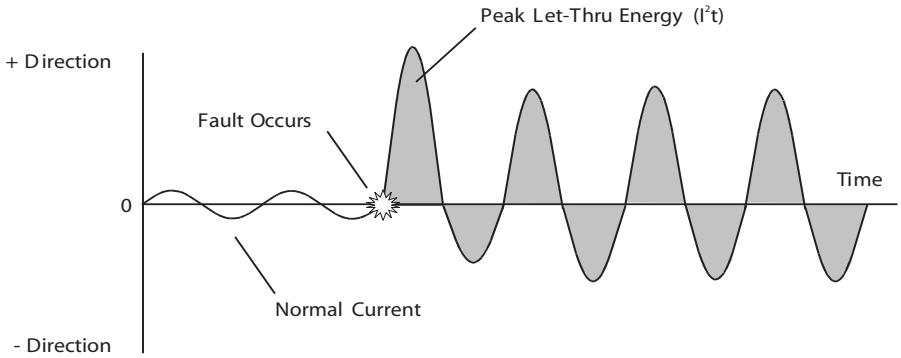


Short-Circuit Current in Unprotected Electrical Circuits

When a short circuit occurs in an unprotected circuit, current will continue to flow until the circuit is damaged, or until the power is removed manually. The peak short-circuit current of the first cycle is the greatest and is referred to as **peak let-through current (I_P)**. The electromagnetic force associated with this current can cause mechanical damage to electrical components.

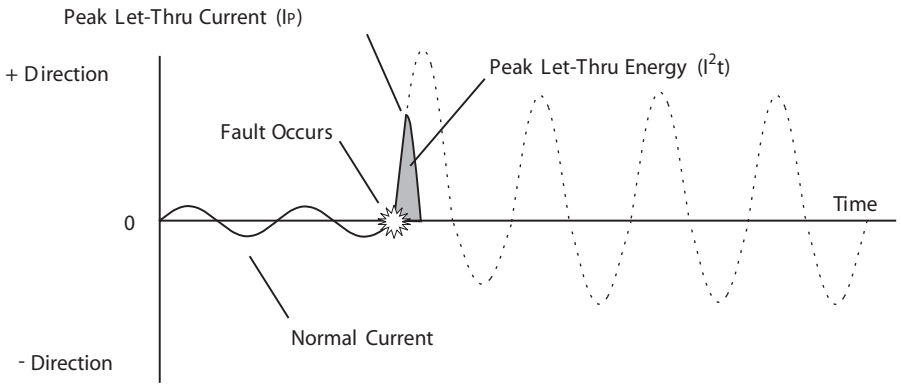


The **maximum destructive energy let-through (I^2t)** is a measure of the energy associated with this current. It is capable of producing enough heat to melt conductors.



Short-Circuit Current in Protected Electrical Circuits

A properly applied overcurrent protecting device will open the circuit quickly, limiting peak let-through current (I_P) and energy (I^2t).



Article 240

Article 240 of the *NEC®* covers overcurrent protection. You are encouraged to become familiar with this material. Article 240.1 (FPN) states that overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation.

Ampacities of Insulated Conductors

Conductors are rated by how much current they can carry continuously, known as **ampacity**. The following illustration is from NEC® Table 310.16. For example, a #8 American Wire Gauge (AWG) copper conductor with Type THW insulation is rated for 50 amperes at 75° C. A #1 AWG copper conductor with Type THW insulation rated at 75° C can carry 130 amperes. To avoid overloads and prevent insulation damage, it is necessary to keep the current from exceeding the conductor's continuous current rating.

Table 310.16 (partial). Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts, 60°C through 90°C (140°F through 194°F) Not More than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size	Temperature Rating of Conductor		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
AWG or kcmil	Types TW, UF	Types FEPW, RH, RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2
	COPPER		
18	—	—	14
16	—	—	18
14	20	20	25
12	25	25	30
10	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260

NEC® Table 1 of Table 310.16 gives ampacities under two conditions: 1) the raceway contains not more than three conductors, plus neutral, and 2) the ambient temperature is not more than 30° C (86° F). If either of these two conditions is exceeded, the values shown must be reduced using derating values provided by *NEC*® (not shown here).

Sizing Conductors and Overcurrent Devices

According to the *NEC®*, a continuous load is *a load where the maximum current is expected to continue for three hours or more* (Article 100 - Definitions). The *National Electrical Code®* provides an example of conductor sizing and the rating of overcurrent protective devices in Article 210.20(A), which has to do with branch circuits. The rating of a branch-circuit overcurrent device serving continuous loads, such as store lighting, shall be not less than the noncontinuous load plus 125% of the continuous load.

Exception: Circuits supplied by an assembly and overcurrent devices that are listed for continuous operation at 100% of their ratings. In this case, the continuous and noncontinuous loads are simply added.

In general, an electrical conductor must be capable of carrying 125% of the full-load current. In a branch circuit, continuous loads such as mercantile lighting must not exceed 80% of the circuit rating. If an electric lighting circuit, for example, had a continuous current rating of 100 amperes, then the conductor would be sized to carry at least 125 amperes. In this example 100 amperes (lighting circuit load) is 80% of 125 amperes (conductor ampacity).

Electric Lighting Circuit Rating = 100 amperes

Conductor Ampacity = 125 amperes (100 amperes x 125%)

There are exceptions and the *NEC®* must be consulted for each application. The exception given in the previous paragraph, for example, provides for 100% rating of a circuit if it is supplied by an overcurrent device and assembly rated for continuous operation. (This rating must be done by a qualified testing laboratory.)

For more information on conductor sizing, see *NEC®* Articles 210.19(A), 210.20(A), and 384.16(D) in the 2005 code book.

Review 1

1. A safety switch with fuses in a single enclosure is referred to as a _____ safety switch.

2. *NEC®* defines "in sight" as visible and not more than _____ feet distant.

3. With an increase in current, heat will _____.

   a. increase
   b. decrease
   c. remain the same

4. Two causes of overcurrent are _____ and _____ _____ .

5. A _____ _____ occurs when two bare conductors touch.

6. An _____ occurs when electrical equipment is required to work harder than it is rated.

7. The peak short circuit current of the first cycle is known as _____ _____ - _____.

8. Peak let-thru _____ is a destructive thermal force.

9. Article _____ of the *NEC®* covers overcurrent protection.

10. Table _____ of the *NEC®* gives ampacities of insulated conductors.

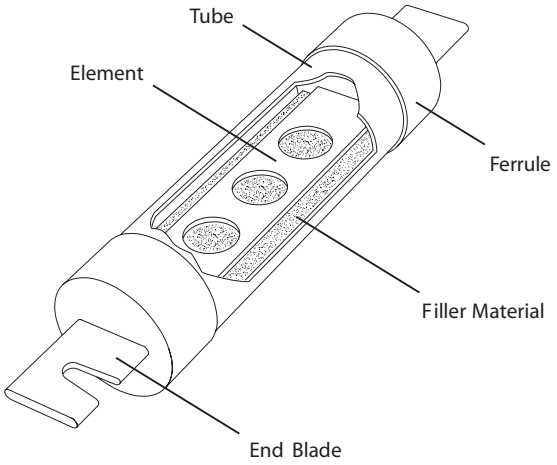
11. In general, the electrical conductor must be capable of carrying _____ % of the full-load current.

Fuses

Circuit protection would be unnecessary if overloads and short circuits could be eliminated. Unfortunately, they do occur. To protect a circuit against these destructive currents, a protective device automatically disconnects the electrical equipment from the power source when a fault condition occurs. A **fuse** is the simplest device for interrupting a circuit experiencing an overload or a short circuit.

Fuse Construction

A typical fuse, like the one shown below, consists of an element electrically connected to ferrules. These ferrules may also have attached end blades. The element provides a current path through the fuse. It is enclosed in a tube, and surrounded by a filler material.

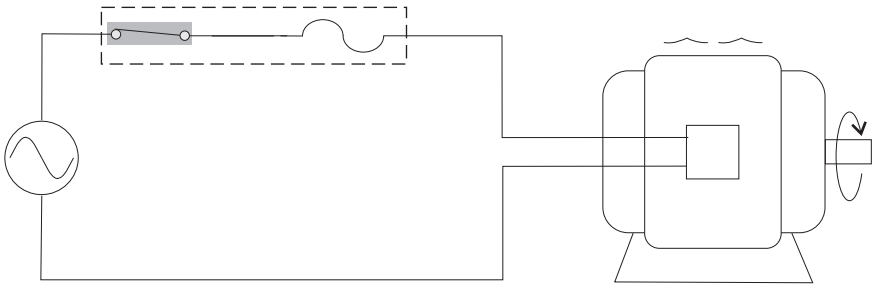


Closed Switch Symbol

As mentioned earlier, switches are normally shown in their "off" or "open" position. For the purpose of illustration, the following symbol can be used to show a switch closed, connecting the load to the power source. This is not a legitimate symbol. It is used here for illustrative purposes only.

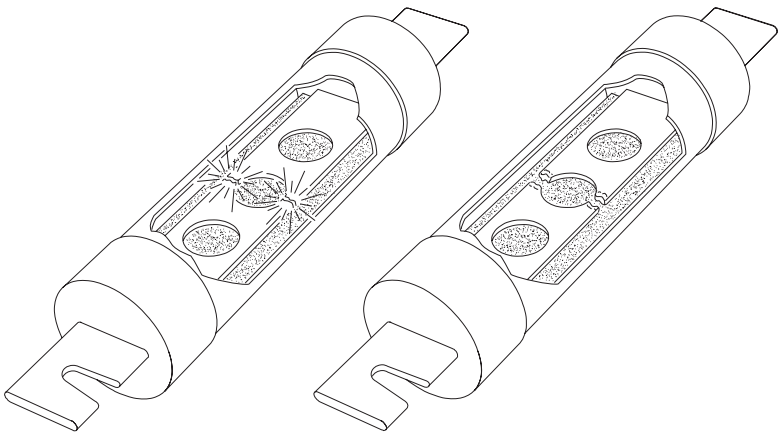
Using a Fuse in a Circuit

In the following example a motor is connected to a voltage source through a fusible safety switch. The switch and fuse function as part of the conductor supplying power to the motor.



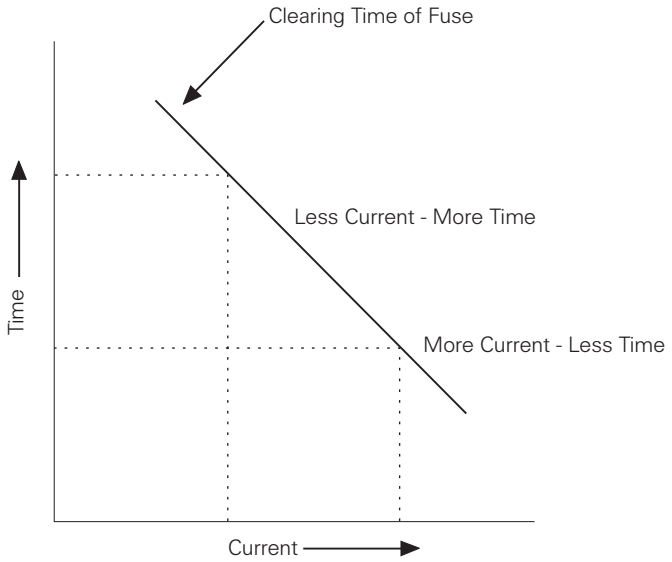
Fuse Subject to Overcurrent

Current flowing through the fuse element generates heat, which is absorbed and dissipated by the filler material. When an overcurrent occurs, temperature in the element rises. In the event of a transient overload condition, the excess heat is absorbed by the filler material. However, if a sustained overload occurs, the heat will eventually melt open an element segment. This will stop the flow of current.



Fuse Clearing Time

Fuses have an inverse time-current characteristic. The greater the overcurrent, the less time it takes for the fuse to open. This is referred to as the **clearing time** of the fuse.

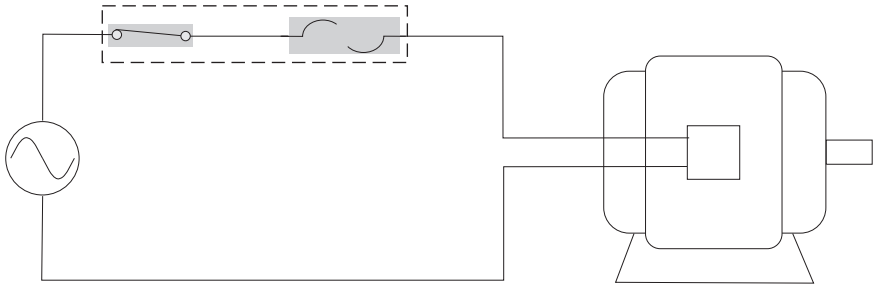


Open Fuse Symbol

For the purpose of explanation the following symbol is used to show an open fuse. This is not a legitimate symbol. It is used here for illustrative purposes only.

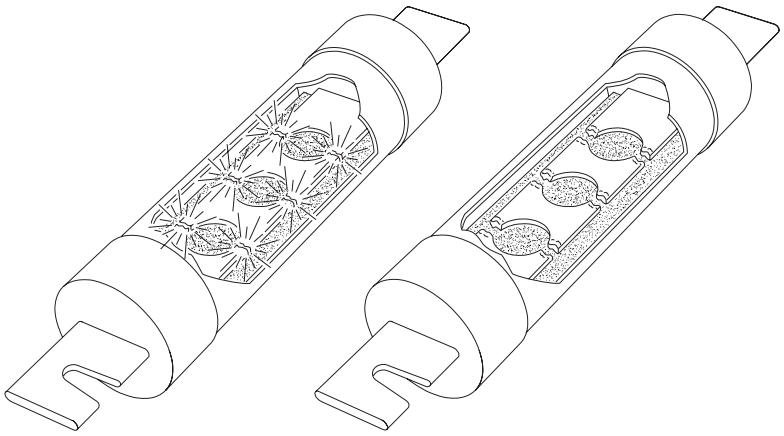
Overload Current

Returning to the example of a motor circuit, if an overload occurs, temperature will rise in the fuse. If the overload persists, the fuse will open. When the fuse opens, power will be removed from the motor, and the motor will coast to a stop.



Short-Circuit Current

Short-circuit current, which can be several thousand amperes, generates extreme heat. When a short circuit occurs, several element segments can melt simultaneously, which helps remove the load from the power source quickly. Short-circuit current is typically cut off in less than half a cycle, before it can reach its full value.



Nontime-Delay Fuses

Nontime-delay fuses provide excellent short circuit protection. However, short-term overloads, such as motor starting current, may cause nuisance openings of nontime-delay fuses. For this reason, they are best used in circuits not subject to large transient surge currents. Nontime-delay fuses usually hold 500% of their rating for approximately one-fourth of a second, after which the current-carrying element melts. This means that these fuses should not be used in motor circuits, which often have starting currents greater than 500%.

Time-Delay Fuses

Time-delay fuses provide both overload and short-circuit protection. Time-delay fuses usually allow five times the rated current for up to ten seconds. This is normally sufficient time to allow a motor to start without nuisance opening of the fuse. However, if an overload condition occurs and persists, the fuse will open.

Fuse Ratings and Classifications

Ampere Rating

Each fuse has a specific **ampere rating**, which is its continuous current-carrying capability. The ampere rating of the fuse chosen for a circuit usually should not exceed the current-carrying capacity of the circuit. For example, if a circuit's conductors are rated for 10 amperes, the largest fuse that should be selected is 10 amperes.

However, there are circumstances where the ampere rating is permitted to be greater than the current-carrying capacity of the circuit. For example, motor and welder circuit fuse ratings can exceed conductor ampacity to allow for inrush currents and duty cycles within limits established by the NEC®.

Voltage Rating

The **voltage rating** of a fuse must be at least equal to the circuit voltage. The voltage rating of a fuse can be higher than the circuit voltage, but never lower. A 600 volt fuse, for example, could be used in a 480 volt circuit, but a 250 volt fuse could not be used in a 480 volt circuit.

Ampere Interrupting Capacity (AIC)

Fuses are also rated according to the level of fault current they can interrupt. This is referred to as **ampere interrupting capacity (AIC)**. A fuse for a specific application should be selected so that it can sustain the largest potential short circuit current that could occur in the application. This is important because, if the fault current exceeded the interrupting ability of the fuse, the fuse could rupture and extensive damage could occur.

UL Fuse Classification

Fuses are grouped into **current limiting** and **non-current limiting** classes based on their operating and construction characteristics. Fuses that incorporate features or dimensions for the rejection of another fuse of the same ampere rating, but with a lower interruption rating, are considered current limiting fuses. Underwriters Laboratories (UL) establishes and standardizes basic performance and physical specifications in developing its safety test procedures. These specifications have resulted in distinct classes of low voltage fuses (600 volts or less). The following chart lists various UL fuse classes.

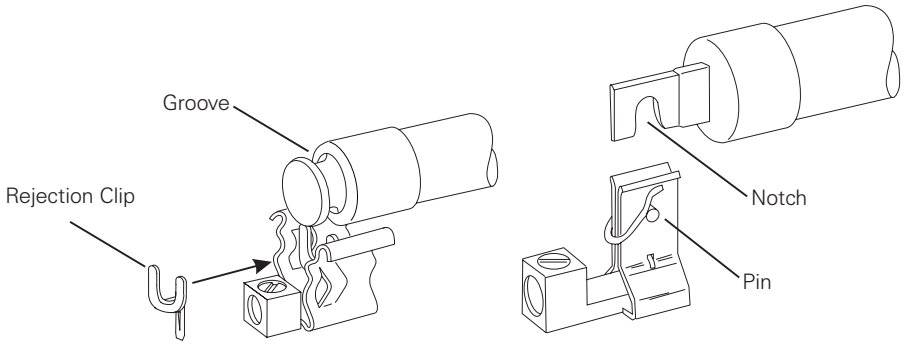
Fuse Ratings

Class	Amps	Volts	Dimensions	Int. Ratings	I^2t, I_p	Circuits
H	1-600A	250 and 600V	NEC standards	10,000A —	Less than 10,000A	General purpose circuits
K5*	1-600A	250 and 600V or less AC	Class H without rejection	100,000A	I^2t - RK5 up to 100A I_p - RK5 up to 100A	Feeder circuits
J	1-600A	600V or less	Diff. From Class H	200,000A	I^2t - Low I_p - Low	Main & feeder circuits
RK1	1/10-600A	600V or less 250 V or less	Class H with rejection feature	200,000A	I^2t - Slightly>J I_p - Slightly>J	Main & feeder circuits (motor load small percent)
RK5 (time delay)	1/10-600A	600V or less 250 V or less	Class H with rejection feature	200,000A	I^2t ->RK-1 I_p -RK-1	Motor starting currents
T	1-1200A	300V AC	Diff. From Class H	200,000A	I^2t - <J I_p - <J	Main & feeder circuits
T	1-800A	600V AC	Diff. From Class H	200,000A	I^2t - =J I_p - =J	Main & feeder circuits
L	601-6000A	600V or less	Bolt type	200,000A	I^2t - Low I_p - Low	Main & feeder circuits

* Class K5 fuses do not prohibit the use of Class H type fuses in a switch.

Class R Current Limiting Fuses

The following illustration shows Class R type fuse holders, which feature rejection clips or pins that permit only Class R fuses to be installed. This prevents installation of a fuse with a lower AIC rating, such as a Class H or K.



Ferrule Type
(60 A Max)

Blade Type
(61 - 600 A)

Review 2

1. Fuses have an _____ time-current characteristic.
2. A fuse can usually interrupt short-circuit current in less than _____ a cycle.
3. Nontime-delay fuses provide excellent _____ circuit protection.
4. _____ - _____ fuses provide overload and short circuit protection.
5. The continuous current carrying capability of a fuse is known as its _____ rating.
6. The voltage rating of a fuse can be _____ than the circuit voltage, but never _____ .
7. The interrupting rating of a Class R fuse is _____ amperes.

Enclosures

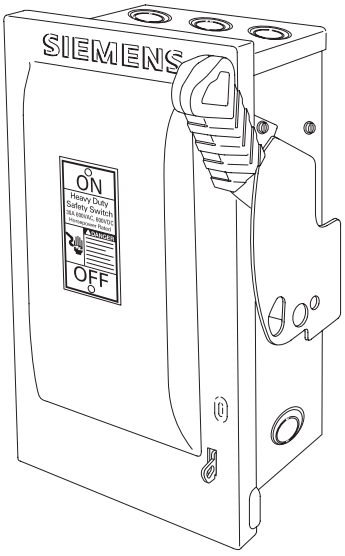
The *National Electrical Code®* defines an enclosure as *the case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage* (Article 100 - definitions). The *NEC®* definition references ANSI/NEMA standard 250.

In addition to ANSI/NEMA standard 250, published by American National Standards Institute and National Electrical Manufacturers Association, UL 50 and UL 508, published by Underwriters Laboratories Inc. are important standards for electrical equipment enclosures. These standards provide enclosure descriptions, features, and test criteria for hazardous (classified) and nonhazardous locations.

The following brief descriptions cover enclosures available for Siemens safety switches. Within the industry, it is common to refer to the enclosure type numbers as NEMA types, but these type numbers also apply to UL 50 and UL 508.

Type 1 Enclosures

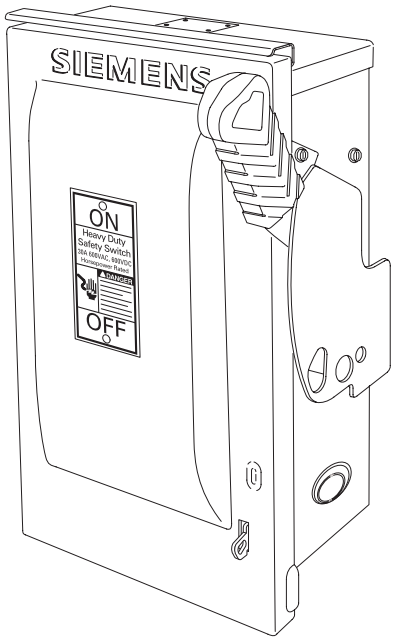
Type 1 enclosures are intended for indoor use primarily to provide protection against limited amounts of falling dirt and contact with the enclosed equipment in locations where unusual service conditions do not exist.



Type 1 Enclosure

Type 3R Enclosures

Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain and sleet. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing.



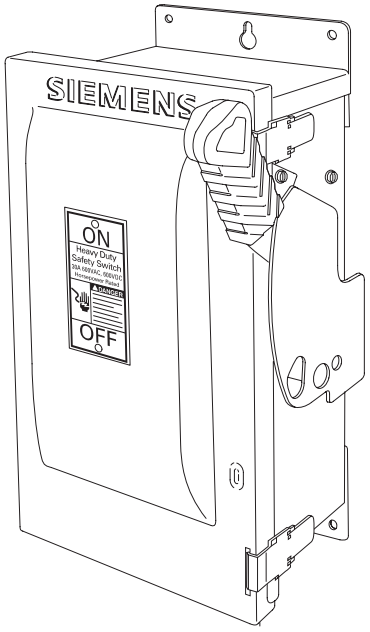
Type 3R Enclosure

Types 4 and 4X Enclosures

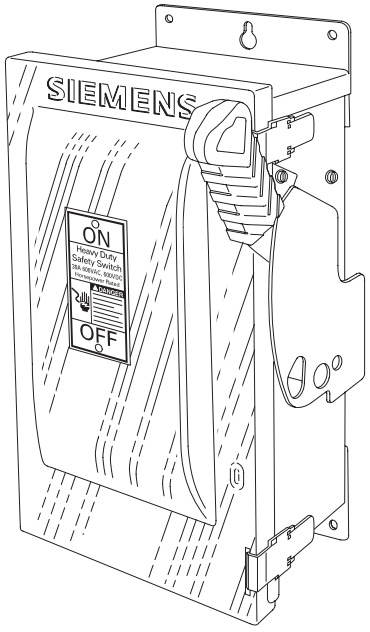
Type 4 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust, rain, splashing water, hose-directed water, and damage from external ice formations. They are not intended to provide protection against conditions such as internal condensation or internal icing.

Type 4X enclosures are made of a material such as stainless steel and are intended primarily to provide a high degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water.

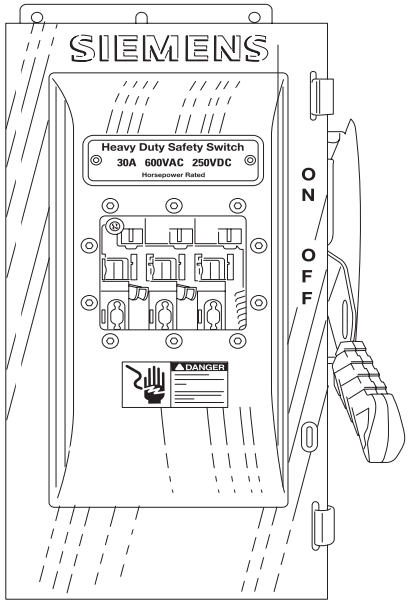
Siemens safety switches are also available in Type 4X stainless steel enclosures with a window to allow viewing of the visible blade position for switches with 30 to 400A ratings. The window also allows viewing of indicating fuses in 30 to 200A fusible switches.



Type 4



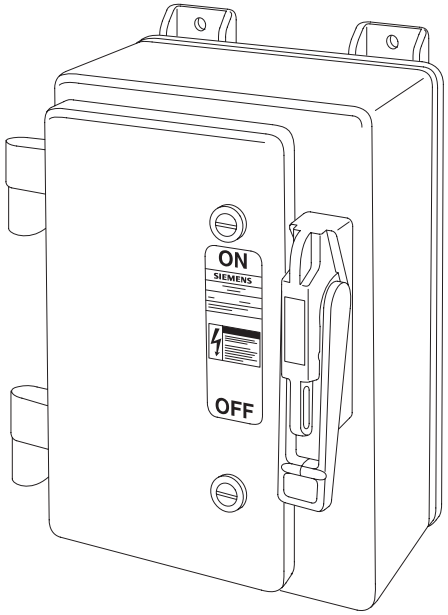
Type 4X Stainless



Type 4X Stainless
with Viewing Window

Non-Metallic 4X Enclosure

Another Siemens safety switch enclosure is a fiberglass-reinforced polyester version of the 4X enclosure. This **non-metallic 4X enclosure** has no external metal parts. It also features external mounting, a cover interlock, and a removable door for easier wiring.



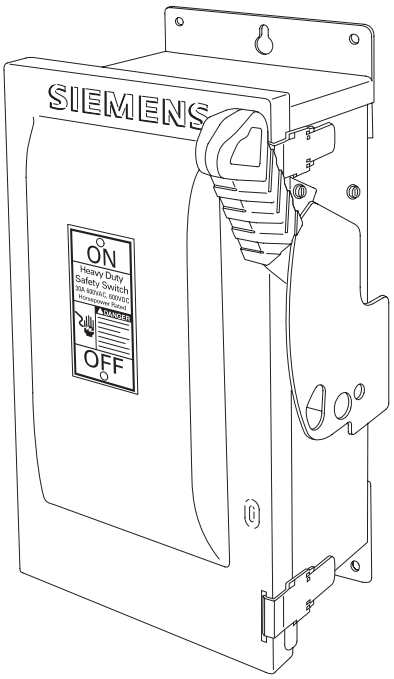
Type 4X Non-Metallic

Types 3S and 12 Enclosures

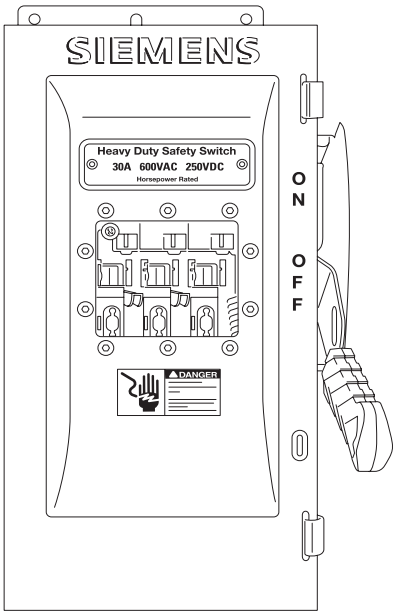
Type 3S enclosures are suitable for use in outdoor locations which require a degree of protection against windblown dust. They are intended to allow operation when ice laden, but are not intended to protect against condensation or internal icing.

Type 12 enclosures provide a degree of protection against dust, falling dirt, and dripping water in indoor locations, but are not intended to protect against conditions such as internal condensation.

Type 12 enclosures are also available with a window to allow viewing of the visible blade position for switches with 30 to 600A ratings and viewing of indicating fuses in 30 to 200A fusible switches.



Type 3S / 12 Enclosure

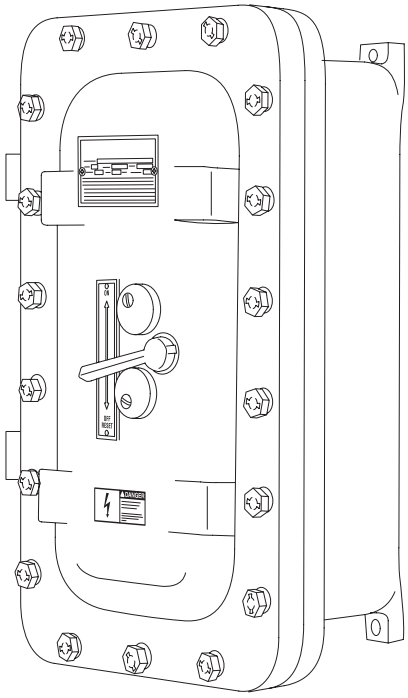


Type 3S / 12 Enclosure
with Viewing Window

Types 7 and 9 Enclosures

Type 7 enclosures are intended for indoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the *NEC®*.

Type 9 enclosures are intended for indoor use in locations classified as Class II, Groups E, F, or G, as defined in the *NEC®*.



Type 7 and 9 Enclosure

Hazardous Environments

Articles 500 through 504 of the *National Electrical Code®* cover the use of electrical equipment in locations where fire or explosions due to gas, flammable liquids, combustible dust, or ignitible fibers may be possible. While you should never specify a hazardous location, it is important to understand the regulations that apply. It is the user's responsibility to contact local regulatory agencies to define the location as Division I or II and to comply with all applicable codes.

Divisions

Division I refers to a situation where hazardous materials are normally present in the atmosphere. **Division II** identifies conditions where the atmosphere may become hazardous as a result of abnormal conditions. For example, if a pipe carrying a hazardous material developed a leak, the surrounding atmosphere could become hazardous.

Classes and Groups

Hazardous locations are further identified by class and group. **Class I, Groups A, B, C, and D** are chemical gases or liquids.

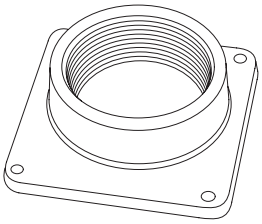
Class II, Groups E, F, and G include flammable dust.

Class III includes all ignitible fibers and lints such as clothing fiber in textile mills. Class III is not divided into groups.

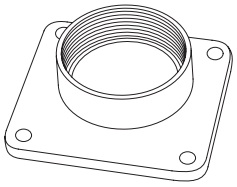
Group	Class I Groups A-D Gases and Liquids	Group	Class II Groups E-G Flammable Dust	Group	Class III Ignitable Fibers
A	Acetylene	E	Metallic Dust	na	Rayon
B	Hydrogen	F	Carbon Dust	na	Jute
C	Acetaldehyde Ethylene Methyl Ether	G	Grain Dust		
D	Acetone Gasoline Methanol Propane				

Hubs

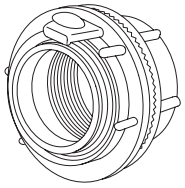
Various **hubs** are available for attaching cable conduit to the enclosures.



ECHV300
3" Conduit Hub
Type 3R Enclosure



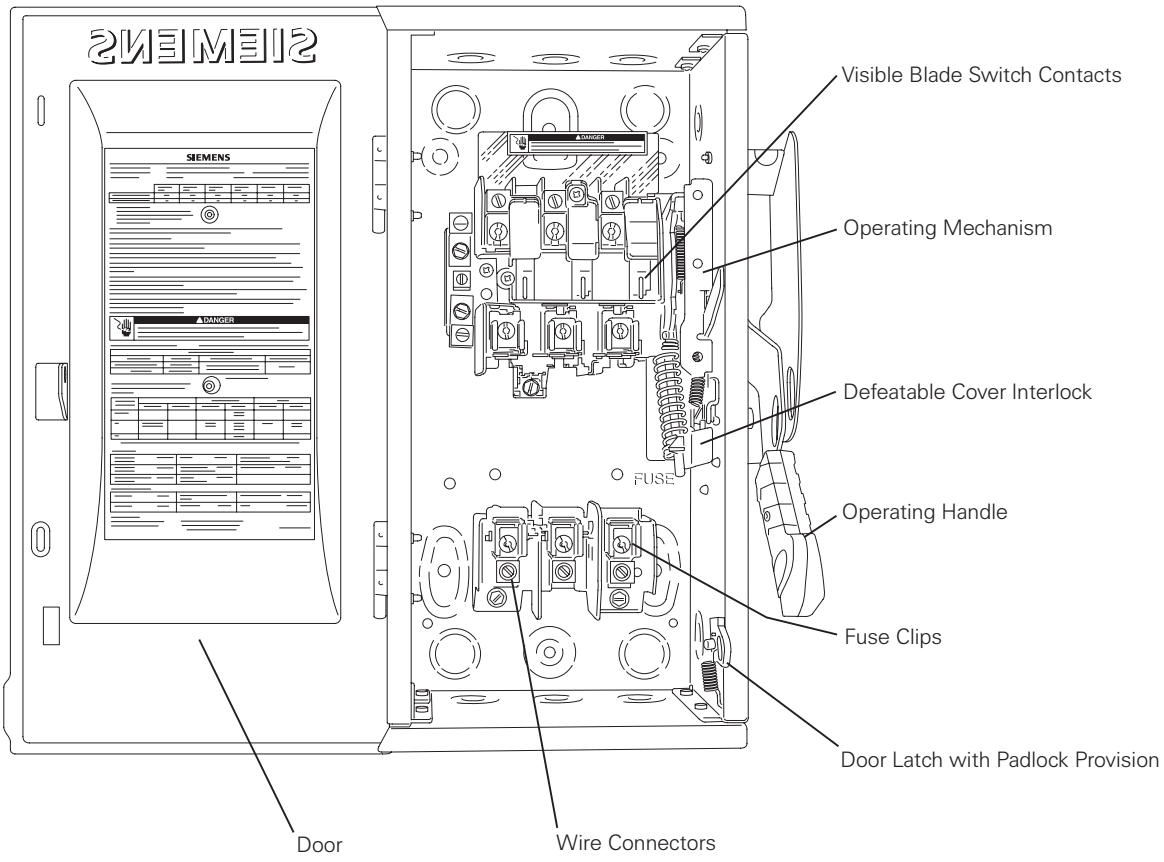
ECHS200
2" Conduit Hub
Type 3R Enclosure



SSH 150
1-1/2" Conduit Hub
Type 4 / 4X Enclosure

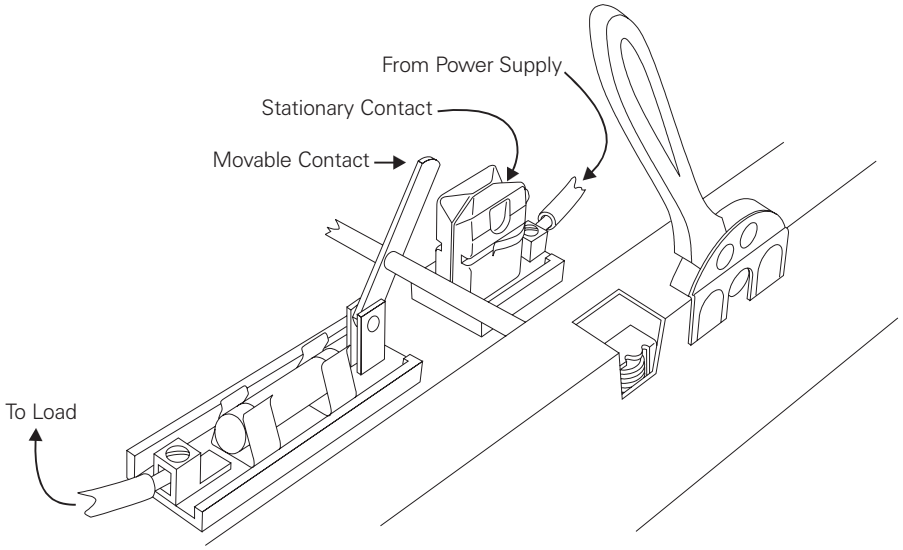
Switch Design

The enclosure houses the switch mechanism, wire connectors, and an operating mechanism. A handle, connected to the operating mechanism, opens and closes the visible blade contacts. If the switch is fusible, the enclosure also houses the fuse clips. Provisions have been made for locking the door and/or switch handle.

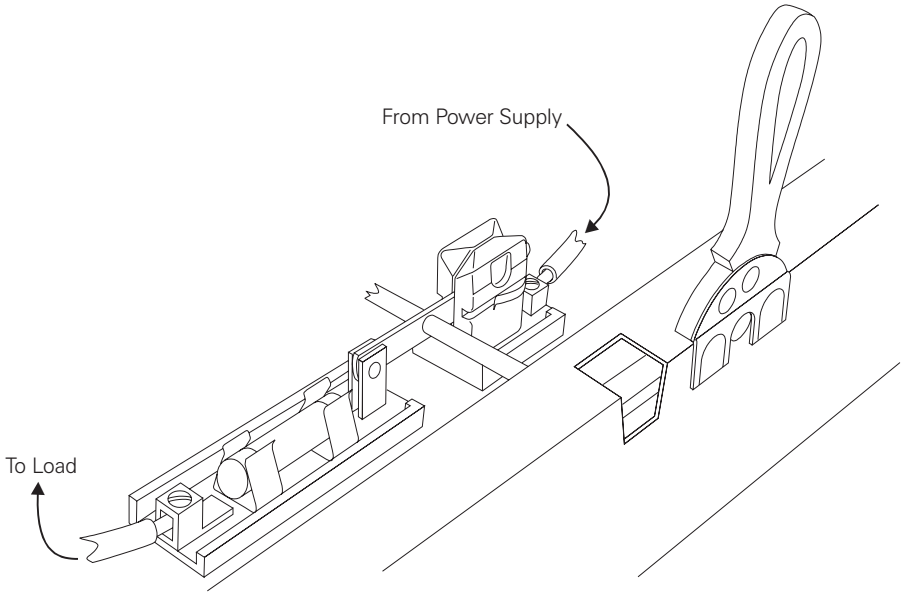


Knife Blade Switch Principle

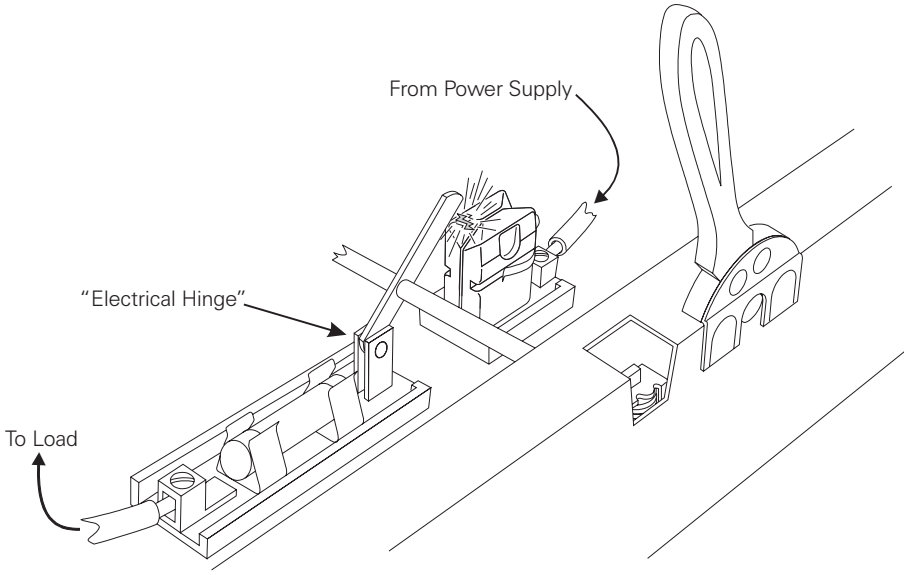
Switches use contacts to break the circuit and stop the flow of current. A typical switch assembly consists of a stationary contact, a hinged movable contact, and an operating handle. The hinged movable contact may also be referred to as a **knife blade**. If the movable contact is not touching the stationary contact, no current flows.



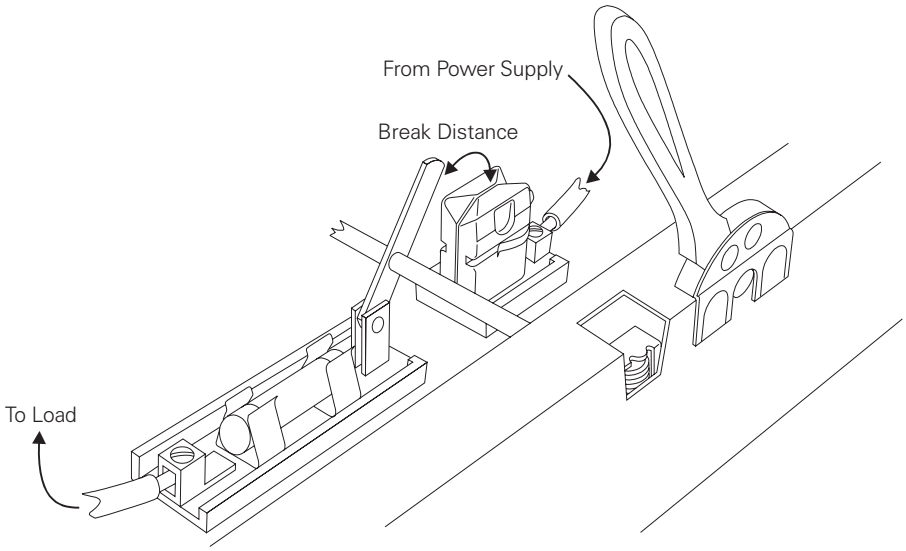
Moving the handle to the "on" position closes the contacts and provides a complete path for current to flow from the power supply to the load.



Moving the handle to the "off" position opens the contacts, interrupting the flow of electricity. As the contacts start to open, current continues to flow across the air gap between the two contacts in the form of an arc. Current continues to flow until the physical distance between the contacts is great enough to interrupt the flow of current.



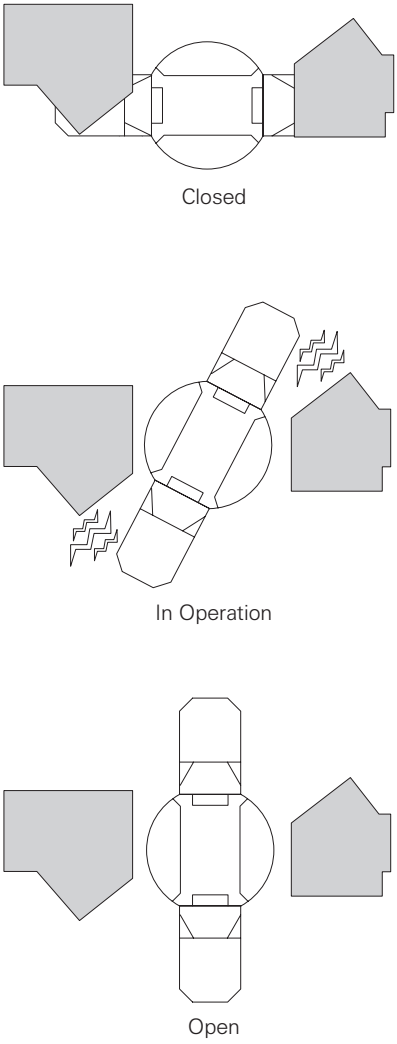
The point at which the arc is extinguished is called the **break distance**.



VBII Safety Switch Design

Unlike the knife-blade switch, the switching action of the Siemens 30-200A **VBII Safety Switch** breaks the arc in two places. As a result, two smaller arcs are created, and heat generation is reduced. The switching speed is also increased, since the breaking distance is effectively doubled. The overall result is enhanced performance and increased longevity.

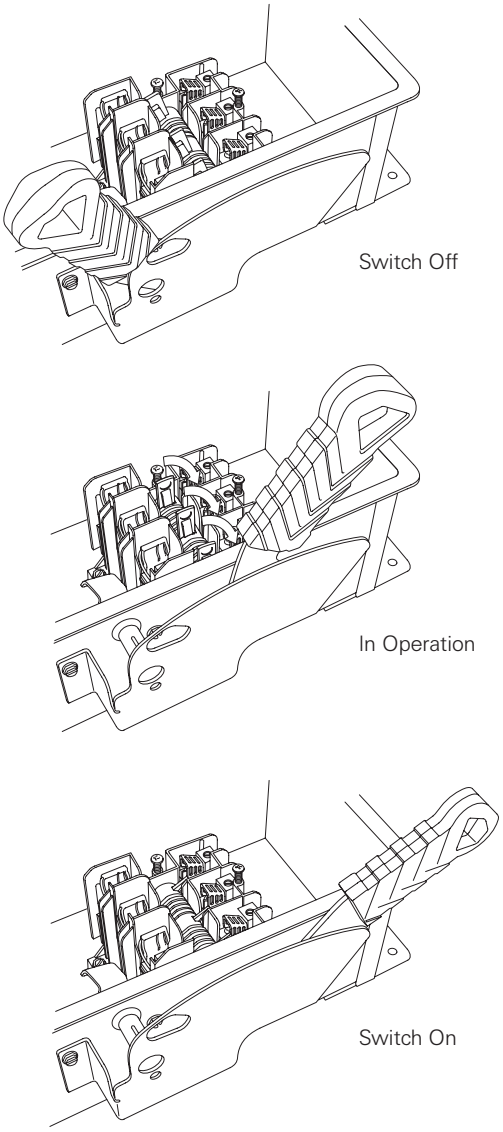
Also, in contrast to the knife blade switch, the VBII Safety Switch blades are self-aligning, ensuring positive contact. Furthermore, the electrical hinge, a wear and friction point, has been eliminated. The result is a fast, positive, and reliable switching action.



VBII Switch Action

Over-Center-Toggle Switch Action

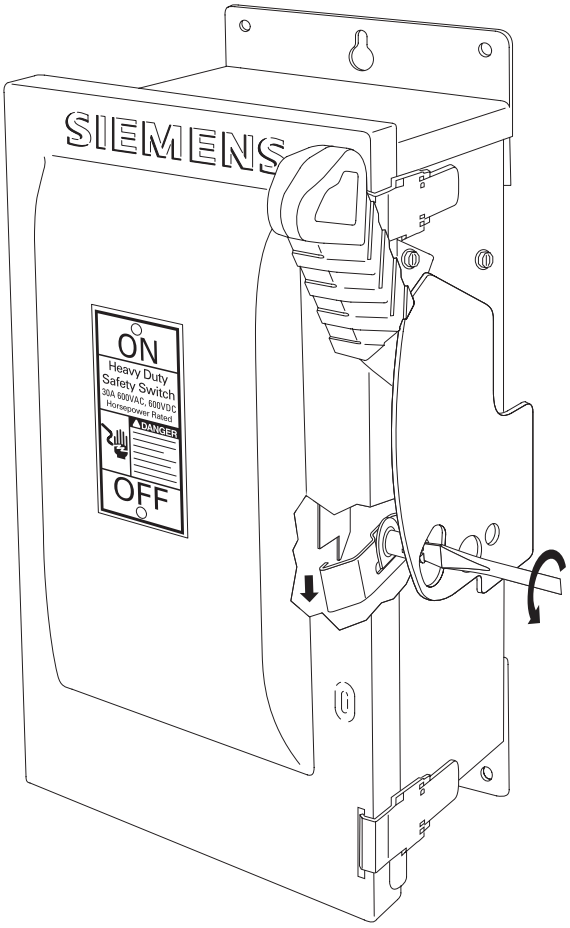
Another feature which enhances the speed of switching is the **over-center-toggle** design. During operation of the switch, as the handle is moved past the midpoint, the switch suddenly and rapidly snaps from off to on or from on to off, depending upon the direction of movement of the handle. Besides enhancing the switching speed, this also gives a positive feel to the switch operation.



VBII "Over-Center-Toggle" Action

Defeatable Cover Interlock

The VBII **cover interlock** prevents someone from opening the door while the switch is in the "on" position. Normally, the interlock also prevents someone from turning the switch on with the door open. However, for the purposes of testing or servicing, the door interlock is defeatable. As shown in the following illustration, this can be done with an ordinary screwdriver.



Review 3

1. Type _____ enclosures are intended for indoor use primarily to provide protection against contact with the enclosed equipment in locations where unusual service conditions do not exist.

2. Type _____ enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain and sleet.

3. Switches use _____ to break the circuit and stop the flow of energy.

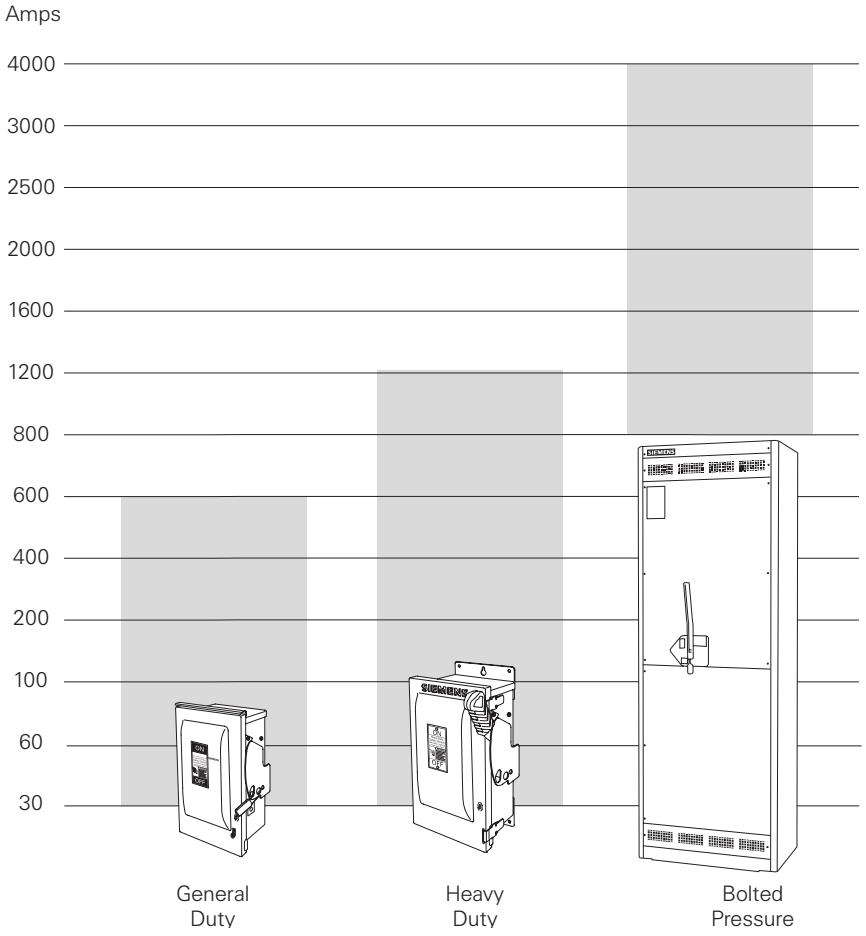
4. The VBII 30-200 A switch design breaks the arc in ____ _____ places, thereby reducing heat and switching time.

Safety Switch Ratings

Ampere Rating

Siemens safety switches are available in two types: **general duty** and **heavy duty**, both of which are listed by Underwriters Laboratories (UL). Every safety switch has a specific **ampere rating**, which is the maximum continuous current it can carry without causing deterioration or exceeding temperature rise limits.

General duty switches are available with ampere ratings of 30, 60, 100, 200, 400, and 600 amperes. Heavy duty switches are rated for 30, 60, 100, 200, 400, 600, 800, and 1200 amperes. Though not discussed in this course, bolted pressure switches with ampere ratings of 800, 1200, 1600, 2000, 2500, 3000, and 4000 amperes are also available.



Short Circuit Withstandability

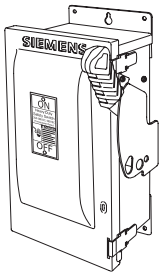
Safety switches must be capable of withstanding the largest potential short circuit current that can occur in the selected application. General duty switches have a maximum **short circuit withstandability** of 100,000 amperes, while the equivalent rating of heavy duty switches is 200,000 amperes.

Voltage Rating

Safety switches are also rated according to the maximum voltage they can handle. The **voltage rating** of the switch must be at least equal to the circuit voltage. In other words, it can be higher than the circuit voltage, but never lower. For example, a safety switch rated for 600 volts can be used on a 480 volt circuit, but a switch rated for 240 volts must not be used on a 480 volt circuit. The following chart reflects available voltage ratings.

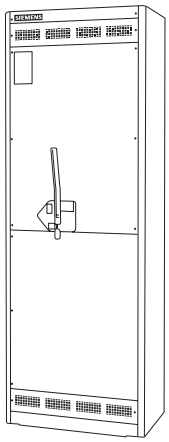
General Duty

240 VAC
250 VDC



Heavy Duty

240 VAC
600 VAC
600 VDC



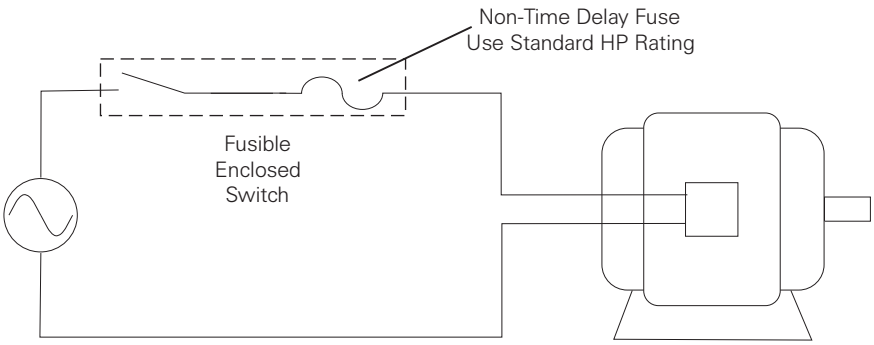
Bolted Pressure

240 VAC
480 VAC
600 VAC*

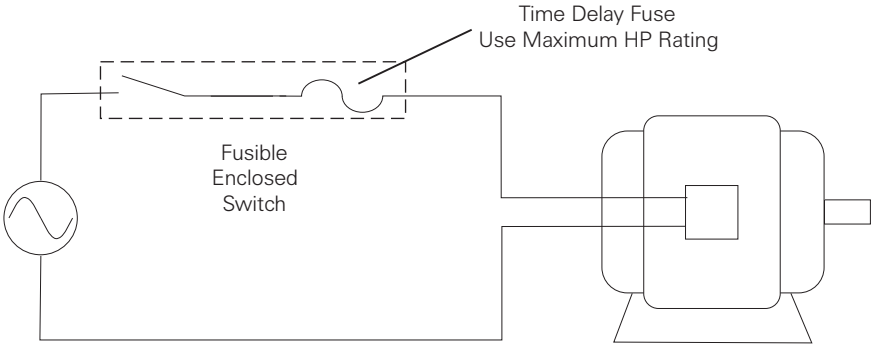
*600 VAC Bolted Pressure Switch is not UL Listed

Dual Horsepower Ratings

All Siemens safety switches have two horsepower ratings for motor applications. This is referred to as **dual horsepower rated**. For example, a switch might have a standard rating of 10 HP and a maximum rating of 30 HP. The standard rating, 10 HP, applies when non-time delay fuses are used.



The maximum rating of 30 HP applies when time delay fuses are used.

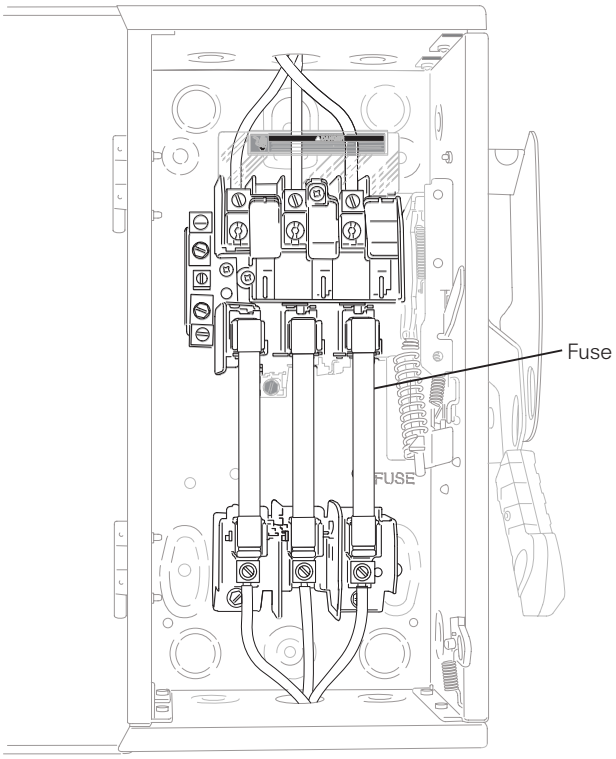


The following chart reflects the range of horsepower ratings for Siemens safety switches.

Safety Switch Type	Voltage	Horsepower Range
General Duty	240 VAC	1½-200
	250 VDC	5-50
Heavy Duty	240 VAC	1½-250
	600 VAC	3-500
	250 VDC	5-50
	600 VDC	15-50

Pole

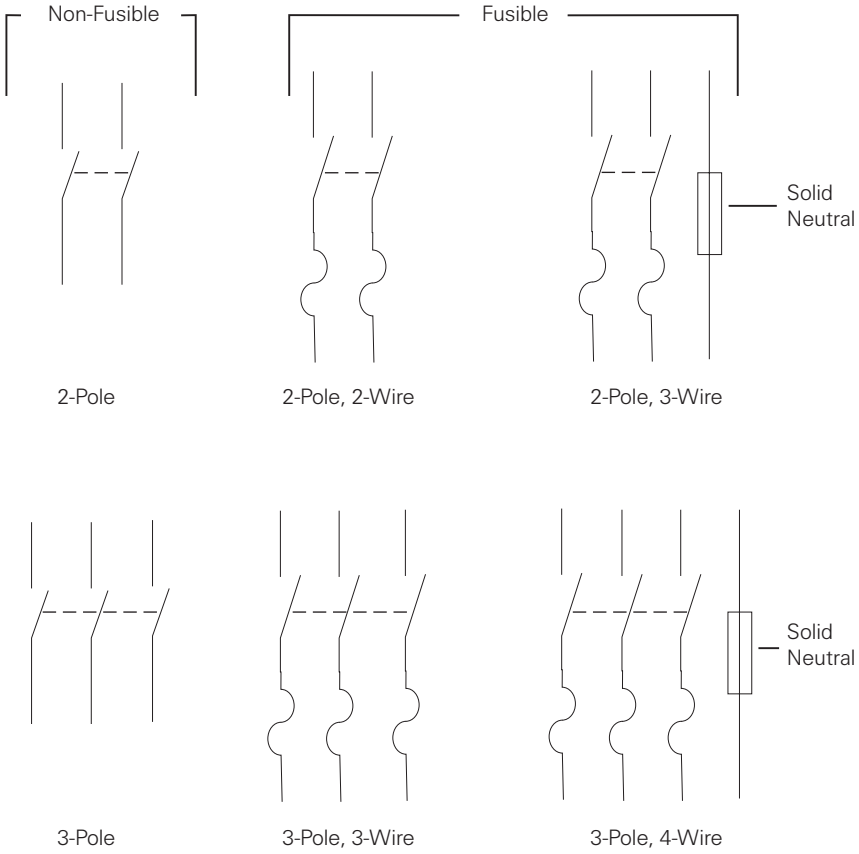
The term **pole** refers to the number of wires that a switch will disconnect at one time. The following drawing, for example, shows a 3-pole safety switch. The three circuits are mechanically connected so that all three poles connect and disconnect the line and load simultaneously when the switch is operated. In the illustration below, each pole is fused for overcurrent protection.



3-Pole, 3-Fuse

Circuit Configurations

Circuit configuration diagrams for 2- and 3-pole safety switches are shown below. Safety switches may be fusible, non-fusible, or fusible with a solid neutral.

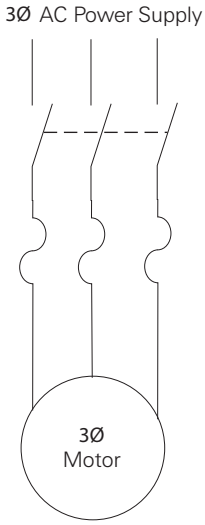


The following circuit configurations are available in Siemens safety switches:

2-Pole
3-Pole
6-Pole (not shown)
2-Pole, 2-Wire
3-Pole, 3-Wire
4-Pole, 4-Wire (not shown)
6-Pole, 6-Wire (not shown)
2-Pole, 3-Wire
3-Pole, 4-Wire

Example

The circuit configuration required depends on the load and the power supply connected to it. For example, a 3-phase motor needs a 3-pole switch to connect it to a 3-phase power supply. If overcurrent protection is required, a fusible 3-pole safety switch should be selected, as in the following example.

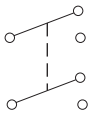


Switch Throws

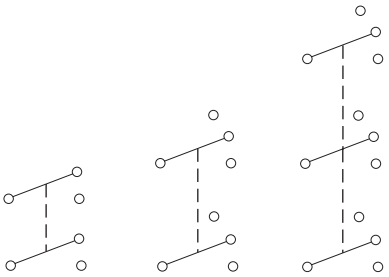
All the example switches shown so far have been single throw switches. **Throw** is the term used to specify the number of circuits to which a conductor can be connected. Switches may be single throw, double throw, or multiple throw. The simplest is a **single pole, single throw**.

Next in complexity is the **single pole, double throw** which can connect a single wire to either of two contacts.

2- and 3-pole single throw switches have already been shown. The **double pole, double throw (DPDT)** switch can connect each of two different wires to two different contacts.



Many different arrangements are possible. The following illustrates only a few of them:



Catalog Numbers

Each type of safety switch has a catalog number. The catalog number provides a description of the safety switch. There are eight parts to the catalog number for a Siemens VBII Safety Switch. The following figure illustrates a typical catalog number.

Catalog Number	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Part 7	Part 8
HF364NRCU=	H	F	3	6	4	N	R	CU

Part 1

Part 1 indicates the switch type. There are five types available: General Duty 10k AIC Max. (Plug Fused and 60A Max. Non-Fused), General Duty, Heavy Duty, Heavy Duty Double Throw, and General Duty Double Throw.

Designator	Switch Type
L	General Duty 10k AIC Max
G	General Duty
H	Heavy Duty
DT	Heavy Duty Double Throw
DTG	General Duty Double Throw

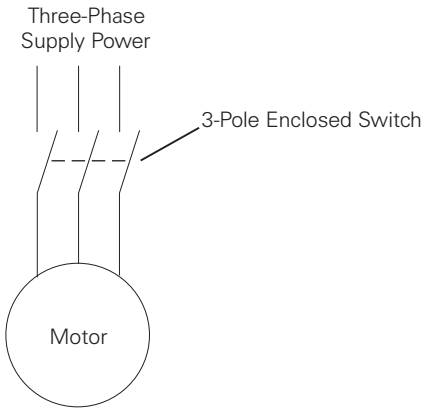
From the above table, one can see that the example switch, type H, is a heavy duty switch.

Part 2

Part 2 indicates whether the switch is fused or non-fused. **F** designates a fused switch, and **NF** designates a non-fused switch. For this example, the switch is fused.

Part 3

Part 3 of the catalog number indicates the number of poles. Siemens VBII safety switches can be provided with 1, 2, 3, 4, or 6 poles. A neutral, if required, is not included in the number of poles. The following drawing shows a 3-pole safety switch used with a 3-phase AC motor. The example catalog number also calls for a 3-pole safety switch.



Part 4

Part 4 of the catalog number indicates the voltage rating. The example catalog number indicates a safety switch with a maximum voltage rating of 600 volts.

Designator	Voltage
1	120V or 120/240V
2	240V
6	600V

Part 5

Part 5 of the catalog number refers to the switch's current rating. The example indicates a safety switch with a 200 ampere rating.

Designator	Amperes
1	30A
2	60A
3	100A
4	200A
5	400A
6	600A
7	800A
8	1200A

Part 6

Part 6 of the catalog number indicates whether or not a neutral is included with the switch. If no neutral is needed, part 6 of the catalog number is simply omitted. If a neutral is needed, an **N** is added to the catalog number, as in the example.

Part 7

Part 7 of the catalog number indicates the type of enclosure. The example catalog number indicates a safety switch in a NEMA Type 3R outdoor enclosure.

Designator	Enclosure Type
Omit	Type1, Indoor
R	Type 3R, Outdoor
S	Type 4/4X, Stainless Steel
X	Type 4/4X, Non-Metallic
J	Type 12, Industrial

Part 8

Part 8 of the catalog number is for special applications. The following table lists the possible applications. For example, **CU** indicates factory-installed copper wire grips, as in the representative catalog number given above.

Designator	Special Applications With:
CH	Crouse-Hinds Receptacle
CJ	Factory J Fuse Spacings
CR	Class R Clips Installed
CU	Copper Wire Grips Installed
G	Factory-Installed Ground Bar
PN	Pyle-National Receptacle
W	Viewing Window

Review 4

1. The _____ rating is the maximum continuous current a safety switch can carry.

2. The maximum short circuit current withstandability of heavy duty switches is _____ amperes.

3. The maximum horsepower available in a 240 VAC general duty safety switch is _____ HP.

4. A _____ describes the number of isolated circuits that can pass through the safety switch at one time.

5. The number 3 in part five of the heavy duty catalog number indicates _____ .

   a. 3-pole
   b. 3R enclosure
   c. 100 amperes
   d. 600 VAC

General Duty Safety Switches

General duty switches are intended for use primarily on power supplies rated at 240 VAC or less, where the available fault current is less than 100,000 amperes (with Class R or T fuses, or 10,000 A max with Class H fuses). They can be supplied in a Type 1 (indoor) or Type 3R (outdoor) enclosure.

Plug Fuse Type Safety Switch

The **general duty plug fuse type switch** is available for 120 or 240 volt systems. It is suitable for 1- or 2-pole applications, and is rated at 30 amperes. A separately supplied, 30-ampere Type S plug fuse is required. This switch is available for use on 2-wire or 3-wire motor applications up to three horsepower. A non-fusible model comes in a 2-pole configuration. It is rated at 60 amperes and can be used with motors up to 10 HP. There are also pullout models available in fused and non-fused versions.

General Duty Switches

The **fusible general-duty safety switch** is available with two or three poles (both with solid neutral) or with four poles. The non-fusible model is available with two or three poles. Fusible switches accept Class H fuses as standard. A field-installable rejection kit is available which rejects all but Class R fuses. All general duty switches have both cover and handle padlocking capabilities.

Ratings

Ampere ratings: 30, 60, 100, 200, 400, or 600 amperes

Fuses: Class H, K, or R (all ampere ratings) or Class T cartridge fuse (70-600 amperes)

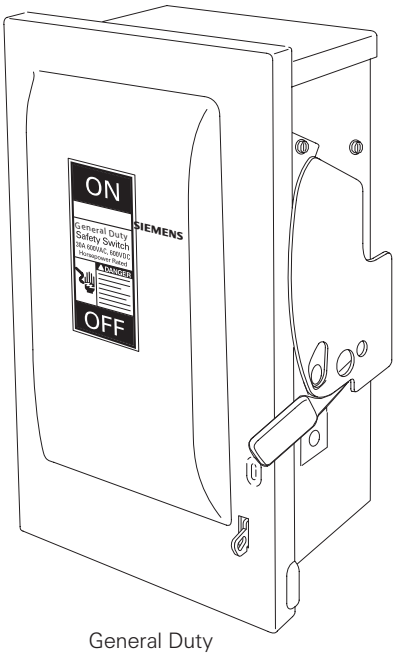
Voltage ratings: 240 VAC, 250 VDC

Max short-circuit current withstandability: 100,000 amperes (with current limiting fuses)

Type 1 Enclosure

General duty switches are available in a **Type 1 enclosure**, which is intended for indoor use. These switches have interlocks to prevent the cover from being opened when the switch is in the "on" position and to prevent the switch from being turned on with the door open. (There is a front-operable release for this feature.)

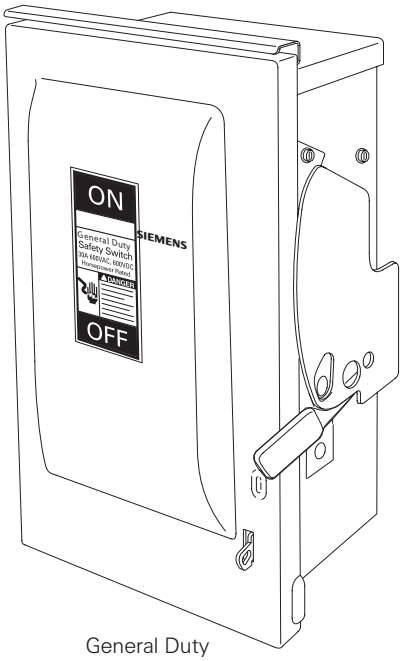
This enclosure is intended primarily to provide protection against contact with the safety switch and is used in locations where unusual service conditions do not exist.



General Duty
Safety Switch
Type 1 Enclosure

Type 3R Enclosure

General duty 2- and 3-pole safety switches are also supplied in a **Type 3R enclosure**, which is intended for outdoor use, and provides a degree of protection against falling rain and sleet. It is also able to withstand the formation of ice on the enclosure without damage, but is not intended to provide protection against conditions such as dust, internal condensation, or internal icing.



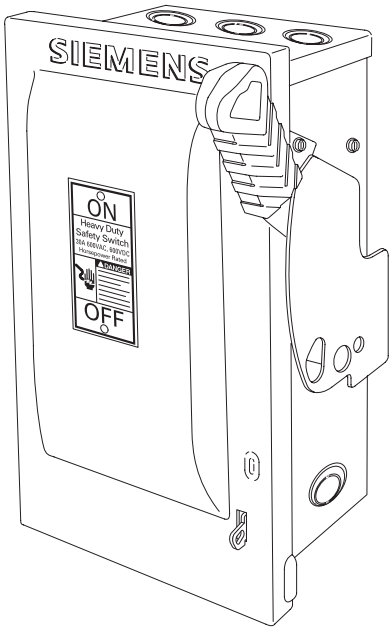
General Duty
Safety Switch
Type 3R Enclosure

Heavy Duty Safety Switches

Type 1 Enclosure

Heavy duty safety switches can be used on power supplies up to 600 Volts, AC or DC, in applications where the available fault current is 200,000 amperes or less.

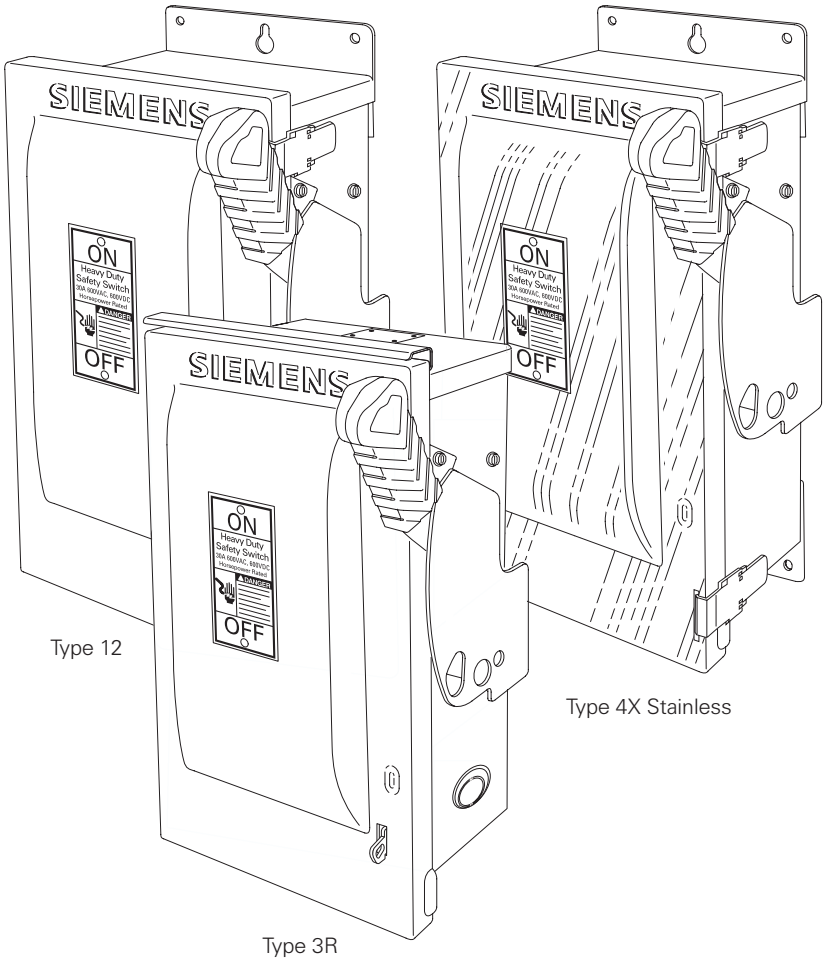
Interlocks prevent someone from inadvertently opening the cover while the switch is in the "on" position or inadvertently turning on the switch while the cover is open. Heavy duty safety switches also have cover and handle padlocking capabilities.



Type 1 Enclosure

Enclosures for Heavy Duty Safety Switches

Heavy duty safety switches can also be supplied with **Type 3R, 4/4X, and 12 enclosures**.



Type 12

Type 4X Stainless

Type 3R

Ratings

Current ratings: 30, 60,100,200, 400, 600, 800, & 1200 amperes

Fuses: Class H, J, K, and R cartridge fuses (up to 600 amperes)
Class T cartridge fuses (up to 1200 amperes)
Class L bolt-in fuses (601-1200 amperes)
(Fusible 800 and 1200 ampere switches have Class L fuse provisions as standard equipment.)

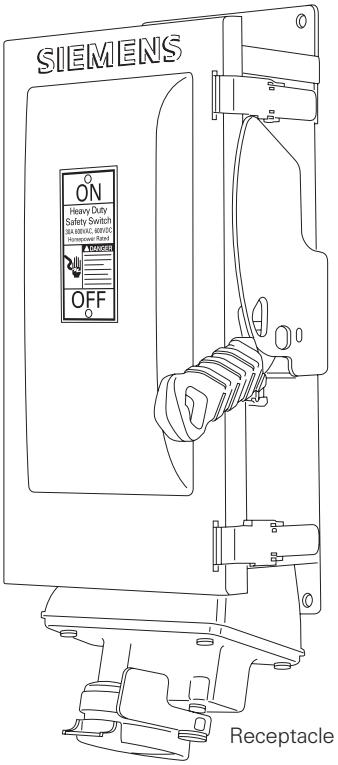
Voltage ratings: 240 /480/ 600 VAC; 250 / 600 VDC

Max short-circuit current withstandability: 200,000 amperes

Interlock Receptacle

Interlock receptacle safety switches provide cord connection for heavy-duty portable equipment such as refrigerated trucks, welders, and other portable electric tools. These switches are fitted with a Crouse-Hinds Arktite® or similar receptacle which is interlocked to prevent insertion or removal of the plug when the switch is in the "on" position. The Crouse-Hinds receptacle switch requires a Crouse-Hinds 4-wire, 3-pole, style 2, grounded APJ plug.

Interlock receptacle safety switches are rated for 30, 60, and 100 amperes. The enclosure meets the requirements for Type 4, 4X, or 12/3R enclosures.

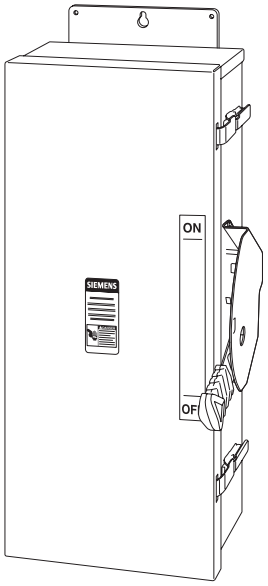


Receptacle

Arktite® is a registered trademark of the Crouse-Hinds Company.

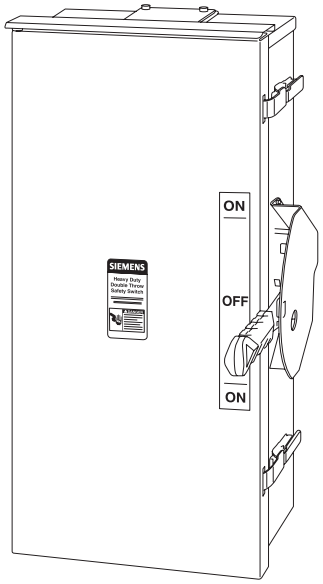
4- and 6-Pole Safety Switches

4- and 6-pole heavy-duty safety switches are available in current ratings of 30 to 200 amperes, in Type 1/3R/12 or Type 4/4X enclosures, fusible or non-fusible. These switches are commonly used as a disconnecting means for 2-speed, 2-winding motors. A 4-pole switch is also used in 3-phase, 4-wire circuits when a switching neutral is required.



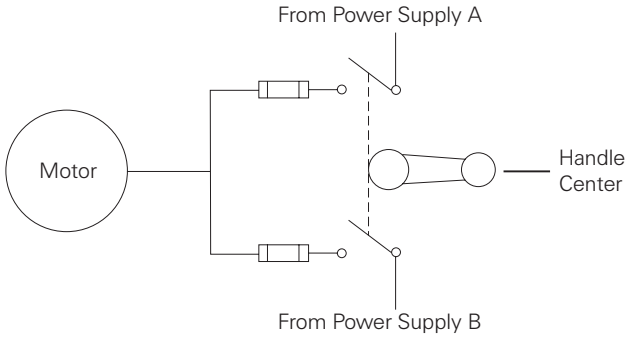
Double Throw Switches

Double throw switches are used to transfer loads from one power source to another. For example, a critical piece of equipment often needs a back-up power supply in case the main power supply fails or needs maintenance. Double throw switches are also used to connect a single power source to either of two loads. 30-600A double-throw fusible switches are available in Types 1 and 3R enclosures, while non-fusible models are available in Types 1 and 3R enclosures for 30 to 1200A, and in 4/4X and 12 enclosures for 30 to 200A. Double throw switches are rated for 240 VAC/250 VDC or 600 VAC.

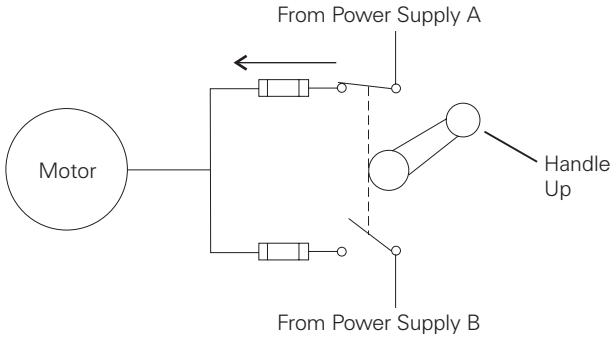


Double Throw Switch Application

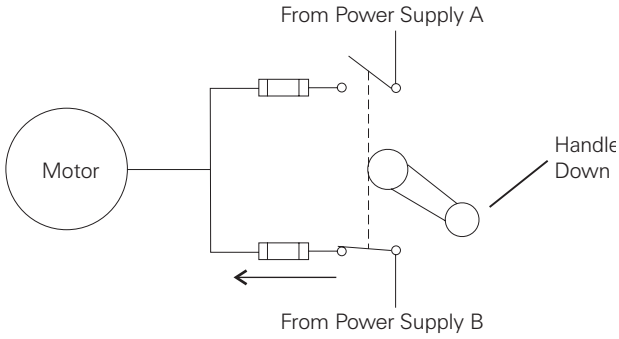
A motor, for example, can be connected through a **double throw switch** to power supply A or power supply B. When the handle is in the center position the switch is off and no power flows to the motor.



Moving the handle to the up position connects the motor to power supply A.



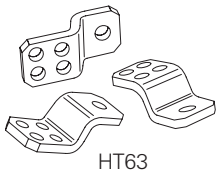
Moving the handle to the down position connects the motor to power supply B.



Safety Switch Accessories

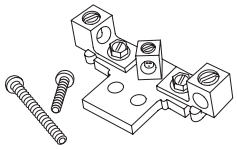
A full range of **accessories** is available for Siemens VBII Safety Switches. Some of these are shown below.

Both general duty and heavy duty switches are field-convertible to accept Class J or Class T fuses.

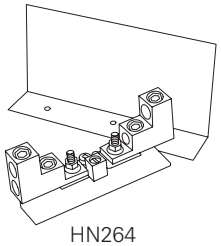


HT63
Class T Fuse Adapter Kit

Standard Neutral Kits can be field installed in both general duty and heavy duty safety switches. UL listed 200% Neutrals are available on 100-600A heavy duty switches.



HN612

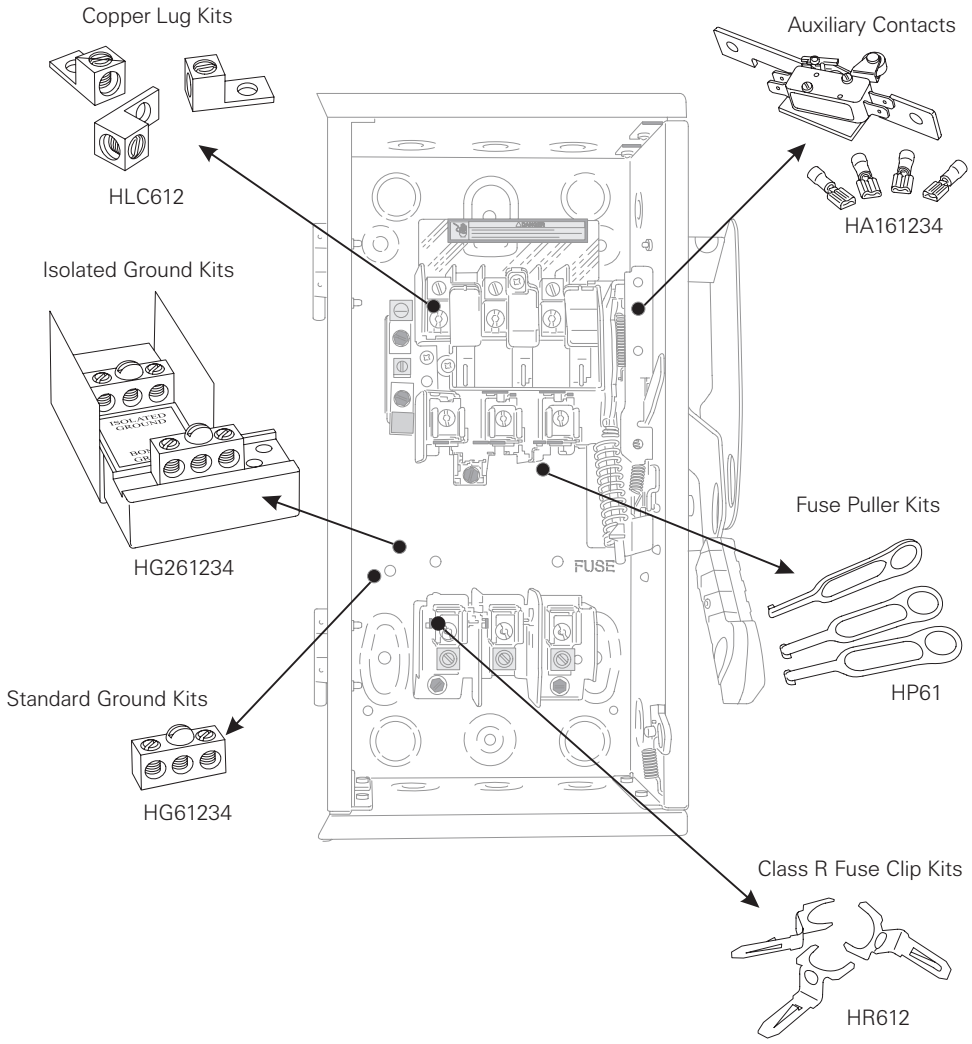


HN264

The Multiple Padlock Accessory is a tamper-proof device to provide for multiple padlocking to meet OSHA or plant requirements.

SL0420
Multiple Padlock Accessory

The following illustrates some of the other accessories available for general and heavy duty safety switches.

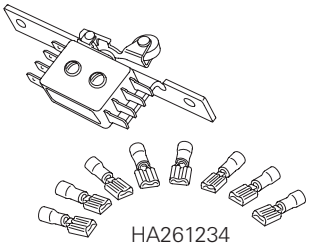


Heavy duty switches are UL approved to accept field installed Copper Lug Kits. Equipment Ground Kits are available for all general duty and heavy duty Switches. They come standard in Type 4/4X and Type 12 switches, and are field installable in Type 1 and Type 3R switches.

Isolated Ground Kits are also available for 30-600A heavy duty switches. Some circuits with a high degree of computer or other electronic loading require an isolated ground to prevent interference from the building ground and neutral lines.

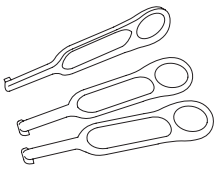
Auxiliary contacts are available only for heavy duty switches. They come with 1 normally open and 1 normally closed or 2 normally open and 2 normally closed contacts.

A PLC Auxiliary Switch for 30 to 200A switches is also available. It has very low contact resistance, which is compatible with the low voltages and currents typically found in PLC circuits.



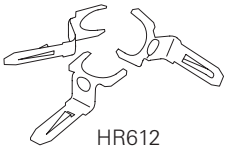
HA261234
Auxiliary Contract Kit

Fuse Puller Kits are field installable in 30 to 100A heavy duty switches.



HP61
Fuse Puller Kit

Class R fuse clips are used to prevent the installation of noncurrent-limiting Class H or Class K fuses. All general and 30-600A heavy duty switches are field convertible to accept Class R Fuse Clip Kits.



HR612
Class R Fuse Clips

Review 5

1. The maximum short circuit current withstandability of general duty switches is _____ amperes.

2. The maximum short circuit current withstandability of heavy duty switches is _____ amperes.

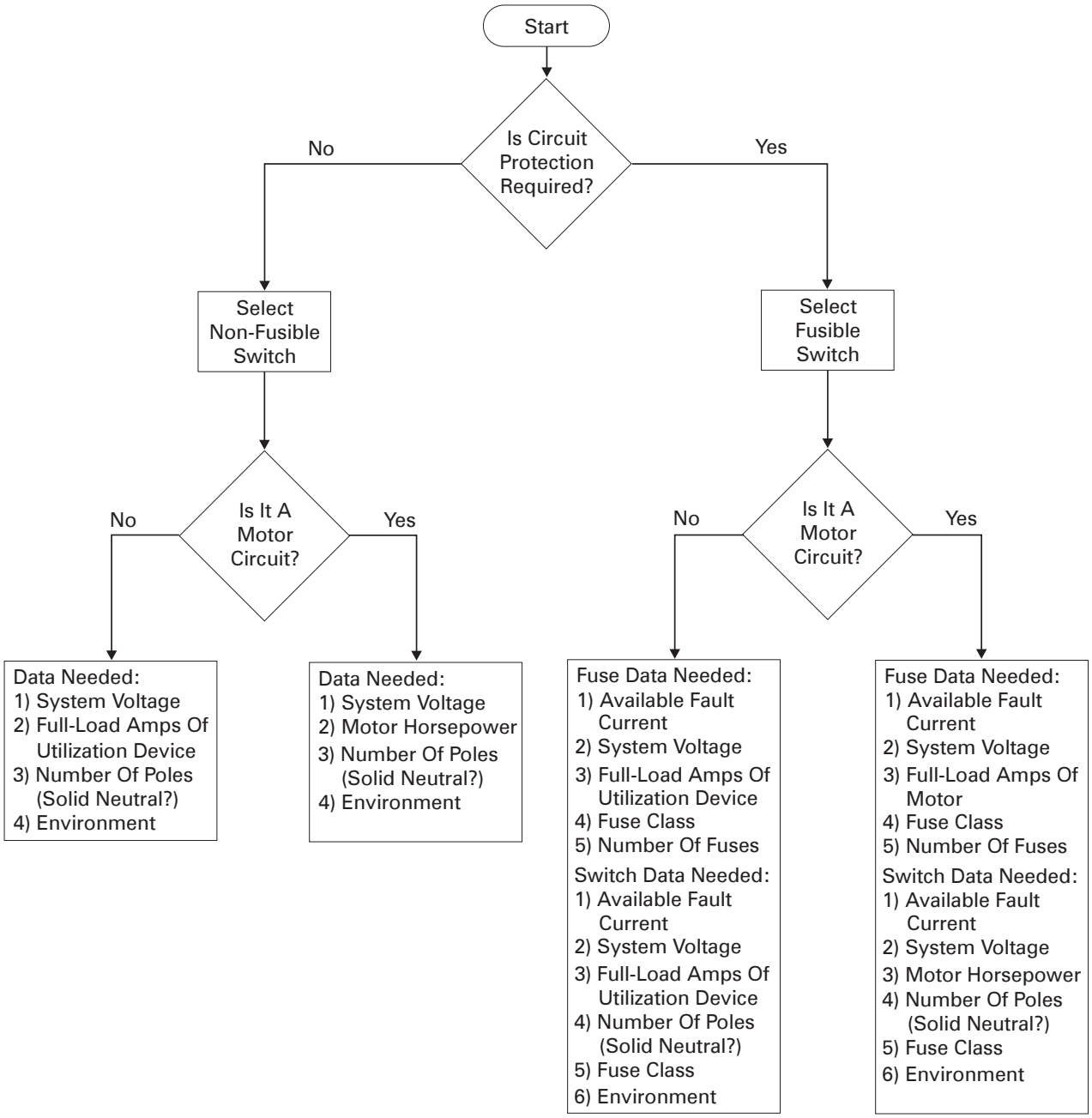
3. The maximum current rating of a VBII heavy duty switch that is <u>not</u> a bolted pressure switch is _____ amperes.

4. The _____ _____ safety switch provides cord connection for heavy duty portable equipment.

5. _____ _____ switches are intended to transfer loads from one power source to another.

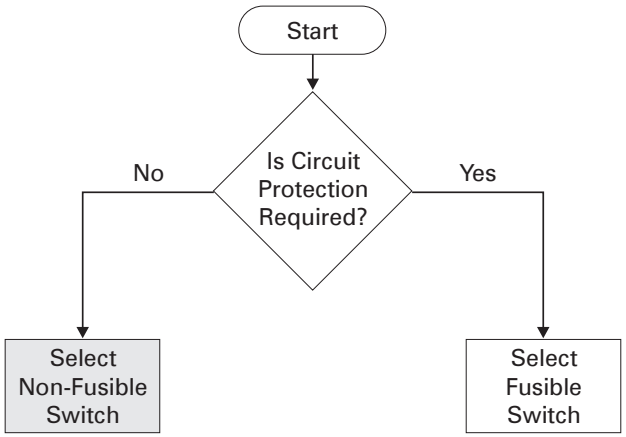
Selecting Safety Switches

While selecting a safety switch is not difficult, flow charts can help to make it even easier. The following flow chart can be used to make key decisions in the selection of a safety switch.



Selecting a Non-Fusible Switch

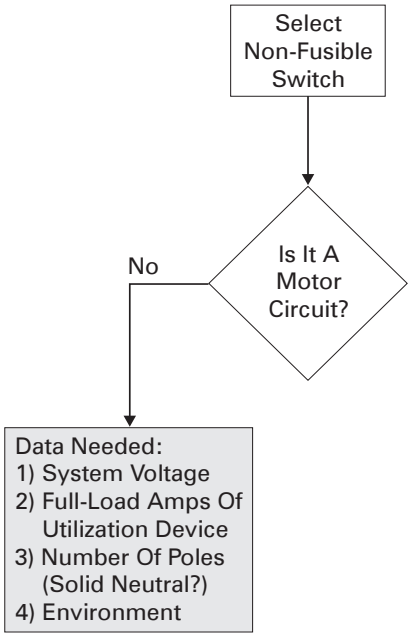
Is circuit protection required? If circuit protection is not required a non-fusible switch would be selected.



Non-Fusible Switch not Used on a Motor Circuit

If a non-fusible switch is selected, is it a motor circuit? If the switch is not used in a motor circuit, the following information must be known:

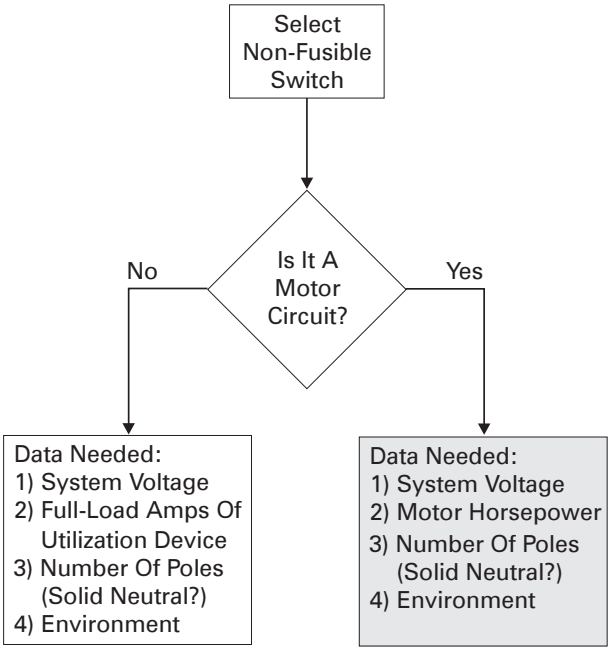
1) System voltage: 120 VAC, 240 VAC, 480 VAC, 600 VAC, 250 VDC, 600 VDC
2) Full-load amperes of the device to be used on the switch
3) The number of poles required, and if a neutral is needed
4) The environment (enclosure type)



Non-Fusible Switch Used on a Motor Circuit

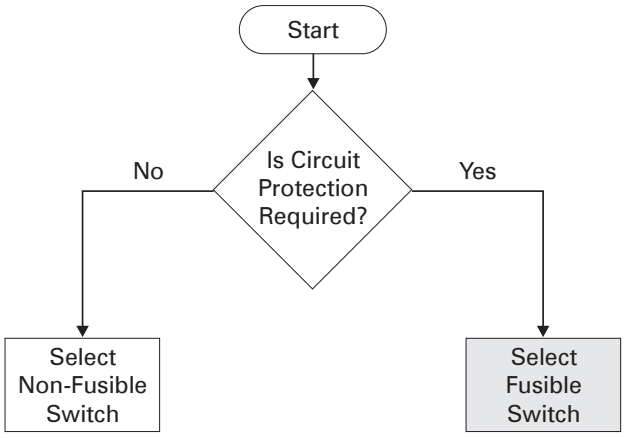
If the switch is used in a motor circuit, the same data is a required, except that motor horsepower replaces full-load current.

1) System voltage
2) Motor horsepower
3) The number of poles required, and if a neutral is needed
4) The environment (enclosure type)



Selecting a Fusible Switch

If circuit protection is required, a fusible switch would be selected.



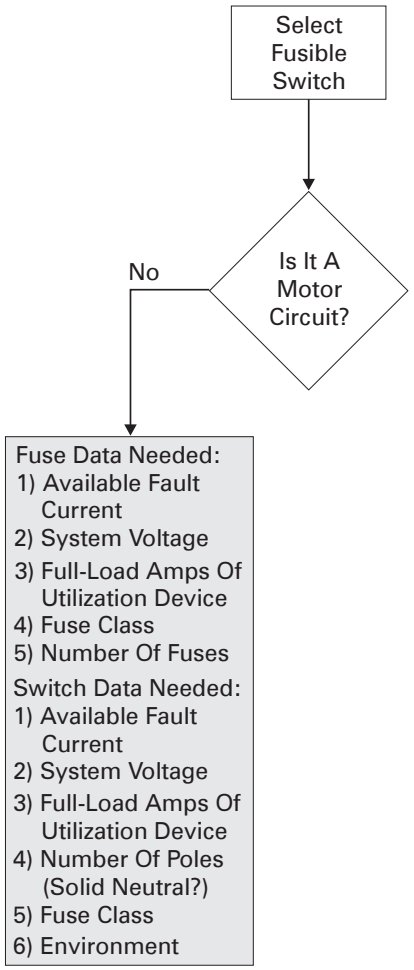
Fusible Switch not Used on a Motor Circuit

If a fusible switch is selected, is it for a motor circuit? If not, the following information must be known to select fuses:

1) Available fault current
2) System voltage
3) Full-load amperes of the device to be used on the switch
4) Fuse class
5) Number of lines to be fused

The following must be known to select a switch:

1) Available fault current
2) System voltage
3) Full-load amperes of the device to be used on the switch
4) Number of poles, and if a neutral is needed
5) Fuse class
6) Environment (enclosure type)



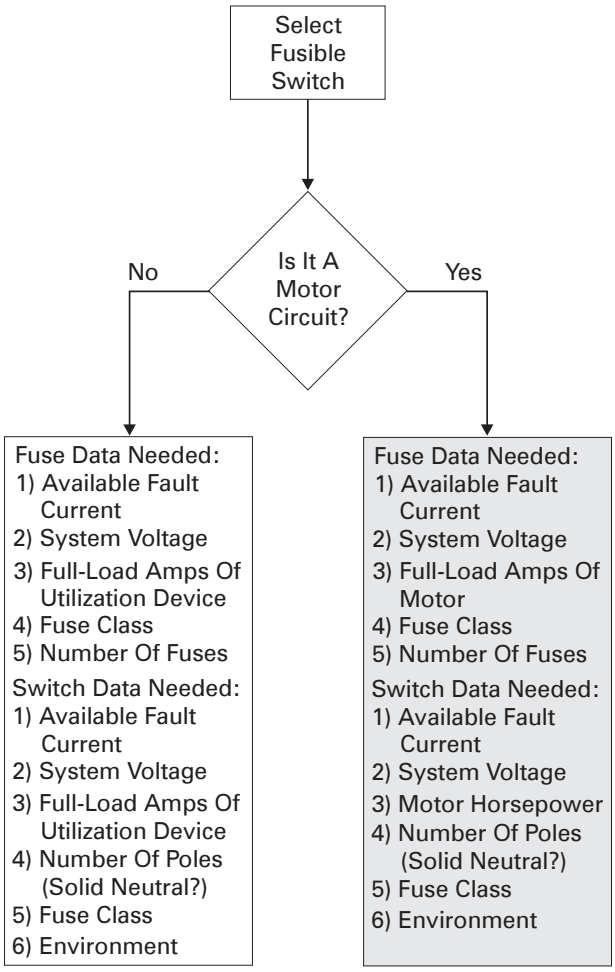
Fusible Switch Used on a Motor Circuit

If the switch is used on a motor circuit, the following information must be known to select a fuse:

1) Available fault current
2) System voltage
3) Full-load amperes required by the motor
4) Fuse class
5) Number of lines to be fused

The following must be known to select a switch:

1) Available fault current
2) System voltage
3) Motor horsepower
4) Number of poles, and if a neutral is needed
5) Fuse class
6) Environment (enclosure type)



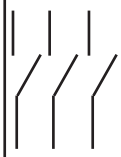
Example of Selecting a Non-Fusible Safety Switch

In the following example, a safety switch needs to be provided for an application that does not require circuit protection. The full-load current of the utilization device is 45 amperes. It is not a motor. The system voltage is 240 VAC, 3-phase, 3-wire (without neutral). The environment is indoors, and there are no unusual conditions such as dust or liquids.

Recall from earlier discussion that, in general, all conductors (including the switch) must be capable of carrying 125% of the full-load current. The full-load current of the utilization device is 45 amperes; a switch must be selected that can carry 56 amperes.

45 amperes
X 125%
56 amperes

Knowing that the switch will be used indoors, with no unusual conditions, a Type 1 enclosure can be selected. The other requirements can be met with a general duty switch. Referring to the General Duty Safety Switches section of the Speedfax catalog, the first 240 volt, 3-pole, non-fusible switch that will handle 56 amperes is a 60 amp switch. The catalog number is GNF322.

		Indoor - Type 1			Outdoor - Type 3R		
System	**Ampere Rating**	Catalog Number	List Price $	Ship Wt. Std. Pkg.	Catalog Number	List Price $	Ship Wt. Std. Pkg
240 Volt Non-Fusible							
2-Pole or 3-Pole							
	30	GNF321			GNF321R		
	60	**GNF322**			GNF322R		
	100	GNF323			GNF323R		
	200	GNF324			GNF324R		
	400	GNF325			Use 600V Switch - HF365R		
	600	GNF326			Use 600V Switch - HF366R		

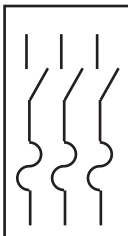
Example of Selecting a Fusible Safety Switch

In the following example a safety switch needs to be provided for an application that does require circuit protection. This application will have a 480 VAC, 3-phase, 75 HP motor, not needing a neutral connection. The customer has specified an RK5 time-delay fuse, for a potential fault current of 200,000 amperes. The switch will be located indoors with no unusual service conditions.

The application requirements for this example dictate selection of a heavy duty, 600 volt, fusible switch. On the appropriate Speedfax page, locate the enclosure type, that is, Indoor — Type 1.

Next, find the 600 Volt Fusible, 3-pole, 3-fuse table. In the 480 VAC, 3-phase, 3-wire section of this table, select a switch with a horsepower equal rating in the maximum (Max.) column that is equal to or greater than 75. The maximum column must be used because the customer selected time delay fuses. (Had non-time delay fuses been specified, the standard horsepower column would be used.) In this example, 125 HP is the first rating meeting the 75 HP requirement. Reading to the left, the catalog number under Indoor - Type 1 is HF364. Also note that this switch has an ampere rating of 200.

Because a Class R fuse is required for this application, a Class R fuse clip kit is also required. This can be found in the accessory section of the Speedfax. In this example, the fuse kit catalog number is HR64.

System		**Indoor - Type 1**			Horsepower Ratings 480 VAC			
	Ampere Rating	Catalog Number	List Price $	Ship Wt. Std. Pkg.	1 Phase, 2 Wire Std.	1 Phase, 2 Wire Max.	3 Phase, 3 Wire Std.	3 Phase, 3 Wire Max.
600 Volt Fusible								
3-Pole, 3-Fuse								
	30	HF361			3	7½	5	15
	60	HF362			5	20	15	30
	100	HF363			10	30	25	60
	200	**HF364**			**25**	**50**	**50**	**125**
	400	HF365					100	250
	600	HF366					150	400
	800	HF367					200	500
	1200	HF368					200	500

Selecting a Fuse

Section 430.6 of the *NEC*® requires that, where the current rating of a motor is used to determine the ampacity of conductors or ampere ratings of switches, branch-circuit overcurrent devices, etc., the values given in Tables 430.247 through 430.250 must be used instead of the actual motor nameplate current rating. According to *NEC*® Table 430.250, a 75 HP, 460 VAC motor has a full-load current of 96 amperes.

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for a motor running at speeds usual for belted motors and motors with normal torque characteristics.

Motors built for low speeds (1200 rpm or less) or high torques may require more running current, and multispeed motors will have full-load current varying with speed. In these cases, the nameplate current rating shall be used.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

	Induction-Type Squirrel Cage and Wound Rotor (Amperes)						
Horsepower	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts
½	4.4	2.5	2.4	2.2	1.1	0.9	-
¾	6.4	3.7	3.5	3.2	1.6	1.3	-
1	8.4	4.8	4.6	4.2	2.1	1.7	-
1½	12.0	6.9	6.6	6.0	3.0	2.4	-
2	13.6	7.8	7.5	6.8	3.4	2.7	-
3	-	11.0	10.6	9.6	4.8	3.9	-
5	-	15.5	16.7	15.2	7.6	6.1	-
7½	-	25.3	24.2	22	11	9	-
10	-	32.2	30.8	28	14	11	-
15	-	48.3	46.2	42	21	17	-
20	-	62.1	59.4	54	27	22	-
25	-	78.2	74.8	68	34	27	-
30	-	92	88	80	40	32	-
40	-	120	114	104	52	41	-
50	-	150	143	130	65	52	-
60	-	177	169	154	77	62	16
75	-	221	211	192	96	77	20
100	-	285	273	248	124	99	26
125	-	359	343	312	156	125	31
150	-	414	396	360	180	144	37
200	-	552	528	480	240	192	49
250	-	-	-	-	302	242	60
300	-	-	-	-	361	289	72
350	-	-	-	-	414	336	83
400	-	-	-	-	477	382	95
450	-	-	-	-	515	412	103
500	-	-	-	-	590	472	118

Table 430.52 of the *NEC®* is provided to help select a fuse that will not open while starting a motor and will still provide adequate overcurrent protection. According to this table, the *NEC®* requires that the ampere rating of an AC motor protected by a time-delay fuse be multiplied by 175%.

Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

	Percentage of Full-Load Current			
Type of Motor	Nontime Delay Fuse	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
Single-phase motors	300	175	800	250
AC polyphase motors other than wound-rotor				
Squirrel cage - other than Design E or Design B energy efficient	300	175	800	250
Design E or Design B energy efficient	300	175	1100	250
Synchronous	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

Multiplying the motor rating of 96 amperes times 175% results in a fuse size of 168 amperes. Since this is a non-standard fuse size, the next standard fuse size of 175 amperes should be selected.

96 amperes	*Full-Load Motor Current*
X 175%	*NEC® Requirement*
168 amperes	*Fuse Rating*

Review 6

1. A _____ safety switch would be selected when circuit protection is not required.

2. A _____ safety switch would be selected when circuit protection is required.

3. When selecting a non-fusible safety switch for utilization device rated at 100 amperes, a switch must be selected that can carry _____ amperes.

4. According to the *NEC®*, the ampere rating of an AC motor protected by a time-delay fuse should be multiplied by _____ %.

Review Answers

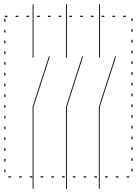
Review 1	1) fusible; 2) 50; 3) a; 4) overload, short circuit; 5) short circuit; 6) overload; 7) peak let-thru; 8) energy; 9) 240; 10) 310.16; 11) 125.
Review 2	1) inverse; 2) half; 3) short; 4) Time-delay; 5) ampere; 6) higher, lower; 7) 200,000.
Review 3	1) 1; 2) 3R; 3) contacts; 4) two.
Review 4	1) ampere; 2) 200,000; 3) 200; 4) pole; 5) c; 6) Throw .
Review 5	1) 100,000; 2) 200,000; 3) 1200; 4) interlock receptacle; 5) Double throw.
Review 6	1) non-fusible; 2) fusible; 3) 125; 4) 175.

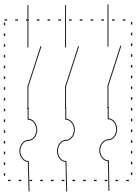
Final Exam

The final exam is intended to be a learning tool. The book may be used during the exam. A tear-out answer sheet is provided. Please fill out the answer sheet neatly and completely. After completing the test, mail the answer sheet in for grading. A grade of 70% or better is passing. Upon successful completion of the test, a certificate will be issued.

1. The following symbol represents a non-fusible enclosed switch:

a. 

c. 

b. 

d. 

2. A safety switch combined with fuses in a single enclosure is referred to as a _____ safety switch.

a.	non-fusible	c.	heavy duty
b.	fusible	d.	general duty

3. The *National Electrical Code*® defines "in sight" as visible and not more than _____ feet distant.

a.	10	c.	25
b.	50	d.	100

4. With an increase of current, temperature will _____ .

a.	increase	c.	decrease
b.	remain the same	d.	increase and decrease

5. Overcurrent protection is covered by *NEC*® article _____ .

   a. 110 c. 780
   b. 410 d. 240

6. The amount of current a conductor can carry on a continuous basis is known as the _____ .

   a. AWG c. instantaneous current
   b. peak current d. ampacity rating

7. According to the NEC®, a continuous load is a load where the maximum current is expected to continue for _____ hours or more.

   a. 2 c. 3
   b. 6 d. 10

8. Fuses have a/an _____ time-current characteristic.

   a. direct c. indirect
   b. proportional d. inverse

9. Class R fuses have an interrupting rating (AIC) of _____ amperes.

   a. 10,000 c. 100,000
   b. 50,000 d. 200,000

10. A UL Type ___ enclosure is intended for indoor use primarily to provide protection against contact with the enclosed equipment in locations where unusual service conditions do not exist.

    a. 1 c. 4
    b. 3R d. 12

11. UL Type _____ enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain and sleet and must remain undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing.

    a. 1 c. 4
    b. 3R d. 12

12. The maximum ampere rating of a general duty switch is _____ amperes.

    a. 200 c. 600
    b. 1200 d. 4000

13. The maximum ampere rating of a heavy duty switch that is not a bolted pressure switch is _____ amperes.

    a. 200 c. 600
    b. 1200 d. 4000

14. Heavy duty switches have a maximum short circuit current withstandability of _____ amperes.

    a. 10,000 c. 50,000
    b. 100,000 d. 200,000

15. The maximum horsepower of a 240 VAC heavy duty switch is _____ HP.

    a. 60 c. 250
    b. 150 d. 500

16. A catalog number beginning with GF3 indicates a _____ _____ safety switch.

    a. general duty, fusible, single pole
    b. general duty, fusible, three pole
    c. general duty, non-fusible, single pole
    d. general duty, non-fusible, three pole

17. The _____ safety switch provides cord connection for heavy duty portable equipment.

a. interlocked receptacle
b. double throw
c. bolted pressure
d. plug fuse

18. Siemens VBII 30-200 amp safety switches use a _____ _____ switch action.

a. Double Break
b. Knife-Blade
c. Stationary Contact
d. Fuse Ejector

19. When selecting a non-fusible switch for use on a non-motor circuit, which of following information is <u>not</u> needed?

a. system voltage
b. full-load amperes
c. fuse class
d. number of poles

20. _____ safety switches are intended to transfer loads from one power source to another.

a. Interlock receptacle
b. Plug fuse
c. Bolted pressure
d. Double throw

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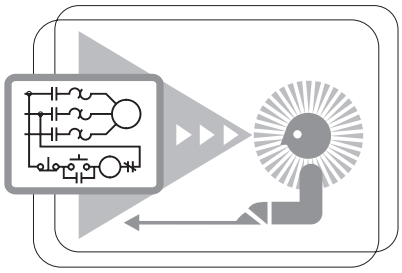

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