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Introduction

Welcome to another course in the STEP 2000 series, **Siemens Technical Education Program**, designed to prepare our distributors to sell Siemens Energy & Automation products more effectively. This course covers **Enclosed Switches** and related products.

Upon completion of **Enclosed 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 enclosed switch
- Explain the operation and benefit of Siemens Vacu-Break® and visible blade designs
- Identify various types of Siemens enclosed switches
- Explain the difference between fusible and non-fusible enclosed switches
- Identify circuit protection ratings for various types of Siemens enclosed switches
- Identify enclosed 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 **Enclosed Switches**. An understanding of many of the concepts covered in **Basics of Electricity** is required for **Enclosed 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.

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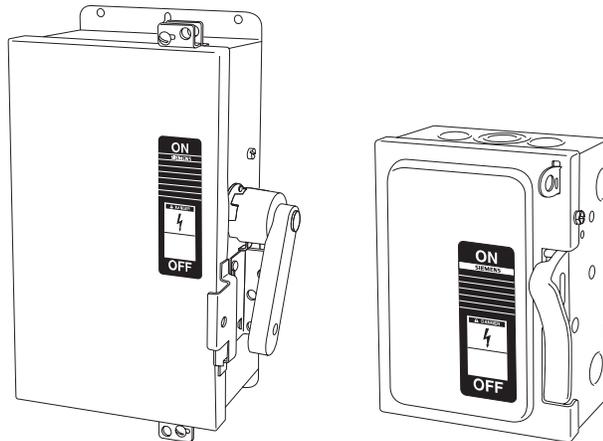
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National Electrical Manufacturers Association is located at 2101 L. Street, N.W., Washington, D.C. 20037. The abbreviation "NEMA" is understood to mean National Electrical Manufacturers Association.

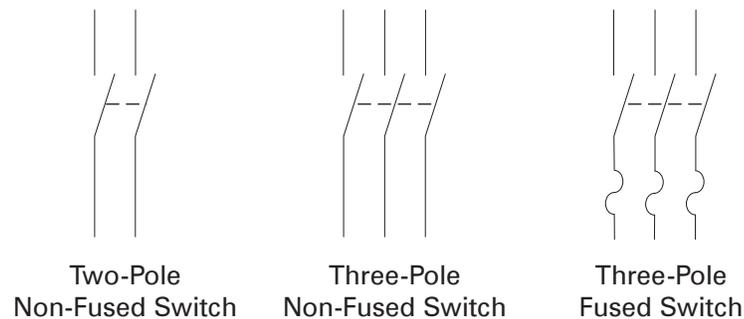
Enclosed Switches

A switch is generally used for two purposes: 1) service entrance, 2) disconnecting means and fault protection for motor circuits. An enclosed switch is simply a switch located in its own enclosure. 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. Enclosed switches may consist of a switch only, or may consist of a switch and fuses. There are two families of enclosed switches: general duty and heavy duty.



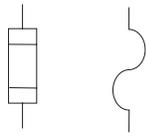
Switch symbols

Symbols are used in a diagram to represent components. The symbol commonly used for a disconnect switch is shown below. The switch is normally shown in its "Off", or "Open" state.



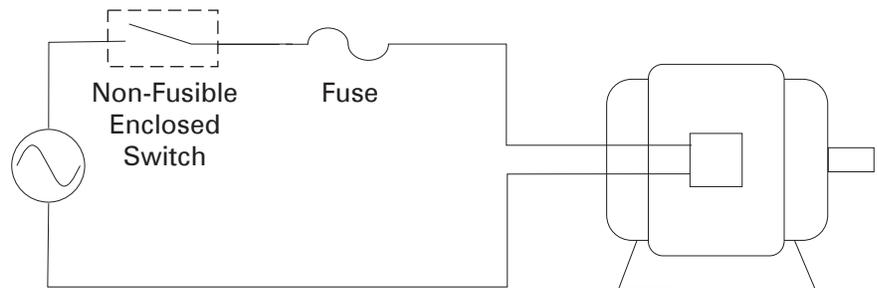
Fuse symbols

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



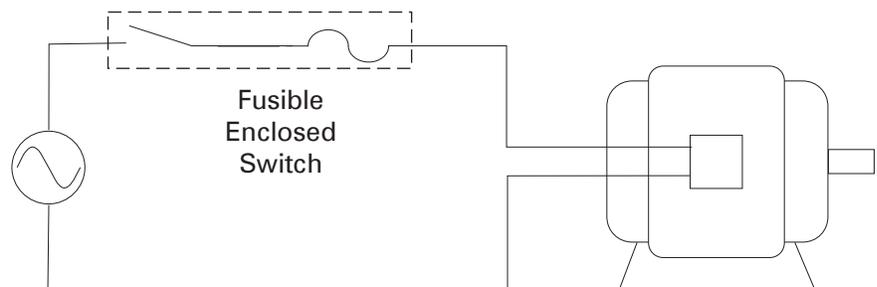
Non-fusible enclosed switch

A switch with no associated fuses is referred to as a non-fusible enclosed switch. A non-fusible enclosed switch has no circuit protection capability. It provides a convenient means to manually open and close the circuit in order to connect and disconnect the load from its source of electrical power. Circuit protection is 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 enclosed switch and a separate fuse.



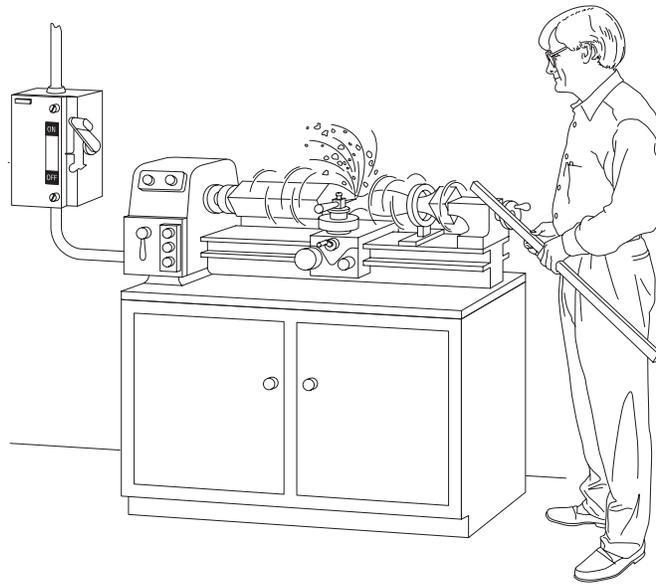
Fusible enclosed switch

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

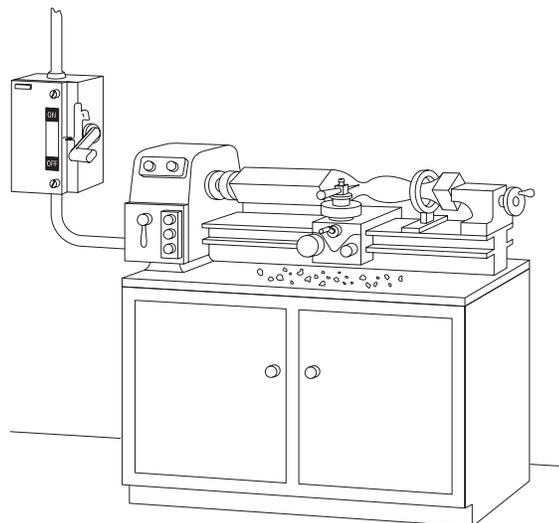


Application

Enclosed 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 430-102b). The NEC® defines “in sight” as *visible and not more than 50 feet (15.24 m) distant* (Article 100 - definitions). Regardless of where the enclosed switch is used, the function is to provide a means to connect and disconnect the load from its source of electrical power.



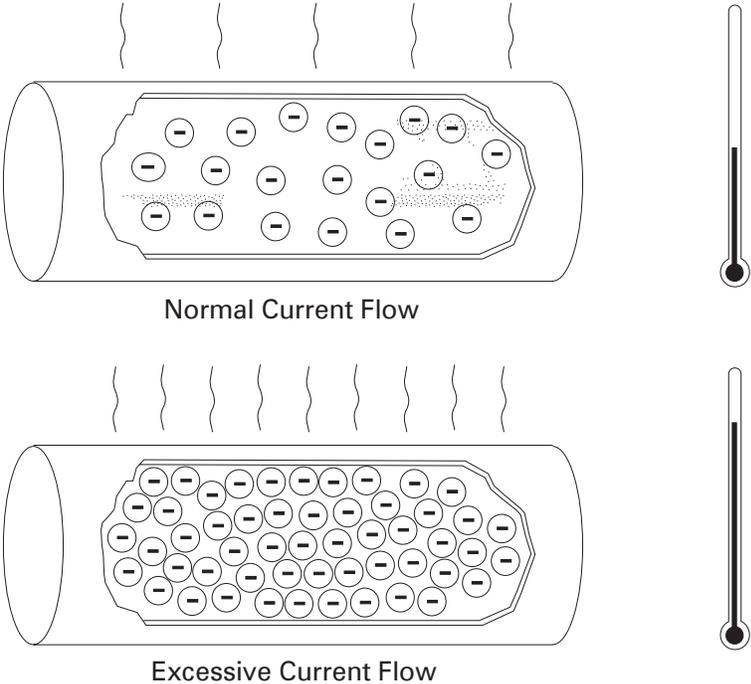
With power removed the operator can safely service the machinery without coming into contact with live electrical components or having the motor accidentally start.



Need For Circuit Protection

Current and temperature

Current flow in a conductor always generates heat. The greater the current flow in any one size conductor, the hotter the conductor. Excess heat is damaging to electrical components and conductor insulation. For that 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.

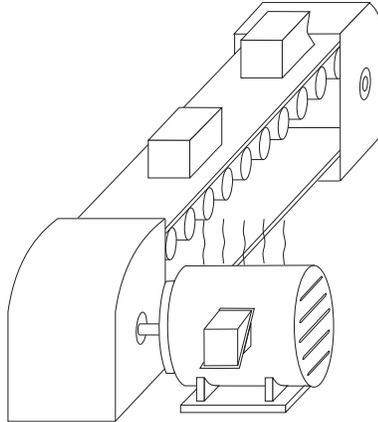


Excessive current is referred to as overcurrent. The *National Electrical Code*® defines overcurrent as *any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault* (Article 100-definitions).

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Overloads

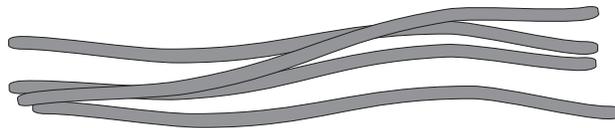
An overload occurs when too many devices are operated on a single circuit, or a piece of electrical equipment is made to work harder than it is designed for. For example, a motor rated for 10 amperes may draw 20, 30, or more amperes in an overload condition. In the following illustration, a package has 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 the circuit is shut down by the overcurrent protector.



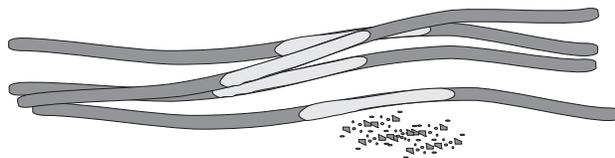
Conductor insulation

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. Heat is one of the major causes of insulation failure of any electrical component. High levels of heat to insulated wire can cause the insulation to breakdown and flake off, exposing conductors.

Good Insulation

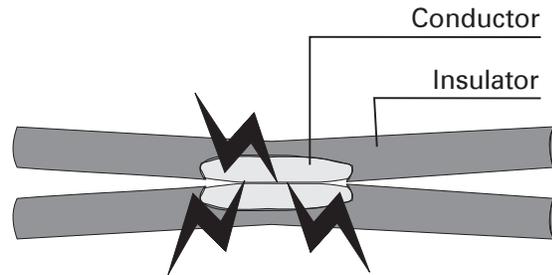


Insulation Affected by Heat



Short circuits

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



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

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

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

$$I = 10 \text{ amperes}$$

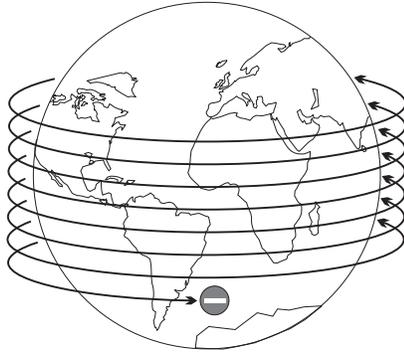
When a short circuit develops resistance drops. If resistance drops to 24 milliohms, current will be 10,000 amperes.

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

$$I = 10,000 \text{ amperes}$$

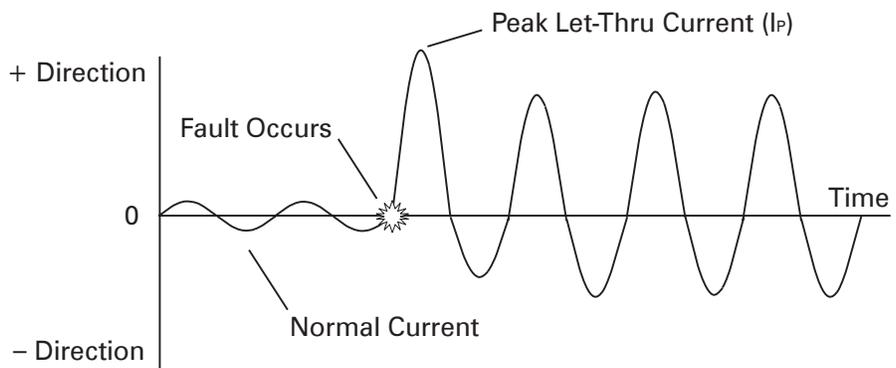
Speed of electrons

The heat generated by this current will cause extensive damage to connected equipment and conductors. This dangerous current must be interrupted immediately when a short circuit occurs. Current (electrons) travels at 186,000 miles per second, which is equivalent to traveling around the earth $7\frac{1}{2}$ times in one second. Slight overcurrents can be allowed to continue for some period of time, but as the overcurrent magnitude increases the protection device must open faster. Short circuits must be interrupted almost instantly to minimize damage.

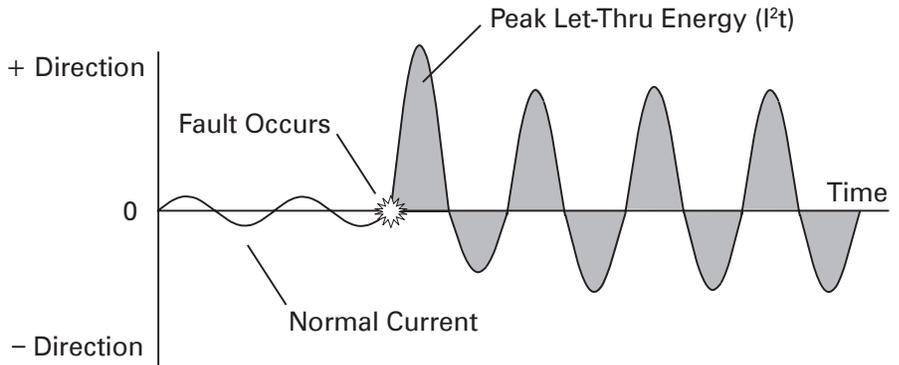


Short circuit current on unprotected electrical circuits

When a short circuit occurs current will continue to flow in an unprotected electrical circuit. The peak short circuit current of the first cycle is the greatest and is referred to as peak let-thru current (I_p). The force of this current can cause damage to wires, switches, and other electrical components of a circuit.

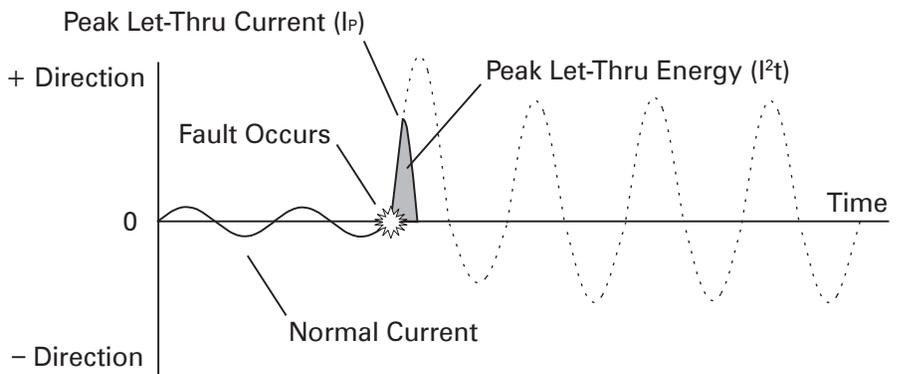


There is also energy let-thru (I^2t). This destructive thermal force is capable of melting conductors.



Short circuit current on protected electrical circuits

A properly used overcurrent protecting device will open the circuit quickly, limiting peak let-thru 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

How hot an insulated conductor can get before it sustains damage needs to be known. Conductors are rated by how much current they can carry on a continuous basis, 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 1-Ampacities of Insulated Conductors (From *NEC*[®] Table 310-16)
Not More Than Three Insulated Conductors in Raceway
(Based on Ambient Temperature of 30°C, 86°F)

Size	COPPER CONDUCTORS			
	60°C (140°F)	75°C (167°F)	85°C (186°F)	90°C (194°F)
	TYPES ①	TYPES ①	TYPES	TYPES
AWG MCM	RUW T TW UF	FEPW RH RHW RUH THW THWN XHHW USE ZW	V, MI	TA, TBS SA, AVB SIS FEP, ① FEPB, ① RHH, ① THHN, ① XHHW ③ ②
18	---	---	---	14
16	---	---	18	18
14	20 ①	20 ①	25	25 ①
12	25 ①	25 ①	30	30 ①
10	30	35 ①	40	40 ①
8	40	50	55	55
6	55	65	70	75
4	70	85	95	95
3	85	100	110	110
2	95	115	125	130
1	110	130	145	150
1/0	125	150	165	170
2/0	145	175	190	195
3/0	165	200	215	225
4/0	195	230	250	260

NEC[®] Table 1 of Table 310-16 gives ampacities under two conditions: the raceway contains not more than three conductors and 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

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 a continuous load and the rating of overcurrent protective devices in Article 210-22(c).

The rating of the branch-circuit overcurrent device serving continuous loads, such as store lighting and similar loads, shall be not less than the noncontinuous load plus 125% of its rating.

Exception: Circuits supplied by an assembly together with its overcurrent devices that is listed for continuous operation at 100% of its rating.

In general, the electrical conductor must be capable of carrying 125% of the full-load current. Continuous loads, such as mercantile lighting, must not exceed 80% of the branch-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 (electric lighting circuit) 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 a 100% rating of a circuit if supplied by an overcurrent device and assembly listed by a qualified testing laboratory for continuous operation. Other references in the *NEC*[®] can be found in Articles 220-3(a), 220-10(b), and 384-16(c).

Review 1

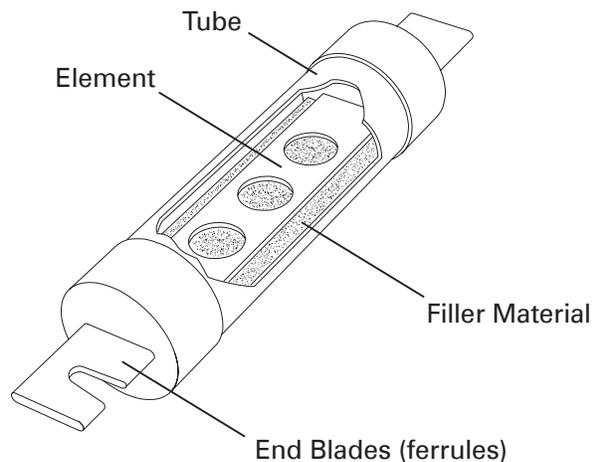
1. An enclosed switch that has a switch and fuses in a single enclosure is referred to as a _____ enclosed switch.
2. *NEC*[®] defines "in sight" as visible and not more than _____ feet distant.
3. With an increase in current, heat will
 - a. increase
 - b. decrease
 - c. remain the same
4. Two causes 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. Electrons travel at a speed of _____ miles per second.
8. The peak short circuit current of the first cycle is known as _____ - _____.
9. Peak let-thru _____ is a destructive thermal force.
10. Article _____ of the *NEC*[®] covers overcurrent protection.
11. Table _____ of the *NEC*[®] gives ampacities of insulated conductors.
12. 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, overloads and short circuits do occur. To protect a circuit against these currents, a protective device must determine when a fault condition develops and automatically disconnect the electrical equipment from the voltage source. 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 end blades or ferrules. The element provides a current path through the fuse. The element is enclosed in a tube and surrounded by a filler material.

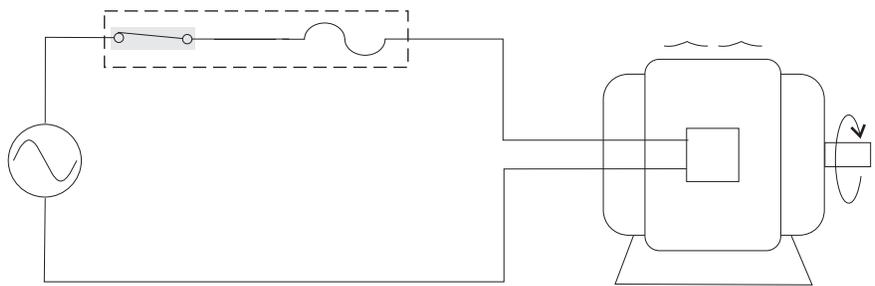


As mentioned earlier, switches are normally shown in their "Off" or "Open" position. For the purpose of explanation the following symbol is used to show the switch closed, connecting the load to the power source. This is not a legitimate symbol. It is used here for illustrative purposes only.



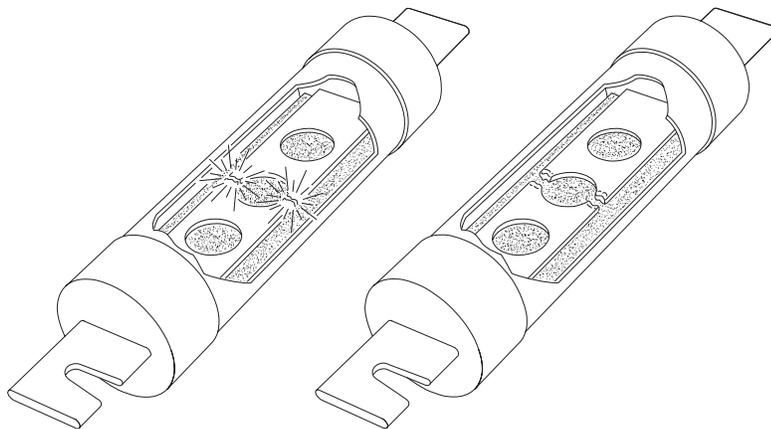
Using a fuse in a circuit

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



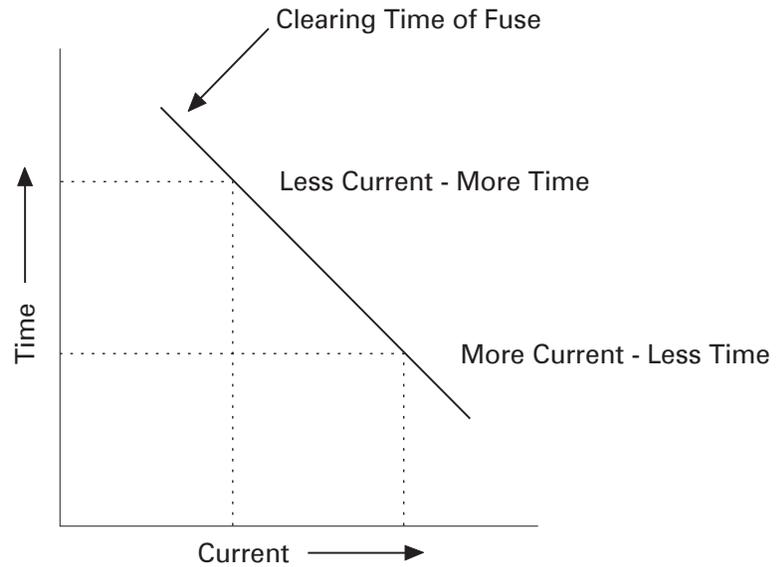
Fuse subject to overcurrent

Current flowing through the element generates heat, which is absorbed by the filler material. When an overcurrent occurs temperature in the element rises. In the event of a harmless transient overload condition the excess heat is absorbed by the filler material. If a sustained overload occurs the heat will eventually melt open an element segment forming a gap; thus stopping 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.

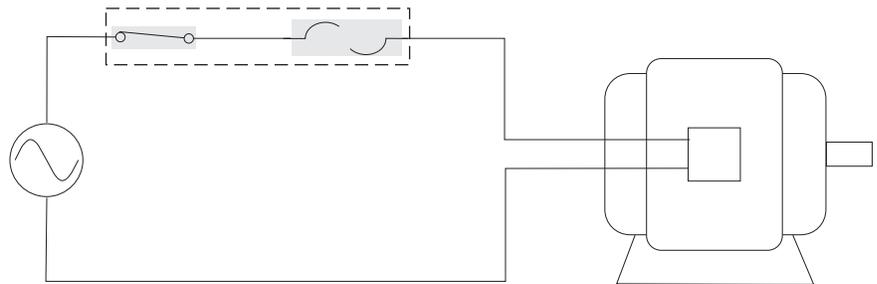


For the purpose of explanation the following symbol is used to show an open fuse. This is not a legitimate symbol. It is used here for illustrative purposes only.



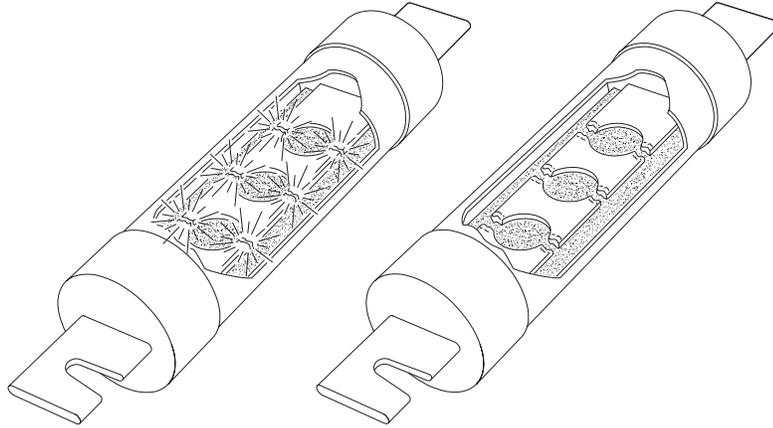
Overload current

When an overload condition exists temperature will rise in the fuse, eventually causing it to open. Power is removed from the motor and it coasts to a stop.



Short-circuit current

Short-circuit current can be several thousand amperes and generates extreme heat. When a short circuit occurs several element segments can melt simultaneously, which helps remove the load from the source voltage 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. Short-term overloads, such as motor starting current, may cause nuisance openings of nontime-delay fuses. 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 second, after which the current carrying element melts. This means that these fuses should not be used in motor circuits which often have inrush (starting) currents greater than 500%.

Time-delay fuses

Time-delay fuses provide 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 unless an overload persists.

Fuse Ratings And Classifications

Ampere rating

Fuses have a specific ampere rating, which is the continuous current carrying capability of a fuse. The ampere rating of a fuse, in general, should not exceed the current carrying capacity of the circuit. For example, if a conductor is rated for 10 amperes, the largest fuse that would be selected is 10 amperes.

There are some specific circumstances when the ampere rating is permitted to be greater than the current carrying capacity of the circuit. For example, motor and welder circuits can exceed conductor ampacity 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, can be used in a 480 volt circuit. 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). When applying a fuse, one must be selected which can sustain the largest potential short circuit current which can occur in the selected application. The fuse could rupture, causing extensive damage, if the fault current exceeds the fuse interrupting rating.

UL fuse classification

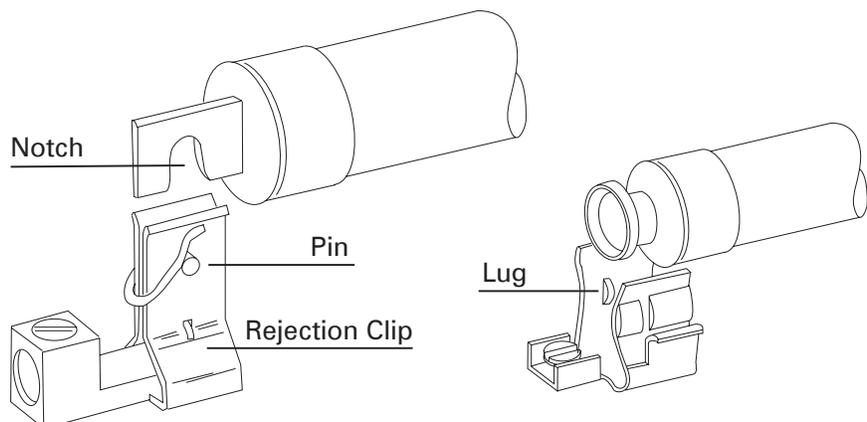
Fuses are grouped into current limiting and non-current limiting classes based on their operating and construction characteristics. Fuses that incorporate features or dimensions for the rejection of another fuse of the same ampere rating but with a lower interruption rating are considered current limiting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

Class	Voltage Rating	Ampere Rating	Interrupting Rating (Amperes)	Sub Classes	UL Standard
G*	300	0-60	100,000		UL 198 C
H	250, 600	0-600	10,000	Renewable Nonrenewable	UL 198 B
J*	600	0-600	200,000		UL 248 B
K	250, 600	0-600	50,000, or 100,000, or 200,000	K1 and K5	UL 198 D
L*	600	601-6000	200,000		UL 248 10
R*	250, 600	0-600	200,000	RK1 and RK5	UL 248 12
T*	300	0-1200	200,000		UL 248 15
T*	600	0-800	200,000		UL 248 15
CC*	600	0-30	200,000		UL 248 4
Plug	125	0-30	10,000	"Edison Base" and Type S	UL 198 F

* Current Limiting Fuses

Class R current limiting fuses

The following illustration shows Class R type fuse holders which feature rejection clips. This permits only the notched Class R fuse to be installed. This prevents a fuse with a lower AIC rating, such as a Class H or K from being installed.



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.

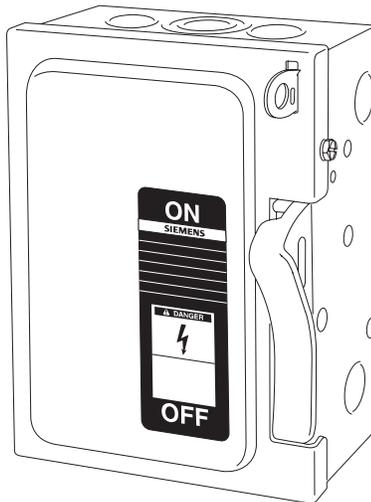
Enclosures

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.

The standard for enclosures of electrical equipment is UL 50, published by Underwriters Laboratories (UL). The standard provides enclosure descriptions, features, and test criteria for hazardous (classified) and nonhazardous locations. The following brief descriptions cover enclosures available for Siemens enclosed switches.

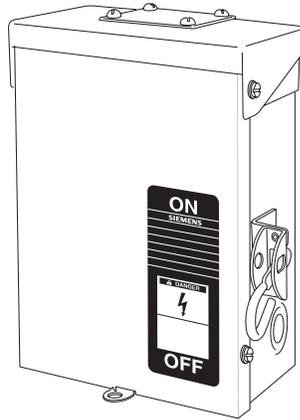
Type 1 enclosures

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.



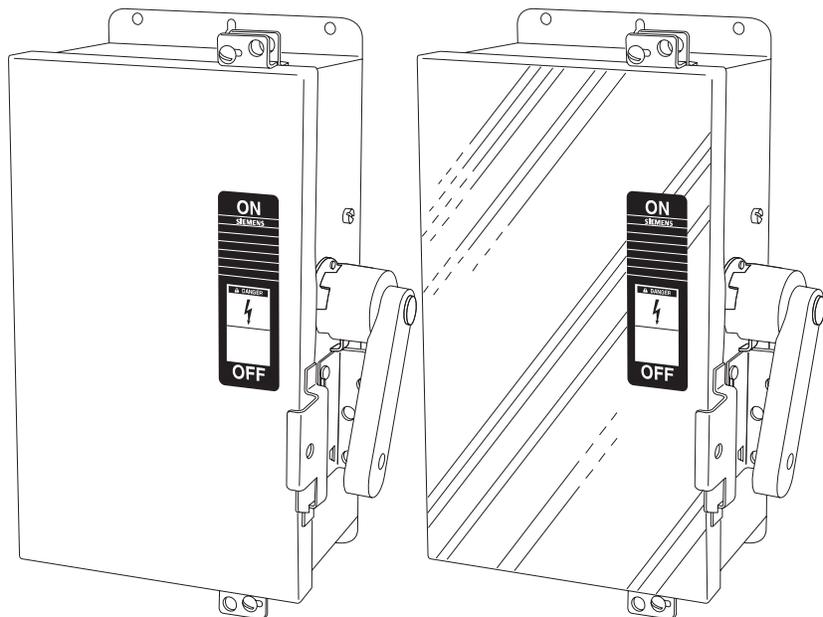
Type 3R enclosures

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



Type 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 provide a high degree of protection against corrosion. Type 4 and 4X enclosures provide a degree of protection from contact with the enclosed equipment.

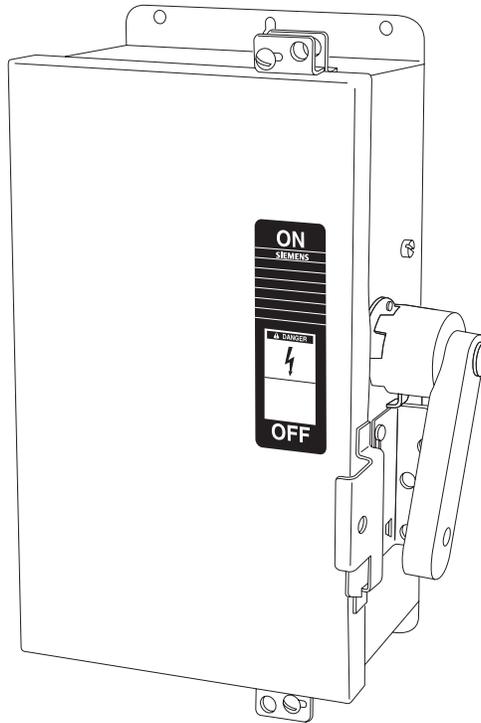


Type 4

Type 4X Stainless Steel

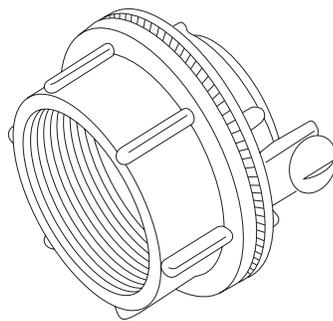
Type 12 enclosures

Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping non-corrosive liquids. They are not intended to provide protection against conditions such as internal condensation.

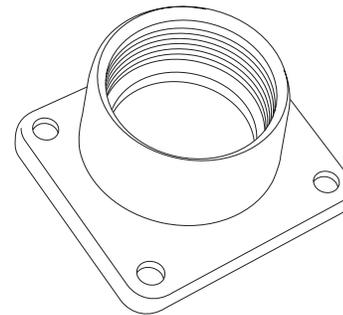


Hubs

Various hubs are available for attaching the cable conduit to the enclosure.



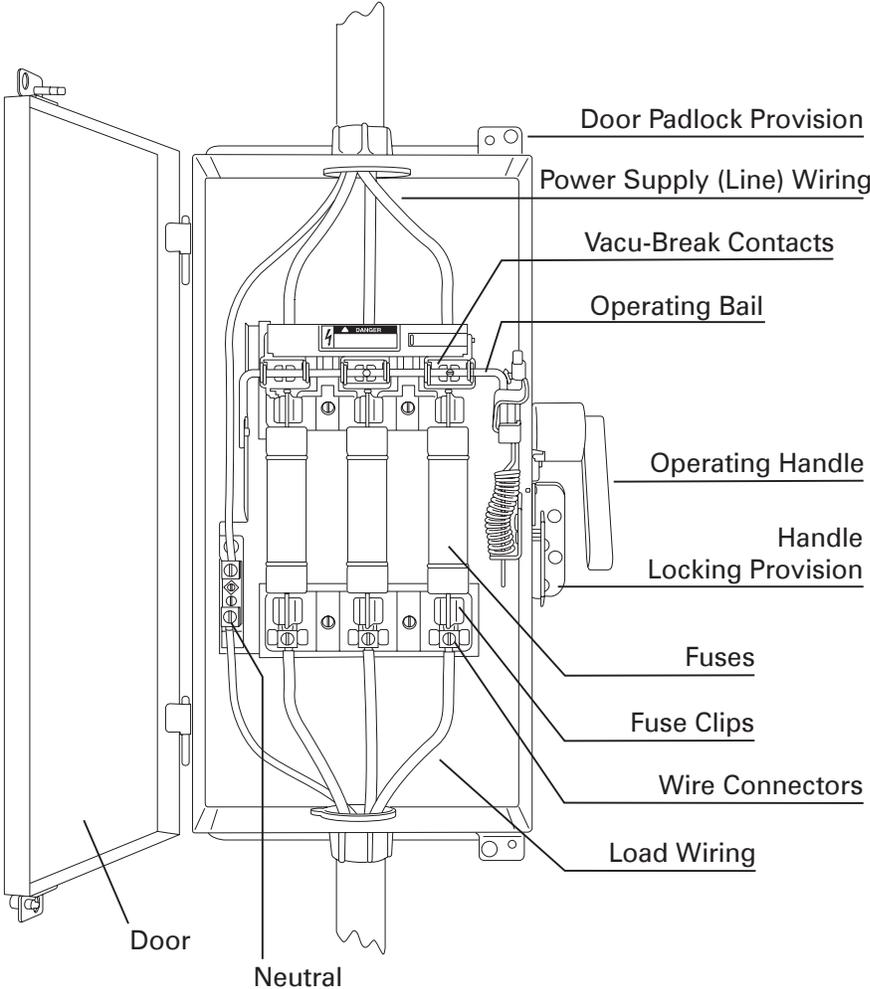
Type 4 Hub



Type 3R Hub

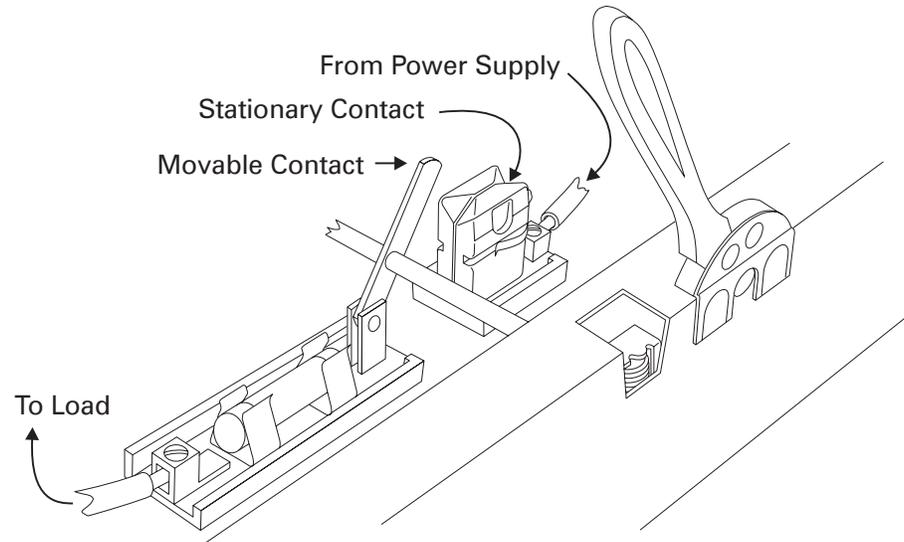
Switch Design

The enclosure houses the switch mechanism (Vacu-Break[®] contacts), wire connectors, and an operating bail. A handle, connected to the operating bail, opens and closes the Vacu-Break contacts. If the switch is fusible the enclosure also houses the fuse clips that accomodates fuses. Provisions are provided to lock the door and/or handle.

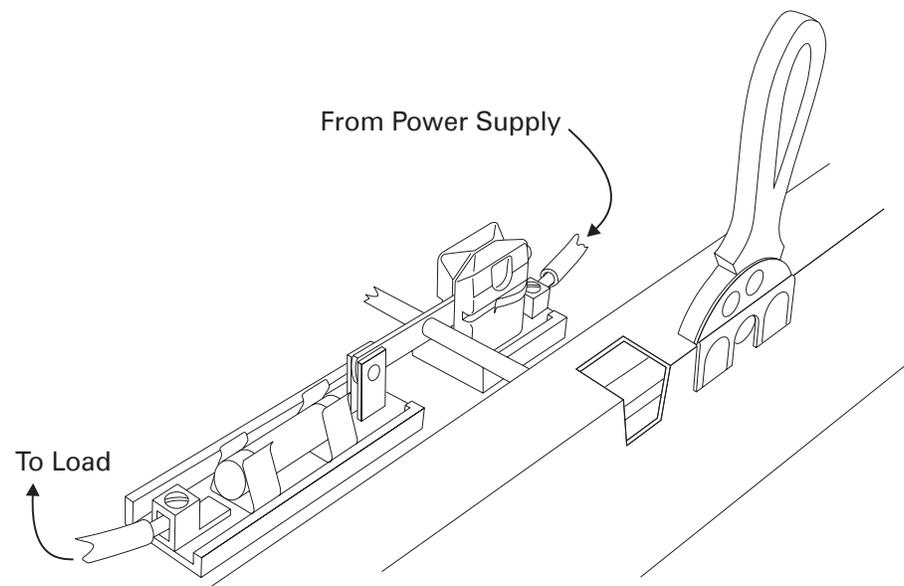


Knife blade switch principle

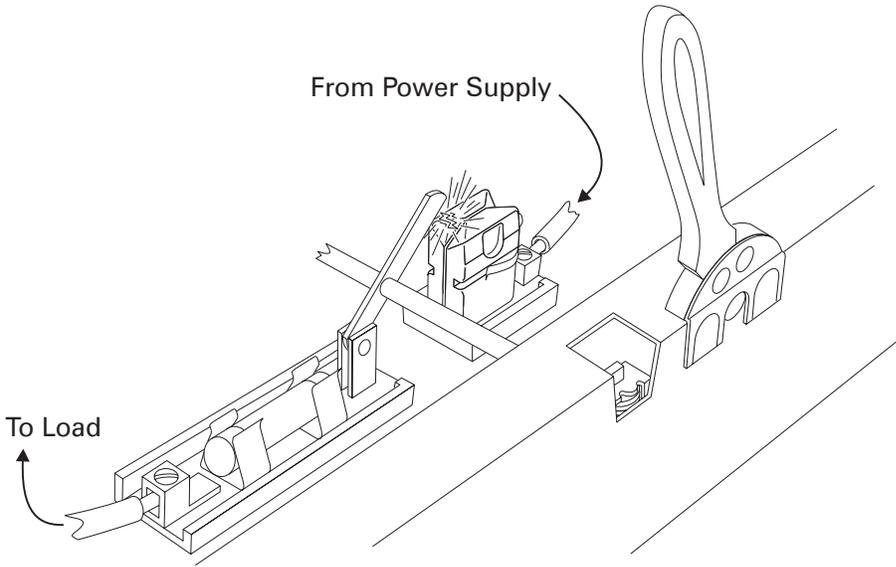
Switches use contacts to break the circuit and stop the flow of current. A typical switch assembly consists of a stationary contact, a hinged movable contact, and an operating handle. The hinged movable contact may also be referred to as a knife blade. If the movable contact is not touching the stationary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



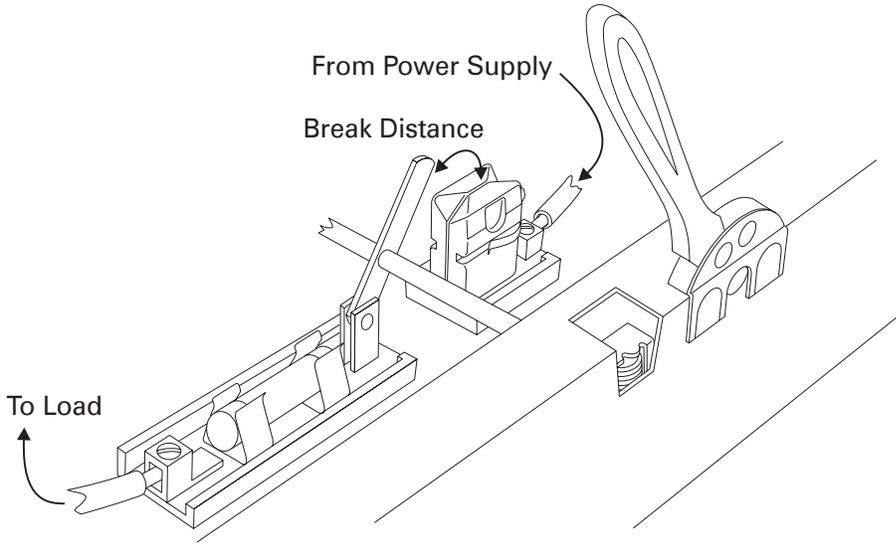
Moving the handle to the "On" position closes the contacts and provides a complete path for current to flow from the power supply to the load.



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.

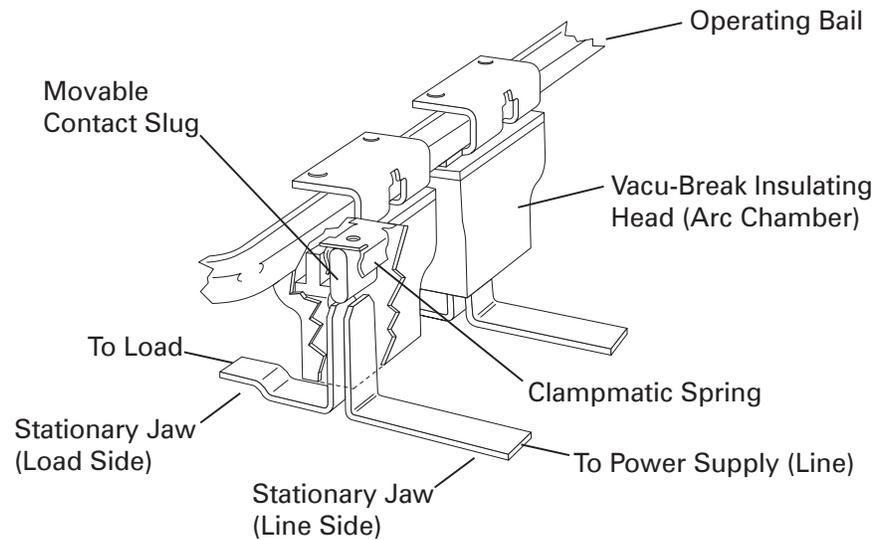


The point at which the arc is extinguished is called the break distance.



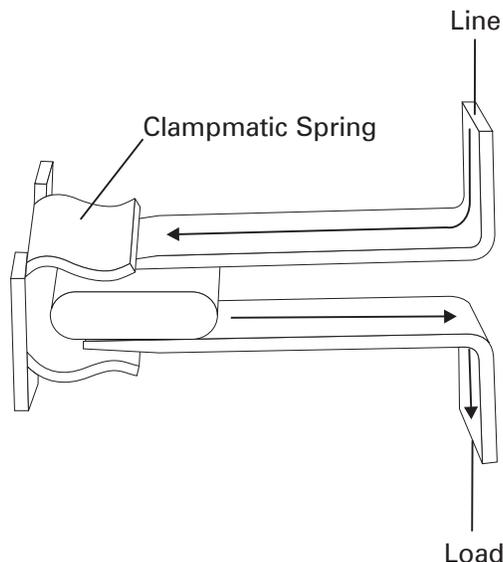
Vacu-Break principle

The Siemens 60 - 600 amp general duty and 30 - 1200 amp heavy duty enclosed switches use an exclusive Vacu-Break[®] principle. The Vacu-Break contacts consist two stationary contact jaws and a movable contact slug. One stationary jaw is connected to the power supply and the other is connected to the load. The movable contact slug is maintained in a Vacu-Break insulating arc chamber along with a Clampmatic[®] spring, and is connected to the operating bail. The operating bail (controlled by the external handle) raises and lowers the movable contact slug. The Vacu-Break head is a totally enclosed arc chamber.

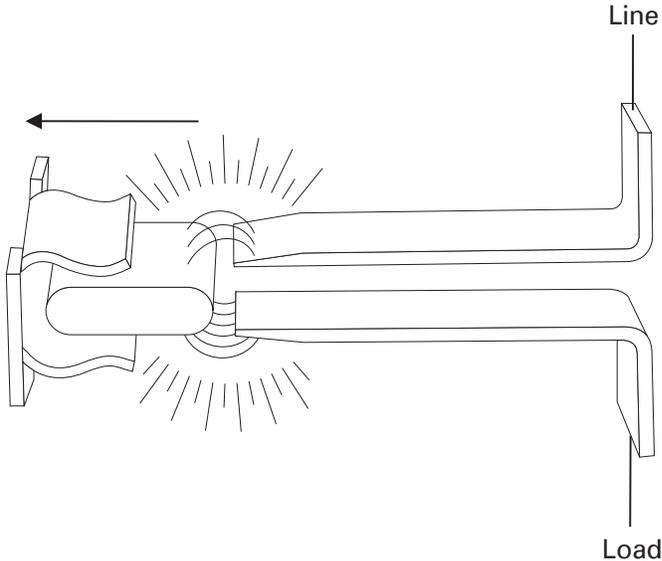


Clampmatic spring

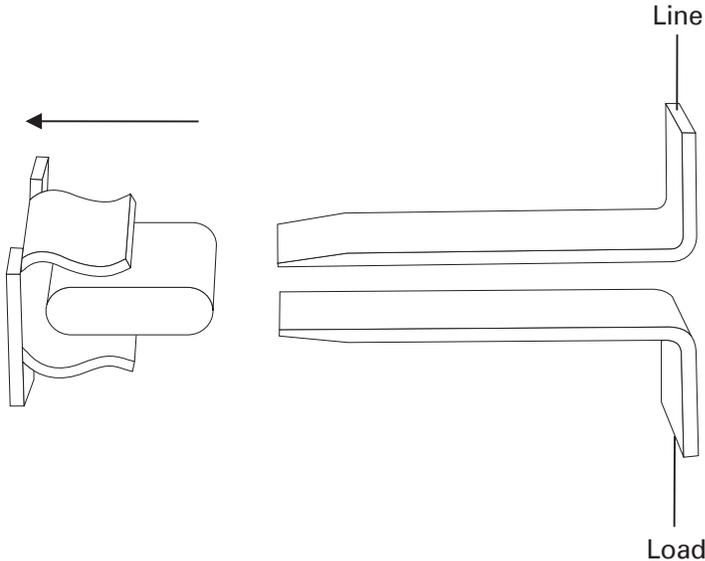
In the "On" position the Clampmatic spring arrangement applies pressure on the stationary jaws, forcing them into positive contact with the movable contact slug. Current flows from the power supply (line) through the stationary jaws, the movable slug, to the load.



As the operating bail moves the Clampmatic spring toward the off position, it slides off the tapered surfaces of the stationary contact jaws. The Vacu-Break contacts form two short arcs. These are easier to extinguish than the larger single arc formed by the knife switch design. The magnetic fields of the two arcs oppose each other, causing the arcs to bend outward against the arc chamber walls.

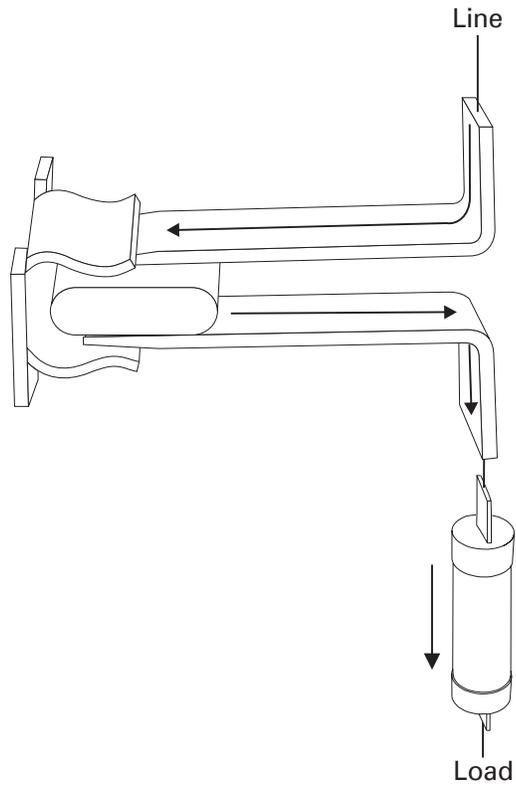


This stretches and cools the arc so it is extinguished quickly and reduces the break distance by one-half. In addition, arcing is directed at non-contact points, reducing scorching and erosion of the primary contact surface.



Fusible enclosed switch

The operation of the Vacu-Break contacts is the same in fusible and non-fusible enclosed switches. When a fusible enclosed switch is used, the fuse is wired in series with the load-side stationary jaw and the load. When the contacts are closed power flows through the switch and fuse to the load. The fuse will interrupt the circuit in the event of an overcurrent.



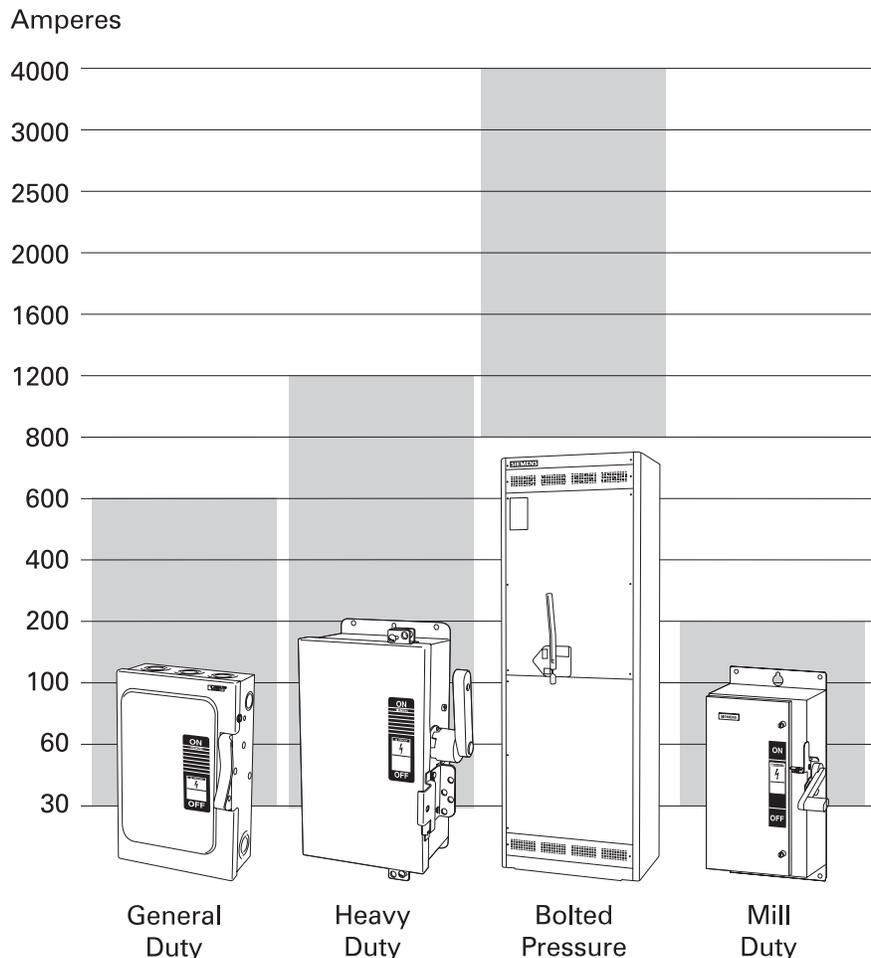
Review 3

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 Vacu-Break head is a totally enclosed _____ chamber.

Enclosed Switch Ratings

Ampere rating

Siemens enclosed switches are available in two types: general duty and heavy duty (includes Vacu-Break®, bolted pressure and mill duty). Siemens enclosed switches are listed by Underwriters Laboratories (UL). Every enclosed switch has a specific ampere rating. The ampere rating is the maximum continuous current an enclosed switch can carry without causing deterioration and without exceeding temperature rise limits. Heavy duty (mill duty) switches are available with ampere ratings of 30, 60, 100 and 200 amperes. General duty switches are available with ampere ratings of 30, 60, 100, 200, 400, and 600 amperes. Heavy duty (Vacu-Break) switches are available with ampere ratings of 30, 60, 100, 200, 400, 600, 800, and 1200 amperes. Enclosed bolted pressure switches are available with ampere ratings of 800, 1200, 1600, 2000, 2500, 3000, and 4000 amperes.

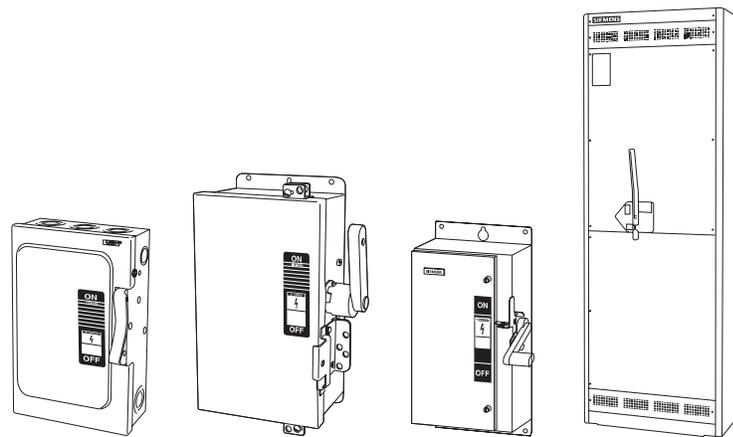


**Short circuit
withstandability**

Enclosed switches must be capable of withstanding the largest potential short circuit current which can occur in the selected application. General duty switches have a maximum short circuit withstandability of 100,000 amperes. Heavy duty switches have a maximum withstandability of 200,000 amperes.

Voltage rating

Enclosed switches are also rated according to the maximum voltage they can handle. The voltage rating of the enclosed switch must be at least equal to the circuit voltage. The voltage rating of the enclosed switch can be higher than the circuit voltage, but never lower. For example, an enclosed switch rated for 600 volts can be used on a 480 volt circuit. An enclosed switch rated for 240 volts cannot be used on a 480 volt circuit. The following chart reflects available voltage ratings.

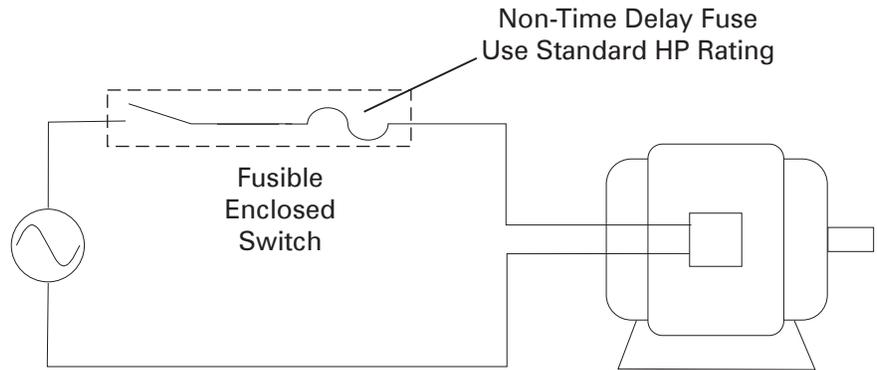


General Duty	Heavy Duty	Mill Duty	Bolted Pressure
240 VAC 250 VDC	240 VAC 600 VAC 250 VDC	240 VAC 600 VAC 250 VDC 600 VDC	240 VAC 480 VAC 600 VAC*

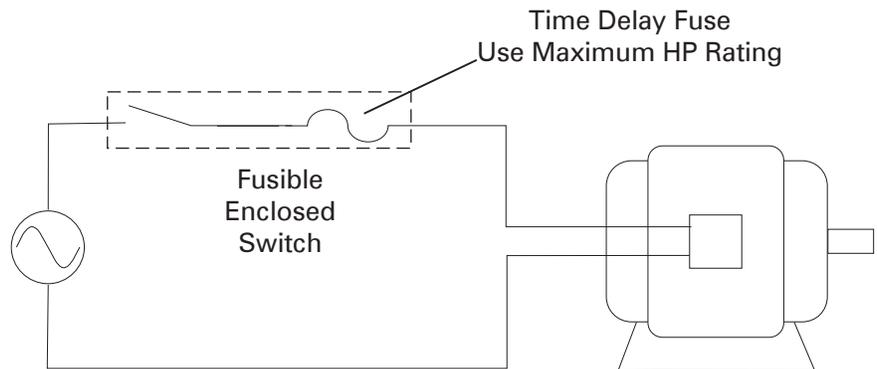
*600 VAC bolted pressure switch is not UL listed.

Dual horsepower ratings

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



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



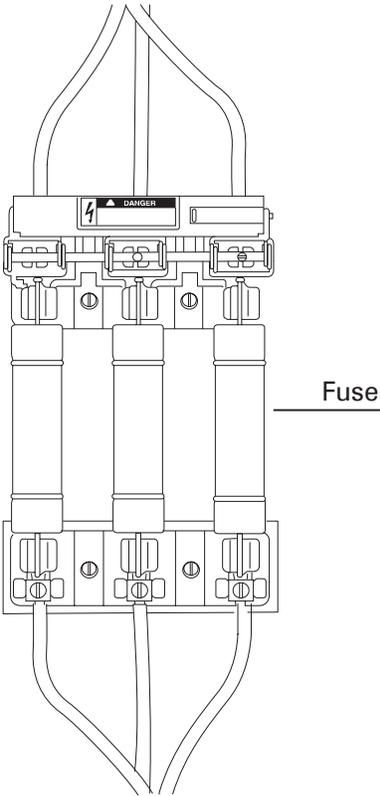
The following chart reflects maximum horsepower ratings of Siemens enclosed switches.

Enclosed Switch	Voltage	Maximum HP
General Duty	240 VAC	1½ - 200
	250 VDC	5 - 50
Heavy Duty	240 VAC	1½ - 250
	600 VAC	3 - 500
	250 VDC	5 - 50
Mill Duty	240 VAC	1½ - 60
	600 VAC	3 - 150
	250 VDC	5 - 40
	600 VDC	10 - 50

Switch Circuit Types And Terminology

Pole

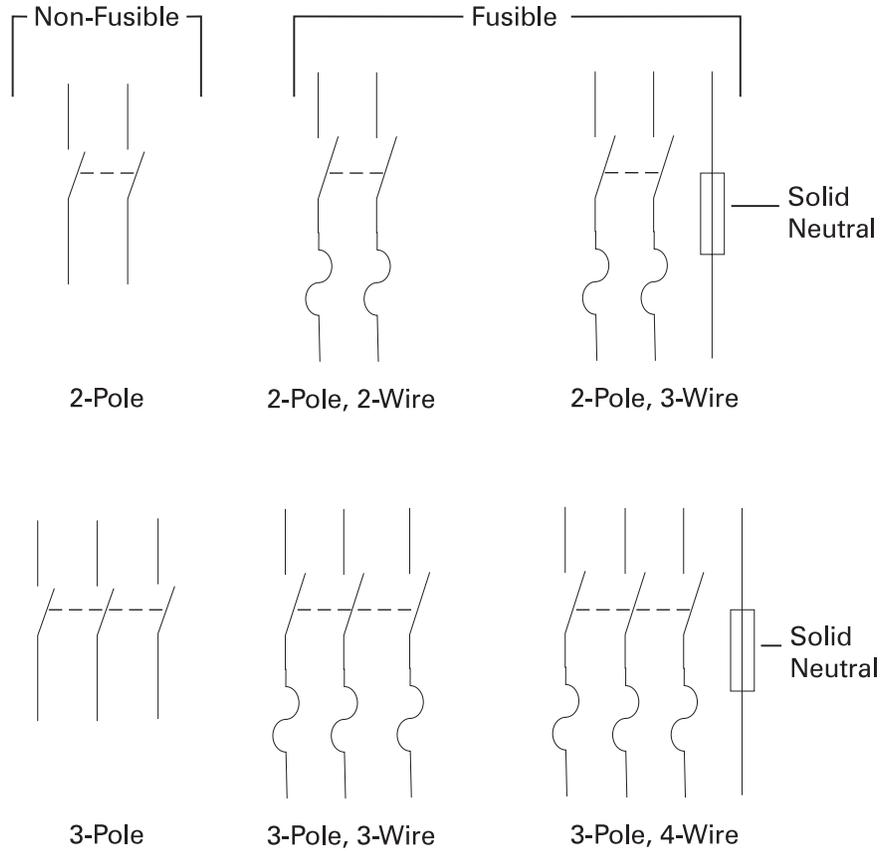
A pole describes the number of wires that a switch will disconnect at one time. The following drawing, for example, shows a 3-pole enclosed switch. The three circuits are mechanically connected so that all three poles connect and disconnect the line and load simultaneously when the switch is operated. Each pole is fused for overcurrent protection.



3-Pole, 3-Fuse

Circuit configurations

The following drawing illustrates circuit configuration diagrams for 2- and 3-pole enclosed switches. Enclosed switches may be non-fusible, fusible, and fusible with a solid neutral.



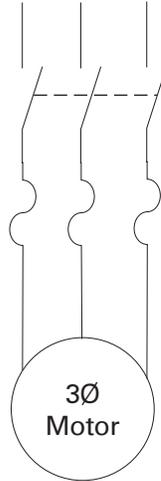
Siemens switches have the following circuit configurations available:

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

Example

The circuit configuration required depends on the connected load and power supply. For example, a three-phase motor connected to a three-phase power supply would use a 3-pole enclosed switch. If the enclosed switch also needs to provide overcurrent protection a fusible enclosed switch would be selected.

3Ø AC Power Supply



Catalog Numbers

To help identify each type of enclosed switch, a catalog number is assigned. The catalog number provides a description of the enclosed switch. There are six parts to the standard enclosed switch. The following figure illustrates a typical catalog number.

Catalog Number	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6
F352MSS =	F	3	5	2	M	SS

Part 1

Part 1 signifies the enclosed switch application. There are several types available, as indicated by the following table. The catalog number used in the above figure is either a heavy duty, or mill duty fusible switch. Additional information provided in the catalog number will reveal that this is a mill duty enclosed switch.

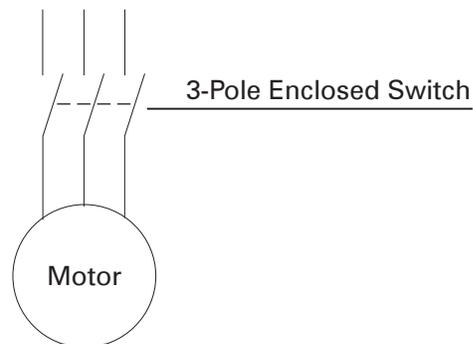
*General Duty 240 V Only, 60 - 600 A	Enclosure Type
JU = Non-Fusible, Indoor JN = Fusible Solid Neutral JF = Fusible	Type 1
NFR = Non-Fusible, Outdoor NR = Fusible Solid Neutral	Type 3R
Heavy Duty 240 V or 600 V	
NF = Non-Fusible SN = Fusible, Solid Neutral F = Fusible	Type 1 Type 4, 4X or Type 12
NFR = Non-Fusible, Outdoor NRH = Fusible Solid Neutral, 240 V Only FR = Fusible, 600 V Only	Type 3R
Mill Duty 240 V or 600 V	
NF = Non-Fusible F = Fusible	Type 3R / 12 Type 4 or 4X

*A different catalog numbering system is used for 30 A general duty switches only, as shown on page 43.

Part 2

Part 2 indicates the number of power supply wires, including the neutral, that an enclosed switch will accommodate. Switches can be provided with 2, 3, 4, or 6 wire positions. A neutral assembly kit must also be ordered when four-wire is required on 600 volt enclosed switches. The following illustration, for example, shows a 3-pole, or 3-wire, enclosed switch used on a 3-phase AC motor. The example catalog number indicates an enclosed switch with three poles and three wires.

Three-Phase
Supply Power



Part 3

Part 3 of the catalog number indicates the maximum AC voltage rating. The example catalog number indicates an enclosed switch with a maximum voltage rating of 600 volts.

2	240 volt
5	600 volt

Part 4

Part 4 of the catalog number indicates the ampere rating. The example catalog number indicates an enclosed switch with an ampere rating of 60 amperes.

1	30 A
2	60 A
3	100 A
4	200 A
5	400 A
6	600 A
7	800 A Non-Fusible
7L	800 A Fusible
8	1200 A Non-Fusible
8L	1200 A Fusible

Part 5

Part 5 of the catalog number indicates the enclosed switch type. The example catalog number indicates a mill duty enclosed switch.

M	Mill Duty
DTK	Double Throw
Blank	General Duty or Heavy Duty

Part 6

Part 6 of the catalog number indicates the type of enclosure. The example catalog number indicates an enclosed switch in a Type 4X, stainless steel enclosure.

SS	Type 4X (Stainless Steel)
W	Type 4 (Painted)
H	Type 12 Industrial (Indoor)
Blank	Type 1 (Indoor) or Type 3R (Outdoor)

Review 4

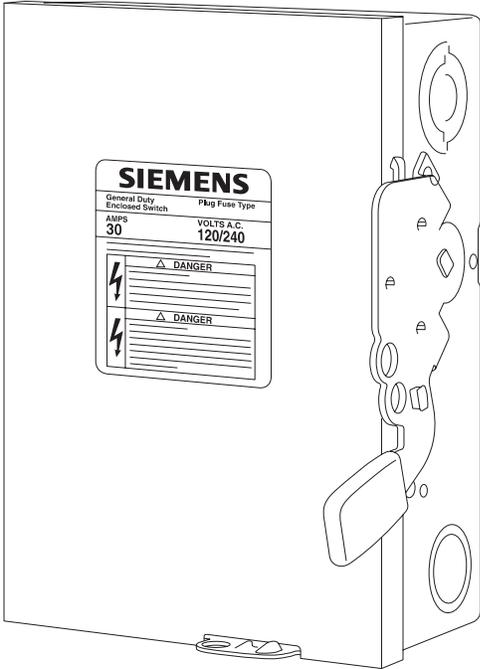
1. The _____ rating is the maximum continuous current an enclosed switch can carry.
2. The maximum short circuit current withstandability of heavy duty and mill duty switches is _____ amperes.
3. The maximum horsepower available in a 240 VAC general duty enclosed switch is _____ HP.
4. A _____ describes the number of isolated circuits that can pass through the enclosed switch at one time.
5. The number "3" in part four of the heavy duty catalog number indicates _____ .
 - a. 3-pole
 - b. 3R enclosure
 - c. 100 amperes
 - d. Mill Duty

General Duty Enclosed Switches

General duty Vacu-Break® type switches can be used on power supplies rated at 240 VAC or less, and where the available fault current is less than 100,000 amperes. General duty switches can be supplied in a Type 1 or Type 3R enclosure.

Plug fuse type enclosed switch

The general duty plug fuse type is available for 120/240 volt systems. The fusible model is suitable for one- or two-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 two-wire or three-wire motor applications up to three horsepower. The catalog numbering system of plug fuse and all other 30 A general duty switches is detailed on page 43. A non-fusible model comes in a two-pole circuit configuration. The non-fusible model is rated at 60 amperes and can be used with motors up to 10 HP.



General duty switches

The fusible general duty enclosed switch is available in two- or three-pole with a solid neutral, or four-pole configurations. The non-fusible model is available with a two- or three-pole configuration. Fusible switches will accept Class R fuses as standard. A field installable rejection kit is available which rejects all but Class R fuses.

Ratings

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

Fuses: 30-600 ampere Class H, K, or R;

100 - 600 ampere T cartridge fuse

Voltage ratings: 240 VAC, 250 VDC

Max short circuit current withstandability: 100,000 amperes*

*Requires current limiting fuses.

Type 1 enclosure

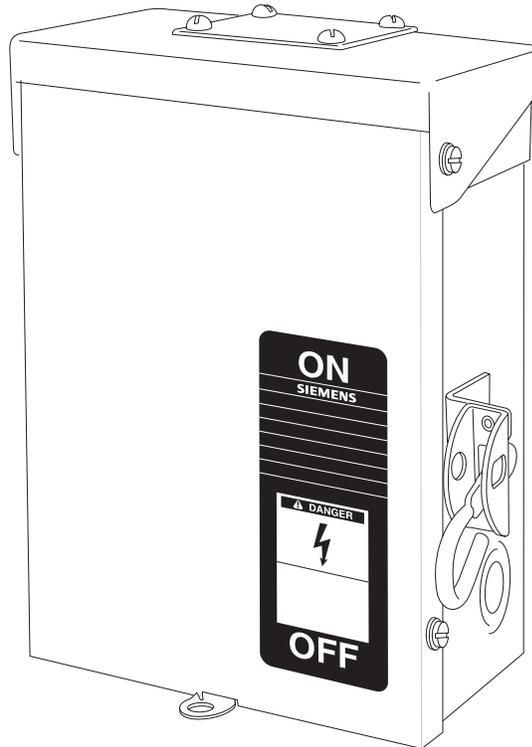
General duty switches are available in a Type 1 enclosure. An interlock prevents the cover from being opened when the switch is in the "On" position. A latch secures the door in the closed position. A padlock can be inserted in the latch. The catalog number for 30 amp switches begin with the letter "G". The catalog number for 60 amp and higher general duty switches in a Type 1 enclosure begin with "JU" (general duty unfused), "JF" (general duty fused), and "JN" (general duty fused with solid neutral).



JN422

Type 3R enclosure

General duty 2- and 3-pole enclosed switches are also supplied in a Type 3R enclosure. The catalog number for the 30 amp switches begin with the letter "G". The catalog number for 60 amp and higher general duty switches in a Type 3R enclosure begin with "NFR" (general duty nonfused, raintight), and "NR" (general duty fused with solid neutral, raintight).



NR422

Numbering system for 30 amp general duty switch

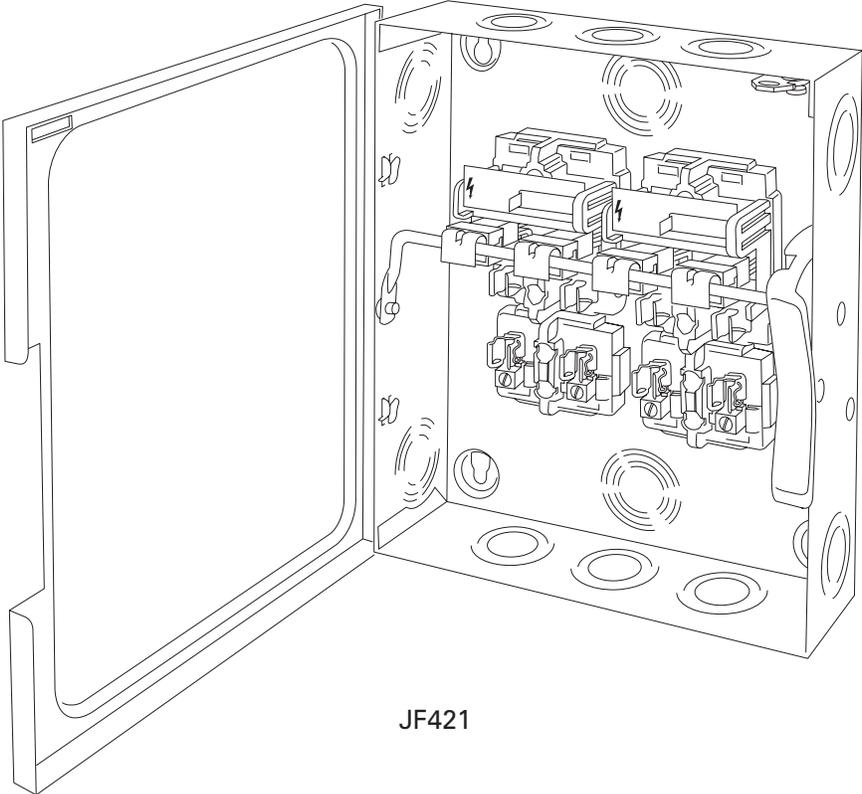
The new 30 amp general duty switches employ a visible blade, double break switching mechanism. For this and other reasons they have a dedicated catalog numbering system.

Catalog Numbering System for Plug Fuse and 30A General Duty Switches

Part 1 Switch Type	Part 2 Fused or Non Fused	Part 3 Number of Poles	Part 4 Voltage Rating	Part 5 Ampere Rating	Part 6 With or Without Neutral	Part 7 Enclosure Type
L=Gen. Duty 10k AIC Max (Plug Fused and 60A Special Application)	F=Fused NF=Non-Fused	1=1	1=120V or 120/240V	1=30A	Omit= Less Neutral N= with Neutral	Omit= Type 1 Indoor R= Type 3R Outdoor
		2=2	2=240V	2=60A		
		3=3				
G=Gen. Duty 100k AIC Max						

4-pole enclosed switch

General duty 4-pole enclosed switches are only available in a Type 1 enclosure, fusible style only. The catalog number begins with "JF" (general duty fused).

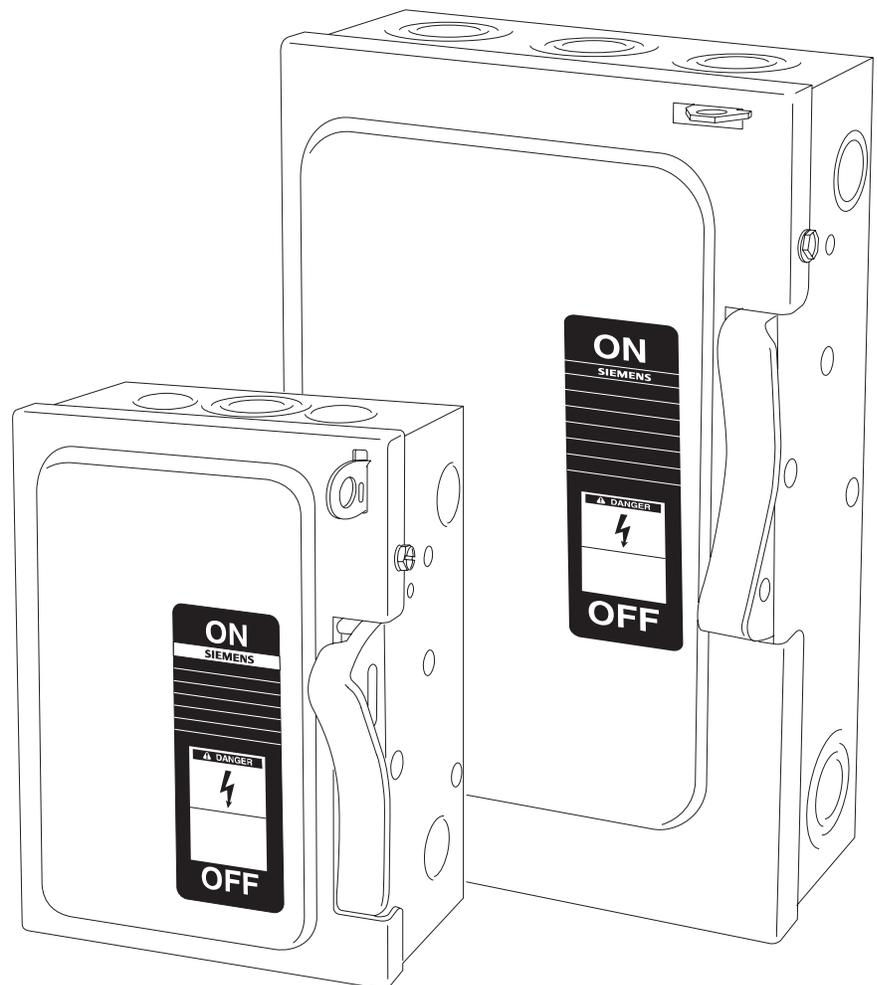


JF421

Heavy Duty Enclosed Switches

Type 1 enclosure

Heavy duty enclosed switches can be used on power supplies rated at 600 VAC or less, and 600 VDC or less. They can be used in applications where available fault current is 200,000 amperes or less. They have an interlock to prevent inadvertent opening of the cover while the switch is in the "On" position, and a mechanism interlock that prevents inadvertent turning on the switch while the cover is open. Heavy duty enclosed switches also have cover and mechanism padlocking capabilities.

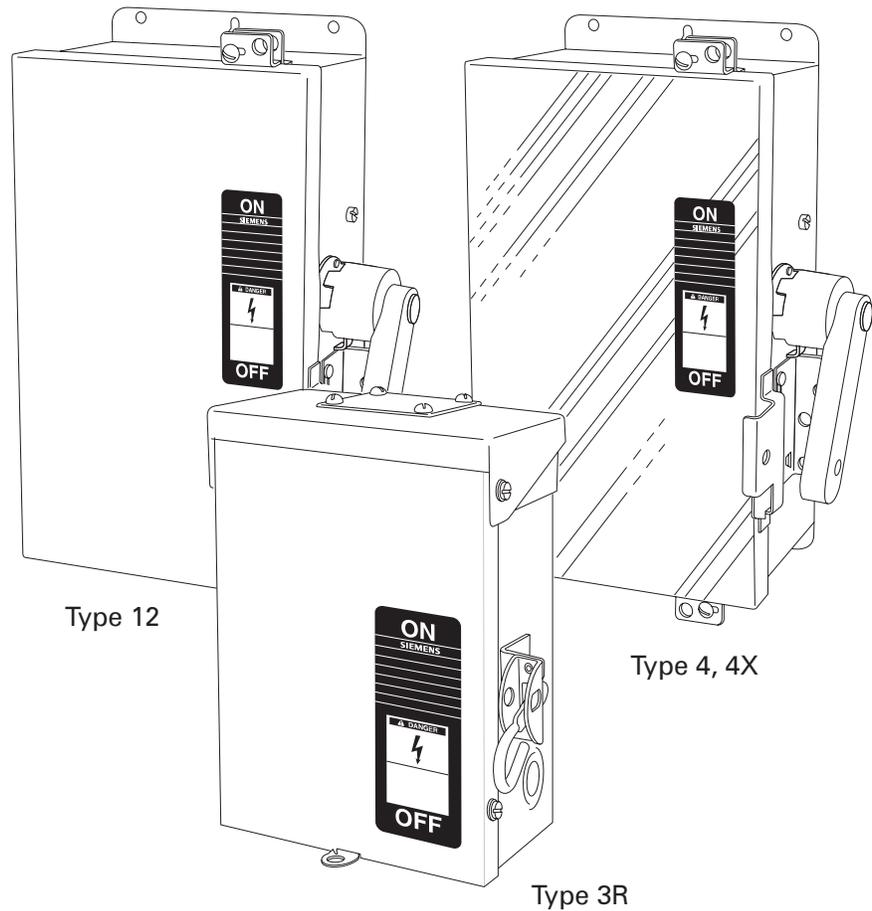


SN421

F351

Enclosures for heavy duty enclosed switches

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



Ratings

Ampere ratings: 30, 60, 100, 200, 400, 600, 800, 1200 amperes
Fuses: 30 - 600 ampere Class G, H, J, K, and R cartridge fuse
30 - 1200 ampere Class T cartridge fuse

Fuses over 600 A are all Class L current limiting type.

Voltage ratings: 240 VAC, 600 VAC, 600 VDC
Max short circuit current withstandability: 200,000 amperes

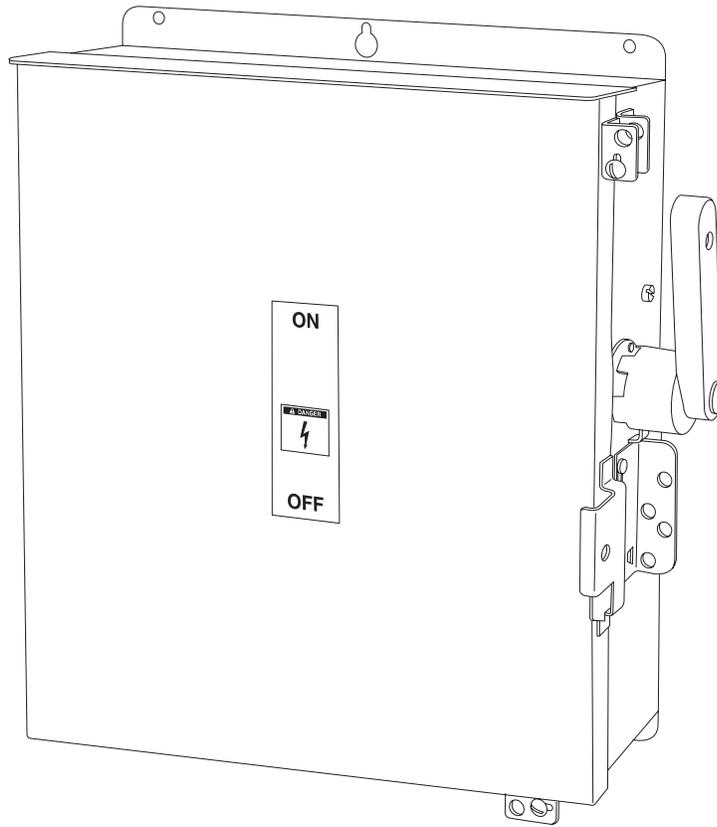
Interlock receptacle

The interlock receptacle enclosed switch provides cord connection for heavy duty portable equipment such as refrigerated trucks, welders, and other portable electric tools. An Arktite® receptacle is provided which is interlocked to prevent insertion or removal of the plug if the switch is in the "On" position. Arktite is a registered trademark of the Crouse-Hinds Company. The receptacle requires a Crouse-Hinds 4-wire, 3-pole, style 2 grounded APJ plug. The interlock receptacle enclosed switch is rated for 30, 60, and 100 amperes. The enclosure meets the requirements for Type 4, 4X, and 12 enclosures. A similar enclosed switch utilizing a Pyle- National receptacle is also available.



Six-pole enclosed switch

A six-pole heavy duty enclosed switch is also available in ampere ratings of 30, 60, and 100 amperes. This switch is supplied in one type of enclosure that satisfies Type 1, 3R and 12 enclosure requirements. A separate switch is available for Type 4 applications. Six-pole enclosed switches are not UL listed.

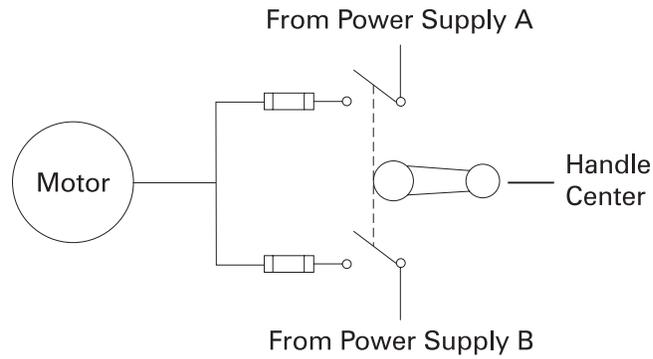


Double throw switch

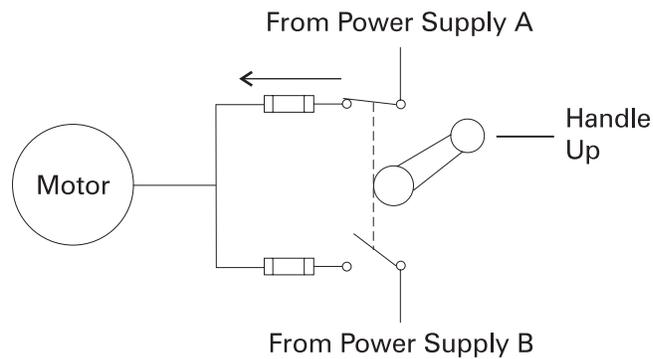
Double throw switches are intended to transfer loads from one power source to another. A critical piece of equipment may need a back up power supply in case the main power supply fails or needs maintenance. Double throw switches are available in fusible and non-fusible types. They are available in Type 4 and Type 12 enclosures for 30 - 200 amp ratings, and Type 1 and Type 3R enclosures for 30 - 800 amp ratings. They are available in 30, 60, 100, 200, 400, 600, and 800 ampere sizes. Double throw switches are rated for 240 VAC/250 VDC or 600 VAC.

Double throw switch application

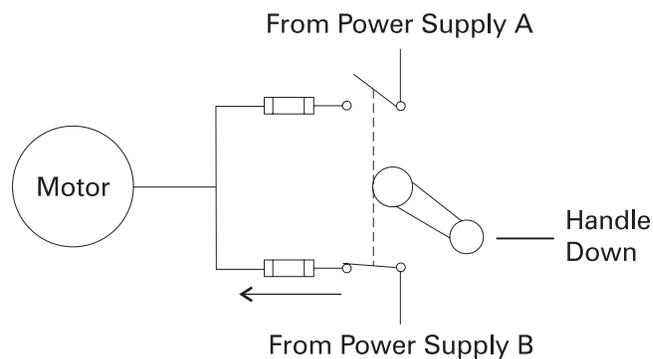
A motor, for example, can be connected through a double throw switch to power supply A or power supply B. When the handle is in the center position the switch is "Off" and no power flows to the motor.



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

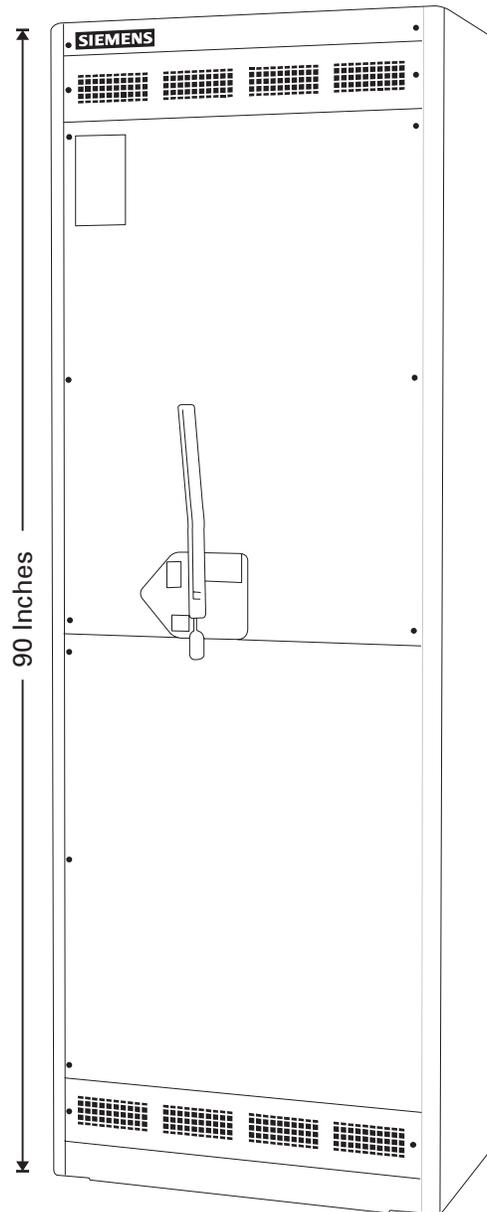


Moving the handle to the down position connects the motor to power supply B.



Bolted Pressure Switch

The bolted pressure switch is also considered a heavy duty switch. Bolted pressure switches are available in 800, 1200, 1600, 2000, 2500, 3000, and 4000 amperes. The maximum short circuit current withstandability is 200,000 amperes. Bolted pressure switches are rated for 240 VAC, 480 VAC, and 600 VAC. The 600 VAC switches are not UL listed.

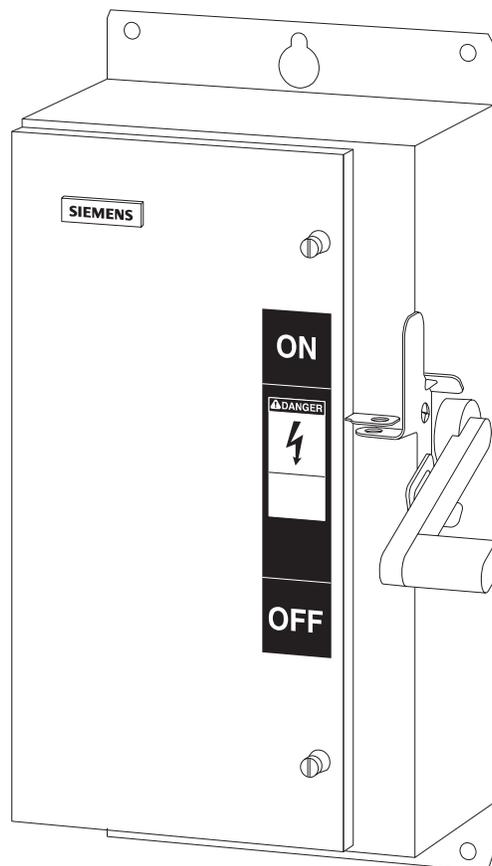


Review 5

1. The maximum short circuit current withstandability of general duty switches is _____ amperes.
2. Plug fuse type enclosed switches require a Type _____ plug fuse.
3. A catalog number that begins with _____ indicates a fusible 60 - 600 amp general duty enclosed switch with a solid neutral in a Type 1 enclosure.
4. The maximum short circuit current withstandability of heavy duty switches is _____ amperes.
5. The maximum current rating of a Vacu-Break heavy duty switch that is not a bolted pressure switch is _____ amperes.
6. The _____ enclosed switch provides cord connection for heavy duty portable equipment.
7. _____ switches are intended to transfer loads from one power source to another.
8. The maximum current rating of a bolted pressure switch is _____ amperes.

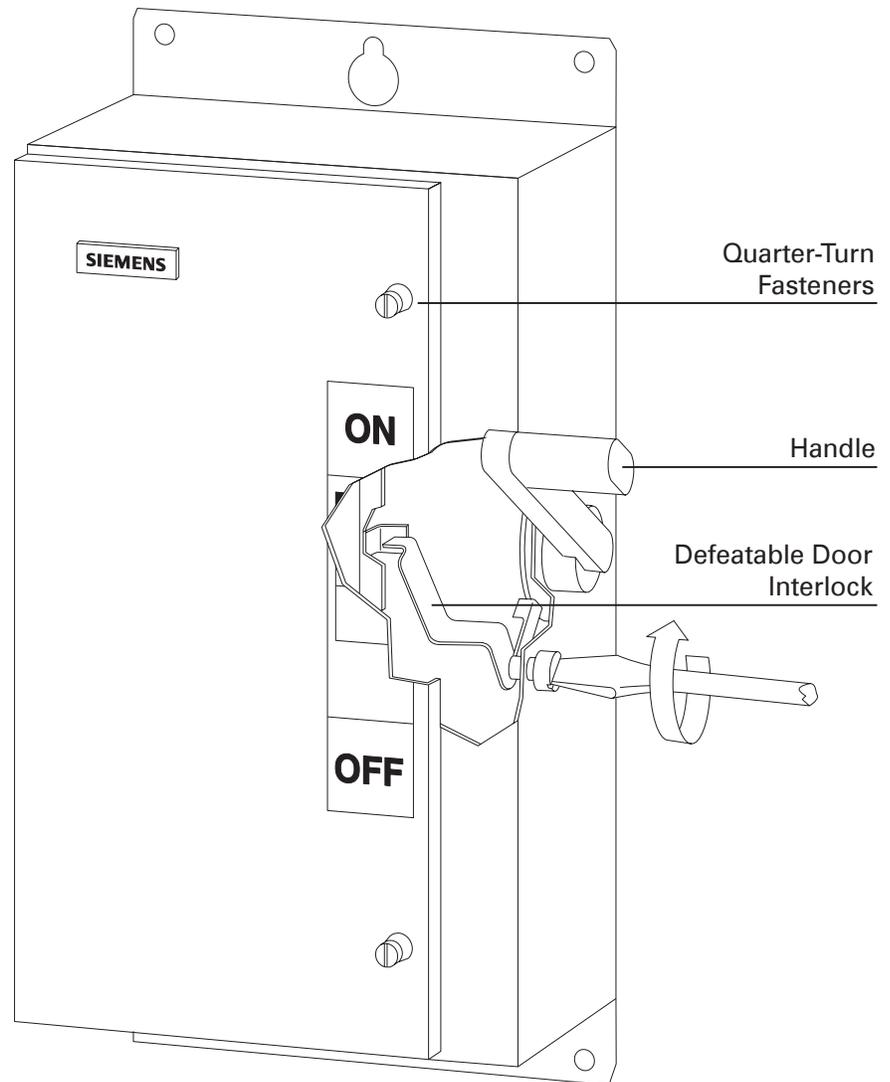
Mill Duty Enclosed Switches

The term mill duty is a Siemens assigned reference to a switch that is UL listed but is designed to exceed normal UL requirements for heavy duty switches. Siemens mill duty switches are designed to work reliably in adverse industrial environments such as steel mills and mining operations. Most switches use a spot welding technique to join seams, then a sealant or caulking is applied between spot welds. Siemens mill duty switches use robotic welding to form a continuous bead which eliminates the need for a sealant. Mill duty switches will not leak when exposed to falling liquid or hose-downs, common in heavy industry. The enclosure is finished with an electrostatic polyester which resists aqueous acids, salts, and various solvents. Mill duty switches are available in Type 3R/12, 4, and 4X (stainless steel) enclosures.



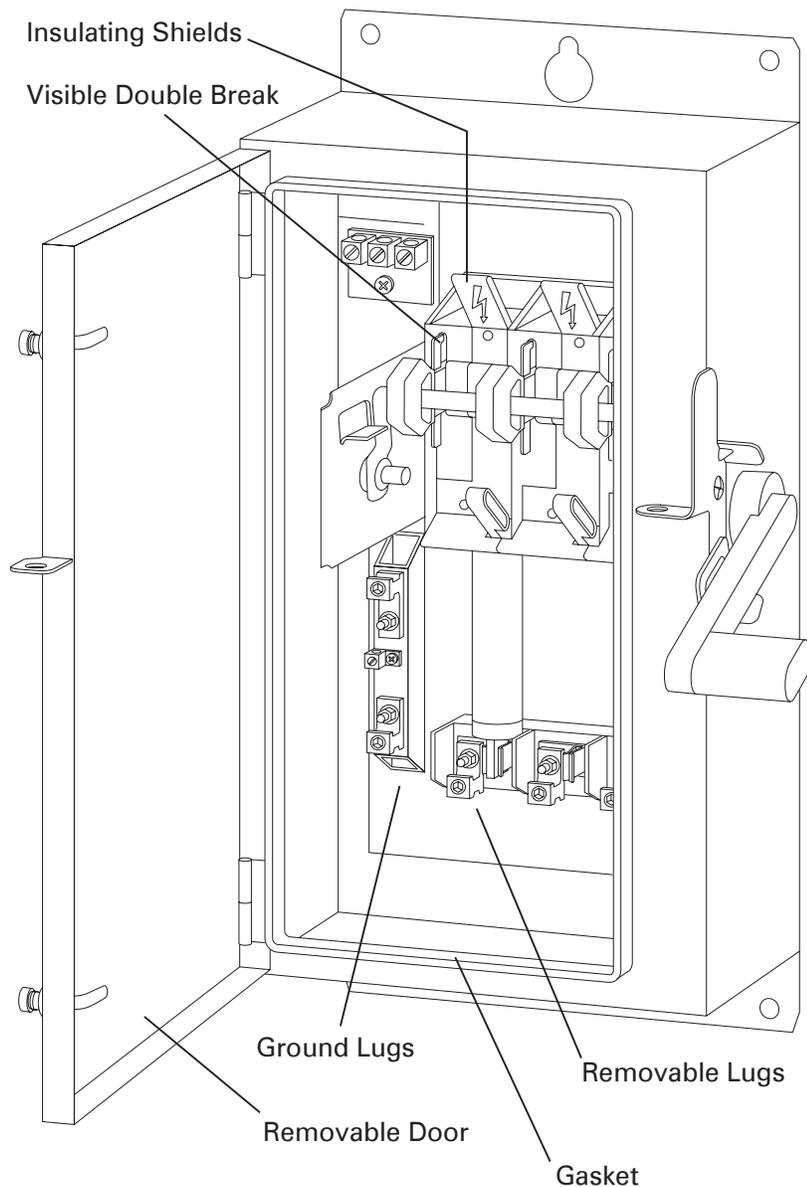
Exterior

Two quarter-turn fasteners provide access to the interior. An externally accessible door interlock prevents the door from being opened when the switch is in the "On" position. The interlock may be defeated with a screwdriver if it is necessary. The door can be padlocked (not visible in the drawing below). The handle provides a visual indication if the switch is in the "Off" or "On" position. In the "Off" position the handle shows black to the operator. In the "On" position the handle shows red to the operator.



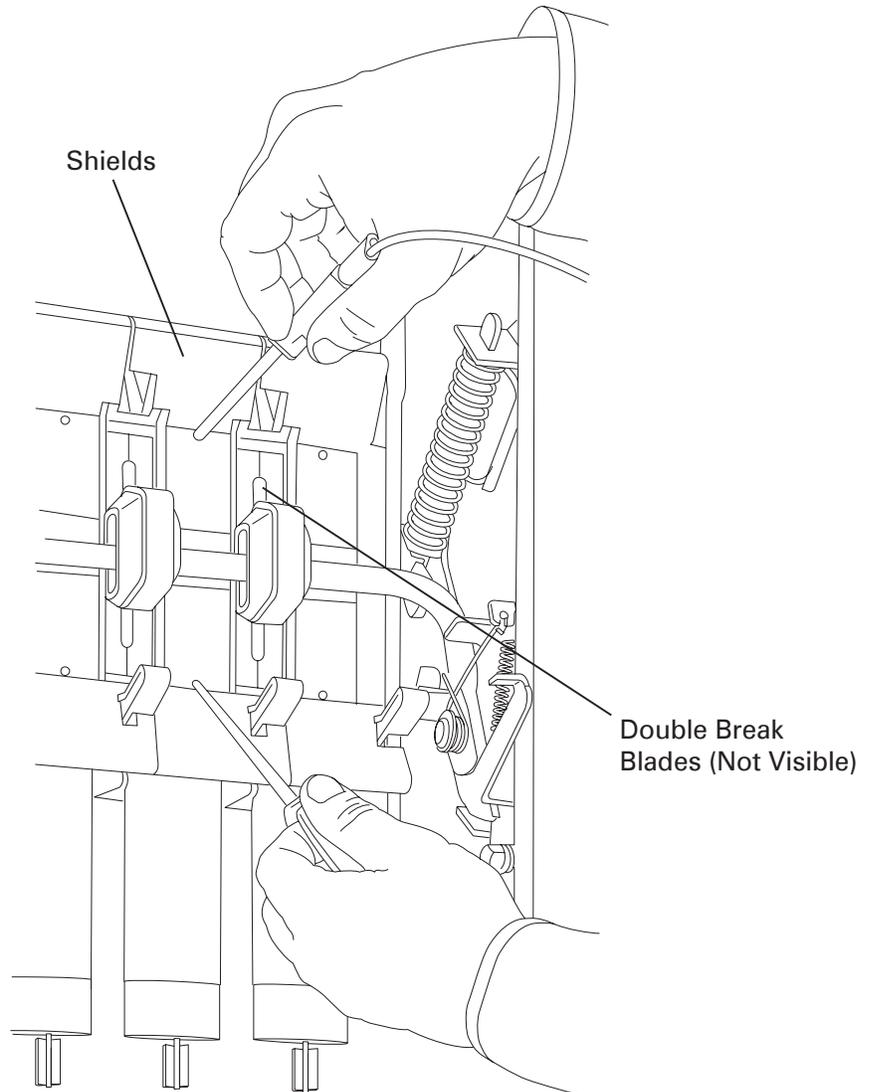
Interior

The door is removable to permit easier installation and accessibility for maintenance. A gasket around the door insures a positive seal when the door is closed. A visible-break switch provides a double break to improve arc interruption. Blades are fully visible in the "Off" position to provide an extra measure of safety. Insulating shields increase operator safety. Cable termination lugs can be removed. These can be replaced with all-copper or compression lugs. Ground lugs are supplied in all mill duty switches.



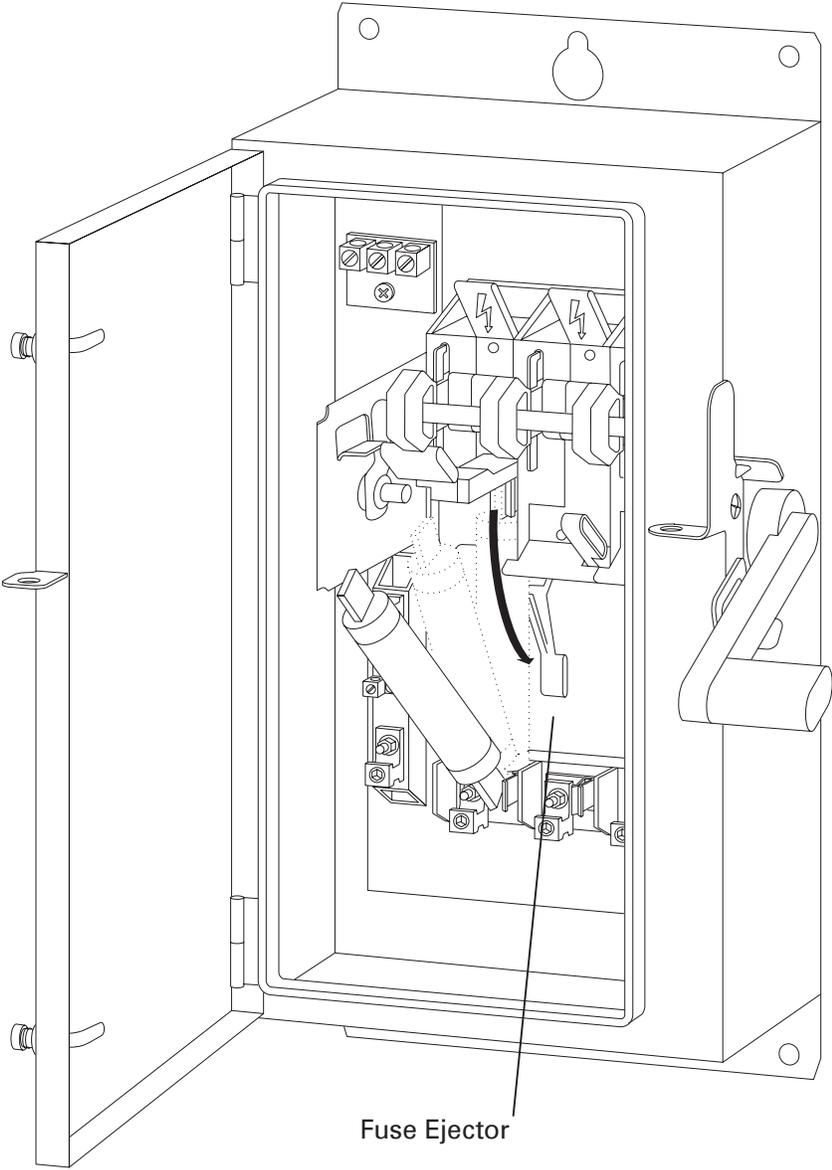
Shields

Shields are provided to cover the incoming line and the line side of the fuse. This gives added protection for maintenance and testing. The shield of each pole is independent. Each pole can be kept covered except the one requiring maintenance. The shields are permanently attached and designed in such a way that the fuse cannot be removed without opening the shield first. In the following illustration the visible-break blades are not visible, indicating the switch is in the "On" position.



Fuse ejectors

Mill duty switches have built-in fuse ejectors. The safety shield is opened, then the fuse ejector is moved in a downward direction, ejecting the fuse.



Ratings

Ampere ratings: 30, 60, 100, 200 amperes

Fuses: 30 - 200 ampere Class H, K, R, and J

Voltage ratings: 240 VAC, 600 VAC, 250 VDC, 600 VDC

Max short circuit current withstandability:

200,000 amperes at 240 VAC, 600 VAC, and 250 VDC

100,000 amperes at 600 VDC

Accessories

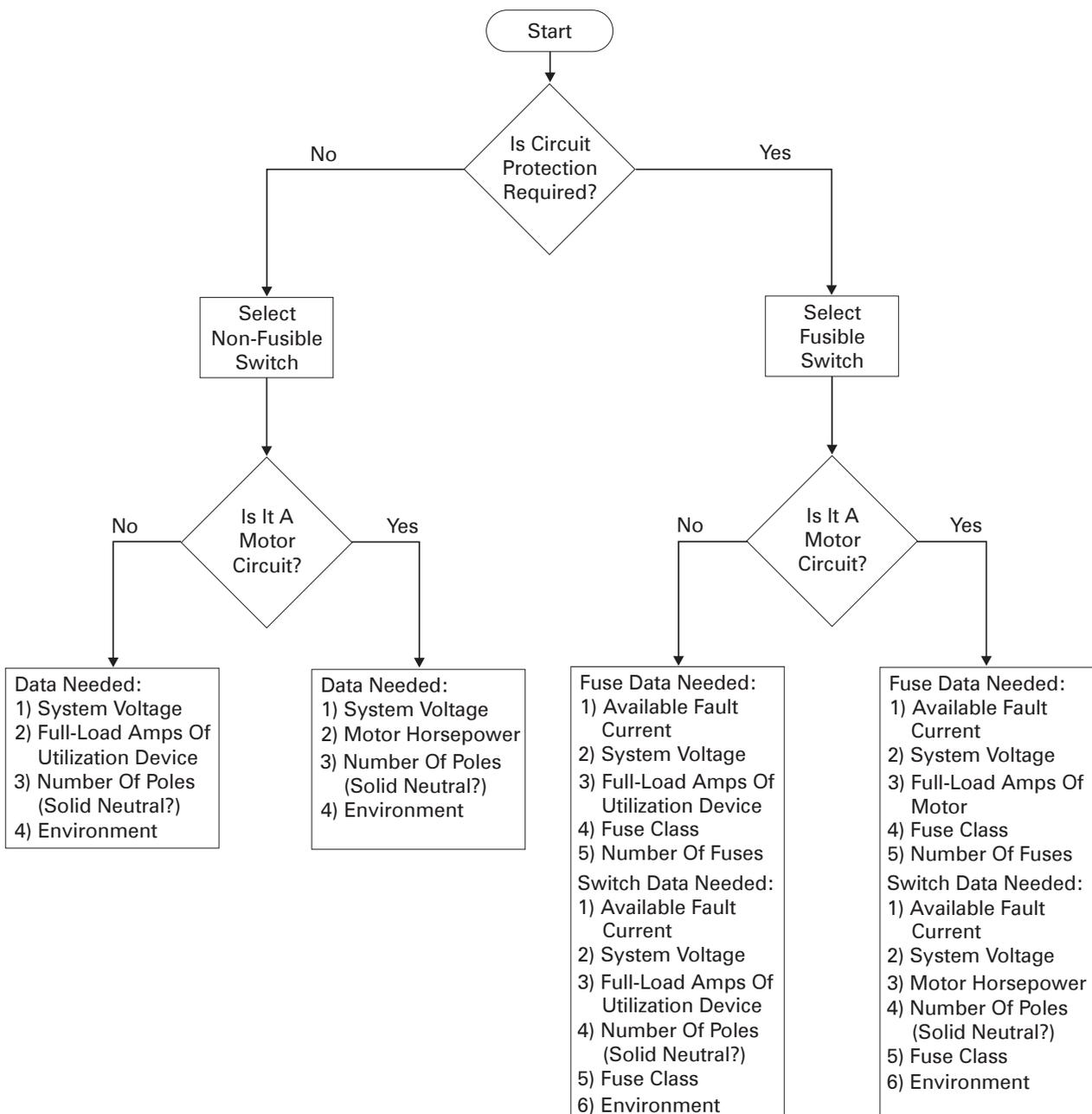
A number of accessories are available for mill duty switches. Compression lugs (not shown), copper lugs, auxiliary contacts (not shown), and a hook-stick operator (not shown) for the switch handle are available.



Copper Lug

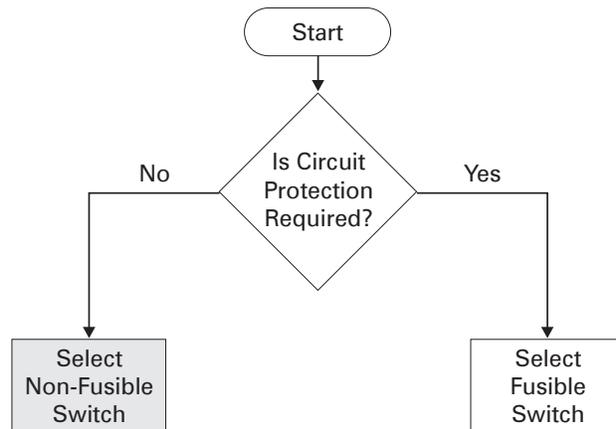
Selecting Enclosed Switches

Selecting an enclosed switch is not difficult. Flow charts make it easy to see where key decisions have to be made. The following flow chart can be used to determine the information necessary to select an enclosed switch.



Selecting a non-fusible switch

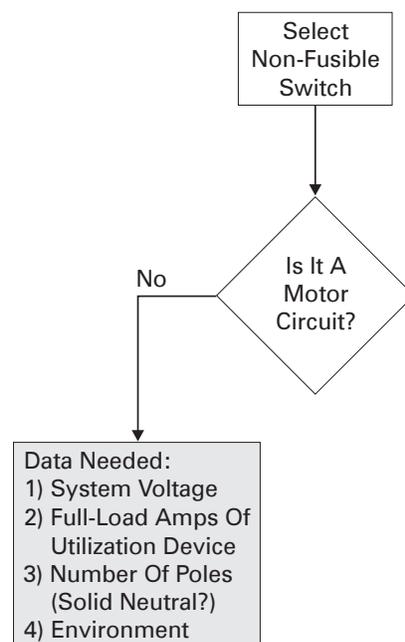
The first question is: Is circuit protection required? If circuit protection is not required a non-fusible switch would be selected.



Non-fusible switch not used on a motor circuit

If a non-fusible switch is selected the next question is: Is it a motor circuit? If the switch is not used on a motor circuit the following information must be known:

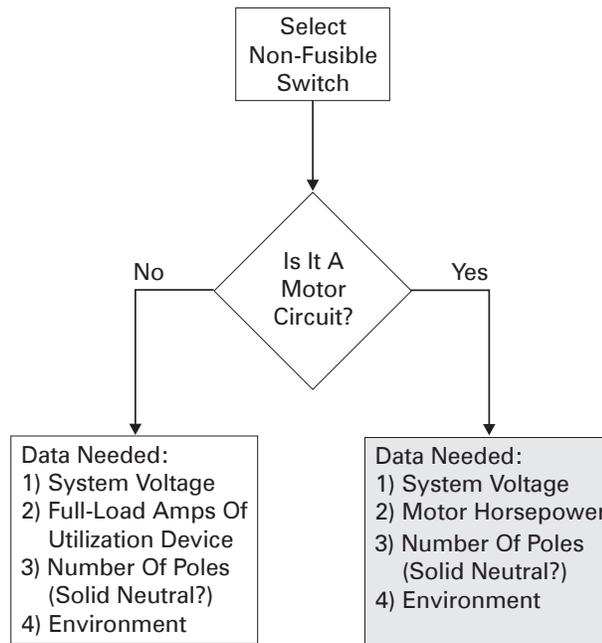
- 1) System voltage: 120 VAC, 240 VAC, 480 VAC, 600 VAC, 250 VDC, 600 VDC
- 2) Full-load amperes of the device to be used on the switch
- 3) The number of poles required and if a neutral is needed
- 4) The environment (enclosure type)



Non-fusible switch used on motor circuit

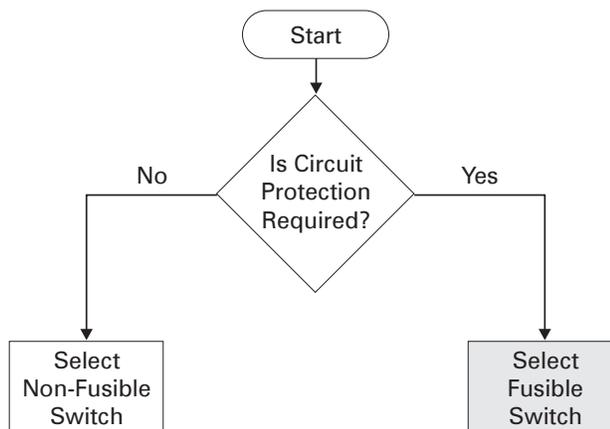
If the switch is used on a motor circuit the same data is a required with the exception of the motor's horsepower.

- 1) System voltage
- 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)



Selecting a fusible switch

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



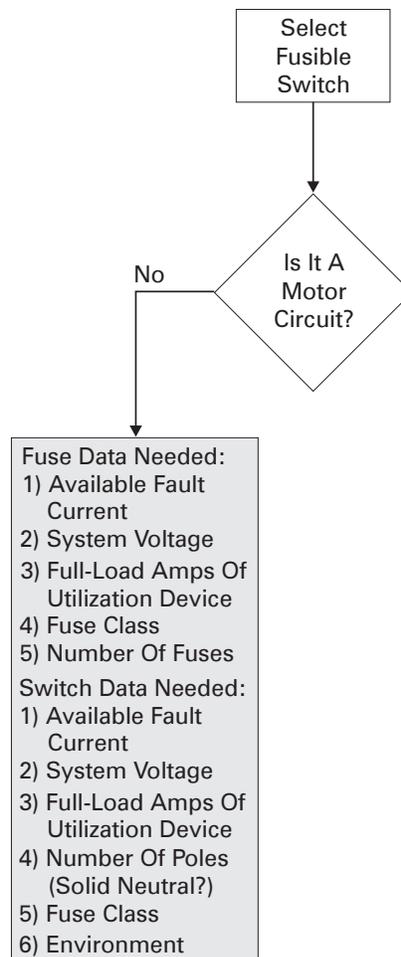
Fusible switch not used on a motor circuit

If a fusible switch is selected the next question is: Is it a motor circuit? If the switch is not 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 of the device to be used on the switch
- 4) Fuse class
- 5) Number of fuses

The following information 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)



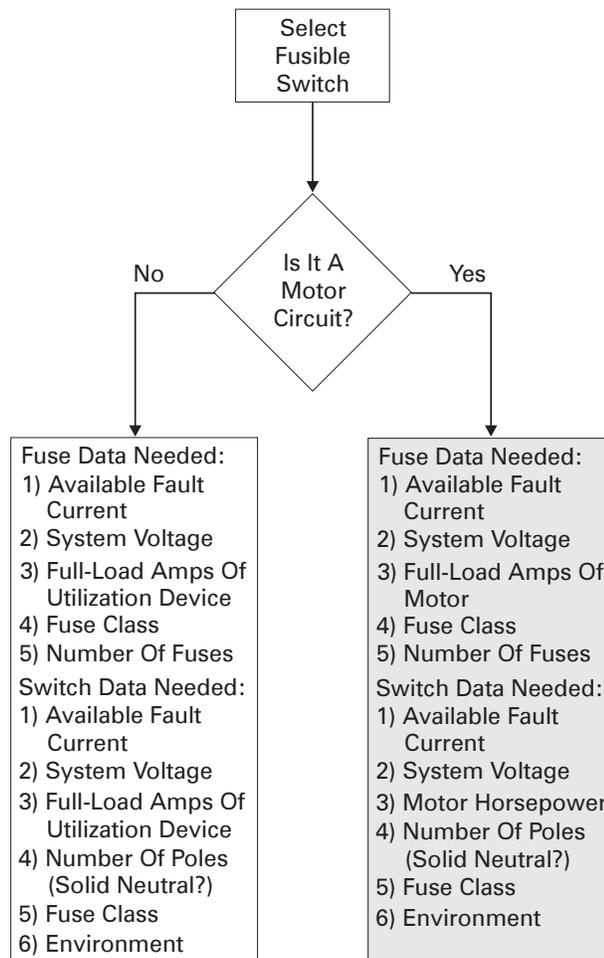
Fusible switch used on a motor circuit

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 motor
- 4) Fuse class
- 5) Number of fuses

The following information 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 enclosed switch

In the following example an enclosed 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, three-phase, three-wire (no neutral). The environment is indoors with no unusual conditions.

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, therefore a switch must be selected that can carry 56 amperes.

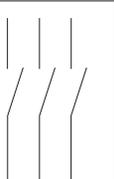
$$\begin{array}{r} 45 \text{ amperes} \\ \times 125 \% \\ \hline 56 \text{ amperes} \end{array}$$

Knowing that the switch will be used indoors with no unusual conditions a Type 1 enclosure can be selected. The requirements can be met with a general duty switch. Referring to the General Duty Vacu-Break Type Enclosed Switches section of the Speedfax catalog, the first 240 volt, 3-pole, non-fusible switch found that will handle 56 amperes is a 60 amp switch. The catalog number is JU322.

System	Ampere Rating	INDOOR - Type 1			OUTDOOR - Type 3R		
		Catalog Number	List Price	Ship Wgt. Std. Pkg.	Catalog Number	List Price	Ship Wgt. Std. PK

240 VOLT NON-FUSIBLE

2-POLE, OR 3-POLE

	30	GNF321			GNF321R		
	60	JU322			NFR322		
	100	JU323			NFR323		
	200	JU324			NFR324		
	400	JU325			Use 600V Switch - NFR355		
	600	JU326			Use 600V Switch - NFR356		

Example of selecting a fusible enclosed switch

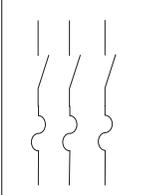
In the following example an enclosed switch needs to be provided for an application that does require circuit protection. This application will have a 480 VAC, three-phase, 75 HP motor. The customer has specified an RK5 time delay fuse for a potential fault current of 200,000 amperes. The switch will be located indoors with no unusual service conditions.

Turning to the Speedfax page covering 600 volt fusible switches, which includes the 480 VAC requirement, the type of enclosure is located. It is indoor, Type 1. Next the 600 volt, three-pole, three-fuse table is found. From the horsepower ratings, 480 VAC, 3-phase, 3-wire column, a switch is selected from the maximum (Max.) column. The maximum (Max.) column is chosen because the customer selected a time delay fuse. Had a non-time delay fuse been specified then the standard (Std.) horsepower column would be used. Read down the maximum (Max.) horsepower column until 125 HP, which is the first rating meeting the 75 HP requirement, is found. Reading to the left the catalog number F354 is found under Type 1. It can also be seen that this enclosed switch is rated for 200 amperes.

System	Ampere Rating	INDOOR - Type 1			Horsepower Ratings			
		Catalog Number	List Price	Ship Wgt. Std. Pkg.	480 Volt AC			
					1 Phase, 2 Wire		3 Phase, 3 Wire	
					Std.	Max.	Std.	Max.

600 VOLT FUSIBLE

3-POLE, 3-FUSE (SOLID NEUTRAL ①)

	Ampere Rating	Catalog Number	List Price	Ship Wgt. Std. Pkg.	Horsepower Ratings			
					3	7½	5	15
	30	F351			5	20	15	30
	60	F352			10	30	25	60
	100	F353			25	50	50	125
	200	F354			-	-	100	250
	400	F355			-	-	150	400
	600	F356			-	-	200	500
	800	F357L			-	-	-	-
	1200	F358L			-	-	-	-

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 430-147 through 430-150 are required to be used instead of the actual motor nameplate current rating. In order for a customer to properly select a fuse, *NEC*[®] Table 430-150 must be referred to. According to *NEC*[®] Table 430-150, a 75 HP, 460 VAC motor has a full-load current of 96 amperes.

Table 430-150. Full-Load Current*
Three-Phase Alternating-Current Motors

HP	Induction Type Squirrel-Cage and Wound-Rotor Amperes						Synchronous Type Unity Power Factor† Amperes				
	115V	200V	208V	230V	460V	575V	2300V	230V	460V	575V	2300V
½	4	2.3	2.2	2	1	.8					
¾	5.6	3.2	3.1	2.8	1.4	1.1					
1	7.2	4.1	4.0	3.6	1.8	1.4					
1½	10.4	6.0	5.7	5.2	2.6	2.1					
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		17.5	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		53	26	21	
30		92	88	80	40	32		63	32	26	
40		119.6	114.4	104	52	41		83	41	33	
50		149.5	143.0	130	65	52		104	52	42	
60		177.1	169.4	154	77	62	16	123	61	49	12
75		220.8	211.2	192	96	77	20	155	78	62	15
100		285.2	272.8	248	124	99	26	202	101	81	20
125		358.8	343.2	312	156	125	31	253	126	101	25
150		414	396.0	360	180	144	37	302	151	121	30
200		552	528.0	480	240	192	49	400	201	161	40

*These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used.

†For 90 and 80 percent power factor, the above figures shall be multiplied by 1.1 and 1.25 respectively.

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.

Table 430-152 of the *NEC*[®] is provided to help select a fuse that will not trip while starting a motor, and still provide adequate overcurrent protection. According to Table 430-152, the *NEC*[®] requires that the ampere rating of an AC motor protected by a time-delay fuse be multiplied by 175%.

Table 430-152. Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

Type of Motor	Percent of Full-Load Current			
	Nontime Delay Fuse	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
Single-phase, all types No code letter	300	175		
All ac single-phase and polyphase squirrel-cage and synchronous motors with full-voltage, resistor or reactor starting:				
No code letter	300	175		
Code letters F to V	300	175		
Code letters B to E	250	175		
Code letter A	150	150		

Multiplying the motor rating of 96 amperes times 175% results in a fuse size of 168 amperes. This is a non-standard fuse size. The next standard fuse size of 175 amperes would be selected.

96 amperes	Full-Load Motor Current
X 175%	<i>NEC</i> [®] Requirement
<hr/> 168 amperes	Fuse Rating

Review 6

1. The term mill duty is a _____ assigned reference to a UL listed switch that is designed to meet or exceed normal UL requirements for heavy duty switches.
2. _____ are provided on mill duty switches to cover the incoming line and the line side of the fuses.
3. Mill duty switches are available in 30 - _____ ampere sizes.
4. A _____ enclosed switch would be selected when circuit protection is not required.
5. A _____ enclosed switch would be selected when circuit protection is required.
6. When selecting a non-fusible enclosed switch for a utilization device rated at 70 amperes, a switch must be selected that can carry _____ amperes.

Review Answers

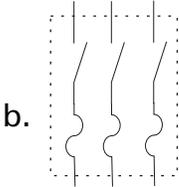
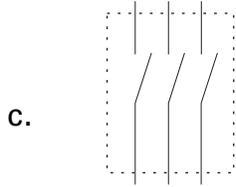
- Review 1** 1) fusible; 2) 50; 3) a; 4) overload, short circuit; 5) short circuit; 6) overload; 7) 186,000; 8) peak let-thru; 9) energy; 10) 240; 11) 310-16; 12) 125.
- Review 2** 1) inverse; 2) half; 3) short; 4) Time-delay; 5) ampere; 6) higher, lower; 7) 200,000.
- Review 3** 1) 1; 2) 3R; 3) contacts; 4) arc.
- Review 4** 1) ampere; 2) 200,000; 3) 200; 4) pole; 5) c.
- Review 5** 1) 100,000; 2) S; 3) JN; 4) 200,000; 5) 1200; 6) interlock recepticle; 7) Double throw; 8) 4000.
- Review 6** 1) Siemens; 2) Shields; 3) 200; 4) non-fusible; 5) fusible; 6) 87.5

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.

Questions

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



2. An enclosed switch combined with fuses in a single enclosure is referred to as a _____ enclosed switch.

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

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

- a. 10
- b. 50
- c. 25
- 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 _____ .
- 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

17. The _____ enclosed switch provides cord connection for heavy duty portable equipment.
- a. interlocked receptacle
 - b. double throw
 - c. bolted pressure
 - d. plug fuse
18. The Siemens 60 - 600 amp general duty and 30 - 1200 amp heavy duty enclosed switches use an exclusive _____ design principle.
- a. Vacu-Break
 - b. Bolted Pressure
 - 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 not needed?
- a. system voltage
 - b. full-load amperes
 - c. fuse class
 - d. number of poles
20. _____ enclosed switches are intended to transfer loads from one power source to another.
- a. Interlock receptacle
 - b. Plug fuse
 - c. Bolted pressure
 - d. Double throw