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Short Circuit and Overload Protection Devices Within an Electrical System

1.0 Introduction

The designer of an electrical system has the responsibility to meet code requirements and to ensure that the equipment and conductors within a system are protected against current flows that will produce destructive temperatures above specified rating and design limits.

This information sheet discusses protective devices that are used within a system, how they work and where they are used.

2.0 Overcurrent protection devices:

Protection against temperature is termed "overcurrent protection." Overcurrents are caused by equipment overloads, by short circuits or by ground faults. An overload occurs when equipment is subjected to current above its rated capacity and excessive heat is produced. A short circuit occurs when there is a direct but unintended connection between line-to-line or line-to-neutral conductors. Short circuits can generate temperatures thousands of degrees above designated ratings. A ground fault occurs when electrical current flows from a conductor to uninsulated metal that is not designed to conduct electricity. These uninsulated currents can be lethal.

The designer has many overcurrent protection devices to choose from. The two most common are fuses and circuit breakers. Many circuit breakers are also known as molded case breakers or MCBs.

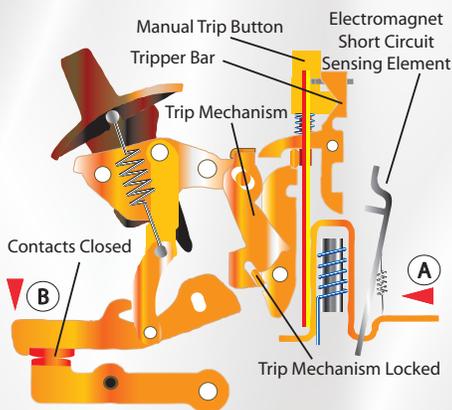
Fuses: A fuse is the simplest form of overcurrent protective device but it can be used only once before it must be replaced. A fuse consists of a conducting element enclosed in a glass, ceramic or other non-conductive tube and connected by ferrules at each end of the tube. (See Diagram 2) The ferrules fit into slots at each end to complete a split in a circuit. Excess current flowing through the fuse melts the device's conducting element and interrupts current flow.

Fuses are rated by the amperage they can carry before heat melts the element. The fuse is ideal for protection against short circuits. Short circuits produce enough amperage to vaporize a fuse element and break connection in one cycle of a 60-cycle system. Fuses are more commonly used in devices connected to a system than within the system's circuit.

Circuit Breakers: Now, conductors in systems are usually protected by circuit breakers. Tripped circuit breakers can be reset after the fault is cleared, an advantage over fuses that must be replaced. (Continued over)

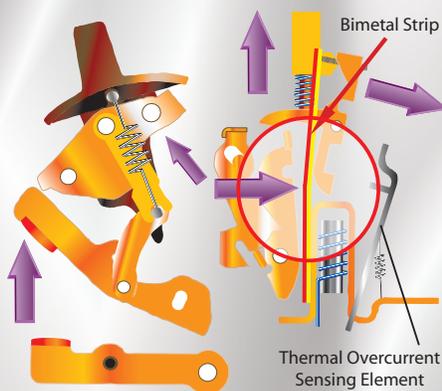
Diagram 1 - Thermal and Magnetic Trip Elements of a Circuit Breaker

Closed Energized Circuit Position



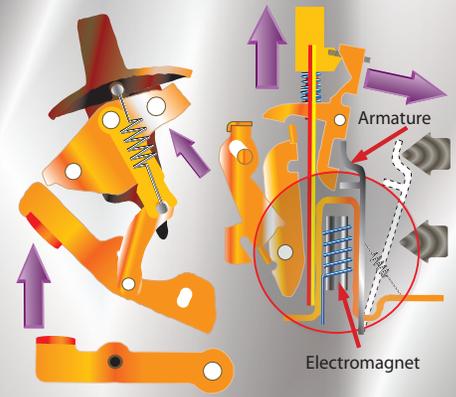
In the "ON" position, as above, the trip mechanism keeps the circuit closed and lets current flow from "A" to "B". The trip mechanism can be engaged manually for overload by thermal sensing and short circuit by an electromagnetic device. There is also a manual trip button.

Tripped Thermal Overload Position



Current flowing through the bimetal strip causes it to heat up. When a certain heat is reached, the strip bends and operates the trip mechanism. The strip is calibrated to start bending when overload amperage is reached. The higher the current flow, the quicker the bimetal trips the breaker.

Tripped Magnetic Short Circuit



Short circuit protection is provided by the electromagnet. The electromagnet produces a magnetic field sufficient to pull the armature only when overload amperages are reached. Tripping occurs when the armature strikes the trip bar. This cuts current flow and releases the armature.

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3.0 Molded Case Circuit Breaker

A molded case circuit breaker, or MCB, has two distinct operating components. (See Diagram 1)

Thermal Trip Component: This component is a bimetal strip that carries the current. When the current exceeds a predetermined limit, heat produced by the excess current causes the strip to bend and trip the trip mechanism, which breaks the contact and interrupts the current.

Magnetic Trip Component: This component is a solenoid that generates a magnetic field created when an electric current passes through its coil. When the flow exceeds predetermined levels, the resulting magnetic force is sufficient to move an armature, held back by a spring, to trip the trip mechanism. This locks the circuit contacts in the open position.

4.0 Breaker Types:

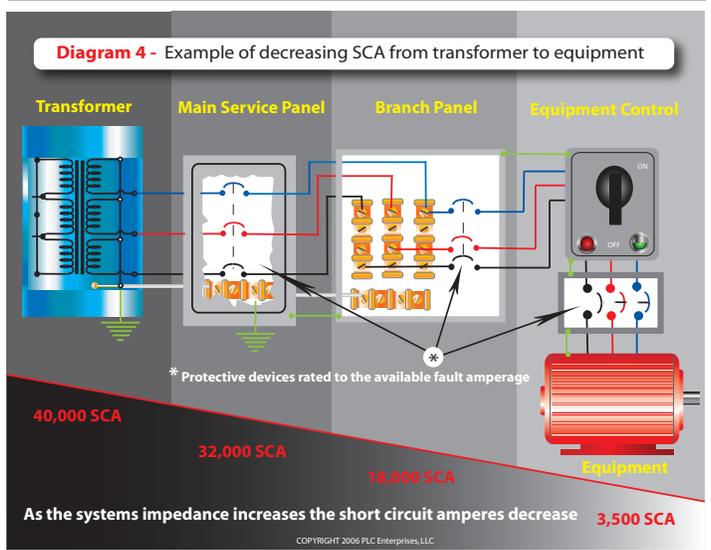
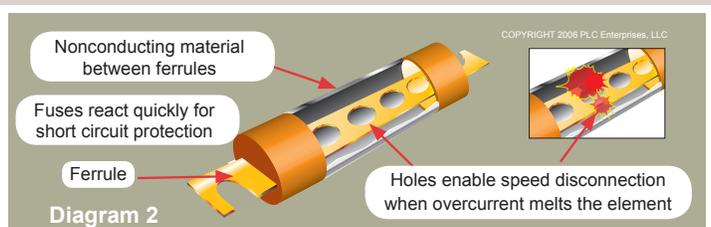
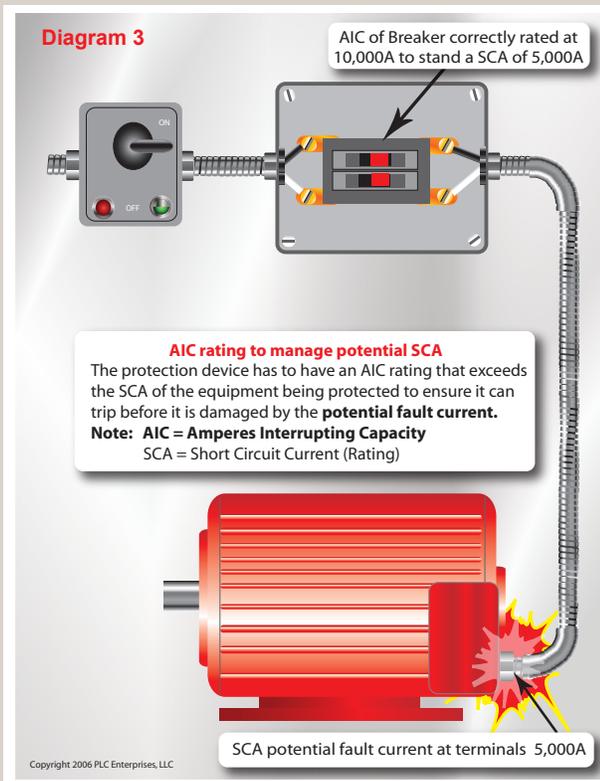
Circuit breakers are available in three types. Systems designers will choose among inverse time trip, adjustable trip or instantaneous trip circuit breakers, depending on the protection sought.

- 1. Inverse Time Trips:** These breakers trip faster as current increases. This provides overload protection but also allows equipment and conductors to carry excessive loads briefly.
- 2. Adjustable Trips:** These breakers are used when the operation of several protection devices in a system must be coordinated. Designers place the lowest rated trips nearest to the devices being protected so that a fault in one area is isolated but allows current elsewhere in the system to continue to flow.
- 3. Instantaneous Trips:** These use only the magnetic element of the trip and provide no overload protection. Also known as motor circuit protectors, or MCPs, they normally are used to protect large motors from short circuits and ground faults.

5.0 Rating protection devices: Short circuits can produce enough thermal and electromagnetic forces to destroy any protective device. When selecting a protective device, it is very important to consider the available short circuit amperage, or SCA, which is the potential amperage at any site in the system. The SCA will be measured at the equipment terminals, the utility transformer and the distribution panel. The highest value will be at the power transformer. The conductivity of the material, its size and its length will reduce the SCA down the line from the transformer. (See Diagram 3)

The correct size overcurrent protection device can be chosen when the system's SCA is known. SCAs are measured in amperes. Fuses and circuit breakers are assigned an amperage interrupting capacity, or AIC, which indicates the SCA that can be sustained before tripping. Unless otherwise designated, fuses are rated 10,000 AIC and circuit breakers are rated 5,000 AIC. (See Diagram 4)

Protection devices are rated to manage both the normal maximum load and the potential short circuit amperage at any given part of the system. Equipment controls should have a short circuit rating that enables them to absorb current while the protective device clears the circuit. If the rating of the controller is lower, a fast-clearing fuse with a lower rating than the controller should be used.



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