Basic Overcurrent Technology

Overcurrent devices may serve several purposes in electrical circuits:

- To protect components, equipment, and associated wiring from the effects of electric circuit overloads and/or short circuits.
- To isolate branch circuits from the main power supply once an overload or short circuit has occurred.

Fuses and circuit breakers are commonly selected as the preferred overcurrent device.

TYPES OF OVERCURRENT

An overcurrent device is constructed to react in a prescribed fashion to varying levels of electrical current, where at pre-determined levels, the device provides interruption of the current flow through it. Any current that exceeds the ampere rating of the fuse or circuit breaker is an overcurrent. Overcurrents are generally classified as either short circuits or overloads and are defined as follows:

- **Short circuit** - a current that greatly exceeds the rating of the device. It is caused when a malfunction or accident creates a break in the normal path allowing electricity to flow directly to ground or another phase. This shorter current path bypasses the resistance offered by the circuit components and the load connected in the normal current path. In this situation there is little resistance to impede the current and the current will build to a level where the heat generated can cause insulation damage and/or equipment breakdown.
- **Overload** - an overcurrent that is within the normal current path. Overloads occur when the current exceeds the value for which the equipment or associated wiring is rated. This typically occurs when too many devices are connected to the circuit or when a device connected to the circuit malfunctions. Overloads are also caused by harmless temporary surge currents; such as when motors are started. These overload currents are normal, usually brief in duration, and have no harmful effect on the circuit components. (It is important that protective devices do not react to such overloads.) Sustained overloads, however, may slowly cause overheating of the wiring and the components. Provided the overload is of sufficient magnitude and duration to activate the device, the circuit protection device shall open before the overload induces system component failures.

SELECTING OVERCURRENT PROTECTION

During normal conditions, an overcurrent protection device must carry the current without nuisance openings. However, when an overload or short circuit occurs the device interrupts the overcurrent and withstands the voltage across the device. To properly select an overcurrent device the following items must be carefully considered:

- **Voltage rating -** represents the maximum system voltage present in the circuit in which the overcurrent device is installed. The system voltage should not exceed this value for proper operation of the device during an overcurrent event.
- **Current Rating -** the amperage value marked on the circuit protection device. The circuit protection device is designed to handle this value under steady operating conditions and at room ambient temperatures. Since field applications often deliver loading conditions and ambient temperatures that vary from ideal nominal settings, it is recommended that circuit designers select device ratings above the nominal circuit current continuous load to prevent nuisance trips. Additionally, the continuous current flowing through the overcurrent protective device should not be more than 80% of the current rating.
- **Characteristics of equipment to be protected -** during the operation of protected equipment, system current can significantly vary. This is particularly evident when motor or other inductive loads in the circuit cause large current surges during start-up. Circuit protection designers should be aware of these surges and/or in-rush characteristics and select the overcurrent protection devices accordingly.
- **Available short circuit current -** during a fault or short circuit condition the fuse or circuit breaker may see a large amount of current. Large DC battery supplies and high current rated electric distribution buses often have this potential for severe short circuits. In these situations, the circuit protection device should have an interrupting rating that is equal to or greater than the short circuit current that can be delivered.
- **Ambient temperature -** the time it takes to interrupt the current is dependent upon the ambient current temperature characteristics. Ambient temperature refers to the temperature of the air immediately surrounding the circuit protection device. The ambient temperature around the fuse or circuit breaker can be appreciably different than the outside room or larger enclosure containing the device. This can occur when the device is contained in a tight area or it is mounted in or near a heat-producing component such as a transformer or resistor. When selecting a fuse or circuit breaker at ambient temperatures significantly different from the stated nominal temperature, the circuit designer should adjust the selected overcurrent protection rating based on the published temperature re-rating curves.

OVERCURRENT PROTECTION DEVICES

Two categories of overcurrent devices are available.

Fuses

The key component of a fuse is the “element’, a short piece of metallic wire or link made of a material with a

relatively low and predictable melting point. Fuses are current-sensitive devices and the resistance is so low that they simply act as a conductor. Circuit protection is provided when the fuse element melts and interrupts an overcurrent. The key criteria used to judge the performance of a fuse is the time-versus-current characteristic curve. This curve can be used to match the fuse with the load. Fuses may be preferred when fast response to a short circuit condition is required or when high available short circuit currents occur. Fuse characteristic curves can be used to carefully size the device to a critical or special application.

Thermal Circuit Breakers

The basic components of a thermal circuit breaker are the thermal alloy element, electrical contacts, and the terminals for external connections. When an overload occurs, heat is generated as the current flows through the thermal alloy element causing it to deflect and separate the electrical contacts, interrupting current flow. An important parameter used to judge the performance of a thermal circuit breaker is the time-versus-current characteristic curve, which is similar to that of a fuse. A thermal circuit breaker is generally not a one-event type device as is a fuse. The resettable features of circuit breakers are often found attractive for use in electrical circuits where non-resetting interruption of current flow is undesirable. ***It is important to note that cycle life of a thermal circuit breaker is impacted both by the operational characteristic of the circuit breaker as well as the relative magnitude and duration of overcurrents or short circuits that the device experiences.*** There are different operational characteristics of **Cooper Bussmann** thermal circuit breakers, which are described below.

CIRCUIT BREAKER OPERATIONAL CHARACTERISTICS

Four different methods for reset are generally available:

- **Type I *(automatic reset):*** the circuit breaker trips and resets in response to the overcurrent condition in a repetitive fashion. ***This version should be used in applications that provide for other self-limiting or non-resettable means (such as after a main fuse, main manual-reset circuit breaker, or momentary switch). These devices, while automatic in reset function, are not designed for long-term cycling conditions in applications where operator awareness of circuit fault or serviceability access is limited, leading to unsatisfactory failure events.*** Refer to SAE J553 or J1625 for additional details.
- **Type II *(modified reset):*** the circuit breaker contains an additional resistive component that enables the device to have only brief trip and reset activity and then afterwards maintains an open circuit condition (except for a low milliamp draw through the resistor). Requires minimum voltage/current to maintain open circuit - see standards for details SAEJ553.
- **Type III *(manual reset):*** the circuit breaker will trip in response to an overcurrent condition after which a reset button or lever extends externally to indicate that the breaker has tripped and is in a non-conducting state. The trip indicator button or lever must be manually activated to return the device to normal operation.
- **Type III *(switchable):*** same as the manual Type III manual reset with the additional feature of allowing the user to open the circuit using an externally accessible trip mechanism.

CIRCUIT BREAKER APPLICATION NOTES

- **Circuit Breaker Performance - Cooper Bussmann** thermal circuit breakers are designed to conform to relevant industry standards (refer to individual models for standard references). ***There are specific performance aspects that may not always make circuit breakers suitable for certain applications, especially in circuits that are incapable of providing enough current to operate the circuit breaker in a timely manner relative to the associated components and wiring.*** It is of utmost importance that the circuit designer investigates components that have finite overload capabilities which are below the time-current levels to initiate timely circuit breaker activation.
- **Evaluation -** Design-in situations require that the user considers all application conditions and conducts operational testing to establish the correctness of ampere/voltage rating as well as overload protection suitability. Further review of industry standards is advised to understand all performance aspects that affect usage.
- **Wiring Considerations -** Additional evaluation of circuit conditions is essential to achieve proper matching of wire sizes to the current load conditions anticipated under normal operating conditions, and estimated abnormal operating conditions when overloads could occur. Thermal circuit breakers and fuses introduce some level of resistance to the current path where installed. These factors should also be considered when choosing wire, both in gauge as well as in temperature rating of insulation.
- **Installation Environment -** Thermal circuit breakers are produced in various configurations. Installation environmental conditions need to be considered and compared to the capability of the particular product of choice. Not all circuit breaker designs are suitable for harsh conditions, such as may be encountered under-hood or external cavities.