Overcurrents and Voltage Ratings

Electrical distribution systems are often quite complicated. They cannot be absolutely fail-safe. Circuits are subject to destructive overcurrents. Harsh environments, general deterioration, accidental damage or damage from natural causes, excessive expansion or overloading of the electrical distribution system are factors which contribute to the occurrence of such overcurrents. Reliable protective devices prevent or minimize costly damage to transformers, conductors, motors, and the other many components and loads that make up the complete distribution system. Reliable circuit protection is essential to avoid the severe monetary losses which can result from power blackouts and prolonged downtime of facilities. It is the need for reliable protection, safety, and freedom from fire hazards that has made the fuse a widely used protective device.

Fuses are constructed in an almost endless variety of configurations. These photos depict the internal construction of Cooper Bussmann Dual-Element, Semi-Tron® and Low-Peak® Class L fuses.

Overcurrents

An overcurrent is either an overload current or a short-circuit current. The overload current is an excessive current relative to normal operating current, but one which is confined to the normal conductive paths provided by the conductors and other components and loads of the distribution system. As the name implies, a short-circuit current is one which flows outside the normal conducting paths.

Overloads

Overloads are most often between one and six times the normal current level. Usually, they are caused by harmless temporary surge currents that occur when motors start up or transformers are energized. Such overload currents, or transients, are normal occurrences. Since they are of brief duration, any temperature rise is trivial and has no harmful effect on the circuit components. (It is important that protective devices do not react to them.) Continuous overloads can result from defective motors (such as worn motor bearings), overloaded equipment, or too many loads on one circuit. Such sustained overloads are destructive and must be cut off by protective devices before they damage the distribution system or system loads. However, since they are of relatively low magnitude compared to short-circuit currents, removal of the overload current within a few seconds to many minutes will generally prevent equipment damage. A sustained overload current results in overheating of conductors and other components and will cause deterioration of insulation, which may eventually result in severe damage and short circuits if not interrupted.

Short Circuits

Whereas overload currents occur at rather modest levels, the short-circuit or fault current can be many hundred times larger than the normal operating current. A high level fault may be 50,000A (or larger). If not cut off within a matter of a few thousandths of a second, damage and destruction can become rampant—there can be severe insulation damage, melting of conductors, vaporization of metal, ionization of gases, arcing, and fires. Simultaneously, high level short-circuit currents can develop huge magnetic-field stresses. The magnetic forces between bus bars and other conductors can be many hundreds of pounds per linear foot; even heavy bracing may not be adequate to keep them from being warped or distorted beyond repair.

Fuses

The fuse is a reliable overcurrent protective device. A “fusible” link or links encapsulated in a tube and connected to contact terminals comprise the fundamental elements of the basic fuse. Electrical resistance of the link is so low that it simply acts as a conductor. However, when destructive currents occur, the link very quickly melts and opens the circuit to protect conductors and other circuit components and loads. Modern fuses have stable characteristics. Fuses do not require periodic maintenance or testing. Fuses have three unique performance characteristics:

1. Modern fuses have an extremely “high interrupting” rating—can open very high fault currents without rupturing.
2. Properly applied, fuses prevent “blackouts.” Only the fuse nearest a fault opens without upstream fuses (feeders or mains) being affected—fuses thus provide “selective coordination.” (These terms are precisely defined in subsequent pages.)
3. Fuses provide optimum component protection by keeping fault currents to a low value...They are said to be “current-limiting.”

The Louisiana Superdome in New Orleans is the world’s largest fully enclosed stadium. The overall electrical load exceeds 30,000,000 VA. Distribution circuits are protected with Cooper Bussmann Low-Peak® fuses.

Voltage Rating - General

This is an extremely important rating for overcurrent protective devices (OCPDs). The proper application of an overcurrent protective device according to its voltage rating requires that the voltage rating of the device be equal to or greater than the system voltage. When an overcurrent protective device is applied beyond its voltage rating, there may not be any initial indicators. Adverse consequences typically result when an improperly voltage rated device attempts to interrupt an overcurrent, at which point it may self-destruct in an unsafe manner. There are two types of OCPD voltage ratings: straight voltage rated and slash voltage rated.

The proper application is straightforward for overcurrent protective devices with a straight voltage rating (i.e.: 600V, 480V, 240V) which have been evaluated for proper performance with full phase-to-phase voltage used during the testing, listing and marking. For instance, all fuses are straight voltage rated and there is no need to be concerned about slash ratings. However, some mechanical overcurrent protective devices are slash voltage rated (i.e.: 480/277, 240/120, 600/347). Slash voltage rated devices are limited in their applications and extra evaluation is required when they are being considered for use. The next section covers fuse voltage ratings followed by a section on slash voltage ratings for other type devices.
Overload Protection

Overcurrents
An overcurrent exists when the normal load current for a circuit is exceeded. It can be in the form of an overload or short circuit. When applied to motor circuits an overload is any current, flowing within the normal circuit path, that is higher than the motor’s normal Full Load Amps (FLA). A short-circuit is an overcurrent which greatly exceeds the normal full load current of the circuit. Also, as its name infers, a short-circuit leaves the normal current carrying path of the circuit and takes a “short cut” around the load and back to the power source. Motors can be damaged by both types of currents.

Single-phasing, overworking and locked rotor conditions are just a few of the situations that can be protected against with the careful choice of protective devices. If left unprotected, motors will continue to operate even under abnormal conditions. The excessive current causes the motor to overheat, which in turn causes the motor winding insulation to deteriorate and ultimately fail. Good motor overload protection can greatly extend the useful life of a motor. Because of a motor’s characteristics, many common overcurrent devices actually offer limited or no protection.

Motor Starting Currents
When an AC motor is energized, a high inrush current occurs. Typically, during the initial half cycle, the inrush current is often higher than 20 times the normal full load current. After the first half-cycle the motor begins to rotate and the starting current subsides to 4 to 8 times the normal current for several seconds. As a motor reaches running speed, the current subsides to its normal running level. Typical motor starting characteristics are shown in Curve 1.

Fast Acting Fuses
To offer overload protection, a protective device, depending on its application and the motor’s Service Factor (SF), should be sized at 115% or less of motor FLA for 1.0 SF or 125% or less of motor FLA for 1.15 or greater SF. However, as shown in Curve 2, when fast-acting, non-time-delay fuses are sized to the recommended level the motors inrush will cause nuisance openings.

Because of this inrush, motors require special overload protective devices that can withstand the temporary overloads associated with starting currents and yet protect the motor from sustained overloads. There are four major types. Each offers varying degrees of protection.