Simultaneously, high level short-circuit currents can develop huge magnetic-conductors, vaporization of metal, ionization of gases, arcing, and fires. Become rampant—there can be severe insulation damage, melting of matter of a few thousandths of a second, damage and destruction can occur. Where a high level of fault may be 50,000A (or larger). If not cut off within a few seconds to many minutes will result in severe damage and short circuits if not interrupted.

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.

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.

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.

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.”

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.
Voltage Rating-Fuses

Most low voltage power distribution fuses have 250V or 600V ratings (other ratings are 125, 300, and 480 volts). The voltage rating of a fuse must be at least equal to or greater than the circuit voltage. It can be higher but never lower. For instance, a 600V fuse can be used in a 208V circuit. The voltage rating of a fuse is a function of its capability to open a circuit under an overcurrent condition. Specifically, the voltage rating determines the ability of the fuse to suppress the internal arcing that occurs after a fuse link melts and an arc is produced. If a fuse is used with a voltage rating lower than the circuit voltage, arc suppression will be impaired and, under some overcurrent conditions, the fuse may not clear the overcurrent safely. 300V rated fuses can be used to protect single-phase line-neutral loads when supplied from three-phase, solidly grounded, 480Y/277V circuits, where the single-phase line-neutral voltage is 277V. This is permissible because in this application, a 300V fuse will not have to interrupt a voltage greater than its 300V rating. Special consideration is necessary for semiconductor fuse applications, where a fuse of a certain voltage rating is used on a lower voltage circuit.

Slash Voltage Ratings

Some multiple-pole, mechanical overcurrent protective devices, such as circuit breakers, self-protected starters, and manual motor controllers, have a slash voltage rating rather than a straight voltage rating. A slash voltage rated overcurrent protective device is one with two voltage ratings separated by a slash and is marked such as 480Y/277V or 480/277V. Contrast this to a straight voltage rated overcurrent protective device that does not have a slash voltage rating limitation, such as 480V. With a slash rated device, the lower of the two ratings is for overcurrents at line-to-ground voltages, intended to be cleared by one pole of the device. The higher of the two ratings is for overcurrents at line-to-line voltages, intended to be cleared by two or three poles of the circuit breaker or other mechanical overcurrent device.

Slash voltage rated overcurrent protective devices are not intended to open phase-to-phase voltages across only one pole. Where it is possible for full phase-to-phase voltage to appear across only one pole, a full or straight rated overcurrent protective device must be utilized. For example, a 480V circuit breaker may have to open an overcurrent at 480V with only one pole, such as might occur when Phase A goes to ground on a 480V, B-phase, corner grounded delta system.

The NEC® addresses slash voltage ratings for circuit breakers in 240.86 restricting their use to solidly grounded systems where the line to ground voltage does not exceed the lower of the two values and the line voltage does not exceed the higher value.

430.83(E) was revised for the 2005 NEC® to address the proper application of motor controllers marked with a slash voltage rating. The words "solidly grounded" were added to emphasize that slash voltage rated devices are not appropriate for use on corner grounded delta, resistance grounded and ungrounded systems.

Slash voltage rated OCPDs must be utilized only on solidly grounded systems. This automatically eliminates their usage on impedance-grounded and ungrounded systems. They can be properly utilized on solidly grounded, wye systems, where the voltage to ground does not exceed the device’s lower voltage rating and the voltage between any two conductors does not exceed the device’s higher voltage rating. Slash voltage rated devices cannot be used on corner-grounded delta systems, whenever the voltage to ground exceeds the lower of the two ratings. Where slash voltage rated devices will not meet these requirements, straight voltage rated overcurrent protective devices are required.

Overcurrent protective devices that may be slashed rated include, but are not limited to:

- Molded case circuit breakers – UL489
- Manual motor controllers – UL508
- Self protected Type E combination starters – UL508
- Supplementary protectors – UL1077 (Looks like a small circuit breaker and sometimes referred to as mini-breaker. However, these devices are not a circuit breaker, they are not rated for branch circuit protection and can not be a substitute where branch circuit protection is required.)

What about fuses, do they have slash voltage ratings? No, fuses do not have this limitation. Fuses by their design are full voltage rated devices; therefore slash voltage rating concerns are not an issue when using fuses. For instance, Cooper Bussmann Low-Peak® LPJ (Class J) fuses are rated at 600V. These fuses could be utilized on systems of 600V or less, whether the system is solidly grounded, ungrounded, impedance grounded, or corner grounded delta.

If a device has a slash voltage rating limitation, product standards require these devices, such as circuit breakers, manual motor controllers, self protected starters, or supplementary protectors to be marked with the rating such as 480Y/277V. If a machine or equipment electrical panel utilizes a slash voltage rated device inside, it is recommended that the equipment nameplate or label designate this slash voltage rating as the equipment voltage rating. UL508A industrial control panels requires the electrical panel voltage marking to be slash rated if one or more devices in the panel are slash voltage rated.
Fuseology

Amp Rating and Interrupting Rating

Slash voltage devices are limited in application to solidly grounded, wye systems due to the nature of the way that these devices are tested, listed and labeled. Any piece of equipment that utilizes a slash voltage rated overcurrent protective device is therefore, limited to installation only in a solidly grounded, wye system and should require marking that notes this limitation.

Equipment that utilizes straight voltage rated overcurrent protective devices provides more value and utilization to the owner or potential future owners than equipment that utilizes slash voltage rated devices. In today’s business environment, machinery and equipment may be moved several times during its useful life. Equipment utilizing slash voltage rated overcurrent devices is not suitable for many electrical systems found in industrial environments.

Amp Rating

Every fuse has a specific amp rating. In selecting the amp rating of a fuse, consideration must be given to the type of load and code requirements. The amp rating of a fuse normally should not exceed the current carrying capacity of the circuit. For instance, if a conductor is rated to carry 20A, a 20A fuse is the largest that should be used. However, there are some specific circumstances in which the amp rating is permitted to be greater than the current carrying capacity of the circuit. A typical example is motor circuits; dual-element fuses generally are permitted to be sized up to 175% and non-time-delay fuses up to 300% of the motor full-load amps. As a rule, the amp rating of a fuse and switch combination should be selected at 125% of the continuous load current (this usually corresponds to the circuit capacity, which is also selected at 125% of the load current). There are exceptions, such as when the fuse-switch combination is approved for continuous operation at 100% of its rating.

Testing Knife-Blade Fuses

A common practice when electricians are testing fuses is to touch the end caps of the fuse with their probes. Contrary to popular belief, fuse manufacturers do not generally design their knife-blade fuses to have electrically energized fuse caps during normal fuse operation. Electrical inclusion of the caps into the circuit occurs as a result of the coincidental mechanical contact between the fuse cap and terminal extending through it. In most brands of knife-blade fuses, this mechanical contact is not guaranteed; therefore, electrical contact is not guaranteed. Thus, a resistance reading taken across the fuse caps is not indicative of whether or not the fuse is open.

In a continuing effort to promote safer work environments, Cooper Bussmann has introduced newly designed versions of knife-blade Fusetron® fuses (Class RK5) and knife-blade Low-Peak fuses (Class RK1) for some of the amp ratings. The improvement is that the end caps are insulated to reduce the possibility of accidental contact with a live part. With these improved fuses, the informed electrician knows that the end caps are isolated. With older style non-insulated end caps, the electrician doesn’t really know if the fuse is "hot" or not. A portion of all testing-related injuries could be avoided by proper testing procedures. Cooper Bussmann hopes to reduce such injuries by informing electricians of proper procedures.

Interrupting Rating

A protective device must be able to withstand the destructive energy of short-circuit currents. If a fault current exceeds a level beyond the capability of the protective device, the device may actually rupture, causing additional damage. Thus, it is important when applying a fuse or circuit breaker to use one which can sustain the largest potential short-circuit currents. The rating which defines the capacity of a protective device to maintain its integrity when reacting to fault currents is termed its “interrupting rating”. The interrupting rating of most branch-circuit, molded case, circuit breakers typically used in residential service entrance panels is 10,000A. (Please note that a molded case circuit breaker’s interrupting capacity will typically be lower than its interrupting rating.) Larger, more expensive circuit breakers may have interrupting ratings of 14,000A or higher. In contrast, most modern, current-limiting fuses have an interrupting rating of 200,000 or 300,000A and are commonly used to protect the lower rated circuit breakers. The National Electrical Code® 110.9, requires equipment intended to break current at fault levels to have an interrupting rating sufficient for the current that must be interrupted. The subjects of interrupting rating and interrupting capacity are treated later in more detail.

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