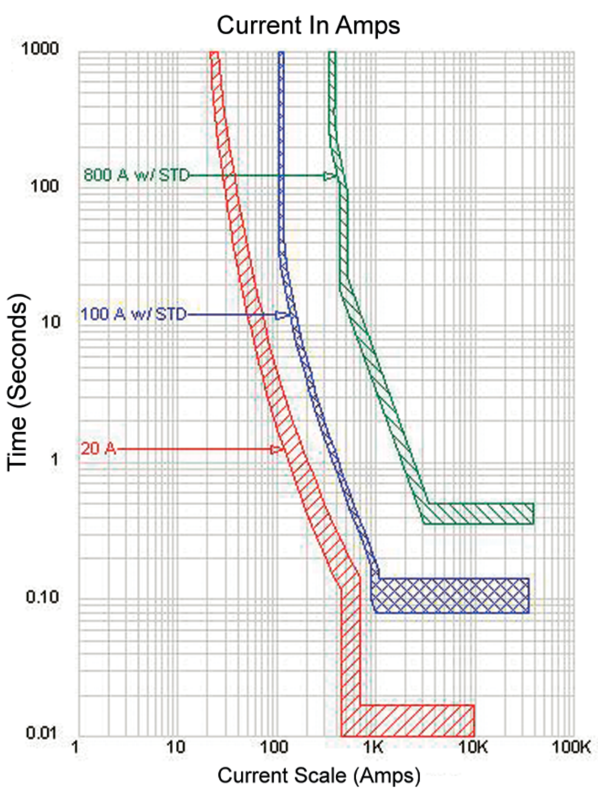
Circuit Breakers

Short-Time-Delay and Instantaneous Override

Some circuit breakers are equipped with short-time delay settings for the sole purpose of improving system coordination. Review the three curves on this page and the next page.

Circuit breaker short-time-delay (STD) mechanisms allow an intentional delay to be installed on low voltage power circuit breakers. Short-time-delays allow the fault current to flow for several cycles, which subjects the electrical equipment to unnecessarily high mechanical and thermal stress. Most equipment ratings, such as short circuit ratings for bus duct and switchboard bus, do not apply when short-time-delay settings are employed. The use of short-time-delay settings on circuit breakers requires the system equipment to be reinforced to withstand the available fault current for the duration of the short-time-delay. Ignoring equipment ratings in relation to the protective device opening time and let-through characteristics can be disastrous. Following is a time-current curve plot for two low voltage power circuit breaker with short-time delay and a 20A MCCB. The 100A CB has a STD set at 6 cycles and the 800A CB has a STD set at 24 cycles. This type of separation of the curves should allow for selective coordination, assuming that the breakers have been serviced and maintained per the manufacturer's requirements. This is an approach to achieve selective coordination that can diminish electrical safety and component protection.

An insulated case circuit breaker (ICCB) may also be equipped with short-time-delay. However, ICCBs will have a built-in override mechanism. This is called the instantaneous override function, and will override the STD for medium to high level faults. This override may “kick in” for faults as low as 12 times (12x) the breaker’s amp rating. (See curve in left column on next page.) This can result in non-selective tripping of the breaker and load side breakers where overlaps occur. This can be seen in the example. (See curve in right column on next page.) As the overlap suggests, for any fault condition greater than 21,000A, both devices will open, causing a blackout.



Low Voltage Power Circuit Breaker with Short-Time-Delay

Zone-Selective Interlocking

Zone-Selective Interlocking (ZSI), or zone restraint, has been available since the early 1990s. ZSI is designed to limit thermal stress caused by short-circuits on a distribution system. ZSI will enhance the coordination of the upstream and downstream molded case circuit breakers for all values of available short-circuit current up to the instantaneous override of the upstream circuit breaker.

Caution: Use of Circuit Breaker Short-Time Delay Settings May Negate Protection and Increase Arc-Flash Hazard

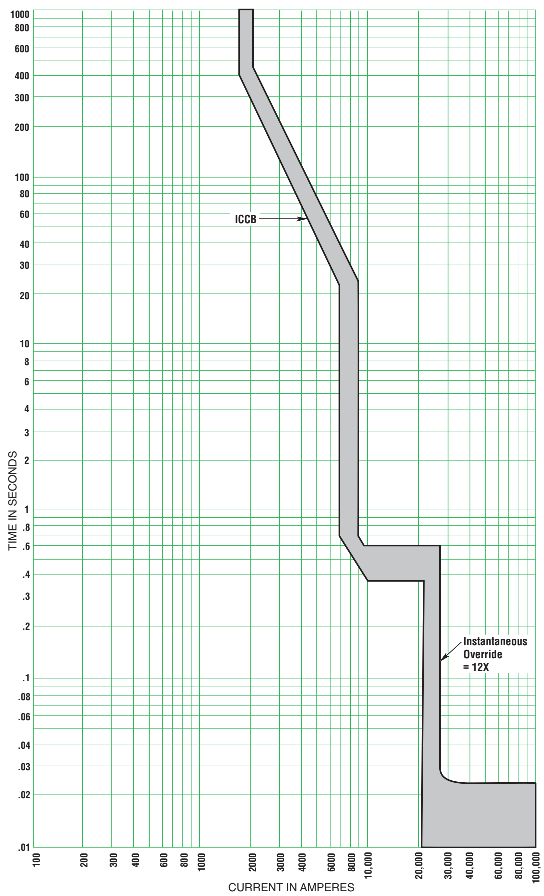
The longer an overcurrent is permitted to flow the greater the potential for component damage. The primary function of an overcurrent protective device is to provide protection to circuit components and equipment. A short-time delay (STD) setting on a circuit breaker can negate the function of protecting the circuit components. A low voltage power circuit breaker with a short-time delay and without instantaneous trip, permits a fault to flow for the length of time of the STD setting, which might be 6, 12, 18, 24 or 30 cycles. This typically is done to achieve fault coordination with downstream circuit breakers. However, there is an adverse consequence associated with using circuit breaker short-time delay settings. If a fault occurs on the circuit protected by a short time delay setting, a tremendous amount of damaging fault energy can be released while the system waits for the circuit breaker short-time delay to time out.

In addition, circuit breakers with short-time delay settings can drastically increase the arc-flash hazard for a worker. The longer an overcurrent protective device takes to open, the greater the flash hazard due to arcing faults. Research has shown that the arc-flash hazard can increase with the magnitude of the current and the time duration the current is permitted to flow. System designers and users should understand that using circuit breakers with short-time delay settings will greatly increase the arc-flash energy if an arcing fault incident occurs. If an incident occurs when a worker is at or near the arc-flash, the worker may be subjected to considerably more arc-flash energy than if an instantaneous trip circuit breaker or better yet a current-limiting circuit breaker or current-limiting fuses were protecting the circuit. The requirements for doing flash hazard analysis for worker safety are found in NFPA 70E “Electrical Safety Requirements for Employee Workplaces."

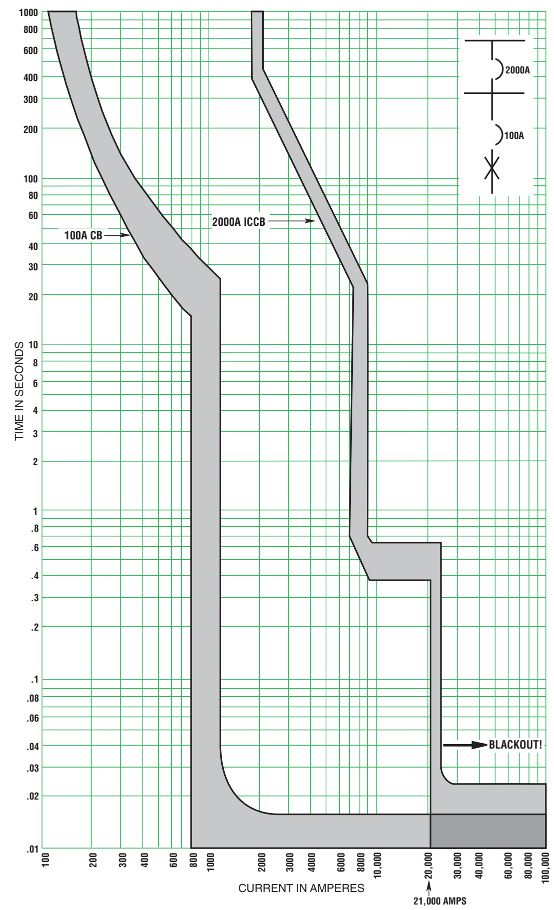
As an example, compare the photos resulting from investigative testing of arcing faults. Further information is provided in “Electrical Safety & Arc-Flash Protection” in this bulletin. A couple of comparison photos are shown on the next page. These tests and others are detailed in “Staged Tests Increase Awareness of Arc-Fault Hazards in Electrical Equipment”, IEEE Petroleum and Chemical Industry Conference Record, September, 1997, pp. 313-322. This paper can be found on the Cooper Bussmann web site at www.cooperbussmann.com/services/safetybasics. One finding of this IEEE paper is that current-limiting overcurrent protective devices reduce damage and arc-fault energy (provided the fault current is within the current-limiting range).

Circuit Breakers

Insulated Case Circuit Breaker–Instantaneous Override



Instantaneous Override Opens at 21,000 Amps



Test 4 shows sequential photos of a circuit protected by a circuit breaker with a short-time delay: interrupted at 6 cycles, so this incident lasted 1⁄10 of a second. The arcing fault was initiated on a three phase, 480V system with 22,600A short circuit available.

Test 3 – Same test circuit as the prior photos, to the left, except the circuit is protected by KRP-C-601SP Cooper Bussmann Low-Peak® Current-Limiting Fuses. In this case these fuses limited the current and the fuses cleared in less than a ½ cycle.

Current-limiting fuses or current-limiting circuit breakers can reduce the risks associated with arc-flash hazards by limiting the magnitude of the fault currents (provided the fault current is within the current-limiting range) and reducing the time duration of the fault. Test 3 photos, to the right, are from tests with the same test setup as shown in Test 4 above, except that KRP-C-601SP Low-Peak current-limiting fuses protect the circuit and clear the arcing fault in less than ½ cycle. The arc-flash was greatly reduced because these fuses were in their current-limiting range. Also, the thermal and mechanical stresses on the circuit components that conducted the fault current were greatly reduced. Recent arc-flash research has shown that arc-flash energy is linearly proportional to the time duration of the fault (given the fault currents are the same). Ignoring the fact that the KRP-C-601SP Low-Peak fuses in Test 3 limited the current let-through, the arc-flash energy released in Test 3 was approximately 1⁄12 that of Test 4 just due to the faster operation of the KRP-C-601SP Low-Peak fuses (less than ½ cycle clearing in Test 3 vs. 6 cycles clearing in Test 4). The actual arc-flash energy was reduced even more in Test 3 because of the current-limiting effect of the KRP-C-601SP Low-Peak fuses.