

NEW for 2002

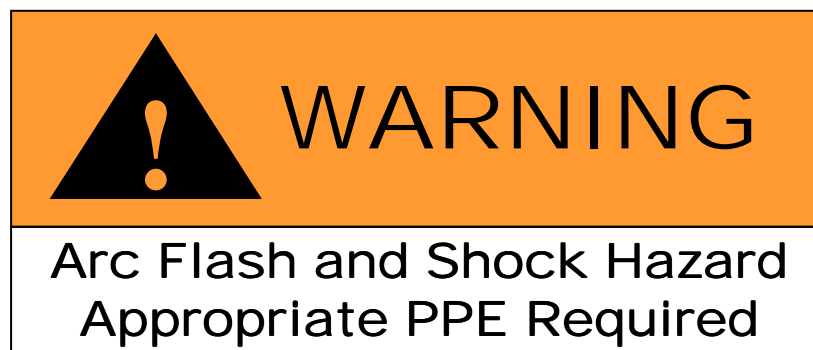
110.16 Flash Protection Field Marking

110.16 Flash Protection. Switchboards, panelboards, industrial control panels, and motor control centers in other than dwelling occupancies, that are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

FPN No. 1: NFPA 70E-2000, *Electrical Safety Requirements for Employee Workplaces*, provides assistance in determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

FPN No. 2: ANSI Z535.4-1998, *Product Safety Signs and Labels*, provides guidelines for the design of safety signs and labels for application to products.

Reprinted from NEC® 2002



Courtesy E.I. du Pont de Nemours & Co.

Figure 1: Example of warning label – this label warns of both arc flash and shock hazards plus reminds workers to use proper PPE (Personal Protective Equipment).

This new requirement is intended to reduce the occurrence of serious injury or death due to arcing faults to workers who work on or near energized electrical equipment. The warning label should remind a qualified worker who intends to open the equipment for analysis or work that a serious hazard exists and that the worker should follow appropriate work practices and wear appropriate personal protection equipment (PPE) for the specific hazard (a non qualified worker must not be opening the equipment).

An arcing fault is the flow of current through the air between phase conductors or phase conductors and neutral or ground. An arcing fault can release tremendous amounts of energy at the point of the arcing in a small fraction of a second. The result can be extremely high temperatures, a tremendous pressure blast and shrapnel (equipment parts) hurling at high velocity (in excess of 700 miles per hour). An accidental slip of a tool or a loose part tumbling across live parts can initiate an arcing fault in the equipment. If a person is in the proximity of an arcing fault, the flash can cause serious injury or death.

Figure 2 shows sequential photos of one of many staged tests that helped to understand and quantify the effects of arcing faults on workers. In this test, mannequins with temperature and pressure sensors were placed in the test cell. This was a 480 volt, three phase system with an available three phase short-circuit current of 22,600 symmetrical rms amperes. A non current-limiting overcurrent protective device was the nearest upstream protective device. An arcing fault was initiated in a combination motor controller enclosure. The arcing fault quickly escalated into a three phase arcing fault in the enclosure. The current flowed for 6 cycles (1/10 second). The temperature recorders (with maximum temperature limit of 457° F) on the neck and hand of the mannequin closest to the arcing fault were pegged (beyond 457° F limit) (threshold for incurable burn is for skin to reach 205° F for 1/10 second). The pressure sensor on this mannequin’s chest pegged the recorder at over 2160 lbs/ft² (the threshold for severe lung damage is 2160 lbs/ft²). This test 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.bussmann.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).



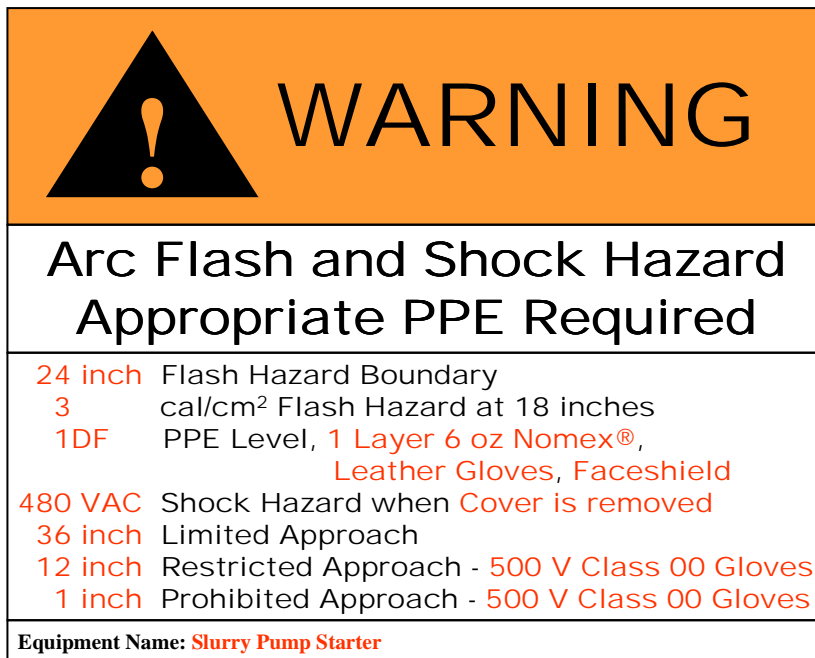
Figure 2: Non-Current Limiting Staged Test.

The type of equipment specified in 110.16 that is likely to be worked on as described is required to have a field affixed arc flash warning label. This will serve as a reminder to qualified workers that a serious hazard exists, that they or their management must assess the risk prior to approaching the hazard and that they must follow the work practices for the level of hazard they may be working on or near.

110.16 only requires that this label state the existence of an arc flash hazard. It is suggested that the party responsible for the label include more information on the specific parameters of the hazard. In this way the qualified worker and his/her management can more readily assess the risk and better insure

proper work practices, PPE and tools. The specific additional information that should be added to the label includes:

- Available Short- Circuit Current
- Flash Protection Boundary
- Incident energy at 18 inches expressed in cal/cm²
- PPE required
- Voltage shock hazard
- Limited shock approach boundary
- Restricted shock approach boundary
- Prohibited shock approach boundary



Courtesy E.I. du Pont de Nemours & Co.

Figure 3: This example label includes more of the vital information that fosters safer work practices.

OSHA regulations state in 1910.333 (a) that workers should not work on live equipment (greater than 50 volts) except for one of two reasons (NFPA 70E Electrical Safety Requirements for Employee Workplaces – 2000 in Part II 2-1.1.1 states essentially the same requirement):

1. Deenergizing introduces additional or increased hazards (such as cutting ventilation to a hazardous location)

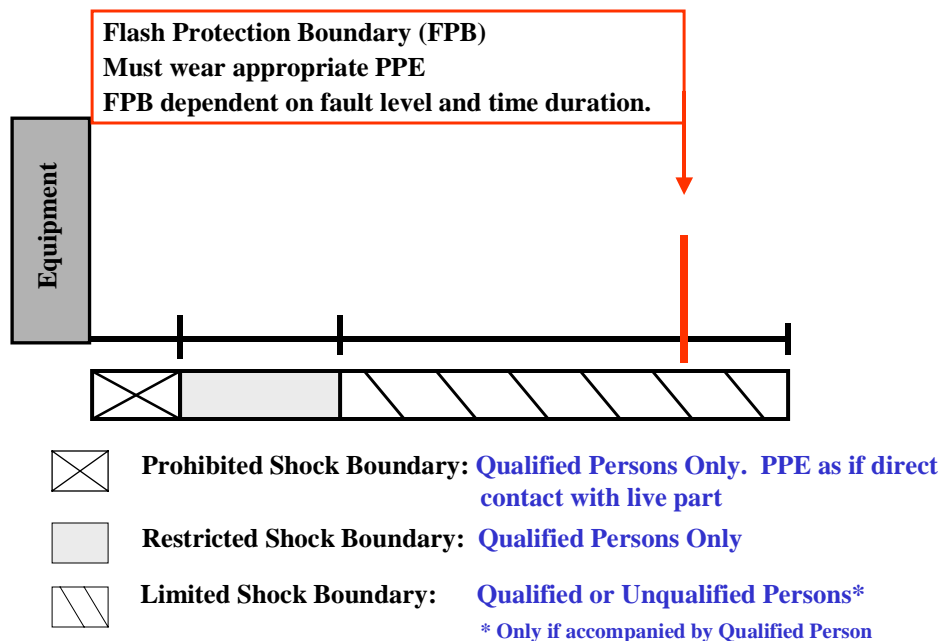
or

2. Infeasible due to equipment design or operational limitations (such as when voltage testing is required for diagnostics).

However, when it is necessary to work on equipment “live”, it is necessary to follow safe work practices, which include assessing the risks, wearing adequate personal protective equipment and using the proper tools.

Until equipment is put into a “safe work condition” (there are procedural steps provided in NFPA 70 E Part II 2-1.1.3) the equipment is considered to be “live”. One of the latter steps in this procedure is a voltage test of each phase conductor to verify they are deenergized. The worker performing this voltage testing must assume the equipment is live and therefore must wear appropriate PPE for the hazard assessed for the specific equipment and circuit parameters.

The arc flash hazard can be assessed prior to working on equipment. Knowing the available bolted short circuit current, the minimum sustainable arcing fault current, and the time duration for the equipment supply overcurrent protective device to open, it is possible to calculate the Flash Protection Boundary (FPB) and Incident Energy Exposure level. NFPA 70E provides the formulas for this critical information as well as other important information on safe work practices, appropriate personal protective equipment and appropriate tools to use. A qualified worker should not enter the flash protection boundary to work on live parts unless he/she is wearing the appropriate PPE for the level of hazard that could occur.



Note: shock boundaries dependent on system voltage level

Figure 4: Graphic illustrating the flash protection boundary and the three shock protection boundaries. The flash protection boundary can be greater than limited shock boundary.

There are viable means to reduce the risks of the shock and flash hazards. Use finger safe products that will reduce the chance that a shock or arcing fault can occur. Use current-limiting fuses or current-limiting circuit breakers. 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. Figure 5 below is the same test setup as shown in Figure 2 except that the arcing fault is cleared by 601 ampere current-limiting fuses. Consequently the arc flash was greatly reduced.

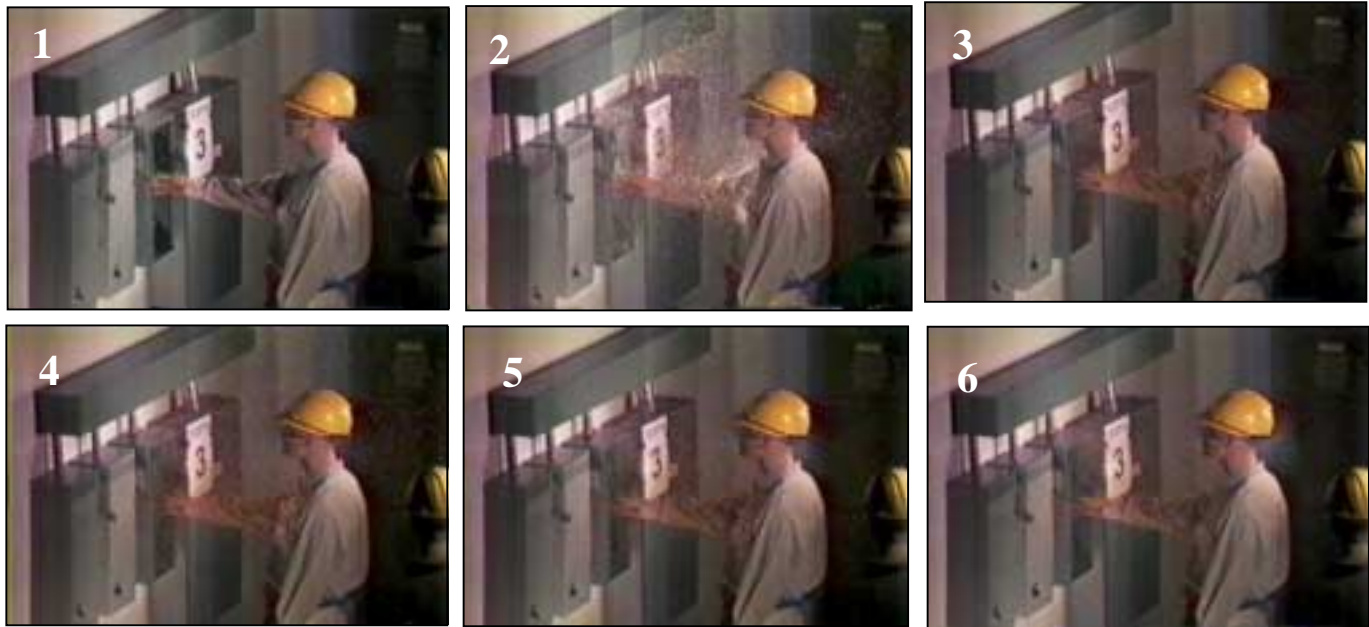


Figure 5 – Current Limiting Staged Test

Compare this to Figure 2, which is the same test setup, but with noncurrent-limiting protection.

To learn more about electrical hazards and safety requirements see Bussmann Safety Basics Handbook for Electrical Safety. Cooper Bussmann also offers a trainers kit for electrical safety training which includes a video, handbook, electronic presentations and more – order Safety Basics Kit Part # SBK from your local Cooper Bussmann distributor. For more information about Safety Basics visit www.bussmann.com/services/safetybasics.