Introduction

There is a great deal of activity in the electrical industry concerning electrical safety. The focus is on the two greatest electrical hazards to workers: shock and arc-flash. In recent years significant knowledge has been gained through testing and analysis concerning arc-flash hazards and how to contend with this type of hazard. This hazard exists when a worker is working on or near exposed, energized electric conductors or circuit parts that have not been placed in an electrically safe work condition. If an arcing fault occurs, the tremendous energy released in a fraction of a second can result in serious injury or death. However, there is a great challenge in getting the message to the populace of the electrical industry so that safer system designs and safer work procedures and behaviors result. Workers continue to sustain life altering injuries or death. NFPA 70E “Standard for Electrical Safety In The Workplace,” 2004, is the foremost consensus standard on electrical safety.

Why is there an NFPA 70E? In 1976 a new electrical standards development committee was formed to assist the Occupational Safety and Health Administration (OSHA) in preparing electrical safety standards. This committee on Electrical Safety Requirements For Employee Workplaces, NFPA 70E, was needed for a number of reasons, including: (1) the NEC® is an installation standard while OSHA also addresses employee safety in the workplace, (2) not all sections in the NEC® relate to worker safety and these are therefore of little value to OSHA’s focus and needs, (3) many safety related work and maintenance practices are not covered, or not adequately covered, in the NEC® and (4) a national consensus standard on electrical safety for workers did not exist, but was needed – an easy to understand document that addresses worker electrical safety. The first edition was published in 1979.

Only Work On Equipment That Is In An Electrically Safe Work Condition

The rule for the industry and the law is “don’t work it hot.” Per OSHA 1910.333(a)(1) and NFPA 70E–2004 130.1, workers should not work on or near exposed live parts except for two demonstrable reasons:

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).

Financial considerations are not an adequate reason to work on or near energized circuits. To violate these regulations and practices is a violation of federal law, which is punishable by fine and/or imprisonment.

Note: deenergized electrical parts are considered as energized until all steps of the lockout/tagout procedure are successfully completed (OSHA 1910.333(b)) and the equipment has been successfully put in an “electrically safe work condition” (NFPA 70E). Voltage testing of each conductor, which is a necessary step while completing the lockout/tagout procedure (putting the equipment in an electrically safe work condition), is considered as working on energized parts per OSHA 1910.333(b) and NFPA 70E – 2004 120.1.

Therefore, adequate personal protective equipment (PPE) is always required during the tests to verify the absence of voltage after the circuits are deenergized and properly locked out/tagged out. Adequate PPE may also be required during load interruption and during visual inspection that verifies that all disconnecting devices are open.

So no matter how well a worker follows safe work practices, there will always be a risk associated with electrical equipment – even when putting equipment in an “electrically safe work condition”. And there are those occasions where it is necessary to work on energized equipment such as when a problem can not be uncovered by trouble shooting the equipment in a deenergized state.

What Can Be Done To Lessen the Risk?

There are a multitude of things that can be implemented to increase electrical safety, from design aspects and upgrading systems, to training, implementing safe work practices and utilizing personal protective equipment. Not all of these topics can be covered in this section. The focus of this section will mainly concern some overcurrent protection aspects related to electrical safety. For some other related electrical safety topics, read the Cooper Bussmann Safety BASICs™ Handbook, Edition 2, and visit the Safety BASICs™ web page at www.cooperbussmann.com.

Shock Protection

There are three shock approach boundaries required to be observed in NFPA 70E - 2004 Table 130.2; these shock approach boundaries are dependent upon the system voltage. The significance of these boundaries for workers and their actions while within the boundaries can be found in NFPA 70E or the Cooper Bussmann Safety BASICs™ Handbook, Edition 2. See Figure 2 for a graphic depiction of the three shock approach boundaries with the flash protection boundary (following the section on Flash Hazard Assessment). For hazard analysis and worker protection, it is important to observe the shock approach boundaries together with the flash protection boundary (which is covered in paragraphs ahead).

Although most electrical workers and others are aware of the hazard due to electrical shock, it still is a prevalent cause of injury and death. One of the best ways to help minimize the electrical shock hazard is to utilize finger-safe products and non-conductive covers or barriers. Finger-safe products and covers reduce the chance that a shock or arcing fault can occur. If all the electrical components are finger-safe or covered, a worker has a much lower chance of coming in contact with a live conductor (shock hazard), or the risk that a conductive part falling across bare, live conductive parts creating an arcing fault is greatly reduced (arc-flash hazard). Shown below are the new CUBEFuses that are IP-20 finger-safe, in addition, they are very current-limiting protective devices. Also shown are Sami fuse covers for covering fuses, Safety J fuse holders for LPJ fuses, CH fuse holders available for a variety of Cooper Bussmann fuses and disconnect switches, with fuse and terminal shrouds. All these devices can reduce the chance that a worker, tool or other conductive item will come in contact with a live part.
Arc Fault Basics

An electrician, that is in an energized panelboard or just putting a system in an electrically safe work condition is potentially in a very unsafe place. A falling knockout, a dislodged skinned wire scrap inadvertently left previously in the panelboard or a slip of a screwdriver can cause an arcing fault. The temperature of the arc can reach approximately 35,000°F, or about four times as hot as the surface of the sun. These temperatures easily can cause serious or fatal burns and/or ignite flammable clothing.

Figure 1 is a model of an arc fault and the physical consequences that can occur. The unique aspect of an arcing fault is that the fault current flows through the air between conductors or a conductor(s) and a grounded part. The arc has an associated arc voltage because there is arc impedance. The product of the fault current and arc voltage concentrated at one point, results in tremendous energy released in several forms. The high arc temperature vaporizes the conductors in an explosive change in state from solid to vapor (copper vapor expands to 87,000 times the volume of solid copper). Because of the expansive vaporization of conductive metal, a line-to-line or line-to-ground arcing fault can escalate into a three phase arcing fault in less than a thousandth of a second. The speed of the event is so rapid that the human system can not react quickly enough for a worker to take corrective measures. If an arcing fault occurs while a worker is in close proximity, the survivability of the worker is mostly dependent upon (1) system design aspects, such as characteristics of the overcurrent protective devices and (2) precautions the worker has taken prior to the event, such as wearing personal protective equipment appropriate for the hazard.

![Electrical Arc](image)

Figure 1. Electrical Arc Model

The effects of an arcing fault can be devastating on a person. The intense thermal energy released in a fraction of a second can cause severe burns. Molten metal is blown out and can burn skin or ignite flammable clothing. One of the major causes of serious burns and deaths to workers is ignition of flammable clothing due to an arcing fault. The tremendous pressure blast from the vaporization of conducting materials and superheating of air can fracture ribs, collapse lungs and knock workers off ladders or blow them across a room. The pressure blast can cause shrapnel (equipment parts) to be hurled at high velocity (can be in excess of 700 miles per hour). And the time in which the arcing event runs its course can be only a small fraction of a second. Testing has proven that the arcing fault current magnitude and time duration are the most critical variables in determining the energy released. Serious accidents are occurring at an alarming rate on systems of 600V or less, in part because of the high fault currents that are possible. But also, designers, management and workers mistakenly tend not to take the necessary precautions that they take when designing or working on medium and high voltage systems.

The Role of Overcurrent Protective Devices In Electrical Safety

The selection and performance of overcurrent protective devices play a significant role in electrical safety. Extensive tests and analysis by industry has shown that the energy released during an arcing fault is related to two characteristics of the overcurrent protective device protecting the affected circuit. These two characteristics are 1) the time it takes the overcurrent protective device to open and 2) the amount of fault current the overcurrent protective device lets-through. For instance, the faster the fault is cleared by the overcurrent protective device, the lower the energy released. If the overcurrent protective device can also limit the current, thereby reducing the actual fault current that flows through the arc, the lower the energy released. Overcurrent protective devices that are current-limiting, and thus may greatly reduce the current let-through, can have a great affect on reducing the energy released. The lower the energy released the better for both worker safety and equipment protection.

The photos and recording sensor readings from actual arcing fault tests (next page) illustrate this point very well. An ad hoc electrical safety working group, within the IEEE Petroleum and Chemical Industry Committee, conducted these tests to investigate arc fault hazards. 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 at www.cooperbussmann.com under Services/Safety BASICS. 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). To better assess the benefit of limiting the current of an arcing fault, it is important to note some key thresholds of injury for humans. Results of these tests were recorded by sensors on mannequins and can be compared to these parameters:

- Just Curable Burn Threshold: 80°C / 175°F (0.1 sec)
- Incurable Burn Threshold: 96°C / 205°F (0.1 sec)
- Eardrum Rupture Threshold: 720 lbs/ft²
- Lung Damage Threshold: 1728 - 2160 lbs/ft²

OSHA Required Ear Protection Threshold: 85 db (for sustained time period)
(Note: an increase of 3 db is equivalent to doubling the sound level.)

Test 4, Test 3 and Test 1: General

All three of these tests were conducted on the same electrical circuit set-up with an available booted three phase, short-circuit current of 22,800 symmetrical RMS amps at 480V. In each case, an arcing fault was initiated in a size 1 combination motor controller enclosure with the door open, as if an electrician were working on the unit “live” or before it was placed in an electrically safe work condition. Test 4 and Test 3 were identical except for the overcurrent protective device protecting the circuit. In Test 4, a 640 amp circuit breaker with a short-time delay is protecting the circuit; the circuit was cleared in 6 cycles. In Test 3, KRP-C-601SP, 601 amp, current-limiting fuses (Class L) are protecting the circuit; they opened the fault current in less than ½ cycle and limited the current. The arcing fault was initiated on the line side of the motor branch circuit device in both Test 4 and Test 3. This means the fault is on the feeder circuit but within the controller enclosure.

In Test 1, the arcing fault is initiated on the load side of the branch circuit overcurrent protective devices, which are LPS-RK 30SP, 30 amp, current-limiting fuses (Class RK1). These fuses limited this fault current to a much lower amount and clear the circuit in approximately ¾ cycle or less.

Following are the results recorded from the various sensors on the mannequin closest to the arcing fault. T1 and T2 recorded the temperature on the bare hand and neck respectively. The hand with T1 sensor was very close to the arcing fault. T3 recorded the temperature on the chest under the cotton shirt. P1 recorded the pressure on the chest. And the sound level was measured at the ear. Some results “peged the meter”. That is, the specific measurements were unable to be recorded in some cases because the actual level exceeded the range of the sensor/recorder setting. These values are shown as >, which indicates that the actual value exceeded the value given but it is unknown how high of a level the actual value attained.
Electrical Safety
Arc-Flash Protection

Photos and results Test 4:
Staged test protected by circuit breaker with short-time delay (not a current-limiting overcurrent protective device). Short-time delay intentionally delayed opening for six cycles (0.1 second). Note: Unexpectedly, there was an additional fault in the wireway and the blast caused the cover to hit the mannequin in the head. Analysis result in incident energy of 5.8 cal/cm² and flash protection boundary of 47 inches per IEEE 1584.

Photos and results Test 3:
Staged test protected by KRP-C-601SP Low-Peak Current-Limiting Fuses (Class L). These fuses were in their current-limiting range and cleared in less than a ½ cycle (0.0083 seconds). Analysis results in incident energy of 1.58 cal/cm² and flash protection boundary of 21 inches per IEEE 1584.

Photos and results Test 1:
Staged test protected by LPS-RK-30SP, Low-Peak Current-Limiting Fuses (Class RK1). These fuses were in current-limiting range and cleared in approximately ¼ cycle (0.004 seconds). Analysis results in incident energy of less than 0.2 cal/cm² and flash protection boundary of less than 6 inches.
A couple of conclusions can be drawn from this testing.

1. Arcing faults can release tremendous amounts of energy in many forms in a very short period of time. Look at all the measured values compared to key thresholds of injury for humans given in a previous paragraph. Test 4 was protected by a 640 A, non-current limiting device that opened in 6 cycles or 0.1 second.

2. The overcurrent protective devices’ characteristic can have a significant impact on the outcome. A 601 amp, current-limiting overcurrent protective device, protects the circuit in Test 3. The current that flowed was reduced (limited) and the clearing time was \( \frac{1}{2} \) cycle or less. This was a significant reduction compared to Test 4. Compare the Test 3 measured values to the key thresholds of injury for humans and the Test 4 results. The measured results of Test 1 are significantly less than those in Test 4 and even those in Test 3. The reason is that Test 1 utilized a much smaller (30 amp), current-limiting device. Test 3 and Test 1 both show that there are benefits of using current-limiting overcurrent protective devices. Test 1 just proves the point that the greater the current-limitation, the more the arcing fault energy may be reduced. Both Test 3 and Test 1 utilized very current-limiting fuses, but the lower amp rated fuses limit the current more than the larger amp rated fuses. It is important to note that the fault current must be in the current-limiting range of the overcurrent protective device in order to receive the benefit of the lower current let-through. See the diagram that depicts the oscillographs of Test 4, Test 3 and Test 1.

3. The cotton shirt reduced the thermal energy exposure on the chest (T3 measured temperature under the cotton shirt). This illustrates the benefit of workers wearing protective garments.

**Flash Hazard Assessment**

NFPA 70E has developed requirements to reduce the risk of injury to workers due to shock and arc-flash hazards. There are three shock approach boundaries required to be observed in NFPA 70E - 2004. As discussed, arc fault currents can release tremendous amounts of energy. NFPA 70E – 2004 requires that before a worker approaches exposed electric conductors or circuit parts that have not been placed in an electrically safe work condition; a flash hazard analysis shall be performed. The flash hazard analysis should determine the flash protection boundary (FPB) and level of personal protective equipment (PPE) that the worker must wear. The flash protection boundary is the distance from the energized parts at which a worker could sustain a just curable burn (bare skin) as a result of an arcing fault. A worker entering the flash protection boundary must be qualified and must be wearing appropriate PPE. Figure 2 depicts the flash protection boundary and the three shock approach boundaries that shall be observed per NFPA 70E - 2004. In an actual situation, before a worker is permitted to approach equipment with exposed, energized parts, these boundaries shall be determined. In addition, the worker shall be wearing the required level of PPE, which can be determined by calculating the incident energy. Until equipment is placed in an “electrically safe work condition” (NFPA 70E – 2004 120.1, it is considered “energized”. It is important to note that conductors and equipment are considered “energized” when checking for voltage while putting equipment in an “electrically safe work condition.”

The incident energy is a measure of thermal energy at a specific distance from an arc fault; the unit of measure is typically in calories per centimeter squared (cal/cm²). The distance from the fault in determining the incident energy depends on the worker’s body position to the live parts. After determining the incident energy in cal/cm², the value can be used to select the appropriate personal protective equipment. There are various types of PPE with distinct levels of thermal protection capabilities termed ‘Arc Thermal Performance Exposure Values (ATPV) rated in cal/cm²’. Note: the most common distance for which incident energy has been determined in tests is 18 inches. If it is necessary to determine incident energy at a different distance, NFPA 70E - 2004 and IEEE 1584 have equations that can be used in many situations (for greater than 18 inches).

Both the FPB and PPE level are dependent on the available fault current and the overcurrent protective device - its clearing time and if it is current-limiting. Knowing the available bolted short-circuit current, the 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 - 2004 and IEEE 1584 provide the formulas for this critical information. By reviewing the calculations, it is important to note that current-limiting overcurrent protective devices (when in their current-limiting range) can reduce the required FPB and PPE level as compared to non-current-limiting overcurrent protective devices.
Simple Method for Flash Hazard Analysis

Anytime work must be done on or near energized electrical equipment or equipment that could become energized, a flash hazard analysis shall be completed. This flash hazard analysis includes, but is not limited to, determining:

1. The Incident Energy Exposure to select the level of PPE needed to complete the task
2. The Flash Protection Boundary to know the approach point to the equipment where PPE will be required.

Various information about the system may be needed to complete this analysis but the two pieces that are absolutely necessary are:

1. The available 3Ø bolted fault current
2. The fuse or circuit breaker type and amp rating.

Consider the following one-line diagram and then follow the examples that take the steps needed to conduct a Flash Hazard Analysis (The following information utilizes formulas based upon IEEE 1584 Guide for Arc-Flash Hazard Analysis.

Steps necessary to conduct a Flash Hazard Analysis when using Low-Peak fuses and the Table 1: Arc-Flash Incident Energy Calculator.

1. Determine the available bolted fault current on the line side terminals of the equipment that will be worked upon.
2. Identify the amperage of the Low-Peak fuse upstream that is protecting the panel where work is to be performed.
3. Consult the Low-Peak Fuse Incident Energy Calculator, Table 1, next page, to determine the Incident Energy Exposure (I.E.) available.
4. Determine the Flash Protection Boundary that will require PPE based upon the incident energy. This can also be simplified by using the column for Flash Protection Boundary (FPB) in Table 1.
5. Identify the minimum requirements for PPE when work is to be performed inside of the FPB by consulting the requirements found in NFPA 70E - 2004.

For more information refer to Cooper Bussmann Safety BASICS Edition 2 Handbook on www.cooperbussmann.com or contact Application Engineering.

Example 1: Flash Hazard Analysis using Cooper Bussmann Current Limiting Fuses.

The following is a simple method when using certain Cooper Bussmann fuses; this method is based on actual data from arcing fault tests with Cooper Bussmann current-limiting fuses. Using this simple method, the first thing that must be done is to determine the incident energy exposure. Bussmann has simplified this process when using LPS-RK-(amp)SP, LPJ-(amp)SP, LP-CC-(amp) or KRP-C-(amp)SP Low-Peak fuses or JJS-(amp) Tron fuses. In some cases the results are conservative; see Note 7.

In this example, the line side OCPD in Figure 3 is a LPS-RK-600SP, Low-Peak current-limiting fuse. Simply take the available 3Ø bolted short-circuit current at the panel, in this case 42,000 amps, and locate it on the vertical column in the Arc-Flash incident Energy Calculator table #1 on the following page. Then proceed directly to the right to the 401-600A fuse column and identify the incident energy (I.E.) and flash protection boundary (FPB).

With 42,000 amps of 3Ø bolted short-circuit current available, the table shows that when relying on the LPS-RK-600SP Low-Peak fuse to interrupt an arcing fault, the incident energy is 0.25 cal/cm². Notice the variables required are the available 3Ø bolted fault current and the ampacity of the Low-Peak current-limiting fuse. See Notes 7 and 8.

The next step in this simplified flash hazard analysis is to determine the Flash Protection Boundary (FPB). With an incident energy exposure of 0.25 cal/cm² and using the same table, the Flash Protection Boundary (FPB) is approximately 6 inches, which is found next to the incident energy value previously located. See Note 6. This FPB distance means that anytime work is to be performed inside of this distance, including voltage testing to verify that the panel is deenergized, the worker must be equipped with the appropriate PPE.

The last step in the flash hazard analysis is to determine the appropriate PPE for the task. To select the proper PPE, utilize the incident energy exposure values and the requirements from NFPA 70E. NFPA 70E has requirements for PPE that are based upon the incident energy exposures. When selecting PPE for a given application, keep in mind that these requirements from NFPA 70E are minimum requirements. Having additional PPE, above what is required, can further assist in minimizing the effects of an arc-flash incident. See Note 3.

Another thing to keep in mind is that PPE available on the market today does not protect a person from the pressures, shrapnel, and toxic gases that can result from an arc-blast, which are referred to as “physical trauma” in NFPA 70E-2004. Existing PPE is only utilized to minimize the potential for burns from the arc-flash. See Notes 1 & 2.
### Arc-Flash Incident Energy Calculator

Cooper Bussmann continues to study this topic and develop more complete data and application tools.

Visit [www.cooperbussmann.com](http://www.cooperbussmann.com) for interactive arc-flash calculators and the most current data.

### Table 1: 1 - 600A

Cooper Bussmann Low-Peak LPS-RK_SP fuses and molded case circuit breakers (MCCB)

Incident Energy (I.E.) values expressed in cal/cm², Flash Protection Boundary (FPB) expressed in inches.

<table>
<thead>
<tr>
<th>Bolted Fault (kA)</th>
<th>1-100A</th>
<th>101-200A</th>
<th>201-400A</th>
<th>401-600A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current (kA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.39</td>
<td>29</td>
<td>&gt;100</td>
<td>&gt;120</td>
</tr>
<tr>
<td>2</td>
<td>0.25</td>
<td>0.25</td>
<td>6</td>
<td>5.20</td>
</tr>
<tr>
<td>3</td>
<td>0.25</td>
<td>0.27</td>
<td>7</td>
<td>0.93</td>
</tr>
<tr>
<td>4</td>
<td>0.25</td>
<td>0.35</td>
<td>8</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>0.25</td>
<td>0.43</td>
<td>9</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>0.25</td>
<td>0.50</td>
<td>10</td>
<td>0.25</td>
</tr>
<tr>
<td>8</td>
<td>0.25</td>
<td>0.65</td>
<td>12</td>
<td>0.25</td>
</tr>
<tr>
<td>10</td>
<td>0.25</td>
<td>0.81</td>
<td>14</td>
<td>0.25</td>
</tr>
<tr>
<td>12</td>
<td>0.25</td>
<td>0.96</td>
<td>15</td>
<td>0.25</td>
</tr>
<tr>
<td>14</td>
<td>0.25</td>
<td>1.11</td>
<td>17</td>
<td>0.25</td>
</tr>
<tr>
<td>16</td>
<td>0.25</td>
<td>1.26</td>
<td>19</td>
<td>0.25</td>
</tr>
<tr>
<td>18</td>
<td>0.25</td>
<td>1.41</td>
<td>20</td>
<td>0.25</td>
</tr>
<tr>
<td>20</td>
<td>0.25</td>
<td>1.56</td>
<td>22</td>
<td>0.25</td>
</tr>
<tr>
<td>22</td>
<td>0.25</td>
<td>1.72</td>
<td>23</td>
<td>0.25</td>
</tr>
<tr>
<td>24</td>
<td>0.25</td>
<td>1.87</td>
<td>24</td>
<td>0.25</td>
</tr>
<tr>
<td>26</td>
<td>0.25</td>
<td>2.02</td>
<td>26</td>
<td>0.25</td>
</tr>
<tr>
<td>28</td>
<td>0.25</td>
<td>2.17</td>
<td>27</td>
<td>0.25</td>
</tr>
<tr>
<td>30</td>
<td>0.25</td>
<td>2.32</td>
<td>28</td>
<td>0.25</td>
</tr>
<tr>
<td>32</td>
<td>0.25</td>
<td>2.47</td>
<td>29</td>
<td>0.25</td>
</tr>
<tr>
<td>34</td>
<td>0.25</td>
<td>2.63</td>
<td>31</td>
<td>0.25</td>
</tr>
<tr>
<td>36</td>
<td>0.25</td>
<td>2.79</td>
<td>32</td>
<td>0.25</td>
</tr>
<tr>
<td>38</td>
<td>0.25</td>
<td>2.93</td>
<td>33</td>
<td>0.25</td>
</tr>
<tr>
<td>40</td>
<td>0.25</td>
<td>3.08</td>
<td>34</td>
<td>0.25</td>
</tr>
<tr>
<td>42</td>
<td>0.25</td>
<td>3.23</td>
<td>35</td>
<td>0.25</td>
</tr>
<tr>
<td>44</td>
<td>0.25</td>
<td>3.38</td>
<td>36</td>
<td>0.25</td>
</tr>
<tr>
<td>46</td>
<td>0.25</td>
<td>3.54</td>
<td>37</td>
<td>0.25</td>
</tr>
<tr>
<td>48</td>
<td>0.25</td>
<td>3.69</td>
<td>39</td>
<td>0.25</td>
</tr>
<tr>
<td>50</td>
<td>0.25</td>
<td>3.85</td>
<td>40</td>
<td>0.25</td>
</tr>
<tr>
<td>52</td>
<td>0.25</td>
<td>3.99</td>
<td>41</td>
<td>0.25</td>
</tr>
<tr>
<td>54</td>
<td>0.25</td>
<td>4.14</td>
<td>42</td>
<td>0.25</td>
</tr>
<tr>
<td>56</td>
<td>0.25</td>
<td>4.29</td>
<td>43</td>
<td>0.25</td>
</tr>
<tr>
<td>58</td>
<td>0.25</td>
<td>4.44</td>
<td>45</td>
<td>0.25</td>
</tr>
<tr>
<td>60</td>
<td>0.25</td>
<td>4.60</td>
<td>45</td>
<td>0.25</td>
</tr>
<tr>
<td>62</td>
<td>0.25</td>
<td>4.75</td>
<td>46</td>
<td>0.25</td>
</tr>
<tr>
<td>64</td>
<td>0.25</td>
<td>4.90</td>
<td>47</td>
<td>0.25</td>
</tr>
<tr>
<td>66</td>
<td>0.25</td>
<td>5.05</td>
<td>48</td>
<td>0.25</td>
</tr>
<tr>
<td>68</td>
<td>0.25</td>
<td>5.20</td>
<td>49</td>
<td>0.25</td>
</tr>
<tr>
<td>70</td>
<td>0.25</td>
<td>5.36</td>
<td>50</td>
<td>0.25</td>
</tr>
<tr>
<td>72</td>
<td>0.25</td>
<td>5.51</td>
<td>51</td>
<td>0.25</td>
</tr>
<tr>
<td>74</td>
<td>0.25</td>
<td>5.66</td>
<td>52</td>
<td>0.25</td>
</tr>
<tr>
<td>76</td>
<td>0.25</td>
<td>5.81</td>
<td>53</td>
<td>0.25</td>
</tr>
<tr>
<td>78</td>
<td>0.25</td>
<td>5.96</td>
<td>53</td>
<td>0.25</td>
</tr>
<tr>
<td>80</td>
<td>0.25</td>
<td>6.11</td>
<td>54</td>
<td>0.25</td>
</tr>
<tr>
<td>82</td>
<td>0.25</td>
<td>6.27</td>
<td>55</td>
<td>0.25</td>
</tr>
<tr>
<td>84</td>
<td>0.25</td>
<td>6.42</td>
<td>56</td>
<td>0.25</td>
</tr>
<tr>
<td>86</td>
<td>0.25</td>
<td>6.57</td>
<td>57</td>
<td>0.25</td>
</tr>
<tr>
<td>88</td>
<td>0.25</td>
<td>6.72</td>
<td>58</td>
<td>0.25</td>
</tr>
<tr>
<td>90</td>
<td>0.25</td>
<td>6.87</td>
<td>59</td>
<td>0.25</td>
</tr>
<tr>
<td>92</td>
<td>0.25</td>
<td>7.02</td>
<td>60</td>
<td>0.25</td>
</tr>
<tr>
<td>94</td>
<td>0.25</td>
<td>7.18</td>
<td>61</td>
<td>0.25</td>
</tr>
<tr>
<td>96</td>
<td>0.25</td>
<td>7.33</td>
<td>61</td>
<td>0.25</td>
</tr>
<tr>
<td>98</td>
<td>0.25</td>
<td>7.48</td>
<td>62</td>
<td>0.25</td>
</tr>
<tr>
<td>100</td>
<td>0.25</td>
<td>7.63</td>
<td>63</td>
<td>0.25</td>
</tr>
<tr>
<td>102</td>
<td>0.25</td>
<td>7.78</td>
<td>64</td>
<td>0.25</td>
</tr>
<tr>
<td>104</td>
<td>0.25</td>
<td>7.93</td>
<td>65</td>
<td>0.25</td>
</tr>
<tr>
<td>106</td>
<td>0.25</td>
<td>8.08</td>
<td>66</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Read notes on the page following these tables. Fuse results based on actual test data. Circuit breaker results are based on IEEE 1584 calculations.

If circuit breakers are not properly maintained, values can be considerably greater.

**Flash Hazard Analysis Tools on** [www.cooperbussmann.com](http://www.cooperbussmann.com)
### Table 1a: 601 - 2000A

Cooper Bussmann Low-Peak KRP-C_SP fuses and circuit breakers; low voltage power circuit breakers (w/std) (LVPCB)

<table>
<thead>
<tr>
<th>Current (kA)</th>
<th>Fuse</th>
<th>LVPCB</th>
<th>I.E.</th>
<th>FPB</th>
<th>Fuse</th>
<th>LVPCB</th>
<th>I.E.</th>
<th>FPB</th>
<th>Fuse</th>
<th>LVPCB</th>
<th>I.E.</th>
<th>FPB</th>
<th>Fuse</th>
<th>LVPCB</th>
<th>I.E.</th>
<th>FPB</th>
<th>Fuse</th>
<th>LVPCB</th>
<th>I.E.</th>
<th>FPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-1200A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1201-1600A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1601-2000A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Electrical Safety

Arc-Flash Incident Energy Calculator

Cooper Bussmann continues to study this topic and develop more complete data and application tools.

Visit [www.cooperbussmann.com](http://www.cooperbussmann.com)

Electrical Safety

Flash Hazard Analysis Tools on [www.cooperbussmann.com](http://www.cooperbussmann.com)

Cooper Bussmann continues to study this topic and develop more complete data and application tools.

Visit [www.cooperbussmann.com](http://www.cooperbussmann.com) for interactive arc-flash calculators and the most current data.
Arc-Flash Protection

Steps necessary to conduct a Flash Hazard Analysis when using Low-Peak fuses and Figures 6 and 7.

1. Determine the available bolted fault current on the line side terminals of the equipment that will be worked upon.
2. Identify the amperage of the Low-Peak fuse upstream that is protecting the panel where work is to be performed.
3. Consult the Low-Peak Fuse Incident Energy Chart, Figure 6, to determine the Incident Energy Exposure available.
4. Determine the Flash Protection Boundary that will require PPE based upon the incident energy. This can also be simplified by using the chart for Flash Protection Boundary in Figure 7.
5. Identify the minimum requirements for PPE when work is to be performed inside of the FPB by consulting the requirements found in NFPA 70E.

Notes for Flash Hazard Analysis Table

General Notes for fuses and circuit breakers:

Note 1: First and foremost, this information is not to be used as a recommendation to work on energized equipment. This information is to help assist in determining the proper PPE to help safeguard a worker from the burns that can be sustained from an arc-flash incident. This information does not take into account the effects of pressure, shrapnel, molten metal spray, or the toxic vapor resulting from an arc-fault.

Note 2: This data is based upon IEEE 1584 Guide for Arc-Flash Hazard Analysis. These methods were created so that the PPE selected from the calculated incident energy would be adequate for 98% of arc-flash incidents. In up to 2% of incidents, incurable burns to the body and torso or death could result. This was based upon PPE with standard arc ratings of 1.2, 8, 25, 40 and 100 cal/cm2. PPE with intermediate ATPV values can be utilized, but at the next lower standard ATPV rating.

Note 3: PPE must be utilized any time that work is to be performed on or near energized electrical equipment or equipment that could become energized. Voltage testing, while completing the lockout/tagout procedure (putting the equipment in an electrically safe work condition), is considered as working on energized parts per OSHA 1910.333(b).

Note 4: The data is based on 32mm (1-1/4") electrode spacing, 600V 300 ungrounded system, and 20’ by 20’ by 20’ box. The incident energy is based on a working distance of 18 inches, and the flash protection boundary is based on 1.2 cal/cm2.

Note 5: The Low-Peak fuse information is based upon tests that were conducted at various fault currents for each Cooper Bussmann KRP-C_SP and LPS-RK_SP fuse indicated in the charts. Actual results from incidents could be different for a number of reasons, including different (1) system voltage, (2) short circuit power factor, (3) distance from the arc, (4) arc gap, (5) enclosure size, (6) fuse manufacturer, (7) fuse class, (8) orientation of the worker and (9) grounding scheme. 100A LPS-RK_SP fuses were the smallest fuses tested. Data for the fuses smaller than that is based upon the 100A data. Arc-flash values for actual 30 and 60A fuses would be considerably less than 100A fuses, however, it does not matter since the values for the 100A fuses are already so low.

Note 6: The fuse incident energy values were chosen not to go below 0.25cal/cm² even though many actual values were below 0.25cal/cm². This was chosen to keep from encouraging work on energized equipment without PPE because of a low FPB.

Note 7: This Arc-Flash Incident Energy Calculator Table can also be used for LPJ_SP, JJS, and LP-CC fuses to determine the incident energy available and flash protection boundary.

Note 8: These values from fuse tests and calculations for circuit breakers take into account the translation from available 3-phase bolted fault current to the arcing fault current.

Note 9: To determine the flash protection boundary and incident energy for applications with other fuses, use the equations in IEEE 1584 or NFPA 70E.

Note 10: The circuit breaker information comes from equations in IEEE 1584 that are based upon how circuit breakers operate.

Note 11: Where the arcing current is less than the instantaneous trip setting (IEEE 1584 calculation methods), the value for incident energy is given as >100cal/cm².

Note 12: The data for circuit breakers up to 400A is based on Molded Case Circuit Breakers (MCCB) with instantaneous trip, for 401-600A it is based on MCCBs with electronic trip units, and the data for circuit breakers from 601 up to 2000A is based on Low Voltage Power Circuit Breakers (LVPCB) with a short time delay. Per IEEE 1584 the short time delay is assumed to be set at maximum.

Note 13: The data for circuit breakers is based upon devices being properly maintained in accordance with manufacturer’s instructions and industry standards. Devices that are not properly tested and maintained may have longer clearing times resulting in higher incident energies.

Method For Other Type Fuses

Table 1 is applicable for Low-Peak and Tron fuses. To determine the flash protection boundary and incident energy for applications with other fuses or Low-Peak fuses under different parameters, use the equations in IEEE 1584 Guide for Arc-Flash Hazard Analysis, or NFPA 70E-2004. The following are the formulas in NFPA 70E - 2004 for calculating the flash protection boundary and incident energy. It is significant to note that the flash protection boundary is dependent upon the available bolted short-circuit current (incorporated in MVAf) (or the let-through current if the overcurrent protective device is current-limiting) and the opening time of the overcurrent protective device (t).

Note, the results from these calculations will differ from the results obtained from the simple table method just covered. These formulas were derived from a broad base of empirical test data and were state of the art when introduced. The simple table method has some artificially conservative assumptions as stated in the notes.

Flash Protection Boundary Calculation

\[
\text{D_{C}} = (2.65 \times \text{MVA_{MVA}} \times 10^9) \\
\text{D_{T}} = (1.96 \times \text{MVA_{MVA}} \times 10^9) \\
\text{MVAbf} = \text{bolted three phase MVA at point of short-circuit} \\
\text{t} = \text{time of exposure in seconds} \\
\]

*Not included in NFPA 70E.

NFPA 70E – 2004 Annex D provides equations for calculating incident energy under some common circumstances. For instance, the incident energy equation for an arcing fault contained in a cubic box (20 inches on each side, opened on one end), on 600V or less systems, with available bolted short-circuit currents of between 16,000 to 50,000 amps is as follows:
**Arc-Flash Protection**

**Incident Energy Calculation (20" cubic box)**

\[ E_{MB} = 1038.7 D_b^{1.4738} t_A \left[ 0.0093 F^2 - 3.453 F + 5.9675 \right] \text{ cal/cm}^2 \]

Where:  
- \( E_{MB} \) = Incident Energy (cal/cm²)  
- \( D_b \) = Distance, (in.) [for Distances ≥ 18 inches]  
- \( t_A \) = Arc Duration, (sec.)  
- \( F \) = Bolted Fault Short Circuit Current kA [16kA to 50kA]

**Example 2: Flash Hazard Analysis For Circuit Breakers Using The Table Method.**

**WARNING** If a Circuit Breaker has not been exercised, tested, and maintained per manufacturers instructions and industry standards (NFPA 70B and other standards), then a longer clearing time may occur, resulting in a higher incident energy calculation. Consult www.cooperbussmann.com or www.NETA.org for more information or technical papers on testing and maintenance and/or consequences to potential arc-flash hazard.

The following is a simplified method using table 1 as done in example 1. Instead of using LPS-RK-600SP, 600A, current-limiting fuse, we will use a 600A Molded Case Circuit Breaker.

With the same 3Ø available short-circuit current current as in example #1, 42,000 amps, locate this on the vertical column (Bolted Fault Current kA) of table 1. Then proceed directly to the right over to the 401-600A MCCB Column. Then record the I.E. (Incident Energy) which should be 5.62 cal/cm². Also, record the value for the FPB (Flash Protection Boundary) which is 51 inches.

The last step in the flash hazard analysis is to determine the appropriate PPE for the task.

If the circuit breaker in question is a power circuit breaker with short time delay feature (no instantaneous trip), the incident energy calculation will increase. For example, with a short time delay feature set at 30 cycles the incident energy at this available fault current could be as high as 67.68 cal/cm² at 18 inches from the arc fault source. So what energy does a body part experience that is closer to the arc fault than 18 inches? The closer to the arcing fault the higher the incident energy and blast hazard. This means that when the flash protection analysis results in relatively high incident energies at 18 inches from the arc fault source, the incident energy and blast energy at the point of the arc fault can be considerably greater. Said in another way, even if the body has sufficient PPE for an 18” working distance, severe injury can result for any part of the body closer than 18” to the source of the arc.

**Exposure Time**

As the previous sections have illustrated, the interruption time of overcurrent protective devices is a major factor in the severity of an arc-flash. Following is a table for some general minimum overcurrent protective device interruption times that can be used for the FBP and incident energy calculations if this data is not available from the manufacturer. “STD Setting” refers to the short time delay setting if a circuit breaker has this feature; typical STDs settings could be 6, 12, 18, 24, or 30 cycles. If an arc-flash analysis is being done for a circuit breaker with adjustable settings, then the maximum settings should be used for the analysis. If the lowest settings are used for the analysis, yet a maintenance person has inadvertently increased the setting to the maximum, then the analysis could yield results that are incorrect and lower than required for proper personnel protection.

<table>
<thead>
<tr>
<th>Type of Device</th>
<th>Minimum Time (Seconds)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current-limiting fuse</td>
<td>0.004</td>
</tr>
<tr>
<td>Circuit Breaker (5kV &amp; 15kV)</td>
<td>0.1</td>
</tr>
<tr>
<td>Standard molded case circuit breakers (600V &amp; below)</td>
<td>0.0083-0.0167</td>
</tr>
<tr>
<td>without short-time-delay (STD)</td>
<td>STD Setting</td>
</tr>
<tr>
<td>with short-time-delay (STD)</td>
<td>STD Setting</td>
</tr>
<tr>
<td>Insulated case circuit breakers (600V &amp; below)</td>
<td>0.033</td>
</tr>
<tr>
<td>without short-time-delay</td>
<td>STD Setting</td>
</tr>
<tr>
<td>with short-time-delay</td>
<td>STD Setting</td>
</tr>
<tr>
<td>Low voltage power (air frame) circuit breakers (600V &amp; below)</td>
<td>0.05</td>
</tr>
<tr>
<td>without-short-time-delay</td>
<td>STD Setting</td>
</tr>
<tr>
<td>with short-time-delay</td>
<td>STD Setting</td>
</tr>
<tr>
<td>Current-limiting molded case circuit breaker (600V &amp; below)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

* These are approximate times for short-circuit currents within the current-limiting range of a fuse or within the instantaneous region of circuit breakers. Lower current values may cause the overcurrent device to operate more slowly. Arc-flash energy may actually be highest at lower levels of available short-circuit current. This requires that arc-flash energy calculations be completed for the range of sustainable arcing currents. Where equivalent RMS let-through data (this is reduced let-through current due to current-limitation) is available, it can be used in the flash distance and incident energy formula. Where data is unavailable, the full available short-circuit must be used.

**Personal Protective Equipment (PPE)**

Employees must wear and be trained in the use of appropriate protective equipment for the possible electrical hazards with which they may face. Examples of equipment could include a hard hat, face shield, flame resistant neck protection, ear protectors, Nomex™ suit, insulated rubber gloves with leather protectors, and insulated leather footwear. All protective equipment must meet the requirements as shown in Table 130.7(C)(8) of NFPA 70E-2004. The selection of the required thermal rated PPE depends on the incident energy level at the point of work.

As stated previously, the common distance used for most of the low voltage incident energy measurement research and testing is at 18 inches from the arcing fault source. So what energy does a body part experience that is closer to the arc fault than 18 inches? The closer to the arcing fault the higher the incident energy and blast hazard. This means that when the flash protection analysis results in relatively high incident energies at 18 inches from the arc fault source, the incident energy and blast energy at the point of the arc fault can be considerably greater. Said in another way, even if the body has sufficient PPE for an 18” working distance, severe injury can result for any part of the body closer than 18” to the source of the arc.

The test parameters were:
- Available fault current = 22,600A at 480Vac.
- OCPD clearing time of six cycles or 0.1 second.
- The level of PPE for this would have to be greater than 5.8 cal/cm² and result in a Hazard Risk Category 2.

**FPB: 47 Inches | I.E.: 5.8 cal/cm²**

Employees must wear and be trained in the use of appropriate protective equipment for the possible electrical hazards with which they may face. Examples of equipment could include a hard hat, face shield, flame resistant neck protection, ear protectors, Nomex™ suit, insulated rubber gloves with leather protectors, and insulated leather footwear. All protective equipment must meet the requirements as shown in Table 130.7(C)(8) of NFPA 70E-2004. The selection of the required thermal rated PPE depends on the incident energy level at the point of work.
**Arc-Flash Protection**

**Expect the Worst Case**
If planning to work on a piece of equipment, it is necessary to do the flash hazard analysis for the worst-case situation that could occur if an incident occurred. For instance, in the diagram below, if the combination controller door were to be opened, the worst-case arc-flash hazard in the enclosure would be on the line-side of the branch-circuit breaker. If an arcing fault occurred in the enclosure, on the line side of the branch-circuit breaker, the 400 amp feeder circuit breaker is the protective device intended to interrupt. So the flash hazard analysis for this combination motor controller enclosure must be determined using the characteristic of the 400 amp feeder circuit breaker.

**Other Arc Fault Hazards**
An arcing fault may create such enormous explosive forces that there is a huge blast wave and shrapnel expelled toward the worker. Neither NFPA 70E – 2004 nor IEEE 1584 account for the pressures and shrapnel that can result due to an arcing fault. There is little or no information on protecting a worker for these risks.

On a somewhat positive note, because the arc pressure blows the worker away, it tends to reduce the time that the person is exposed to the extreme heat of the arc. The greater the fault current let-through, the greater the explosive forces. It is important to know that product standards do not evaluate a product for a worker’s exposure to arc-flash and blast hazards with the door(s) open. Equipment listed to a Nationally Recognized Testing Laboratory product standard is not evaluated for arc-flash or arc blast protection (with the door(s) open) because the equipment is tested with the doors closed. Once a worker opens the doors, the parameters under the evaluation testing and listing do not apply.

**Caution:**
(1) A worker using PPE with adequate cal/cm² ratings for high incident energy arc-flash hazards may still incur severe injury or death due to the arc blast or shrapnel. For instance, review the results for Test 4 on page 118. Generally, the higher the incident energy, the higher the blast energy that will result. (2) For systems 600V and less, NFPA 70E – 2004 has an alternate method to find the flash protection boundary (four foot qualified default) and PPE selection (using two tables – a. hazard risk category by tasks table and b. PPE and tools for each hazard risk category table). Although, these methods can be more convenient, there are very important qualifiers and assumptions in the tables’ notes and legends. It is possible for a specific situation to be beyond the assumptions of these tables and therefore, in these situations, the tables are not to be used.

**Summary About the Risks From Arc Faults**
Arc faults can be an ominous risk for workers. And an uneducated eye can not identify whether the risk is low, medium or high just by looking at the equipment. Current-limiting overcurrent protection may reduce the risk. In other words, if an incident does occur, current-limiting overcurrent protective devices may reduce the probability of a severe arc-flash. In many cases, using current-limiting protective devices greatly reduces the arc-flash energy that might occur for the range of arc fault currents that are likely. However, current-limiting overcurrent protective devices do not mitigate the potential hazard in all situations. This is especially true as the overcurrent protective devices get into the larger amp sizes. But all things being equal, systems with protective devices that have a high degree of current-limitation generally lower the risks. But it is still necessary to follow all the requirements of NFPA 70E and other safe work practices.

**General Recommendations For Electrical Safety Relative to Overcurrent Protection**
(1) Finger-safe products and terminal covers: utilize finger-safe overcurrent protective devices such as the CUBEFuse or insulating covers over the overcurrent protective devices, disconnect terminals and all terminations.

(2) Proper interrupting rating: be absolutely sure to use overcurrent protective devices that have adequate interrupting ratings at their point of application. An overcurrent protective device that attempts to interrupt a fault current beyond its interrupting rating can violently rupture. Consideration for interrupting rating should be for the life of the system. All too often, transformers are replaced or systems are upgraded and the available short-circuit currents increase. Modern fuses have interrupting ratings of 200,000 and 300,000 amps, which virtually eliminates this hazard contributor.

(3) Current-limiting overcurrent protection: use the most current-limiting overcurrent protective devices possible. There are a variety of choices in the market for overcurrent protective devices. Many are not marked as current-limiting and therefore can not be considered current-limiting. And then for those that are marked current-limiting, there are different degrees of current-limitation to consider. For Cooper Bussmann, the brand to use for 600V and less, electrical distribution applications and general equipment circuit protection is Low-Peak fuses. The Low-Peak family of fuses is the most current-limiting type fuse family for general protection and motor circuit protection.

(4) Upgrade existing fuse systems: if the electrical system is an existing fusible system, consider replacing the existing fuses with the Low-Peak family of fuses. If the existing fuses in the clips are not the most current-limiting type fuses, upgrading to the Low-Peak family of fuses can reduce the hazards associated with arc-flash. Visit www.cooperbussmann.com to review a service for the Low-Peak upgrade, referred to as the Productivity Protector.

(5) Install current-limiting overcurrent protection for actual loads: if the actual maximum full load current on an existing main, feeder or branch circuit is significantly below its designed circuit ampacity, replace the existing fuses with lower amp rated Low-Peak fuses. Or, if the OCPD is a circuit breaker, put a fused disconnect with Low-Peak fuses in series with the circuit breaker. For instance, an industrial found that many of their 800 amp feeders to their MCCs were lightly loaded; so for better arc-flash protection they installed 400 and 600 amp current-limiting fuses and switches in the feeders.

(6) Reliable overcurrent protection: use overcurrent protective devices that are reliable and do not require maintenance to assure performance per the original specifications. Modern fuses are reliable and retain their ability to react quickly under fault conditions. When a fuse is replaced, a new factory calibrated fuse is put into service – the circuit has reliable protection with performance equal to the original specifications. If mechanical overcurrent protective devices are utilized, be sure to perform the manufacturer’s recommended periodic exercise, maintenance, testing and possible replacement. When an arc fault or overcurrent occurs, the overcurrent protective device must be able to operate as intended. Thus, for mechanical overcurrent protective devices, this may require testing, maintenance, and possible replacement before resetting the device after a fault interruption.
Arc-Flash Protection

(7) Within sight motor disconnects: install Hp rated disconnects (with permanently installed lockout provision) within sight and within 50 feet of every motor or driven machine. This measure fosters safer work practices and can be used for an emergency disconnect if there is an incident.

Flash Protection Field Marking: New NEC® Requirement

110.16 Flash Protection: Switchboards, panelboards, industrial control panels, meter socket enclosures 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-2004 Standard for Electrical Safety in the Workplace 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® 2005

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 protective equipment (PPE) for the specific hazard (a non-qualified worker must not be opening or be near open energized equipment).

2005 NEC® 110.16 only requires that this label state the existence of an arc-flash hazard.

Where To Get Help

Professional Services
Cooper Bussmann provides electrical safety services including:
1. Electrical system one-line diagram development
2. Short-circuit current analysis
3. Overcurrent protective device time-current curve characteristic analysis
4. Overcurrent protective device coordination analysis
5. Arc-flash hazard analysis
6. Arc-flash hazard label production
7. Electrical safety program development
8. Electrical safety training
9. Annual maintenance

Contact your local Cooper Bussmann sales engineer or call 636-207-3294.

Materials to Help Understand the Issues and Solutions
Go to www.cooperbussmann.com under electrical safety. There is an on-line arc-flash hazard calculator, several technical papers, Safety BASICs Handbook Edition 2, and more.

Training Kits
There are two kits to assist in training personnel. Part # SBK Safety BASICs Kit for trainers, which includes handbook, many electronic presentations following the handbook, video, and more. Part # SBTH Safety BASICs Kit for participants includes 10 copies of the handbook and participants guides. These can be ordered from authorized Cooper Bussmann distributors. Description on www.cooperbussmann.com under Safety BASICs.