Communicating the dangers associated with energized electrical equipment is one of the core elements of any workplace electrical safety program. One of the most vital steps of that process is classifying various tasks according to the Hazard/Risk Category levels listed in NFPA 70E, Standard for Electrical Safety in the Workplace. Understanding these tables is imperative, particularly in Canada, because the forthcoming CSA Z462 Workplace Electrical Safety Standard will be technically harmonized with NFPA 70E.

NFPA 70E Table 130.7(C)(11) uses five Hazard/Risk Category levels for various tasks. These levels range from zero to four. In the CSA Z462 Consensus Draft, dated April 2, 2008, the equivalent table is referred to as Table 5.

As important as it is to understand these tables, it’s equally important to understand the limitations of these tables. If these limitations are not considered in your arc flash hazard evaluation, it may lead to selecting an incorrect level of arc flash rated Personal Protective Equipment (PPE), thus jeopardizing the safety of the electrical worker.

Two Alternate Methods To Determine PPE

The most challenging step of an arc flash hazard evaluation is determining how to classify tasks for different electrical equipment types operating at varying voltage levels. Two alternate methods are available for classifying the arc flash Hazard/Risk Category level associated with a particular task.

The first method is to use Table 130.7(C)(9)(a), a “lookup” table that lists different tasks on energized equipment and their associated Hazard/Risk Category levels. In the CSA Z462 Consensus Draft the equivalent table is referred to as Table 4. Although some question the use of Table 130.7(C)(9)(a), there are many situations which require the...
use of this table, which we will discuss in this article.

The second method is to have a Professional Engineer in
Canada use power system analysis software to conduct a
more thorough arc flash hazard analysis. In this case, we rec-
ommend using the more rigorous calculation guidelines pro-
vided by IEEE 1584-2002 Standard and/or NFPA 70E-2004
Annex D, also Annex D in CSA Z462.

When to Use Table 130.7(C)(9)(a)
As mentioned previously, there are situations which require
Table 130.7(C)(9)(a), for example, when it’s necessary to per-
form emergency work on energized electrical equipment that
does not have proper arc flash hazard labels. The table is also
useful for determining the required PPE for electrical equip-
ment inspection, such as when an arc flash hazard analysis is neces-
sary and you have to collect electrical equipment nameplate data.

The tables may also be used as part of a simplified electrical
safety program for smaller facilities. Take, for example, facili-
ties that use simple radial systems with fewer than 20 buses.

Table 130.7(C)(9)(a) lists and classifies tasks involving
such equipment as switchboards, panelboards, Motor Control
Centres (MCCs), switchgear and motor starters. For example,
the table classifies the “insertion or removal of individual
starter ‘buckets’ from MCC” (600V class) as a task with Haz-
ard/Risk Category 3 (8 < cal/cm² < 25).

According to footnote 4 of the table, the maximum avail-
able bolted short-circuit current limit is 65kA. In addition, the
footnote indicates that the maximum fault clearing time (arc-
ing time) should be about 0.33 seconds or 20 cycles.

Validate Results With Power System Analysis Software
You can use power system analysis software to validate the
Hazard/Risk Category level the table provides. For example,
Figure 1, which uses IEEE 1584-2002, displays a typical MCC
configuration with an arc fault simulation at bus MCC-1.

According to IEEE 1584, the simulation uses typical values
for gaps (distances between energized bare conductors in mm).
Working distance is estimated to be 24 inches (conversely, the
NFPA 70E table doesn’t provide arc flash protection boundary
or working distances). The MCC has a maximum available
bolted short-circuit current of 25kA.

According to the displayed results on the one-line diagram
in Figure 1, the program determined a Hazard/Risk Category
Level 3 for the faulted location (MCC-1). In this case, the Haz-
ard/Risk Category level agrees with the one listed in the table.

Analysis Software Takes Safety To Next Level
Using power system analysis software, you can perform a
different simulation for the same MCC, only this time using
the maximum available bolted short-circuit current of 65kA.
As you can see from the results in Table 1, the incident energy
level could easily reach Hazard/Risk Category 4 or higher
simply by using the maximum values of short circuit current.

The results of Table 1 illustrate that the PPE rating suggested
by NFPA 70E, Table 130.7(C)(9)(a) may not be adequate for the
task. According to IEEE 1584-2002, the typical working
distance is 18 inches for a 0.480V MCC. Yet Case 4 shows that
the incident energy level for an 18-inch working distance almost
exceeds the limit of Hazard/risk Category 4 (40 cal/cm²).

![Figure 1. Arc flash simulation for a typical MCC](Image 622x61 to 647x77)

**Table 1. Incident Energy for a fault at MCC-1 for different working distances**

<table>
<thead>
<tr>
<th>Case ID</th>
<th>Ibf at Fault Location (kA)</th>
<th>Main Breaker Fault Clearing Time (sec)</th>
<th>Working Distance (inch)</th>
<th>Incident Energy at MCC-1 (cal/cm²)</th>
<th>Hazard/Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>23.3</td>
<td>0.300</td>
<td>18</td>
<td>11.9</td>
<td>3</td>
</tr>
<tr>
<td>Case 2</td>
<td>23.3</td>
<td>0.300</td>
<td>24</td>
<td>13.81</td>
<td>3</td>
</tr>
<tr>
<td>Case 3</td>
<td>64.8</td>
<td>0.300</td>
<td>18</td>
<td>24.31</td>
<td>3</td>
</tr>
<tr>
<td>Case 4</td>
<td>64.8</td>
<td>0.330</td>
<td>24</td>
<td>38.98</td>
<td>4</td>
</tr>
</tbody>
</table>

**Note:** Ibf denotes a bolted 3-phase short-circuit current

What’s lacking in the NFPA 70E table is the working distance – one of the most dominant factors in the calculation. Even if the available bolted fault current and the fault clearing time stays within the noted limits, the results listed in the table may not provide sufficient protection. Because the table results are generalized, and not specific to a particular system, it is not wise to solely rely on the table to recommend PPE levels on MCCs.

Let’s look at another example for a common task, like energized work on metal clad switchgear above 1kV. According to Table 130.7(C)(9)(a), PPE rated for Category 4 is recommended for the insertion or removal of circuit breakers from cubicles with the doors open.

In this case, we can take a 4.16kV switchgear with typical working distance and conductor gaps based on IEEE 1584 2002 (WD = 36 inches and Gap = 102mm). Figure 2 exhibits a one-line diagram for typical medium voltage switchgear and the simulated arc flash results for two locations within the equipment.

Incident energy has been calculated for two cubicles. One is a load CB cubicle, which indicates incident energy within Hazard/Risk Category 3 limits. Yet the Main CB cubicle shows a potential incident energy release almost beyond that of Hazard /Risk Category 4.

Although these results are in agreement with those recommended by Table 130.7(C)(9)(a), any variation in the clearing time or bolted short circuit current may cause the incident energy to exceed the levels of Hazard/Risk Category 4. Clearly, the table fails to establish the limits for the bolted fault current.

**NFPA 70E Tables vs. A Thorough Analysis**

The potential differences between the PPE rating recommended by Table 130.7(C)(9)(a), versus those recommended by the more thorough arc flash hazard analysis, are significant. Table 2 summarizes comparisons made between the NFPA 70E
Table categories against those obtained by the IEEE 1584-2002 method. Please note that this table is not comprehensive and only illustrates a brief summary of a few of the comparisons made for tasks at different voltage levels.

The Hazard/Risk Categories obtained using Table 130.7(C)(9)(a) may be less conservative for tasks expected to be within Hazard/Risk Category 3 and 4 levels. It may be possible to use the table for tasks involving Hazard/risk Categories 0, 1 and 2, as long as the available bolted short-circuit current and arcing time are within the limits specified in the table footnotes.

The comparisons presented in Table 2 demonstrate why performing a thorough arc flash hazard analysis instead of solely relying on Table 130.7(C)(9)(a) is recommended.

### Checking TCC Curves

Regardless of the expected task Hazard/Risk Category level, you should always perform a thorough check of the Time Current Characteristic curves (TCCs) of the protective device expected to clear the arc fault. Variations in the short circuit current levels and clearing times may result in higher arc flash energies. Figure 3 depicts a quick method to check if a combination of bolted fault current and arcing time yield incident energy levels below the PPE rating.

Purple and green curves in the TCC view of Figure 3 represent an incident energy level of 25 cal/cm² for 600V class MCCs and switchgear. The curves were generated using typical working distances of 24 and 18 inches. To yield more conservative results, make sure the example assumes the systems are ungrounded.

The curves show the relationship between bolted fault current and fault clearing time. If the bolted fault current increases, the required clearing time should be less to ensure it doesn’t exceed the incident energy level.

According to Figure 3, the right side of the curves represents the maximum bolted fault current and corresponding arcing time combination that yields 25 cal/cm² (onset of hazard/risk Category 4 level). An overcurrent relay curve is shown below the incident energy curves.

The bolted fault current is shown below as an arrow. As long as the fault current and the TCC curve are below the incident energy curve, then the incident energy should be less than the allowable limit. A set of curves of this type can be developed for each of the types of equipment listed in Table 130.7(C)(9)(a).

### Conclusion

Although it’s still necessary to continue the use of NFPA 70E tables under some circumstances, care must be taken to ensure it is only applied under the conditions and limitations stated in the table footnotes. Careful consideration must be given to the effect of variables not listed in the table(s), such as working distances and equipment configuration (grounding and gaps between conductors).

These parameter variations may cause the incident energy exposure to be much larger than the level suggested by the table. That’s why the best approach for determining the arc rating of PPE is by having a detailed engineering-based arc flash hazard analysis study completed.

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**Table 2.** Summary of comparisons made between Table 130.7(C)(9)(a) and IEEE 1584 results.