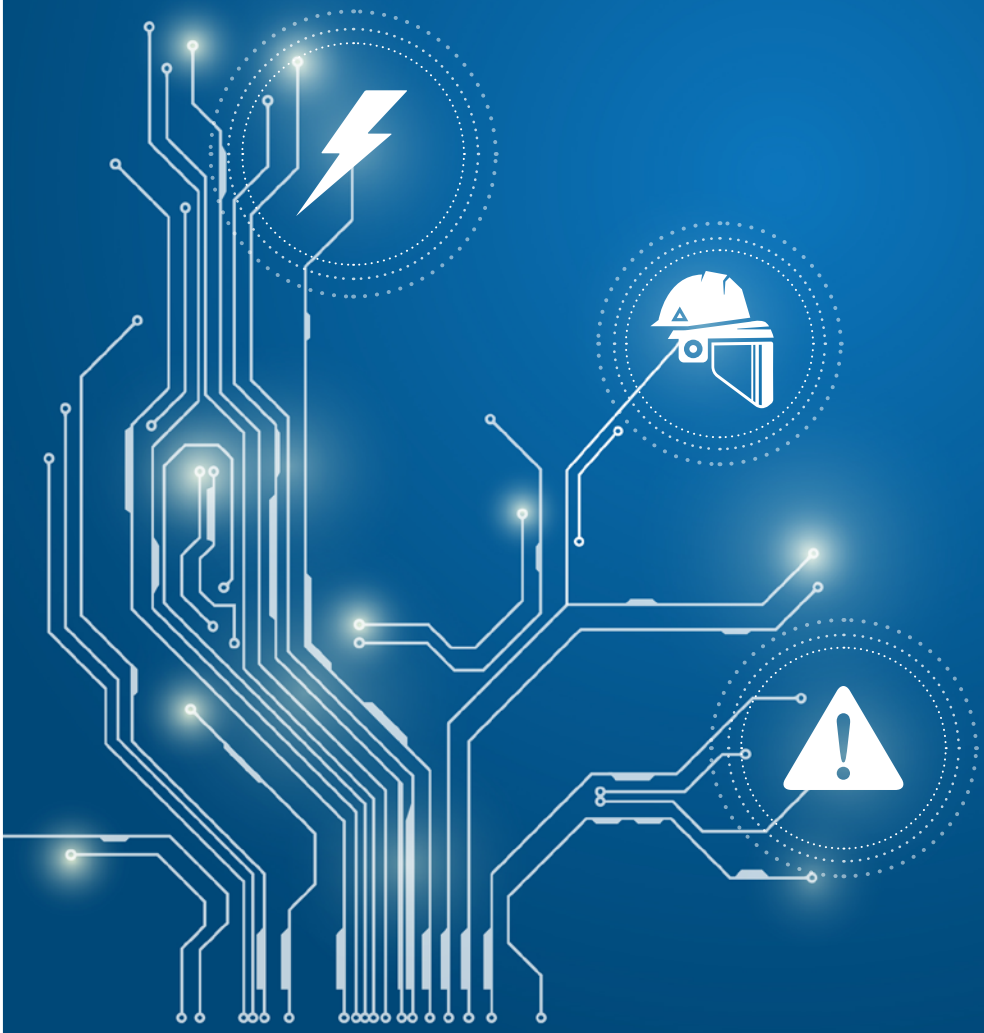
Confidence in Arc Flash Labeling

Complex Concepts Understood



A WHITE PAPER BY PAUL ZOUSKI, P.E. / NFPA 70E COMPLIANCE SPECIALIST – ELECTRICAL

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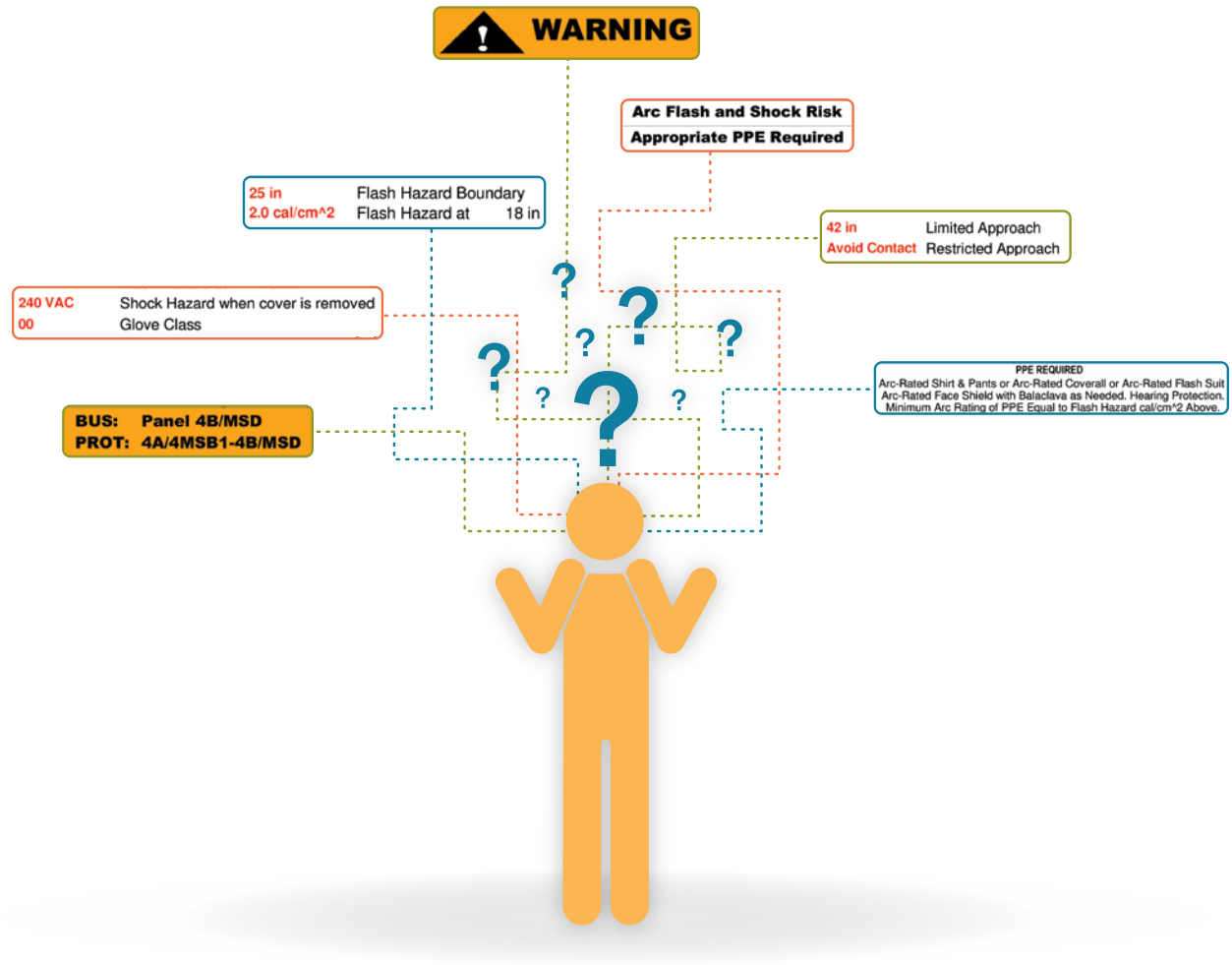


Introduction

Arc flash labeling and compliance with OSHA standards can be a confusing subject. Searching for what is required to be in compliance with OSHA regulations for arc flash can lead to more confusion, since arc flash itself is not specifically addressed in any of OSHA's regulations. The OSHA requirement for arc flash labeling is enforced under *Personal Protective Equipment* and *Hazard Communication*. This article will describe the specifics of arc flash labels and how to obtain accurate and compliant labels for the equipment at your facility.

What is Required for Compliance

It is important to note that arc flash labels are only a small portion of what needs to be in place to be compliant with OSHA standards for electrical safety. Arc flash labels are a tool to be used as part of a comprehensive electrical safety plan. OSHA regulations reference *NFPA 70E-The Standard for Electrical Safety in the Workplace* as the adopted standard for electrical safety. This paper will focus on what is required for *NFPA 70E*-compliant arc flash labeling. All *NFPA 70E* references are from the 2018 edition.

Arc flash labeling is used to inform workers of the hazard they are exposed to when working on or near electrical equipment. Like other hazards that are on a work site, workers need to be informed of the hazard that is present and what they need to do to protect themselves. In some ways, the labels can be thought of as a Safety Data Sheet (SDS) for electrical hazards. The information on the label tells workers the specific hazard at the labeled piece of equipment, and what type of personal protective equipment (PPE) is required to safely work on or near that equipment. When people begin to review their arc flash labeling needs, they can often be overwhelmed and surprised by the amount of equipment that is part of or is connected to their electrical system. Common questions are **"What equipment needs to be labeled?" and "What do the labels need to say?"** *NFPA 70E* Section 130.5(H) provides guidance on both of these topics.

130.5(H) Equipment Labeling. Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label…

This section is clear on some specific equipment (switchboards, panelboards and motor control centers) but also is subject to interpretation with industrial control panels and the statement *"that are likely to require examination, adjustment, servicing or maintenance while energized."* It's important to remember the intent of the labeling, which is to let a worker know if a hazard is present and if so, what the hazard is. Consider the different equipment you have. **Are your workers or outside electrical workers likely to have to work on this equipment while it is energized to repair it, troubleshoot it or perform routine maintenance? Will they be exposed to live parts while they perform these tasks?** If so, then the equipment needs a label.

130.5(H) goes on to say the label shall contain all of the following information:

(1) Nominal system voltage
(2) Arc flash boundary
(3) At least one of the following:
a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both
b. Minimum arc rating of clothing
c. Site-specific level of PPE.

Nominal system voltage is the voltage present at the equipment and is information that should be readily available from a review of the electrical system. The arc flash boundary and all of the items listed under Item 3 are not set values based on voltage, current or other readily available characteristics of the equipment.

Items 2 and 3 of the labeling requirements are what lead to common noncompliant labeling. Because these values are specific to the equipment, they cannot be covered by any "standard" label. The required information cannot come on a preprinted roll of labels that you can apply to all of your equipment. These values must be obtained through an Arc Flash Risk Assessment.

How to obtain the equipment-specific information for the labels (Arc Flash Risk Assessment)

In order to fully understand the arc flash hazards present on a site, an Arc Flash Risk Assessment must be performed. *NFPA 70E* provides guidance on Arc Flash Risk Assessment.

130.5 Arc Flash Risk Assessment

(A) General. An arc flash risk assessment shall be performed:

(1) To identify arc flash hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

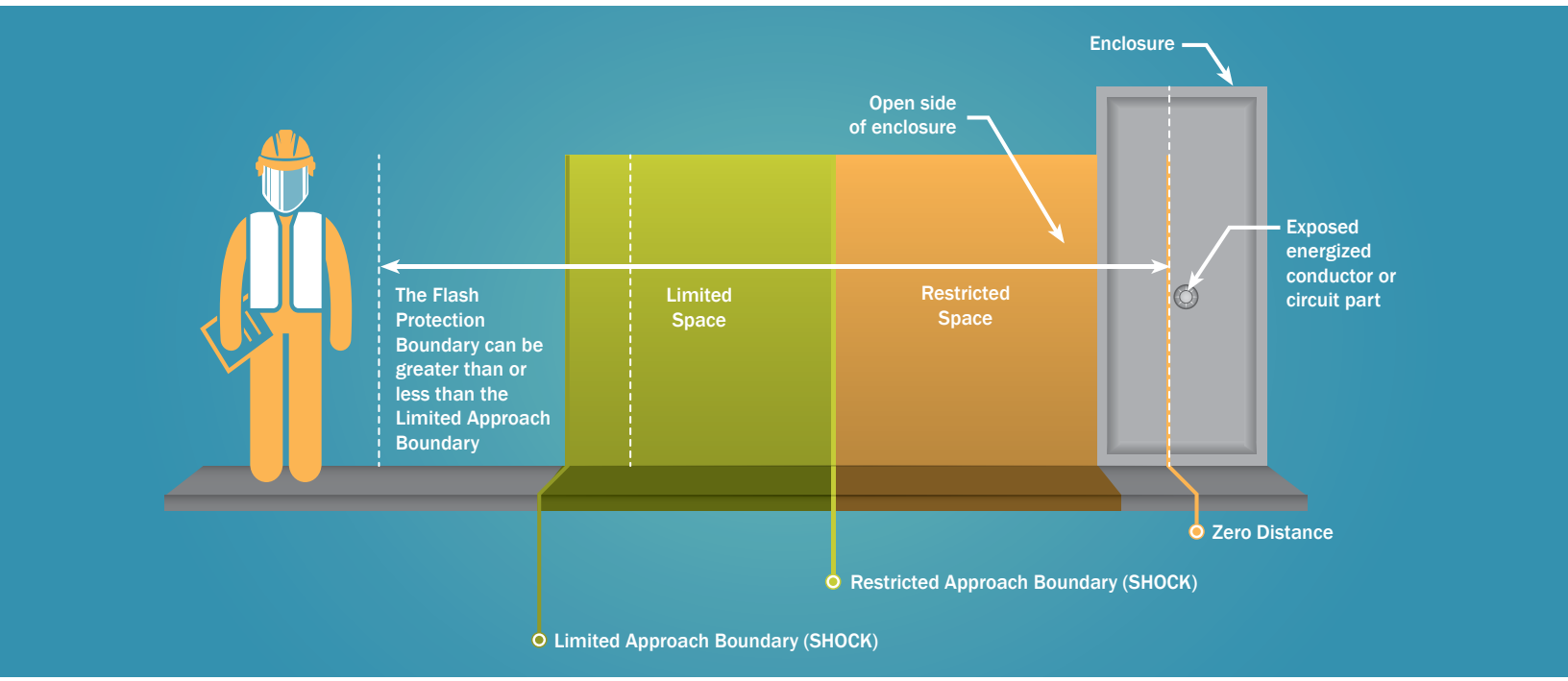
(3) To determine if additional protective measures are required, including the use of PPE.

The article goes on to provide the guidance we need to find the Arc Flash Boundary required for the label:

130.5(E) Arc Flash Boundary.

(1) The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm^2 (5 J/cm^2)

(2) The arc flash boundary shall be permitted to be determined by the Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) when the requirements of these tables apply.



130.5(E)(1) describes information that can only be obtained by mathematical calculation. Arc boundaries are calculated using the **Lee Equation**:

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

where:
D_c = distance in feet of person from arc source for a just curable burn
MVA_{bf} = bolted fault MVA at point involved
t = time of arc exposure in seconds

The bolted fault MVA at the point involved is obtained from additional calculations based on the available fault current from the utility, the size and the length of the conductors serving the equipment. The time of arc exposure is based on the clearing time of the breaker or fuse ahead of the location based on the available fault current.

130.5(E)(2) references tables in *NFPA 70E* that are available for reference to determine the arc flash boundary. 130.7(C)(15)(a) provides information for ac systems and 130.7(C)(15)(b) provides information for dc systems.

While the tables appear to be a quick solution to finding the arc flash boundary, close review reveals limitations. For example, let's look at the first entry in Table 130.7(C)(15)(a)

130.7 ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)

The entry states that a panelboard rated 240 volts and below has an arc flash boundary of 19 inches; however, look at all the parameters that are stipulated. To ensure you are within the parameters you need to know the maximum fault current at the location and the fault clearing time. If both values are known, we can calculate actual arc flash boundary using the Lee Equation shown above. Assuming the equipment meets these parameters could result in improperly labeled equipment. This could result in injuries to workers because of improper PPE.

Following the determination of the arc flash boundary we have one additional piece of information required for a compliant label:

130.5(H)(3) At least one of the following:

a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both
b. Minimum arc rating of clothing
c. Site-specific level of PPE.

130.5(H)(3)(a) gives the option of listing the available incident energy or the arc flash PPE Category from Tables.

The incident energy can be obtained by mathematical calculation using the **Doughty Neal Equation** for an arc in a box:

$$E_{MB} = 1038.7 D_B^{-1.4738} t_A [0.0093F2 - 0.3453F + 5.9675]$$

where:
E_{MB} = maximum 20 in. cubic box incident energy, cal/cm^2
D_B = distance from arc electrodes, in. (for distances 18 in. and greater)
t_A = arc duration, sec
F = short-circuit current, kA (for the range of 16kA to 50kA)

The important thing to notice is that if we have already done the calculations required to find the arc flash boundary using the Lee equation, we have all the values that we need to calculate the incident energy.

Similar to the arc flash boundary, the arc flash PPE category can be obtained from tables. Looking again at the first entry in Table 130.7(C)(15)(a):

Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

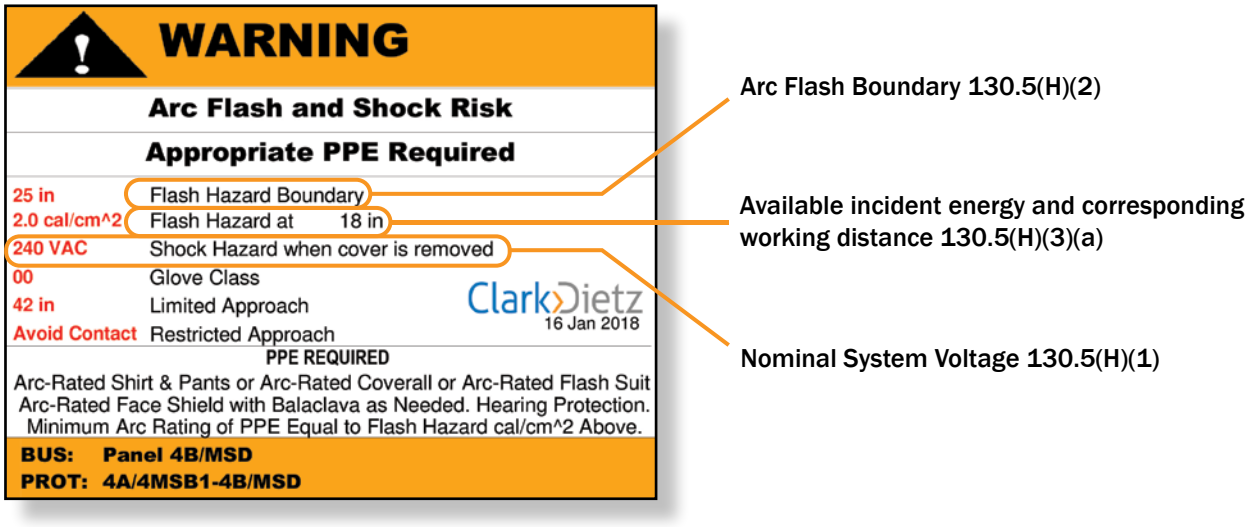
Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)

The entry states that a panelboard rated 240 volts and below has an arc flash PPE category of 1. The same parameters are required to be met to ensure the accuracy of this determination.

Two options remain to complete our label. Section 130.5(H)(3)(b) Minimum arc rating of clothing, can be determined based on the calculated incident energy by selecting a cal/cm^2 value greater than the incident energy. If the tables were used to determine the Arc Flash PPE Category, Table 130.7(C)(15)(c) Personal Protective Equipment can be used.

The remaining option is section 130.5(H)(3)(c) Site-specific level of PPE. This allows the option for a PPE listing that matches the locations electrical safety plan. For example, if your company uses a color code for hazard levels (green, yellow, red, etc) the standard allows you to continue use of these identifiers on your labels.

With the information obtained, a compliant label can be produced.



Staying up to Date

An arc flash risk assessment and labeling is an ongoing process. *NFPA 70E* Article 130.5(G) states:

The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect results of the analysis. The incident energy analysis shall also be reviewed for accuracy at interval levels not to exceed 5 years.

Changes occur to electrical systems both internal to your facility and external on the utility side of your connection. External changes that can affect results include additional users in your neighborhood or changes to the transformer serving your facility. Internal changes that can affect results include addition of large loads, additions to your facility, remodeling of your facility or repurposing of areas of your facility.

Another important date to consider is that *NFPA 70E* is updated every three years. The latest version available is the 2018 edition. A new release of the standard may not require an update to the study, but it should be reviewed for any major changes. For example, the 2015 edition brought on many major changes, including elimination of Level 0 hazards.

Benefits of the Incident Energy Analysis Method

NFPA 70E provides guidance and tables that can be used to create code-compliant labeling for your equipment. However, to use the tables correctly, calculations need to be performed to make sure that the parameters listed in the tables are applicable to your equipment. Misapplication of these tables can lead to improper labeling and can result in injuries to workers.

An Arc Flash Risk Assessment utilizing incident energy analysis ensures accurate labeling of your equipment and the highest level of protection for your employees. Electrical engineers that specialize in these studies have access to software and equipment libraries that can model your electrical system and perform all the required calculations quickly and accurately. When it comes to safety trust professionals to assist you with understanding complex concepts such as arc flash. Clark Dietz can perform the required calculations and provide assistance to assure that your equipment is labeled properly.

To learn more about the process of an Arc Flash Risk Assessment, contact Clark Dietz or check back for upcoming articles.

Contact us at info@clarkdietz.com to find out what's best for your facility.

About the Author

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Mr. Zouski is an experienced project engineer specializing in electrical design and cost estimating for academic, corporate, governmental, and industrial facilities. He designs to required specifications, with a focus on the economy, safety, reliability, quality and sustainability of the result. Paul is keenly aware of the importance of continuous operations and provides the necessary attention to minimize service disruption during construction. He utilizes his background as a commercial electrical inspector and electrician to conduct efficient field investigations and ensure constructible designs. Paul received his Bachelor of Science in Electrical Engineering from the University of Wisconsin-Platteville and is a registered professional engineer in Wisconsin, Illinois, and Texas. He has also received training from NFPA and has successfully completed the comprehensive examination on the educational requirements of the *NFPA 70E-Electrical Safety in the Workplace* Seminar.

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