THE WORKPLACE GUIDE TO ARC FLASH SAFETY

Get answers to your arc flash and NFPA 70E questions

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With the rising frequency of reported arc flash accidents, and the potential for serious injury or death, arc flash is a serious concern. It's important to increase safety and compliance in your workplace by better understanding and identifying arc flash hazards. In this guide, get answers to your questions and learn more about arc flash events, the NFPA 70E standard, and how to reach compliance with labeling and risk assessments.

CHAPTER 1

UNDERSTANDING ARC FLASH

Understanding Arc Flash

What is Arc Flash?

ARC FLASH: A short circuit through air that flashes over from one exposed live conductor to another conductor or to ground. This electrical fault can create a dangerous release of energy, including thermal energy, acoustical energy, pressure wave or debris.

How Can an Arc Flash Occur?

There are a number of ways an arc flash can occur, including:

- Coming close to a high-amp source with a conductive object can cause the electricity to flash over
- Dropping a tool or creating a spark can ignite an arc flash
- Failing equipment due to use of substandard parts, improper installation, or even normal wear and tear
- Breaks or gaps in insulation
- Dust, corrosion or other impurities on the surface of the conductor

What Impacts the Size of an Arc Flash Event?

Common variables that impact the size and energy of an arc flash include[1]:

- Amperage
- Voltage
- Arc Gap
- Closure Time
- Distance from Arc
- 3 Phase vs. Single Phase
- Confined Space

DID YOU KNOW?

An average of 30,000 arc flash incidents occur per year.[2]

What are the Dangers of an Arc Flash Event?

Physical Injury

Without the proper labeling, training and personal protective equipment (PPE), an arc flash occurrence can lead to serious burn injuries, concussions, hearing loss, shrapnel injuries, broken bones and even death. An arc flash occurrence can reach thousands of degrees, and skin exposure for just 1/10 of a second at 203˚F can lead to third degree burns.

To help keep your workplace safe, train your employees in safe work practices and utilize labels and awareness to keep the message in the forefront of your workers' minds and reinforce the desired behavior in your facility.

Financial Impact

An arc flash occurrence can have a productivity and financial impact as well. Total costs for arc flash accidents can range from $12-15 million, including medical expenses, downtime, equipment replacement, lawsuits, and insurance and litigation fees[4]. According to the Occupational Safety and Health Administration (OSHA), some facilities have been fined for over $500K for not being compliant with electrical safety regulations.

DID YOU KNOW?

Arc flash incidents lead to over 2,000 hospitalizations. An average hospital stay is 19 days, at approximately $18,000 per day.[1]

CHAPTER 2

THE NFPA 70E STANDARD

The NFPA 70E Standard

What is NFPA 70E?

OSHA cites and fines employers for failure to protect employees from the dangers of arc flash under regulation 29 CFR 1910.333(a). The National Fire Protection Association (NFPA) details how to comply with this regulation through the NFPA 70E standard, "Standard for Electrical Safety in the Workplace."

What Does the NFPA 70E Standard Include?

According to the NFPA 70E standard, there are six primary responsibilities that facilities must meet, including:

1. Training for employees
2. Written safety program in place that is actionable
3. PPE available for employees
4. Insulated tools
5. Arc flash hazard degree calculations
6. Properly labeled equipment

Learn more about how risk assessments and labeling can help you reach compliance in the following chapters.

DID YOU KNOW?
An arc flash event can reach
35,000°F[1]

CHAPTER 3

ARC FLASH RISK ASSESSMENTS

Arc Flash Risk Assessments

Why is a Risk Assessment Performed?

An arc flash risk assessment is done for many reasons, including:

1. To prevent worker injury or death
2. To minimize equipment damage
3. To minimize system downtime
4. To comply with codes and safety regulations
5. To meet insurance requirements
6. To avoid litigation expenses

What is a Risk Assessment?

An arc flash risk assessment is a key part of what OSHA requires as it relates to electrical hazards. NFPA 70E requires employers to conduct an arc flash risk assessment to determine the amount of thermal energy that could be generated from an arc flash incident. This information is then used to define a flash protection boundary around the potential source and determine the level of arc-rated apparel and other PPE required to protect employees who cross the boundary from the potential heat, light and blast of an incident.

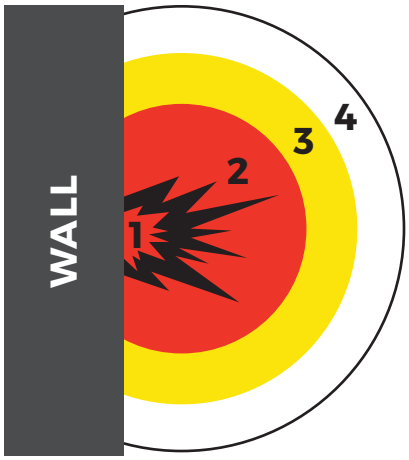
At minimum, the safety program needs to be audited at intervals not to exceed 3 years and arc flash risk assessments shall be periodically reviewed at intervals not to exceed 5 years.

What is an Arc Flash Boundary?

An arc flash boundary is the distance at which an electrical arc can flash outward and endanger employees working on electrical equipment. Additional boundary requirements include:

- **Conductive Articles of Jewelry and Clothing:** Watchbands, bracelets, rings, key chains, necklaces, metal frame glasses, etc. shall not be worn within the restricted approach boundary.
- **Working Space:** Shall not be used for storage. Space shall be kept clear to permit safe operation and maintenance.
- **Barricades:** When the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.
- **Insulated Tools:** Employees shall use insulated tools when working inside the restricted approach boundary of exposed energized electrical conductors.

Take a look at the below visual to learn more about each boundary area:



1. **Exposed Conductor, or Circuit**
2. **Restricted Approach Boundary** (increased likelihood of electric shock)
3. **Limited Approach Boundary** (shock hazard exists)
4. **Arc Flash Boundary** (distance where up to 2nd degree burns are likely to occur - it could be 1 inch to 20 feet and greater of less than the other boundaries, depending on incident energy)

What is the Next Step?

Once an arc flash risk assessment has been conducted, in which the arc flash boundary, the incident energy at the working distance and the personal protective equipment required has been determined, the label must then contain these important elements.

DID YOU KNOW?

80% of electrical worker fatalities are due to burns, not shock.[2]

CHAPTER 4

ARC FLASH LABELING

Arc Flash Labeling

Who is Responsible for Labeling?

Arc flash labeling is the responsibility of the employer, not the manufacturer or installer of the equipment.

What Should be Labeled?

The regulation states that relevant electrical equipment shall be field marked to warn qualified persons of potential electric arc flash hazards. Labeling is required for any piece of electrical equipment that is likely to require examination, adjustment, service or maintenance while energized, creating the potential for an arc flash incident to occur. Thus, many employers are also labeling bus ducts and other electrical equipment not specifically called out in the NEC.

The NEC provides the following examples of electrical equipment that must be field marked with a warning label:

- Switchboards
- Panel Boards
- Motor Control Centers
- Industrial Control Panels
- Meter Socket Enclosures
- And More

DID YOU KNOW?

Exposure of 203˚F for just one-tenth of a second (6 cycles) is enough to cause a third degree burn.[1]

What if Electrical Equipment is Updated?

Any modifications or renovations to electrical equipment that will change data on the label will require an updated arc flash risk assessment and label according to the NFPA 70E standard. Unless changes to the electrical distribution system render the label inaccurate, labels applied prior to the effective date of the current NFPA standard are acceptable if they complied with the standard version in effect at the time the labels were applied.

While the labeling requirements for equipment installed prior to the 2002 NEC Provision are not specifically stated, OSHA's general duty clause for hazard warning may apply here. Should the equipment be modified or upgraded in any way, then a label must be affixed.

From a safety perspective, the hazard is the same regardless of when the equipment was installed. Consequently, most employers are simply labeling all the appropriate equipment, regardless of when it was installed.

Where Should Labels be Placed?

The NEC requirement states that the marking must be in a location that is clearly visible to qualified persons before they begin work. Typically, the label is placed outside the panel or enclosure door. In some cases, companies choose to put the label inside the door to protect it from harsh environments. However, this should only be done if the door must be opened (allowing the label to be seen) in order to remove the panel face or enclosure.

The key point is that the label should be easily noticeable by workers before they may be exposed to any potentially dangerous live parts.

How Durable Should Labels Be?

Arc flash labels must be able to withstand their usage environment. This means that the print should not fade and the adhesive should be aggressive enough to avoid peeling. When necessary, an overlaminate should be applied to protect the printed surface from harsh chemicals and exposure to sunlight.

DID YOU KNOW?

The majority of patients with electrical burns were injured while working.[3]

What Label Format Should be Used?

Design and formatting of the labels should conform with the ANSI Z535 Series of Standards For Safety Signs & Tags, according to Article 130.7(E)(1) of NFPA 70E. This format typically includes:

- Header
- Message
- Pictogram (If used. Currently there is not a widely-accepted symbol for indicating an arc flash hazard)

What ANSI Header Should be Used?

Neither the NFPA 70E nor the NEC requirements specify whether to use a "Danger" or "Warning" header. However, NFPA 70E does recommend identifying those situations in which there is a hazard to the worker.

A commonly used guideline is to use a red "Danger" header when the voltage is over 600 volts or when the incident energy is over 40 cals/cm2. Many employers have also standardized to using the "Danger" signal word to indicate a situation where serious injury or death WILL occur. If it is less than that threshold, an orange "Warning" header is used. The employer has the final decision on which words appear on the labels, but it is imperative that consistency be maintained on all the labels throughout the facility.

What Should Appear on an Arc Flash Label?

1. **Nominal System Voltage** A value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g. 120/240 volts, 480/277 volts, 600 volts).

2. **Arc Flash Boundary** The distance at which an electrical arc can flash outward, which may endanger employees working on electrical equipment, where up to 2nd degree burns are likely to occur.

3. **At Least One of the Following**

   a. Available incident energy and the corresponding working distance (An incidental energy analysis is used to help predict the incident energy of an arc flash for a specified set of conditions. Incident energy is the amount of energy impressed on a surface, a certain distance away from the source, generated during an electrical arc event. This should be measured and labeled in cal/cm2). Or the arc flash PPE category in Table 130.7(C)(15)(A) (b) or 130.7(C)(B) for equipment. But not both.

OR

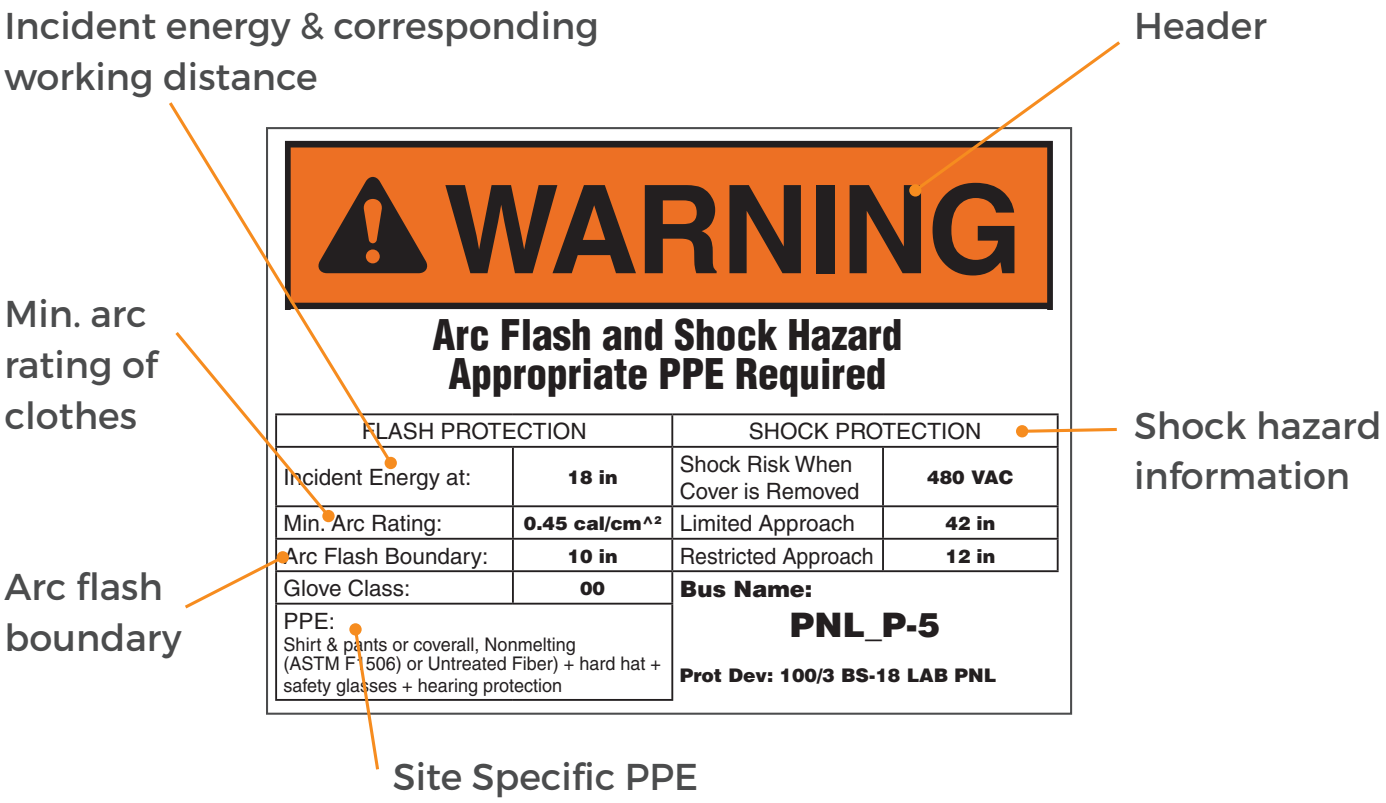
   b. Minimum arc rating of clothing (This also should be expressed in cal/cm2. Arc rated clothing indicates it has been tested for exposure to an electrical arc. This was formally expressed as lame resistant in previous NFPA editions).

OR

   c. Site specific level of PPE.

4. **Additional and Optional Hazard Information** Some safety-conscious employers go one step further by including shock hazard information on the label. After all, as long as you are going through the trouble to warn employees of arc flash hazards, why not provide similar safety guidance for the other electrical hazard – shock? These labels provide complete arc flash hazard information, plus shock hazard information on the applicable voltage, approach boundaries, and insulated glove and tool requirements.

Take a look at the below label example to see what should be included on an arc flash label:



CHAPTER 5

WORKPLACE SOLUTIONS

Workplace Solutions

What are Some Labeling Options?

When it comes to establishing a compliant facility with arc flash labels, there are a number of options to choose from:

- **Pre-Printed Labels:** Pre-printed arc flash labels with the arc flash PPE category and a list of the required PPE, relieving the employer from having to hand-write this information. As with the check box labels, a version for both arc flash and shock hazards is available.
- **On-Demand Label Printing:** Create and print customized arc flash labels when and where you need them with an on-demand label printer. This option avoids the time and trouble associated with handwriting many labels and it allows labels to be printed in batches as the project transitions from one area of the plant to another. It is also a quicker solution compared to selecting, ordering and waiting for pre-printed labels to arrive.

Who Should Perform Arc Flash Risk Assessments?

Completing a best-in-class Arc Flash Risk Assessment in-house requires time, resources and analysis software to accurately calculate arc flash risk. In addition, simple miscalculations can lead to incorrect incident energy levels resulting in the improper use of PPE. Finding an Arc Flash Risk Assessment service performed by a licensed engineer using power system analysis software will enable you to not only reach compliance, but maintain compliance. Addition services also include Arc Flash Audits and Arc Flash Safety Training.

DID YOU KNOW?

34% **of burn patients injured on the job received flash injuries.[3]**

Learn more about arc flash labeling, assessments and products that meet your needs at BradyID.com/arcflash

References:

1 Workplace Safety Awareness Council. (2007). *Common Electrical Hazards in the Workplace Including Arc Flash.* Retrieved 2017, from https://www.osha.gov/dte/grant_materials/fy07/sh-16615-07/electrical_hazards2.ppt

2 Johnson, D. (2013, May 31). *ISHN.com.* Retrieved 2017, from Arc Flash Statistics: http://www.ishn.com/articles/96001-arc-flash-statistics

3 Richard B. Campbell, D. A. (2015). *Occupational Injuries from Electrical Shock and Arc Flash Events.* Fire Protection Research Foundation.

4 inoLECT. (2013). *Arc Flash FAQ.* Retrieved 2017, from inoLECT.com: http://www.inolect.com/images/ArcFlash%20FAQ.pdf

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