



PREDICTIVE SERVICE®

Technical Paper:

Arc Flash Hazard Analysis - What You Should Know to Mitigate Your Risk and Keep Your Employees Safe

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Arc Flash Hazard Analysis – What you should know.

As a company who offers many services supporting the design, installation and maintenance of electrical systems, Predictive Service places the utmost regard in electrical safety. We have strict internal guidelines involving our personnel when engaged in field work around electrical system and energized devices. We share our knowledge and experience with our clients to ensure their employee safety and minimize the risk to their assets and facilities. It is with that knowledge and experience that we believe an Arc Flash Hazard Analysis is required not only to ensure compliance to any applicable code or regulations but as a main component of a quality electrical safety program.

An arc flash occurs as a result of an electrical fault generating an arc that ionizes the air, leading to combustion. The usual causes of electrical hazards can be mechanical (such as accidental touching, dropping of tools or metal parts, or closing into faulted lines and loose connections) or environmental (such as water, dust, impurities and corrosion at contact surfaces, or failure of insulating materials). Arc flash is the most common electrical event in the workplace today and the resulting explosion generates hazards capable of severe injury or death.

National Fire Protection Association (NFPA) NFPA 70E was originally developed at the request of the Occupational Safety and Health Administration (OSHA) as an extension of the National Electric Code (NEC), in order to help OSHA address the inspection of electrical hazards in the workplace and *"provide a practical safe working area for employees relative to the hazards arising from the use of electricity"*.

The 2012 NFPA 70E update provides new information about the effects of arc flash, arc blast, and Data Center hazards, as well as recent developments in electrical design and Personal Protective Equipment (PPE). In order for a work environment to be electrically safe, the energy that workers are exposed to must be minimized while work is being performed.

It is important to understand regulations in OSHA and requirements in NFPA 70E related to working on “live” equipment. OSHA regulations state in 1910.333 that workers should not work on live equipment (greater than 50 volts) except for one of two reasons:

1. De-energizing introduces additional or increased hazards (such as cutting ventilation to a hazardous location)
2. Infeasible due to equipment design or operational limitations (such as when voltage testing is required for diagnostics).

However, when it is necessary to work on equipment “live”, it is necessary to follow safe work practices, which include assessing the risks, wearing adequate personal protection equipment and using the proper tools. The warning label required by the National Electrical Code (NEC) 110.16 (see figure 1 below) reminds personnel regarding this practice. It must also be noted that even when de-energizing the system, performing a voltage test requires proper PPE.

OSHA 29 CFR-1910, Subpart S provides the legal requirement for employers to guard against arc flash hazards. It sets general requirements for safe work practices, PPE, and hazard analysis. OSHA enforces arc flash safety regulations in the United States. Its authority to do so stems from Section 5(a)(1) of the Occupational Health and Safety act, which states that employers "shall furnish to each of his employees employment and a place of employment which are free

from *recognized hazards* that are causing or are likely to cause death or serious physical harm to his employees".

OSHA considers arc flash to be a "recognized hazard" for which appropriate safety standards (most importantly, NFPA 70E) exist. While OSHA does not mandate that employers follow NFPA 70E, failure to do so may result in a citation in the event of an arc flash incident which NFPA 70E compliance could have prevented. In addition, various states have OSHA state plans which mandate compliance with NFPA 70E. OSHA fines for unsafe electrical work can add considerably to the costs of an arc flash incident. *Violations can carry penalties of up to \$250,000 for individuals or \$500,000 for companies.*

Labeling

The only labeling specifically required is identified in NFPA 70. NEC-2005 Article 110.16 identifies the minimum arc flash warning label requirements that must be field installed at time of installation. The article states:

110.16 Flash Protection. Switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers in other than dwelling occupancies, which 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. 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 workers should follow appropriate work practices and wear appropriate personal protection equipment (PPE) for the specific hazard.



Figure 1: Label with Minimum Requirements

To improve safety and worker compliance, additional information can be included on the label including the flash hazard boundary, working distance and required PPE. When additional labeling is included, it must be assured that the information is understood by everyone required to work on the equipment.

Whereas NFPA 70 (NEC) covers the installation of electrical equipment that is assumed de-energized, 70E was developed to cover the maintenance of the equipment where it has traditionally been energized.

This is the reason requirements, such as those in Section 110.16 on the arc flash hazard warning label and Section 110.26(A) on working space, exist in the NEC.

Although the NEC anticipates that the equipment covered in Section 110.16 may be worked on while energized, it may not be, which is why the NEC labeling requirement does not mandate more specific provisions on the requisite level of personal protective equipment (PPE). Article 110.16 points to NFPA 70E for the detailed information on strategies and methods to protect employees. Task-oriented PPE requirements fall within the scope of NFPA 70E. Section 130.3(C) covering the equipment labeling requirement was added to the 2009 edition of NFPA 70E, and that is where you can find detailed information about what equipment labels require to protect employees against the arc flash

hazard. The NEC labeling requirements apply to any electrical equipment installed or modified after 2002.

Arc Flash Hazard Analysis

The labeling program defined in NEC Article 110.16 is a good first step in establishing an electrical safety program. Predictive Service considers this step as the first phase of the overall safety program development. Qualified employees or contractors who will be near or working on these components must be aware of the specific risk and the appropriate level of PPE required.

An Arc Flash Hazard Analysis will properly define the hazard to the employee or contractors in specific terms. NFPA 70E stipulates three shock boundaries and a flash protection boundary that must be known and observed. The shock boundaries are dependent on the system parameters. The standard provides the formulas for this critical information as well as other important information on safe work practices, personal protection equipment and tools to use.

The NFPA 70E – includes several requirements related to arc flash and energized work.

- Appropriate safety-related work practices shall be determined before any person approaches exposed live parts within the Limited Approach Boundary by using both shock hazard analysis and flash hazard analysis.
- A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

- The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed.

Definitions

- *Limited Approach Boundary* - A shock protection boundary not to be crossed by unqualified persons unless escorted by a qualified person.
- *Restricted Approach Boundary* - A shock protection boundary to be crossed by only qualified persons. When crossed the use of shock protection techniques and equipment is required.
- *Prohibited Approach Boundary* - A shock protection boundary only to be crossed by qualified persons. When crossed the same protection is required as if direct contact is made with the live part.
- *Flash Protection Boundary* - Distance at which the incident energy level equals 1.2 cal/cm² for fault clearing time greater than 0.1 seconds. For voltages greater than 1000V, use 1.5 cal/cm² for clearing times that are 0.1 seconds or faster.

Personal protective equipment (PPE) is required to limit workers exposure to incident energy should an incident occur. Incident energy causes burns, which are the major hazard to individuals from an arc flash. As a benchmark, 1.2 cal/cm² is the energy at which a 2nd degree burn will occur. At 3 cal/cm² a light weight cotton shirt may ignite. One layer of flame-retardant material typically provides protection up to 4 cal/cm². Three layers of flame-retardant material typically provide protection up to 25 cal/cm². The PPE should be based on the highest expected incident energy from the calculations.

The NFPA 70E standard provides 5 Arc Rating levels of PPE

- Class 0 for incident energy up to 1.2 cal/cm²
- Class 1 for incident energy up to 4 cal/cm²
- Class 2 for incident energy up to 8 cal/cm²
- Class 3 for incident energy up to 25 cal/cm²
- Class 4 for incident energy up to 40 cal/cm²

Once the incident energy, flash boundary and required PPE are determined, labels can be generated and displayed on each piece of equipment or results can be documented for reference. (See figure 2)

 WARNING		
Arc Flash and Shock Hazard Appropriate PPE Required		
Equipment type	600 V	Switchgear
Grounding	Grounded	
Working distance	18 inches	
Available 3Ph bolted current	20 kA	
Limited approach boundary	42 inches	
Restricted approach boundary	12 inches	
Prohibited approach boundary	1 inches	
Incident energy at work distance	4.85 cal/cm ²	
Flash protection boundary	47 inches	
Hazard Risk Category	2	
Equipment name	PANEL ABC	

Figure 2 – Arc Flash Hazard Warning Label Example

Adequate PPE is also required during the tests to verify the absence of voltage after the circuits are de-energized and properly locked out/tagged out. When used, PPE represents the last line of defense against injury. The protection is not intended to prevent all injuries but to mitigate the impact of an arc flash upon the individual, should an incident occur. In many cases, the use of PPE has saved lives or prevented injury.

It is important to realize that too much PPE can also be a hazard. Workers can be protected for more incident energy that is available but may not be able to perform their intended duties due to heat stress, poor visibility, and limited body movement. At all times, professional judgment must always be used in the selection of adequate PPE.

Following the information contained herein does not guarantee complete safety, and users should take all reasonable, independent steps necessary to minimize risks from arc flashes. If you want more information about further steps in developing a complete electrical safety program or additional information about conducting an arc flash hazard analysis, please contact your Predictive Service representative.