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Feature

How Do I Perform Arc Flash Labeling to Comply with NFPA 70E?

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Many industrials have performed arc flash hazard analysis studies for their facilities. However, when they have tried to implement the field labeling associated with results of the arc flash study, they have met with some varying opinions on what is and is not required. This narrative provides information associated with arc flash labeling. It summarizes both current regulations and NFPA 70E criteria. Additionally, it provides recommendations associated with implementing this guidance within the industrial environment.

As a starter, excerpts from OSHA requirements, NFPA 70 (*NEC),* and NFPA 70E are provided below. The requirements and guidance information will be used as the basis for subsequent discussions.

29CFR1910, SubPart S – Electrical

"§ 1910.303 General Requirements.

(2) Guarding of live parts.
1910.303(2)(iii) states:
(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter."

"§ 1910.335 Safeguards for personnel protection.
(b) Alerting techniques.. The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:

(1) Safety signs and tags. Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by 1910.145.
(2) Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

(3) Attendants. If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees."

NFPA 70, National Electric Code – 2005

Article 110.16 Flash Protection.

Switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies and 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."

Article 110.27 Guarding of Live Parts.

(C) Warning Signs. Entrances to rooms and other guarded locations that contain exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter."

NFPA 70E Table 130.7(C)(10) Protective Clothing and Personal Protective Equipment (PPE) Matrix

Hazard/Risk Category Number	Protective Systems for Hazard/Risk Category					
	-1 (Note 7)	0	1	2	3	4
Protective Clothing & Equipment						
Non-melting (according to ASTM F 1506-00) and Untreated Natural Fiber						
a. T-shirt (short sleeve)	X			X	X	X
b. Shirt (long sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants (long)			X (Note 4) (Note 5) AN	X (Note 6) (Note 7) AN	X (Note 9) X (Note 9) AN	X (Note 5) AN
c. Coverall						
d. Jacket, parka, or rainwear						
FR Protective Equipment (Note 1)						
a. Flash suit jacket (2-layer)						X
b. Flash suit pants (2-layer)						X
c. Head Protection						
1. Hard hat			X	X	X	X
2. FR hard hat liner					AR	AR
d. Eye Protection						
1. Safety Glasses	X	X	X	AL	AL	AL
2. Safety Goggles				AL	AL	AL
e. Face and head area protection						
1. Arc-rated face shield, or flash suit hood				X (Note 8)		
2. Flash suit hood					X	X
3. Hearing protection (ear canal inserts)				X (Note 8)	X	X
f. Hand protection						
Leather gloves (Note 2)			AN	X	X	X
g. Foot protection						
Leather work shoes			AN	X	X	X

Legend:
AN = As needed
AL = Select one in group
AR = As required
X = Minimum required

Notes:
1. See Table 130.7(C)(11). Arc rating for a garment is expressed in cal/cm^2.
2. If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.
3. Hazard/Risk Category "-1" is only defined if determined by Notes 3 or 6 of Table 130.7(C)(9)(a).
4. Regular weight (minimum 12 oz/yd^2 fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. The FR pants used to Hazard/Risk Category 1 shall have a minimum arc rating of 4.
5. Alternate is to use FR coveralls (minimum arc rating of 4) instead of FR shirt and FR pants.
6. If the FR pants have a minimum arc rating of 8, long pants of non-melting or untreated natural fiber are not required beneath the FR pants.
7. Alternate is to use FR coveralls (minimum arc rating of 4) over non-melting or untreated natural fiber pants and T-shirt.
8. A faceshield with a minimum arc rating of 8, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or, alternatively, flash suit hood), is required.
9. Alternate is to use two sets of FR coveralls (the inner with a minimum arc rating of 4 and the outer coverall with a minimum arc rating of 5) over non-melting or untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over non-melting or untreated natural fiber clothing.

Figure 1

NFPA 70E, Standard for Electrical Safety in the Workplace – 2004 Edition

Article 110.6 Training Requirements

(D) Employee Training.

(1) Qualified Person. A qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electric hazards that might be present with respect to that equipment or work method.

(a) Such persons shall also be familiar with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still unqualified for others.

(b) An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direction supervision of a qualified person shall be considered to be a qualified person for the performance of those duties."

Article 130.3 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."

NFPA 70E Table 130.7(C)(11) Protective Clothing Characteristics		
Typical Protective Clothing Systems		
Hazard/Risk Category	Clothing Description (Typical number of clothing layers is given in parentheses)	Minimum Arc Thermal Performance Exposure Value (ATPV)* or Breakopen Threshold Energy (EBT)* Rating of PPE cal/cm^2
0	Non-melting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd^2 (1)	N/A
1	FR shirt and FR pants or FR coverall (1)	4
2	Cotton underwear - convention short sleeve and brief/shorts, plus FR shirt and FR pants (1 or 2)	8
3	Cotton underwear plus FR shirt and FR pants plus FR coverall, or cotton underwear plus two FR coveralls (2 or 3)	25
4	Cotton underwear plus FR shirt and FR pants plus multilayer flash suit (3 or more)	40
Note: Arc rating is defined in Article 100 and can be either ATPV or EBT. ATPV is defined in ASTM F 1959-99 as the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn based on the Stoll curve. EBT is defined in ASTM F 1959-99 as the average of the five highest incident energy exposure values below the Stoll curve where the specimens do not exhibit breakopen. Ebt is reported when ATPV cannot be measured due to FR fabric breakopen.		

Figure 2

Article 130.3(B) Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis. Where it has been determined that work will be performed within the Flash Protection Boundary …., the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from the prospective arc source for the specific task to be performed. Flame-resistant (FR)…

Article 130.7(E) Alerting Techniques.

(1) Safety Signs and Tags. Safety sign, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of ANSI Standard Z535 given in Table 130.7(F).

Discussion

From Article 110.16 of the *NEC*, it is evident that arc-flash labels, or field marking, should be provided any place there is a potential for exposing a worker to energized circuitry greater than 50 volts. This field marking should be provided in accordance with the requirements of ANSI Z535. Supporting requirements are provided in the NEC and OSHA standards associated with providing signage to warn employees about the electrical hazards. These requirements are also parroted within applicable NFPA 70E guidance. What is not specifically stated is what should be on the labels.

There is some guidance within NFPA 70E as to what information should be made available to assist qualified employees in ascertaining electrical hazards. For arc-flash hazards, this guidance includes performing an analysis to determine the Flash Protection Boundary (FPB) and appropriate personal protective equipment (PPE). Also important in selecting PPE is a determination of working distance for the activity to be performed. As one becomes more familiar with dealing with the results of arc-flash analyses, it will become obvious that working distances are very important in selecting PPE. NFPA 70E has provided the following tables (Figure 1 and Figure 2) for use in making PPE decisions. Remember to include review of the information provided in the table notes, including current Tentative Interim Amendments (TIAs), to ensure appropriate application of the tables.

To summarize the discussion so far, the following objectives should be considered while implementing arc-flash labeling in a facility:

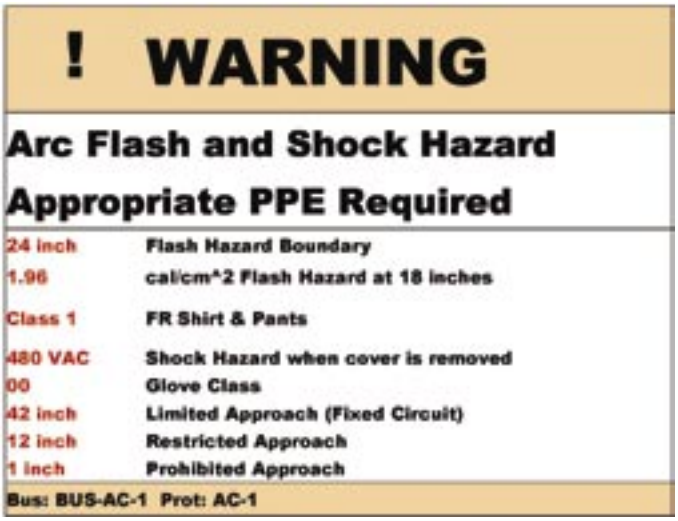
1. Field marking is required to warn employees of arc-flash hazards.
2. Qualified electrical workers should have access to analytical information such as the FPB, working distance, and incident energy so that they can adequately ascertain the level of risk and the appropriate PPE.

Implementation Recommendations

There are many ways to implement the labeling requirements. Some implementation recommendations are provided below for typical options being implemented in industrial environments. All of these recommendations meet the labeling requirements discussed above.

Detailed Arc Flash Labeling On Each Component

One approach is to provide detailed labeling on each component within the electrical infrastructure of a facility where energized circuits may be exposed to workers.



Commercially available software programs for electrical systems are available for performing the hazard analysis and for printing the labels to a file. One advantage to implementing this type of process is that the analytical information associated with the arc–flash hazard is on the label, and, with this detailed information, the qualified personnel can make decisions on how to mitigate the hazard. A disadvantage is that the development of the analytical model required for performing this effort can be costly, and, with an infrastructure change, the labels may need to be replaced.

Generic Arc Flash Labeling On Each Component

Another approach is to provide generic labeling on each component within the electrical infrastructure of a facility where energized circuits may be exposed to workers.

The advantage to implementing this type of process is that with any infrastructure change, the label need not be replaced. The disadvantage is that the analytical information associated with arc-flash hazard that is required for qualified personnel to make decisions about the hazard is not readily available within the label: therefore, another mechanism for providing that information to the worker will be required. Some industrial facilities have procedurally resolved this issue by requiring an energized work permit which requires that the information be provided within the permit. Others have prepared task assessment sheets for each electrical distribution panel and posted them on or near the panels. With either an energized work permit or the task assessment sheets, the needed information is provided for the worker to assist them in selecting appropriate PPE. This application of work task assessment sheets for each panel may also delineate different PPE requirements, similar to Tables 130.7(C)(9)(a) of NFPA 70E, for different work tasks on the panels.

Detailed and Generic Arc Flash Labeling Components

The approach which seems to be implemented most of the time is to provide generic labeling for components having a Hazard Risk Category (HRC) of "0" and detailed labeling for components having a HRC of "1" or greater. With this approach, labeling is provided for each component within the electrical infrastructure for a facility where energized circuits may be exposed to workers. The analytical information associated with the arc-flash hazard for most conditions is readily available within the label. A disadvantage to this approach is that with some infrastructure changes some of the labels may still need to be replaced.

With each implementation recommendation above, there should also be a program of electrical safety training with specific emphasis on identifying and mitigating the arc-flash hazard. Additionally, other guidance within NFPA 70E includes recommendations associated with the use of job briefings, planning, and energized work permits. The use of prepared task assessment sheets, as discussed above, should also be considered for each electrical distribution panel. All of these activities should be performed to control, mitigate, or remove the potential effects of electrical hazards in the workplace.

As Operations Manager of ESCO Energy Services Company, Lynn brings over 25 years of working knowledge in design, permitting, construction, and startup of mechanical, electrical, and instrumentation and controls projects as well as experience in the operation and maintenance of facilities.Lynn is a Professional Engineer, Certified Energy Manager and has a BS in Nuclear Engineering from the University of Tennessee.