Arc Flash Warning Labels Booklet

Risk Management

Revised June 2016

ACWA JPIA
YOUR BEST PROTECTION

This booklet is designed to be used by a *"qualified"* person only.

For the purposes of this booklet, a *"qualified"* person is defined as either a qualified electrician or individual possessing a recognized engineering degree; having the knowledge, training, and experience to successfully demonstrate the ability to solve or resolve problems relating to the subject matter.

IMPORTANT NOTICE

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Arc Flash Warning Labels

NFPA 70E

Arc flash, a type of electrical explosion, is one of the most complex workplace risks that exist. It is often described using technical terminology and acronyms. Also, several basic concepts and definitions are key to understanding how arc flash hazards are measured and how this information can be used to help protect personnel. Below are the most important ones with simple explanation.

Incident Energy Exposure

This is the amount of thermal incident energy to which the worker's face and chest could be exposed at working distance during an electrical arc event. Incident energy is measured in joules per centimeter squared (J/cm^2) or calories per centimeter squared (cal/cm^2). *Minimum reported incident energy is 0.25 cal/cm2 which is the accuracy limit of the test equipment.*

Incident Energy at Arc Flash Boundary

A value in cal/cm^2 to determine arc flash boundary (AFB) distance at that Incident Energy. The Incident Energy of 1.2 cal/cm^2 for **bare skin** is used in solving equation for arc flash boundary in IEEE 1584 *Guide for Performing Arc Flash Hazard Calculations*. However, the Guide equation for arc flash boundary can be solved with other incident energy levels as well such as the rating of proposed personal protective equipment (PPE). The Incident Energy at Arc Flash Boundary value should be equal or above incident energy to second degree burn for bare skin exposure.

Arc Flash Boundary

The arc flash boundary is an approach limit at a distance from exposed live parts or enclosed live parts if operation, manipulation, or testing of equipment creates a potential flash hazard, within which a person could receive a second degree burn if an electrical **arc flash** were to occur. A worker entering the arc flash boundary must be qualified and must be wearing appropriate PPE. The arc flash boundary is required to be calculated by NFPA 70E.

Hazard Level

This is the minimum level of Personal Protective Equipment in calories per centimeter squared, as evaluated in IEEE Standard 1584, with the intent to protect the worker from the thermal effects of the *arc flash* at working distance from the source of the arc.

Revised June 2016

Arc Flash Warning Labels

NFPA 70E

Min Incident Energy, cal/cm^2	Max Incident Energy, cal/cm^2	Hazard Level	Required Min Rating of PPE, cal/cm^2
Eb + 0.001	**4**	**1**	**4**
4.001	**8**	**2**	**8**
8.001	**25**	**3**	**25**
25.001	**40**	**4**	**40**
40.001	**and above**	**Consult**	**Not Available**

Recommended Personal Protective Equipment (PPE)

Hazard Level	Personal Protective Equipment (PPE)
1	Arc rated (AR) shirt and AR pants or AR coverall, AR face shield, AR jacket, safety glasses, hard hat, ear canal inserts, heavy duty leather gloves, leather footwear.
2	Arc rated (AR) shirt and AR pants or AR coverall, AR flash suit hood, AR jacket, safety glasses, hard hat, ear canal inserts, heavy duty leather gloves, leather footwear.
3	Arc rated (AR) coverall over AR shirt and AR pants, AR flash suit, AR hood, safety glasses, hard hat, ear canal inserts, AR gloves, leather footwear.
4	Multi-layer arc rated (AR) flash suit over AR coverall over AR shirt and AR pants, AR flash suit hood, safety glasses, hard hat, ear canal inserts, AR gloves, leather work shoes.

Arc Flash Warning Labels

NFPA 70E

Equipment Class

Classes of equipment included in IEEE 1584 and typical bus gaps are shown in table below:

Classes of equipment	Typical bus gaps, mm
Open Air	10 - 40
Low-voltage switchgear	32
15kV switchgear	152
5kV switchgear	104
Low-voltage MCCs and panel boards	25
Cable	13

Gap between Conductors

Equipment bus gap in mm. Gaps of 3 to 40 mm were used for low voltage testing to simulate gaps between conductors in low voltage equipment and cables. Gaps 13, 104 and 152 mm. were used in 5 and 15kV equipment testing. For cases where gap is outside the range of the Empirical model, the theoretically derived Lee method can be applied and it is now included in ARCAD's arc flash assessment software.

Grounding Type

Two grounding classes are applied in the IEEE 1584 procedure, as follows:
a) Ungrounded, which included ungrounded, high-resistance grounding and low-resistance grounding.
b) Solidly grounded.

Working Distance

Typical working distance is the sum of the distance between the worker standing in front of the equipment, and from the front of the equipment to the potential arc source inside the equipment. Arc-flash protection is always based on the incident energy level on the person's face and body at the working distance not the incident energy on the hands or arms. The degree of injury in a burn depends on the percentage of a person's skin that is burned. The head and body are a large percentage of total skin surface area and injury to these areas is much more life threatening than burns on the extremities. Typical working distances are shown in the following table.

Arc Flash Warning Labels

NFPA 70E

Classes of equipment	Typical working distance, mm
Low-voltage switchgear	610
15kV / 5kV switchgear	910
Low-voltage MCCs and panel boards	455
Cable	455

Arc Duration / Total Clearing Time

Use protective device characteristics, which can be found in manufacturer's data. For fuses, the manufacturer's time current curves may include both melting and clearing time. If so, use the clearing time. If they show only the average melt time, add to that time 15%, up to 0.03 seconds, and 10% above 0.03 seconds to determine total clearing time. If the arcing fault current is above the total clearing time at the bottom of the curve (0.01 seconds), use 0.01 seconds for the time.

For circuit breakers with integral trip units, the manufacturer's time-current curves include both tripping time and clearing time.

For relay operated circuit breakers, the relay curves show only the relay operating time in the time-delay region. For relays operating in their instantaneous region, allow 16 milliseconds on 60 Hz systems for operation. The circuit breaker opening time must be added. Opening times for particular circuit breakers can be verified by consulting the manufacturer's literature.

Available 3 Phase Bolted Fault Current

Available 3 phase bolted fault current for the range of 700A to 106kA at the point where work is to be performed is entered into this box in kA.

Effect of arc current variation on determination of clearing time

For protective devices operating in the steep portion of their time-current curves, a small change in current causes a big change in operating time. Incident energy is linear with time, so arc current variation may have a big effect on incident energy. The solution is to make two arc current and energy calculations; one using the calculated expected arc current and one using a reduced arc current that is 15 percent lower.

Arc Flash Warning Labels

NFPA 70E

Are your Arc Flash Labels Compliant with NFPA 70E – 2015?

NFPA 70E – Standard for Electrical Safety in the Workplace has been revised and the requirements in this document are being enforced by OSHA. The requirements for selection of Personal Protective Equipment (PPE) and Arc Flash labels have changed.

For many years, Arc Rated Clothing Manufacturers used the Hazard Risk Categories (HRC) from the PPE Matrix table 130.7(C) (16). This allowed the user to select, and manufacturers to produce, Arc Rated (AR) garments in ranges that matched the hazard risk categories. This was an easy to understand approach that seemed to adequately protect the workers. However, it was not technically correct. The PPE Matrix table 130.7(C) (16) was originally conceived to be used and applied only when using the Task that the electrician is performing. The table is based upon the hazard and the perceived risk.

The flow chart below shows the path on the left using this Task Method. Table 130.7(C) (15) (A) (a) list various tasks that an electrician might perform. Then, based upon the task they are performing and the condition of the equipment, the user determines if there is an arc flash hazard. If there is an arc flash hazard, then the user must go to table 130.7(C) (15) (A) (b) and look up the type and voltage of the equipment they will be working on. If the available short circuit current and upstream protective device clearing times are less than the table parameters, then the user can proceed and use the table to determine the Arc Flash PPE Category. Once the Arc Flash PPE Category is known, then the PPE Matrix Table 130.7(C) (16) is used to determine the minimum energy level of the Arc Rated clothing and additional PPE.

The other assessment method involves using the IEEE 1584 equations and calculating the Arc Flash energy and arc flash boundary. Then, the user uses a different PPE Matrix table H.3 (b) to determine the required PPE.

Arc Flash Warning Labels

NFPA 70E

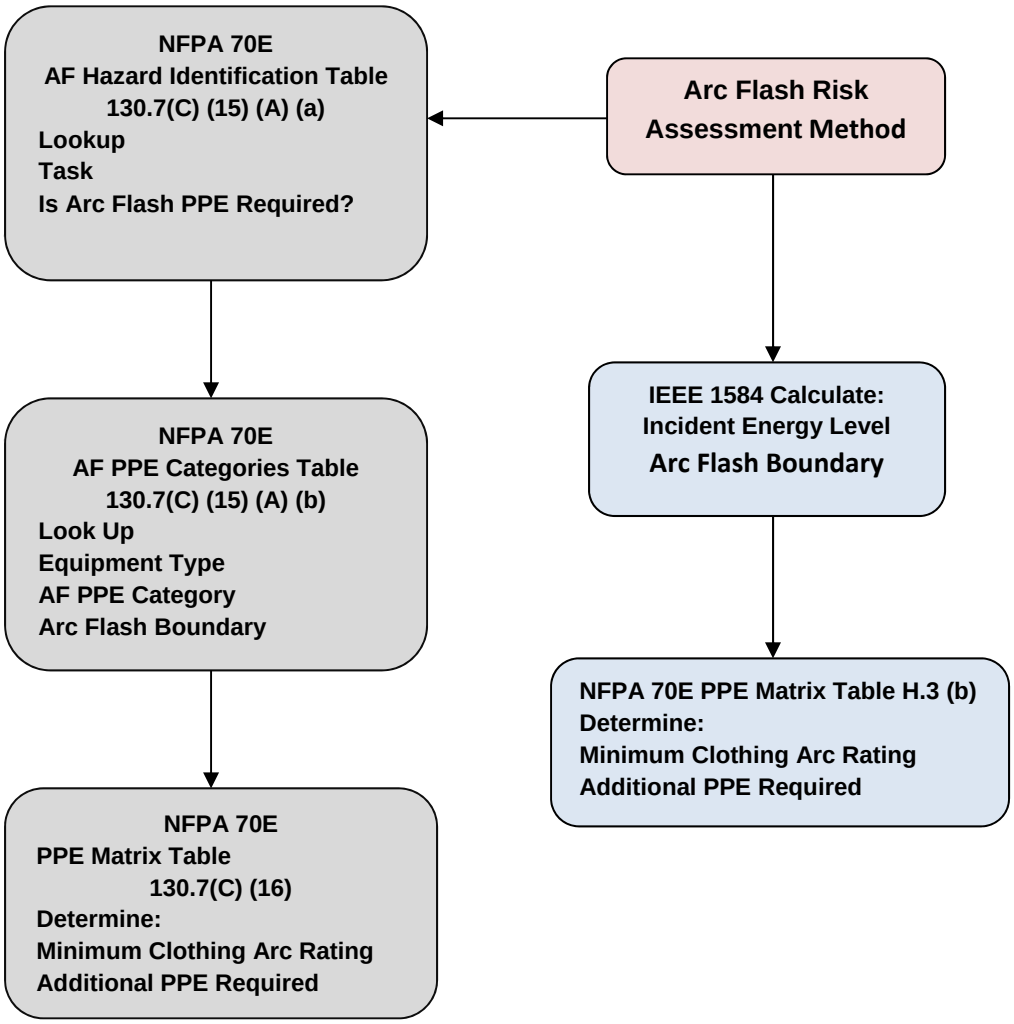

Figure 1 - Arc Flash Hazard Analysis Methods

The Standard Section 130.5 (C) for selecting Arc Flash PPE states the following:

One of the following methods shall be used for the selection of PPE. Either, **but not both, methods** shall be permitted to be used on the same piece of equipment. The results of an incident energy analysis to specify an arc flash PPE Category in Table 130.7(C) (16) shall not be permitted.

(1) Incident Energy Analysis Method. 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. Arc-rated clothing and other PPE shall be used by the

employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the distance at which the incident energy was determined. Informational Note: For information on estimating the incident energy, see Informative Annex D. For information on selection of arc-rated clothing and other PPE, see Table H.3 (b) in Informative Annex H.

(2) Arc Flash PPE Categories Method. The requirements of 130.7(C) (15) and 130.7(C) (16) shall apply when the arc flash PPE category method is used for the selection of arc flash PPE.

The majority of facilities are electing to use the IEEE 1584 Arc Flash Hazard Analysis due to the short circuit and clearing time limits of Table 130.7(C) (15) (A) (b). This method has proven to be more accurate and wider application range.

What you put on the label depends upon the method that you used. Other information is also required and is listed below. An example of best practices Arc Flash Label is shown below. Note the absence of the HRC number because the IEEE 1584 method has been used.

Section 130.5 (D) lists the items that should be shown on the Arc Flash labels.

Equipment Labeling

Electrical equipment such as switchboards, panel boards, 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 field-marked with a label containing all 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)(b) 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

Arc Flash Warning Labels

NFPA 70E

Figure 2 – NFPA 70E – 2015 Compliant Arc Flash Label

Instructions

1. Open an online arc flash calculator.
   http://www.easypower.com/arc_flash/arc_flash_calculator.php

2. Choose the type of equipment you are using from the drop down box labeled "Equipment Type" or choose from the drop down box labeled "Equipment Class." The terms may vary depending on the calculator, but the first option will always ask you to choose the type of equipment you're working with.

3. Choose the correct values for the choices given, such as "Bolted Fault" and "Clearing Time." Depending on the type calculator you are using, you may be given drop down, sliders or blank boxes to use for inputting additional information. Certain calculators offer more choices than others, depending on how complex you want your calculations to be.

4. Click the "Calculate" or "Calculate Arc Flash" button once you have filled out all the requested information. Your results will be displayed either above or below the calculator. It will give information about the arc flash itself, and possibly recommend the type of safety gear needed for the given situation.

Live Electrical Work Permit

Work Request (To be completed by the **person requesting the review.)**			
Work site location: (Building & room number)		Work order/project no.:	
Planned **start** date/time:		Planned **end** date/time:	
Description of the work to be performed:			
Equipment requested to be shut down: (specify how long)			
	☐Until work is complete ☐Temporarily, while barriers are being placed		
Requested by:	Signature:	Title:	Date:

Hazard Analysis (To be completed by the **Electrically Qualified Persons doing the work**.)		
Arc Flash Approach Boundaries:	Determined by: __ Labels __ NFPA 70E Tables __Voltage	
Arc Flash approach boundary-	_____ft _____in	
Limited approach boundary-	_____ft _____in ☐Work will be conducted within this boundary.	
Restricted approach boundary-	_____ft _____in ☐Work will be conducted within this boundary.	
System / Equipment Voltage	☐120 ☐ 240 ☐ 480 ☐ 600 ☐ _____	
Hazard/risk category for the task:	☐**1** ☐**2** ☐**3** ☐**4**	
ATPV rating (in cal/cm^2) for FR clothing:	☐**4 (Cat 1)** ☐**8 (Cat 2)** ☐**25 (Cat 3)** ☐**40 (Cat 4)**	
Additional personal protective equipment (PPE) required for each Hazard/risk (Category is listed on back.)		
Means employed to restrict the access of unqualified persons from the work area:	☐Signs/tags ☐Barricades ☐Attendants	
Has a documented job briefing with detailed procedures been conducted?	☐Yes, see attached ☐No	
Do you agree that the work described above can be done safely? (signatures required from two trained persons - *minimum*).	Electrically Qualified Person(s) 1) 2) 3) 4)	Date
Justification for the live work request:	☐Shut down creates an increased/additional hazard (specify): _____ _____ _____ ☐Shut down is infeasible due to design or operational limitations (specify): _____ _____ _____	
The next available date for shutdown is:		
Request for energized electrical work:	Electrical qualified person:	Date:

Proposed Energized Electrical Work Permit Review (To be completed by **Management**.)		
Proposed energized electrical work has been reviewed and approved by:	Supervisor:	Date:
	Safety Representative:	Date:
	General Manager:	Date: