

## **2012 NFPA 70E:** *Electrical Safety In The Workplace*

This easy-to-use Leader's Guide is provided to assist in conducting a successful presentation. Featured are:

**INTRODUCTION:** A brief description of the program and the subject that it addresses.

**PROGRAM OUTLINE:** Summarizes the program content. If the program outline is discussed before the video is presented, the entire program will be more meaningful and successful.

**PREPARING FOR AND CONDUCTING THE PRESENTATION:** These sections will help you set up the training environment, help you relate the program to site-specific incidents, and provide program objectives for focusing your presentation.

**REVIEW QUESTIONS AND ANSWERS:** Questions may be copied and given to participants to document how well they understood the information that was presented. Answers to the review questions are provided separately.

### **INTRODUCTION**

The National Fire Protection Association, NFPA, is the leading authority on electrical safety, especially in relation to protecting electrical workers from burn injuries associated with arc blasts. The most recent 2012 NFPA 70E standard has many changes and updates as compared to the outdated 2009 edition. In this program, the dual hazards of electric shock and arc flash are clearly explained and highlighted with dramatic arc flash footage, full-scale explosions and realistic reenactments of flammable clothing ignition due to arc flash incidents. While convincing your workers of the importance of wearing proper PPE, the video also explains the critical parts of the 2012 70E standard in detail.

Topics include qualified electrical worker requirements, creating an electrically safe working condition, confirming a zero energy state, energized electrical work permits, approach boundaries, incident energy level, arc flash boundaries, hazard risk categories and how to properly dress for arc flash protection.

### **PROGRAM OUTLINE**

#### **QUALIFIED ELECTRICAL WORKERS & THE NFPA 70E**

- Qualified electrical workers—these highly valued employees and contractors have the skills, the training and the knowledge to construct, to service and to operate a wide variety of electrical systems and equipment.
- Qualified electrical workers not only know how to make various electrical systems work properly, they also know how to perform their jobs safely.
- For electrical workers to work safely, they must be able to recognize and avoid the hazards posed by the job task and equipment on which they are working.
- Unfortunately, working safely isn't always the case. Many electrical workers are killed or injured each year. Many are unqualified for the task they are attempting to perform, while others simply choose to ignore the safe electrical work practices they have been trained to follow.
- In either case, the result can be serious injury or death from electric shock, severe burns or both. To prevent these types of incidents, electrical workers must understand and follow up-to-date electrical safe work practices and procedures.
- These safe work practices are maintained and published by the National Fire Protection Association, the NFPA, in their document number 70E.

#### **2012 NFPA 70E QUALIFIED PERSON REQUIREMENTS**

- It's important to understand that NFPA 70E uses several strategies to facilitate worker safety starting with the requirement that workers be properly qualified for the work being performed.

- The 2012 definition of a qualified person is as follows: "A qualified person is one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved."
- Electrical workers who meet this definition of a "qualified electrical worker" will be able to determine the nominal voltage for the equipment or system; determine the required approach distances for electrical shock and burn hazards; distinguish exposed energized conductors and circuits from other parts of the equipment; and properly select, care for and use the appropriate personal protective equipment for both shock protection and arc flash protection.
- Being properly qualified is just one on the NFPA's safe work strategies. Other safe work requirements include performing work under an electrically safe work condition whenever it is feasible to do so, and when creating an electrically safe work condition is not feasible, following prescribed safe work practices.
- These work practices may include restricting access with barricades and signs, establishing various approach boundaries, requiring specific protective equipment for electric shock and arc flash hazards and job planning requirements, which include hazard analysis, job safety briefings and the use of energized work permits.

### **ARC FLASH HAZARDS**

- Qualified workers must be able to "recognize and avoid the hazards involved." This requires that electrical workers understand that there are two main hazards presented by energized electrical equipment:
- The first hazard is direct contact with or coming too close to exposed live parts that can lead to an electric shock.
- The second hazard is exposure to the sudden, violent release of energy associated with an electric arc, which is commonly called an arc flash.
- The 2012 NFPA states that an arc flash hazard may exist when "energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or closed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc."
- This means an arc flash hazard exists anytime energized parts are exposed or any time people interact with equipment in a way that could cause an arc flash even if the equipment's covers are on or its doors are properly closed.
- Some examples of common tasks which are considered arc flash hazards include racking out a circuit breaker or operating an electrical disconnect switch. Because of the existence of this hazard, workers who perform these types of tasks must be "qualified" to do so; by definition, these workers must be able to recognize and avoid this hazard.
- While this doesn't mean that anybody who opens or closes a switch or resets a tripped circuit breaker must be a fully-trained qualified electrician, it does mean that workers must be "Task Qualified," meaning that they are qualified with respect to specific equipment and work methods but remain unqualified for other electrical-related tasks.

### **CREATING AN ELECTRICALLY SAFE WORKING CONDITION**

- The most effective way to prevent any type of injury related to electrical hazards is creating an electrically safe working condition. Creating an electrically safe working condition must always be the first choice for electrical workers.
- The NFPA's definition of an electrically safe work condition is "a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked and tagged in accordance to established standards, tested to ensure the absence of voltage and grounded if determined necessary."

- To create an electrically safe work condition, first determine all possible sources of electrical supply to the equipment.
- Next, disconnect any active loads then open the disconnecting device for each source.
- Visually verify, if possible, that all blades of disconnecting devices are fully open or that draw-out type circuit breakers are withdrawn to the fully disconnected position.
- Then, apply company approved locks and tags to the open disconnecting devices in accordance with your facility's lockout/tagout procedures.
- Finally, the most important part is testing to verify that no voltage exists and grounding when necessary.

### **CONFIRMING A ZERO ENERGY STATE**

- Testing for a zero energy state must be done using a "known working voltmeter." This is why you must verify that your voltmeter is functioning properly by measuring a known voltage source immediately prior to voltage testing.
- To confirm a zero energy state, test each phase conductor or circuit part both phase to ground and to phase, for all phases.
- Then, test your meter again on a known voltage source. Be aware that some meters have a self-testing feature; however, using this feature is not an approved method for verifying a working voltmeter.
- Testing your meter before and after voltage testing ensures that a broken meter won't incorrectly verify a zero energy state.
- Of course, make sure your meter is rated for the voltage and class of equipment you are testing. Exceeding a meter's rated voltage or class can lead to a serious incident.
- Remember that until you have verified the existence of an electrically safe working condition, the equipment must be considered energized. This means that all electrical safe work practices must be followed, including establishing approach boundaries, using appropriate insulated tools as well as donning voltage rated shock protection and appropriate arc flash protection.
- However, once an electrically safe work condition is created, no electrical hazards exist. This means that shock and arc flash protection are no longer necessary and may be removed.
- This also means that other workers who are not qualified electrical workers may enter the area as needed.

### **INSTANCES WHEN ENERGIZED WORK IS PERMITTED**

- Creating an electrically safe working condition is always the preferred method to ensure your safety. In fact, the NFPA 70E requires that an electrically safe work condition be created unless it is not feasible to do so.
- Just remember that "not feasible" is not the same thing as "not convenient." The regulation allows energized work to be performed under limited conditions.
- Energized work is permitted when it can be demonstrated that de-energizing introduces additional or increased hazards. Some examples include life support equipment, emergency alarm systems or hazardous location ventilation equipment.
- Energized work is permitted when it can be demonstrated that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

- Energized work is permitted on electrical conductors and circuit parts which operate at less than 50 volts and it is determined that there is no increased exposure to electric burns or arcs.
- When these conditions are met, working on energized conductors or circuit parts is permitted; however, with limited exceptions, this energized repair work shall only be done with an approved, written energized electrical work permit.

### **ENERGIZED ELECTRICAL WORK PERMITS**

- A change made to the 2012 NFPA 70E requires an energized electrical work permit when working within the limited approach boundary or the arc flash boundary of exposed energized electrical conductors or circuit parts that are not placed in an electrically safe work condition.
- The purpose of the energized electrical work permit is to ensure that all hazards are considered and all precautions taken before work is performed on energized parts.
- The energized work permit will include but is not limited to the following information:  
A description of the circuit and equipment to be worked on as well as their location;  
Justification for why the work must be performed in an energized condition;  
A description of the safe work practices to be employed;  
The results of a shock hazard analysis which includes the voltage to which workers will be exposed and a description of required shock protection equipment and approach boundaries;  
The results of an arc flash hazard analysis which includes a description of required arc flash protective clothing and equipment as well as the arc flash boundary;  
The means used to restrict the access of unqualified persons from the work area;  
Evidence of the completion of a job briefing which includes any job-specific hazards;  
And finally, the signature of authorized members of management approving the work to be performed while energized. This approval process must include an electrically knowledgeable person.
- There are specific exceptions to the requirement for an energized electrical work permit. They are visual inspections (if the restricted approach boundary is not crossed), testing, circuit identification and troubleshooting.

### **APPROACH BOUNDARIES**

- One tried and true method to avoid being shocked is to stay a safe distance from energized conductors or parts.
- In keeping with this safety principle, NFPA 70E establishes three approach boundaries: the Limited Approach Boundary, the Restricted Approach Boundary and the Prohibited Approach Boundary. The distance from an energized part to each of these boundaries increases as voltage increases.
- Before crossing these boundaries and moving closer and closer to exposed energized parts, workers need increasing levels of qualifications, protective equipment and permits.
- These boundary distances are listed in NFPA Table 130.4 (C)(a) for alternating current or AC systems and 130.4(C)(b) for direct current or DC systems. Qualified electrical workers must be able to determine these distances for the equipment on which they work.

#### **Limited Approach Boundaries**

- The boundary farthest away from the energized part is the Limited Approach Boundary.
- This Limited Approach Boundary is established as the minimum control boundary to keep unqualified persons a safe distance from exposed live parts.
- Without a marked boundary, an unqualified co-worker could accidentally come in contact with live parts.

- Unqualified persons may not cross the Limited Approach Boundary unless briefed on the hazards and escorted by a qualified person.
- In addition, only insulated tools may be carried or used inside the Limited Approach Boundary.

### **Restricted Approach Boundaries**

- Moving closer to energized parts and crossing the "Restricted Approach Boundary" requires you to be a qualified person and have a work plan. You must use only insulated tools, and you must wear all required protective equipment including rubber insulating gloves.
- When using rubber insulated gloves, always wear leather protectors to avoid damaging the glove and to provide thermal protection in the event of an arc flash.
- Failing to wear gloves, even around control wiring, leads to fatal electrocutions each year. Wearing gloves is one of the most effective things you can do to prevent being shocked. Make it a habit.

### **Prohibited Approach Boundaries**

- The closest and final boundary is the "Prohibited Approach Boundary". Crossing this boundary is the equivalent of performing "live work" and all applicable safety practices must be followed.

### **THE INCIDENT ENERGY LEVEL & THE ARC FLASH BOUNDARY**

- An arc flash is a violent eruption of energy from an electrical source. An arc flash is often caused by the introduction of conductive material such as a tool or test lead, leading to a flashover.
- The amount of heat energy available to burn you during an arc flash is called the "Incident Energy Level." Incident energy is measured in calories per centimeter squared. The amount of heat energy that will cause a second degree burn on unprotected skin is 1.2 calories per centimeter squared.
- The Arc Flash Boundary is established at the distance from a potential arc source at which the Incident Energy Level is determined to be 1.2 calories per centimeter squared. In other words, the Arc Flash Boundary is the distance from an arc source where an unprotected worker will receive a second-degree burn.
- The incident energy of an arc flash depends on how much current is available, how quickly that current can be shut off and how far away a worker is from the arc source.
- Various methods for calculating incident energy and the Arc Flash Boundary are illustrated in NFPA 70E Annex D.
- To make it easier for workers to determine an appropriate Arc Flash Boundary, the 2012 edition of the NFPA 70E has included an Arc Flash Boundary for common types of electrical equipment and systems. This information is contained in Table 130.7(c)(15)(a) for AC systems and Table 130.7 (C)(15)(b) for DC systems.
- Before using this information you must ensure that your equipment and system specifications match those listed in the table. If they do not, an appropriate arc flash analysis must be performed to determine the arc flash boundary.
- Listing Arc Flash Boundaries in table 130.7(C)(15) is a major revision to the 2012 NFPA and replaces the "Default" Arc Flash Protection Boundary of four feet which was defined by prior editions of the NFPA for conforming electrical systems.
- In most instances, the Arc Flash Boundary is the outermost of all approach boundaries and should be marked with barricading and hazard signage. A simple system which can be used to meet this requirement is using red "Danger—High Voltage" barricade tape which includes the proper signage.

## **ARC-RATED CLOTHING & PPE**

- Arc-rated clothing is designed to withstand both the intense heat and force of an arc blast without breaking open or bursting into flames.
- Clothing that is not arc-rated, such as 100 percent cotton or wool, can burst into flames and continue to burn even after the arc is extinguished.
- When unprotected workers cross the Arc Flash Protection boundary without arc-rated clothing and protective clothing, they place themselves at risk of serious burn injury.
- Because burn patient survival is largely dependent on the percentage of body burned, preventing your clothing from igniting during an arc flash is often the difference between life and death.
- Remember that the Incident Energy Level of an arc flash is measured in calories per centimeter squared. The effectiveness of arc-rated clothing and equipment is also measured in calories per centimeter squared. To provide an appropriate level of protection, arc-rated clothing and protective equipment is selected to meet or exceed the Incident Energy Level of a potential arc flash.
- A change to the 2012 NFPA 70E requires equipment be field labeled with the Nominal System Voltage, the Arc Flash Boundary and at least one of the following items: available incident energy and corresponding working distance, minimum arc rating of clothing, required level of PPE or the highest Hazard Risk Category (HRC) for the equipment.
- Having this critical information readily available makes the selection of proper arc-rated PPE easier for electrical workers.
- The NFPA has established Hazard Risk Categories. Each Hazard Risk category requires a specific level of arc flash protection, measured in calories per centimeter squared, as well as other protective equipment.
- The NFPA has determined the Hazard Risk Category for common electrical tasks and listed them in The required arc-rated clothing and other PPE for each Hazard Risk Category can be found in table 130.7(C)(15)(a) and (b).
- Some common PPE elements in this table are hearing protection, leather gloves and a hard hat.
- When hearing protection is required, it should be an ear canal insert.
- When a hard hat is required it is to be a dielectric hard hat. Typically, a Class E hardhat rated for electrical work up to 20,000 volts is used.
- When leather gloves are required, they shall be at least .7 millimeters thick or arc-rated. If rubber insulating gloves are to be worn, the combination of rubber glove and leather protector meets the requirement for a leather glove.

## **THE FIVE HAZARD RISK CATEGORIES**

- Category Zero is the only hazard risk category where non-melting natural fiber clothing such as 100 percent cotton or wool is allowed. This clothing must be long sleeves and long pants.
- Other PPE required includes safety glasses, hearing protection and leather gloves.
- Hazard Risk Category One requires arc-rated clothing of four calories per centimeter squared, a hard hat and an arc-rated face shield or flash suit hood. Also required are safety glasses, hearing protection and leather gloves.

- Job tasks rated as Hazard Risk Category Two require eight calories per centimeter squared of arc flash protection and an arc-rated face shield combined with an arc-rated balaclava or an arc-rated flash suit hood.
- Flash suit hoods must contain a rated dielectric hard hat. Also required are a hard hat, safety glasses, hearing protection, leather gloves and leather work shoes.
- It's important to note that requiring an arc-rated face shield with arc-rated balaclava or an arc-rated flash suit hood for all Category Two tasks is a major change for the 2012 NFPA 70E. This change eliminated the hazard risk category of Category Two\* (asterisk) found in the outdated 2009 regulation.
- Hazard Risk Category Three requires a minimum of 25 calorie per centimeter squared arc-rated protection.
- Hazard Risk Category Four requires a minimum of 40 calories per centimeter squared arc-rated protection.
- These categories also require an arc-rated flash suit hood a hard hat, safety glasses, hearing protection, leather work shoes and leather gloves.
- For ease of PPE selection and cost savings many facilities only use Category Two or Category Four PPE. At these facilities, electrical workers dress in Category Two as standard work practice, then add a Category Four flash suit and hood for any task that exceeds Category Two.

#### **HOW TO DRESS FOR ARC FLASH PROTECTION**

- You may dress in layers of arc-rated material if the rated protection for the layering meets the requirements of the task being performed.
- Consult NFPA 70E Annex M for the proper way to choose systems with the total calories of protection you need when layering. You need to understand that non-arc-rated material, even 100 percent cotton, cannot be counted towards your total level of protection.
- Your outermost layer must be made of arc-rated material. Your under layers should also be made of arc-rated material or 100 percent natural fibers like cotton or wool.
- If non arc-rated under layers are used, be extra careful that your outer layers are completely closed so flammable under layers are not exposed to an arc blast.
- Also, do not wear any conductive material such as rings, watches, metal-frame eye wear or other metal jewelry. These items are not only shock hazards but can cause serious burn injury when super-heated by an arc flash or direct contact with electricity.

## **PREPARE FOR THE SAFETY MEETING**

Review each section of this Leader's Guide as well as the DVD or digital media. Here are a few suggestions for using the program:

Make everyone aware of the importance the company places on health and safety and how each person must be an active member of the safety team.

Introduce the program and then play it without interruption. Review the program content by presenting the information in the program outline.

### **Here are some suggestions for preparing your video equipment and the room or area you use:**

Check the room or area for quietness, adequate ventilation and temperature, lighting and unobstructed access.

Check the seating arrangement and the audiovisual equipment to ensure that all participants will be able to see and hear the program.

## **CONDUCTING THE PRESENTATION**

Begin the meeting by welcoming the participants. Introduce yourself and give each person the opportunity to become acquainted if there are new people joining the training session.

Explain that the primary purpose of the program is explain the critical parts of the 2012 NFPA 70E standard while stressing the importance of wearing the proper clothing and personal protective equipment.

Introduce the program. Play it without interruption. Review the program content by presenting the information in the program outline.

Lead discussions about specific situations and job tasks at your facility where 2012 NFPA 70E guidelines apply and what clothing and PPE are required to avoid arc flash injuries.

After watching the program, the viewer will be able to explain the following:

- How an electrically safe working condition is created;
- When energized work is permitted and when a energized electrical work permit is required;
- What Limited, Restricted and Prohibited Approach Boundaries are;
- How Incident Energy Levels and Arc Flash Boundaries are calculated;
- What protection is required from the five Hazard Risk Categories;
- How to properly dress for protection from arc flashes.



**2012 NFPA 70E:**  
***Electrical Safety In The Workplace***  
***REVIEW QUIZ***

Name \_\_\_\_\_ Date \_\_\_\_\_

*The following quiz is provided to check how well you understand the information presented during this program.*

1. Creating an electrically safe work condition is the most effective way to prevent any type of injury related to electrical hazards.
  - a. true
  - b. false
  
2. Which boundary is located farthest away from energized parts?
  - a. the Limited Approach Boundary
  - b. the Restricted Approach Boundary
  - c. the Prohibited Approach Boundary
  
3. Unqualified workers are never permitted to cross the Limited Approach Boundary.
  - a. true
  - b. false
  
4. The amount of energy that will cause a \_\_\_\_\_ degree burn on unprotected skin is 1.2 calories per centimeter squared.
  - a. first
  - b. second
  - c. third
  
5. The incident energy of an arc flash depends on \_\_\_\_\_.
  - a. how much current is available during a fault
  - b. how quick the current can be shut off
  - c. how far away a worker is from the arc source
  - d. all of the above answers.
  
6. The default arc flash protection boundary of four feet has been replaced by listings in table 130.7(C)(15) of the 2012 NFPA 70E.
  - a. true
  - b. false
  
7. In most instances, the arch flash boundary is the \_\_\_\_\_ of all approach boundaries to the electrical hazard.
  - a. closest
  - b. outermost
  
8. When hearing protection is required while performing electrical work, ear muffs should be used.
  - a. true
  - b. false
  
9. When dressing in layers for arc flash protection, your outermost layer must be made of arc-rated material.
  - a. true
  - b. false

***ANSWERS TO THE REVIEW QUESTIONS***

1. a

2. a

3. b

4. b

5. d

6. a

7. b

8. b

9. a