

## **SAFE ELECTRICAL WORK PRACTICES & 2015 NFPA 70E®**

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**

Every year, electrical workers are seriously injured or killed by contacting energized parts or being subjected to an electrical arc flash. To prevent these types of incidents, these workers and the organizations for which they work must understand and follow up-to-date electrical safety-related electrical work practices, maintenance requirements and administrative controls. One of the leading authorities on electrical safety is the National Fire Protection Association, the NFPA. Their document number 70E is recognized by many regulatory authorities and organizations as the "best practices" for electrical safety. This program provides an overview of the 2015 edition of NFPA 70E and shows how following its guidelines helps keep electrical workers safe.

Topics include approach boundaries, skills required of qualified electrical workers, selecting arc-rated clothing and protective equipment, arc flash PPE categories, creating an electrically safe working condition, when energized work is permitted and energized electrical work permits.

### **PROGRAM OUTLINE**

#### **THE TWO HAZARDS OF ELECTRICITY**

- In order to identify and avoid electrical hazards, workers must first understand that there are two main hazards presented by energized electrical equipment.
- The first hazard of electricity is electric shock, which can occur when a worker makes direct contact with or comes too close to energized parts.
- The second hazard of electricity is exposure to an arc flash. Unprotected workers can suffer severe burns when exposed to the sudden, violent release of energy associated with an electric arc, as was this worker who neglected to wear arc-rated clothing.

#### **INTRODUCTION TO APPROACH BOUNDARIES**

- To protect workers from the hazards of electricity, the NFPA 70E establishes approach limits at specific distances from exposed energized parts or potential arc sources. These approach limit distances are also referred to as "approach boundaries."
- In a major change to the 2015 NFPA 70E, the number of approach boundaries to protect against electric shock has been reduced from three to two.
- The two approach boundaries for shock protection are the Limited Approach Boundary and the Restricted Approach Boundary.
- The Limited Approach Boundary is the shock protection boundary farthest away from the energized parts and is established to keep unqualified persons a safe distance from exposed live parts.

- Unqualified workers may not cross the Limited Approach Boundary unless briefed on the hazards and continuously escorted by a qualified person.
- The Restricted Approach Boundary is the shock protection boundary closest to the energized parts and may only be crossed by qualified electrical workers following safe electrical work-practices which include wearing appropriate shock protection PPE and using insulated tools.
- The distance from an energized part or conductor to the each of these boundaries increases as the nominal voltage increases.
- There is also an approach boundary established to protect workers from exposure to an arc flash, the Arc Flash Boundary.
- When an arc flash hazard exists, the arc flash boundary is typically the outermost of all approach boundaries and must be marked with barricading and hazard signage.
- One method used to meet this requirement is using red "DANGER HIGH VOLTAGE" barricade tape which serves the dual purpose of being both a barricade and a danger sign.
- Workers may not cross the Arc Flash Boundary unless they are briefed on the hazards and are wearing arc-rated clothing and protective equipment appropriate for the job task they intend to perform.

### **QUALIFIED ELECTRICAL WORKERS**

- One important principle of electrical safety is that an electrical worker must be "qualified" for the work to be performed.
- The 2015 NFPA 70E defines a qualified person as follows: "A qualified person is one who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to identify and avoid the hazards involved."
- The words "has demonstrated" and "identify" are new 2015 additions to the definition of qualified person.
- This change requires an electrical worker to demonstrate their skills and knowledge to a qualified observer, including the ability to identify electrical hazards. Recordkeeping and documentation of this skill demonstration should be maintained by the employer or organization.
- Some skills that a qualified electrical worker should be able to demonstrate include:  
Distinguish exposed energized conductors and circuit parts from other parts of the equipment;  
Determine the nominal voltage of exposed energized conductors and circuit parts;  
Determine the approach boundary distances;  
And demonstrate the decision making process necessary to perform job safety planning, hazard identification, risk assessment and the selection of appropriate risk control methods including personal protective equipment.

### **APPROACH BOUNDARY DISTANCES FOR SHOCK PROTECTION**

- One of the required skills of a qualified electrical worker is determining the approach boundary distances for the equipment on which they intend to work.
- The approach boundary distances for shock protection are dependent on the nominal system voltage in AC systems and on the potential difference in DC systems.
- Once this information is known the approach boundaries may be looked up in table 130.4(D)(a) for alternating current or AC systems and in table 130.4(D)(b) for direct current or DC systems. These table designations are new for the 2015 70E document.
- Referencing the table for a 480-volt AC system yields a Limited Approach Boundary of 1 meter or 3 feet 6 inches and a Restricted Approach Boundary of 30 centimeters or 12 inches.

## **ARC FLASH BOUNDARY DISTANCE**

- Qualified workers must also be able to determine the Arc Flash Boundary for the job task they intend to perform.
- During an arc flash event, a large amount of thermal energy or “heat energy” is released. This thermal energy is measured in units known as calories.
- The amount of thermal energy at a given distance from an arc source is referred to as the incident energy.
- To give you an idea of the amount of heat energy in a calorie, it takes approximately 1.2 calories per square centimeter to cause the onset of a second degree burn on unprotected skin.
- A second degree burn, while painful, is also very curable and typically causes no lasting damage.
- It is for this reason that the Arc Flash Boundary is placed at the distance from an arc source where an unprotected worker will receive the onset of a second degree burn on unprotected skin.
- In other words, the Arc Flash Boundary is placed at the distance from an arc source where the incident energy is 1.2 calories per square centimeter.

## **DETERMINING THE ARC FLASH BOUNDARY**

- One method which can be used to determine the Arc Flash Boundary distance is to perform an incident energy analysis.
- An incident energy analysis is a calculation based on the specific design and condition of the electrical system in question. The incident energy analysis is used to predict the incident energy of a potential arc flash.
- Two of the critical factors used during an incident energy analysis are the maximum amount of short-circuit current available and the speed of any overcurrent protection.
- You may consult 2015 NFPA 70E Annex D for more information on an incident energy analysis.
- To make it easier for electrical workers to determine the Arc Flash Boundary distance, the NFPA has performed an incident energy analysis for common electrical systems and lists the Arc Flash Boundary for these systems in table 130.7(C)(15)(A)(b) for AC systems and 130.7(C)(15)(B) for DC systems.
- It’s critical for you to understand that the NFPA developed these tables based on the specific short-circuit current and fault clearing times listed in the table. If your equipment does not match these specifications, you may not use this table to determine the Arc Flash Boundary distance and must use an incident energy analysis.

## **SELECTING ARC-RATED CLOTHING AND PROTECTIVE EQUIPMENT**

- Arc-rated clothing and protective equipment 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 equipment, they place themselves at risk of serious burn injury.
- These burns are often made much worse by the ignition of flammable clothing. 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.
- This is why it is so important for workers to select appropriate arc flash protection.

- Remember that the incident energy level of an arc flash is measured in calories per square centimeter. The effectiveness of arc-rated clothing and protective equipment is also measured in calories per square centimeter.
- To provide an appropriate level of protection, arc-rated clothing and protective equipment must be selected to meet or exceed the predicted incident energy level of a potential arc flash at the working distance of the task to be performed.
- The working distance is the distance of a worker's face and chest area from a potential arc source while performing a specific task.
- One method to determine the appropriate arc flash protection is to perform an incident energy analysis and calculate the incident energy at the working distance. Then select arc flash protection rated to meet or exceed this amount of thermal energy.
- To make it easier for electrical workers to determine appropriate arc flash protection, the NFPA has calculated the incident energy level at the working distance of common job tasks performed on common electrical systems. They have also determined the appropriate arc flash protection for those job tasks and have listed it in Table 130.7(C)(15)(A)(b) for AC systems and Table 130.7(C)(15)(B) for DC systems.
- Again, it's critical for you to understand that the NFPA developed these tables based on the specific short-circuit current, fault clearing time and working distance listed in the table. If your planned task does not match these specifications, you may not use this table to determine the appropriate arc flash protection.
- These tables list the required arc flash protection as being in one of four PPE Categories. We will next explain the requirements of each PPE Category Level.

## **PPE CATEGORIES**

- In a major change for the 2015 NFPA 70E, the 5 Hazard Risk Categories have been removed and replaced with four PPE Category Levels of arc flash protection. Each PPE Category requires a specific level of protection, measured in calories per square centimeter.
- There are many job tasks that do not present an arc flash hazard and do not require arc flash PPE. Table 130.7(C)(15)(A)(a) can be consulted to determine if arc flash PPE is required. When no arc hazards exist, electrical workers may wear long sleeves and long pants made from non-melting natural fiber clothing such as 100 percent cotton or wool.
- PPE Category One requires a worker to wear arc-rated clothing of at least four calories per square centimeter, a voltage rated hard hat and an arc-rated face shield or arc-rated flash suit hood.
- PPE Category Two requires a worker to wear arc-rated clothing of at least eight calories per square centimeter, a voltage rated hardhat and an arc-rated face shield combined with an arc-rated balaclava. If desired, an arc-rated flash suit hood may be used instead of the face shield and balaclava.
- PPE Level Three requires a worker to wear arc-rated clothing of at least 25 calories per square centimeter and an arc-rated flash suit hood.
- PPE Level Four requires a worker to wear arc-rated clothing of at least 40 calories per square centimeter and an arc-rated flash suit hood.
- In addition to the required arc-rated clothing and voltage-rated hardhat, electrical workers must also wear safety glasses, earplugs, proper footwear and arc-rated gloves or voltage-rated gloves with leather protectors.
- Also, keep in mind that electrical workers should 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.

## **EQUIPMENT LABELS**

- As you have seen, determining the appropriate arc flash protection and establishing the Arc Flash Boundary can be complicated. To make it easier for electrical workers to determine this important information, the 2015 NFPA 70E requires that the owner of electrical equipment install field-labels on equipment.
- These labels must display the nominal system voltage, the Arc Flash Boundary and at least one of the following items: the Arc Flash PPE Category and/ or the Minimum Arc Rating of clothing and PPE.
- If an incident energy calculation was used to determine the appropriate PPE, then the incident energy level and corresponding working distance may be substituted on the label for the Arc Flash PPE Category.
- Having this critical information readily available on the equipment label makes selection of proper arc-rated PPE much easier for electrical workers.

## **ELECTRICALLY SAFE WORKING CONDITION**

- The best way for electrical workers to protect themselves from the shock hazard and arc flash hazard presented by electricity is to create 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 working 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 working 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 of electrical supply.
- 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: testing to verify there is an absence of voltage and grounding when necessary.

## **VERIFYING AN ABSENCE OF VOLTAGE**

- Testing for an absence of voltage must be done using an adequately rated test instrument.
- The test instrument must be verified to be working properly by measuring a known voltage source immediately prior to voltage testing and again immediately afterwards.
- When testing to confirm an absence of voltage, test each phase conductor or circuit part both phase to ground and to phase, for all phases.
- 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.
- Once the existence of an electrically safe working condition is verified, then 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.

## **ENERGIZED WORK**

- Remember, creating an electrically safe working condition is always the preferred method to ensure your safety. In fact, the 2015 NFPA 70E requires that an electrically safe working condition be created before performing any work unless one the following conditions exist.
- 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 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.
- 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. Just remember that infeasible is not the same thing as inconvenient.
- Finally, an addition to the 2015 NFPA 70E specifically allows for the normal operation of energized electrical equipment as long as the equipment meets all of the following conditions: the equipment must be properly installed and maintained; the equipment doors and covers are closed, in place and secured, and there is no evidence of impending failure.
- An informational note in the 2015 NFPA 70E further explains that equipment is considered properly installed and maintained when it has been installed and maintained in accordance with the manufacturer's recommendations as well as all applicable industry codes and standards.
- Evidence of impending failure includes evidence of arcing, overheating, loose or bound equipment parts or deterioration.

## **THE ENERGIZED ELECTRIC WORK PERMIT**

- The 2015 NFPA 70E has revised the requirements for when an energized electric work permit is required as compared to the 2012 Edition.
- In the few instances when energized work is permitted, the 2015 edition requires a permit anytime the following conditions exist.
- An energized electrical work permit is required anytime work is performed within the Restricted Approach Boundary.
- An energized electrical work permit is also required anytime a worker interacts with equipment when an increased likelihood of injury from an exposure to an arc flash hazard exists.
- It's important to note that conductors or circuit parts do not have to be exposed for an increased likelihood of an arc flash to occur.
- Some tasks create an increased likelihood of an arc flash and may therefore now require an energized electric work permit.
- 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 the shock risk assessment which includes the voltage to which personnel will be exposed;
  - The Limited Approach Boundary and the Restricted Approach Boundary as well as the necessary personal protective equipment and shock protective equipment to safely perform the assigned task.
- Also required on the permit are:

The results of the Arc Flash Risk Assessment;

The Arc Flash Boundary distance;

The available incident energy level at the working distance or the arc flash PPE category;

The necessary personal protective equipment to protect against the arc flash hazard.

- The permit should also document the means used to restrict the access of unqualified persons from the work area and provide evidence of the completion of a job briefing.
- Finally, it should include the signature of authorized members of management approving the work to be performed while energized. This approval process must include an electrically knowledgeable person.

#### **EXCEPTIONS TO THE PERMIT**

- The NFPA 70E provides a few specific exceptions to the requirement for an energized electrical work permit, including a few new exceptions added to the 2015 edition.

- An energized electrical work permit is not required under the following conditions:

Testing, troubleshooting and voltage measuring;

Thermography and visual inspections if the Restricted Approach Boundary is not crossed;

Access to or egress from an area with energized equipment if no electrical work is performed and the Restricted Approach Boundary is not crossed;

General housekeeping and non-electrical tasks if the Restricted Approach Boundary is not crossed.

## **PREPARE FOR THE SAFETY MEETING**

Review each section of this Leader's Guide as well as the program. 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. Play it without interruption. Review the program content by presenting the information in the program outline.

Copy the review questions included in this Leader's Guide and ask each participant to complete them.

Make an attendance record and have each participant sign the form. Maintain the attendance record and each participant's test paper as written documentation of the training performed.

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 to provide viewers with an overview of the 2015 edition of NFPA 70E and show how following its guidelines helps keep electrical workers safe.

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

Lead discussions about the cranes operated at your facility and precautions operators must take to prevent property damage and injuries.

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

- What the approach boundaries and how their distances are determined;
- What skills qualified workers must be able to demonstrate;
- How to properly select arc-rated clothing and protective equipment;
- What levels of protection are required in each of the four PPE Categories;
- How an electrically safe working condition is created;
- When energized work is permitted;
- What information can be found on an energized electrical work permit.



**SAFE ELECTRICAL WORK PRACTICES & 2015 NFPA 70E®**  
**REVIEW QUIZ**

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

*Please provide answers to the following to show how well you understand the information presented during this program.*

1. Which of the following approach boundaries is not established for shock protection?
  - a. the limited approach boundary
  - b. the arc flash boundary
  - c. the restricted approach boundary
2. The approach boundary distances for shock protection are dependent on the nominal system voltage in AC systems and on the potential difference in DC systems.
  - a. true
  - b. false
3. It takes approximately 1.2 calories per square centimeter of thermal energy to cause the onset of a \_\_\_\_\_ burn on unprotected skin.
  - a. first-degree
  - b. second-degree
  - c. third-degree
4. Which of the following is not a critical factor when calculating incident energy?
  - a. the equipment manufacturer
  - b. available short-circuit current
  - c. speed of overcurrent protection
5. To provide an appropriate level of protection, arc-rated clothing and protective equipment must be selected to meet or exceed the incident energy level of a potential arc flash at the \_\_\_\_\_.
  - a. outermost boundary
  - b. restricted approach boundary
  - c. working distance
6. Owners of electrical equipment are not required by the NFPA 70E to install field-labels on equipment.
  - a. true
  - b. false
7. When should a voltage test instrument be verified to be working properly?
  - a. immediately prior to testing
  - b. immediately after testing
  - c. both immediately prior to testing and immediately after testing
8. Energized work is permitted when it can be demonstrated that de-energizing introduces additional or increased hazards.
  - a. true
  - b. false
9. An energized electrical work permit is required anytime work is performed inside the limited approach boundary.
  - a. true
  - b. false
10. An energized electrical work permit is not required to perform general housekeeping and non-electrical tasks as long as the \_\_\_\_\_ boundary is not crossed.
  - a. arc flash
  - b. limited approach
  - c. restricted approach

***ANSWERS TO THE REVIEW QUESTIONS***

1. b
2. a
3. b
4. a
5. c
6. b
7. c
8. a
9. b
10. c