Safe Electrical Work Practices and the 2024 NFPA® 70E® for Electrical Workers

LENGTH: 28 MINUTES **Production Year: 2023**

PROGRAM SYNOPSIS:
This program provides electrical workers with an understanding of the requirements of the 2024 NFPA® 70E® that relate to the safe performance of electrical work. It explains the dual hazards of electric shock and arc flash as well as the factors that contribute to the severity of injury. Electrical workers will also learn the conditions that require an electrically safe work condition to be established as well as the step-by-step process of creating and verifying an electrically safe work condition.

After viewing this program, electrical workers will have an understanding of the incident energy associated with an arc flash and how this is used to establish the Arc Flash Boundary distance and select proper arc-rated clothing and PPE. The importance of wearing arc-rated clothing is visually demonstrated by example and the viewer will learn that flammable clothing such as polyester will worsen any burn injury.

PROGRAM OBJECTIVES:
After watching the program, the participant should be able to explain the following:
- What the two hazards of electricity are and what factors contribute to the amount of damage they can cause;
- Which circumstances permit the performance of energized work;
- What the requirements for a qualified person are;
- How to create and verify an electrically safe work condition;
- What the requirements for the two approach boundaries and the Arc Flash Boundary are;
- Which clothing and personal protective equipment is required for each of the four Arc Flash PPE Categories.

PROGRAM OUTLINE:
INTRODUCTION
- As an electrical worker, you are asked to perform a wide variety of tasks while interacting with various types of electrical equipment and systems. While doing so, you may be exposed to hazards presented by electricity.
- Protecting electrical workers from the hazards of electricity is the purpose of your organization's Electrical Safety Program and its safe work practices and procedures.
- One of the leading authorities on electrical safety is the National Fire Protection Association, the NFPA®. Their standard for electrical safety in the workplace, "70E®", is the established method for electrical safety compliance, and has been incorporated by reference into many safety and health regulations.
- Chapter One of NFPA® 70E® provides the blueprint for creating an electrical safety program and is the genesis of the safety rules and procedures you must follow while performing electrical-related work.

TWO HAZARDS OF ELECTRICITY
- As an electrical worker, it's important to understand that there are two main hazards of electricity: an electric shock hazard and an arc flash hazard.
- An electric shock hazard is defined as "a source of possible injury or damage to health associated with current through the body caused by contact or approach to exposed energized electrical conductors or circuit parts."
- There are multiple factors that contribute to the severity of injury or damage to health resulting from electric shock including the magnitude of the electrical current, the frequency of the power source, and the path and time duration of electric current through the body.
- The physiological reaction to electric shock ranges from perception, muscular contraction, inability to let go, ventricular fibrillation, tissue burns, and death.
- Another hazard associated with electricity is an arc flash hazard.
- An arc flash hazard is defined as "a source of possible injury or damage to health associated with the release of energy caused by an electric arc."

- The severity of injury or damage to health resulting from exposure to an arc flash is impacted by the amount of fault current, the duration of the arc event, the worker's distance from the electric arc's source, and the protective equipment worn by the worker.
- An arc flash event is not likely to occur under normal operating conditions. However, certain tasks and conditions will increase the likelihood of an arc flash incident.

QUALIFIED PERSON

- One important safety principle contained in NFPA® 70E® is that an electrical worker must be "qualified" for the work to be performed.
- A qualified person is defined as "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 the hazards and reduce the associated risks."
- In addition, a qualified person must be trained and knowledgeable in the construction and operation of equipment or a specific work method, and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.
- As an electrical worker, it's important to understand that you may be qualified with respect to certain equipment and tasks but remain unqualified for others.
- Do not attempt to work with electrical equipment or systems unless you have been qualified by your employer for the work to be performed.
- Electrical workers must receive annual "contact release" training.
- Contact release refers to the safe release of workers who are in contact with energized parts.
- In addition, any employees responsible for responding to medical emergencies must be trained in first aid, cardio-pulmonary resuscitation (CPR), and the use of an automated external defibrillator (AED) when one is provided as part of the emergency response plan.

APPROACH BOUNDARIES

- Qualified electrical workers must be familiar with the various approach boundaries established by NFPA® 70E®. Approach boundaries are established to keep unqualified workers and/or unprotected workers a safe distance from energized electrical conductors or circuit parts.
- There are two approach boundaries for electric shock protection: the Limited Approach Boundary and the Restricted Approach Boundary.
- The "Limited Approach Boundary" is the electric shock protection boundary farthest away from the exposed energized 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 electric shock protection boundary closest to the exposed 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.
- Electric shock protection PPE must include voltage-rated gloves any time the nominal voltage is 50 Volts or greater.
- There are no circumstances which would allow an unqualified person to cross the Restricted Approach Boundary.

ARC FLASH BOUNDARY AND PPE

- In addition to the two shock protection approach boundaries, there is also an "Arc Flash Boundary."
- The purpose of the Arc Flash Boundary is to limit the severity of a potential burn injury to unprotected workers should an arc flash occur.
- During an arc flash event, a large amount of thermal energy or "heat energy" is released. The amount of thermal energy is greatest closest to the arc source and decreases with distance away from the arc source.
- The Arc Flash Boundary is placed at the distance from a potential arc source where the amount of thermal energy will result in the onset of a second-degree burn on unprotected skin.
- When unprotected workers cross the Arc Flash 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. Clothing that is not arc-rated, such as 100% cotton or wool, can burst into flames and continue to burn even after the arc is extinguished. Other fabrics such as

polyester or nylon can also melt into the skin, making a burn even worse. These types of meltable fabrics should NOT be worn by electrical workers.

- Workers may not cross the Arc Flash Boundary unless they are briefed on the hazards and are wearing appropriate arc-rated clothing and protective equipment.
- Arc-rated clothing is designed to withstand both the intense heat and force of an arc flash without breaking open or bursting into flames. Arc-rated clothing and PPE help protect electrical workers from burn injury during an arc-flash event.

HAZARD ELIMINATION / ELECTRICALLY SAFE WORK CONDITION

- Of course, the most effective way to protect electrical workers from the hazards presented by electricity is to eliminate the hazard completely by creating an electrically safe work condition.
- In fact, NFPA® 70E® requires that hazard elimination be the first priority in the hierarchy of risk control methods.
- An electrically safe work condition is defined as "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 for the absence of voltage, and, if necessary, temporarily grounded for personnel protection."
- An electrically safe work condition must be established and verified prior to performing work on electrical conductors and circuit parts operating at voltages equal to or greater than 50 Volts.
- The process of creating an electrically safe work condition is commonly referred to as the "Control of Hazardous Energy." Of course, some people may also refer to it as "Lockout/Tagout" but keep in mind that applying locks and tags is just one step in the multi-step process of creating an electrically safe work condition.
- Section 120.6 of NFPA® 70E® lists eight steps which must be followed when establishing and verifying an electrically safe work condition.
- Step 1 is to determine all possible sources of electrical supply to the specific equipment.
- Step 2 is to interrupt the load current by disconnecting any active loads and then opening the disconnecting device for each source of electrical supply.
- Step 3 is to visually verify, if possible, that all blades of disconnecting devices are fully open, and that draw-out type circuit breakers are withdrawn to the "test" or "fully disconnected" position.
- Step 4 is to release any stored electrical energy, such as that found in capacitors.
- Step 5 is to block or relieve any stored nonelectrical energy in devices to the extent that circuit parts cannot be unintentionally energized by such devices.
- Step 6 is to apply lockout/tagout devices in accordance with a documented and established procedure.
- Step 7 is to use an adequately rated test instrument to test each phase conductor or circuit part, at each point of work, for the absence of voltage.
- And finally, when the possibility of induced voltages or stored electrical energy exists, Step 8 requires that all conductors and circuit parts be grounded prior to touching.
- Temporary protective grounds must be installed if it can be reasonably anticipated that the de-energized parts could come into contact with other energized parts.
- Before using your meter or other test instrument to verify an absence of voltage, it must first be verified to be working properly by measuring a known voltage source.
- When testing to confirm an absence of voltage, test each phase conductor or circuit part, both phase to ground and phase to phase, for all phases.
- Once voltage testing is complete, the test instrument must again be verified on a known voltage source.
- As an electrical worker, it's critical that you understand this key point; until the existence of an electrically safe work condition has been verified, you must treat the equipment as if it is energized.
- This means that all safe work practices, such as shock and arc flash protection applicable to the circuit voltage and energy level, must be used.
- However, once the electrical conductors and circuit parts are verified to be in an electrically safe work condition, then no electrical hazards exist, and shock and arc flash protection are no longer necessary and may be removed.
- In addition, other workers who are not qualified electrical workers may enter the area as needed.
- Employees involved in the Lockout/Tagout Program must be trained in the lockout/tagout procedures as well as their responsibilities in the execution of those procedures. Lockout/tagout re-training must take place at least every three years.

JOB SAFETY PLAN AND JOB BRIEFING

- Prior to starting any job that involves exposure to electrical hazards, NFPA® 70E® requires that a job safety plan be completed and a job briefing be conducted.
- The required job safety plan must include the following: a description of the job and the individual tasks; identification of the electrical hazards associated with each task; an Electric Shock Risk Assessment for tasks involving an electric shock hazard; an Arc Flash Risk Assessment for tasks involving an arc flash hazard; and, the work procedures involved, the special precautions to be taken, and the methods to be used to identify and control the sources of hazardous energy.
- The required job briefing must be conducted with all involved employees and must include all elements of the job safety plan as well as the information contained on an energized electrical work permit, if one is required.

ENERGIZED WORK

- As we mentioned earlier, eliminating the electrical hazards by creating an electrically safe working condition is the first priority. However, Section 110.2 (B) of NFPA® 70E® contains the following five exceptions which permit energized work.
- **Energized Work Exception Number One:**
- The normal operation of energized electrical equipment is permitted as long as a "normal operating condition" exists. So, what is considered a normal operating condition? When all of the following are satisfied:
- The equipment is properly installed and maintained. The equipment is rated for the available fault current. The equipment is used in accordance with instructions included in the listing and labeling, and in accordance with the manufacturer's instructions. The equipment doors are closed and secured. The equipment covers are in place and secured. And there is no evidence of impending failure.
- Evidence of "impending failure" includes evidence of arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or water damage.
- **Energized Work Exception Number Two**:
- An energized disconnecting means or isolating element may be operated to achieve an electrically safe work condition or to return equipment to service. This allows for a circuit to be de-energized locally without going upstream, so long as a risk assessment has been performed and no unacceptable risk has been identified.
- **Energized Work Exception Number Three**:
- 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.
- Examples of work that may be infeasible in a de-energized state include start-up, testing, troubleshooting, and voltage measuring.
- **Energized Work Exception Number Four**:
- Energized work is permitted when the employer can demonstrate that de-energizing introduces additional risk or increased hazards.
- Examples include the interruption of life support equipment, the deactivation of emergency alarm systems, or the shutdown of hazardous location ventilation equipment.
- **Energized Work Exception Number Five**:
- Energized work is permitted when the electrical conductors and circuit parts operate at less than 50 Volts, and it is determined that there will be no increased exposure to electric burns or to explosion due to electric arcs. When making this determination, the capacity of the energy source and the over-current protection that exists between the source and the worker must be considered.
- When performing energized work under one of these five exceptions, you may also need to complete an Energized Electrical Work Permit.
- Completing an Energized Electrical Work Permit is required when the work to be performed is within the restricted approach boundary or a worker interacts with the equipment while an increased likelihood of injury from exposure to an arc flash hazard exists, even if the conductors or circuit parts are not exposed.

SHOCK RISK ASSESSMENT / APPROACH BOUNDARIES

- As we discussed earlier, the Job Safety Plan requires both an Electric Shock Risk Assessment and an Arc Flash Risk Assessment be performed when these hazards may exist. We will now discuss each of these in more detail.

- When required, the Electric Shock Risk assessment is performed to identify the electric shock hazards, estimate the likelihood of the occurrence of injury or damage to health, estimate the potential severity of injury or damage to health, and determine if additional protective measures are required
- The operating condition of the electrical equipment, its condition of maintenance, and its design are all important factors that must be considered when estimating the likelihood and severity of a potential injury.
- If the Electric Shock Risk Assessment determines that the use of personal protective equipment or other additional protective measures are required, then the voltage to which personnel will be exposed must be determined, the electric shock protection approach boundaries must be determined, and the PPE and other equipment required to protect workers from the electric shock hazard must be determined.
- To determine the shock protection approach boundaries, NFPA® 70E® provides Table 130.4(E)(a) for alternating current or "AC" systems and Table 130.4(E)(b) for direct current or "DC" systems.
- Once the nominal voltage is determined, the shock protection approach boundaries may be looked up in the appropriate table. For example, for an exposed, fixed-circuit part with a nominal voltage of 480 Volts AC, the limited approach boundary is 3 feet 6 inches, and the restricted approach boundary is 1 foot.

ARC FLASH RISK ASSESSMENT / ARC FLASH BOUNDARY / ARC FLASH PPE

- When required, the Arc Flash Risk assessment is performed to identify arc flash hazards, estimate the likelihood of the occurrence of injury or damage to health, estimate the potential severity of injury or damage to health, and determine if additional protective measures are required, including the use of arc-rated clothing and PPE.
- The operating condition of the electrical equipment, its condition of maintenance, and its design are all important factors that must be considered when estimating the likelihood and severity of a potential arc flash incident. In addition, the available fault current and the speed of any over-current protection must also be considered.
- Recall that earlier in the program we stated "an arc flash event is not likely to occur under normal operating conditions. However, certain tasks and conditions will increase the likelihood of an arc flash incident."
- To help determine the likelihood of an arc flash occurring, NFPA® 70E® provides Table 130.5(C).
- When it is determined that an arc flash event is likely, the appropriate safety-related work practices must be determined, the Arc Flash Boundary must be determined, and the PPE to be used within the Arc Flash Boundary must be determined.
- The preferred method used to determine the Arc Flash Boundary distance is to perform an "incident energy analysis" to determine the distance from a potential arc source at which the thermal energy is calculated to be 1.2 calories per square centimeter. This calculated distance is the Arc Flash Boundary.
- 1.2 calories per square centimeter is the amount of thermal energy that will cause the onset of a second degree burn on unprotected skin. The purpose of the Arc Flash Boundary is to prevent serious burn injury to unprotected workers.
- An incident energy analysis will also determine the amount of thermal energy to which a worker will be exposed during a potential arc flash.
- The distance of a worker's face and chest area from a potential arc source while performing a specific task is known as the "working distance" and the thermal energy to which the worker may be exposed is known as the "incident energy exposure level."
- To protect against thermal burns when working inside the Arc Flash Boundary, arc-rated clothing and protective equipment must be selected to meet or exceed the incident energy exposure level.
- Table 130.5 (G) describes the required arc-rated clothing and PPE to be used when the incident energy exposure level has been calculated to be 1.2 calories per square centimeter or greater.
- When this is the case, an arc-rated long sleeve shirt and pants, arc-rated coveralls, an arc-rated flash suit, or a tested and verified system of layers of these items must be selected.
- To protect hands against burns, arc-rated gloves or rubber insulating gloves with protectors must be selected.
- In addition, leather footwear, hearing protection, and safety glasses or safety goggles are required.
- When incident energy exposure is calculated to exceed 12 calories per square centimeter, a hard hat combined with an arc-rated flash suit hood must be used for head, face, and chin area protection.
- When incident energy exposure is calculated to be 12 calories per square centimeter or less, a hard hat combined with an arc-rated face shield and arc-rated balaclava may be selected for head, face, and chin area protection in lieu of a flash suit hood if desired.

TABLE METHOD: ARC FLASH BOUNDARY AND PPE CATEGORIES

- For certain configurations of electric equipment and circuits, NFPA® 70E® provides a series of reference tables as an alternate method for determining the Arc Flash Boundary and selecting appropriate arc-rated clothing and PPE.
- Table 130.7(C)(15)(a) applies to certain AC systems and Table 130.7(C)(15)(b) applies to certain DC systems.
- Before using these tables, you must ensure that the circuit and equipment match all specifications listed in the table's notes, as well as the available fault current and fault clearing times noted in the table.
- These tables specify the required arc flash PPE by listing an "arc-flash PPE category."
- Table 130.7(C)(15)(c) may then be consulted to determine the PPE requirements for each Arc Flash PPE Category.
- Arc Flash PPE Category One requires arc-rated clothing of at least 4 calories per square centimeter. Also required is an arc-rated face shield or an arc-rated flash suit hood.
- Arc Flash PPE Category Two requires arc-rated clothing of at least 8 calories per square centimeter. Also required is an arc-rated face shield combined with an arc-rated balaclava or an arc-rated flash suit hood.
- Arc Flash PPE Category Three requires a tested and verified system of arc-rated clothing of at least 25 calories per square centimeter. Also required is an arc-rated flash suit hood.
- Arc Flash PPE Category Four requires a tested and verified system of arc-rated clothing of at least 40 calories per square centimeter. Also required is an arc-rated flash suit hood.
- Each arc flash PPE category also requires the following protective equipment: a voltage-rated hard hat; safety glasses or safety goggles; hearing protection; leather footwear; and, arc-rated gloves or voltage-rated gloves with protectors.

EQUIPMENT LABELS

- We have now discussed two methods that can be used to determine the Arc Flash Boundary and required arc-rated clothing and PPE: the incident energy calculation method and the PPE category method.
- Fortunately, electrical workers do not have to determine this information from scratch each time they perform work.
- Section 130.5(H) requires that the owner of electrical equipment install field-labels on equipment. These labels must display the nominal system voltage and the Arc Flash Boundary.
- To help electrical workers select appropriate arc-rated clothing and PPE, the equipment's field-label must also display at least one of the following items: the available incident energy and corresponding working distance or the equipment's arc flash PPE category (but not both); the minimum arc-rating of clothing; or, a site-specific level of PPE.
- Electrical workers should be familiar with the labels on the equipment they plan to interact with and be able to select arc-rated clothing and PPE based in the label's information.

CONCLUSION

- In this program, we have provided an overview of the Safety-Related Work Practices and requirements listed in Chapter 1 of NFPA® 70E®. Keep in mind that your organization's electrical safety program and procedures are based on the 70E® standard.
- And while we have covered a lot of information, keep in mind that we have not covered the entirety of the 70E® standard, nor have we explained all aspects of electrical safety.
- As an electrical worker, you have a responsibility to follow your employer's required safe electrical work practices.
- Make sure you are qualified before performing any electrical-related task.
- Participate in the required job planning and briefing.
- Understand that creating an electrically safe work condition is always the first priority.
- And, treat all electrical conductors or circuit parts as energized until it is verified that an electrically safe work condition has been established.
- Electrical workers must never let their guard down around electricity. By following the safety-related work practices required by NFPA® 70E® and their employer, electrical workers can ensure they will return home each day safe, healthy, and injury free.

Safe Electrical Work Practices and the 2024 NFPA® 70E® for Electrical Workers

ANSWERS TO THE REVIEW QUIZ

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

Safe Electrical Work Practices and the 2024 NFPA® 70E® for Electrical Workers
REVIEW QUIZ

Name_____Date_____

The following questions are provided to determine how well you understand the information presented in this program.

1. Chapter One of NFPA® 70E® provides the blueprint for creating an electrical safety program and is the genesis of the safety rules and procedures you must follow while performing electrical related work.

a. True
b. False

2. The two main hazards of hazards of electricity are _____.

a. A spark hazard and a flame hazard
b. A blinding hazard and a burn hazard
c. An electric shock hazard and an arc flash hazard

3. There are two approach boundaries for electric shock protection: the Limited Approach Boundary and the Restricted Approach Boundary.

a. True
b. False

4. Workers may not cross the Arc Flash Boundary unless they are briefed on the hazards and are wearing appropriate arc-rated clothing and protective equipment.

a. True
b. False

5. The amount of thermal energy at a given distance from an arc source is referred to as the _____.

a. Incandescent Energy
b. Incident Energy
c. Caloric Energy

6. The Arc Flash Boundary must be placed at an approach limit distance where the amount of thermal energy could result in the onset of a _____ burn.

a. First-degree
b. Second-degree
c. Third-degree

7. You must treat all electrical conductors and circuit parts as energized until the existence of an electrically safe work condition has been properly verified.

a. True
b. False

8. Energized work is permitted when the electrical conductors and circuit parts operate at less than _____, and it is determined that there will be no increased exposure to electric burns or to explosion due to electric arcs.

a. 10 Volts
b. 50 Volts
c. 100 Volts

9. Arc Flash PPE Category Four requires a tested and verified system of arc-rated clothing of at least 40 calories per square centimeter.

a. True
b. False

10. Section 130.5(H) requires that the owner of electrical equipment install field-labels on equipment that will display the nominal system voltage and the Arc Flash Boundary.

a. True
b. False