Electrical Safety-Related Work Practices and the 2021 NFPA® 70E® for Electrical Workers

LENGTH: 22 MINUTES

PROGRAM SYNOPSIS:
This program provides electrical workers with an understanding of those requirements of the 2021 NFPA 70E that relate to the safe performance of electrical work. It also explains the dual hazards of electric shock and arc flash as well as the factors that contribute to the severity of injury. To assist in meeting the annual requirement for contact release training, this program provides an explanation of electrical contact release and demonstrates how to safely remove a worker from an energized source.

The program provides a clear explanation of the two approach boundaries used for shock protection, the Limited Approach Boundary and the Restricted Approach Boundary, as well as the approach boundary used for arc flash protection, the Arc-Flash Boundary. The definition of a qualified electrical worker is explained in addition to the knowledge and skills required for a qualified electrical worker to cross the Restricted Approach Boundary. Also included are the restrictions and exceptions for unqualified workers related to the various approach boundaries.

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 or meltable clothing such as polyester will worsen any burn 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. In addition, the program describes those limited instances when energized work is allowed as well as the safe work practices and procedures that must be followed when performing work involving electrical hazards. This includes the Energized Electrical Work Permit, job planning and job briefing, the establishment of approach boundaries and the selection of arc-rated clothing and PPE.

To assist electrical workers in selecting the appropriate shock and arc-flash protection, the program explains the information that may be found on equipment hazard labels such as the nominal voltage, the Arc-Flash PPE Hazard Category and the incident energy at the working distance. The appropriate arc-rated PPE for each hazard category is also explained. In addition, to assist electrical workers in understanding how approach boundary distances and appropriate PPE are determined, the program explains and references the appropriate look-up tables contained in the regulation.

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
- There are a wide variety of electrical equipment and electrical-related tasks that workers may be exposed to as they perform their job duties each day.
- 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 recognized by many regulatory authorities as the "best practices" for electrical safety and has been incorporated by reference into many safety and health regulations.

TWO HAZARDS OF ELECTRICITY
- The 2021 NFPA 70E focuses on protecting workers from the two main hazards of electricity: the shock hazard and the arc flash hazard.
- A 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 several factors that contribute to the amount of damage caused by an electric shock, including:

—The amount of electric current,
—The frequency of the power source,
—The current's path through the body,
—The time duration of the shock event.

- The other main hazard associated with electricity is an arc flash. 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."
- There are several factors that contribute to the amount of damage that may be caused by an arc flash, including:

—The amount of fault current,
—The duration of the arc event,
—The distance of a worker from an electric arc source,
—The protective equipment worn by the worker.

QUALIFIED PERSON

- One important safety principle contained in the NFPA 70E is that an electrical worker must be "qualified" for the work to be performed.
- A qualified person is defined 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 the hazards and reduce the associated risks.
- 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.
- The training requirements also require that a qualified person be familiar with insulated tools and shielding materials, test equipment and PPE.
- A qualified person must also be trained in the selection of an appropriate test instrument to verify the absence of voltage and be able to demonstrate its use and understand its limitations.
- It's important to understand that a person may be qualified with respect to certain equipment and tasks, but still be unqualified for others.
- The training requirements listed in Article 110.6 also include annual "contact release" training for all employees exposed to electrical shock hazards. Contact release refers to the safe release of workers who are in contact with energized parts.
- When a person is being shocked, a potential rescuer must not touch the shock victim because of the risk of also being shocked.
- When possible, the power source for the conductor or equipment should be interrupted or opened in order to safely release the victim.
- If this is not possible, a non-conductive object can be used to push the victim away from the energized conductor or circuit part.

APPROACH BOUNDARIES

- To help protect workers from shock and arc flash hazards, the NFPA has established the concept of approach boundaries. 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 shock protection: the Limited Approach Boundary and the Restricted Approach Boundary.
- The Limited Approach Boundary is the 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 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.
- Shock protection PPE must include voltage rated gloves anytime the nominal voltage is greater than 50 volts.
- There are no circumstances which would allow an unqualified person to cross the Restricted Approach Boundary.

ARC FLASH BOUNDARY AND PPE

- There is one approach boundary for arc flash protection: the Arc Flash Boundary.
- During an arc flash event, a large amount of thermal energy, or "heat energy," is released. The amount of thermal energy at a given distance from an arc source is referred to as the "Incident Energy."
- The amount of incident 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 approach limit distance where the amount of thermal energy of a potential arc flash is limited to that which will result in the onset of a second-degree burn on unprotected skin.
- 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.
- 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 percent cotton or wool, can burst into flames and continue to burn even after the arc is extinguished. Other fabrics such as polyester or nylon will also melt into the skin, making a burn even worse.
- Arc-rated clothing and protective equipment must be selected to meet or exceed the predicted incident energy 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.

ELECTRICALLY SAFE WORK CONDITION

- One method that can be used to eliminate electrical hazards is to create an electrically safe work condition. 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 to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection."
- The requirement to create an electrically safe work condition is listed in Article 110.3, which states that energized conductors or circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:

—The employee is within the Limited Approach Boundary;

—The employee interacts with equipment, where conductors or circuit parts are not exposed, but an increased likelihood of injury from an exposure to an arc flash hazard exists.

- It's important to note that an electrically safe work condition is not a procedure, but rather a temporary state wherein all electrical conductors or circuit parts to which a worker may be exposed are maintained in a de-energized state.

CREATING AN ELECTRICALLY SAFE WORK CONDITION

- The process for establishing and verifying an electrically safe work condition is listed in Article 120.5.
- To create an electrically safe work condition, first, determine all possible sources of electrical supply to the equipment. Next, interrupt the load current by disconnecting 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, and that draw-out type circuit breakers are withdrawn to the "test" position or to the "fully disconnected" position.
- Next, release any stored electrical energy, such as that found in capacitors. Block or relieve any stored nonelectrical energy in devices so that circuit parts cannot be unintentionally energized by their movement.
- Then, apply lockout/tagout devices in accordance with a documented and established procedure.
- After the lockout/tagout devices have been applied, the next step is to test each phase conductor or circuit part for an absence of voltage.
- Testing for an absence of voltage must be done using an adequately rated, portable test instrument. For voltages over 1,000 volts, a non-contact, capacitive test instrument is permitted.
- The test instrument must be verified to be working properly by measuring a known voltage source immediately prior to voltage testing.
- 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, immediately verify the test instrument again on a known voltage source.
- When there is a possibility of induced voltages or stored energy, all circuit conductors and parts should be grounded before touching them.
- Temporary protective grounds should be installed when the possibility exists that the conductors or circuit parts could come in contact with other exposed energized parts or conductors.
- Remember, until you have verified the existence of an electrically safe work condition and all other provisions of Article 120 have been met, the electrical conductors and circuit parts are not considered to be in an electrically safe work condition and all safe work practices 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.
- 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.

JOB SAFETY PLAN AND JOB BRIEFING

- Article 110 also requires that a job safety plan be completed and a job briefing be conducted by the employee in charge prior to starting any job that involves exposure to electrical hazards.
- The job safety plan must be documented and completed by a qualified person for each electrical-related job task. The job safety plan must include the following:

—A description of the job and the individual tasks,

—Identification of any electrical hazards associated with each task,

—A shock risk assessment for tasks involving a shock hazard,

—An arc flash risk assessment for tasks involving an arc flash hazard,

—The methods to be used to identify and control the sources of hazardous energy,

—The work procedures involved,

—Any special precautions to be taken.

- The job briefing must be conducted with all involved employees prior to beginning any job with exposure to electrical hazards. The job briefing 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 an electrical worker, you realize that there may be some circumstances when performing energized work is necessary.
- In Article 110.4, the 2021 NFPA 70E outlines the limited circumstances where performing energized work is permitted.
- Energized work is permitted when it can be demonstrated that de-energizing introduces additional or increased hazards. Examples of additional hazards include the interruption of life support equipment, deactivation of emergency alarm systems or the shutdown of hazardous location ventilation equipment.
- 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 overcurrent protection that exists between the source and the worker must be considered.
- 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 testing, troubleshooting, voltage measuring and thermography.
- The normal operation of energized equipment is also permitted as long as "normal operating conditions" exist. For a normal operating condition to exist:

—The equipment must be properly installed and maintained;
—The equipment must be 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,
—All equipment covers are in place and secured,
—There is no evidence of impending failure.

- Evidence of impending failure includes evidence of arcing, overheating, loose or bound equipment parts or deterioration.

WORK INVOLVING ELECTRICAL HAZARDS

- Only qualified workers are permitted to work on electrical conductors or circuit parts that have not been placed in an electrically safe work condition;
- An energized electrical work permit shall be completed when the work to be performed is within the Restricted Approach Boundary or the worker interacts with the equipment when conductors or circuit parts are not exposed, but an increased likelihood of injury from exposure to an arc flash hazard exists.
- Article 130 provides exceptions to the requirement for an Energized Electrical Work Permit. A qualified person who is following appropriate safe work practices and using required PPE may perform the following work without an energized electrical work permit:

—Testing, troubleshooting or voltage measuring,
—Thermography, ultrasound or visual inspections if the restricted approach boundary is not crossed,
—Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed,
—General housekeeping and non-electrical tasks, provided that the restricted approach boundary is not crossed.

- Before a qualified person is permitted to work within the Limited Approach Boundary, they must, at a minimum, be additionally trained on and able to demonstrate the following:

—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 the corresponding voltages to which they will be exposed,
—Demonstrate the decision-making process necessary to perform job safety planning, identify electrical hazards, risk assessment and the selection of appropriate risk control methods including personal protective equipment.

DETERMINING BOUNDARIES

- Once the nominal voltage is determined, the shock protection approach boundaries may be looked up in Table 130.4(E)(a) for alternating current, or AC, systems and in Table 130.4(E)(b) for direct current, or DC, systems.
- One method that electrical workers can use to determine both the Arc Flash Boundary and the appropriate arc flash PPE is to utilize the tables provided in Article 130.
- First, use Table 130.5(C) to determine the likelihood of an arc flash occurrence. If an arc flash occurrence is likely, then Table 130.7(C)(15)(a) may be used for common AC systems and Table 130.7(C)(15)(b) may be used for common DC systems to determine the Arc Flash Boundary and the required Arc Flash PPE Category.
- Before using these tables, you must ensure that the circuit and equipment upon which you intend to work match the available fault current and fault clearing times noted in the table.

ARC FLASH PPE CATEGORIES

- Table 130.7(C)(15)(c) contains the PPE requirements for each Arc Flash PPE Category.
- Arc Flash PPE Category One requires arc-rated clothing of at least four calories per square centimeter or 16.75 joules per square centimeter. This must include arc-rated long sleeves and long pants or arc-rated coveralls.
- Also required are an arc-rated face shield or an arc-rated flash suit hood and heavy leather gloves, arc-rated gloves or voltage-rated gloves with leather protectors.
- Arc Flash PPE Category Two requires arc-rated clothing of at least eight calories per square centimeter or 33.5 joules per square centimeter. This must include arc-rated long sleeves and long pants or arc-rated coveralls.

- Also required are arc-rated face shield combined with an arc-rated balaclava or an arc-rated flash suit hood and heavy leather gloves, arc-rated gloves or voltage-rated gloves with leather protectors.
- Arc Flash PPE Category Three requires a system of arc-rated clothing that provides a minimum of 25 calories per square centimeter or 104.7 joules per square centimeter.
- Also required are an arc-rated flash suit hood and arc-rated gloves or voltage-rated gloves with leather protectors.
- Arc Flash PPE Category Four requires a system of arc-rated clothing that provides a minimum of 40 calories per square centimeter or 167.5 joules per square centimeter.
- Also required are an arc-rated flash suit hood and arc-rated gloves or voltage-rated gloves with leather protectors.
- In addition, each of the four arc-flash PPE categories also requires the following protective equipment: a voltage-rated hard hat, safety glasses or safety goggles, ear canal insert-type hearing protection and leather footwear.
- It's important to understand that if your equipment does not match the specifications noted in Table 130.7(C)(15)(a) or 130.7(C)(15)(b) then you may not use these tables to determine the Arc Flash Boundary distance or the appropriate arc flash PPE.
- An incident energy analysis must be performed instead. When using an incident energy analysis to determine appropriate arc flash PPE, Table 130.5(G) must be used to select arc-rated clothing and other PPE.

EQUIPMENT LABELS

- The 2021 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 two items: The arc flash PPE category and/or the minimum arc rating of clothing and PPE; or, if an incident energy calculation was used to determine the appropriate arc flash PPE, then the incident energy level and corresponding working distance should be substituted on the label for the arc flash PPE category.
- Having this critical information readily available on the equipment label makes the selection of proper arc-rated clothing and PPE much easier for electrical workers.

CLOSING

- In this program, we have provided an overview of the safety-related work practices and requirements listed in Chapter One of the 2021 NFPA 70E.
- Keep in mind that we have not covered the entirety of the 70E regulation in this program, nor have we explained all aspects of electrical safety. Each worker and employer has a responsibility to become familiar with all aspects of the NFPA 70E, other applicable electrical and safety regulations as well as your facility's Electrical Safety Program.
- Always make sure you are qualified for the work you intend to perform, then use your skill, knowledge and dedication to following safe work practices to ensure that you safely complete each electrical-related work task.

Electrical Safety-Related Work Practices and the 2021 NFPA® 70E® for Electrical Workers

ANSWERS TO THE REVIEW QUIZ

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

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REVIEW QUIZ

Name_____Date_____

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

1. The 2021 NFPA 70E focuses on protecting workers from the two main hazards of electricity: _____.

a. The shock hazard and the noise hazard
b. The arc flash hazard and heat stress
c. The shock hazard and the arc flash hazard

2. Which of the following is NOT a factor that contributes to the amount of damage caused by an arc flash?

a. The amount of fault current
b. The protective equipment worn the by the worker
c. The duration of the arc event
d. The location of the Arc-Flash Boundary

3. When a person is being shocked, a potential rescuer must not touch the shock victim because of the risk of also being shocked.

a. True
b. False

4. Unqualified personnel may cross the Restricted Approach Boundary if they are wearing the required shock and arc-flash protection.

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. 50 volts
b. 120 volts
c. 240 volts

9. Arc-flash PPE _____ requires a system of arc-rated clothing that provides a minimum of 8 calories per square centimeter or 104.7 joules per square centimeter.

a. Category 1
b. Category 2
c. Category 3
d. Category 4

10. Which of the following is NOT required to be listed on a field label?

a. Nominal System Voltage
b. Maximum Fault Current
c. Arc Flash Boundary
d. Arc Flash PPE Category