

TITLE: 2926 2009 NFPA 70E:

Electrical Safety-Related Work Practices

25 MINUTES

PRODUCTION YEAR: 2009

PROGRAM SYNOPSIS:

Qualified electrical workers are exposed to a wide variety of electrical equipment and systems and their work is critical to the successful operation of their facility. They must have a lot of knowledge to stay safe as well as determination and a commitment to personal safety. Following safe work practices and wearing proper PPE isn't always the fastest or easiest way to get your work accomplished, but it is the only way to make sure you come home safe at the end of the day. This program explains the safe electrical work practices required of the latest NFPA 70E regulation, while showing arc flash explosions, incident reenactments and FR clothing tests to convince workers of the need to follow these important safety rules.

Topics include safe electrical work conditions, energized electrical work permits, approach boundaries, the Incident Energy Level, the Arc Flash Protection Boundary, hazard risk categories and arc-rated clothing and PPE requirements.

SHOOTING LOCATION: A variety of industrial environments where electrical work is conducted

PROGRAM OBJECTIVES:

- How to create an electrically safe work condition;
- When energized work is permitted and when an energized electrical work permit is required;
- What the three approach boundaries are and what tools and protective equipment each requires;
- How to determine the Incident Energy Level and the Arc Flash Protection Boundary;
- What PPE and clothing are required when performing tasks in each of the five hazard risk categories;
- How to properly dress to achieve arc flash protection.

INSTRUCTIONAL CONTENT:

BACKGROUND

- Qualified electrical workers are exposed to a wide variety of electrical equipment and systems, and their work is critical to the successful operation of their facility.
- Electrical work can be dangerous. Each year, electrical and maintenance workers, as well as unqualified co-workers, are injured or killed from contact with energized parts or burns from arc flash incidents.
- 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.

REQUIREMENTS OF NFPA 70E

- NFPA 70E uses several strategies to facilitate worker safety. First is the requirement that workers be properly qualified for the work being performed.
- Next, it is required that work be performed under electrically safe conditions whenever feasible and when creating an electrically safe working condition is not feasible, following prescribed safe work practices.
- These work practices include restricting access with barricades and signs, establishing various approach boundaries and requiring specific protective equipment for electric shock and arc flash hazards.
- Finally, NFPA 70E includes job planning requirements, which include hazard analysis, job briefings and energized work permits.

DEFINITION OF A QUALIFIED WORKER

- The 2009 definition of a qualified person is as follows: "A qualified person shall be trained and knowledgeable of the construction and operation of the equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to the equipment or work method."
- The term "recognize and avoid the electrical hazards" reflects a change from prior editions. This definition requires a qualified worker to have a master of the following skills and knowledge: a) the ability to determine nominal voltage; b) an understanding of required approach distances for electrical shock and burn hazards; c) an ability to distinguish exposed energized conductors and circuits from other parts of equipment; and, d) selection and use of personal protective equipment for both shock protection and arc flash protection.
- It's important to note that OSHA makes a distinction between low-voltage and high-voltage qualified electrical workers. OSHA defines high-voltage as being above 600 volts; just remember that if you are not high-voltage qualified, 600 volts is your cut-off voltage.
- Also, understand that workers can be "task qualified," meaning they are qualified with respect to specific equipment or methods, but remain unqualified for other electrical tasks.
- Working beyond your level of qualification or on unfamiliar equipment places you and others at risk.

TWO MAIN HAZARDS OF ENERGIZED ELECTRICAL EQUIPMENT

- There are two main hazards presented by energized electrical equipment. First, direct contact or coming too close to exposed live parts can lead to an electric shock.
- The second is exposure to the sudden, often-violent release of energy associated with an electric arc, called an arc flash.
- An arc flash releases a huge amount of energy and can reach temperatures up to 35,000 degrees, causing significant damage to anything in its path, including you.

- The 2009 NFPA redefined an arc flash hazard as “a state that occurs when exposed energized parts are present or when interacting with a piece of equipment could cause an arc flash.” This means that switching or device operation is considered an arc flash hazard.

SAFE ELECTRICAL WORKING CONDITIONS

- NFPA 70E contains safe electrical work practices that when followed, will reduce the risk of both shock and burn hazards. By far, the most effective safe work practice, and always the first choice, is to remove the hazard by creating an electrically safe working condition.
- 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, determine all possible sources of electricity supplied to the equipment.
- Disconnect any active loads, then open then disconnecting device for each source.
- Visually verify, if possible, that all blades of the disconnecting devices are fully open or that draw-out type circuit breakers are withdrawn to the fully-disconnected position.
- Apply lockout/tagout devices to the open disconnecting devices in accordance with your facility’s lockout/tagout procedures.
- Finally, the most important part: testing to verify that no voltage exists. Workers who assume that their lockout was successful but fail to confirm it are often shocked to find out otherwise.
- Immediately prior to voltage testing, verify that the voltmeter is functioning properly by measuring a known voltage device.
- Then test each phase conductor or circuit part, both phase-to-phase and phase-to-ground to verify no voltage is present.
- Then test your meter again on a known voltage source. 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 you are testing. Exceeding a meter’s rated voltage can lead to a serious incident.
- Until you have verified the existence of an electrically safe working condition, the equipment must be considered energized and all electrical safe work practices must be followed, including establishing approach boundaries, using appropriate insulated tools, voltage-rated shock protection and appropriate arc flash protection.
- Once an electrically safe work condition is created, however, no electrical hazards exist and shock and arc flash protection are no longer necessary.

WHEN ENERGIZED WORK IS PERMITTED

- NFPA 70E requires an electrically safe work condition be created unless it is not feasible to do so. The regulations allow energized work to be performed under the following 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, it shall only be done with an approved work permit.

ENERGIZED ELECTRICAL WORK PERMITS

- Known as an “Energized Electrical Work Permit,” its purpose 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 and a description of the safe work practices to be employed.
- Also included are 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 protection boundary is included.
- The permit also lists the means used to restrict the access of unqualified persons from the work area and evidence of the completion of a job briefing, which includes any job-specific hazards.
- Finally, it will include the signature of an authorized member of management who approves the work to be performed while energized.
- There are specific exceptions to the requirement for an energized electrical work permit. An addition to the 2009 regulation allows a visual inspection to be performed with no permit if the restricted approach boundary is not crossed; other exceptions include 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 distance from an energized part to each of these boundaries increases as the 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.
- The boundary farthest away from the energized part is the Limited Approach Boundary; the next boundary is the Restricted Approach Boundary; and, the boundary closest to the energized part is the Prohibitive Approach Boundary.

- These boundaries are listed in NFPA Table 130(2)(C). Qualified electrical workers must be able to determine these distances for the equipment on which they work.

The Limited Approach Boundary

- The Limited Approach Boundary is established to keep unqualified persons a safe distance from exposed live parts. For example, the Limited Approach Boundary for a fixed circuit part 750 volts and below is three feet, six inches.
- 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 escorted by a qualified person.
- In addition, only insulated tools may be carried beyond the Limited Approach Boundary.

The Restricted Approach Boundary

- Moving closer to energized parts and crossing the Restricted Approach Boundary requires you to be a qualified person and have a written work plan.
- You must use insulated tools and you must wear all required equipment, including rubber-insulating gloves.
- Here's a common example: for voltage testing 120-volt control circuits, Table 130(2)(C) lists the Restricted Approach Boundary up to 300 volts as "avoid contact."
- Testing is considered "touching;" therefore, voltage testing control circuits requires the use of rubber-insulating gloves.
- When using rubber-insulating gloves, always wear leather protectors to avoid damaging the glove.
- 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.

The Prohibited Approach Boundary

- 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.
- This includes wearing all required protective equipment and using insulated tools as well as having an energized electrical work permit with management approval.

ARC FLASHES

- 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 screwdriver, leading to a flashover.
- Up to 80 percent of all electrical injuries are burns, resulting from an arc flash and made 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.
- Arc-rated clothing, sometimes called FR or flame-resistant clothing, is designed to withstand the intense heat of an arc blast without bursting into flames.
- Clothing that is not arc-rated, even 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.

THE INCIDENT ENERGY LEVEL & ARC FLASH PROTECTION BOUNDARY

- The amount of heat energy available to burn you during an arc flash is called the Incident Energy Level and is measured in calories per calories/cm². The amount of heat energy that will just cause a second-degree burn on unprotected skin is 1.2 calories/cm².
- The Incident Energy Level at any distance from the arc source can be calculated by performing an arc flash analysis using the methods described in NFPA 70E Annex D.
- The Arc Flash Protection Boundary is established at the distance from a potential arc source at which the Incident Energy Level is determined to be 1.2 calories/cm². In other words, the Arc Flash Protection Boundary is the distance from an arc source where an unprotected worker will just receive second-degree burns.
- The Incident Energy Level of an arc flash is limited by the amount of available fault current, measured in thousands of amps or "kA" and the time it takes to trip any current-limiting devices such as circuit breakers and fuses is measured in cycles. For a 60-hertz electrical system, a cycle is one-sixtieth of a second.
- For 60-volt systems where the product of available fault current and clearing time is 100,000 amp-cycles or less, the NFPA 70E establishes an Arc Flash Protection Boundary of four feet. This 100,000 amp-cycle parameter is a standard change for the 2009 70E.
- For systems greater than 600 volts or those that exceed 100,000 amp-cycles, an arc hazard analysis must be performed to determine the Arc Flash Protection Boundary.
- In most instances, the Arc Flash Protection Boundary is the outermost of all approach boundaries and should be marked with red "Danger-Keep Out" barricade tape and hazard signage.
- Again, for conforming systems up to 600 volts, the Arc Flash Protection Boundary is four feet. Any worker crossing this boundary must be qualified and wear appropriate arc flash protection.
- Remember that the Incident Energy Level of an arc flash is measured in calories/cm². The effectiveness of arc-related clothing and equipment is also measured in calories/cm².
- Arc-rated clothing and protective equipment is selected to meet or exceed the Incident Energy Level of any potential arc flash.

HAZARD RISK CATEGORIES

- To help workers select clothing and other PPE for arc flash protection, the NFPA has established Hazard Risk Categories. Each Hazard Risk Category requires a specific level of arc flash protection, measured in calories/cm², as well as other protective equipment.

- The NFPA has also calculated Hazard Risk Category for common electrical job tasks and listed them in table 130.7(C)(9) for easy reference. Before using this table, be sure your electrical equipment meets the parameters listed in the footnotes of this table.
- A change to the 2009 NFPA 70E requires that equipment be field labeled with either the Hazard Risk Category or the calculated incident energy at a defined working distance. Having this critical information readily available makes selecting proper arc-rated PPE easier for electrical workers.
- Of course, not all equipment is yet labeled in this manner, so Hazard Risk Categories and selection of proper PPE is a critical part of any job briefing and written work plan.
- When equipment is labeled with PPE requirements as determined by an arc flash study, wear the PPE required by the label or follow your company's policies.

Hazard Risk Category Zero

- A common example of a Category Zero job task is operating a circuit breaker or fused switch with the door closed.
- 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 includes long sleeves and long pants.
- Other PPE required includes safety glasses, hearing protection and leather gloves.
- When performing a switch of a circuit breaker or fuse, don't become complacent; remember the left-hand rule. Stand to the side, take a deep breath and hold it, then operate the switch with your left hand.
- You'll be glad you did if the switch triggers an arc flash. Holding an inhaled breath will prevent you from inhaling superheated air during an arc flash, which can burn your lungs.

Hazard Risk Category One

- Some common Category One job tasks include operating a 480-volt fused switch with the door open and testing 120-volt control circuits.
- Hazard Risk Category One requires arc-rated clothing of four calories/cm², a dielectric hardhat and an arc-rated face shield or flash hood. Also required are safety glasses, hearing protection and leather gloves or rubber-insulated gloves with leather protectors.
- The arc-rated face shield requirement is a standard change for 2009. Be sure to select an arc-rated face shield; a standard face shield will not withstand an arc blast. It can burn and melt, causing additional injury.

Hazard Risk Category Two

- An example of a Hazard Category Two job is operating a 13.8 kilovolt switch with the door closed or performing non-contact inspections of 600-volt equipment without crossing the Restricted Approach Boundary.
- Job tasks rated as Hazard Risk Category Two require eight calories/cm² of arc flash protection with a dielectric hardhat and an arc-rated face shield or flash hood.
- The most common dielectric hardhat is Class E and is rated for 20,000 volts and are designed for electrical work; flash suit hoods must contain a rated dielectric E hardhat.
- Also required are safety glasses, hearing protection and leather gloves or rubber-insulated gloves with leather protectors.
- Certain jobs are assigned a Hazard Risk Category 2* (asterisk). This Hazard Risk Category requires the same protection as Category 2 with additional face protection in the form of an eight calories/cm² "sock hood" or an arc-rated flash hood.
- An example of a Hazard Risk Category 2* job is voltage testing equipment rated between 240 volts and 600 volts.

Hazard Risk Category Three & Four

- Hazard Risk Category Three requires a minimum of 25 calories/cm² arc-rated protection and Hazard Risk Category Four requires a minimum of 40 calories/cm² arc-rated protection.
- These categories also require an arc-rated flash hood over a properly-rated dielectric hardhat, safety glasses, hearing protection, leather work shoes and arc-rated gloves or rubber-insulated gloves with leather protectors.
- An example of a Hazard Category Three job task is opening hinged covers to expose bare energized parts on equipment rated between one kilovolt and 38 kilovolts.
- An example of a Hazard Category Four job task is inserting or removing circuit breakers on equipment rated between one kilovolt to 38 kilovolts.
- For ease of PPE selection and cost-savings, many facilities only use Category Two or Category Four PPE. At these facilities, 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.
- You should note that the NFPA 70E standard requires a proper hazard analysis. Using the 70E tables to select PPE is only acceptable if an engineering study has determined the equipment meets the table footnote requirements. For non-conforming systems, an arc flash calculation must be performed to determine the proper protective equipment and Arc Flash Protection Boundary.

DRESSING 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 Annex M for the proper way to calculate your total calories of protection when layering.
- An important change for 2009 is that non-FR material, even 100 percent cotton, cannot be counted toward your total level of protection.
- Your outermost layer of clothing must be made of FR material. Make sure your outer layers are completely buttoned so under layers are not exposed.
- All under layers of clothing should be 100 percent natural fibers like cotton or wool. Never wear synthetic materials such as polyester or nylon.
- Also, do not wear any conductive material such as rings, watches or earrings. These items are not only shock hazards, but can cause serious burn injury when superheated by an arc flash.