SAFETY SERVICES COMPANY®

STUDENT EDITION

DO-IT-YOURSELF

ARC FLASH

TRAINING PROGRAM

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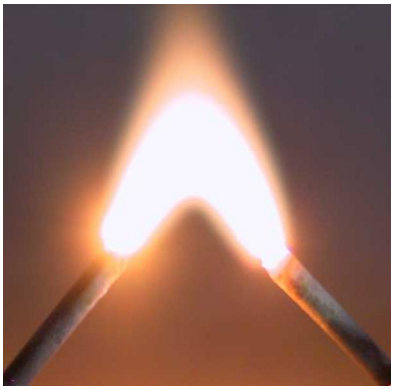
SECTION 1 INTRODUCTION

Arc flash prevention is specific training intended for both qualified and unqualified workers who may be exposed to the hazards of accidental electrical discharges from equipment or other power sources. Before completing this training all employees should successfully complete a general electrical safety training course.

A) What is Arc Flash?

Arc flash is the light and heat produced by the release of energy from an electric arc. Arc blast is the explosion and pressure wave created by that arc.

An arc occurs any time electricity bridges the gap between an energized conductor and another material. It can be minor or major, and can be caused by:



- Dust
- Dropping tools
- Accidental touching
- Condensation
- Material failure
- Corrosion
- Faulty Installation

A typical arc flash event is over in about a half a second, but the concussive forces it creates can result in internal injuries and severe hearing damage.

The energy of an arc flash is measured in calories per square centimeter (Cal/cm^2). The potential of this energy is used to determine the level of PPE-rated clothing and approach distance boundaries required when working around energized equipment. PPE is required and arc flash boundaries start where the potential is 1.2 Cal/cm^2. This amount of energy will create a second-degree burn on bare skin.

Three factors affect the severity of an arc flash. The combination of these will establish the intensity of the flash and the potential of injury. These factors are:

- Fault current - The amount of current available at the source of the incident
- Arcing time - The length of time it takes for a protective device to interrupt the current flow
- Distance - How far a worker is from the source of the flash

These factors are key considerations when an arc flash risk assessment is performed.

B) Why is Protection Needed?

The light and heat produced by an arc flash are capable of causing substantial damage, fire, or injury.

When an uncontrolled arc forms at high voltages, arc flashes can produce deafening noises, supersonic concussive-forces, super-heated shrapnel, and temperatures greater than the surface of the sun. The power of an arc blast is capable of vaporizing nearby materials.

In some cases, the pressure wave has sufficient energy to snap the heads of 3/8-inch steel bolts and to knock over construction walls. An arc blast can cause the following injuries:

- Injuries from large shock waves that can blow personnel off their feet
- Large shock waves that can blow personnel off their feet
- Loss of memory or brain function from concussion
- Hearing loss from ruptured eardrums. The sound associated with the blast can greatly exceed the sound of a jet engine
- Exposure risks from flying debris. For example, shrapnel wounds from metal parts
- Shock hazard due to touching energized conductors
- Other physical injuries from being blown off ladders, into walls, etc.

The energy released by an arc flash rapidly vaporizes the metal conductors involved, blasting molten metal outward with extraordinary force. A typical arc flash incident can be inconsequential but could produce a more severe explosion, and cause the destruction of equipment, fire, and injury—not only to an electrical worker but also to bystanders.

While Federal OSHA does not have regulations that specifically address arc flash, regulations regarding power generation and personal protective equipment (PPE) include information on dealing with electrical power hazards.

The primary standards covering arc flash come from the National Fire Protection Association (NFPA), and the Institute of Electrical and Electronics Engineers (IEEE). If an OSHA regulation is more demanding than NFPA or IEEE, OSHA’s will be followed.

This Arc Flash training incorporates changes included in the new National Fire Protection Agency (NFPA) 70E 2015 standard.

C) When is Arc Flash Protection Required?

During an arc flash, electrical energy vaporizes the metal, which changes from solid state to gas vapor, expanding it with explosive force. For example, when copper vaporizes it suddenly expands by a factor of 67,000 times in volume.

In addition to the explosive blast, called the arc blast, the intense heat produced by the arc also causes damage. The metal plasma arc produces tremendous amounts of light energy. Nearby objects, including people, absorb this energy and are instantly heated to vaporizing temperatures.

Dangers of Arc Flash

- An arc flash can cause minor injuries, third degree burns and potential death as well as other injuries including blindness, hearing loss, nerve damage and cardiac arrest
- Fatal burns can occur when the victim is several feet from the arc. Serious burns are common at a distance of 10 feet
- The temperature at the source of an arc flash can reach 35,000° F or about four times the temperature of the surface of the sun
- Arcs spray droplets of molten metal and shrapnel can be propelled at a high speed and can penetrate the body 10 feet away.
- Blast pressure waves have thrown workers across rooms and knocked them off ladders. Pressure on the chest can be higher than 2000 lbs. /sq. ft.
- Clothing can be ignited several feet away. Clothed areas can be burned more severely than exposed skin

D) Arc Flash Incident Causes

An arc flash happens when electric current flows through an air gap between conductors. Accidents caused by touching a test probe to the wrong surface or slipped tool are the most common cause of an arcing fault.

Generally, there are three main causes of arc flashes:

- **Human error –** unsafe work procedures, maintenance mistakes, and mishandling tools, wires and metal covers
- **Negligent preventive maintenance –** not checking for loose termination, allowing dust and debris build-up (critical in medium voltages and higher), and not testing stored energy (e.g. spring-operated bolted pressure switches)
- **Improper electrical equipment/system design –** incorrect modifications or using older equipment that doesn't meet current arc flash standards

The most common cause of arc flash accidents is human error. Regardless of how much electrical experience the employee may have, phase-to-phase and phase-to-ground contact often happens because an employee is distracted while performing energized work. Another typical cause is failure to use an insulated tool. Other factors include dropping conductive items into the enclosure (for example, panel board screws), the accumulation of conductive dust inside the enclosure and simple equipment failure.

The majority of arc flash incidents involve 480VAC three-phase enclosures. Control panels, disconnects, buss switches, motor control centers, and switchgear are the common locations of these types of accidents.

E) Electrical work

Only a qualified person may perform work where there is a risk of arc flash. OSHA defines a "qualified" person as “someone who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installation and the hazards involved."

OSHA regulations

Both workers, and supervisors who have electrical workers on their shift are required to have training in the OSHA regulations and must understand them. Not only do qualified electrical workers require this training, but also their supervisors need the same training so they understand the problems and issues faced by working on or near exposed, energized electrical conductors and parts.

Workers that OSHA would consider unqualified also need some level of safety training. Painters, janitors, helpers, apprentices, and any other worker who may come in contact with equipment that could be exposed and energized will require electrical safety training. Mostly, this training consists of being made aware of the hazards and how to avoid them (where not to put your fingers or that aluminum paint roller extension, for example).

F) Responsibilities

Employer Responsibilities

The “Employer” is responsible for:

- Meeting all OSHA, NFPA, and/or IEEE requirements
- Developing and maintaining a company electrical safety program
- Defining and enforcing company safety policies and procedures
- Conducting all necessary safety training and retraining

Employee Responsibilities

Employees must follow the requirements of the Arc Flash Hazard label by wearing the proper personal protective equipment (PPE), using the proper insulated tools and other safety-related precautions. This includes not working on or near the circuit unless you are a “qualified” worker.

Qualified Person

A qualified person will 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.

- Such persons must also be familiar with the proper use of the special precautionary techniques, applicable electrical policies and procedures, PPE, insulating and shielding materials, and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others.
- Such persons permitted to work within the limited approach boundary will, at a minimum, be additionally trained in all of the following:
  - Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment
  - Skills and techniques necessary to determine the nominal voltage of exposed, energized electrical conductors and circuit parts
  - Approach distances specified and the corresponding voltages to which the qualified person will be exposed
- Decision-making process necessary to be able to do the following:
  - Perform the job safety planning
  - Identify electrical hazards
  - Assess the associated risk(s)
  - Select the appropriate risk control methods from the hierarchy of controls, including personal protective equipment
- An employee who is in training for the purpose of obtaining the skills and knowledge necessary to be considered a qualified person, who in the course of such training demonstrates an ability to perform specific duties safely at his or her level of training, and who is under the direct supervision of a qualified person, will be considered to be a qualified person for the performance of those specific duties
- Tasks that are performed less than once per year will require retraining before the performance of the work practices involved
- Employees will be trained to select an appropriate test instrument and must demonstrate how to use a device to verify the absence of voltage, including interpreting indications provided by the device. The training must include information that enables the employee to understand all limitations of each test instrument that might be used
- The employer will determine, through regular supervision or through inspections conducted at least annually, that each employee is complying with the safety-related work practices required

Unqualified Persons

An unqualified worker is defined as one who has not had training, or does not possess the experience with the equipment, systems, and/or voltage to be permitted to perform the work alone.

G) Electrical Training

The company is responsible for ensuring the following training requirements are met.

Training for Qualified Persons

Qualified persons (i.e. those permitted to work on or near exposed energized parts) must, at a minimum, be trained in and familiar with the following:

- The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment
- The skills and techniques necessary to determine the nominal voltage of exposed live parts
- Qualified electrical worker safety training needs to include such items as electrical hazard awareness, the applicable OSHA regulations, use of PPE and equipment, conducting a Hazard/Risk Analysis, and the NFPA 70E.

Training for Unqualified Persons

All employees are required to have completed basic electrical safety training, and be knowledgeable on the potential electrical hazards associated with their jobs.

Retraining

Retraining in safe work practices and changes to standards will be performed at least every three years. An employee will receive additional training (or retraining) if any of the following conditions exists:

- Supervision or annual inspections indicate that the employee is not complying with the safety-related work practices
- New technology, new types of equipment, or changes in procedures require using new or revised safe work practices
- The employee must use safety-related work practices that are not normally used during his or her regular job duties

OSHA regulations and NFPA-70E standards mandate all equipment operating at 50 volts and higher must be tested for electrical shock and potential Arc Flash Hazards (AFH).

To work on any energized equipment above 50 volts, an energized work permit is required. A work permit is critical and cannot be bypassed by simple labeling. Employers are directly responsible for work permitting, safety programs, training, and planning.

H) Emergency Response Training

First Aid, Emergency Response, and Resuscitation

Employees responsible for responding to medical emergencies must be trained in first aid and emergency procedures, cardiopulmonary resuscitation (CPR), and the use of an automated external defibrillator (AED) if an employer's emergency response plan includes the use of this device. Refresher training shall occur annually.

l) Contact Release Training

Employees who may exposed to shock hazards will be trained in methods of how to safely release victims from contact with exposed energized electrical conductors or circuit parts. Refresher training shall occur annually.

Electric Shock

When exposed to an energized electrical conductor and the electricity courses through their body, it can cause their muscles to contract and they “freeze” onto the electrical source and are unable to let go.

Identify the Hazard

Workers need to know if they are working in an area with an identified electrical shock hazard. Before working where a shock hazard exists, both qualified and non-qualified electrical personnel need to discuss the locations of the hazards and where they can disconnect the circuit (e.g. disconnect switch, circuit breaker, main breaker, etc.).

If a safe work permit is necessary (e.g. Confined Space, LOTO) then these hazards and their controls will be identified on the permit and discussed with affected employees.

First Turn Off the Power

The first option is to turn off the power at the source (e.g. disconnect switch, circuit breaker, main breaker, etc.). Then immediately initiate the emergency response as required by your site’s Emergency Action Plan, and start first aid or CPR according to and within your training until emergency response arrives.

Releasing the Victim

If the power can’t be disconnected quickly, the second option is to safely and forcibly release the victim. This may mean dislodging, hitting, or prying the victim with a nonconductive material, while remaining in a safe location.

First, examine the scene and look for possible areas of stored electrical energy, fire and hot surfaces and avoid them. Ideally your hands and feet should be dry, you are wearing protective equipment, and standing on a clean dry non-conductive surface like a rubber blanket or other insulating material.

Then knock, pry, or drag the victim from the conductor with nonconductive material such as: hot stick, shotgun sticks, nonconductive rope, insulated extension cord, insulated tool, wooden board, or nonconductive conduit. For example loop the cord around their body and pull strong enough to break their grip.

First Aid

Check for breathing and pulse, and if necessary administer CPR or use an AED, according to your level of training, until emergency personnel arrive.

Even if conscious, victims need professional help. They could also suffer heartbeat irregularities or a heart attack up to several hours later even if the shock isn’t enough to immediately disrupt the heartbeat.

J) Quiz

1. Arc flash is the light and heat produced by the release of energy from an electric arc.

   A) True
   B) False

2. What is the incident energy analysis used for?

   A) To determine the location of an arc flash boundary
   B) To determine the level of PPE required
   C) To determine the location of a restricted area boundary
   D) To identify the source of an arc flash

3. What is the most common cause of arc flash incidents?

   A) Equipment failure
   B) Poor maintenance
   C) Outdated equipment
   D) Human error

4. Which of the following is NOT an arc flash related injury?

   A) Burns
   B) Hearing damage
   C) Hypoxia
   D) Blindness

5. Someone who is authorized to perform electrical work on energized circuits is called a ____?

   A) Journeyman electrician
   B) Apprentice electrician
   C) Qualified person
   D) Master electrician

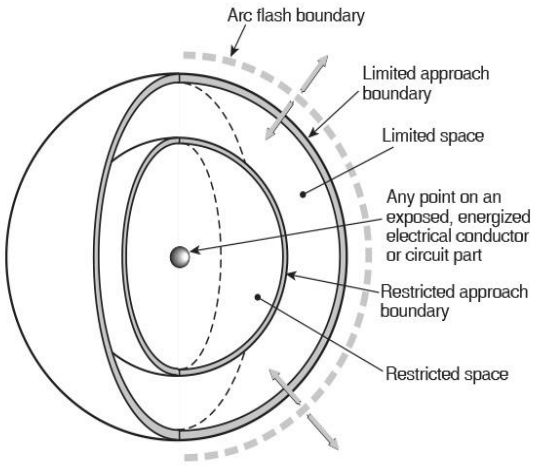
SECTION 2 ARC FLASH BASICS

All workers who may be exposed to the risk of arc flash while working on or around electrical energy need to understand the standards and regulations associated with the hazards of arc flash.

A) Arc Flash Boundary Zones

There are three arc flash boundaries defined by the NFPA 70E -2015 regulation. These apply to all workers, qualified or not. They are:

- Arc Flash boundary (outer boundary)
- Limited approach boundary
- Restricted Approach boundary



Arc Flash Boundary

The flash boundary is the farthest established boundary from the energy source. If an arc flash occurred, this boundary is where an employee would be exposed to a curable second-degree burn.

Limited Approach Boundary

The limited approach boundary may only be entered by qualified persons or unqualified persons that have been advised, and are escorted by a qualified person.

Restricted Approach Boundary

Only qualified persons may approach, or take any conductive object, into the restricted area. No conductive articles may be worn within the restricted area if they could create an electrical contact hazard.

No employee may come closer to exposed energized electrical conductors or circuit parts operating at 50 volts or more than the established restricted approach boundary, unless one of the following conditions applies:

- The qualified person is insulated or guarded from the energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves or insulating gloves and sleeves are considered insulation only with regard to the energized parts on which work is being performed
- The energized electrical conductors or circuit parts operating at 50 volts or more are insulated from the qualified person and from any other conductive object of a different potential
- The qualified person wears approved arc flash protective equipment to prevent contact with energized equipment or any other conductive object

B) Recognizing hazards

Most electrical workers have no idea how to assess the hazard, much less, how to assess the risk associated with the task. Both are critical for worker safety. Evaluating the voltage hazard is fairly straightforward. The nominal voltage (system design voltage) determines the glove class.

Evaluating the arc flash hazard is simple if the system has had an arc flash study performed on it. The arc flash protection boundary and incident energy at working distance will be listed on the label.

If no arc flash study has been done, the tables in NFPA 70E standard can be used to choose PPE and equipment. Be certain to use the notes at the end of the tables, however, or the PPE you choose may be inadequate for the hazard.

How do you evaluate the risk? The incident energy listed on the arc flash label or the arc-rated PPE and clothing specified in 70E are both based on three things:

- Equipment that is properly designed and engineered
- Equipment that is properly installed in accordance with all applicable codes and standards
- Equipment that is properly maintained

If any of these conditions are not met, the actual incident energy risk the worker could face is unknown. Maintenance is too easy to put off, either due to cost cutting or lack of problems.

Incident energy is proportional to time. If the time of exposure is doubled, the incident energy received by a worker doubles. Improper maintenance of circuit breakers is one primary reason the time of exposure could increase. If a circuit breaker should operate in no more than 4 cycles, but it operates in 8 cycles, the arc rating of your PPE is going to be less than it needs to be.

Other items that affect performing tasks where arc flash is a risk are:

- Equipment condition
- Equipment age
- Equipment configuration
- Environment
- Loading
- Lack of maintenance
- Equipment operating history
- Any other factor that may contribute to improper operation

C) PPE

In addition to standard PPE such as hard hats, hearing protection, and safety eyewear, employees working in areas where electrical hazards are present must be provided with and use protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed.

Arc Flash PPE

Employees, who are working within the restricted approach space, must wear their PPE as defined in the NFPA standard. When employees are working within the arc flash boundary, they must wear protective clothing and other PPE that protects all parts of the body inside the arc flash boundary.

Common arc rated PPE requirements include:

- Shirts must be tucked into pants and fastened at the wrist and collar
- An arc flash balaclava (hood) is required where incident energy is more between 1.2 to 12 calories/cm^2
- Non-melting clothing is required
- Non-AR clothing worn under AR clothing must be made of all-natural non-melting fibers

The PPE provided to employees must meet the following criteria:

- Movement and Visibility - Arc-rated clothing must cover all ignitable clothing and allow for movement and visibility
- Head Protection may consist of either an arc-related balaclava or hood
- An arc-rated balaclava will be used with an arc-rated face shield when the back of the head is inside of the arc flash boundary
- An arc-rated hood must be used when the expected incident energy exposure exceeds 12 cal/cm2. When exterior air is supplied into the hood, the air hoses and pump housing must be either covered by arc-rated materials or constructed of non-melting and non-flammable materials.
- Arc flash face protection consists of a face shield that has an arc rating suitable for the flash hazard. The face shield should have a wraparound guarding to protect the face, shin, forehead, ears, and neck area. Face shields without an arc rating may not be used. Always wear eye protection (safety glasses or goggles) under face shields or hoods
  - If employees use hairnets or beard nets, or both, these items must be arc rated
- Eye Protection - Employees will wear eye protective equipment whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion
- Hearing Protection - Employees must wear hearing protection whenever working within the arc flash boundary
- Body Protection - Employees will wear arc-rated clothing wherever there is possible exposure to an electric arc flash above the threshold incident energy level (1.2 cal/cm_2).
- Hand and Arm Protection - Hand and arm protection will be worn where:
  - There is a danger of hand and arm injury from electric shock due to contact with energized electrical conductors or circuit parts. Rubber insulating gloves must be rated for the voltage for which the gloves will be exposed
  - There is a danger of hand and arm injury from arc flash burns
- Arc flash hand protection should consist of either heavy-duty leather gloves or insulating rubber gloves. When insulating rubber gloves are used for shock protection, leather protectors must be worn over the rubber glove.
- Foot Protection - When insulated footwear is required as protection against step and touch potential hazards, dielectric footwear is required. Insulated soles may not be used as primary electrical protection

Arc Rated Protective Equipment

Arc Flash Suits must be quickly and easily removable. The entire arc flash suit, including the hood's face shield, must have an arc rating that is suitable for the expected arc flash exposure.

Head Protection may consist of either an arc-rated balaclava or hood.

- An arc-rated balaclava will be used with an arc-rated face shield when the back of the head is within the arc flash boundary
- An arc-rated hood must be used when the expected incident energy exposure exceeds 12 cal/cm$_2$. When exterior air is supplied into the hood, the air hoses and pump housing must be either covered by arc-rated materials or constructed of non-melting and nonflammable materials

Arc flash face protection consists of a face shield that has an arc rating suitable for the arc flash exposure. The face shield should have a wraparound guarding to protect the face, chin, forehead, ears, and neck area. Face shields without an arc rating may not be used. Always wear eye protection (safety glasses or goggles) under face shields or hoods.

Arc flash hand protection should consist of either heavy-duty leather gloves or insulating rubber gloves. When insulating rubber gloves are used for shock protection, leather protectors must be worn over the rubber gloves.

Foot protection should consist of heavy-duty leather footwear that provides arc flash protection to the feet and when exposure is greater than 4 cal/cm^2.

PPE Categories

The 2015 NFPA standard has revised the PPE (hazard/risk) categories, eliminating category 0 because the new PPE table only specifies PPE for work within the arc flash boundary. If there is no arc flash hazard, then no arc flash PPE is required.

The following table is a summary of the NFPA 70E PPE categories. For complete information, refer to the table included in the NFPA standard.

PPE Category	As Needed (AN) Optional	As Required (AR)	Selection Required (SR)
1 (Minimum Arc rating of 4 cal/cm^2)	Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner	Hard hat Hearing protection Heavy duty leather gloves Leather footwear	Safety glasses or goggles
2 (Minimum Arc rating of 8 cal/cm^2)	Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner	Hard hat Hearing protection Heavy duty leather gloves Leather footwear	Safety glasses or goggles
3 (Minimum Arc rating of 25 cal/cm^2)	Arc-rated jacket, parka, rainwear, or hard hat liner	Arc-rated long-sleeve shirt and pants or Arc-rated coverall Arc-rated arc flash suit jacket, pants, and hood Arc-rated gloves Hard hat Hearing protection Heavy duty leather gloves Leather footwear	Safety glasses or goggles
4 (Minimum Arc rating of 40 cal/cm^2)	Arc-rated jacket, parka, rainwear, or hard hat liner	Arc-rated long-sleeve shirt and pants or Arc-rated coverall Arc-rated arc flash suit jacket and pants Hard hat Hearing protection Heavy duty leather gloves Leather footwear	Safety glasses or goggles

Care of Arc Flash PPE

Arc flash PPE must be maintained in a safe, reliable condition. The protective equipment must be visually inspected before each use and immediately following any incident that can reasonably be suspected of having caused damage.

Work clothing or arc flash suits that are contaminated or damaged to the extent that their protective qualities are impaired must not be used. Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials may not be used.

- The PPE must be stored in a manner that will prevent damage from harmful conditions, such as moisture, dust, or contamination from flammable or combustible materials
- Insulating gloves shall be given an air test, along with the inspection
- Electrical protective equipment shall be subjected to periodic electrical tests
- Always follow the manufacturer's instructions for the care and maintenance of arc-rated apparel
- When arc-rated clothing is cleaned, always follow the manufacturer's instructions to avoid loss of protection. Arc-rated clothing loses its protective properties over time due to wear and cleaning
- When arc-rated clothing is repaired, the same arc-rated materials used to manufacture the arc-rated clothing must be used to provide repairs

Factors for Selecting Protective Clothing

Clothing and equipment that provide worker protection from shock and arc flash hazards will be used. If arc-rated clothing is required, it must cover any parts of the body that may be exposed to the hazard, as well as all flammable apparel while allowing movement and visibility.

Clothing and equipment required for the degree of exposure will be permitted to be worn alone or integrated with flammable, non-melting apparel. Garments that are not arc-rated are not permitted to be used to increase the arc-rating of a garment or of a clothing system.

- Layering
  - Non-melting, flammable fiber clothing may be used as under layers in conjunction with arc-rated garments in a layered system
  - If non-melting, flammable fiber clothing is used as under layers, the system arc rating must be sufficient to prevent breakopen of the innermost arc-rated layer to prevent ignition of flammable under layers
  - Clothing that is not arc-rated may not be used to increase the arc rating of a clothing system
- Outer Layers - Clothing worn as outer layers over arc-rated clothing, such as jackets or rainwear, must also be made from arc-rated material
- Under layers - Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex are not permitted as fabric under layers (underwear) next to the skin
- Coverage - Clothing will cover all potentially exposed areas as completely as possible. Shirt and coverall sleeves must be fastened at the wrists; shirts must be tucked into pants, and shirts, coveralls and jackets must be closed at the neck

Fit – Avoid wearing tight-fitting clothing. Loose fitting clothing provides additional thermal insulation because of air spaces. Arc-rated apparel should fit properly and not interfere with the work task.

Interference – Clothing should result in the least interference with the task but still provide the necessary protection. The work method, location, and task could influence your protective equipment selection.

D) Insulated Tools and Equipment

Always use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts where tools or handling equipment might make accidental contact.

Requirements for Insulated Tools

The following requirements shall apply to insulated tools:

- The tools must be rated for the voltages on which they are used
- Only use the proper tool for the job
- Inspect tools and equipment before each use. Look for damage to the insulation or damage that can limit the tool from performing its intended function

Additional Tools and Equipment

Always use fuses or fuseholder handling equipment that is designed for the circuit voltage to remove or install a fuse if the fuse terminals are energized.

Ropes and handlines used within the limited approach boundary of exposed energized electrical conductors, or used where an electrical hazard exists, must be nonconductive.

Fiberglass reinforced plastic rods and tubes used for live-line tools must meet the requirements of the applicable electrical codes and standards.

Portable ladders used where an employee or ladder could contact exposed energized electrical conductors or circuit parts must have nonconductive side rails. Nonconductive ladders must meet the applicable ANSI standards for ladders.

Protective shields, barriers, or insulating materials must be used to protect employees from shock, burns, or other electrically related injuries when they are working within the limited approach boundary. When normally enclosed energized conductors or circuit parts are exposed for maintenance or repair, they must be guarded to protect unqualified persons from contact with the energized conductors or circuit parts.

Rubber-insulating equipment used to protect workers from accidental contact with energized conductors or circuit parts must meet the ASTM standards.

Plastic guard equipment used to protect employees from accidental contact with energized conductors or circuit parts, or energized equipment or material from contact with the ground, will meet the ASTM standards.

Physical or mechanical (field-fabricated) barriers may not be installed any closer to the electrical hazard than the restricted approach boundary distance.

E) Alerting Techniques

Safety Signs and Tags

Safety signs, safety symbols, or accident prevention tags that meet ANSI standards must be used to warn employees about electrical hazards.

Barricades

Barricades, used in conjunction with safety signs, are required when it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts. Conductive barricades cannot be used where they might increase the chance of exposure to an electrical hazard. Barricades must not be placed any closer to the electrical hazard than the limited approach boundary. If the arc flash boundary distance is greater than the limited approach boundary, barricades may not be placed closer than the arc flash boundary.

Attendants

If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant must be positioned to warn and protect employees. The primary duty and responsibility of the attendant is to keep unqualified employees outside a work area where they might be exposed to electrical hazards. An attendant must remain in the area as long as there is a potential for employees to be exposed to the electrical hazards.

Look-Alike Equipment

When work is being performed on equipment that is de-energized in a work area with other energized equipment that is similar in size, shape, and construction, one of the alerting methods listed above must be used to prevent employees from accessing the lookalike equipment.

F) **Quiz**

1. Arc-rated clothing should be_____

   A) Tight fitting
   B) Made of nylon
   C) Made of polyester
   D) Loose fitting

2. Restricted approach boundaries must be established for all energized circuits operating at _____ or more.

   A) 25 volts
   B) 50 volts
   C) 120 volts
   D) 480 volts

3. Which is **NOT** considered an arc flash PPE device?

   A) Balaclava
   B) AR suit
   C) Respirator
   D) Safety glasses or goggles

4. Which is NOT an arc flash boundary?

   A) Arc flash boundary
   B) Limited access boundary
   C) Prohibited boundary
   D) Restricted boundary

5. Arc-rated clothing loses its protective characteristics due to wear and cleaning.

   A) True
   B) False

SECTION 3 SAFE PRACTICES

If it has been determined that de-energizing a circuit is not feasible, and the employee must work “hot”, the company will enforce the safety-related work practices to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts.

These safety-related work practices should include information on the following:

- Arc Flash Risk Assessment
- Job Briefing
- Energized Electrical Work Permit
- Written Safety Program

A) Arc Flash Risk Assessment

An arc flash risk assessment will be performed before permitting an employee to work on energized equipment. The results of the assessment must determine if an arc flash hazard exists. If an arc flash hazard exists, the risk assessment must identify:

- The appropriate safety-related work practices to be followed
- The arc flash boundary
- The PPE to be used within the arc flash boundary
- Be updated whenever a modification or renovation takes place, and reviewed at least every five years, to account for changes in the electrical distribution system that could affect the results of the arc flash risk assessment
- Take into consideration the design of the overcurrent protective device, its opening time and its condition of maintenance

A shock risk assessment will be conducted to:

- Determine the voltage that employees will be exposed to
- The boundary requirements
- The PPE necessary required to minimize the possibility of electric shock

A risk control process will be established to implement risk control according to a hierarchy of methods as follows:

- Elimination
- Substitution
- Engineering controls
- Awareness
- Administrative controls
- PPE

B) Planning and Preparation

Job Briefing

Before starting each job, the employee in charge must conduct a job briefing with the employees involved. The briefing will cover such subjects as hazards associated with the job, work procedures involved, special precautions, energy source controls, PPE requirements, and the information on the energized electrical work permit, if required. A planning checklist should be completed and reviewed at the briefing. Additional job briefings will be held if changes that might affect the safety of employees occur during the course of the work.

ENERGIZED ELECTRICAL WORK PERMIT

When energized work is required, an energized electrical work permit will be issued under the following conditions:

- When work is performed within the restricted approach boundary
- When the employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists

Elements of Work Permit

The energized electrical work permit must include, but not be limited to, the following items:

- Description of the circuit and equipment to be worked on and their location
- Justification for why the work must be performed in an energized condition
- Description of the safe work practices to be employed
- Results of the shock risk assessment including:
  - The voltage to which personnel will be exposed
  - The limited approach boundary
  - The restricted approach boundary
  - The personnel and protective equipment necessary to safely perform the assigned task
- Results of the arc flash risk assessment including:
  - Available incident energy at the working distance or arc flash PPE category
  - Necessary PPE to protect against the hazard
  - Arc flash boundary
- The means employed to restrict access by unqualified persons to the work area
- Records of completion of a job briefing, including a discussion of any job-specific hazards
- A copy of an energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s)

C) Safe Practices

The first rule of performing electrical work is to de-energize the circuit or equipment before beginning work. If de-energizing is not feasible, the proper safe practices and protective equipment must be used.

To ensure the safety of workers engaged in electrical work where arc flash hazards exist, the company's safe practices should be followed. The sections below provide information on the safe practices for the following:

- Insulation
- Labeling
- Guarding
- Barricades
- Ground Fault Circuit Interrupters (GFCI)
- Grounding (secondary protection)
- Testing
- Lockout/tagout

Insulation

Always use insulated tools, equipment, and required PPE when working on or around energized equipment.

Equipment Labeling

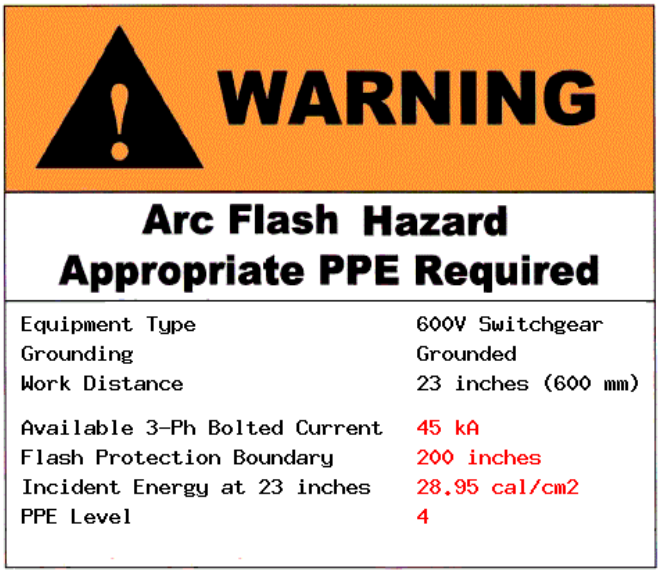
Each piece of equipment operating at 50 volts or more and not put into a de-energized state must be evaluated for arc flash and shock protection. This evaluation will determine the actual boundaries (i.e. prohibited, limited, restricted etc.) and will inform the employee of what PPE must be worn.

Once the evaluation is complete, an Arc Flash Hazard warning label must be attached to the equipment and easily visible to employees who may work on the energized equipment.

Minimum arc flash labels – example

Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized must be field-marked with a label containing all the following information:

- Nominal system voltage
- Arc flash boundary
- At least one of the following:
- Available incident energy and the corresponding working distance or
- Arc flash PPE category for the equipment
- Minimum arc rating of clothing
- Site-specific level of PPE



Detailed (preferred) arc flash label - example

Guarding

Always use protective shields, barriers, or insulating materials to protect yourself from shock, burns, or other electrically-related injuries when working inside the limited approach boundary. When normally enclosed energized conductors or circuit parts are exposed for maintenance or repair, they must be guarded to protect unqualified persons from contacting the energized conductors or circuit parts.

Barricades

Barricades will be used to prevent or limit employee access to work areas containing energized conductors or circuit parts. Do not use conductive barricades where they might increase the chance of exposure to an electrical hazard. Do not place barricades any closer to the electrical hazard than the limited approach boundary. If the arc flash boundary distance is greater than the limited approach boundary, barricades should be placed outside the arc flash boundary.

Ground Fault Circuit Interrupters (GFCI)

Ground fault circuit interrupters should be used whenever possible. GFCIs help protect you from electrical shock by continuously monitoring the circuit. However, a GFCI does not protect a person from line-to-line hazards such as touching two “hot” wires (240 volts) at the same time or touching a “hot” and neutral wire at the same time. Also, be aware that instantaneous currents can be high when a GFCI is tripped. A shock may still be felt.

Grounding

Use temporary (secondary grounds) whenever feasible to protect yourself from electrical hazards. Temporary protective grounds should be placed so that they do not expose employees to hazardous differences in potential. Grounds should be placed close enough to protect workers, but not so close that they can strike them if the grounds should become reenergized.

Never use components for personal protective grounds that are not sized or approved for that purpose such as welding cables and clamps or automotive jumper cables. If a short circuit current hits them, they can vaporize or get blown off the conductor. The resulting arc flash will certainly damage equipment and could cause a fire, injury, or death to nearby workers.

Testing

Always use live-dead-live testing when performing voltage tests. Test the voltage detector on a known live circuit, test all circuits that should be de-energized, and then retest the voltage detector on a known live circuit. Keep in mind that voltage detectors can go bad after an initial test.

Lockout/Tagout

When working with electricity, turning the equipment off is not enough. Someone could turn the equipment back on unaware of the work in progress, or there could be stored electrical energy in some electrical components even if the equipment is turned off.

Before working on the electrical equipment, de-energize all circuits, deactivate controls, and lockout and tagout all de-energized circuits and equipment in the *off* position. Only authorized personnel may perform lockout/tagout procedures.

Once the on/off switch is securely locked out, the switch must be tagged. The tag serves as a warning to let others know why the switch has been turned off.

In case only a tag system (tagout) is used to prevent the equipment to be re-energized, employers must train employees in the following limitations of tags:

- Tags are warning devices affixed to energy-isolating devices and do not provide physical restraint on those devices as the restraint provided by a lock
- When a tag is attached to an energy control device, it must not to be removed without authorization of the person responsible for attaching it, and should never be bypassed, ignored, or otherwise defeated
- Tags must be legible and understandable by all employees
- Tags and their methods of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace
- Tags can provide a false sense of security, so understanding their meaning is a critical part of the overall energy control program
- Tags must be securely attached to energy-isolating devices so that they cannot be inadvertently or accidentally detached during use

The tagout device must be a prominent warning device. The lock and the tag are warning signs. If you see equipment that is locked and tagged, do not touch it. If you are required to work on electrical equipment, you must be trained in the proper lockout/tagout procedures.

D) Other Precautions

Alertness

Employees must be alert at all times when they are working within the limited approach boundary and in work situations when electrical hazards might exist.

Employees are not permitted to work within the limited approach boundary of energized electrical conductors or circuit parts if they are recognizably impaired due to illness, fatigue, or other reasons.

Employees must be alert for changes in the job or task that may lead them or persons outside of the electrically safe work condition to become exposed to additional hazards that were not part of the original plan.

Blind Reaching

Do not reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

Illumination

Do not enter spaces where electrical hazards exist unless there is sufficient lighting to allow you to perform the work safely.

If there is inadequate lighting, or an obstruction prevents you from seeing the work to be performed, do not attempt to perform any task within the limited approach boundary of energized electrical conductors or circuit parts.

Wearing Conductive Articles

Do not wear conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) within the restricted approach boundary or where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.

Using Conductive Materials, Tools, and Equipment

Conductive materials, tools, and equipment that are in contact with any part of your body must be handled in such a way that prevents accidental contact with energized electrical conductors or circuit parts. These materials and equipment can include, but are not limited to, long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

Workers are required to ensure that conductive tools or materials are not carried or used any closer to exposed energized electrical conductors or circuit parts than established by the applicable boundary limits.

Confined or Enclosed Work Spaces

If you are required to work in a confined or enclosed space (such as a manhole or vault) that contains exposed energized electrical conductors or circuit parts, the company must provide, and then you must use protective shields, protective barriers, or insulating materials to avoid inadvertent contact with these parts.

Doors and Hinged Panels

When working in enclosures with doors or hinged panels, these items must be secured to prevent them from swinging into an employee and causing contact with exposed energized electrical conductors or circuit parts.

Clear Spaces

The space required for performing electrical work may not be used for storage. This space must be kept clear to permit safe operation and maintenance of electrical equipment.

Housekeeping Duties

Employees must not perform housekeeping duties inside the limited approach boundary where there is a possibility of contact with energized electrical conductors or circuit parts, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions) cannot be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.

Occasional Use of Flammable Materials

In areas where flammable materials such flammable gases, vapors, or liquids; combustible dust; and ignitable fibers or flyings are occasionally present, electric equipment capable of igniting them is not permitted unless measures are taken to prevent hazardous conditions from developing.

Anticipating Failure

If there is evidence that electric equipment could fail and injure employees, the electric equipment shall be de-energized, unless the employer can demonstrate that de-energizing introduces additional hazards or increased risk or is infeasible because of equipment design or operational limitation. Until the equipment can be de-energized or repaired, employees must be protected from hazards of the impending failure of the equipment by barricades and other alerting techniques.

Routine Opening and Closing of Circuits

Only load-rated switches, circuit breakers, or other devices specifically designed for disconnecting purposes will be used for the opening, reversing, or closing of circuits under load conditions. Do not use cable connectors, fuses, terminal lugs, and cable splice connections for disconnecting, except in an emergency.

Reclosing Circuits after Protective Device Operation

If a circuit is de-energized by a GFCI, fuse, circuit breaker, or other protective device, do not manually reenergize until it has been determined that the equipment and circuit can be safely energized. Do not repeatedly reclose circuit breakers or reenergize circuits. Once it is determined that the automatic operation of the protective device was caused by an overload rather than a fault condition, the circuit may be reenergized.

Safety Interlocks

Only qualified persons are permitted to defeat or bypass an electrical safety interlock over which they have sole control, and then only temporarily while they are working on the equipment. The safety interlock system must be returned to its operable condition when the work is completed.

FINAL EXAM

1. What is the energy potential that defines an arc flash hazard?

   A) 1.0 cal/cm2
   B) 1.2 cal/cm2
   C) 2.4 cal/cm2
   D) 4.8 cal/cm2

2. The majority of arc flash incidents involve what voltage?

   A) 120 v, single phase
   B) 240 v. three phase
   C) 480 v. three phase
   D) 10kv, three phase

3. Arc flash incidents can injure workers at a distance of _____

   A) 3 feet
   B) 5 feet
   C) 10 feet
   D) 50 feet

4. What are the factors that affect the severity of an arc flash incident?

   A) Fault current
   B) Arcing time
   C) Distance
   D) Humidity

5. An unqualified person may enter the limited approach area without an escort.

   A) True
   B) False

6. The temperature at the source can be _____

   A) 2,500 °F
   B) 15,000 °F
   C) 35,000 °F
   D) 64,000 °F

7. The lockout/tagout of energy sources may only be performed by a trained authorized person.

   A) True
   B) False

8. An arc flash assessment is conducted to determine if an arc flash risk exists.

    A) True
    B) False

9. If work on an energized circuit or device operating at over 50 volts is necessary, a written electrical permit is required.

    A) True
    B) False

10. An arc flash warning label is required on all equipment where an arc flash hazard is present.

    A) True
    B) False

11. What is the least effective means of controlling arc flash risk?

    A) Elimination
    B) Awareness
    C) PPE
    D) Administrative controls

12. Live-dead-live testing should be performed on all circuits to ensure which of the following?

    A) The test equipment is working properly
    B) The circuit to be worked on is de-energized
    C) The circuit to be worked on is energized
    D) The circuit protective device is functioning

13. Equipment arc flash warning signs must identify the flash protection boundary distance.

    A) True
    B) False

14. Electrical circuits that have been de-energized by a protective device must be inspected for possible fault conditions before being re-energized.

    A) True
    B) False

15. Electrical circuits and devices should always be considered energized until tested.

    A) True
    B) False