OES Arc Flash Plan



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# OES Arc Flash Plan

## ****1.0 Purpose and Scope****

The purpose of this written plan is to educate students, staff, and faculty of the hazards associated with Arc Flash.

OSHA standard 1910.335(a)(2)(ii) defines Arc Flash as a flashover of electric current through air in electrical equipment from one exposed live conductor to another or to ground. The effects produce intense heat, sound blast, and arc blast due to a sudden expansion of air. This written Arc Flash Plan describes methods to prevent the cause of electric arcs from happening, which are:

1. Dust and Impurities
2. Corrosion and break down of insulation
3. Water vapor/condensation
4. Accidental touching
5. Dropping of tools
6. Over voltages and surges
7. Improper work practices and procedures

Definitions:

Arc Flash is the light and heat produced from an arc forming between one conductor and another through air or one conductor and ground through air.

Arc Blast is the shockwave produced which can break apart conductors, throw molten metal, rupture ear drums, damage internal organs, break bones or throw workers.

## 2.0 Administrative Duties

Due to the severity of injuries produced by Arc Flash and Arc Blast, it is very important that only properly trained individuals are exposed to this type of hazard. (See training section)

There are three boundaries associated with the qualified and unqualified in terms of shock limits:

Prohibited Shock Boundary: Qualified persons only. The level of PPE worn is the same as if direct contact with a live part.

Restricted Shock Boundary: Qualified persons only.

Limited Shock Boundary: Qualified or unqualified persons only if accompanied by a qualified person.

## 3.0 Boundaries

## Approach/Protection Boundaries

## The National Fire Protection Association (NFPA) has developed specific approach boundaries designed to protect employees while working on or near energized equipment. These boundaries are:

1. Flash Protection Boundary (outer boundary)
2. Limited Approach
3. Restricted Approach
4. Prohibited Approach (inner boundary)

Flash Protection Boundary (outer 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 (1.2 calories/cm2).

Limited Approach: An approach limit at a distance from an exposed live part where a shock hazard exists.

Restricted Approach: An approach limit at a distance from an exposed live part which there is an increased risk of shock.

Prohibited Approach (inner boundary): A distance from an exposed part which is considered the same as making contact with the live part.

**How to Determine the Approach Boundaries**

Since different equipment will have different approach boundaries, calculations must be made on each piece of equipment. There exist several ways to establish these boundaries and the method you select depends on personal preference, resources available and quality desired.

NFPA Tables: Refer to NFPA 70E – 2000 Table 3-3.9.1 or Table 130.7(C)(9)(a) NFPA 70E – 2004.

Formula Method: NFPA 70 E and IEEE Standard 1584 provide formulas that can be used to accurately deter in the approach.

Approach Calculator: IEEE has provided a spreadsheet-based calculator to assist in determining approach boundaries. Although this calculator does help expedite the calculations, detailed information about the equipment and circuit is still required and this often necessitates the use of an electrical engineer.

Software: Various software products exists on the market today which can simplify and expedite the approach boundary calculations. The software may also be able to create one-line diagrams and approach boundary labels as required by NFPA 70E.

**Ways to Protect the Worker**

There are numerous ways to protect workers from the threat of electrical hazards. Some of the methods are for the protection of qualified employees doing work on electrical circuit, and other methods are geared towards non-qualified employees who work near energized equipment.

Protective methods include:

1. De-energizing the circuit
2. Work practices
3. Insulation
4. Guarding
5. Barricades
6. Ground Fault Circuit Interrupters (GFCI)
7. Grounding

Additionally, the use of alerting techniques are effective ways to warn employees (especially non-qualified) of the dangers present.

Use safety signs, safety symbols, or accident prevention tags. Often, the use of such signs alone is not adequate as an employee (especially a non-qualified employee) may accidentally come in direct contact with an energized circuit. In these instances, a barricade shall be used in conjunction with safety signs.

Use barricades to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

An attendant shall be stationed to warn and protect employees if signs and barricades do not provide enough warning and protection from electrical hazards.

**4.0 Lockout/Tagout**

Because a deenergized circuit can easily be energized while an employee is working on it, the circuits energizing the parts shall be locked out or tagged or both [see 1910.333(b)(2)]

Electric equipment that has been deenergized but have not been locked out or tagged shall be treated as energized parts [see 1910.333(b)(1)]

The employer must develop and maintain a written copy of the lockout / tagout procedures and make it available to employees. [see 1910.333(b)(2)(i)]

Only qualified persons may work on electric circuit parts or equipment that have not been deenergized. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools. [see 1910.333(c)(2)]

**What if the Equipment Can’t Be Deenergized?**

OSHA requires that live electrical parts be deenergized before the employee works on or near them unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. [see 1910.333(a)(1)]

OSHA does understand that sometimes it is infeasible to deenergize electrical equipment and they have made allowances for this. This includes testing of electric circuits that can only be performed with the circuit energized.

Another example is work on circuits that form an integral part of a continuous industrial process in a chemical plant that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

OSHA has also made allowances for not deenergizing electrical equipment when it would increase current hazards or create additional hazards, including such times as:

1. interruption of life support equipment
2. deactivation of emergency alarm systems
3. shutdown of hazardous location ventilation equipment
4. removal of illumination for an area

**If You Must Work on Energized Circuits**

If it has been determined that deenergizing a circuit is not feasible and the employee must work “hot”, the employer shall develop and enforce safety-related work practices to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards. [see 1910.333(a)]

These safety related work practices could include:

1. Energized Electrical Work Permit
2. Personal Protective Equipment
3. Insulated Tools
4. Written Safety Program

**Who is a Qualified Worker**

In an effort to reduce electrical injuries in the workplace, OSHA has determined that only qualified persons work on or around energized circuits or equipment. (1910.399)

Qualified person: One who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved. Note 1 to the definition of "qualified person:" Whether an employee is a "qualified person" will depend upon various circumstances in the workplace. For example, it is possible and, in fact, likely for an individual to be considered "qualified" about certain equipment in the workplace, but "unqualified" as to other equipment.

Note 2 to the definition of "qualified person:" An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

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

1. The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.
2. The skills and techniques necessary to determine the nominal voltage of exposed live parts, and
3. The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.

## 5.0 Personal Protective Equipment (PPE)

Personal Protective Equipment is an integral part of any employer’s safety program. OSHA has determined that PPE, although a good way to protect employees, should be used as a last line of defense.

Prior to using PPE, the employer must determine if other means of protection are available. OSHA uses the following control measures for employee protection:

1. Elimination (get rid of it)
2. Substitution (substitute for something less hazardous)
3. Engineering Controls (equipment)
4. Administrative Controls (people or processes)
5. Personal Protective Controls (what you wear)

**PPE for the Head**

Employees must wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts [see 1910.335(a)(1)(iv)].

ANSI Z89.1-1986 OSHA requires that protective helmets purchased after July 5, 1994, must comply with the performance guidelines in the ANSI Z89.1-1986, American National Standard for Personal Protection—Protective Headwear for Industrial Workers Requirements or shall be demonstrated to be equally effective.

ANSI Z89.1-1986 separates protective helmets into two different types and three different classes.

Type 1 helmets incorporate a full brim (brim fully encircles the dome of the hat)

Type 2 helmets have no encircling brim, but may include a short bill on the front

Regarding electrical performance, ANSI Z89.1-1986 recognizes three classes:

Class A Helmets reduce the force of impact of falling objects and also reduce the danger of contact with exposed low-voltage electrical conductors. Helmet shells are proof tested at 2,200 volts of electrical charge.

Class B Helmets reduce the force of impact of falling objects and also reduce the danger of contact with exposed high-voltage electrical conductors. Helmet shells are proof tested at 20,000 volts.

Class C Helmets reduce the force of impact of falling objects but offer no electrical protection.

Every protective helmet that conforms to the requirements of ANSI Z89.1-1986 must be appropriately marked to verify its compliance. The following information must be marked inside the hat:

1. Manufacturers name
2. The ANSI Z89.1-1986 designation
3. Class designation (A, B, or C)

ANSI Z89.1-1997 In 1997 ANSI revised its head protection standard. The 1997 version of ANSI Z89.1 contains a few notable changes.

ANSI Z89.1-1997 no longer uses Type 1 and Type 2 to describe the brim characteristics of a protective helmet. The new Type designation is as follows:

Type I helmets offer protection from blows to the top of the head.

Type II helmets offer protection from blows to both the top and sides of the head Z89.1-1997 also changed the class designations for protective helmets.

Under Z89.1-19974, the following three classes are recognized:

1. Class G (General) Helmets -This is equivalent to the old Class A. Class G helmets are proof tested at 2,200 volts.
2. Class E (Electrical) Helmets - This is equivalent to the old Class B. Class E helmets are proof tested at 20,000 volts.
3. Class C (Conductive) Helmets – This class provides no electrical insulation; the class designation did not change from the old standard.

**PPE for the Eyes and Face**

Employees shall wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion. [see 1910.335(a)(1)(v)] [ANSI Z87.1-2015]

When working on energized parts, the possibility of arc flash exists, and the employee must be protected. Dangers could include heat, flying hazards and molten metal, therefore the PPE must be durable, non-conductive, heat resistant and provide deflection qualities.

As with much of the arc flash PPE, the heat resistance is measured in calorie/cm2. Remember an unprotected worker exposed to a 1.2 Cal/cm2 energy burst would result in second degree burns.

**PPE for the Body (FR Clothing)**

As we learned earlier, employees working in areas where there are potential electrical hazards must be provided with, and must use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed [see 1910.335(a)(1)(i)]. This would include flame resistant (FR) clothing.

During an arc flash event the temperatures can reach an excess of 35,000 degrees. Even at temperatures much lower, typical daily wear clothing would do little to protect the worker from being seriously injured. In fact, at such high temperatures, the clothing will ignite and continue to burn on the body well after the arc flash has dissipated. This is where serious injury and death often occur.

To counteract the extreme heat from an arc flash, FR clothing is required. FR clothing can take the form of pants, shirts, coveralls, jackets, parkas, and full flash suits. Obviously, fit, comfort and flexibility are important but the greatest indicator of adequate FR clothing for a given task is based on the “arc thermal performance value” (ATPV).

The ATPV is incident energy on a material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn. Manufacturers of FR clothing will provide an ATPV rating on their clothing and you must match the ATPV with the potential exposures in the workplace.

**Inspection and Maintenance of FR Clothing**

When inspecting and maintaining FR clothing, you must always follow the manufacturer's recommendations; however, here are some basic guidelines for follow:

1. Do not use fabric softeners, starches, or bleaches when washing
2. Wash FR clothing separate from other laundry
3. Wash at low temperatures (110 – 120 degrees F max)
4. Tumble dry at the lowest setting possible

FR clothing must be visually inspected prior to each use. FR clothing that becomes contaminated with grease, flammable liquids, etc. should be removed and laundered.

**PPE for the Hands (Gloves)**

Since employees working on energized electrical parts are using their hands, obviously that part of the body (hands and arms) is most susceptible to electric shock and must be protected.

Insulating gloves provide an excellent means of protecting the workers from accidental electrical contact. To be effective the insulating gloves must have high insulative qualities, while also being comfortable, durable, and flexible.

Because safety is involved, the employer and employee must become familiar with the differences between the various types and classes of insulating gloves available.

**Maintenance of PPE**

Protective equipment must be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by 1910.137 [see 1910.335(a)(1)(ii)]

Properly storing PPE after use helps to extend the life of the equipment. Furthermore, exposing equipment out of extreme weather conditions such as heat, cold, etc. will only weaken it and it will need to be replaced prior to use.

**Training Required for PPE**

The employer shall provide training to each employee who is required to use PPE. The employee must be trained to know at least the following:

1. When PPE is necessary
2. What PPE is necessary
3. How to properly don, doff, adjust, and wear PPE
4. The limitations of the PPE
5. The proper care and maintenance of the PPE

The employee shall demonstrate an understanding of the training and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE [see 1910.132(f)(2)].

The employer must verify that each affected employee has received and understood the required training and certify in writing, the date(s) of training, name of the employee trained, and the subject trained [see 1910.132(f)(4)].

**Re-training the Employee**

If an employer has reason to believe that an employee who has already been trained does not have the understanding and skill required, the employer must retrain the employee.

Some examples of when retraining may be needed are as follows:

1. Changes in the workplace.
2. Changes in the types of PPE to be used.
3. Inadequacies in an affected employee’s knowledge.
4. Use of PPE indicate the employee lacks understanding or skill.

The four levels of PPE that are suitable for Arc Flash hazards can be found in NFPA 70E. Those categories are:

**PPE Category 1 – Minimum Arc Rating 4 cal/cm2**

PPE CAT 1 represents the lowest level in which Arc Rated PPE is required. Requiring a single layer of arc-rated PPE, workers need the following clothing:

1. Required Clothing: Long sleeve shirt (or jacket) and pants or AR coverall with minimum arc rating of 4 cal/cm2.
2. Required Face and Head Protection: Face shield (with wrap around guarding…i.e., balaclava) or arc flash suit hood.
3. As Needed: Arc rated jacket, rainwear, parka, hard hat liner.

**PPE Category 2 – Minimum Arc Rating 8 cal/cm2**

PPE CAT 2 can likely be met with a single layer of Arc Rated PPE. In fact, the majority of companies with exposures requiring CAT 1 typically opt for CAT 2 clothing to cover both categories. Today, the comfort of PPE CAT 1 and 2 is comparable so it makes more sense to choose CAT 2 clothing.

1. Required Clothing: Arc rated long sleeve shirt and pants, or arc rated coverall with minimum arc rating of 8 cal/cm2.
2. Required AR Face and Head Protection: Arc rated arc flash suit hood or AR face shield, sock hood/balaclava with minimum arc rating of 8 cal/cm2.
3. As Needed: Arc rated jacket, rainwear, parka, hard hat liner.

In addition to AR clothing, the following products are required or to be used as needed:

1. Required Hand Protection: Heavy-Duty leather gloves.
2. Additional PPE: Hard hat, eye protection (glasses, goggles) hearing protection.
3. Footwear: Leather footwear (as needed)

**PPE Category 3 – Minimum arc rating 25 cal/cm2**

PPE Category 3 and 4 require additional layers of PPE. Arc flash suit hoods are required and rubber insulating gloves & leather protectors or arc rated gloves are required. For PPE Category 3; workers need the following clothing:

1. Required Clothing: Arc rated flash suit jacket and AR pant or coverall with minimum arc rating of 25 cal/cm2.
2. Required AR Face and Head Protection: Arc rated flash suit hood with minimum arc rating of 25 cal/cm2.
3. Required AR Hand Protection: Rubber insulating gloves and leather protectors, or arc rated gloves.
4. As Needed: Arc rated jacket, rainwear, parka, hard hat liner.

In addition to AR clothing, the following PPE is required:

1. Additional PPE: Hard hat, eye protection (glasses, goggles) hearing protection (inserts), leather footwear.

**PPE Category 4 – Minimum Arc Rating 40 cal/cm2**

The final PPE Category requires AR clothing with a minimum rating of 40 cal/cm2.

1. Required Clothing: Arc rated flash suit jacket and AR pan or coverall with minimum arc rating of 40 cal/cm2.
2. Required AR Face and Head Protection: Arc rated flash suit hood with minimum arc rating of 40 cal/cm2.
3. Required AR Hand Protection: Rubber insulating gloves and leather protectors, or arc rated gloves.
4. As Needed: Arc rated jacket, rainwear, parka, hard hat liner.

In addition to AR clothing, the following PPE is required:

1. Additional PPE: Hard hat, eye protection, (glasses, goggles), hearing protection (inserts), leather footwear.

**6.0 Training**

Training is a valuable asset regarding any task, especially when dealing with the risk of electrical shock. The training requirements for this task is based on the competency of the individual. Employees must be trained in and familiar with the safety-related practices required that pertain to their respective job assignments.

1. Scope

The training requirements contained in this section apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of 1910.303 through 1910.308.

Note: Employees in occupations listed in Table S-4 face such a risk and are required to be trained. Other employees who also may reasonably be expected to face comparable risk of injury due to electric shock or other electrical hazards must also be trained.

(b) Content of training

(1) Practices addressed in this standard. Employees shall be trained in and familiar with the safety-related work practices required by 1910.331 through 1910.335 that pertain to their respective job assignments.

(2) Additional requirements for unqualified persons. Employees who are covered by paragraph (a) of this section but who are not qualified persons shall also be trained in and familiar with any electrically related safety practices not specifically addressed by 1910.331 through 1910.335 but which are necessary for their safety.

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

1. The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.
2. (ii) The skills and techniques necessary to determine the nominal voltage of exposed live parts, and
3. (iii) The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.

Note 1: For the purposes of 1910.331 through 1910.335, a person must have the training required by paragraph (b)(3) of this section in order to be considered a qualified person. (a), (b) and (c) 80 Training Requirements in OSHA Standards General Industry

Note 2: Qualified persons whose work on energized equipment involves either direct contact or contact by means of tools or materials must also have the training needed to meet 1910.333(C)(2).

(c) Type of training. The training required by this section shall be of the classroom or on-the-job type. The degree of training provided shall be determined by the risk to the employee.

**7.0 Point of Contact**

For any questions, comments, or matters pertaining to this written plan, please contact [oeshelp@clemson.edu](mailto:oeshelp@clemson.edu).