Train-the-Trainers Guide to

Electrical Safety For General Industry

A Review of Common OSHA Regulations and Workplace Violations

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Common Electrical Hazards

It's Your Life – Protect it!

It's not a secret – electricity can

Fast Fact: A 15 amp circuit breaker was designed to protect equipment – not people!

Arc flash can be caused by many things including:

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

Three factors determine the severity of an arc flash injury:

- Proximity of the worker to the hazard
- Temperature
- Time for circuit to break

Because of the violent nature of an arc flash exposure when an employee is injured, the injury is serious – even resulting in death. It's not uncommon for an injured employee to never regain their past quality of life. Extended medical care is often required, sometimes costing in excess of $1,000,000.

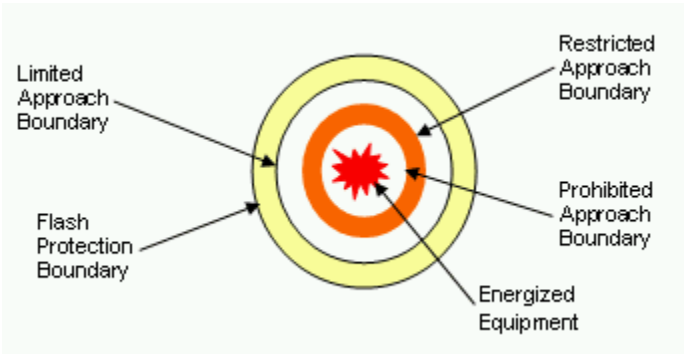
Typical Results from an Arc Flash

- Burns (Non FR clothing can burn onto skin)
- Fire (could spread rapidly through building)
- Flying objects (often molten metal)
- Blast pressure (upwards of 2,000 lbs. / sq.ft)
- Sound Blast (noise can reach 140 dB – loud as a gun)
- Heat (upwards of 35,000 degrees F)

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:

- Flash Protection Boundary (outer boundary)
- Limited Approach
- Restricted Approach
- Prohibited Approach (inner boundary)


Limited
Approach
Boundary
Restricted
Approach
Boundary
Flash
Protection
Boundary
Prohibited
Approach
Boundary
Energized
Equipment

Here are a few of the protective methods:

- De-energize the circuit
- Work Practices
- Insulation
- Guarding
- Barricades
- Ground Fault Circuit Interrupters (GFCI)
- Grounding (secondary protection)

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

Alerting techniques might include safety signs, safety symbols, or accident prevention tags. Often times, 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.

A barricade is an effective way 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.

If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

What if we Can't Deenergize the Equipment

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)]

Fast Fact: Live parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

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 deenreergizing electrical equipment when it would increase current hazards or create additional hazards, including such times as:

- interruption of life support equipment,
- deactivation of emergency alarm systems,
- shutdown of hazardous location ventilation equipment,
- removal of illumination for an area.

Lockout and Tagout

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:

- 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, and
- The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.

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.

Fast Fact: It's the employer's responsibility to determine the training required and to ensure that the employee is adequately training for the tasks undertaken.

Under Z89.1-1997, the following three classes are recognized:

- Class G (General) Helmets - This is equivalent to the old Class A. Class G helmets are proof tested at 2,200 volts.

- Class E (Electrical) Helmets - This is equivalent to the old Class B. Class E helmets are proof tested at 20,000 volts.

- Class C (Conductive) Helmets - This class provides no electrical insulation; the class designation did not change from the old standard.

Every protective helmet that conforms to the requirements of ANSI Z89.1-1997 must be appropriately marked to verify its compliance. The following information must be marked inside the hat:

- Manufacturer's name
- The “ANSI Z89.1-1997" designation
- Class designation (G, E or C)
- Date of manufacture

Also instructions related to maintenance of the helmet, sizing and service life guidelines must also accompany the protective helmet.

ANSI Z89.1-2003

The most current ANSI standard is Z89.1-2003 and most new protective helmets will reference this current standard. In this revision ANSI made an effort to align with other national standards. The Type and Class designations are the same as the 1997 standard.

PPE for the Eyes & Face

Employees shall wear protective equipment for the eyes or face wherever ther the eyes

tive eGClass design'mhce w aCTj-fly(gu

contaminated with grease, flammable liquids etc shall be removed and sent to be laundered.

FAST FACT: Clothing made from acetate, nylon, polyester, rayon (alone or in blends) is prohibited when employees are working around energized electrical parts, unless the employer can demonstrate that the fabric has been treated to withstand the conditions that may be encountered or that the clothing is worn in such a manner as to eliminate the hazard involved.

PPE for the Hands (Gloves)

Since employees working on energized elm pof0 eno Tclli0.a

FAST FACT: Do not use leather protectors alone for protection against electric shock. Serious injury or death could result. Always use proper rubber insulating gloves.

Glove Liners and Powder

Glove liners provide a more comfortable fit and reduce friction between the hand and the insulating glove. For additional comfort and ease of putting on and off, glove dust is recommended. Glove dust is a cooling, frictionless powder that absorbs moisture and perspiration when wearing rubber gloves.

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)]

When speaking of "inspected" OSHA is speaking of a very-frequent visual review of the equipment. When OSHA speaks of "testing" they are referring to something a little more detailed (see "Protective Equipment Testing Schedule" – Figure P-1)

Insulating equipment must be inspected for damage before each days use and anytime damage is suspected. Typical damage to insulating equipment might include the following:

- Embedded foreign objects (metal slivers, splinters)
- Holes, punctures, tears or cuts
- Ozone damage (fine cracks)
- Swelling, softening, sticky or hardening
- Damage from chemicals

Insulating equipment must also be stored in a way that does not damage the material. The following items can cause damage:

- Temperature extremes
- UV damage (from sunlight)
- Excessive humidity
- Ozone (UV rays, arcing)
- Foreign materials (oils, petroleum products, hand lotion, baby powder)

Proper storage extends the service life of gloves. Folds and creases strain natural rubber and cause it to cut from ozone prematurely. Storing rubber gloves in the right size bag and never forcing more than one pair into each bag will help equipment last longer.

Glove Air Tests

Before each days use OSHA requires air testing on insulated gloves and ASTM F 496 provides details on how to perform the test. To conduct the test, fill the glove with air and hold against your cheek to feel for and hear releasing air.

A portable glove inflator is easy to use and provides a definite validation of the gloves integrity. The glove is secured to the inflator using a nylon strap and fastened with hook & pile or a rubber o-ring. Inflation is accomplished by pumping the bellows of the inflator against any smooth flat surface.

Electrical Testing of Electrical Prot ective Equipment

Electrical protective equipment must undergo periodic electrical tests to ensure its protective qualities are still present. The American Society for Testing and Materials (ASTM) provides detailed information about the requires testing (see http://www.astm.org)

Protective Equipment Testing Schedule	
Equipment	When to Test
Gloves	Before first issue and every six months after that.*
Blankets / Sleeves	Before first issue and every 12 months after that.
Line Hose / Covers	Upon indication that insulating value is devalued.

Figure P-1

* If the protective equipment has been electrically tested, but not issued for use it may not be placed in service unless it has been electrically tested within the previous 12 months.

Other Protective Equipment

Based on the employee's exposure, other forms of PPE may be necessary. For instance if working in a toxic (including an oxygen deficient) environment, an employee would be required to provide the employee with respiratory protection

How to Determine What PPE Must be Worn

There does not exist a "one size fits all" requirement for the type of PPE that must be worn when working with electrical hazards. Different levels of hazards require different level of personal protection.

To compensate for these variables, OSHA requires that *"the employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment*" [see 1910.132(d)(1)].

Once a hazard is identified (i.e. exposed electrical parts) the employer:

"shall verify that the required workplace hazard assessment has been performed through a written certification that identifies" [see 1910.132(d)(1)]:

- the workplace evaluated;
- the person certifying that the evaluation has been performed;
- the date(s) of the hazard assessment; and
- identifies the document as a certification of hazard assessment.

This written certification must be performed for each piece of equipment worked on and be broken down into various tasks that will be performed (i.e. voltage testing, install circuit breaker).

Guidance From NFPA 70E

Developing a written PPE certification or Job Hazard Analysis can be a difficult task; however NFPA 70E provides some very good guidance.

NFPA uses a three-step process as follows:

Step 1: Determine the Hazard / Risk Category Classification based on NFPA 70E Table 130.7(C)(9)(a)

Task	Hazard / Risk Category	V-Rated Gloves	V-Rated Tools
Panelboards & Switchboards >240V and up to 600V			
CB or Fuse Switch Operation With covers ON	0	No	No
CB or Fuse Switch Operation With covers OFF	1	No	No
Work on energized parts, including voltage testing	2*	Yes	Yes

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

2* Indicates that a double layer switching hood and hearing protection is required in addition to other category 2 PPE requirements.

Step 2: Select Protective Clothing and Personnel Protective Equipment (PPE) Matrix based on NFPA 70E Table 130.7(C)(10).

Personal Protective Clothing	Hazard / Risk Category Number					
FR Clothing:	-1	0	1	2	3	4
Long-sleeved Shirt			X	X	X	X
Pants			X	X	X	X
Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
Jacket, Parka, Rainwear			AN	AN	AN	AN

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

Personal Protective Equipment	Hazard / Risk Category Number					
FR Protective Equipment:	-1	0	1	2	3	4
Hard Hat			X	X	X	X
Safety Glasses	X	X	X	AL	AL	AL
Flash Suit Hood					X	X
Hearing Protection				X (note 8)	X	X

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

Hazardous (Classified) Locations

Hazardous locations - also know as “Classified Locations” are an often misunderstood entity and therefore a source of constant under-protection.

The National Electrical Code (NEC) defines hazardous locations as those areas "where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings."

Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following:

- aircraft hangars,
- gasoline dispensing and service stations,
- bulk storage plants for gasoline or other volatile flammable liquids,
- paint-finishing process plants,
- health care facilities,
- agricultural or other facilities where excessive combustible dusts may be present,
- marinas,
- boat yards,
- petroleum and chemical processing plants
- textile mills

Since electrical equipment can become a source of ignition in hazardous locations, standards have been developed to provide classifications, installation methods and appropriate electrical equipment designations for these areas.

Fast Fact: An important feature of the revised Hazardous Classification rule is the requirement for employers to document the designation of hazardous locations within their facilities.

This allows workers who install, inspect, maintain, or operate equipment in these areas to identify the correct equipment or system components to be used to ensure worker safety.

Hazardous locations are classified in three ways by the National Electrical Code:

TYPE CONDITION NATURE

Hazardous Location Types

We'll first examine the various "Types" of hazardous locations. There are three types of hazardous locations.

Some typical Class II locations are:

- Grain elevators;
- Flour and feed mills;
- Plants that manufacture, use or store magnesium or aluminum powders;
- Producers of plastics, medicines and fireworks;
- Producers of starch or candies;
- Spice-grinding plants, sugar plants and cocoa plants; and
- Coal preparation plants and other carbon handling or processing areas.

Class III Locations

The third type of hazardous location is called a "Class III Location". This classification is created by the presence of easily ignitable fibers or flyings. Typically these fibers and flyings are not suspended in the air, but can collect around machinery or on lighting fixtures and where heat, a spark or hot metal can ignite them. Some typical Class III locations are:

- Textile mills, cotton gins;
- Cotton seed mills, flax processing plants; and
- Plants that shape, pulverize or cut wood and create sawdust or flyings.

Hazardous Location Conditions

After identifying the three types of hazardous locations, we next move to the actual "conditions" found within each of those three types of hazardous locations.

When hazards would be expected to be present in everyday production operations or during frequent repair and maintenance activity they are considered "normal conditions" and have been designated as "Division 1"

For Example: Good examples of Class I, Division 1 locations would be the areas near open dome loading facilities or adjacent to relief valves in a petroleum refinery, because the hazardous material would be present during normal plant operations.

When hazards are expected to be confined within closed containers or closed systems and will be present only through accidental rupture, breakage or unusual faulty operation they are considered "abnormal conditions" and have been designated as "Division 2".

NOTE: There are no specific groups for Class III locations

For Example: How would we classify a storage area where LP gas is contained in closed tanks?

LP gas is a Class I substance (gas or vapor). It's Division 2 because it would only be in the atmosphere if an accidental rupture or leakage occurred, and it is Group D material.

The table below summarizes the various hazardous (classified) locations.

Summary of Class I, II, III Hazardous Locations			
Classes	Groups	Divisions	
		1	2
Class I Gases, Vapors & Liquids	A: Acetylene B: Hydrogen, etc. C: Ester, etc. D: Hydrocarbons. fuels	Normally explosive and hazardous	Not normally present in an explosive concentration but may accidentally exist.
Class II Dusts	E: Metal dusts (conductive and explosive) F: Carbon dusts (some are conductive, all are explosive) G: Flour, starch, grain, combustible plastic or chemical dust (explosive)	Ignitable quantities of dust are or may be in suspension, or conductive dust may be present	Dust not normally suspended in an ignitable concentration (but may accidentally exist). Dust layers are present.
Class III Fibers & Flyings	Textiles, woodworking etc. (easily ignitable but not usually explosive)	Handled or used in manufacturing	Stored or handled in storage (exclusive of manufacturing)

An Alternate to Divisions

Historically, Divisions have been used to differentiate between conditions within a Classification, however the 2000 edition of NFPA 70E incorporates an alternative way to designate Divisions.

The “Zone Classification” system is based on various European standards that were developed by the International Electrotechnical Commission (IEC). The IEC formalized this zone system, which is now used to classify the majority of the

Fast Fact: Be very careful when shipping, handling, installing or maintaining explosion proof equipment. Even slight damage to a flame path can permit burning gases to escape, igniting the surrounding atmosphere.

Class II Requirements

In Class II locations the hazard is not explosive gas or vapors, its ignitable dust and therefore the design criteria for equipment in a Class II location is unique.

Class II equipment is designed do that the explosive dust is kept away from equipment housed within the enclosure so that no internal explosion can take place. Although the dust may ignite, the concern for a heavy explosion (like with gas or vapor) is eliminated and a lighter construction is feasible. Also, the need for flame paths in eliminated in Class II equipment.

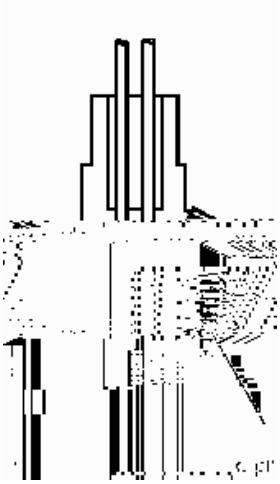
Fast Fact: Class I, Division 1 equipment is called “explosion proof” while Class II equipment is called “dust-ignition proof”.

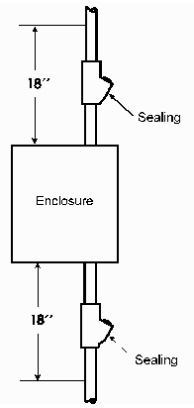
Class II equipment must be designed with the following in mind:

- It must seal out the dust.
- It must operate below the ignition temperature of the hazardous substance.
- It must allow for a dust blanket.

Fast Fact : The build-up of dust collecting on top of the device can cause it to run "hot" and ignite the surrounding atmosphere. Class II equipment must be able to accommodate for this “dust blanket”

After pulling the wires through the conduit, fitting and enclosures, the electrician would fill the fitting with a chemical compound that hardens and effectively seals the passageway from dusts and gases.





In Class I locations each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors, or other apparatus which may produce arcs, sparks, or high temperatures, conduit seals shall be placed as close as practicable and in no case more than 18 inches (457 mm) from such enclosures.

Fast Fact : Class I equipment must be explosion proof and the standard requires that the enclosure resist four times the maximum pressure expected in the hazardous location.
For instance if explosion testing shows a maximum pressure for a junction box of 250 pounds per square inch (psi), to get approval, the box must be able to withstand 1,000 psi of hydrostatic pressure - FOUR TIMES the maximum anticipated pressure of 250 psi.

What About Protection on Other Systems

OSHA regulations extend protection to temporary wiring receptacles of higher voltage and current ratings (such as 125-volt, single-phase, 30-ampere and 480-volt, three-phase receptacles).

It better protects employees from ground-fault hazards than the construction rule because it covers other equipment that is just as subject to damage as 120-volt, single-phase, 15- and 20-ampere equipment and that is more prevalent today than when the construction rule was promulgated over 28 years ago.

Are Extension Cords Allowable by OSHA

This question comes up frequently and yes extension cords (flexible cord sets) are allowable for use in both construction and general industry environments. However, OSHA does have certain rules that must be followed when using extension cords.

Permitted Use of Flexible Cords

Flexible cords and cables may be used only for [see 1910.305(g)(1)(ii)(A) – (F)]:

Additionally prior to using an extension cord, the employee must examine the outer jacket to determine if the cord is adequate for the load.

Cord and plug connected equipment and flexible cord sets (extension cords) which remain connected once they are put in place and are not exposed to damage need not be visually inspected until they are relocated.

Overcurrent Protection Devices

Overcurrent protection such as circuit

Table S-1. -- Minimum Depth of Clear Working Space at Electric Equipment, 600 V or Less

Nominal voltage to ground	Minimum clear distance for condition

Disconnecting Means of Motors

When working with electrical motors, extra caution shall be given to the disconnection means. The disconnecting means for the motor shall be "within sight of" the motor. OSHA has determined that "within sight" means within 50'.

Additionally, the disconnecting means shall be readily accessible and plainly indicate whether it is in the open (off) or closed (on) position.

If more than one disconnect is provided for the same equipment, only one disconnecting means need be readily accessible.
[see 1910.305(j)(4)(i) and (iv) – (v)]

Fast Fact: When a circuit breaker is used as a switch (i.e. stadium lighting) the circuit breaker must be labeled as "SWD" and identify what lighting it controls.

Cabinets, Boxes and Fittings

Another frequent safety issue and common OSHA violation concerns pull boxes, cabinets, junction boxes and fittings. These items can become a "weak link" in the electrical circuit due to a number of different root causes.

Conductors entering cutout boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. [see 1910.305(b)(1)(i)]

All pull boxes, junction boxes, and fillings shall be provided with covers and if covers are metal they must be grounded. [see 1910.305(b)(2)(i)]

Other Prohibited Wiring Uses

No wiring systems of any type may be installed in ducts used to transport dust, loose stock, or flammable vapors. No wiring system of any type may be installed in any duct used for vapor removal or for ventilation of commercial-type cooking equipment, or in any shaft containing only such ducts. [see 1910.305(a)(1)(iii)]

Temporary Power and Lighting

There does exist circumstances where temporary power and lighting is needed for an extended period of time and OSHA has made allowances for these circumstances.

Temporary power and lighting may be used for Christmas lighting, carnivals, etc. however the duration of time shall not exceed 90 days. This rule is also applicable to experimental work and emergencies.

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