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Understanding arc flash hazards

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An arc flash is an undesired electric discharge that travels through the air between conductors or from a conductor to a ground. The flash is immediate, but the result of these incidents can damage equipment and cause severe injury, including burns.

According to the National Fire Protection Association (NFPA) 70E (2012), more than 2,000 people are admitted to intensive care burn units each year as a result of severe arc flash burns they received during an arc flash incident. Fatalities occur at a rate of approximately one per day in the United States, with nonfatal arc flash incidents occurring approximately 5 to 10 times per day. Even these nonfatal arc flash incidents consistently result in many serious burns and injuries requiring weeks to months of intensive care hospital stays and many months of painful rehabilitation.



Primary causes of arc flashes

An arc flash may be caused by an element in a breaker or service area that could compromise the distance between energized components. Incidents often occur when workers fail to make certain equipment has been properly de-energized. The most effective and foolproof way to eliminate the risk of electrical shock or arc flash is to simply de-energize the equipment.

Potential causes of an arc flash may include:

- Workers mistakenly dropping tools on live parts
- Pests entering switchgear through openings
- Faulty operation of a load break switch
- Dust or moisture accumulating to weaken air insulated bus bars
- Improper use of test equipment

Electrical arc flashes produce some of the highest temperatures known to occur on earth, up to 35,000 degrees F (19,426 degrees C). This is four times the temperature of the surface of the sun, which is 9,000 degrees F (4,982 degrees C). This intense heat causes a sudden expansion of air, which results in a blast with very high air pressure.

Worker dangers

An arc flash can cause injuries ranging from minor to third degree burns, and even death. Other injuries include blindness, hearing loss, nerve damage, and cardiac arrest.

Blast pressure waves have thrown works across rooms and knocked them off ladders. Pressure on the chest can be higher than 2,000 pounds per square foot.

Furthermore, arc flashes spray droplets of molten metal at high speeds; these droplets are propelled for distances up to 10 feet. This blast shrapnel can penetrate the human body.

Protecting workers

The best way to prevent arc flash incidents from occurring is to de-energize equipment before beginning work. The industry standards are designed to protect workers and the workplace in the few instances where turning off the power could create a greater hazard to people or processes than leaving it on.

The NFPA has developed specific approach boundaries designed to protect employees while working on or near energized equipment. These boundaries are:

Flash protection boundary: The outer boundary is the farthest established boundary from the energy source. If an arc flash occurred, this is where a worker would be exposed to 1.2 calories/centimeters squared (cal/cm²), resulting in a curable second degree burn. Personal protective equipment (PPE) must be worn to prevent second degree or greater burns in the event of an arc flash.

Limited approach boundary: The distance from a live part where a shock hazard exists and an unqualified person may safely stand. No untrained worker may approach any closer to the energized part than this boundary.

Restricted approach boundary: This boundary can be crossed only by qualified workers who have completed required training and who wear appropriate PPE. In addition, the worker must have an approved work permit and written plan for the job. The plan should include shock-prevention procedures designed to keep all portions of the worker's body from crossing the *prohibited approach boundary* at any time.

Prohibited approach boundary: A distance from a live part that is the same as making contact with the live part. Crossing this boundary with unprotected (conductive) body parts or tools risks the occurrence of an electrical arc. Any body part that crosses this boundary must be protected with PPE rated appropriately for direct contact with the part. Only qualified workers wearing appropriate PPE, having specified training to work on energized conductors or components, and having a documented plan justifying the need to perform this work may cross the boundary and enter this space. The worker must obtain a risk assessment before entering the prohibited space.

If employers are having "live" electrical work performed, the facilities must provide:

- A written safety program with defined responsibilities
- Calculations for the degree of arc flash hazard
- PPE for workers
- Training for workers
- Tools for safe work
- Warning labels on equipment

Warning labels

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. After the arc flash hazard analysis is completed, warning labels are printed and affixed to the electrical equipment. The labels should include the level of PPE required, the flash hazard boundary, the flash hazard, the shock hazard, and approach distances.

There is no specified requirement for the design of arc flash warning labels. However, the OSHA and NFPA recommend following ANSI Z535.4, which offers two options for signal words and colors:

- The signal word DANGER, which appears in white letters on a red background, signifies the most serious threats. It should not be used throughout a facility, but only in cases of extreme danger. A guideline is to use DANGER where incident energy is above 40 cal/cm², which is the highest energy for which PPE is considered effective.
- The signal word WARNING, appearing in black letters on an orange background, is appropriate for use in any instance where a hazard could cause death or serious injury.

Common OSHA standards cited for arc flash

The NFPA 70E national consensus standard is a comprehensive standard that contains detailed information on how to protect workers from arc flashes. Employers should consider and adopt NFPA 70E when employees work on an electrical system. NFPA 70E is not an OSHA requirement. But that does not matter. OSHA requires employers to protect employees from electrical hazards, including arc flash.

OSHA issues citations based on the requirements of NFPA 70E through existing Agency regulations. The most common OSHA standards cited for arc flash include:

- **29 CFR 1910.132(d)(1)**—Requires employers to perform a PPE hazard assessment to determine necessary PPE.
- **29 CFR 1910.332(b)(1)**—Practices addressed in this standard. Employees must 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.
- **29 CFR 1910.333(b)(2)(iv)(B)**—A qualified person must use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and must verify that the circuit elements and equipment parts are de-energized.
- **29 CFR 1910.335(a)(1)(i)**—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.
- **29 CFR 1910.335(a)(1)(iv)**—Requires employees to wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.
- **29 CFR 1910.335(a)(1)(v)**—Employees must wear protective equipment for the eyes or face wherever there is the danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

- **29 CFR 1910.335(a)(2)**—Employees must use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or circuit parts.
- **29 CFR 1910.269(I)(6)(iii)**—Requires employers to ensure that each employee working at electric power generation, transmission, and distribution facilities who is exposed to the hazards of flames or electric arcs does not wear clothing that could increase the extent of injury to such a hazard.
- **29 CFR 1926.28(a)**—The employer must require that employees wear appropriate PPE during construction work.

Safe workplace

The most effective and foolproof way to eliminate the risk of electrical shock or arc flash is to simply de-energize the equipment. But, in some cases, turning off the power is just not possible. Understanding arc flash and its potential hazards, calculating risk, knowing the importance of labeling, and the proper use of PPE can maintain the effective use of live electrical equipment and parts. Essentially, OSHA and NFPA requirements should be followed to develop and implement an effective electrical safety program—and ultimately save lives.