



Arc Flash Solutions

Q. What is an arcing fault?

A. An arcing fault is the flow of current through the air between phase conductors or phase conductors and neutral or ground. An arcing fault can release tremendous amounts of concentrated radiant energy at the point of the arcing in a small fraction of a second resulting in extremely high temperatures, a tremendous pressure blast, and shrapnel hurling at high velocity (in excess of 700 miles per hour).

Q. What causes an Electrical Arc?

A. Arcs can be initiated by a variety of causes, such as when:

- Workers incorrectly think the equipment is de-energized and begin to work on it energized.
- Workers drop or improperly use tools or equipment components in energized equipment.
- Dust, water or other contamination accumulate and cause insulation breakdown.
- Connections loosen, overheat, reach thermal runaway and fail.

Q. What is my risk to being exposed to arc flash?

A. The exposure to arc flash depends on the following:

- Number of times the workers perform a task involving exposed live equipment
- Complexity of the task performed, need to use force, available space, safety margins, reach, etc.
- Training, skills, mental and physical agility, coordination with helper
- Tools used
- Condition of equipment
- The available short circuit current and the condition and rating of the overcurrent protective equipment.

Q. What can happen if I am exposed to arc flash?

A. Exposure to an arc flash frequently results in a variety of serious injuries and in some cases death. Workers have been injured even though they were ten feet or more away from the arc center. Worker injuries can include damaged hearing, eyesight, and severe burns requiring years of skin grafting and rehabilitation.

Equipment can be destroyed causing extensive downtime and requiring expensive replacement and repair. The cost of treatment for the injured worker can exceed \$1,000,000/case. Significant litigation fees, insurance increases, fines, and accident investigation costs can occur. This does not include work in progress loss or job layoffs as a result of the process interruption. These cumulative costs can exceed \$10,000,000.

Q. What can I do to reduce my risk to arc flash exposure?

A. Preventive maintenance, worker training, and an effective safety program can significantly reduce arc flash exposure. Preventive maintenance should be conducted on a routine basis to ensure safe operation. As part of a preventive maintenance program, equipment should be thoroughly cleaned and routine inspections should be conducted by qualified personnel who understand how to uncover loose connections, overheated terminals, discoloration of nearby insulation, and pitted contacts. A comprehensive preventive maintenance plan should also include:

- Using corrosion resistant terminals and insulate exposed metal parts if possible
- Sealing all open areas of equipment to ensure rodents and birds cannot enter
- Verifying that all relays and breakers are set and operate properly

Q. Why are the standards for arc flash changing?

A. Arc Flash first became an industry concern in the early 1980's with the publication by Ralph Lee titled, "The Other Electrical Hazard: Electric Arc Blast Burns." Similar studies illustrated that too many people were suffering injuries as a result of arc flash incidents. Therefore, early adopters in the petrochemical industry took steps to establish the first set of practices designed to better protect employees and electrical contractors. Soon other industries recognized the need for additional protection against arc flash hazards. These new industry standards developed by the NEC and others were designed to protect electrical workers from the hazards of shock, electrocution, arc flash, and arc blast.

Q. What is a calorie?

A. A calorie is the energy required to raise one gram of water one degree Celsius at one atmosphere. The onset of second-degree burns will occur at 1.2 calories per centimeter squared per second. One calorie per centimeter squared per second, can be equal to holding your finger over the tip of the flame of a cigarette lighter for one second.

Q. Are all arcs equal?

A. No. Arcs vary in intensity and duration. The intensity is measured in calories per centimeter squared per second as described above and is dependent on fault current magnitude. The duration of the arc depends on how quickly the protective device interrupts the fault. Intensity and duration must be known to calculate the incident energy to which a worker could be exposed. From this information, the proper personal protective equipment (PPE) can be specified.

Q. How do you determine what PPE is required?

A. In order to select the proper PPE, incident energy must be known at every point where workers may be required to perform work on energized equipment. These calculations need to be performed by a qualified person such as an electrical engineer. All parts of the body that may be exposed to the arc flash need to be covered by the appropriate type and quality of PPE. Proper PPE can include Flame Resistant clothing, hardhat, hood, face shield, safety glasses, gloves, shoes, etc. depending upon the magnitude of the arc energy.

Q. What standards regulate arc flash hazards?

A. There are four main regulations governing arc flash. They include:

- **OSHA Standards 29-CFR, Part 1910.** Occupational Safety and Health Standards. 1910 sub part S (electrical) Standard number 1910.333 specifically addresses Standards for Work Practices and references NFPA 70E.
- The National Fire Protection Association (**NFPA Standard 70** "The National Electrical Code" (NEC) contains requirements for warning labels
- **NFPA 70E** provides guidance on implementing appropriate work practices that are required to safeguard workers from injury while working on or near exposed electrical conductors or circuit parts that could become energized.
- **The Institute of Electronics and Electrical Engineers (IEEE) 1584** Guide to Performing Arc-Flash Hazard Calculations.

Q. Who enforces these new standards?

A. OSHA is an enforcer of safety practices in the workplace. OSHA 1910.132(d), and 1926.28(a) states that the employer is responsible to assess the hazards in the work place, select, have, and use the correct PPE, and document the assessment. Though OSHA does not, per se, enforce the NFPA 70E standard, OSHA considers the NFPA standard a recognized industry practice and the administration's field inspectors carry with them a copy of the NFPA 70E and use it to enforce safety procedures related to arc flash.

The employer is required to conduct hazard assessment in accordance with 29CFR1910.132(d)(1). Employers who conduct the hazard/risk assessment, and select and require their employees to use PPE, as stated in the NFPA 70E standard, are deemed in compliance with the Hazard Assessment and Equipment Selection OSHA Standard.

Electrical inspectors across the country are now enforcing the new labeling requirements set forth in the 2002 National Electric Code (NEC).

Q. What data is required to be on the new arc flash warning labels?

A. 110.16 only requires the label state the existence of an arc flash hazard. But for obvious reasons the industry has adopted as a de facto standard, labels that also include the following information:

- Flash Protection Boundary
- Incident energy at 18" expressed in cal/cm²
- PPE required
- Voltage shock hazard
- Limited shock approach boundary
- Restricted shock approach boundary
- Prohibited shock approach boundary

Q. How do I determine the flash protection boundary?

A. The flash protection boundary is based on voltage, available short-circuit current and predicted fault duration. The NFPA 70E provides FOUR acceptable methods of determining flash protection boundary:

- Analysis based on IEEE 1584
- Analysis based on NFPA 70E 130.3(A) and Annex D
- Simplified Two-Category FR Clothing System, Annex H
- The hazard risk categories provided by Table 130.7(C)(9)(a)

Q. Which method of determining flash protection boundary is the best?

A. All of the known methods have some limitations. The tables provided by NFPA may be easy to use but they are based on typical equipment and systems and are only approximations. They also require information from an up to date short circuit and coordination study. Detailed analysis yields different results than the tables do. Therefore, whatever standard you use, it is necessary to understand its limitations. Years of industry application experience have resulted in the IEEE1584 standard referenced in NFPA 70E as being the preferred method for a comprehensive arc flash analysis.

Q. What is the difference between NFPA 70E and IEEE 1584 Calculations?

A. NFPA 70E method estimates incident energy based on a theoretical maximum value of power dissipated by arcing faults. This is believed to be generally conservative. In contrast, IEEE 1584 estimates incident energy with empirical equations developed from statistical analysis of measurements taken from numerous laboratory tests.

Q. How does an effective preventive maintenance program reduce arc flash hazards?

A. A preventive maintenance program on protective devices is recommended as part of the arc flash program. All arc flash calculations require the arc clearing time in order to determine incident energy and establish the flash protection boundary. The clearing time is derived from the engineering coordination study based on what the protective devices are supposed to do. If maintenance and testing is not performed it could result in extended clearing times, unintentional time delays, open or shunted current transformers, open coils or dirty contacts. All of these factors could cause the results of flash hazard analysis to be inaccurate—causing the flash protection boundary to potentially be inaccurate. This could also affect the recommendations for the proper PPE. For this reason, it is recommended that facilities adopt NFPA 70B Recommended Practice for Electrical Equipment Maintenance.

Q. What is a flash hazard?

A. A flash hazard is defined in NFPA 70E as a dangerous condition associated with the release of energy caused by an electric arc.

Q. Why should I have a short circuit and protective device coordination study performed prior to the arc flash hazard analysis?

A. Arc flash calculations completed in conjunction with short circuit calculations and protective device coordination help ensure that the most accurate arc flash hazard results are achieved. Arc flash hazard boundaries are based on voltage, available short-circuit current and predicted fault duration derived from these analyses.

Q. What is the flash protection boundary?

A. The flash protection boundary is the distance from the arc source at which the potential incident heat energy from an arcing fault falling on the surface of the skin is 1.2 calories/cm².

Q. What is “Limited Approach Boundary”?

A. The limited approach boundary defines a boundary around exposed live parts that may not be crossed by “unqualified” person unless accompanied by “qualified” persons.

Q. What is “Restricted Approach Boundary”?

A. The restricted approach boundary is the area near the exposed live parts that may be crossed only by “qualified” persons using appropriate shock prevention techniques and equipment.

Q. What is “Prohibited Approach Boundary”?

A. The prohibited approach boundary is the area near exposed live parts that may be crossed only by “qualified” persons using the same protection as if direct contact with live parts is planned. This is defined by the nominal voltage.

Q. What is the definition of a “qualified” person?

A. A qualified person is one who has received documented training in the hazards of working on energized equipment in general, and has been trained in the hazards of the particular equipment to be serviced. Training must include the use and proper application of PPE.

Q. What data is required for a Short Circuit Analysis?

A. Typical data that is required for a short circuit analysis includes the equipment type, voltage, withstand rating, MVA/KVA, impedance, X/R ratio, and phases/connection.

Q. What data is required for Protective Device Coordination Study?

A. For relays you will need to determine the relay type, CT ratio, pickup (tap) setting, delay type (curve) and setting time dial. For fuses you’ll need the fuse type, amp rating, voltage, and peak let-through current. For circuit breakers you will need the circuit breaker type, fault clearing time, pickup setting, delay curve, and delay setting.

Q. What is an Arc Flash Study/Analysis?

A. An Arc Flash Study/Analysis is an engineering study that determines the amount of current that could flow at any point in an electrical system, and the timing required for the nearest circuit protective device to operate to clear a fault.

Q. What data is required for an Arc Flash Study?

A. Depending on the method of calculation, you will need to determine the type of enclosure, gap between exposed conductors, grounding type, phases/connection, and working distance.

Q. What is the hazard/risk category?

A. The hazard/risk category is specified as a number representing the level of danger, which depends upon the incident energy. The category ratings range from 0 to 4 where category 0 represents little or no risk, and category 4 signifies the greatest risk. Above category 4 (>40 calories/cm²) all equipment is considered too dangerous to work on energized because of the tremendous pressure blast.

Q. When is it okay to work on “energized” or “live” equipment?

A. It is always preferable to work on de-energized equipment. However, OSHA regulations state in 1910.333 (a) that workers should not work on live equipment (greater than 50 volts) except for one of two reasons, 1) De-energizing introduces additional or increased hazards such as cutting ventilation to a hazardous location, or 2) Infeasible due to equipment design or operational limitations such as when voltage testing is required for diagnostics. When it is necessary to work on energized equipment you should follow safe work practices including assessing the risks, wearing proper PPE, and using the proper tools.

Q. How can equipment design impact arc flash hazards?

A. The incident energy exposure caused by an arc flash can be affected by the system configuration, system fault levels, and exposure time. System fault levels can be reduced by changing the system configuration to reduce available fault current, and by using current limiting devices such as fuses, breakers, and reactors. Using faster acting relays and trip devices can reduce arcing time or exposure time. A protective device coordination study should also be conducted to ensure proper device settings. Instantaneous relays could also improve clearing times, limiting the arc exposure time. Fuse ratings and characteristics should also be evaluated to determine if a smaller and/or faster fuse could be used to help reduce the exposure time.

Q. What is “incident energy”?

A. Incident energy is defined in NFPA 70E as, “the amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.”

Q. What is an “electrically safe” work condition?

A. An electrically safe work condition is defined as a state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.