Arc Flash

Frequently Asked Questions

VERTIV

Electrical Reliability Services

Q1. 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 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).

Q2. What causes an electrical arc?

A. An arc occurs when electric current flows between two or more separated energized conducting surfaces. Some arcs are caused by human error including dropped tools, accidental contact with electrical systems, and improper work procedures. Another common cause of an arc is insulation failure. A buildup of dust, contamination, and corrosion on insulating surfaces can provide a path for current flow. Sparks created during racking of breakers, replacement of fuses, and closing into faulted lines can also produce an arc. Birds, rodents, and other animals can inadvertently bridge the space between conductors or cause leads to slap together, creating an arcing fault.

Q3. Are all arcs equal?

A. No. You must conduct a hazard assessment to determine the level(intensity) of energy from the arc in calories. Then you can determine the proper personal protective equipment (PPE) needed.

Q4. What is incident energy?

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

Q5. What is my risk to being exposed to arc flash?

A. The risk of arc flash exposure depends on:

- Number of times a worker performs 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

Q6. 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 10 feet or more away from the arc center. Worker injuries can include permanent loss of hearing or eyesight, and severe burns requiring years of skin grafting and rehabilitation.

Equipment can be destroyed causing lengthy downtime and requiring expensive replacement and repair. The cost of treatment for the injured worker can exceed $1 million per case. This does not include significant litigation fees, insurance increases, fines, accident investigation, etc. Nor does it take into account the cost of lost production.

Q7. What is an arc flash hazard?

A. An arc flash hazard is defined in NFPA 70E as a source of possible injury or damage to health associated with the release of energy caused by an electric arc.

Q8. What standards regulate arc flash hazards?

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

1. **OSHA Standards 29 CFR, Part 1910** Occupational Safety and Health Standards, subpart S (electrical) standard number 1910.333 specifically addresses standards for work practices and references NFPA 70E; subpart R (special industries) standard number 1910.269 addresses safety requirements for electric power generation, transmission and distribution facilities.
2. **NFPA Standard 70** National Electrical Code (NEC) contains requirements for warning labels.
3. **NFPA 70E** Standard for Electrical Safety in the Workplace 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 are or will become energized.
4. **Institute of Electrical and Electronics Engineers (IEEE) 1584** Guide for Performing Arc Flash Hazard Calculations provides a method of calculating the incident energy to define the safe working distance and aid in selection of overcurrent protective devices and PPE.

Q9. Who enforces these standards?

A. OSHA is an enforcer of safety practices in the workplace. OSHA 1910.132(d) and 1926.28(a) state 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 enforce the NFPA 70E standard, the organization does recognize it as industry practice and the administration's field inspectors carry a copy of NFPA 70E for use in addressing safety procedures related to arc flash.

The employer is required to conduct hazard assessment in accordance with 29 CFR 1910.132(d)(1). Employers who conduct the hazard/risk assessment and select and require their employees to use PPE, as stated in NFPA 70E, are deemed in compliance with the Hazard Assessment and Equipment Selection OSHA standard.

Electrical inspectors across the country also enforce the labeling requirements set forth in the NEC.

Q10. Why did the standards for arc flash change?

A. Arc flash concerns were first publicized in the early 1980s with the release of a paper 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. New requirements included in industry standards such as National Fire Protection Association (NFPA) 70E were designed to reduce electrical workers' exposure to the hazards of shock, electrocution, arc flash, and arc blast.

Q11. What is the definition of a "qualified" person?

A. A qualified person is one who has demonstrated skills and knowledge related to the construction, operation, and installation of the electrical equipment, and has received safety training to recognize and avoid the hazards involved.

Q12. 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.

Q13. 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.
2. De-energizing is 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 must follow safe work practices including assessing the risks, wearing proper PPE, and using the proper tools.

Q14. 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.

Q15. 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 dimension between exposed conductors, grounding type, phases/connection, and working distance.

Q16. 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 per square centimeter.

Q17. 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. NFPA 70E provides three acceptable methods of determining flash protection boundary:

- Simplified Table 130.7(c)(15)(a) +(b)
- Analysis based on NFPA 70E Annex D
- Analysis based on IEEE 1584

Q18. What is limited approach boundary?

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

Q19. 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.

Q20. 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.

Q21. 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. Detailed analysis yields different results than the tables do. Therefore, whatever standard you use, it is necessary to understand its limitations. Evaluate using multiple methods and compare the results to determine the approach that is most appropriate for your facility.

Q22. Why should I have a short circuit and protective device coordination study performed prior to the arc flash risk assessment?

A. The Petroleum and Chemical Industry Committee (PCIC) recommends that arc flash calculations be completed in conjunction with short circuit calculations and protective device coordination to 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.

Q23. 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.

Q24. 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.

Q25. What data is required to be on arc flash warning labels?

A. NEC section 110.16 only requires the label state the existence of an arc flash hazard. However, NFPA 70E 130.5(H) states that equipment labels must include the information below.

1. Nominal system voltage
2. Arc flash boundary
3. At least one of the following:
    a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both
    b. Minimum arc rating of clothing
    c. Site-specific level of PPE

Hazard-specific parameters are also suggested such as the following:

- Limited shock approach boundary
- Restricted shock approach boundary

Q26. What is the arc flash PPE category?

A. The arc flash PPE category is specified as a number representing the level of danger, which depends upon the incident energy. The category ratings range from 1 to 4, where category 1 represents little or no risk, and category 4 is the most dangerous level where energized work may still be performed.

Q27. 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 square centimeter per second. One calorie per centimeter squared per second is said to be approximately equal to holding your finger over the tip of the flame of a cigarette lighter for one second.

Q28. How do you determine what PPE is required?

A. In order to select the proper PPE, incident energy must be known at every location 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 arc-rated clothing, hard hat, face shield, safety glasses, gloves, shoes, and more depending upon the magnitude of the arc energy.

Q29. 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 routinely inspected 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:

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

Q30. 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 and is based on how quickly protective devices would operate under ideal circumstances. If maintenance and testing is not performed, the result could be extended clearing times or unintentional time delays caused by 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, possibly leading to an inaccurate flash protection boundary. This could also affect the recommendations for the proper PPE. For these reasons, NFPA 70E 205.3 and 205.4 outline maintenance requirements.

Q31. 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 sizes should also be evaluated to determine if a smaller fuse could be used since smaller fuses reduce the exposure time.