Arc flash risk assessment

A complete guide to compliance

Arc flash and electrical safety

Employees who work on or around energized equipment or machinery are exposed to electrical hazards, including arc flash, daily while on the job. Even in situations where an employee isn't directly working on energized electrical parts, there could be exposure to an arc flash hazard. Employers have a responsibility to identify and protect employees from these hazards. Regulatory bodies, including the Occupational Safety and Health Administration (OSHA) and The National Fire Protection Association (NFPA), regulate, and set the standards for, electrical safety in the workplace.

A requisite step in protecting employees is to perform an assessment of the workplace which identifies hazards, estimates the likelihood of hazard occurrence, outlines potential injuries associated with each hazard and determines the Personal Protective Equipment (PPE) required to work safely around the potential hazard. This four-step process is outlined in OSHA's Risk Assessment and Equipment Selection Standard 29 CFR 1910.132. Specifically, a current and accurate Arc Flash Risk Assessment will help reduce employee exposure to arc flash hazards. Arc flash risk assessments are very complex studies that require a solid foundation in the latest study performance standards and the application of that information to the specific work environment. What follows is a review of arc flash events, an outline of the assessment process and a review of additional compliance needs. In combination, these components will help keep employees safe.

What is an arc flash event?

An arc flash is the release of energy over a very short time period, through an electrical arc. These events are often caused by human error or equipment failure in an electrical system. During the event, energy is released in the form of heat, intense ultraviolet and infrared light, blast pressure waves and intense sound waves. Additionally, smoke, toxic fumes, molten metal and flying shrapnel may accompany the electrical event. In many ways, an arc flash event is very similar to a bomb. A person in proximity to an arc flash blast can suffer severe burns, collapsed lungs, loss of vision, ruptured eardrums, soft tissue injuries, broken bones or even death.

The NFPA defines an arc flash occurrence as "when an electrical current passes through air between ungrounded conductors or between ungrounded and grounded conductors." The temperatures in an arc flash event can reach temperatures of 35,000° F which is three-times hotter than the surface of the sun.

Causes of an arc flash event

There are two major causes of arc flash events:

Human error

The most prevalent cause is human error. Examples of human error include accidental contact of energized circuit parts with conductive tools or body parts, lack of training or insufficient training and installation issues including incorrect wiring or improper labeling.

Equipment failure

The other major cause of arc flash events is equipment failure. These equipment failures can take on many forms and include, loose connections causing arcing or overheating, improper equipment rating for the system in which it is installed and the breakdown of insulation on cables or other energized parts allowing current to flow outside of its intended path. Poor maintenance can exacerbate equipment failures leading to rust, dust, debris, condensation or exposure to water triggering an arc flash event. Transient events from utilities, lightning or events generated from within the facility can also cause an arc flash event. Finally, an employee who is interacting with a piece of improperly maintained piece of equipment needs to be able to recognize possible signs of imminent failure, such as excessive heat or noise.

Arc flash events — the numbers

- 5 to 10 arc flash accidents occur every day in the US [1]
- More than 2,000 people are treated annually in burn centers with arc flash injuries [1]
- Approximately 1 death per day occurs from arc flash incidents [1]
- $1.5M average cost of medical treatment [1]
- 8 to 12 months away from work [1]
- $10 to $15M average litigation cost [2]

Employers who take all of the necessary steps to protect and train their employees from an arc flash event have a much lower likelihood of an incident occurring. Lower incident rates translate to reduced litigation costs and fines for employers should an incident occur, provided that the incident was caused by employee negligence or failure to comply with employer policies.

How is an arc flash risk assessment performed?

An arc flash risk assessment is performed to identify arc flash hazards in an electrical system and to identify PPE to mitigate the hazard. To accurately determine an arc flash hazard, three pieces of information must be known about each point in the electrical system (bus) to determine the incident energy and arc flash hazard at that point:

1. How much current flows to each bus.
2. How long the current flows.
3. How close a person could be standing to the bus.

Short circuit study

A short circuit study is executed to determine how much current flows to each bus. This process requires data collection on the physical electrical system to determine its electrical characteristics. Information about wires, cables, conduits and transformers defines the impedance of the system which is used to determine the available fault current at each bus. Information about breakers and / or fuses defines the operating time of overcurrent protective devices for each bus. Knowing the fault current and clearing time of the overcurrent protective device allows for the magnitude and duration of the fault current to be determined at each bus. How close a person is standing to the bus is called the working distance and is typically assumed to be 18 inches below 1000V. The information from the short circuit study is subsequently used in the arc flash study, protective device coordination and device evaluation.

The first step in an arc flash risk assessment is the data collection phase. On-site data collection involves gathering information about the physical characteristics of the electrical system that is used to characterize its electrical properties. One-line diagrams, equipment submittal documents and equipment documentation are all useful at this stage. While completing on-site data collection, all precautions should be taken to protect the engineer from electrical hazards

and arc flashes. These precautions can include de-energizing, engineering practices and the use of PPE. The utility company is contacted at this point and asked to provide information about its connection.

Once data collection is completed, it is typically entered into modeling software along with the utility company's contribution. The data is used to create an interactive model in a one-line diagram format. After the model is complete, the engineer can run various simulations and scenarios. These scenarios allow the engineer to determine the worst possible arc flash hazard, give insight on mitigating hazards, improve device coordination and identify inadequate devices.

Protective device coordination study

A comparison of the operating characteristics of breakers is done to determine if the protective device closest to a fault will operate. Well-coordinated systems isolate faults in the system and minimize outages due to the opening of a protective device. Recommendations should be made to ensure that the device immediately upstream of a faulted bus will operate, localizing the fault.

Arc flash study

To determine the worst possible arc flash hazard for a bus, calculations must be performed using the information from the short circuit study. All of the data from the arc flash labels will be derived from this study. This includes the determination of incident energy and personal protective equipment.

Device evaluation

Device evaluation determines if the equipment and protective devices are adequate for the available fault currents in the system. It is imperative to have equipment and devices rated to interrupt the fault current safely without damage or failure. The device evaluation is completed by comparing the available fault current determined during the short circuit study to the interrupting rating of the device or equipment.

What should be included in an arc flash risk assessment?

Several useful tools are generated during a thorough assessment that help those involved in the risk assessment make informed decisions. The most-common deliverables are labels on electrical equipment and a physical report with the findings.

Arc flash labels

An arc flash label is required for any piece of equipment that could require examination, adjustment, service or maintenance while energized. Remember, arc flash events are often caused by human error, and working on a piece of equipment while energized creates the potential for an arc flash incident to occur. To comply with NFPA 70 110.16, equipment including, but not limited to, switchboards, switchgears, panel boards, industrial control panels, motor control centers, production line equipment cabinets and safety disconnect switches, must have labels that inform qualified persons of the arc flash hazard potential. The preceding applies to any piece of equipment operating at 50V or above. This label must be permanently affixed to the equipment, must not be handwritten and must be durable enough to withstand the environment in which it is installed.

The label must include the following:

- Nominal system voltage and shock boundaries
- Arc flash boundary
- Incident energy and working distance OR PPE category
- Minimum arc rating of PPE

Report

The physical report resulting from a risk assessment should include the following information and findings:

One-line diagrams

A schematic drawing of the equipment evaluated in the assessment should be provided. This should be delivered in PDF and AutoCAD® format. The drawing shows the interconnection of all of the components included in the assessment.

System input data

The data that was used as the basis of the system is shown in the input section. This includes all of the cable sizes and lengths, utility, motor, generator data, etc.

Settings table

A table showing the existing and recommended settings for selected protective devices should be provided. This gives the user a quick reference for the device settings for those with adjustable settings.

Settings table

Circuits that have breakers with adjustable trip settings present an opportunity to optimize system performance. A thorough study identifies and outlines breaker settings and potentially recommends fuses that improve coordination and reduce arc flash hazards. It is important to understand the tolerance for potential nuisance tripping and exposure to hazards when determining the balance between coordination and mitigation.

Recommendations

Circuits that have breakers with adjustable trip settings present an opportunity to optimize system performance. A thorough study identifies and outlines breaker settings and potentially recommends fuses that improve coordination and reduce arc flash hazards. It is important to understand the tolerance for potential nuisance tripping and exposure to hazards when determining the balance between coordination and mitigation.

Maintaining the arc flash risk assessment

After an arc flash risk assessment has been completed it is important to maintain the accuracy of the data in the study. Changes in utility contribution, installation or removal of machinery and renovations can impact available fault currents. For this reason, arc flash risk assessments are required to be updated in intervals not to exceed five years or when significant changes are made to the system.

Process

- An engineer comes on-site to evaluate the current arc flash labeling and verify the accuracy of the previous arc flash assessment by completing spot checks on equipment, settings of overcurrent protective devices and PPE in use by employees.
- While on-site, the engineer reviews job assessment checklists, energized work permits and the overall written safety program to determine if it is in compliance with NFPA 70E.
- The engineer should conduct confidential interviews with employees who work directly on electrical equipment to determine if they see any gaps in electrical safety.
- The engineer compiles the audit information, identifies issues of non-compliance and makes recommendations to improve electrical safety where they exist.

Additional Requirements to be Compliant

Having an arc flash risk assessment and labels is only part of the compliance process with OSHA, NFPA and the Institute of Electrical and Electronics Engineers (IEEE). Other steps must be taken to be fully compliant.

Training

Employees who face exposure to electrical hazards must be trained in arc flash and electrical hazards in accordance with NFPA 70E. Full-day training is recommended for employees who have not received training in the past. Annual

refresher courses can be conducted by the safety department or management at the employee's facility. Four-hour training courses are available for employees who have received the full-day training more than three years ago. Certificates should be issued at the conclusion of each class.

Written safety program

Employers must have a written safety program dealing specifically with electrical hazards. This program must be reviewed annually. Documentation of an annual review must be kept. Any changes in industry standards must be implemented in the written safety program. This safety program must also include a pre-job briefing checklist and an energized work permit.

PPE

Employees who will be working on, or near, electrical hazards must be provided with PPE appropriate for the job being performed and for the body parts involved in the work being performed. The PPE must be provided at no cost to the employee and shall be maintained and repaired as needed.

Insulated tools

When working on, or around, energized electrical equipment, employees must use insulated tools. These tools should be rated at least 1000V. A good practice is to use two-part insulation. This provides a visual indication of outer layer damage allowing the tool to be taken out of service before issues arise.

What to look for when considering an arc flash risk assessment

Engineers

There is added value in having a dedicated engineer or team of engineers execute each step of the assessment from start to finish. Some companies rely on third parties, such as electrical contractors, to collect the data needed to complete an arc flash assessment. The contractor may not be familiar with what data needs to be collected for an arc flash assessment. As a best practice, the engineer(s) that performs the assessment should also be collecting the data needed for the assessment. This reduces discrepancies in what is collected vs. what is documented. The engineer(s) who collected the data, performed the calculations, produced the report and installed the labels has in-depth knowledge of the strengths and weaknesses within a system and can convey them thoroughly.

Engineered analysis method

NFPA 70E outlines two methods to determine arc flash hazards – the category method and the incident energy analysis. Incident energy analysis is a more thorough and accurate method, making it the preferred choice. Both methods require an accurate short-circuit study to be performed first.

- The incident energy analysis is a comprehensive method that involves quantifying and determining an arc flash hazard numerically for each bus. This information is used to identify PPE and an arc flash boundary adequate for each bus.
- The category method uses tables to assign a category number to each bus. It is often very conservative.

Engineer autonomy

Autonomous engineers are familiar with most pieces of equipment. These engineers can work alone, tackling all activities designed to be safely completed by one person. This limits the need for a maintenance technician or electrician to accompany the arc flash engineer. When considering your options for an arc flash risk assessment, always ask the provider to clearly explain your responsibilities as the client. "Will I need to assign a resource? Will I need to hire a resource? Are you outsourcing or subcontracting any part of this project?"

Partnering with Brady

When you partner with Brady, you can be confident that your arc flash assessment will be done completely and accurately without being a burden to you. Brady uses the engineered analysis method (IEEE) to provide you the information you need with precision. In addition to labeling every piece of equipment, we provide you with complete reporting and documentation to help you address all of your electrical safety program needs. And don't worry about us; our engineers perform all of the data collection, including the removal of panel covers, so you don't have to. No third-parties, no hand-offs, just peace of mind.

1. Campbell, Richard B and Dini, David A, Occupational Injuries From Electrical Shock and Arc Flash Events, Fire Protection Research Foundation, March 2015 https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Electrical/RFArcFlashOccData.ashx?la=en
2. Jennifer Busick, Don't Let Arc Flash Cost You, EHS Daily Advisor, August 19, 2015 https://ehsdailyadvisor.blr.com/2015/08/dont-let-arc-flash-cost/

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