



An Eaton Arc Flash Handbook

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Protect what matters most

Nothing is more important than worker safety, but if you haven't taken the proper steps to mitigate the risks of arc flash, you're jeopardizing what matters most, and you could be breaking the law.

This handbook will help you begin your journey to reset arc flash safety in your facility, including how to do the following:

- **Become familiar with the laws, regulations and standards:** OSHA, NFPA 70, NFPA 70E and IEEE 1584
- **Understand the risks:** an arc flash study is the first step
- **Protect workers:** use the results of the study to label equipment, set arc flash boundaries and identify the proper personal protective equipment (PPE)
- **Train workers:** ensure that workers understand results of the study, safe work practices, labels, boundaries and PPE
- **Mitigate arc flash hazards:** modify your work practices, electrical equipment or electrical system, or install arc resistant replacement gear

At Eaton, we want to see that every person who operates, maintains or works around electrical equipment goes home safe and sound every day, so we're providing this reference handbook to help improve arc flash safety. If you don't have the expertise you need on staff, Eaton has the breadth, depth and experience to help you protect what matters most.

Get answers at Eaton.com/ArcFlashAnswers



Electrical safety

I Choose ZERO

At Eaton, safety comes first.

“I Choose Zero” is the name of Eaton’s safety program designed to achieve the goal of zero lost time due to injuries and enhance overall personnel safety.

Our commitment extends well beyond Eaton employees; we want to see zero lost time across all industries and all businesses. That’s why our Electrical Engineering Services and Systems team, one of the largest and most experienced teams of power system engineers and field service specialists in the industry, offers a complete, turnkey arc flash safety solution to help you reset safety in your facility.



Electrical safety program

An effective workplace safety culture starts with a solid electrical safety program. The National Fire Protection Association's (NFPA) Standard for Electrical Safety in the Workplace handbook (NFPA 70E) provides a framework for developing such a program, including principles, controls and procedures.

- **Principles** of an electrical safety program may include things such as proper maintenance of equipment; de-energizing equipment where possible; identifying, reducing and protecting employees from electrical hazards; and using the proper tools.
- Electrical safety program **controls** may include development of procedures, training employees to be qualified to do the assigned work, identification of tasks within the arc flash boundary and more.
- **Procedures** may consist of determining and assessing employee qualifications, hazards, personal protective equipment (PPE), tools and one-line diagrams.

While this isn't meant to be a comprehensive look at the information NFPA 70E provides about electrical safety programs, it does seek to convey the scope and magnitude of developing one. This handbook covers many of the elements addressed in the NFPA 70E standard and can help you get started on your journey to reset safety.

Hierarchy of risk controls

The 2018 edition of NFPA 70E places an enhanced emphasis on the hierarchy of risk controls, moving it out of the informative annex and making it a requirement in article 110.1(H).

Eaton has extensive expertise providing services and solutions to help you improve arc flash safety in accordance with the hierarchy of risk controls.

Elimination: Physically remove the hazard

All hazards are identified and eliminated. OSHA 3885 defines Elimination as “A change in process or workplace condition that removes the hazard or ensures that no worker can be exposed to a hazard under any foreseeable circumstances.”

Substitution: Replace the hazard

Replace hazard with equipment that reduces frequency, probability or potential severity of exposure to a lesser extent.

Engineering controls: Isolate people from the hazard

Reduce the frequency or the consequence of exposure to a potential hazard by incorporating designs that provide that function automatically, without any action by personnel.

Awareness: Increase visibility of the hazard

Incorporate signs, labels or audible warnings alerting personnel of the potential presence of hazards that could not be eliminated or reduced.

Administrative controls: Change the way people work

Administrative controls refer to policies and procedures which workers must follow in order to reduce risk of injury.

Personal protective equipment: Protect the worker

Require personnel to wear PPE to protect against remaining risks due to electric shock and arc flash, among others. While important, PPE is still considered to be the least effective control measure because of the opportunity for human error.

Source: NIOSH

Laws, regulations and standards

The following play a key role in keeping electrical environments safe through continual research, communications and enforcement.

OSHA

Occupational Safety and Health Administration

Establishes safe and healthful working conditions for workers by setting and enforcing standards and by providing training, outreach, education and compliance assistance

NFPA 70E

**National Fire Protection Association,
Standard for Electrical Safety in the Workplace**

Provides a practical standard that addresses the electrical safety-related practices in the workplace

NFPA 70

National Electric Code

Regionally adoptable standard for the safe installation of electrical wiring and equipment

IEEE 1584

**Institute of Electrical and Electronics Engineers,
Guide for Performing Arc Flash Hazard Calculations**

Presents methods for the calculation of arc-flash incident energy and arc-flash boundaries

What's new in NFPA 70E?

The NFPA 70E standard for Electrical Safety in the Workplace is updated every three years. Here is a summary of the key changes you'll see in the 2018 edition.

Changes to NFPA 70E 2018 Edition	Section
Added a new general requirement for hazard elimination to be the first priority in the implementation of safety-related work practices	105.4
Added a requirement to inspect newly installed or modified equipment	110.1(B)
Moved the hierarchy of risk control methods from an informational note to a requirement; risk assessment has been revised to include human error	110.1(H)
Revised to require a job safety plan before work tasks begin	110.1(I)
Added an electrical safety program requirement to investigate electrical incidents	110.1(I)
Table 130.5(C) (previously Table 130.7(C)(15)(A)(a)) has been revised and relocated from the arc flash PPE category method to the arc flash risk assessment in Article 130.5	Table 130.5(C)
Table 130.5(G) (previously Table H.3(b)) has been revised and relocated from the arc flash risk assessment in Article 130.5	Table 130.5(G)
Rewritten to provide clarity for conducting a risk assessment and applying risk controls	Informative Annex F
Revised with updated information and data for electrical shock and arc flash injuries	Informative Annex K

Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

De-energized

Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Electrical safety program

A documented system consisting of electrical safety principles, policies, procedures and processes that directs activities appropriate for the risk associated with electrical hazards.

Electrically safe work condition

A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection.

Energized

Electrically connected to, or is, a source of voltage.



Did you know?

OSHA enforces workplace safety under the law, but the OSHA electrical safety standards are not prescriptive. The requirements of NFPA 70E are prescriptive, but are not mandated by law; however, they are considered to be the minimum consensus requirements for safe electrical work procedures, and OSHA may use them as the basis for issuing citations.

In **2014**, OSHA published the Electric Power Generation, Transmission, and Distribution and Electrical Equipment Final Rule that requires employers to do the following to protect workers from flames and electric arc hazards:

- The employer must assess the workplace to identify workers exposed to flame or electric-arc hazards.
- No later than **January 1, 2015**, employers must estimate the incident heat energy of any electric-arc hazard to which a worker would be exposed.
- No later than **April 1, 2015**, employers generally must provide workers exposed to hazards from electric arcs with protective clothing and other protective equipment with an arc rating greater than or equal to the estimated heat energy.



Is it time to reset safety?

Are you familiar with the laws, standards and tools to help you enhance arc flash safety in your facility?

Arc flash hazards

Arc flash threatens personnel safety, and companies face lawsuits, fines, equipment damage, facility downtime and lost production.

What arc flash events really mean to you are problems. Safety problems. Legal problems. Financial problems. Are you prepared?



What is an arc flash?

An arc flash event releases a tremendous amount of energy in the form of thermal heat, toxic fumes, pressure waves, blinding light, sound waves and explosions that can result in serious injury including critical burns, collapsed lungs, loss of vision, ruptured eardrums, puncture wounds and even death.

According to the National Fire Protection Association, an arc flash occurs “when an electric current passes through air between ungrounded conductors or between ungrounded conductors and grounded conductors.” Temperatures can reach 35,000°F – more than three times hotter than the temperature of the sun! These excessive temperatures cause the air and metal in the path of the arc to expand and explode, creating an arc blast.

Common causes of arc flash include:

Human error

- Accidental contact (people, animals, tools)
- Incorrect wiring, labeling or installation
- Improper use of tools
- Failure to notice signs of impending failure
- Insufficiently trained employees

Equipment failure

- Insulation breakdown
- Utility transients and lightning
- Poor maintenance (dust, corrosion, condensation)
- Loose connections
- Interaction with equipment that has not been properly maintained
- Improperly rated equipment



The threat is real: what you should know about arc flash and what you can do to protect your people and equipment from dangerous arc flash events.

The power of an arc flash

The inverse square law and incident energy

As the distance from energized equipment decreases by half, the incident energy increases by approximately a factor of four.

The significance of 1.2 cal/cm²

If you hold your fingertip over a lit candle for one second, you will experience thermal energy of 1.2 cal/cm².

A worker who experiences this amount of thermal energy may experience a second-degree burn, which causes pain, swelling and blistering but doesn't impact the tissue and blood vessels as a third-degree burn would.

The 1.2 cal/cm² threshold is used for setting arc flash boundaries and selecting PPE. By following proper procedures, the thermal energy on a workers skin will be limited to 1.2 cal/cm² in the event of an arc flash incident.

Heat intensity dependent upon

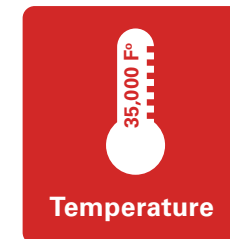
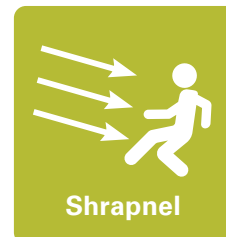
- Power of the arc
- Distance from the arc
- Duration of the arc

Physical dangers

- Heat
- Shrapnel
- Pressure
- Sound
- Intense UV and IR light

Risks to personnel

- Burns
- Wounds
- Broken bones
- Hearing loss
- Vision loss
- Lung injuries
- Chronic pain
- Scarring
- Death



Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

Arc flash hazard

A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

Informational Note No. 1: The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.

Electrical hazard

A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn or arc blast injury.

Exposed

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated or insulated.



Did you know?

An arc blast is comparable to the blast from a stick of dynamite.



Is it time to reset safety?

Are your employees exposed to arc flash hazards in their daily work?

Arc flash studies

To reset safety, start with a study.

Employers must “furnish a workplace that is free from recognized hazards causing or likely to cause death or serious physical harm,” per Section 5(a)(1) of OSHA’s Occupational Safety and Health (OSH) Act.

Employers must “estimate the incident heat energy of any electric-arc hazard to which a worker would be exposed” per OSHA 29 CFR parts 1910 and 1926.

The first and perhaps most important step in understanding, and then addressing the hazards in the workplace is an arc flash study.



What's in a study?

The threat of arc flash is real, and the consequences of an event can be devastating. The initial step in addressing this risk is to have an arc flash study performed, but beware - not all studies are equal, and an inferior study unnecessarily endangers your employees and your business.

To gauge the quality of a study, first, verify that the study will be performed by experienced engineers. Inquire about their education, licenses and experience.

Then, ask about their ability to offer a turnkey solution after the study.

- Q:** Can they train employees on how to interpret the study, read warning labels, choose the correct PPE and properly maintain electrical equipment?
- Q:** Do they have the ability to help you develop an effective electrical safety program?
- Q:** Can they provide products and services to help reduce high incident energy identified in the study?

Finally, ask for a sample of the final report.

- Q:** What information will be included, and will it provide recommendations to improve safety in your facility?

Compare the sample report against the following checklist to ensure you'll get comprehensive and actionable information.

7 things to look for in an arc flash study report

Not all studies are equal, and an inferior study unnecessarily endangers your employees and business. Does your existing or proposed report provide comprehensive and actionable information?

Use this checklist to find out.

- Executive summary
- One-line diagram
- Short circuit analysis
- Protective device coordination study
- Protective device settings table
- Arc flash incident energy analysis
- Input data used in the analysis

Get the complete worksheet [here](#).

Scaling a study in large facilities or campuses

Sometimes, it's not practical to commission a study for an entire facility or campus, especially when faced with personnel and budget constraints. Yet, postponing can leave employees exposed to a greater risk of being injured by an arc flash event.

You can get started now while working within the constraints of your available resources. These key questions will help you pinpoint where to start. Once you address arc flash safety in the identified areas, you will have the know-how and experience to then schedule arc flash studies in other parts of your business, while ensuring that you've taken the proper steps to minimize the risk of arc flash in the areas most critical to your business.

- Q:** Which equipment is critical to your operations?
- Q:** Which equipment needs to stay energized for maintenance and troubleshooting?
- Q:** Which building is most critical if an outage occurs?
- Q:** What is the age of your equipment?
- Q:** What resources do you have for supporting an arc flash study?

Get the complete worksheet [here](#).



**Arc flash analysis -
understanding maximum
and minimum fault levels**

Powering industry through education

[Understanding maximum and minimum fault levels](#)

Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

Incident energy

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. Measured in calories per square centimeter (cal/cm²).

Electrical safety

Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.

Authority having jurisdiction (AHJ)

An organization, office, or individual responsible for enforcing requirements of a code or standard, or for approving equipment, materials, an installation or a procedure.

Interrupting rating

The highest current at rated voltage that a device is identified to interrupt under standard test conditions.

Service point

The point of connection between the facilities of the serving utility and the premises wiring.

Short circuit current rating

The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria.

Single-line diagram

Diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.



Did you know?

When calculating incident energy for especially complex electrical systems, the Authority Having Jurisdiction (AHJ) may require specialized training, licensure or registration.

An arc flash study must be reviewed for accuracy at least every five years, or when there are changes to the facility power distribution system or the incoming utility power.



Is it time to reset safety?

Do you have an up-to-date arc flash study?

Does your study report provide comprehensive and actionable information?

Arc flash labels, boundaries and PPE

Per NFPA 70E, section 130.5(H), electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing or maintenance while energized shall be marked with a label.


The label must show the nominal system voltage, the arc flash boundary and information to select the proper PPE.

This may include the available incident energy and corresponding working distance, minimum arc rating of clothing or site-specific level of PPE.




Arc flash labels: How to interpret label content

- A** The owner of the electrical equipment is responsible for providing arc flash warning labels which are required on electrical equipment over 50V that could be accessed while energized.
- B** An arc flash boundary is the distance at which the incident energy equals 1.2 cal/cm², and arc-rated PPE is required for any employee within the arc flash boundary.
- C** The working distance is the distance from a person's face and chest to the prospective arc source. Typical working distances, primarily based on equipment type, are published in IEEE standard 1584 and used in studies to perform the incident energy calculations.
- D** While performing two sets of calculations for the load side and the line side of the main breaker on specific equipment is not specified in NFPA 70E, Eaton recommends making this a standard practice to enhance productivity and safety for equipment that has adequate isolation of the main protective device.
- If the calculation is performed on the line side only, the entire switchgear lineup may be incorrectly thought to have incident energy above 40 cal/cm² and not able to be worked on while energized.
 - If the calculation is performed on the load side only, the calculated incident energy value will be relatively low, putting workers on the line side in danger.
- E** Calculated incident energy is the amount of thermal energy (cal/cm²) at a distance from an electrical arc event and indicates the level of PPE required to protect workers.
- F** Nominal voltage, limited and restricted approach boundaries, and PPE glove rating are also displayed on the label to help protect workers from electric shock.
- G** Eaton's labels display the arc flash study report number for reference.



WARNING



SHOCK & ARC FLASH HAZARD

Location: MAIN SWGR **G**
Report#: TQS12345.1 Rev.0

Issued: JULY-2018

LINE SIDE of MAIN	13' 6" B ARC FLASH BOUNDARY
	32 cal/cm² CALCULATED INCIDENT ENERGY AT 36" WORKING DISTANCE C
LOAD SIDE of MAIN	3' 10" ARC FLASH BOUNDARY
	6 cal/cm² CALCULATED INCIDENT ENERGY AT 36" WORKING DISTANCE

480V Shock Hazard Limited Approach Boundary: **3' - 6"**

Min. Glove Class: 00 Restricted Approach Boundary: **1' - 0"**

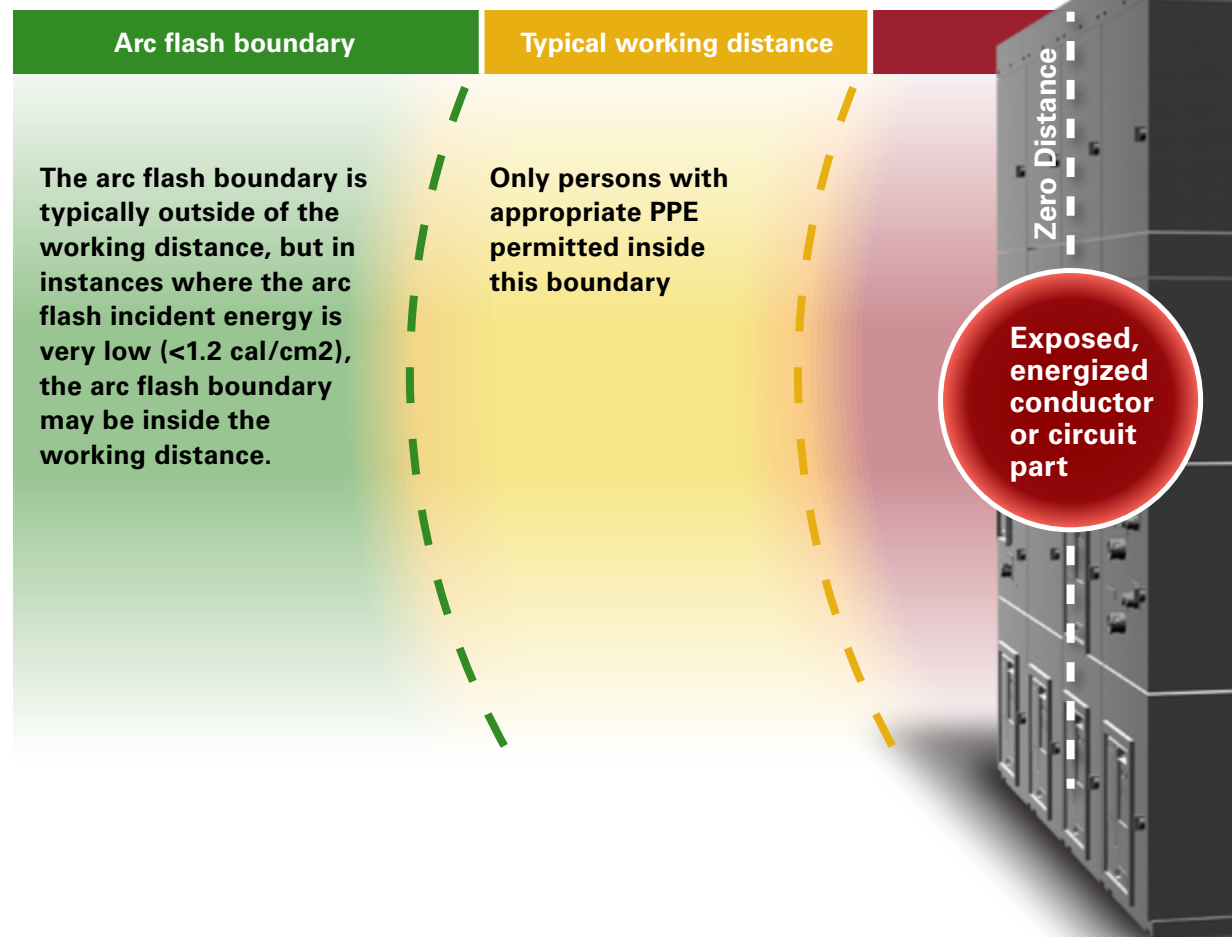
Arc flash boundary

The **arc flash boundary** is calculated based on the arcing current and clearing time. It is the distance at which the incident energy equals 1.2 cal/cm². At this distance, a person would be expected to receive a just curable burn on exposed skin if a worst-case arc fault occurs. The arc flash boundary is independent of the shock protection boundaries, which are fixed based on voltage. The arc flash boundary may be inside or outside the shock boundaries depending on the system configuration.

The **working distance** is the distance from a person's face and chest to the prospective arc source. Typical working distances, primarily based on equipment type, are published in IEEE standard 1584 and used in studies to perform the incident energy calculations. At this distance and with the proper PPE, it is expected that a person's head and torso would be protected. Additional PPE is necessary for any body parts, such as arms and hands, that are inside the working distance.

Low-voltage does not imply a low arc flash hazard and high-voltage does not necessarily imply a significant arc flash hazard.

Electrical equipment type	Working distance
Low-voltage panelboards and switchboards	18 in
Low-voltage switchgear	24 in
Medium-voltage switchgear	36 in



Personal protective equipment (PPE)

NFPA 70E arc flash PPE category method tables vs. incident energy analysis method

Two methods can be used in an arc flash risk assessment to determine appropriate arc flash PPE. One is the incident energy analysis method using IEEE standard 1584 calculations, which results in an incident energy value expressed as cal/cm² at a typical working distance. The second is the arc flash PPE category method, which results in appropriate arc flash PPE selected directly from the NFPA 70E tables.

Do you know which is superior for PPE identification?

Example of an IEEE standard 1584 calculation

Bus Name	Device Name	Bus kV	Bus Bolted Fault kA	Device Bolted Fault kA	Arcing Fault kA	Trip Time (s.)	Bkr. Opening (s.)	Ground	Equip	Gap mm	AF Boundary	Working Distance	Incident Energy (cal/cm ²)
PANELA	PANELA FDR	485 mm (19 in)	12.57	12.57	6.56	2	0	yes	PNL	25	6' 2"	1' 6"	13.4

Example of an NFPA 70E arc flash PPE category method

Equipment type	Arc flash PPE category	Arc flash boundary
Panelboards or other equipment rated 240V and below Parameters: Maximum of 25kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in)

On the surface, it would appear that the NFPA 70E arc flash PPE category method is a simple lookup; however, in order to use these tables correctly, the assumptions must be verified by doing some level of calculations.

Test your knowledge

Using the NFPA 70E arc flash PPE Category Method, can you confidently answer these questions? If not, what would you have to do in order to verify the assumptions on the table?

1. Does your panel operate under the 25kA short circuit current?
2. Does your panel meet the 0.03 sec (2 cycles) fault clearing time?
3. What is the working distance?

In most systems, the answers to these questions are not easily determined without performing additional analysis. The incident energy analysis method is the preferred industry standard to calculate the exact hazard to provide your workers with the most accurate arc flash data.

Arc flash labels and personal protective equipment (PPE)

Powering industry through education

Arc flash labels and personal protective equipment

Answers

1. The short circuit current is dependent on the system, not the equipment type, so calculations to verify the following are required: available fault current from the utility, upstream transformer impedance and kVA rating, and upstream cable type, size and length.
2. A coordination study is required to validate this time because most protective devices do not operate at this fault clearing time unless the available fault current is quite high. It's also necessary to know the available fault current to determine clearing time.
3. The working distance for most panelboards is 18 inches. Making assumptions without validating them will result in inaccurate data which puts employees in danger, either by specifying insufficient PPE, or by specifying excessive PPE, which results in reduced dexterity, visibility and comfort.

Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

Arc flash boundary

When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for one second.

Arc flash suit

A complete arc-rated clothing and equipment system that covers the entire body, except for hands and feet.

Arc rating

The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy break open threshold.

Balaclava (sock hood)

An arc-rated hood that protects the neck and head except for the facial area of the eyes and nose.

Limited approach boundary

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Restricted approach boundary

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Working distance

The distance between a person's face and chest area and a prospective arc source.

Informational note: Incident energy increases as the distance from the arc source decreases.



Did you know?

The maximum available fault current is not a good approximation of the fault current that would be sustained in an arc flash event; typically, it's much lower because arcing faults have a higher impedance.

When using the incident energy analysis method, Table 130.5(G) provides guidance on selection of PPE with two levels of exposure:

1. Incident energy exposures equal to 1.2 cal/cm^2 up to 12 cal/cm^2
2. Incident energy exposures greater than 12 cal/cm^2

For both levels, appropriate PPE must have an arc rating equal to or greater than the estimated incident energy



Is it time to reset safety?

Do employees know how to read a label? Do they know what PPE is required? Are they wearing the correct PPE?

Are subcontractors exposed and are they wearing the proper PPE?

Arc flash safety training

A top-notch safety culture incorporates comprehensive training for employees focusing on the specific hazards associated with electrical energy.

Per NFPA 70E, Article 110, employees shall be trained in safety-related work practices and procedural requirements, as necessary, to provide protection from the electrical hazards associated with their respective job or task assignments.

It is the employer's responsibility to see that this training occurs and is documented, and it may be conducted in the classroom, on-the-job or a combination of both, determined by the risk to the employee.



Training to enhance arc flash safety

Why training is critical

Ensure that your employees are able to:

- Recognize hazards
- Interpret arc flash labels
- Understand arc flash boundaries
- Understand PPE requirements
- Interpret arc flash study results
- Train others in work flow

Retrain when:

- Retraining has not occurred within three years
- New equipment, including PPE, or new technology is introduced into the work environment
- New or revised procedures are to be used
- Inspection indicates employees are not properly complying with safety related work practices

Training records:

- Verify employee training annually
- Document what training the employee has received
- Document when an employee has demonstrated proficiency
- Retain the documentation throughout the employee's employment

What to look for in training

A trainer who:

- Has experience with equipment from various manufacturers
- Is familiar with electrical standards and regulations
- Has helped companies develop safe work practices
- Is knowledgeable with up-to-date tools and equipment used in electrical work

A training curriculum that includes:

- Understanding standards and regulations
- Identifying hazards
- Establishing safe work practices
- Interpreting an arc flash study
- Reading an arc flash label and selecting the proper PPE
- Using tools, including insulated hand tools, live-line tools, grounding cables, voltage detectors, etc.
- Operating and maintaining electrical equipment

Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

Qualified person

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.



Did you know?

Arc flash is just one training aspect of an electrical safety program. Be sure to train employees on lockout/tagout (LOTO), workspace and barriers, and shock hazard. For expert training, turn to Eaton's trainers, the same electrical engineers who not only perform arc flash analyses, but also install, commission, troubleshoot and maintain electrical equipment every day.

If you're not properly maintaining your electrical equipment, incident energy may be higher than expected, increasing safety risk. A maintenance training program covers:

- Preventative maintenance schedules
- Proper operation and maintenance of equipment
- Use of interlocks
- Required tools
- How to recognize signs of impending equipment failure



Is it time to reset safety?

Are employees qualified to perform the work they're doing?

Are unqualified employees required to receive any electrical related safety training?

Are your employees trained to identify the arc flash hazard and reduce the associated risk?

Arc flash mitigation solutions

After the incident energy has been calculated throughout your facility and workers have been provided with the proper PPE and training, continue to enhance arc flash safety with products and solutions that can help mitigate the magnitude, duration and even the likelihood of an arc flash event.



You've had an arc flash study. Now what?

Mitigating the hazards and risks of arc flash

Your arc flash study report from Eaton provides recommendations to reset safety in your facility. The short circuit analysis identifies overdutied equipment, the protective device coordination study indicates the degree of selectivity in your system, and the arc flash incident energy analysis calculates available fault current, clearing time and incident energy at the working distance.

Chances are, you will discover that your facility is deficient in one or more of these categories, and the following are opportunities for improving safety and mitigating arc flash hazards.

Work practice modifications

- Work on gear only when it is de-energized
- Limit source power (utility power, generator power, de-energizing part of system)
 - » Operating scenarios include normal utility operation and alternative sources of power such as diesel standby generators
- Modify standard work documents/practices
 - » Lockout/tagout (LOTO)
 - » Sequence of operation
 - » Remote racking
- Safely interact with equipment to perform preventative maintenance or electrical inspection of the gear
 - » Infrared (IR) windows
 - » Visible blade viewing windows
 - » Double-door line isolation switch
 - » Insulgard
- Kirk Key Interlock Systems

Equipment or system modifications

- Arcflash Reduction Maintenance Switch
- Zone Selective Interlocking (ZSI)
- Current limiting devices
- Differential relay schemes
- Arc flash relay
- High-resistant grounding
- Power Xpert dashboard (HMI)
- Breaker setting adjustments
- Bypass isolation Automatic Transfer Switch (ATS)
- High and low impedance transformers
- Fused switch to breaker retrofills

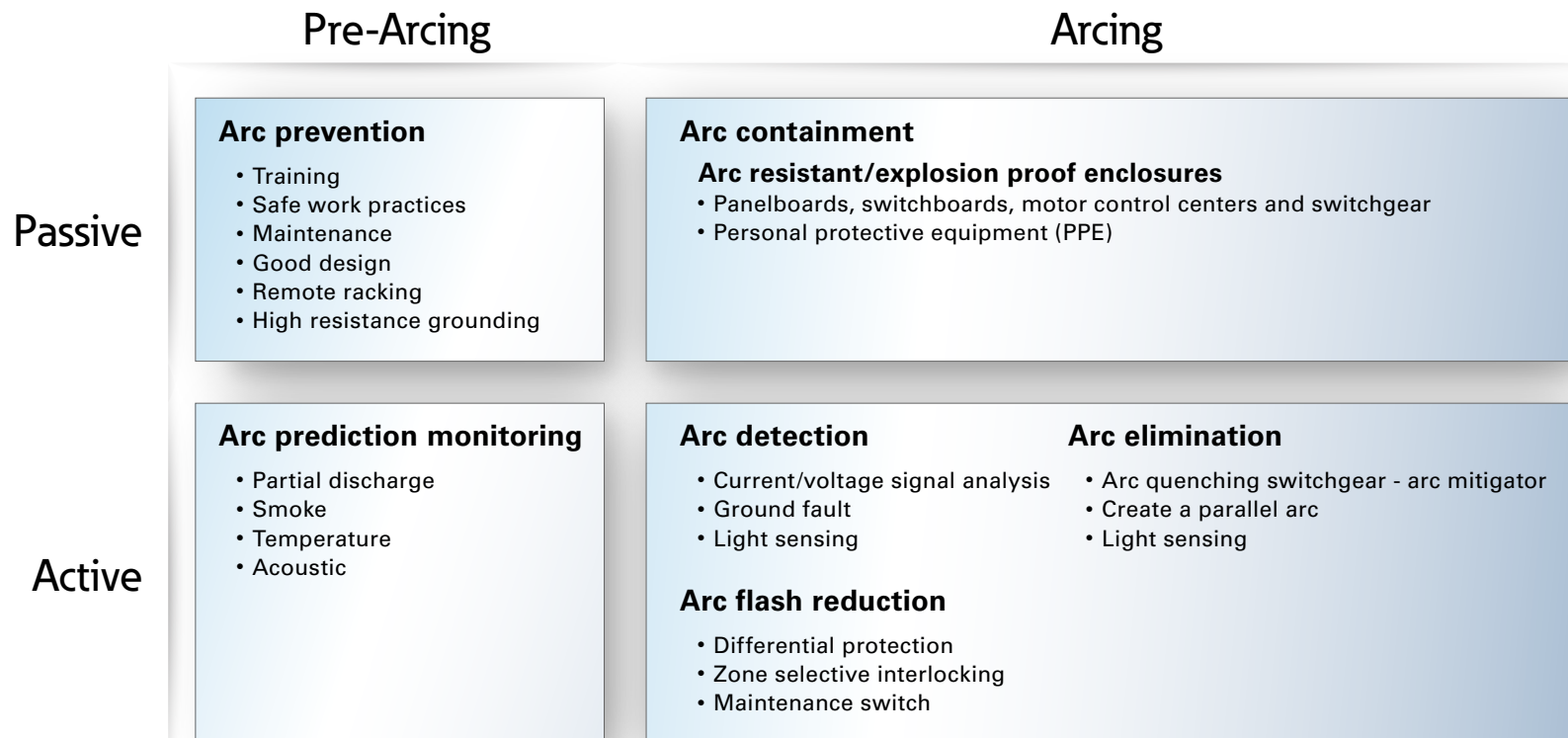
Arc resistant replacement gear

- Flashgard motor control centers (MCC)
- Low-voltage and medium-voltage arc resistant switchgear type 2B
 - Type 2:** Arc resistance provided from the front, sides and rear
 - Type 2B:** Arc resistance is maintained even while opening designated low voltage compartments
- Medium-voltage metal-clad switchgear type 2B
- Variable frequency drives type 2B
- Arc quenching Magnum DS switchgear

Safety and reliability: no compromise necessary

The easiest way to lower arc flash incident energy is to reduce the fault clearing time. However, lowering the pickup and time delays of protective devices to make them trip faster may compromise coordination and system reliability. It is important to have a balance between system selectivity and protection. The following solutions help to improve arc flash safety and reduce incident energy levels, but not compromise protective device coordination.

Selectivity is the practice of optimizing and coordinating the settings on adjustable protective devices (breakers, protective relays, etc.) so that the device immediately upstream of a given fault is the device to trip and effectively clear the fault. Achieving selectivity ensures that under a given fault condition, the loss of load to other, non-affected branches of the system are minimized. A simple example is if there's a fault in your kitchen stove, you want only the breaker on that circuit in your home to trip, not the device that feeds the whole neighborhood!



Definitions from NFPA 70E 2018: Standard for Electrical Safety in the Workplace

Circuit breaker

Device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Current limiting overcurrent protective device

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Fuse

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Arc resistant switchgear

Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.



Did you know?

Eaton's arc quenching switchgear detects and contains an arc fault in less than 4 milliseconds, drastically reducing the incident energy.

Per NEC section 240.87, arc energy reduction (ARMS, ZSI, differential relay schemes or arc quenching switchgear) is required for any circuit breaker that can be adjusted to 1200A or above, regardless of settings.



Is it time to reset safety?

What methods do you use to mitigate arc flash hazards?

Are you prepared?

The threat of arc flash is real, and the consequences of an event can be devastating: lawsuits, fines, equipment damage, operations downtime, lost production and most significant, personnel injury or death. An effective arc flash safety program incorporates the elements shown below.



Single-line diagram

Shows how electrical distribution equipment is connected and how power flows, from the incoming power source through each individual load, and is necessary to understand the system as a whole



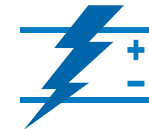
Protective device coordination study

Ensures that only the affected portion of the system is taken offline if there is a fault



Incident energy analysis

Calculates the arc flash boundary, working distance and incident energy per NFPA 70E



Short-circuit study

Calculates available fault current, compares it to the equipment ratings, and identifies overdutied equipment that needs to be replaced



Arc flash warning labels

Affixed to electrical equipment to indicate the incident energy, working distance and arc flash boundary for that piece of equipment, and is used to select the proper personal protective equipment (PPE)



Safety training

Educates employees about how to interpret the study, the one-line diagram, the arc flash warning labels and choosing appropriate PPE



Documented electrical safety program

A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards



Mitigation solutions

Helps to lower incident energy at locations of concern, typically those with high incident energy over 40 cal/cm²



Personal protective equipment (PPE)

Protects a qualified worker in the event of an arc flash event, and is meant to be used only after recognizing the hazards and taking steps to minimize or eliminate them



Electrical maintenance

Helps to ensure that protective devices such as breakers, relays and trip units will clear a potential arcing fault



Arc flash study update

Required when changes occur in the electrical system that could affect the results of the analysis, or every five years, and ensures that the study results and labels are accurate

How to reset safety in your facility



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preparedness

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