



# ARC FLASH SAFETY

## INSTANT ACTION GUIDE

### Knowledge is Power

Protect your workers with expert guidance on:

- PPE Requirements
- Arc Flash Boundaries
- LO/TO Procedures
- Compliance Standards

# DuraLabel®



## Electrical Safety Boundaries

### Arc Flash Boundary:

This is the distance from equipment at which an arc flash could cause second-degree burns. Unprotected workers should keep clear.

### Limited Approach Boundary:

Workers without special training should stay outside this boundary, unless they have appropriate protection and are escorted by a specially-trained person.

### Restricted Approach Boundary:

Only specially-trained workers should cross this boundary. When work is to be performed on energized equipment, crossing this line requires an approved written work plan.



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# REGULATIONS & STANDARDS

## Ensure OSHA Compliance

Employers are required by OSHA to provide a safe workplace for their employees through the "General Duty Clause."

Where hazards exist that might require PPE, employers should determine what equipment is needed, provide the PPE for employee use, and communicate the necessary information to any affected employees (29 CFR §1910.132(d)).

**OSHA's rules for electrical safety require employers to mark electrical equipment with "voltage, current, wattage, or other ratings as necessary" (29 CFR §1910.303(e)). OSHA also mandates the use of signs or similar devices to "warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts" (29 CFR §1910.335(b)).**



## What is an Arc Flash?

An electrical explosion; begins with a small spark that becomes a runaway arc, drawing more and more power until it destroys the conductors around it or the power is cut off.

Arc flashes may cause personal injury through electric shock, thermal burns, and physical trauma.



## OSHA Electrical Safety Requirements

Regulations in OSHA 29 CFR 1910 Subpart S, part of OSHA's General Industry regulations, discuss electrical safety. These regulations state that "Safety related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts...." In general, employers have a number of responsibilities under this regulation:



Creation and documentation of a facility electrical safety plan with defined responsibilities



Documented training in electrical and arc-flash safety, for both electrical workers and any other workers who might be affected



Identification and analysis of arc flash hazards



Provision of adequate personal protection equipment



Placement of warning labels on equipment



Provision of proper tools for safe electrical work



Verification, through annual inspections, that individual employees are complying with established safe work practices

# ABOUT THE REGULATIONS

## Rules for Electrical Installations: The NEC

The National Electrical Code (NEC) is published by the NFPA to describe acceptable electrical installations. The standard is intended to protect life and property from the hazards of electricity.

Equipment should be clearly marked to warn electrical workers of the arc flash hazard.

The NEC requires service equipment rated for 1200 amps or more to display the following:

- Nominal system voltage
- Available fault current at the protective devices
- Clearing time for those devices, based on the available fault current.
- Date of the label

These specific requirements are met if the equipment has an arc flash label “in accordance with acceptable industry practice.”

## NFPA 70E Arc Flash Training Requirements

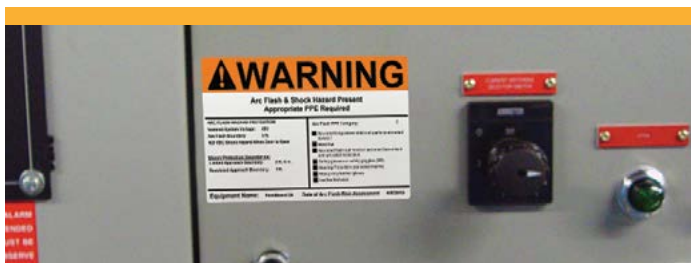
The [NFPA](#) describes its general training requirements in Article 110.2. The requirements there are divided into two broad categories:

- **Emergency Response Training.** Includes basic shock response training as a requirement for all workers exposed to shock hazards. More in-depth training is required for workers who are designated as responders for medical emergencies.

This training category requires a refresher at least once per year.

- **Employee Training.** This category covers OSHA-style worker training, separated into sections for qualified and unqualified persons. The NFPA offers more detailed training requirements for qualified workers.

This training category requires a refresher at least once every three years.



## NFPA 70E Recommendations

NFPA 70E is a guide for safe electrical work. Its recommendations for arc flash risk assessment and equipment labeling appear in Article 130.5.

NFPA 70E requires labels on workplace electrical equipment that is “likely to require examination, adjustment, servicing, or maintenance while energized.” Arc flash warning labels under NFPA 70E must inform workers about the equipment’s:

- Power level
- Potential for arc flash
- Appropriate personal protective equipment (PPE).





# HOW TO EVALUATE YOUR FACILITY

The detailed arc flash warning labels described by NFPA 70E need to be created in the field, rather than at the equipment's point of manufacturing order to reflect the installations, supplies, and loads in place. A facility evaluation is needed in order to find the appropriate details.

## Arc Flash Risk Assessments

A risk assessment needs to be performed to provide effective protection from hazards.



Step One recognizes a potential hazard. Step Two combines the severity and likelihood of an injury to assess the overall risk presented by that hazard. Step Three determines actions to prevent or minimize injury. This general process can be applied to any type of hazard.



## Identify A Hazard

An electrical hazard may be present whenever an employee works near a substantial electrical charge or current. Arc flash incidents arise during installation, removal, repair, or other service on energized equipment.

Ordinary operation will not present a substantial risk of arc flash if all the following are true:

- The equipment has been properly installed and maintained
- The equipment is used according to manufacturer instructions
- All equipment doors, covers, or panels are in place, closed, and secured appropriately
- There is no evidence of impending failure

Table 130.5(C) in the [NFPA 70E](#) standard provides a quick guide to whether a given task is likely to pose an arc flash hazard. Many facilities follow the guidance of the [IEEE 1584](#) standard for analyzing arc flash hazards with a detailed and engineering-focused approach.

# CONDUCTING AN ARC FLASH HAZARD STUDY

## What Comprises an Arc Flash Hazard Analysis?

The purpose of an arc flash hazard study is to determine the location and severity of arc flash hazards and to suggest appropriate courses of action to minimize them. The study requires electrical engineering expertise and in-depth knowledge of a facility's electrical system.

## An arc flash study consists of the following steps:

### Collect System Data

Data collection requires a review of existing documentation, drawings, equipment specifications, short-circuit, and coordination studies, followed by manually collecting data to fill in any gaps.

### Model the System

Identify any variant modes of operation. Each mode of operation should be analyzed to determine if it results in hazard conditions that differ significantly from normal operations.

### Determine Arcing Fault Currents

IEEE 1584 presents formulas for determining arcing fault currents. It is conservative to calculate three-phase values for arc fault currents.

### Determine Fault-Clearing Times

IEEE 1584 recommends calculating fault-clearing times based on both 100% and 85% of the calculated arc fault current to account for possible fluctuations.

### Calculate Incident Energy

The IEEE formulas are considered more accurate, while the NFPA 70E formulas produce relatively conservative results. Incident energy levels depend on a range of environmental conditions such as temperature, humidity, and equipment geometry, in addition to the values used in the equations. A working distance must be assumed to calculate incident energy.

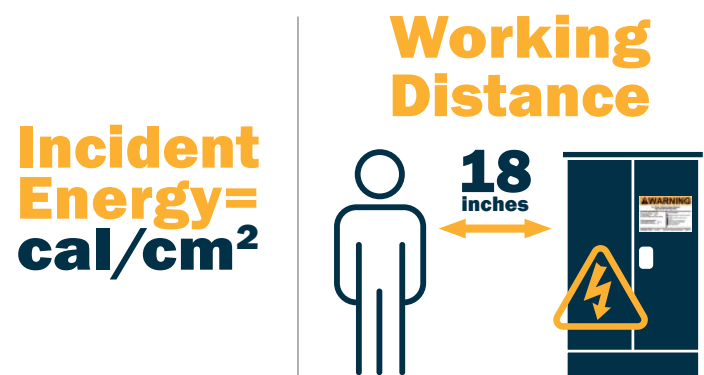
### Calculate Arc Flash Protection Boundaries

NFPA 70E provides three acceptable methods to determine these boundaries:

- Using NFPA 70E tables 220.2(B)(2) and 220.6(B)(9)
- Using the formulas in NFPA 70E Annex B
- Using the formulas in IEEE 1584

The data collected and calculated in the course of the study is put to various uses and include printing warning labels for equipment, determining required PPE, and training workers. Data may also be analyzed to optimize the system itself.

## Incident Energy and Working Distance



Incident energy is measured in  $\text{cal}/\text{cm}^2$ , and the working distance is the expected distance from an arc to a worker's face and chest (often estimated as 18 inches). The available incident energy and corresponding working distance offer the most detailed technical information a worker can use to decide which equipment is appropriate.

Incident energy and working distance are calculated for each piece of equipment and installation present, and must be documented in your facility's electrical safety program.



# HOW TO EVALUATE YOUR FACILITY

## Assess the Risks

Risk assessment is necessary for any task where there is an arc flash hazard:

- How likely is an arc flash to occur with the type of work performed and the equipment involved?
- How much energy would be released in an arc flash if one occurred during that work?
- How severe could the worker's resulting injuries be?

NFPA 70E offers two approaches to risk assessment:

- Incident Energy Analysis: uses the technical details of a piece of equipment and its installation to calculate the expected heat energy that would be directed at a worker. This provides detailed information that can be used to choose appropriate protections for the worker.
- PPE Category: offers a shortcut for common scenarios, and include general recommendations for protective steps.



## Choose the Right Protective Measures

The Hierarchy of Controls offers a systematic way to think about how to protect workers. It starts with the most effective protections and ends with the least effective.

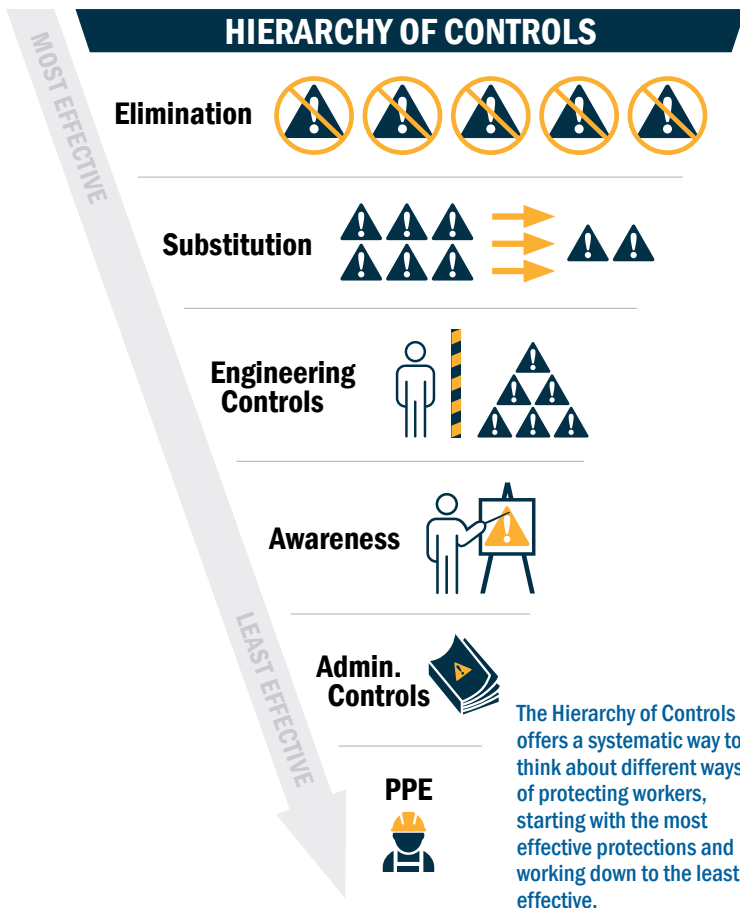
The steps of the Hierarchy of Controls are:

1. **Elimination:** Removes the hazard entirely
2. **Substitution:** Replaces a severe hazard with a less severe one
3. **Engineering Controls:** Changes the work environment or equipment to separate workers from the hazard
4. **Awareness:** Provides the information that workers need to make safe decisions during work
5. **Administrative Controls:** Creates formal procedures to work safely under anticipated conditions
6. **Personal Protective Equipment:** Limits the severity of any injuries with a last line of defense

## How to Maintain Electrical Safety

NFPA 70E requires arc flash risk assessments be reviewed at least once every five years. This helps ensure that the information shown is correct, and up-to date.

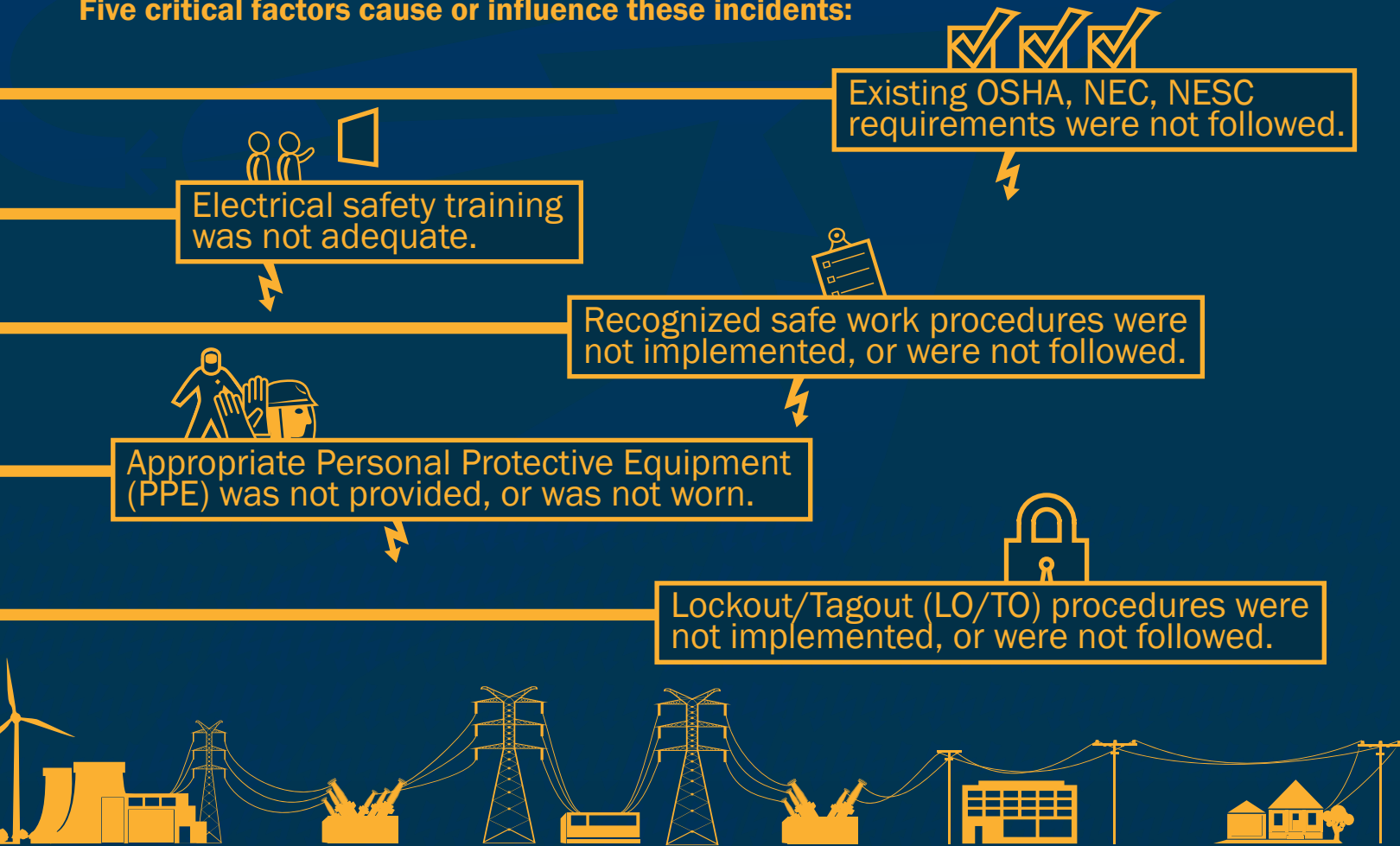
Your assessments must be documented. Include the date of the assessment on any labels or instructions to inform workers of the deadline for the next review.



# Prevent Electrical Incidents

According to NIOSH, in more than a third of electrical incidents, there was no safety program or written safe work procedures. In fact, many of the victims have no safety training at all.







Five critical factors cause or influence these incidents:



## Establish Electrically Safe Conditions

The best way to prevent an electrical injury is to simply turn the power off.

### 6 Ways to Charge Up Your Electrical Safety

-  Identify all possible sources of power to the equipment
-  Shut down the power, and then systematically disconnect each power source
-  Visually verify that all disconnections are complete if possible
-  Lock or tag out the power sources to prevent accidental re-energizing
-  Use an adequate test instrument to confirm that the equipment has been de-energized
-  Apply a grounding device rated for the available fault current when voltage may be induced

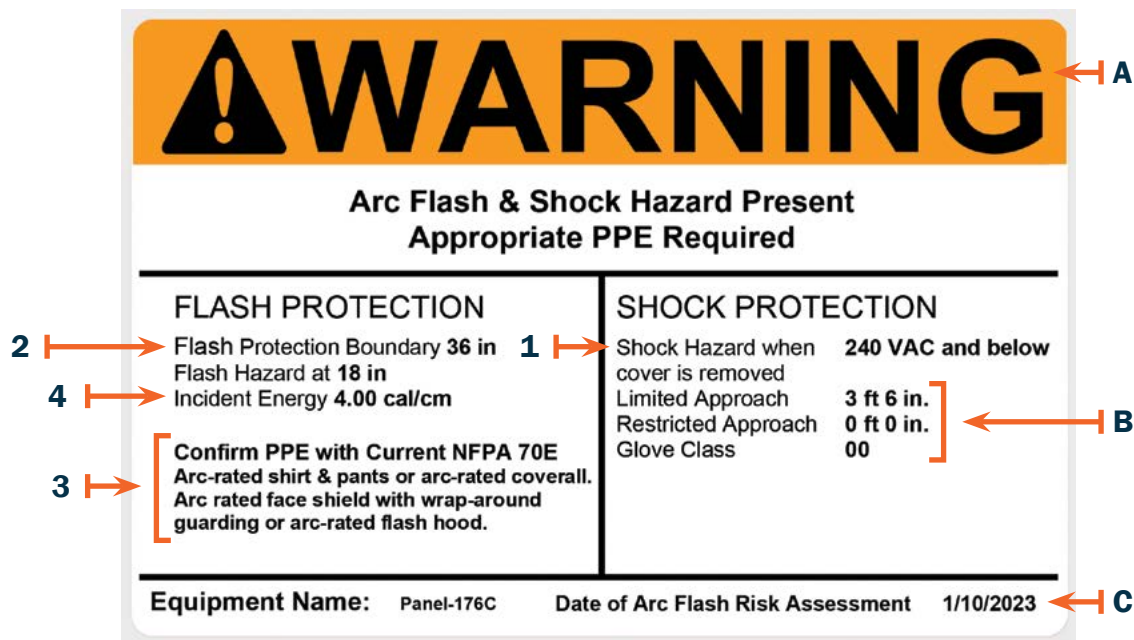


# ARC FLASH LABEL REQUIREMENTS

## NFPA 70E 2021

NFPA 70E includes tables that give estimations for arc flash boundaries in specific situations.

Arc flash labels are described in section 130.5(H), "workplace electrical equipment that is to be examined, adjusted, or serviced should be labeled with all four of the following":



## Requirements

- 1. Nominal System Voltage** – The nominal system voltage, offers a quick way to assess the potential shock hazard and general degree of danger represented by a system. It can be measured in VAC (volts, alternating current) or VDC (volts, direct current). Common values are 120, 208, 220, and 480.
- 2. Arc Flash Boundary** – The arc flash boundary, is the distance from the equipment at which an unprotected person would receive second-degree burns in the event of an arc flash. The distance is calculated in a variety of ways, and the calculation method must be documented. It does not need to appear on the label.
- 3. Protective Equipment** – Protective equipment provides workers with information about the personal protective equipment (PPE) needed to work on the labeled equipment safely.
- 4. Incident Energy at a Working Distance** – The available incident energy and corresponding working distance offer the most detailed technical information. Incident energy is measured in cal/cm<sup>2</sup>, and the working distance is the expected distance from an arc to a worker's face and chest (often estimated as 18 inches). These technical details can be used to decide on appropriate protective equipment.

## Other Label Elements

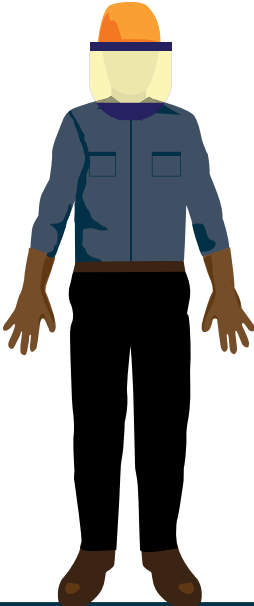



- A. Warning/Danger Header** – These labels warn of a hazard that could result in serious injury or death. An ANSI Z535-compliant header should be used. The header can be either an orange band with the word "WARNING" in black, or a red band with the word "DANGER" in white. "Danger" should be used for more serious threats.
- B. Shock Boundaries** – Electrical equipment that poses an arc flash hazard also presents a shock hazard. The Limited Approach Boundary is a distance from the equipment that should only be crossed by qualified workers, or workers properly equipped and accompanied by a qualified worker. The Restricted Approach Boundary, should only be crossed by qualified workers with a written and approved plan of action.
- C. Date of Risk Assessment** – All arc flash labels should include a Date of Risk Assessment. NFPA 70E requires the analysis to be reviewed at least once every five years, and labels must be updated whenever the relevant information has changed. CSA Z462 (the Canadian standard to NFPA 70E) requires this date appears on the label.



# ARC FLASH PPE CATEGORIES

## NFPA 70E 2021

The National Fire Protection Association (NFPA) uses four Arc Flash PPE Categories to classify ranges of arc flash hazards, and the corresponding requirements for Personal Protective Equipment (PPE). These categories inform workers about the protection they need while working on energized equipment.

PPE CATEGORY 1	PPE CATEGORY 2	PPE CATEGORY 3	PPE CATEGORY 4
<p>Minimum Arc Rating of <b>4 cal/cm<sup>2</sup></b></p> <p><b>Arc Rated Clothing:</b></p> <ul style="list-style-type: none"> <li>• AR long-sleeve shirt and pants, or AR coverall</li> <li>• AR face shield, or AR flash suit hood</li> <li>• AR jacket, parka, rain wear, or hard hat liner (as needed)</li> </ul> 	<p>Minimum Arc Rating of <b>8 cal/cm<sup>2</sup></b></p> <p><b>Arc Rated Clothing:</b></p> <ul style="list-style-type: none"> <li>• AR long-sleeve shirt and pants, or AR coverall</li> <li>• AR flash suit hood, or AR face shield and AR balaclava</li> <li>• AR jacket, parka, rain wear, or hard hat liner (as needed)</li> </ul> 	<p>Minimum Arc Rating of <b>25 cal/cm<sup>2</sup></b></p> <p><b>Arc Rated Clothing:</b></p> <ul style="list-style-type: none"> <li>• As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants</li> <li>• AR flash suit hood</li> <li>• AR gloves</li> <li>• AR jacket, parka, rain wear, or hard hat liner (as needed)</li> </ul> 	<p>Minimum Arc Rating of <b>40 cal/cm<sup>2</sup></b></p> <p><b>Arc Rated Clothing:</b></p> <ul style="list-style-type: none"> <li>• As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants</li> <li>• AR flash suit hood</li> <li>• AR gloves</li> <li>• AR jacket, parka, rain wear, or hard hat liner (as needed)</li> </ul> 
<p><b>Protective Equipment:</b></p> <ul style="list-style-type: none"> <li>• Hard hat</li> <li>• Safety glasses or safety goggles</li> <li>• Hearing protection (with inserts)</li> <li>• Heavy-duty leather gloves</li> <li>• Leather footwear (as needed)</li> </ul>	<p><b>Protective Equipment:</b></p> <ul style="list-style-type: none"> <li>• Hard hat</li> <li>• Safety glasses or safety goggles</li> <li>• Hearing protection (with inserts)</li> <li>• Heavy-duty leather gloves</li> <li>• Leather footwear</li> </ul>	<p><b>Protective Equipment:</b></p> <ul style="list-style-type: none"> <li>• Hard hat</li> <li>• Safety glasses or safety goggles</li> <li>• Hearing protection (with inserts)</li> <li>• Leather footwear</li> </ul>	<p><b>Protective Equipment:</b></p> <ul style="list-style-type: none"> <li>• Hard hat</li> <li>• Safety glasses or safety goggles</li> <li>• Hearing protection (with inserts)</li> <li>• Leather footwear</li> </ul>

Each category includes a minimum Arc Rating (AR) value for the required PPE. This value is determined by the PPE manufacturer to indicate the amount of heat energy (in cal/cm<sup>2</sup>) that the clothing can absorb or block before the wearer is burned. (Second-degree burns are expected when skin is exposed to 1.2 cal/cm<sup>2</sup> of incident energy.)

Category 1 and 2 requirements can be met with a single layer of arc-rated PPE. To meet category 3 or 4 requirements, multiple layers of PPE may be required. These layers need to be tested together to receive a complete system arc rating.

## DURALABEL SAFETY SOLUTIONS

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### TORO MAX INDUSTRIAL PRINTER

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