

Outline

- Why Electrical and Arc Flash Safety?
- What is Arc Flash?
- Getting Started with NFPA 70e
- Things to implement now



Why Electrical and Arc Flash Safety?



Electrical hazards

The causes of injuries and deaths:

- Fire
- Electrical shock,
- Arc-flash, and
- Arc-blast.

**These
Incidents
can be
Prevented**



Electric Shock

Electrocution is the fourth leading cause of industrial fatalities, after traffic, homicide, and construction accidents.

Electrocution is the cause of 380 deaths a year in the US

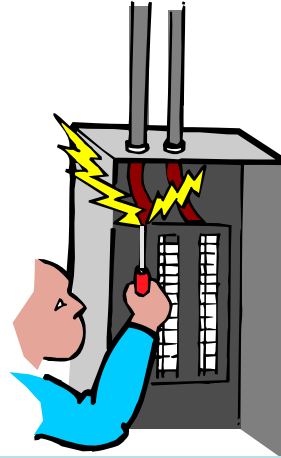
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Electric Shock

About 30,000 electrical shock accidents occur each year.

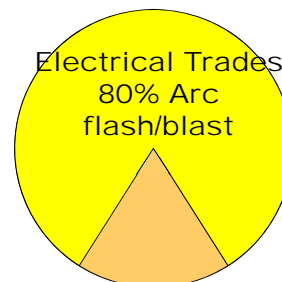
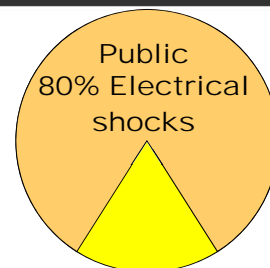
- It is estimated that about 1000 fatalities each year are due to electrocution,
- More than half of these occur while servicing energized systems of less than 600 volts.
- These systems are used in the die casting plant, your office and your home



Shock vs. Arc Flash/Blast

80% of electrical injuries to the general public and non-electrical trades employees are caused by electrical shocks.

80% of serious electrical injuries to employees who work with electricity are caused by arc flash/blast.



What is arc flash?



Arc Flash and Arc Blast

An electrical explosion
Breakdown of the resistance of
air resulting in an
electrical arc where there
is:

Sufficient voltage in an
electrical system; and,
A path to ground or
another (different) voltage.



This arc causes:

Arc Flash – heat and radiant energy; and,
Arc Blast – pressure and mechanical energy



Small Arc Flash and Arc Blast Events

The 120 volt outlets in homes and die casting plant offices
 Not supplied with enough energy to produce a significant arc flash/blast
 Nasty arcing may cause a fire



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Arc-Flash

Demonstration



Non-FR clothing burns after arc exposure

Bright, intense flash from the arc

electrical panel

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Arc-Flash

Sudden release of electrical energy through the air

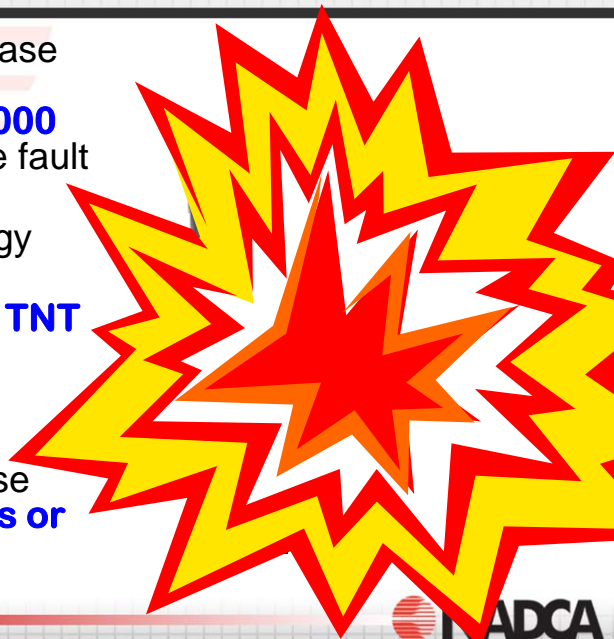
- High-voltage gap exists and
- A breakdown between conductors.
- Thermal radiation (heat)
- Temperatures can reach **35,000°F.**
- Bright, intense light that can cause burns.
- Exposure to these extreme temperatures burn the skin.
- Causes ignition of clothing and adds to the burn injury.



Arc Blast for Qualified Persons

Single phase-to-phase fault on a **480V system with 20,000 amps** of available fault current

- Releases energy equivalent to **1.5 pounds of TNT**
- Resulting devastation is comparable.
- Arcs often cause serious **injuries or death**



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Getting Started with NFPA70e



Occupational Safety and Health Act



- **All employers** are required to comply with OSHA safety and health standards.
- In addition, employers must provide their employees with a work place that is free from recognized hazards likely to cause death or serious physical harm.
- Employers can be cited if there is a recognized hazard and they do not take reasonable steps to prevent or correct the hazard.

OSHAct, Sections 5 (a) (1), 17 (k); 29 USC 651 Et. Seq.



To help employees follow the rules,
employers are required to

- **Make reasonable efforts to identify hazards (hazard assessment)**
- **Establish rules (work rules, policies, or procedures)**
- **Effectively communicate those rules (training)**
- **Inspect the plant to determine if rules are being followed (follow-up)**
- **Take Action to enforce compliance**



OSHA Review Commission, OSHA Act Section 5 (a), 17 (k)



OSHA refers to the National Fire Protection Association electrical safety standards to explain and supplement the OSHA standards

Compliance with NFPA 70E on electrical safety is identified by OSHA as “one way of ensuring” that an employee is adequately protected

OSHA uses NFPA and other consensus standards to make sure employers meet the requirements of the OSHA General Duty Clause

NFPA 70e in a Nutshell

- Live parts are to be deenergized **and** locked out, tagged, or both before an employee works on or near them
- There are special rules for the few cases where work on or near live parts is allowed



29 CFR 1910.333 (a) (1) and (b) (2) - - NFPA 70E - 110.8 (A) (1)



Working on or near exposed de-energized parts

Deenergized conductors are required to be locked out or tagged or both

If deenergized parts are not locked out or tagged - treat the parts as energized



29 CFR 1910.333 (b) (1) - - NFPA 70E 120.2 (A)




De-energize live parts

Before an employee works on or near live parts, the employer must show that:


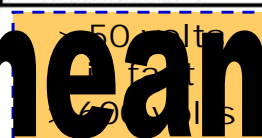
- Deenergizing introduces additional or increased hazards or increases the risk of equipment damage or operational limitations

Live parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to live parts or to exposure to energized parts.

29 CFR 1910.333 (a) (1) - NFPA 70E - 110.8 (A) (1)




Infeasible doesn't mean INCONVENIENT

OSHA provides some examples


Working live is permitted only for very serious and compelling reasons to prevent

- Interruption of life support equipment,
- Deactivation of emergency alarm systems,
- Shutdown of hazardous location ventilation equipment, or
- Removal of illumination for an area.



Serious

29 CFR 1910.333 (a) (1)
NFPA 70E - 110.8 (A) (1)



OSHA provides some examples

In addition, work on energized circuits is permitted

- Where such work is needed because of infeasibility due to equipment design or operational limitations
- Testing of electric circuits that can only be performed with the circuit energized



29 CFR 1910.333 (a) (1) - NFPA 70E - 110.8 (A) (1)



If exposed live parts are not de-energized:

Other safety-related work practices shall be used to protect employees

- Protect employees against contact with energized circuit parts directly or indirectly with any part of their body
- Work practices are to be suitable for the work conditions and voltages



29 CFR 1910.333 (a) (2) - NFPA 70E 110.8 (B) (1)



OSHA and Industry Standards

- Electricity is hazardous in complex and sometimes surprising ways.
- This is addressed by drawing a distinction between two types of employees:
 - “qualified” those who are familiar with the specific electrical working methods, practices and safety procedures
 - “unqualified” those who are not – everybody else
 - Only electrical hazards are considered. One may be qualified for many things and not be “unqualified” for the electrical task being performed.



Training for “qualified” persons

Employees who are to work on or near exposed parts must be trained in and familiar with the following:

- Skills necessary to distinguish exposed live parts from other electrical parts
- Be able to determine nominal voltage
- Necessary clearance distances specified and the corresponding voltages



29 CFR 1910.332(b) (2)
NFPA 70E – 110.6 (D) (1)



Arc Flash for Qualified Persons

Severe burns or death may be caused by

- **Clothing that ignites instantly**
- **Continues to burn** long after the arc has subsided
- Enclosed spaces and panel doors that don't open fully **increase the danger**



Proper PPE is essential

Employees' hands and faces are often **6 – 12 inches** from the arc flash event



Keys to understanding NFPA 70E

• Limits of Approach and Boundaries

- Safe distances from exposed energized electrical conductors

• Hazard/Risk Categories

- A rating system for the relative electrical hazard of tasks

• Arc Ratings

- Values identify the level of performance of PPE in an electrical arc discharge

Table 130.7(C)(9) Hazard/Risk Category Classifications and Use of Rubber Insulating Gloves and Insulating Hand Tools

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
0	N	N	N
0	N	N	N
0	N	N	N
1	Y	Y	Y
1	N	N	N
1	N	N	N
0	Y	Y	Y



Flash Protection Boundary

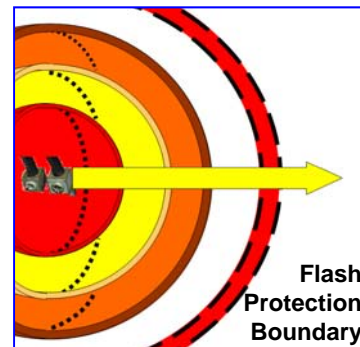
Flash Protection Boundary

unprotected person would receive at least a 2nd degree burn from an arc flash – “blister boundary”

Default distance

4 foot minimum for equipment up to 600 V

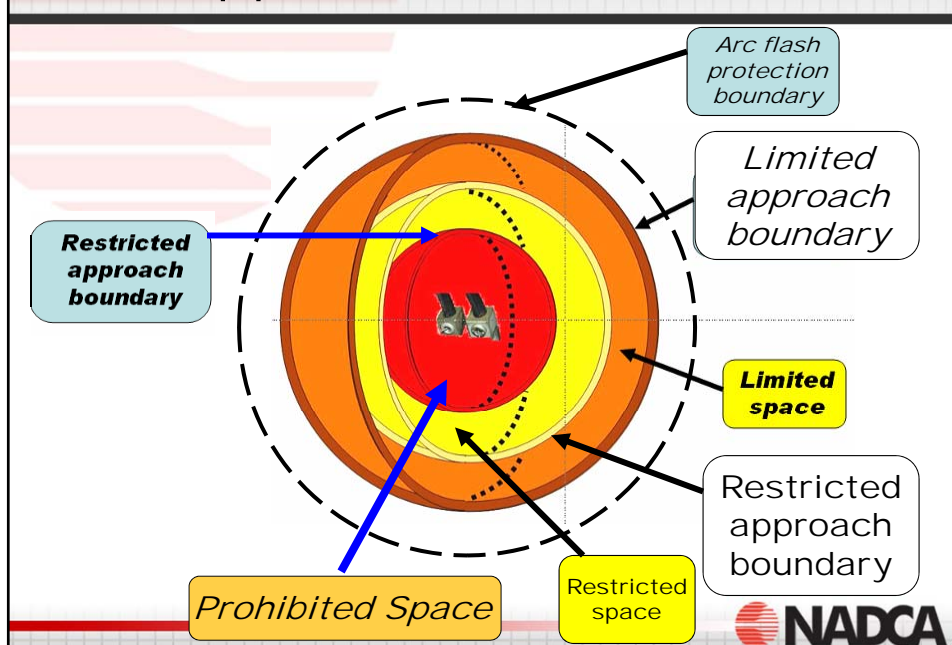
- Increased for higher voltages
- **Crossing this boundary requires wearing appropriate PPE**
- Qualified persons only
- Unqualified must be accompanied



NFPA 70E – Article 100, 130.3 (A) (1)



Approach Boundaries



Hazard/Risk Categories

Rating system ranking the relative electrical hazard of tasks

Rated 0 through 4 for low or little risk to relatively high risk

Each category is assigned a minimum arc thermal performance

Hazard/Risk Category	Minimum Rating (Cal/cm ²)
0	N/A
1	4
2	8
2*	8
3	25
4	40

Question: How to determine the Hazard/Risk Category?

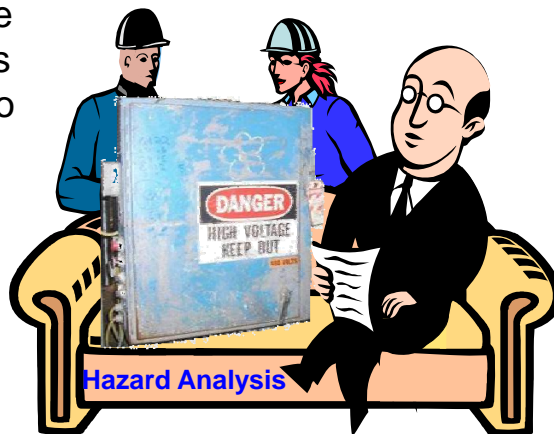
Answer: There are two methods to determine them.



Option 1: Hazard Analysis

Analysis of the **shock hazard and flash protection boundary** including necessary **PPE** is required

- Review on change or every five years
- Consideration is to be given to over-current device
 - Design
 - Opening time
 - Condition and
 - Maintenance



NFPA 70E Article 110.8 (B) and 130.3



Option 2: Hazard Analysis

In lieu of detailed incident energy analysis

The 130.7 (C) (9) to (11) **tables on hazard/ risk categories and PPE** may be used

Improper maintenance can **increase overcurrent opening time and incident energy**. For more see

- NFPA 70E Chapter 2 on electrical maintenance
- NFPA 70E hand book and Safety Program book

NFPA 70E Article 130.3 Exception No. 2



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Table 130.7(C)(9) Hazard/Risk Category Classifications

and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools

Tasks Performed on Energized Equipment	Hazard/ Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Panelboards or Other Equipment Rated 240 V and Below — Note 1			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	0	N	N
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	0	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	1	Y	Y

Table 130.7 (C) (9)

General Notes (applicable to the entire table):

- (a) Rubber insulating gloves are gloves rated for the maximum line-to-line voltage upon which work will be done.
- (b) Insulated and insulating hand tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done, and are manufactured and tested in accordance with ASTM F 1505, *Standard Specification for Insulated and Insulating Hand Tools*.
- (c) Y = yes (required), N = no (not required).
- (d) For systems rated less than 1000 volts, the fault currents and upstream protective device clearing times are based on an 18 in. working distance.
- (e) For systems rated 1 kV and greater, the Hazard/Risk Categories are based on a 36 in. working distance.
- (f) For equipment protected by upstream current limiting fuses with arcing fault current in their current limiting range (1/2 cycle fault clearing time or less), the hazard/risk category required may be reduced by one number.

Specific Notes (as referenced in the table):

1. Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.
2. Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.
3. Maximum of 42 kA short circuit current available; maximum of 0.33 sec (20 cycle) fault clearing time.
4. Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycle) fault clearing time.



Table 130.7 (C) (9)

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3. Maximum of 42 kA short circuit current available; maximum of 0.33 sec (20 cycle) fault clearing time.
4. Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycle) fault clearing time.

Fast acting devices can significantly reduce

- Hazard/risk category
- Energy released in an event

Application of the table is limited by:

- Available short circuit current and
- Maximum fault clearing time

These values must be determined to utilize the table

Overcurrent opening time affects the available arc flash intensity.



Hazard/Risk Categories and Arc Rating

Field marking of equipment

Label must show the available incident energy OR required level of PPE

Circuit components - as installed - will determine the incident energy and the level of hazard

Marking of equipment as installed is required



NFPA 70E Article 130.3 (C)



Electrical Safety Program - Principles

- (1) Inspect and evaluate electrical equipment
- (2) Maintain equipment insulation and enclosure integrity
- (3) Plan every job and document first-time procedures
- (4) Deenergize, if possible
- (5) Anticipate unexpected events

- (6) Identify and minimize hazards
- (7) Protect employees from
 - shock,
 - burn, blast, and
 - Any other hazards
- (8) Use the right tools for the job
- (9) Assess people's abilities
- (10) Audit these principles

NFPA 70E
Article 110.7 (C)
Annex E.1



Electrical Safety Procedures OSHA Questions

Have safe procedures for electrical tasks been **identified, developed and implemented?**

- Are they **written out** if at all complex?
- Have procedures been **communicated** to employees through training?
- Is there **follow up** to verify implementation?
- **Are there consequences** if the procedures are not implemented?

**OSHA's
Questions**



Good Practices to
Implement Now



Electrical

Good Practices

- Don't damage electrical cords – handle them carefully
- Don't use them to raise or lower equipment
- Don't fasten cords with staples or hang them so they could be damaged
- Don't use a damaged or defective electrical item – take it out of service until repaired and tested



5
Don'ts

29 CFR 1910.334 (a) - - NFPA 70E - 110.9 (B)



Protective equipment and tools

When working near exposed energized conductors or circuit parts:

- use **insulated tools** or handling equipment
- Use properly **insulated fuse handling equipment**



CAUTION

USE INSULATED
FUSE PULLER TO
CHANGE FUSES

29 CFR 1910.335 (a) (2) (i)
NFPA 70E - 130.7 (D) (1) (a)



Electrical Safety Program

The National Electrical Code is **NOT** intended to **protect** personnel from **Abnormal Conditions**.

Normal protection not in place, e.g.:

- Panel **covers removed**
- **Temporary wiring**
- **Guards removed** or missing
- Limit **switches not functional**
- **Equipment damaged**



An electrical safety program is needed



Thank you

