

Electrical Arc Flash Safety



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SQUARE D

What is an Arc Flash?



NFPA 70E says an arc flash hazard is:

A dangerous condition associated with the release of energy caused by an electric arc

A hazard beyond shock and electrocution

Two Types of Major Electrical Faults Can Occur

■ Bolted faults

- Low impedance and high current
- Energy is contained by the conductor (bus or cable)
- Cleared quickly by circuit breakers or fuses
- Arcing is confined within the circuit breaker or fuse
- Usually no damage to equipment
- Relatively low safety risk to personnel

■ Arcing faults

- High impedance (air) results in lower current
- Persist longer and propagate
- High release of heat and blast energy
- Are very destructive and dangerous to personnel

Causes of Bolted and Arcing Faults

■ What causes these types of faults?

□ Bolted faults (low impedance and high current)

■ Commonly caused by

- Improper connections after maintenance
- Installation errors

□ Arcing faults (high impedance, lower current)

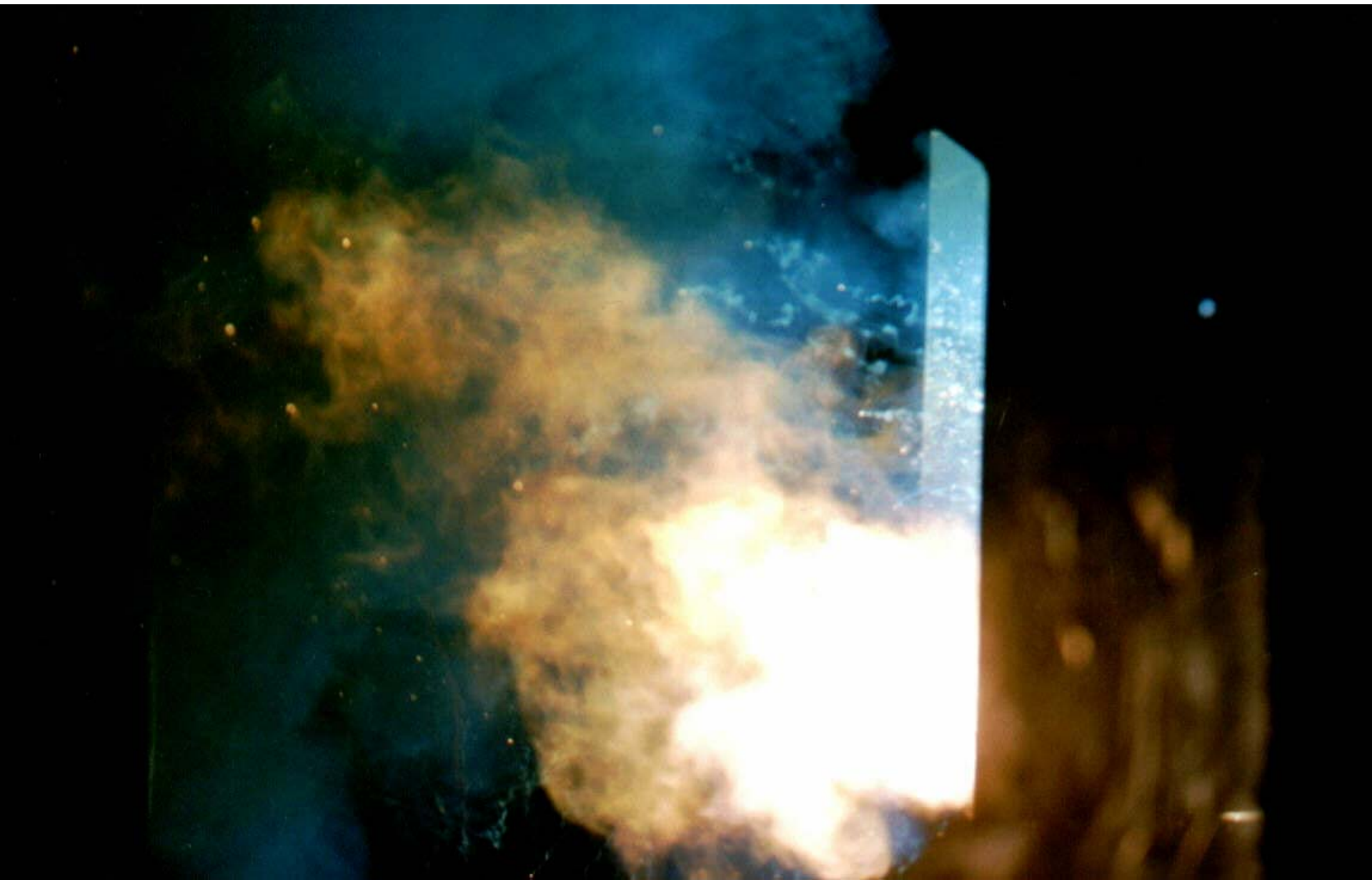
■ Commonly caused by

- Careless cover or device removal
- Foreign object (tool) dropped into equipment
- Misalignment of moving contacts (parts failure)
- Dirt contamination or dielectric breakdown
- Entry of foreign body (rodent, snake, squirrel)

Bolted and Arcing Fault Characteristics

- Arcing fault incident energy released is:
 - Greater at higher bolted fault current levels
 - Reduced by dynamic impedance (air)
 - And increased by the time duration of the arc
- The most controllable factor in reducing the incident energy is time
- Current flow in a 480V arcing fault is approximately half that of the bolted fault current (impedance of air)
- Fuses or circuit breakers are the first line of defense in reducing arcing fault incident energy
- Calculating arc fault incident energy is a very complex engineering task

What an Arcing Fault Looks Like



Electrical Arc Facts

- **Arc is electric current passing through air**
 - Shock potential from contact with arc
- **Temperature of arc plasma center is greater than 5000°F (some say much higher)**
 - Radiated heat burns
- **Pressure wave generated from arc**
 - Impact to hearing, etc
 - Gaseous copper is 44,000 times solid
 - Molten metal expelled from equipment at high speed
- **Arc fault results from something wrong or out of place**

Some arc flash injury statistics

Five to ten arc flash explosions occur in electrical equipment every day in the United States, according to statistics compiled by Cap-Schell, Inc., a Chicago-based research and consulting firm that specializes in preventing workplace injuries and deaths.

Injuries from arc flash events range from minor injuries to third degree burns and potential death due to the energy released.

Other injuries include blindness, hearing loss, nerve damage, and cardiac arrest.

The average cost of medical treatment for survivors of arc flash incidents is \$ 1,500,000

Total costs including litigation can be \$8M - \$10M

Results of an Arc Flash



■ Other non-human consequences

- Downtime
- Lost revenue
- Loss of product
- Equipment damage
- Regulatory impact
- OSHA citation and fines



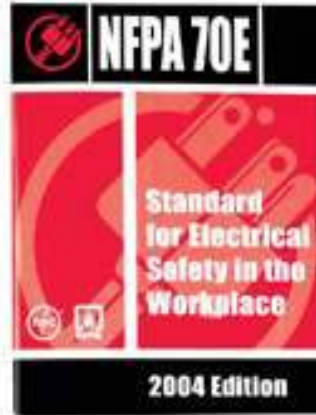
Applicable Documents



NFPA70 (NEC)



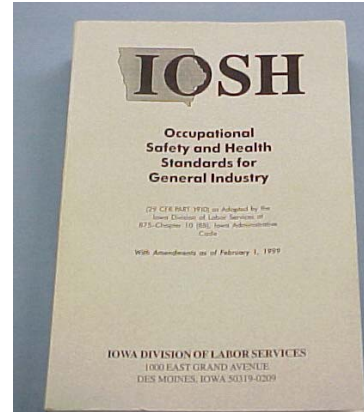
Governs Electrical Installations



NFPA70E-2004



Governs Employee Workplace Safety



OSHA 29 CFR Part 1910



OSHA Standards (Iowa Shown)



IEEE 1584 -2002



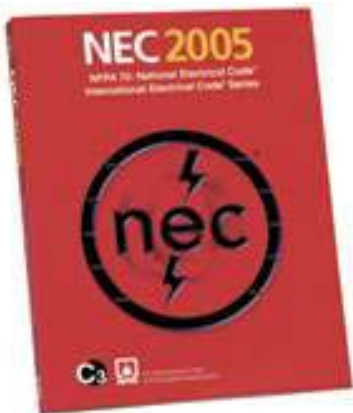
Guide for Performing Arc Flash Hazard Calculations

New Requirements on Facilities

- **NFPA 70E and NEC state that facilities must provide:**
 - Safety program with defined responsibilities
 - Analysis for arc flash hazard degree
 - Training for workers
 - Personal protective equipment (clothing) for workers
 - Tools for safe work
 - Warning labels on equipment

Result: Facilities must take steps to comply.

Requirements: 2005 NEC



110.16: “Switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized shall be **field marked to warn qualified persons of potential electric arc flash hazards**. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.”

Warning for awareness, to prepare for future work

Field marked - not marked by manufacturer

No mention of values - only warning of hazard


References NFPA 70E, ANSI Z535.4


Example Equipment Label



Illustrates minimum requirement. This is an example, not a recommendation.

Present label


**DANGER**


**HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION**

- This equipment must be installed and serviced only by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors, and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

New label

**DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**



- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E
- This equipment must only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

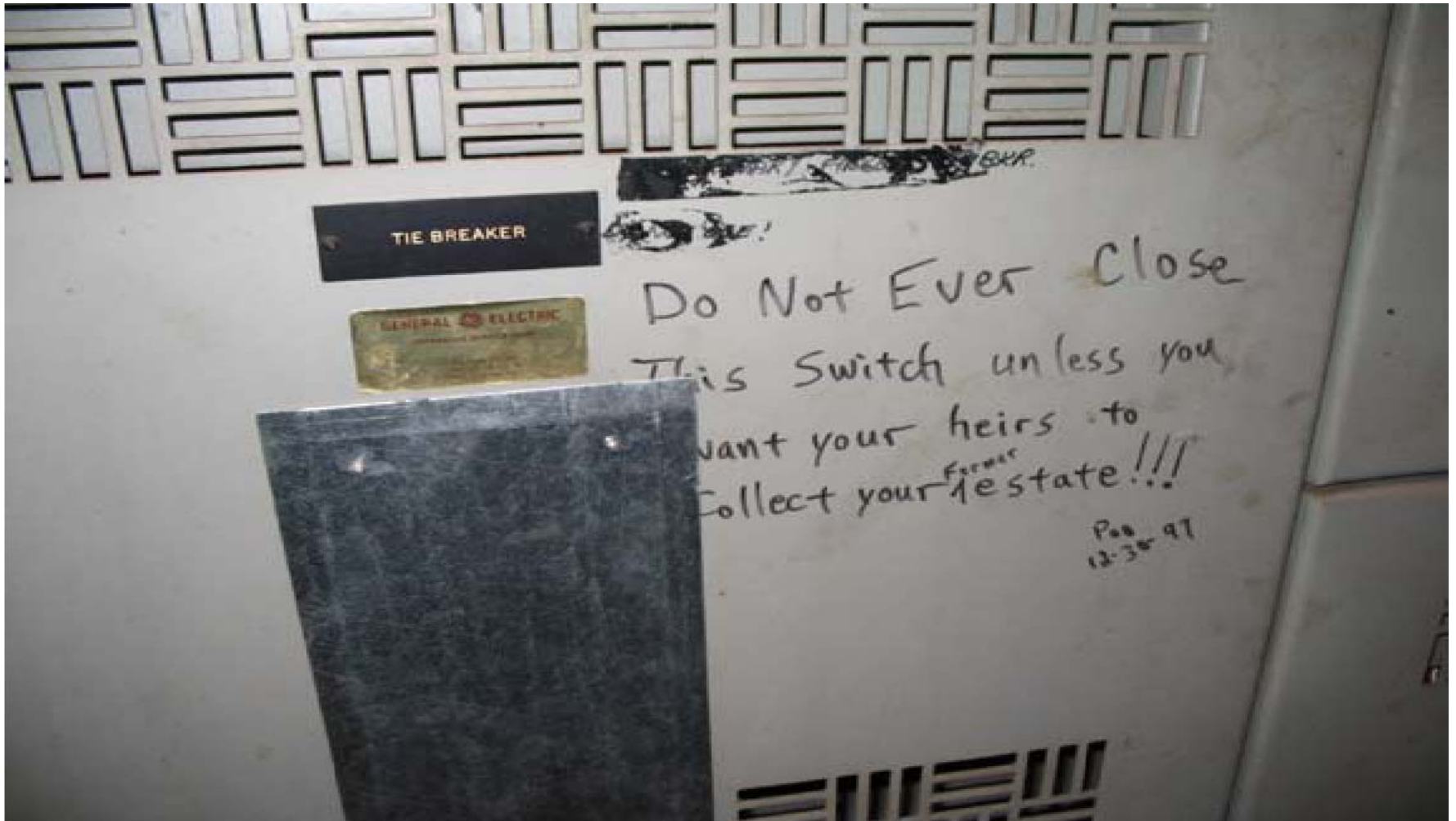
The Importance of Proper Hazard Warning Labels

- What is a “failure to adequately warn”?
- ANSI Z535.4, UL 969, and ISO standards
- OSHA always cites to the most current labeling standards (ANSI Z535.4)
- The standards define the colors, symbols, materials and wording used on labels
- Labels should be designed to accommodate standards changes
- From a risk exposure and safety standpoint, proper labeling is very important

Example of Arc Flash Label with Data Values

 DANGER		
	Arc Flash and Shock Hazard Appropriate PPE Required	
	23 inch Flash Protection Boundary 3.3 cal/cm ² Incident Energy at 18 inches Class 1 Hazard/Risk Cat. See NFPA 70E for PPE 480 VAC Shock Hazard when cover is opened	
	42 Limited Approach 12 Restricted Approach 1 Prohibited Approach	} Boundaries in inches See NFPA 70E
Eqpt. Name: DIST PNL B	FO#: 20044773	Date: 1/26/2006
Data values on this label are provided by Square D Engineering Services analysis performed on FO# shown above. Any modification of equipment, adjustment of trip unit settings, or failure to properly maintain equipment will invalidate these values. For more information contact Square D Engineering Services at 1-888 SQUARED.		
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Inadequate labeling example



Who is a “Qualified Person” ?

NFPA 70E and the National Electrical Code (NEC) define a qualified person as “**One who has skills and knowledge** related to the construction and operation of the electrical equipment and installations **and has received safety training on the hazards involved.**”

Training on the hazards is required by definition

OSHA

29 CFR 1910.333

“Live parts to which an employee may be exposed **shall be de-energized before the employee works on or near** them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible.”

The fundamental requirement is to de-energize!

When you allow work to be done energized, you take a risk.

Working Energized

Examples of increased or additional hazards

Interruption of:

- Life support systems
- Emergency alarm systems
- Hazardous location ventilation

Examples of infeasible circumstances:

- Start-up testing
- Trouble shooting and diagnostics
- Work on circuits that form an integral part of a continuous process

Source: NFPA 70E 2004 Article 130 (Working on or near live parts)

OSHA

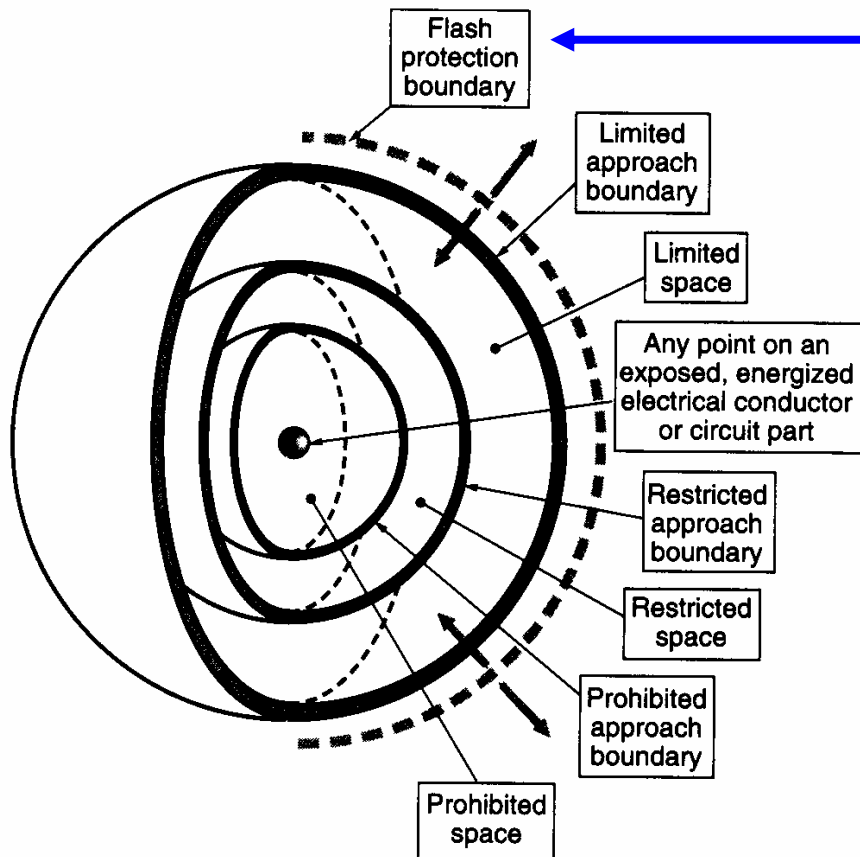
29 CFR 1910.335

Personal Protective Equipment

“Employees working in areas where there are potential electrical hazards shall be provided with, and **shall use, electrical protective equipment** that is appropriate for the specific parts of the body to be protected and for the work to be performed.”

Notice that OSHA does not specifically mention calculations or NFPA 70E. However, since NFPA 70E is a recognized, published standard available to the industry, OSHA will always cite using requirements of NFPA 70E.

Limits of Approach



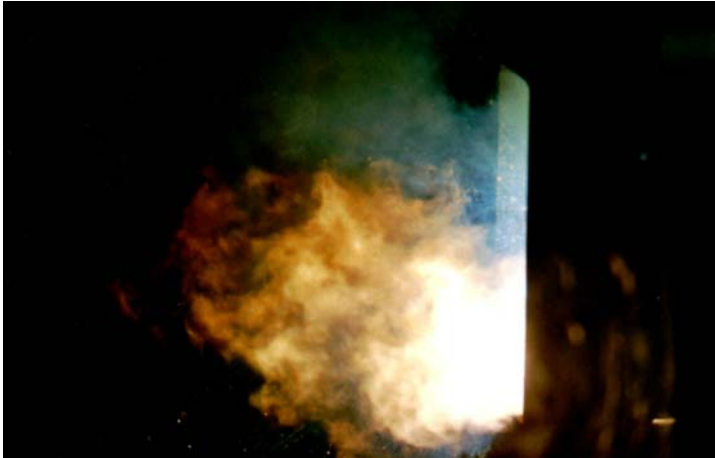
Flash protection boundary:

An approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electric arc flash were to occur. (NFPA 70E 2004)

It is generally accepted that a second degree burn results from exposure of incident energy of 1.2 cal/cm^2

NFPA 70E, Fig. C.1.2.4

Incident Energy



The amount of energy impressed on a surface, a certain distance from the source, generated during an arc event.

Incident energy is measured in calories/cm² or Joules/cm².

The incident energy defines the PPE category required

(Ref: NFPA 70E 2003 ROC, IEEE 1584)

Flash Hazard Analysis

A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the flash protection boundary shall use (NFPA 70E 130.3)



Desired output for each equipment:

- Flash protection boundary distance
- Incident energy
- Hazard / risk category for PPE selection

Determine PPE Hazard Risk Category

Category	Cal/cm ²	Clothing
0	N/A	Untreated cotton (Square D uses 2 Cal/cm ²)
1	4	FR shirt & FR pants
2	8	Cotton underwear plus FR shirt & FR pants
3	25	Cotton underwear plus FR shirt & FR pants plus FR coverall
4	40	Cotton underwear plus FR shirt & FR pants plus double layer switching coat and pants

From incident energy calculated value
Output category for Personal Protective Equipment

Note that melt-able fabrics and other similar synthetics are never permitted

Source: NFPA 70E 2004 table 130.7(C)(11)

PPE Examples (courtesy Oberon Company)

