SIERRA COLLEGE

Safety Refresh

Lesson Plan

- Safety Refresh

- Next week
  - Basic construction, framing
  - Measuring

Some Statistics

- 286 Fatalities and 4,100 cases of lost time due to electrical shock or electrical burns each year from 1992-1998
  - 98% of the fatalities due to electrical shock
  - 38% injuries were due to flash burns
- 113 electrocutions in 2004
- Financial costs can be staggering
  - Can exceed $13 Million for one incident

Hazards of Electricity

- Electric Shock and Electrocution
  - Electric Current through Body – Electrocution and Burns
- Arc-Flash
  - Burns due to high heat and molten metal
  - Fire Ignition
- Arc-Blast
  - Hearing loss due to blast explosion
  - Lacerations/Punctures from blast debris
  - Percussion force
  - Explosion

Effects of Current on the Body

Electrical Safety in the Workplace *Ray A Jones, PE © 2001*

- ***Men***
- Perception Threshold
  - 0.001 Amps (1 mA)
- Painful Shock
  - 0.009 Amps (9 mA)
- Cannot Let-Go Level
  - 0.010 Amps (10 mA)
- Ventricular Fibrillation
  - 0.100 Amps (100 mA) 3 Seconds
  - 0.200 Amps (200 mA) 1 Second
- Heart Failure
  - 0.5 Amps (500 mA)
- Organ Burn and Cell Breakdown
- 1.5 Amps (1500 mA)

- ***Women***
- Perception Threshold
  - 0.0007 Amps (0.7 mA)
- Painful Shock
  - 0.0012 Amps (1.2 mA)
- Cannot Let-Go Level
  - 0.010 Amps (10 mA)
- Ventricular Fibrillation
  - 0.100 Amps (100 mA) 3 Seconds
  - 0.200 Amps (200 mA) 1 Second
- Heart Failure
  - 0.5 Amps
- Organ Burn and Cell Breakdown
  - 1.5 Amps

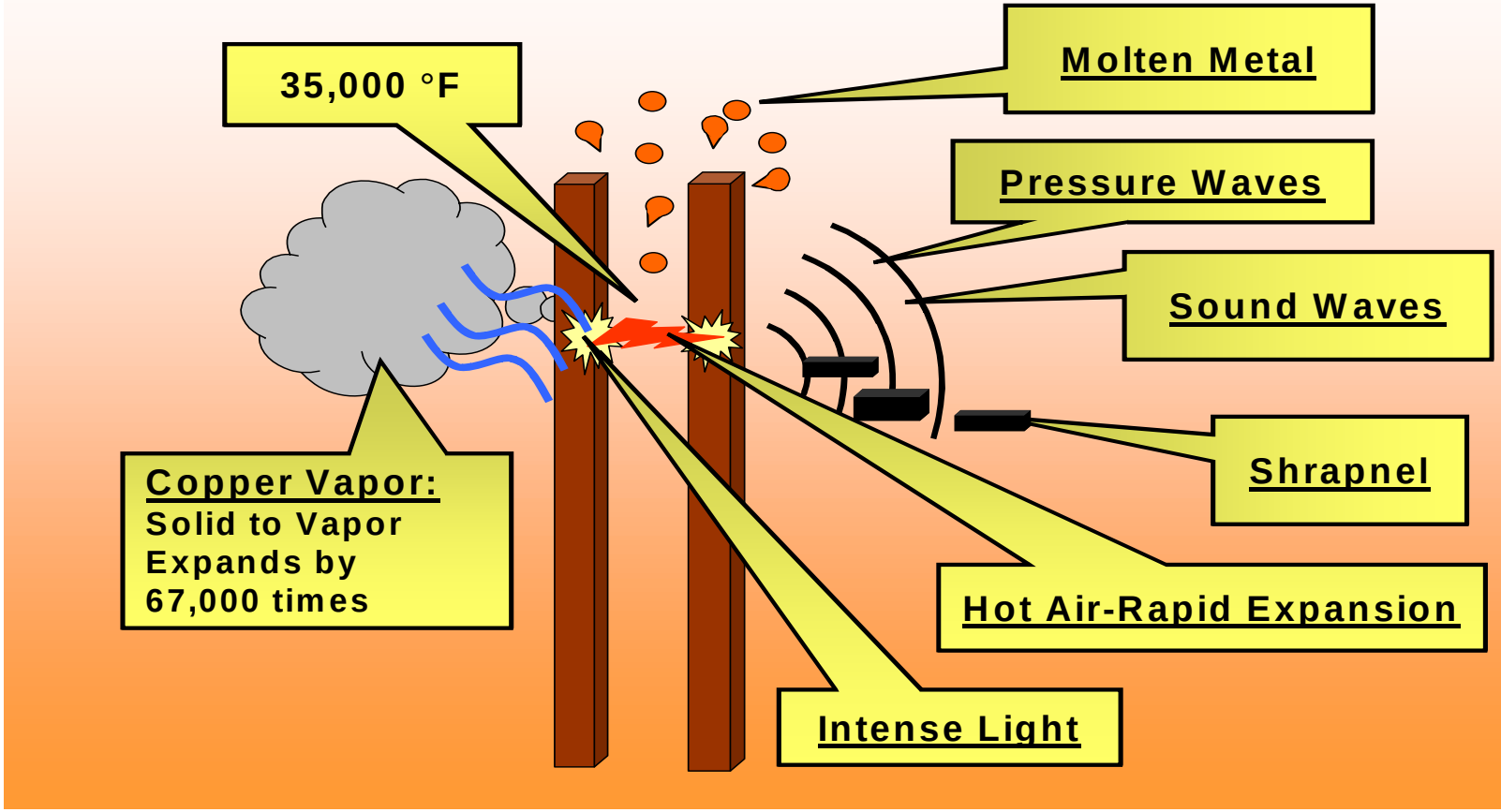
Two Types of Burns from Shock

- Surface Burns
  - Caused by entrance and exit of electrical currents through the body
  - Can be caused by a very small amount of current
  - 1st degree to 3rd degree
- Internal Tissue Burns
  - Caused by current flowing through organs of the body
  - Caused by currents in excess of 1.5 amps
  - 3rd degree
  - Internal organs
  - **Typically fatal**

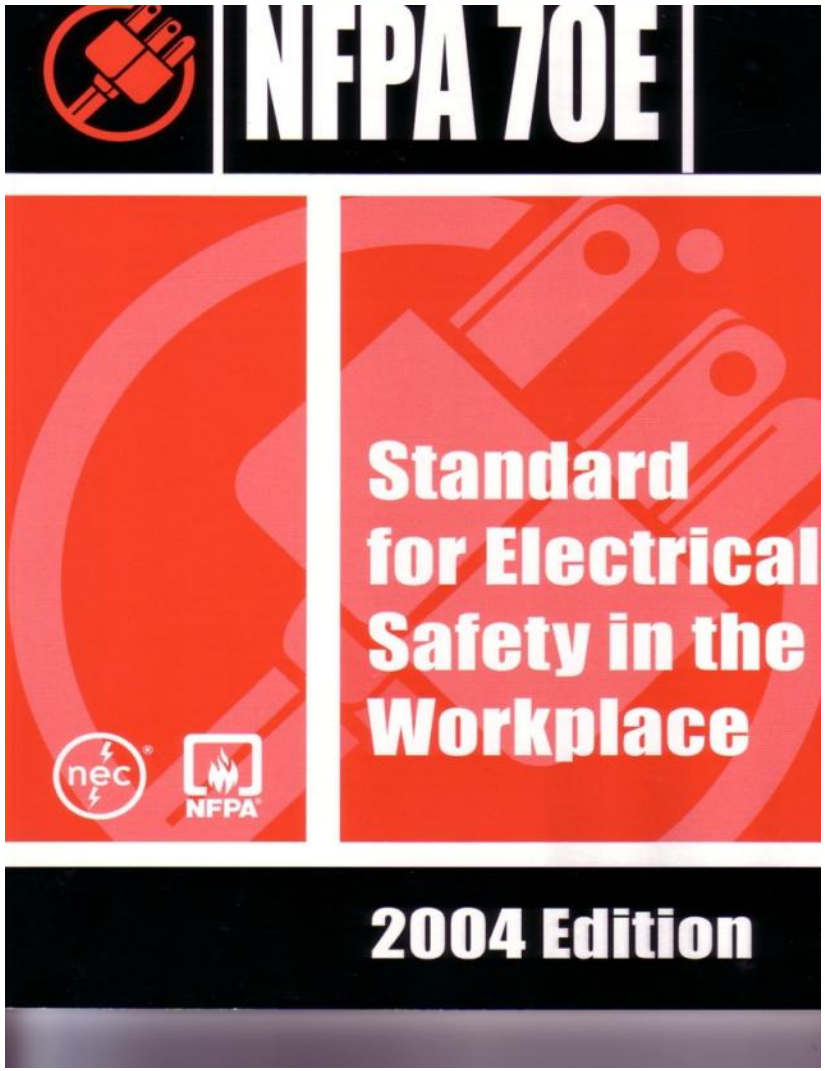
Arc-Flash

- Electric current passes through air, between a “Hot” conductor and ground, or between “Hot” conductors
- Temperatures can reach 35,000 ^{0}F
- Exposure can easily cause skin burns & ignite clothing
- Clothing or PPE that Burns and Melts is a Real Problem
- Most serious arcs are those in 3-phase systems that turn into 3-phase faults

Electrical Arc



Electrical Safety in the Workplace



NEC - OSHA - NFPA 70E

- OSHA 1910 and 1926

  Subparts S and K Relate to Electricity

  The “shall do” to ensure workplace safety

- NFPA 70E – Electrical Safety in the Workplace

  The “how to” meet OSHA requirements

- NEC – National Electric Code NFPA 70

  The “installation” requirements

NFPA 70E Organization

- 4 Chapters and 13 Annexes
- **Chapter 1** “Safety Related Work Practices”
  - Article 100 - Definitions
  - Article 110 - General Requirements
  - Article 120 - Establishing an Electrically Safe Work Condition
  - Article 130 - Working On or Near Live Parts
- **Chapter 2** “Safety Related Maintenance Requirements”
- **Chapter 3** “Safety Requirements for Special Equipment”
- **Chapter 4** “Installation Safety Requirements”

Article 130 Requirements

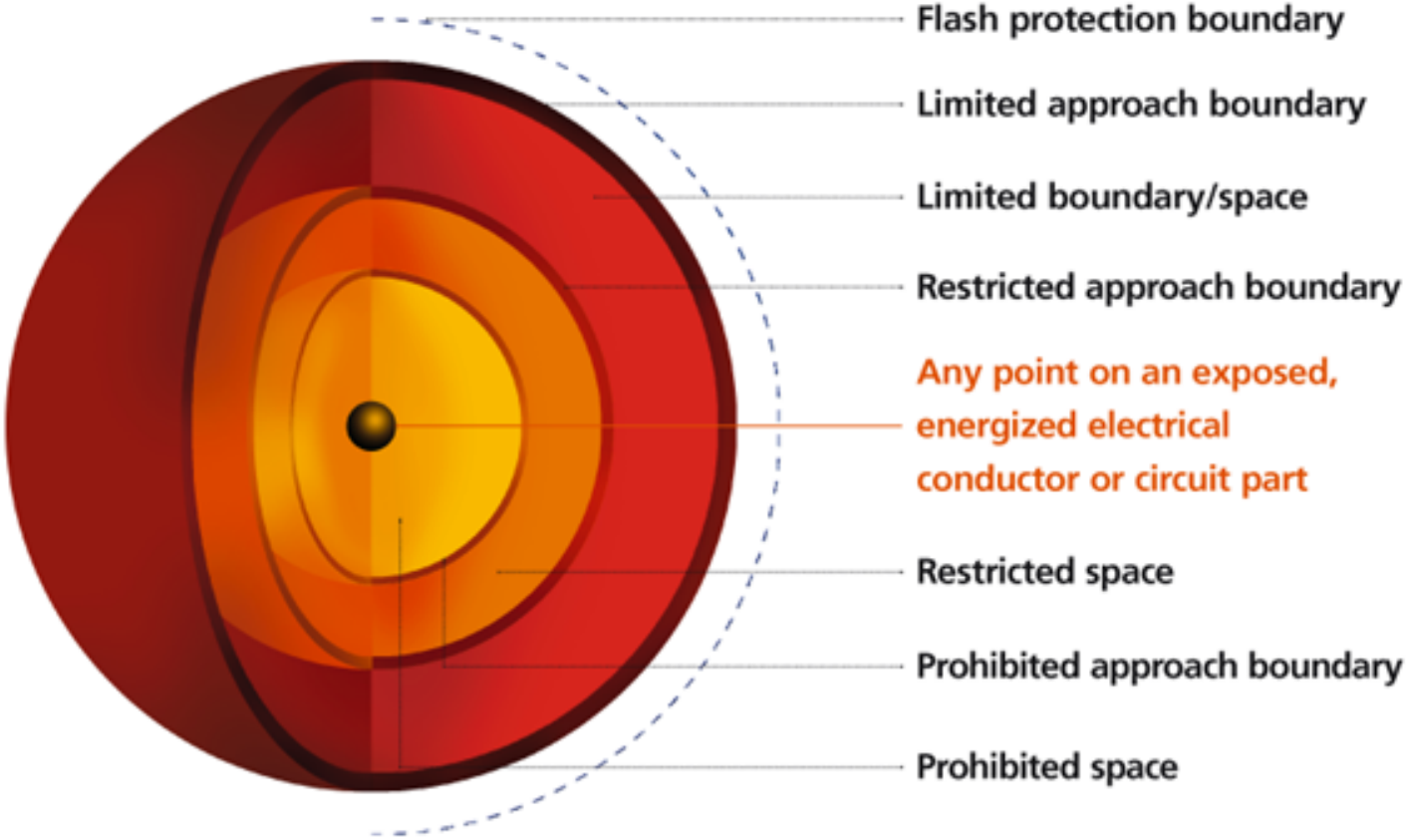
- A Permit is Required for Energized Work
  - But Diagnostic Work is not subject to permit
- Boundaries for Shock and Arc-Flash
- Hazard/Risk Categories (HRCs)
- Determination of the degree of protection required to safeguard workers involves both a Shock and Arc-Flash Hazard Analysis

What is Energized Work?

- Any activity On or Near exposed **energized conductors** where a real hazard exists from contact or equipment failure that can result in electric shock, arc flash burn or arc blast.
- Working On - Coming in contact with **live parts** with the hands, feet, or other body parts, with tools, probes or with test equipment
- Working Near – Inside the **Limited Approach Boundary**

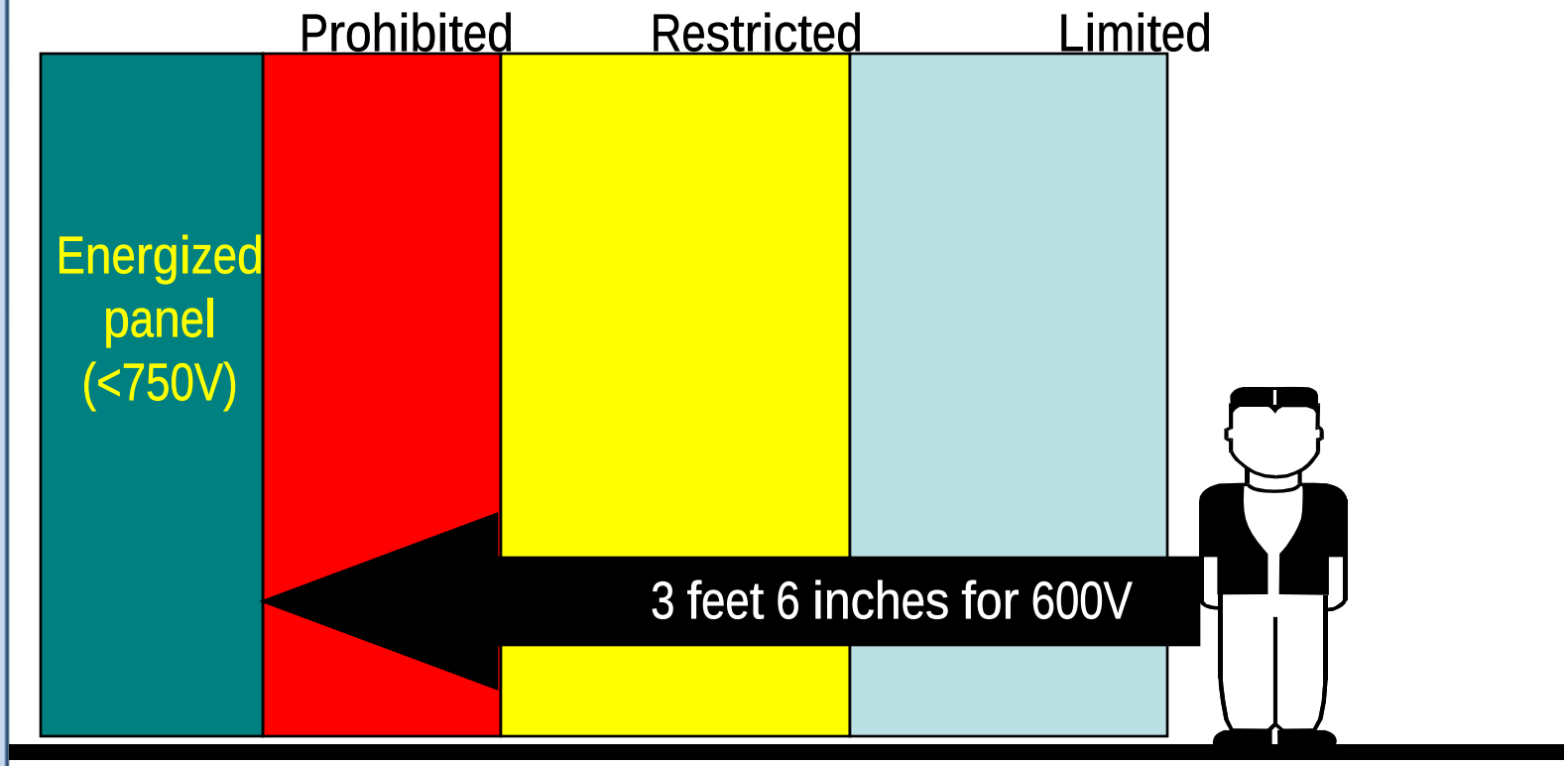
Shock and Arc Boundaries

Limited Boundary
NFPA 70E Approach Boundaries



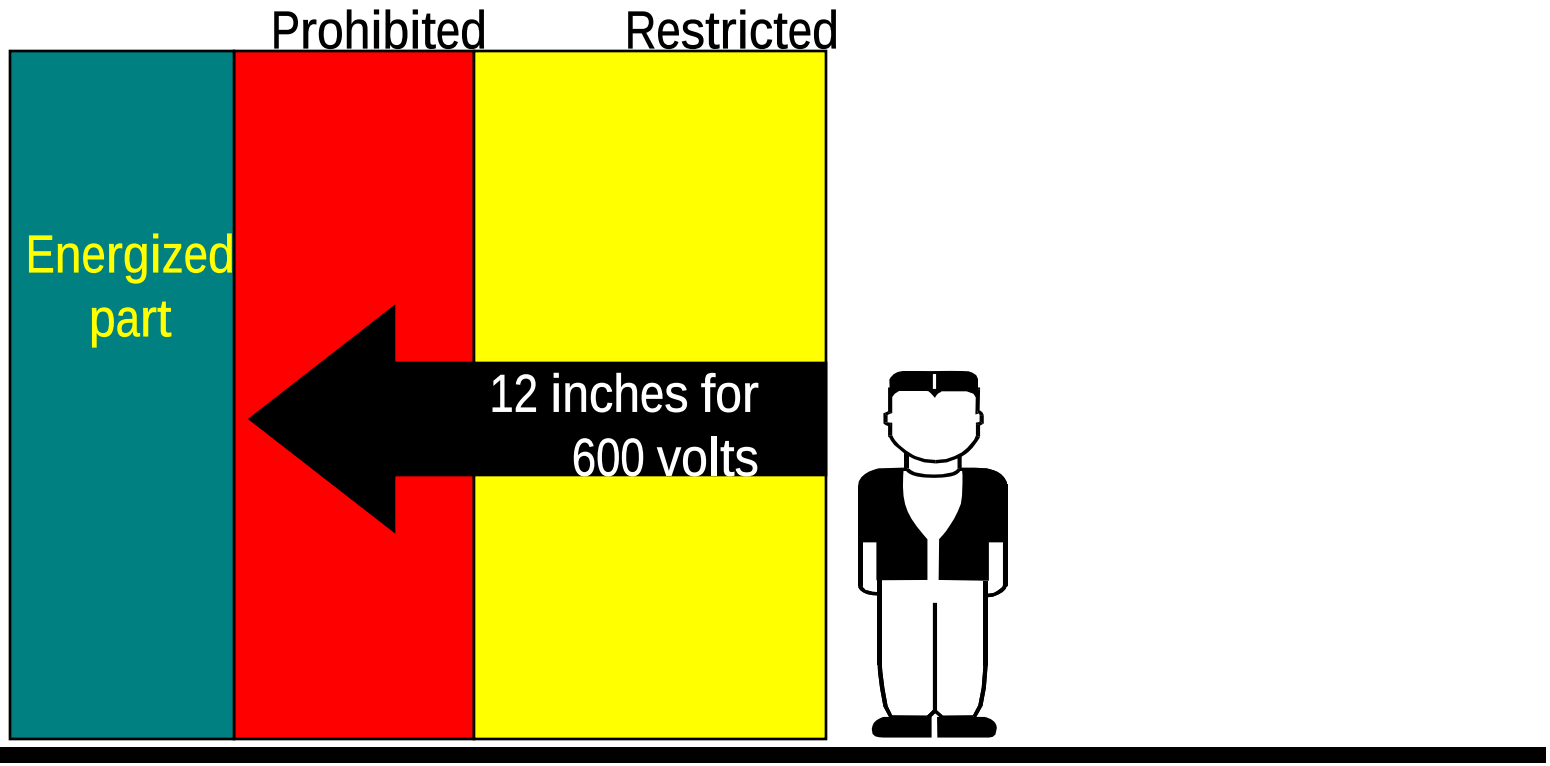
The limited boundary is for unqualified personnel. No unqualified person may approach any exposed energized conductor any closer than the limited approach boundary. The limited approach boundary is determined by referring to Table 2-1.3.4 in NFPA 70E – Page 51. (2000 Edition. Note that in the 2000 Edition NFPA has added the concept of movable or fixed conductors. In 2000 edition unqualified workers may approach non-moving conductors (fixed buswork for example) more closely than those which may move (overhead lines for example).

Limited Approach Boundary



The closest distance an “unqualified” person can approach, unless escorted by a “qualified” person.

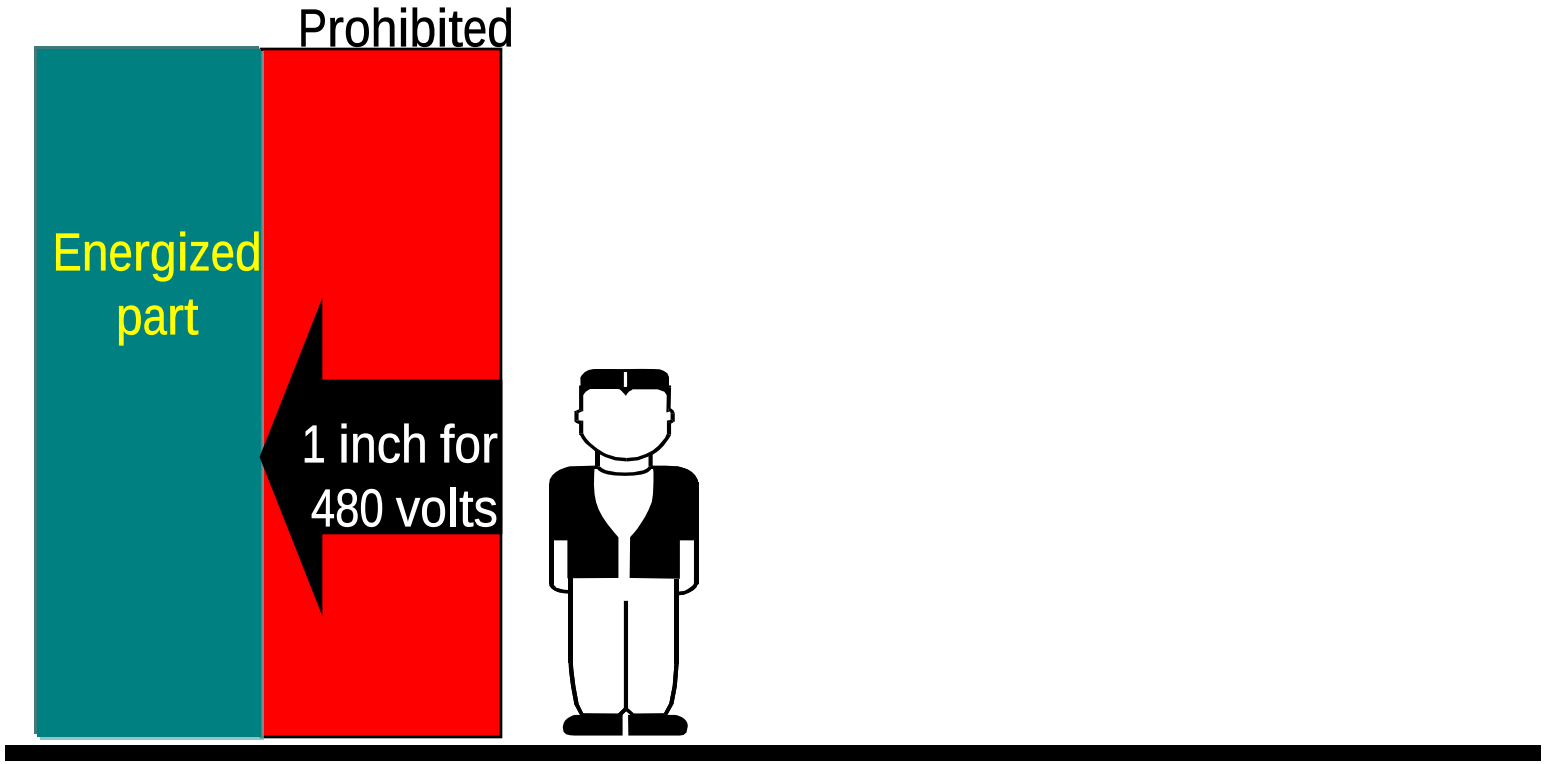
Restricted Approach Boundary



The closest distance to exposed live parts a “qualified” person can approach w/out proper PPE and tools.

To cross this boundary, the qualified person must wear PPE and have proper tools.

Prohibited Approach Boundary



Crossed ONLY by a “qualified” person, which when crossed by body part or object, requires the same protection as if direct contact was made with the live part.

Approach Boundaries Shock Protection

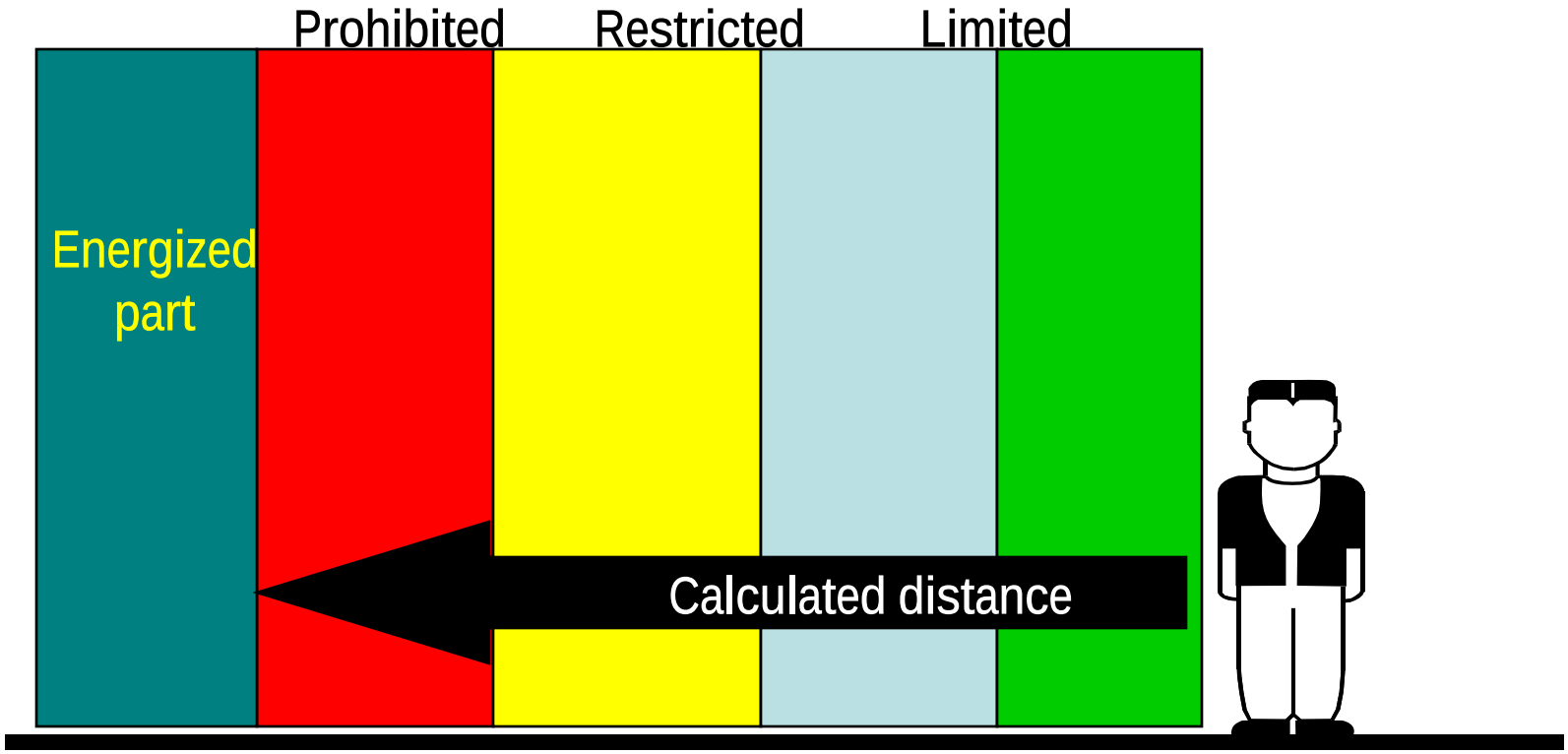
TABLE 130.2(C) Approach Boundaries to Live Parts for Shock Protection.
(All dimensions are distance from live part to employee.)

(1)	(2)	(3)	(4)	(5)
Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary[1]		Restricted Approach Boundary[1]; Includes Inadvertent Movement Adder	Prohibited Approach Boundary[1]
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 to 750	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1 ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5 ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	965.2 mm (3 ft 2 in.)	635 mm (2 ft 1 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	991 mm (3 ft 3 in.)	812.8 mm (2 ft 8 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.093 m (3 ft 7 in.)	939.8 mm (3 ft 1 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.22 m (4 ft 0 in.)	1.07 m (3 ft 6 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.6 m (5 ft 3 in.)	1.45 m (4 ft 9 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.59 m (8 ft 6 in.)	2.44 m (8 ft 0 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.43 m (11 ft 3 in.)	3.28 m (10 ft 9 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.55 m (14 ft 11 in.)	4.4 m (14 ft 5 in.)

Note: For Flash Protection Boundary, see 130.3(A).

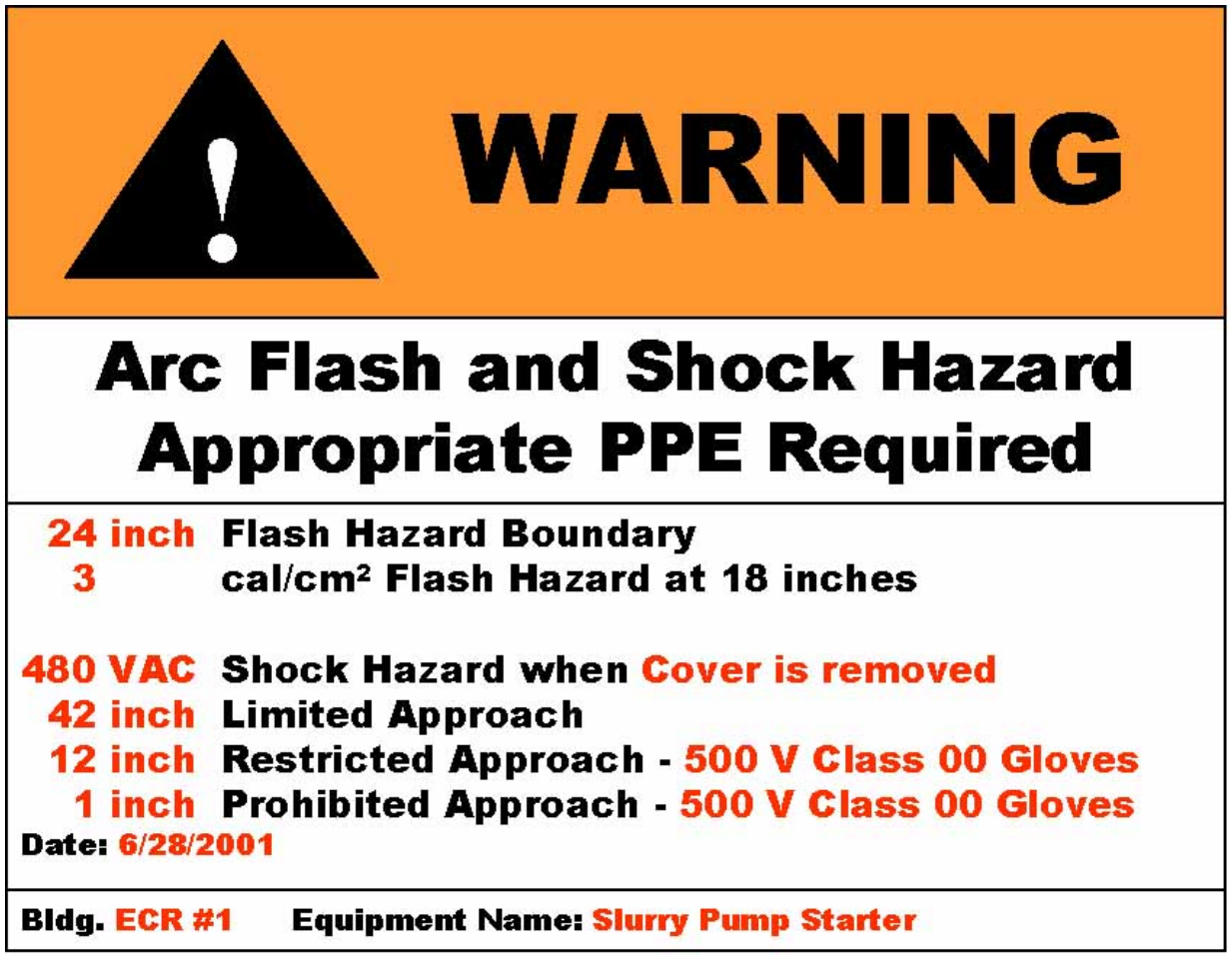
[1]See definition in Article 100 and text in 130.2(D)(2) and Annex C for elaboration.

Flash Protection Boundary



- The distance from exposed live parts within which a person could receive a second degree burn if an arc flash were to occur. (1.2 cal/cm2 with an exposure time of 1 second)
- Arc flash PPE is required within this boundary.
- Note: Distance may be less than or greater than the shock protection boundaries.

Typical Equipment Label



Personal Protective Clothing

Incident Energy From (cal/cm2)	Incident Energy To (cal/cm2)	Hazard Risk Category	Clothing Description	Clothing Layers	Required Minimum Arc Rating of PPE (cal/cm2)	Notes
0.0	1.2	0	Untreated Cotton	1	N/A	
1.2	4.0	1	FR Shirt & Pants	1	4	
4.0	8.0	2	Cotton Underwear + FR Shirt & Pants	1 or 2	8	
8.0	25.0	3	Cotton Underwear + FR Shirt & Pant + FR Coverall	2 or 3	25	
25.0	40.0	4	Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	3 or more	40	

Examples of PPE

Hazard Risk Category 0

Hazard Risk Category 1

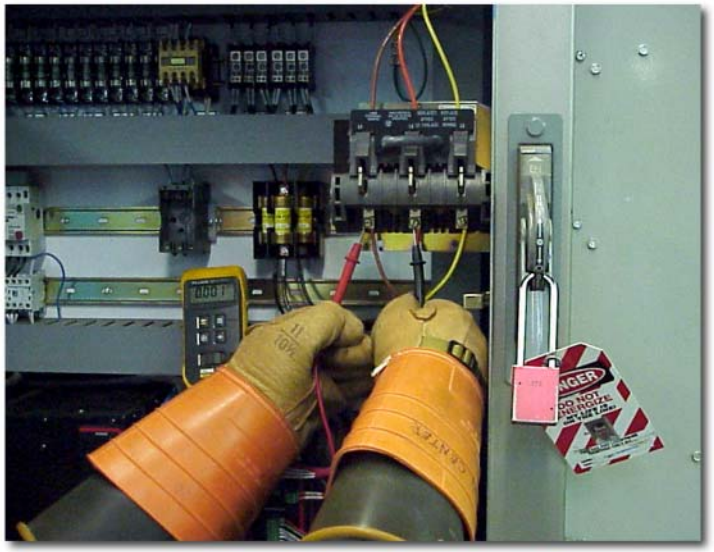
Hazard Risk Category 2

Hazard Risk Category 3

Hazard Risk Category 4

Energy Instructor

www.energyinstructor.info



Consequences of an Arc-Flash Incident

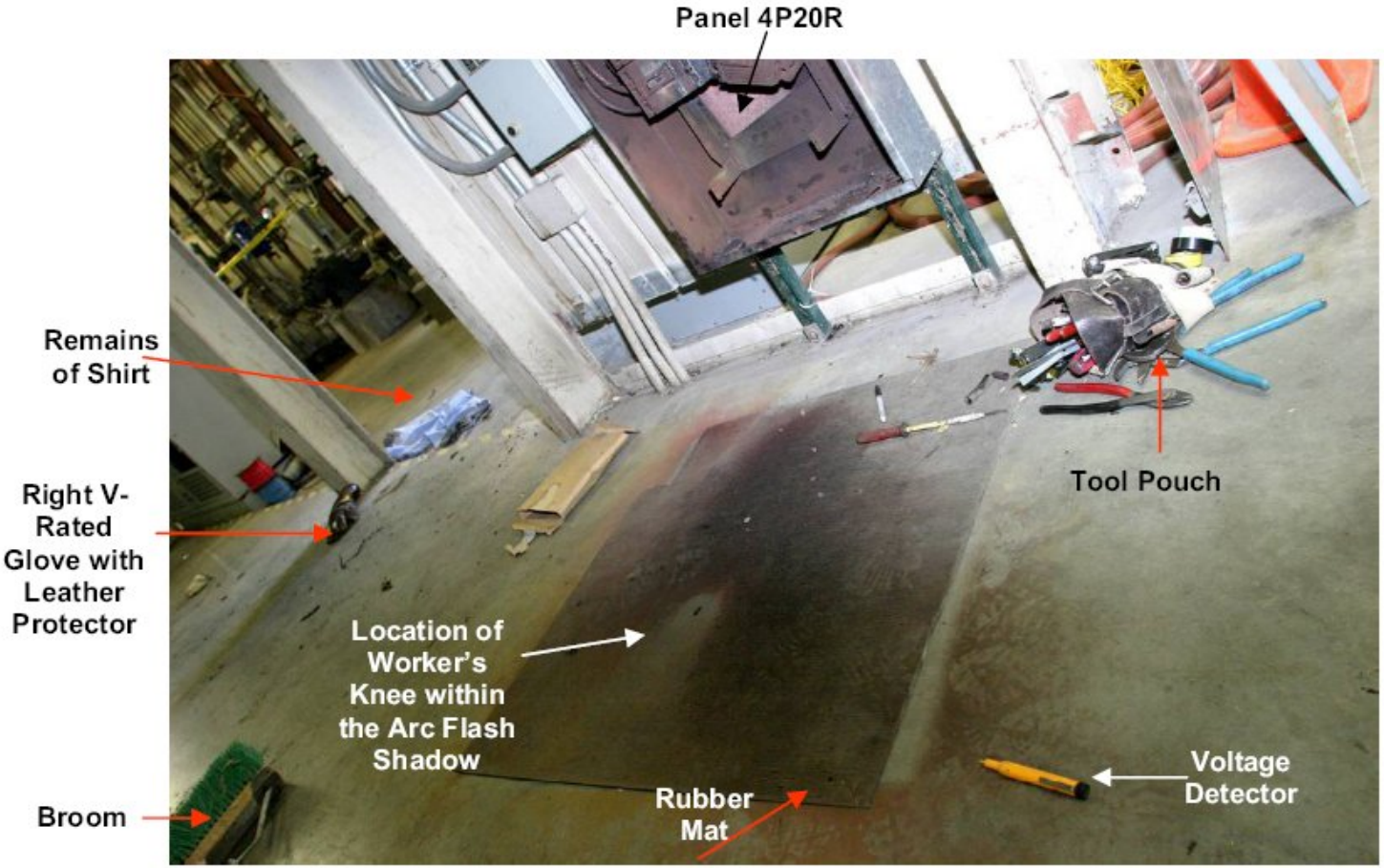


Figure 2-3. The insulating mat with the outline of BSE-1's knee in the arc flash shadow

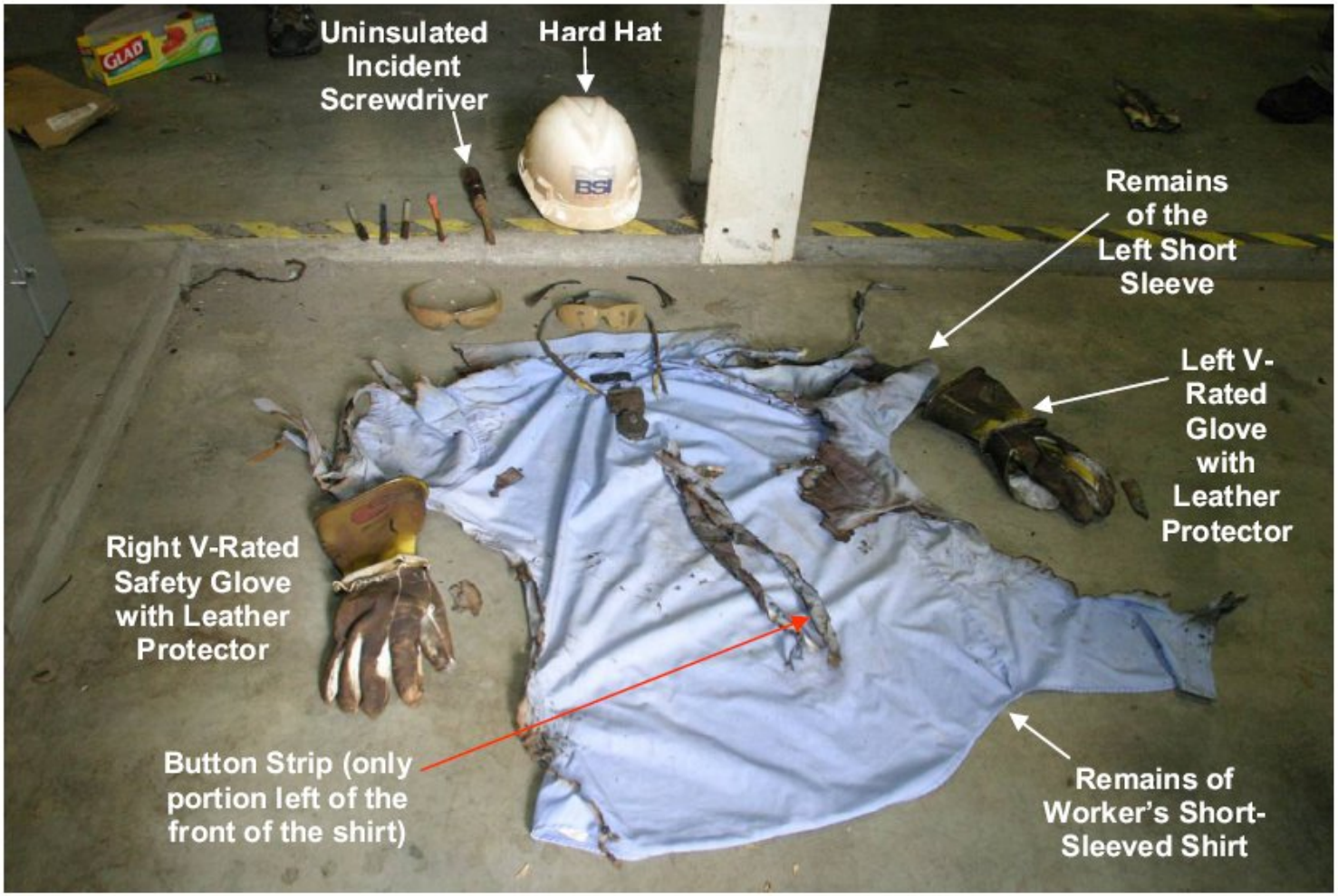


Figure 2-6. BSE-1's burned shirt and his flash-damaged PPE and tools

Mitigation of Electrical Hazards

- Work De-Energized
- Engineer Out the Hazard
- Follow Electrical Safe Work Practices
  - Employ Lockout/Tagout of Hazardous Electrical Energy Sources
  - Use Voltage Insulating PPE and Equipment
  - Use PPE for Arc-Flash Protection
  - Use Ground Fault Circuit Interrupters

Safe Work Practices

- Should be pretty intuitive
  - Be Alert
  - Use Common Sense
  - No blind reaching. If view is obstructed, you cannot work on live parts.
  - Illumination must be provided
  - Conductive articles (jewelry, clothing) shall not be worn

Wear and Care of PPE

- Wear Cotton
- Avoid Scratching Eye Protection
- No Bleach or Fabric Softeners
- Wear Clothing Loose, rather than Tight
- Layering Increases Protection
- Dry is Better than Wet

Safe Work Practices

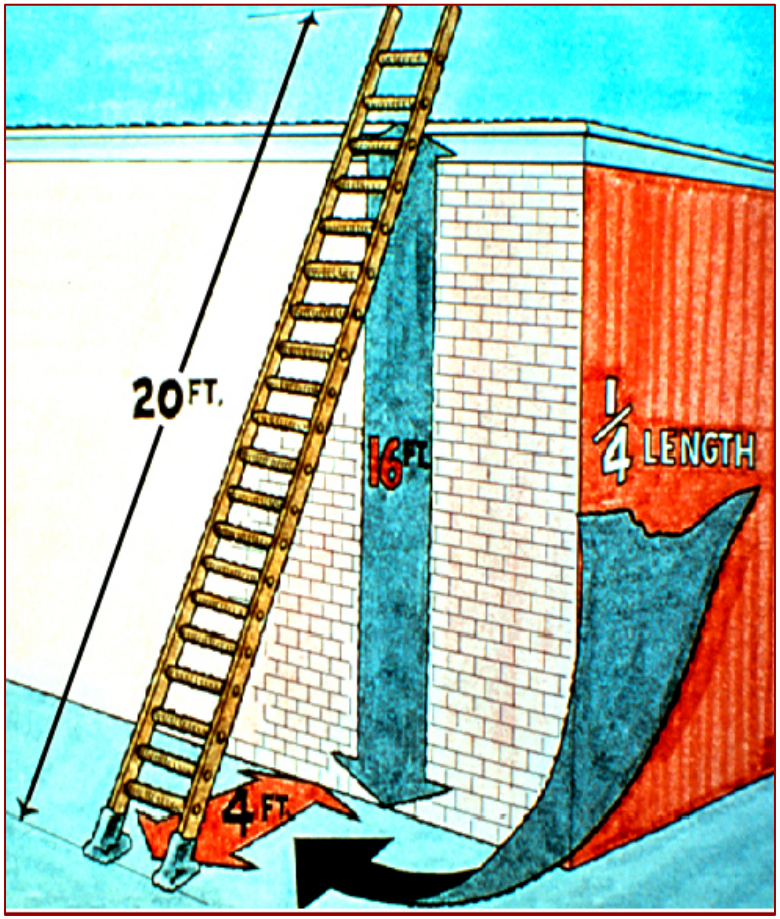
- Plan for Emergencies
  - Know how to de-energize Quickly
  - Be prepared to pull classmate free with an Insulated Rescue Hook
  - Have the Means Available to Contact Emergency Personnel
    - (916) 660-7120; extension 7120 on Rocklin campus
    - (916) 781-6200 or (916) 225-3255 on RG campus
  - Know CPR & Where AED's are located

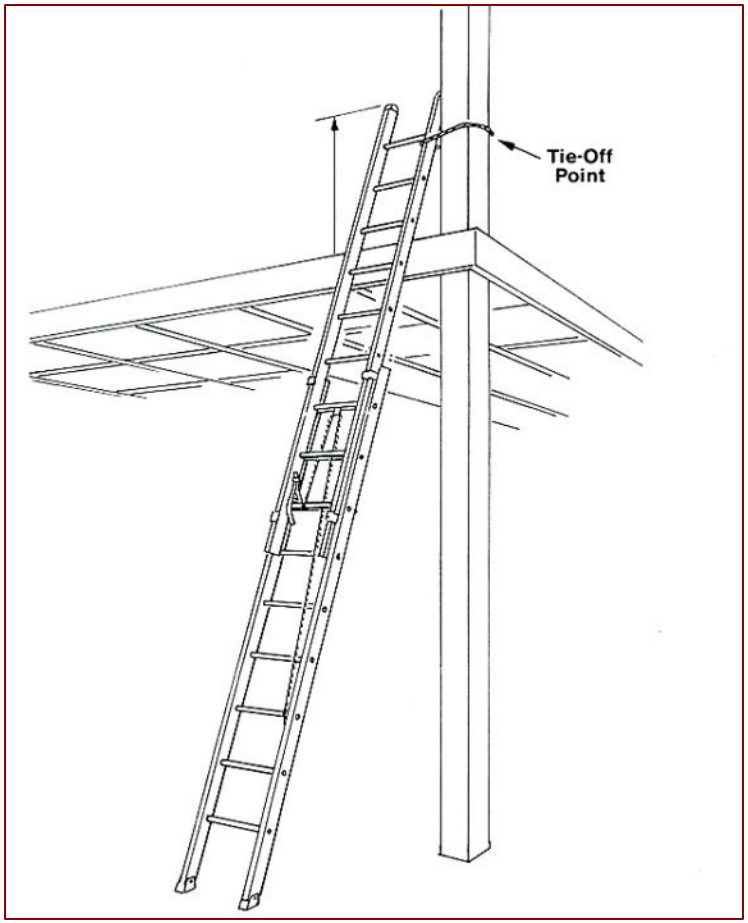
Fall Protection

- What's wrong in this picture?

Fall Protection

- What are these pictures telling us?





Fall Protection

- Some relevant numbers
  - 6ft — Fall protection required for work above this height
  - 39in to 45in — Guard rails top height – open floors & platforms
  - 3 ½ in — Toe guard minimum height – platforms
  - 30ft — Maximum distance for safety nets
  - 19in — Max vertical break without ladder or stairway
  - 30in — Max stairway height without handrail
  - 30° to 50° — Allowable stairway rise/run angle
  - 20in — Stairway platform space beyondb door swing