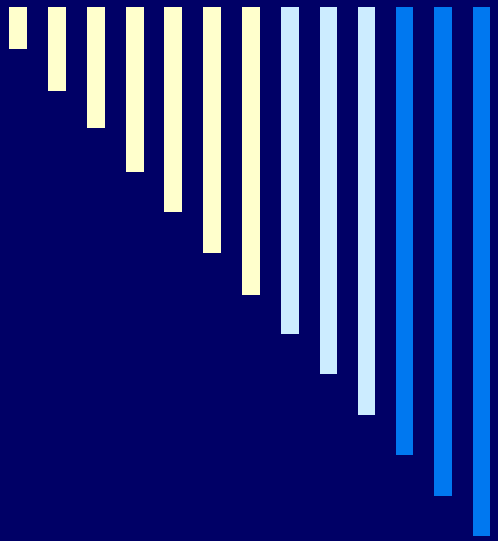


ESHQ Coordinators Meeting

NFPA 70E

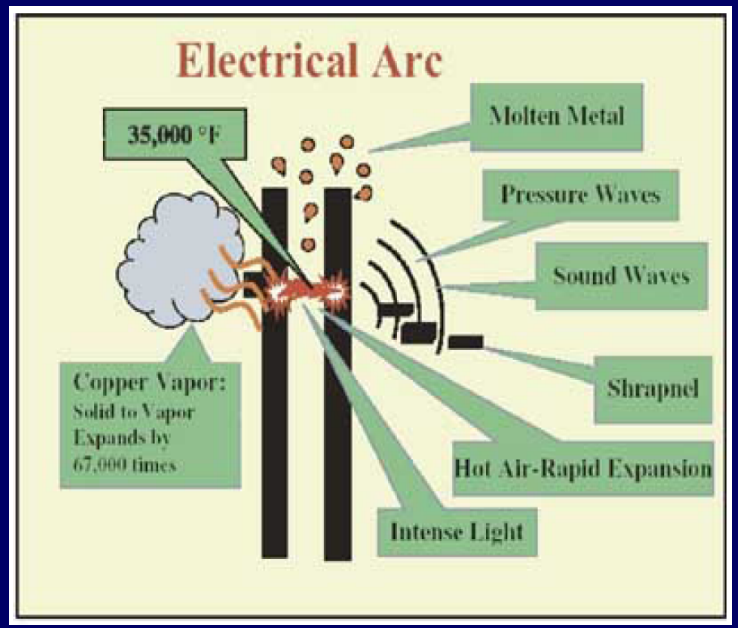
Hazards, Risks and Controls

The “Other” Electrical Hazard

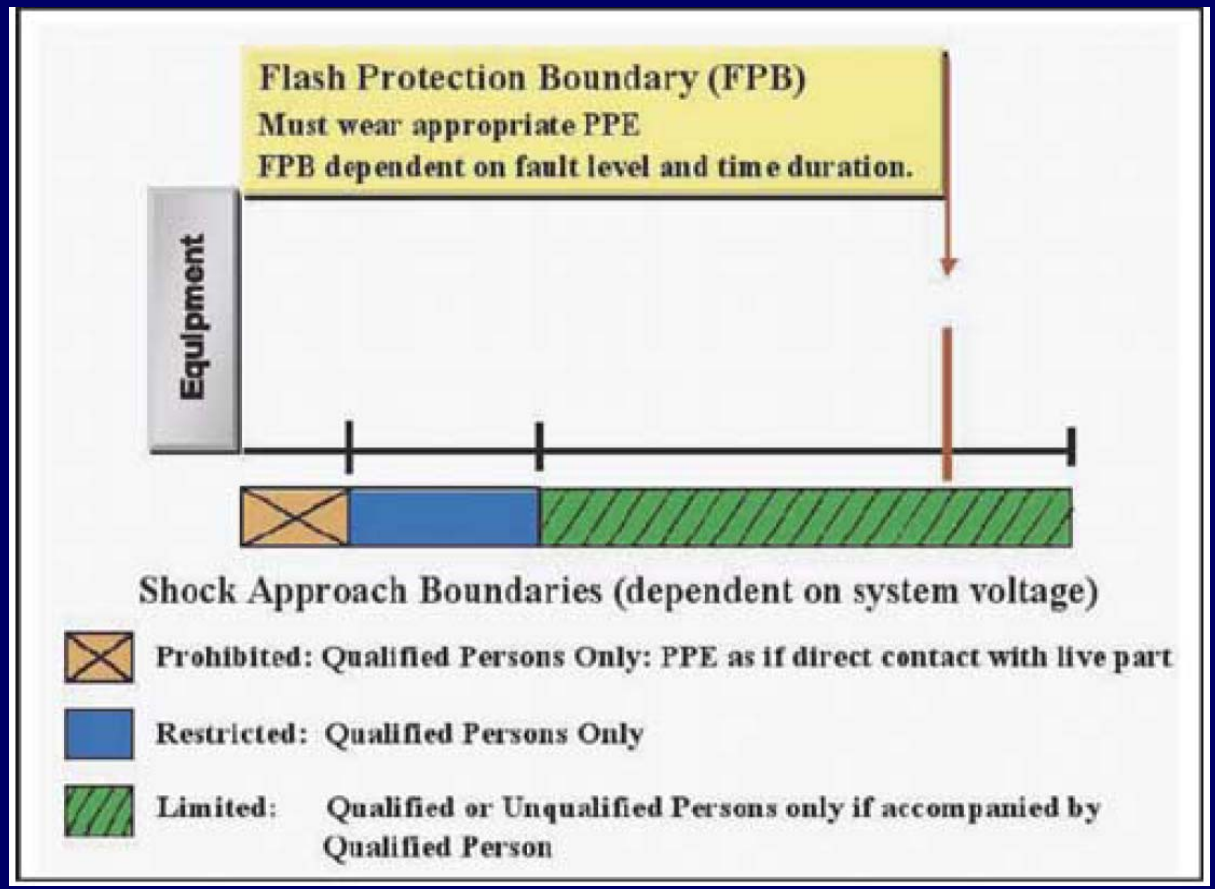
- Arc flash:
  - Concentrated kinetic energy of electrons radiating outward, creating pressure waves (eardrum and lung damage), high-intensity flash (eye damage) and superheated ball of gas (skin burns and melting)
- Sheer volume of low voltage equipment in industry accounts for greatest number of arc flash events

Electrical Arc Flash

- A second-degree burn threshold, or a "just curable burn threshold," is skin temperature raised to 175°F for 0.1 second
- A third-degree burn threshold or "incurable burn threshold," is skin temperature raised to 200°F for 0.1 second
- Eardrum damage > 720 lbs/ft^2
- Lung damage > 1728 lbs/ft^2



Flash Protection Boundary and Shock Approach Boundaries



Causes of Arc Flash Accidents

- Dust, impurities, and corrosion at contact surfaces
  - Produces heat, loosening contact and creating sparks
  - Sparks start arcs
- Sparks produced during
  - Racking of breakers
  - Replacement of fuses
  - Breakers/fuses closing into faulted lines
- Failure of insulating materials
- Snapping of leads at connections due to human, rodents or birds
- Accidental touching / dropping of tools, nuts-bolts, or metal parts

IEEE Test 4

Figure 3. Test 4 - 22,600 - A rms, 480-V, fault initiated on line lug of size 1 starter, feeder protected by a 640-A noncurrent-limiting overcurrent protective device, and fault was cleared in 6 cycles.

IEEE Test 3

Figure 4. Test 3 - 22,600-A rms, 480-V, fault initiated on line lug of size 1 starter, feeder protected by a 601-A current-limiting device and fault was cleared in 1/2 cycle.

IEEE Test 1

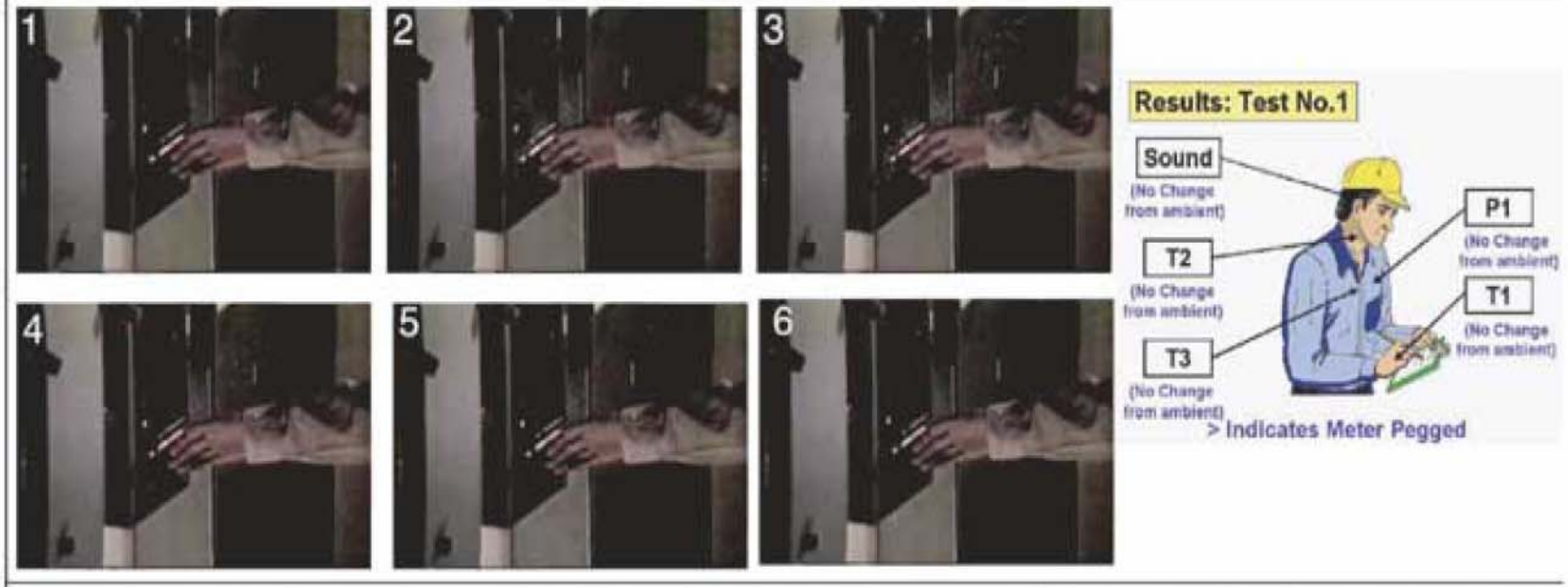


Figure 5. Test 1 - 22,600-A rms, 480-V, fault initiated on load side of a 30-amp current-limiting device in the size 1 starter, and fault was cleared in less than 1/4 cycle.

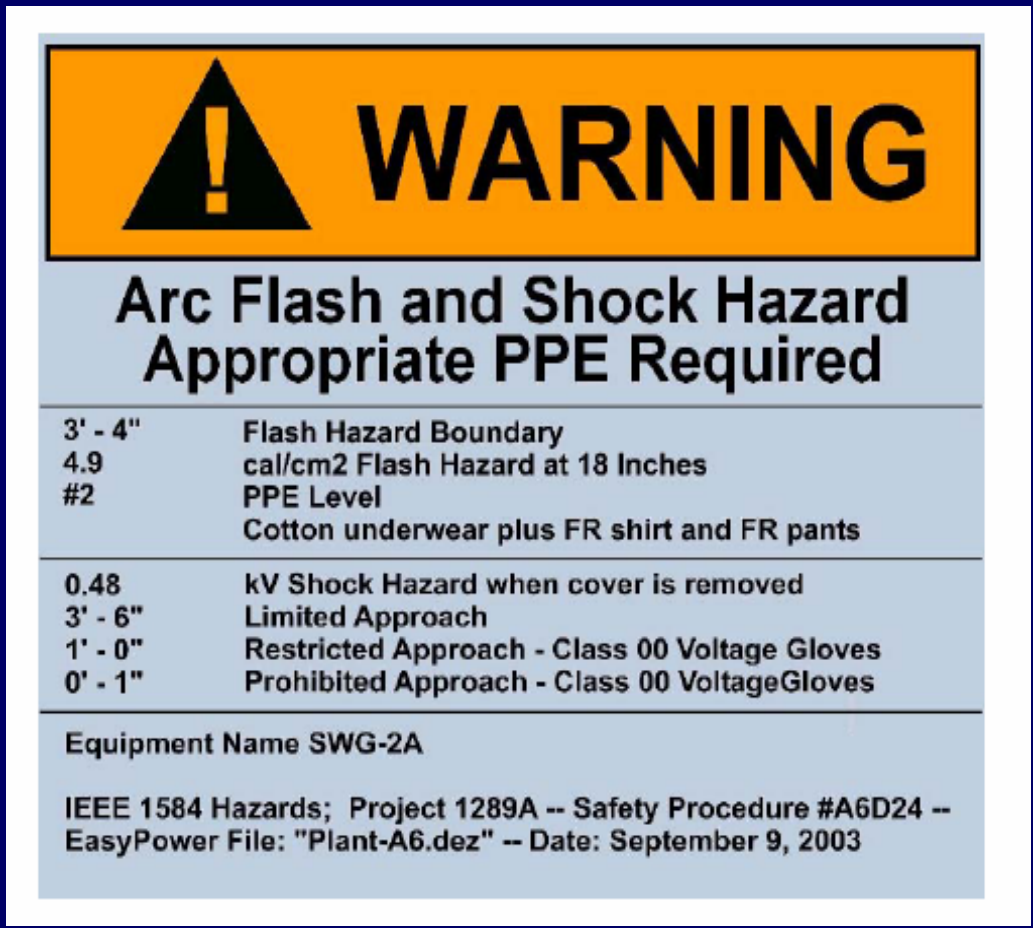
RISK

- 5 to 10 arc-flash injuries per day in US
  - Injuries require treatment in special burn center
  - Does not include hospital treated injuries
- DOE has begun aggressive compliance with:
  - NFPA 70E PPE requirements
  - NEC labeling requirements

Arc Flash Analysis

- Table method or calculation is required by NFPA 70E prior to allowing work
- The hazard may be small for systems of less than 240 volts with limited fault current
- Any system over 240 volts probably has the capability to have significant arc flash event
- BNL is initially using NFPA 70E Tables until a calculation is done

Possible BNL Label



Reducing the Risk

- Preventive maintenance
- Work Hot only when unavoidable and only under permit
- All locations where workers are exposed will be analyzed
- All breaker panels capable of arc flash will be labeled
- NFPA 70E Tables must be used until calculation is performed
- Panels rated 208 volts or less can generally be ignored if
  - Service transformer is less than 125 kVA
    - Qualified BNL staff must identify these circuits first
- BNL will be identifying circuits to reduce fault current
  - Fuses can be added
  - Smaller transformers can be used

NFPA 70E PPE Requirements

NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

Table 3-3.9.1 Hazard Risk Category Classification

Task (Assumes Equipment Is Energized, and Work Is Done Within The Flash Protection Boundary)	Hazard / Risk Category	V-Rated Gloves	V-Rated Tools
Panelboards rated 240 V and below – Notes 1 and 3	-	-	-
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 parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N

Notes:

1. 25 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
3. For <10 kA short circuit available, the Hazard / Risk Category required may be reduced by one Number.

NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

Table 3-3.9.2 Protective Clothing and Personal Protective Equipment (PPE) Matrix

Protective Clothing & Equipment	**Protective Systems for Hazard/Risk Category**					
Hazard/Risk Category Number	**-1** (Note 3)	**0**	**1**	**2**	**3**	**4**
Untreated Natural Fiber	-	-	-	-	-	-
a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)	-	-	-	-	-	-
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			X (Note 5)	X (Note 7)	X (Note 9)	X (Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN

NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

Table 3-3.9.2 Protective Clothing and Personal Protective Equipment (PPE) Matrix

Protective Clothing & Equipment	**Protective Systems for Hazard/Risk Category**					
Hazard/Risk Category Number	**-1** (Note 3)	**0**	**1**	**2**	**3**	**4**
FR Protective Equipment	-	-	-	-	-	-
a. Flash suit jacket (2-layer)						X
b. Flash suit pants (2-layer)						X
Head protection	-	-	-	-	-	-
a. Hard hat			X	X	X	X
b. FR hard hat liner					X	X
Eye protection	-	-	-	-	-	-
a. Safety glasses	X	X	X	AL	AL	AL
b. Safety goggles				AL	AL	AL
Face protection double-layer switching hood				AR (Note 8)	X	X
Hearing protection (ear canal inserts)				AR (Note 8)	X	X
Leather gloves (Note 2)			AN	X	X	X
Leather work shoes			AN	X	X	X

Typical Protective Clothing Systems			
Hazard / Risk Category	**Clothing Description (Number of clothing layers is given in parentheses)**	**Total Weight oz/yd^2**	**Minimum Arc Thermal Performance Exposure Value (ATPV)* or Break-open Threshold Energy (E_{BT})* Rating of PPE cal/cm^2**
0	Untreated cotton (1)	4.5 – 7	N/A
1	FR shirt and FR pants (1)	4.5 – 8	5
2	Cotton underwear plus FR shirt and FR pants (2)	9 – 12	8
3	Cotton underwear plus FR shirt and FR pants plus FR coverall (3)	16 – 20	25
4	Cotton underwear plus FR shirt and FR pants plus double layer switching coat and pants (4)	24 – 30	40

***ATPV is defined in the ASTM P S58 standard arc test method for flame resistant (FR) fabrics as the incident energy that would just cause the onset of a second degree burn (1.2 cal/cm^2). E_{BT} is reported according to ASTM P S58 and is defined as the highest incident energy which did not cause FR fabric break-open and did not exceed the second-degree burn criteria. E_{BT} is reported when ATPV cannot be measured due to FR fabric break-open.**

Circuit Breaker Operation With Covers on (≤ 600V ac rms)

- Safety Glasses
- Natural Fiber Long Sleeve Shirt
- Natural Fiber Long Pants

Circuit Breaker Trips

- When a circuit has been de-energized by a protective device, do not manually re-energize the circuit without first investigating the cause. Do not perform repetitive manual re-closing of breakers or replacing of fuses.
- BNL electrical protocols allow **ONE attempt** to manually re-close a breaker that has tripped. If the breaker trips again after this attempt, the cause of the trip must be investigated by a qualified person.

Fused Switch Operation With Covers on (≤ 600V ac rms)

- Safety Glasses
- Natural Fiber Long Sleeve Shirt
- Natural Fiber Long Pants

Voltage Testing / LOTO Verification (≤ 240 Volts ac rms)

- Voltage Rated Gloves
- Voltage Rated Tools
- Denim Cotton Blue Jeans
- Flame Resistant Long Sleeve Shirt (≥4 cal/cm^2)
- Hard Hat
- Safety Glasses (non-conductive)
- Training (see next slide)
- Generic Energized Work Permit
- Category III Multimeter

Training & Qualifications

- BNL Electrical Safety I (TQ-ELECSAF1)
- BNL LOTO Authorized Employee (HP-OSH-151B-W)
- Department/Division PPE Orientation
- Must be Qualified By Supervisor to Perform Task

Voltage Testing / LOTO Verification (≤ 240 Volts ac rms)

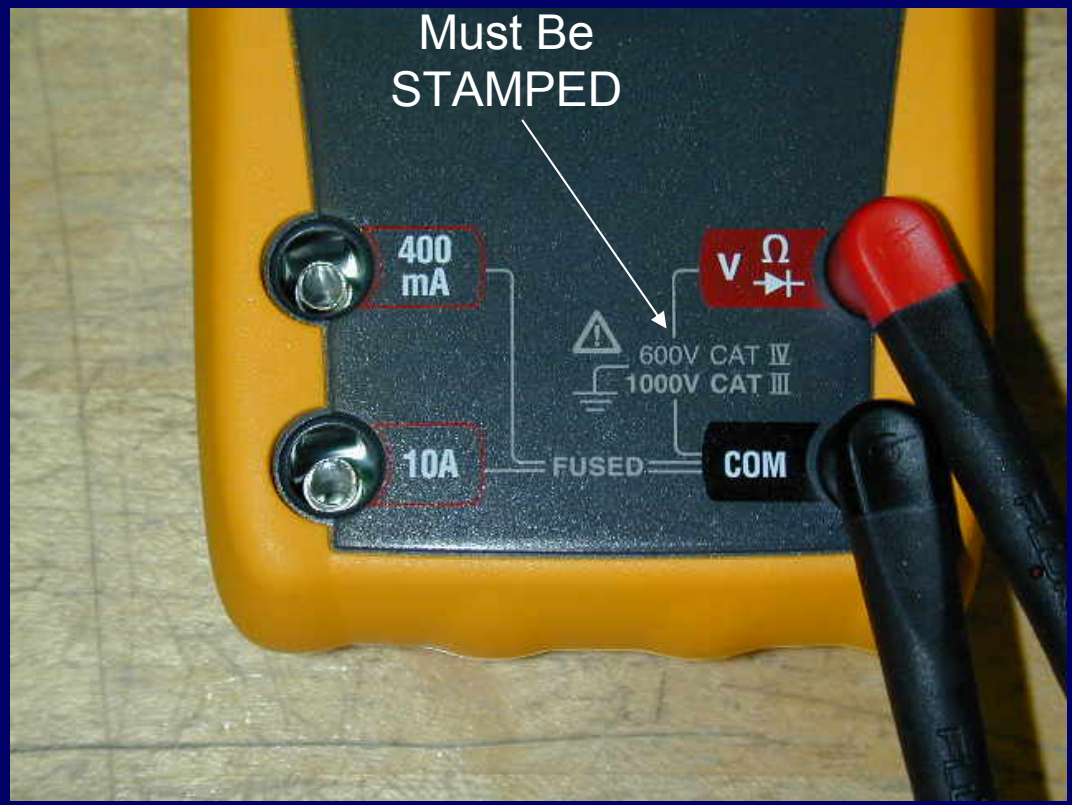
Where Can I Buy the Proper PPE?

- **FR SHIRTS:**
  - Working Class Clothes
  - http://www.workingclassclothes.com/FRwrkshirt.htm
  - INDURA Arc Rating 6.3 cal/cm^2 (KHAKI) {$35.95 each}
  - **GLOVES:**
  - Chris Zubyk at BBP 610-827-0138
  - 500 volt rated kits: cotton liner, yellow v-rated gloves, leather gloves & bag $45.00
  - 500 volt gloves only $25.00
  - Test $5.00/pair

Where Can I Buy the Proper PPE?

- **HARD HAT:**
  - BNL Stock K70330
- **NON-CONDUCTIVE SAFETY GLASSES:**
  - BNL stock #K63450, safety glasses must be compliant with ANSI Z87.1 (stamped Z87), do not use chemical splash protection goggles - (they will melt during an arc flash).

Meter Requirements
CAT III or CAT IV



Arc Flash at SLAC

Figure 3-4. Worker wearing the correct protective clothing and PPE

Figure 3-5. Worker wearing the eye and hearing protection to be worn under the double-layer switching hood

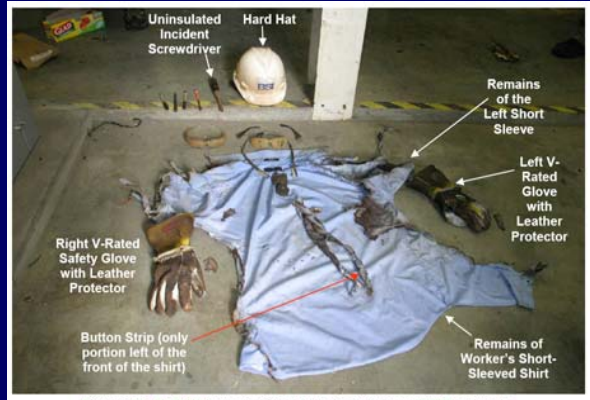


Figure 2-6. BSE-1's burned shirt and his flash-damaged PPE and tools

Figures 2-2a and b. Panel 4P20R after the arc flash

The End