MARTA Training Part I , July 16, 2015

# Arc Flash Fundamentals & Compliance

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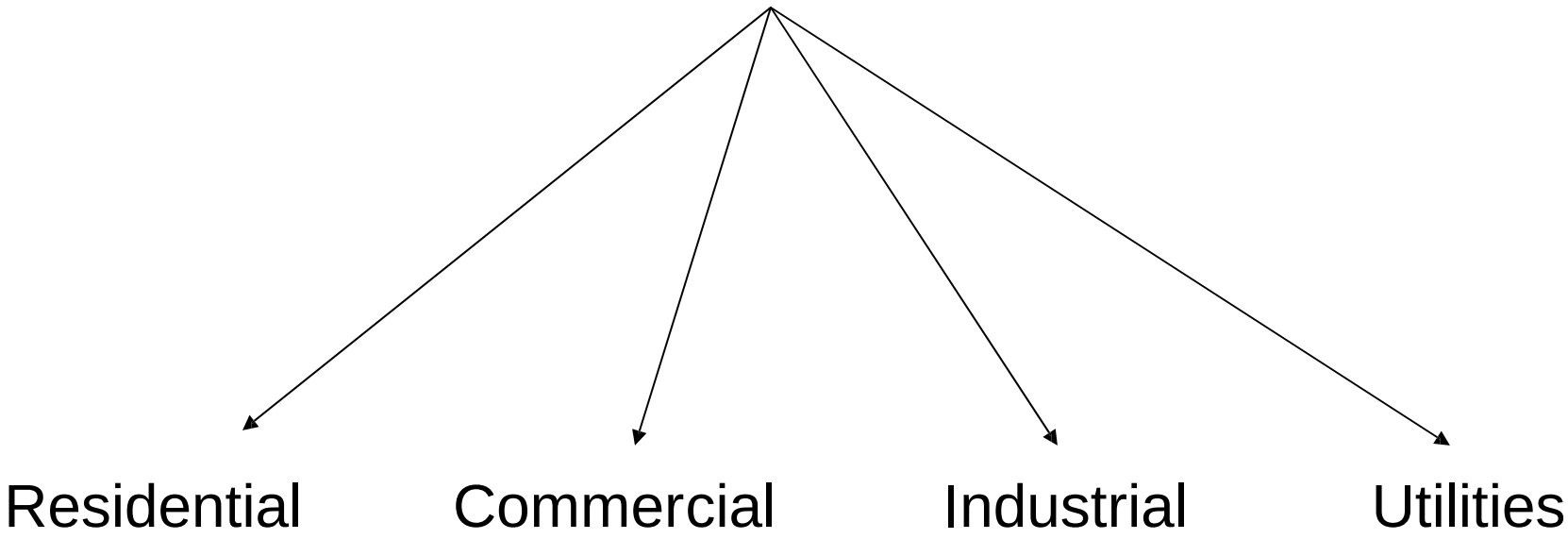
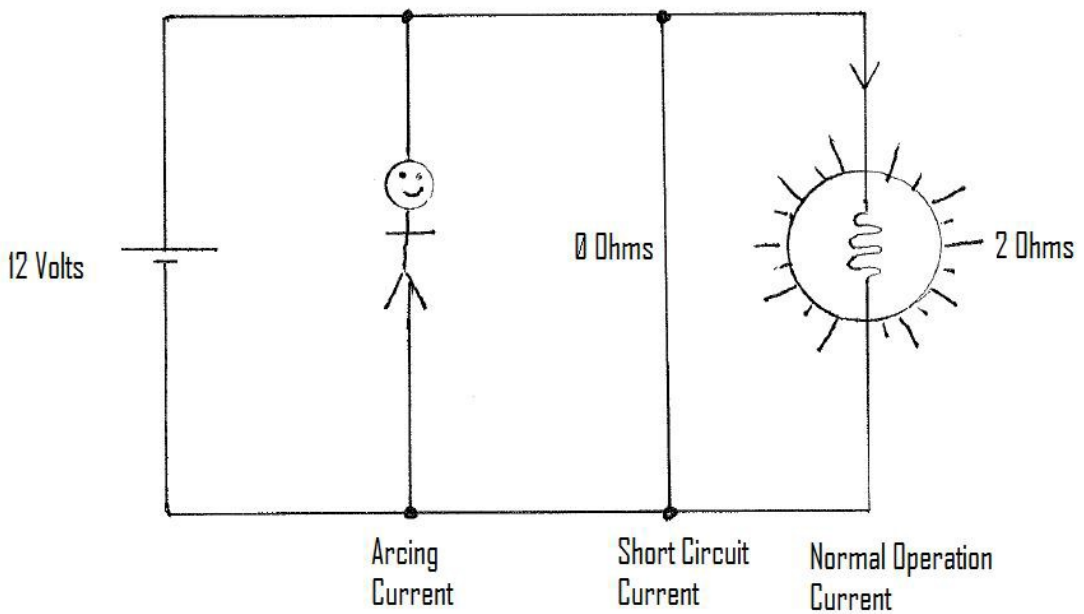
# Classification of Electric Power By User Class



# What are Watts?

- Amps
- Volts
- Watts = Amps x Volts
- Watt Hour (Energy) = Amps x Volt x Hours

# Electric Systems Normal Operations, Short Circuit, and Arcing Currents



# Human Reaction to Current

- 10 mA  Let Go Current
- 30 mA  Stop Breathing
- 75 mA  Fibrillation Threshold
  (Stops the Heart)
- >5 A  Tissue Burning
- 12 A  Your Hair Dryer

# Annual Electrical Burn Statistics Department of Labor

- 4000+ Admissions to burn centers with severe Arc Flash Burns
- 3600 Disabling injuries
- 400 – 600 Deaths

# Electrical Injuries by Percentage

- 77% Electrical Arc Injuries
- 21% Permanent Disabilities
- 3% Death

# HOW FAR CAN YOU GO?

Fatal burns do occur at >10 feet.

# Arc Flash Incident

- A dangerous release of energy created by an electric short circuit

- Energy is released in the following forms:
  - Arc Blast: 35,000$^{o}$ F (Sun surface is 9,000$^{o}$ F)
  - Thermal Radiation: Blinding light
  - Pressure Wave: Ear drum rupture at 720 lbs/sq ft
  - Debris / Projectiles / Molten Material: Inhaling debris

# Threshold of Second & Third Degree Burns

- Second Degree Burns – Just curable, skin bubbles at 1.2 cal/cm$^2$, 176$^o$ F for 0.1 sec.

- Third Degree Burns – Complete destruction of skin, needs grafting, 205$^o$ F, for 0.1 sec.

One calorie = 4.184 Joules = 1.163 X 10$^{-6}$ KWH = 0.003964 BTU

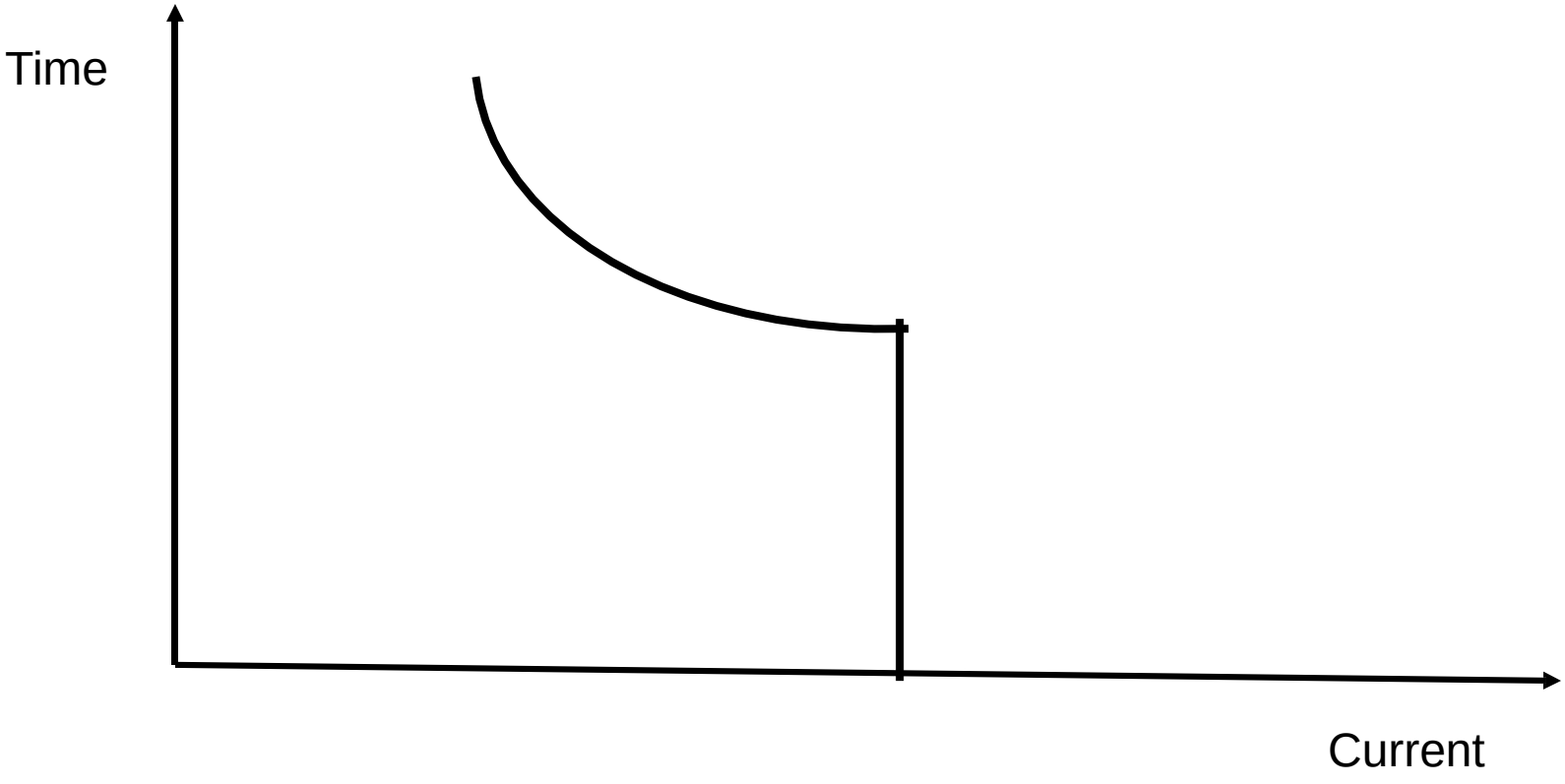
# Fundamentals of Electric System Protection

# Protective Device Clearing Time

- Current Limiting Fuse < ½ cycle (1/60 sec)
- Low Voltage Breaker 1-6 cycles (with instantaneous element)
- Low Voltage Breaker 30 cycles (without instantaneous element)
- Medium Voltage Breaker 8 cycles + relay time

# Switchgear

# Overcurrent and Instantaneous Protection



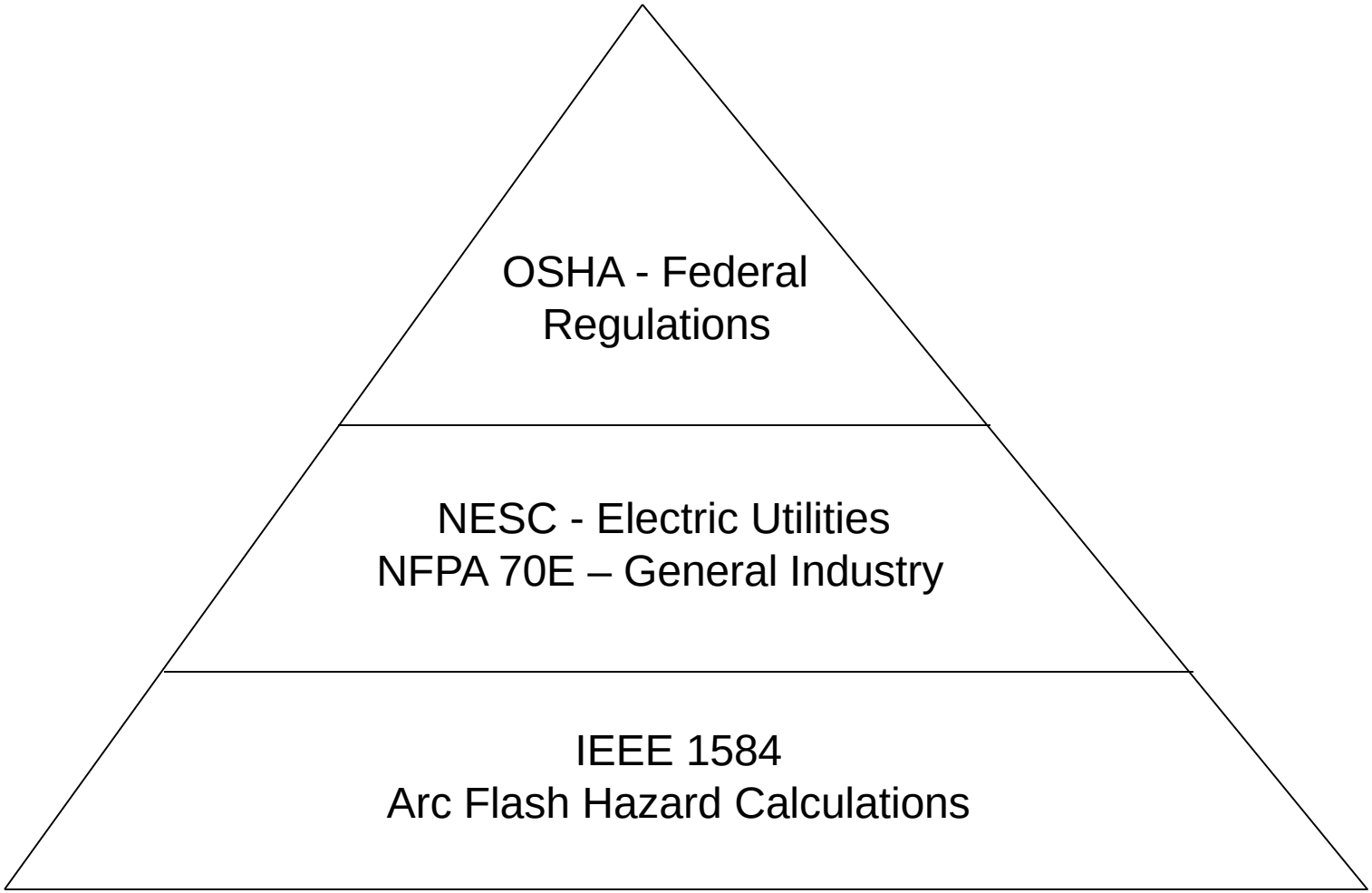
# Protective Devices Coordination (1 of 2)

The main mission is to isolate the smallest portion of the faulted distribution system.

# Protective Device Coordination (2 of 2)

- Reliability versus Safety
- Arcing Current < Bolted Short Circuit Current

# How Do Regulations Stack?



# IV Calculations Based on IEEE 1584

How do you purchase a size 11 black shoe?

# Personal Protective Equipment

- Determine incident energy based on short circuit current and overcurrent device clearing time.
- Then select the appropriate PPE.

# Hazard/Risk Category (HRC) Classification

| Required Minimum Arc Rating (cal/cm$^2$) | HRC | Components |
|---|---|---|
| 4 | 1 | FR shirt and FR pants or FR Coveralls |
| 8 | 2 | FR shirt and FR pants or FR Coveralls |
| 25 | 3 | FR shirt and FR pants or FR Coveralls and arc flash suit selected so the system arc rating meets the required minimum |
| 40 | 4 | FR shirt and FR pants or FR Coveralls and arc flash suit selected so the system arc rating meets the required minimum |
| >40 | Don't be a dead hero!<br>Work de-energized. | |

# Level 1 PPE

- Level 1 PPE

Level 1 PPE must provide protection to 5 calories/cm$^2$ from potential Arc Flash Thermal Energy. Level 1 PPE total clothing weight usually is 4.5 oz/yd$^2$ to 8 oz/yd$^2$ and may consist of:

- FR long sleeve shirt and FR long pants, FR Coveralls or 50” FR smock;
- Safety glasses with side shields and electrically non-conductive frames;
- Polycarbonate or propionate goggles, if goggles are required;
- Electrically-rated safety shoes;
- Electrically non-conductive hardhat; and
- Arc Flash Hazard rated gloves shall be worn to protect against the Arc Flash Hazard energy for this level of PPE.

# Level 2 PPE

- Level 2 PPE

Level 2 PPE must provide protection to 8 calories/cm$^2$ from potential Arc Thermal Energy, Level 2 PPE total clothing weight of all layers usually is 9 oz/yd$^2$ to 12 oz/yd$^2$ and may consist of:

| | |
|---|---|
| First Layer | • 100% cotton underwear, including short sleeve shirt |
| Second Layer | •FR long sleeve shirt and FR long Pants, FR Coveralls or 50” smock. |
| Other PPE: | •Safety glasses with side shield and electronically non-conductive.<br>• Electrically non-conductive hardhat.<br>• Hearing protection.<br>•Arc Flash rated gloves shall be worn to protect against the Arc Flash Hazard energy for this level PPE. |

# Level 3 PPE

- Level 3 PPE

Level 3 PPE must provide protection to 25 calories/cm$^2$ from potential Arc Thermal Energy, Level 3 PPE total clothing weight of all layers usually is 16 oz/yd$^2$ to 20 oz/yd$^2$ and may consist of:

| | |
|---|---|
| First Layer | • 100% cotton underwear, including short sleeve shirt |
| Second Layer | •FR long sleeve shirt and FR long Pants, FR Coveralls or 50" smock. |
| Third Layer | • Single layer Nomex 50" length smock or coveralls.<br>• Nomex hood or hood cape.<br>• Wrap around arc rated face shied. |
| Other PPE: | •Safety glasses with side shield and electronically non-conductive.<br>• Electrically non-conductive hardhat.<br>• Electrically rated safety shoes.<br>• Polycarbonate or propionate goggles, if goggles are required.<br>• Hearing protection.<br>•Arc Flash rated gloves shall be worn to protect against the Arc Flash Hazard energy for this level PPE. |

# Level 4 PPE

- Level 4 PPE

Level 4 PPE must provide protection to 40 calories/cm$^2$ from potential Arc Thermal Energy, Level 4 PPE total clothing weight of all layers usually is 24 oz/yd$^2$ to 30 oz/yd$^2$ and may consist of:

| | |
|---|---|
| First Layer | • 100% cotton underwear, including short sleeve shirt |
| Second Layer | • FR long sleeve shirt and FR long Pants, FR Coveralls or 50” smock. |
| Third Layer | • Multi0ply Nomex III 50” length switcher’s coat.<br>• Nomex switcher’s hood with wrap around arc rated face shied. |
| Other PPE: | •Safety glasses with side shield and electronically non-conductive.<br>• Electrically non-conductive hardhat.<br>• Electrically rated safety shoes.<br>• Polycarbonate or propionate goggles, if goggles are required.<br>• Hearing protection.<br>•Arc Flash rated gloves shall be worn to protect against the Arc Flash Hazard energy for this level PPE. |

# Questions and Comments

# WHY NFPA 70E?

1. OSHA tells you what to do.

2. NFPA 70E tells you how to do it.

3. NFPA 70E is revised every three years.

4. NFPA 70E 2015 became effective on August, 2014 and often is cross-referenced as part of OSHA.

# NFPA 70E 2015 UPDATE (1 of 3)

1. Hazard Risk Category (HRC) is replaced by PPE level or arc-rated PPE.

2. Elimination of Hazard Risk Category 0.

3. Elimination of Shock Prohibited Approach Boundaries.

# NFPA 70E 2015 UPDATE (2 of 3)

4. Arc flash study must be performed by April 1, 2015 and every 3-5 years thereafter.

5. Risk assessment replaced hazard analysis.

# NFPA 70E 2015 UPDATE (3 of 3)

6. Arc flash PPE table was replaced by two tables.

   a. Table 130.7 (C) (15)(a) determines existence of arc flash hazard.

   b. Table 130.7 (C) (15)(b) recommends clothing and PPE.

# ELIMINATION OF PPE for CLOSED DOOR OPERATIONS

Under the following conditions:

- Equipment properly installed and maintained.
- Covers for all other equipment are secured.
- No evidence of impending failure.