Electrical Safety for Cable Testing & Fault Locating

Presented by: Mark Franks
Moderator

Ron Spataro
AVO Training Institute Marketing Manager
Send us your questions and comments during the presentation.
Electrocution: One of OSHA’s Fatal Four

2,000 admitted to burn centers annually because of arc flash

Electrical accidents are catastrophic but they are preventable

Qualified worker must be trained to recognize and avoid hazards

Most testing incidents involve verification and lockout/tagout

Safety policies are the responsibility of the company

Testing personnel trained in precautions, policies and procedures

Emphasis on de-energizing and lockout/tagout

Trained in first aid, CPR and emergency procedures
Agenda

- Electrical Hazard Recognition
- Electrical Protection
- Test Area Safety Check
- Training Requirements
- Summary
Electrical Hazard Recognition

- OSHA mandates:
  - Hazard assessment be conducted
  - PPE selected and provided

- PPE and protective measures must be employed to protect employees from job related hazards

- Shock protection available from 500 volts to 36,000 volts
Electrical Hazard Recognition

Shock

Arc

Blast
Electrical Hazard Recognition

The four major types of electrical injuries are:

- Direct
  - Electrocution
  - Electrical Shock
  - Burns

- Indirect
  - Falls
Electrical Hazard Recognition

Demonstration of fatal shock
- Average Working conditions with 120-volts
- Person is perspiring
- Average resistance is 1000-ohms from hand-to-hand

250 ohms
500 ohms
250 ohms
1000 ohms Total
Hand-to-hand, or
Hand-to-foot, or

500-ohms
Foot-to-foot
Electrical Hazard Recognition

- Received when current passes through the body

- Severity of shock depends on:
  - Path of current through the body
  - Amount of current flowing through the body
  - Length of time the body is in the circuit
Electrical Hazard Recognition

- The most common shock related, nonfatal injury is a burn.
- Burns caused by electricity may be of three types:
  - Electrical burns
  - Arc burns
  - Thermal contact burns
- Electrical burns need to be given immediate medical attention.
- Electrical burns are often disabling or fatal.
Electrical Hazard Recognition

- Electrical burns occur when a person touches electrical wiring or equipment
- Burns typically occur on the hands
- Clothing may catch on fire and a thermal burn may result
Electrical Hazard Recognition

- **An arc-blast** is a luminous electrical discharge that occurs when high voltages exist across a gap between conductors and current travels through the air.

- Temperatures as high as 35,000°F have been reached in arc-blasts.
Electrical Hazard Recognition

Four primary hazards associated with an arc-blast are:

- Arching gives off thermal radiation (heat) and intense light causing burns
- Intense sound wave produced often 165 db
- Arc produces a considerable pressure wave blast
  - Example: A person 2 ft. away from a 25,000-amp arc feels a force of about 480 lbs. on the front of the body
- Copper and aluminum components melt and vaporize
  - Expanding its volume plus 60 times reaching great distances
Electrical Protection

- Personal Protective Insulation
- Warning Signs
- Protective Grounding
- Test Area Guarding
- Electrical Protective Devices
- Other Protective Equipment
Electrical Protection-Insulation

- Personal Protective Equipment
  - Defective PPE may not be used:
    - If holes, tears, punctures, or cuts are present
    - Texture changes: Swelling, softening, hardening, or becoming sticky or inelastic.
    - An embedded foreign object
    - Any other defect that damages the insulating properties
Electrical Protection-Warning Signs

- Observe all Electrical Warning Signs
  - Signage on Test Equipment
  - Signage on Electrical Power Installations
  - Test Area
Electrical Protection-Grounding

- The only way to ensure that a system will remain de-energized is to short-circuit and ground that system
- Grounds may be removed temporarily during testing
- If grounds are not practical, other safe work practices may apply
- Remember… “It’s not dead unless it’s grounded”
Electrical Protection-Grounding

- Provide maximum safety for personnel
- Equalize voltage differences at worksite
- Dissipate static voltages
- Protect against induced voltages from adjacent energized systems
- Cause protective devices to operate as quickly as possible
- Minimize the magnitude and duration of the hazard
Electrical Protection-Grounding

- Verification
- Inspection
- Grounding
Electrical Protection-Grounding

- Verify circuit is de-energized
- Pre and post check voltage detector
- Grounds shall be suitable in size and connected to ground first, then to the cable or bus
- Only after properly grounded can conductors be disconnected for testing
- Conductors not being tested shall remain grounded
- Ground end “first on-last off”
Electrical Protection-Test Area Guarding

- Safety signs and tags
- Barricades
- Attendants

HAZARDOUS VOLTAGE
UNQUALIFIED PERSONNEL
KEEP OUT
Electrical Protection-Test Area Guarding

- Uninvolved personnel keep away from the test location or equipment
- Use barricades, ropes, danger tape etc. to secure the test area
- Remote end is secured or barricaded
- Post a guard if necessary to protect the area
- Personnel in the test area to a minimum
- Advise personnel of hazards when allowed in the test area
Electrical Protection-Test Area Guarding

Guarding

- Type of isolation that uses various structures to close off live electrical parts
- These structures include:
  - Boxes
  - Screens
  - Covers
  - Partitions
  - Fences
  - Barrier tape
Electrical Protection-Test Area Guarding

Attendant

Danger Tape

Barricade
Electric Protection-Devices

- **Ground Fault Circuit Interrupters (GFCI)**
  - Detects the difference in current between two circuits wires
  - This difference in current could happen when electrical equipment isn’t working correctly
  - GFCI are set at about 5mA and are designed to protect workers and not equipment
Electrical Protection- Other PPE

Foot Protection

- Footwear will be marked “EH” if it’s approved for electrical work.
- EH = Electrical Hazard
- Footwear must be kept dry, even if it is marked “EH”
Electrical Protection - Other PPE

- **Head Protection**
  - Hard hat (insulated nonconductive)
  - Class B & E
  - Always wear your hat with the bill forward
  - Do not store anything in the top of your hat while wearing it
Types of arc protective clothing

- Daily Wear
- Arc Flash Suits

Employees must be trained if exposed to hazards of flames or electric arc

Employees cannot wear clothing that could add to the extent of the injuries
Electrical Protection- Other PPE

Wearing Apparel

- Wear Arc Rated wearing apparel when conducting demonstrations in areas designated as Arc Flash Zones.
- Arc rating should be sufficient to address the specific hazard present.
Electrical Protection- Other PPE
Safe Work Practices

Use safe work practices when working with electric test equipment

Plan your work

- Coordinate your work and take advantage of what others know about identifying and controlling hazards
- Conduct pre-Job discussion with all those involved in the equipment demo
- You are “in charge” of the test area

Power Authority should Lock out and Tag out circuits and equipment

- Shut off the circuit
- Lock and tag out the circuit at the distribution panel
- Test the circuit to make sure it’s de-energized
- Install Personal Protective Grounds when required
Safe Work Practices

• Do not work in wet conditions that would create potential electrical shock hazards

• Avoid contact with overhead power lines
  – Be at least 10 feet away from high-voltage transmission lines energized up to 50 kV. (increase distance for higher voltages)

• Use proper wiring and connectors for test equipment supply
  – Avoid overloading circuits
  – Test GFCIs prior to use
  – Make sure switches and insulation are in good condition
  – Never use a three prong plug with the third prong broken off
  – Make sure test power sources are accessible for operation in case of an emergency
Safe Work Practices

- Use and maintain test equipment properly
  - Inspect test equipment prior to use
  - Damaged equipment must be removed from service
  - Keep equipment and cords away from heat, oil and sharp objects

- Using appropriate personal protective equipment
  - Wear safety glasses to avoid eye injury
  - Wear proper foot protection
  - Wear a hard hat
  - Wear Arc Rated FR apparel where required
  - Follow the manufacturer’s directions for cleaning/maintaining PPE
Safe Work Practices

• Test Engineer in charge should inspect the test area prior to each series of tests ensuring all safety precautions are in place and being observed.

• After completion of test demonstration, test equipment shall be de-energized and placed in an electrical safe work condition.

• Always meet the minimum PPE and safety requirements when on customers premises.
Safe Work Practices

Personal Protective Equipment

• Use, store and maintain your electrical PPE in a safe, reliable condition
• Wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts
• Wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion
• Safety glasses should be UV rated and Non-Conductive
Safe Work Practices

- High capacitance property of cable requires discharging
- Use discharge resistor stick when available
- Solidly ground with approved grounds
- Discharge approximately 4 times the test time after DC testing
- Always re-apply grounds after VLF AC test on cable
Safe Work Practices
Minimum Approach Distances (MAD)

- Table 1 lists the Limited Approach Boundaries for un-qualified personnel
- Restricted Approach Boundaries for qualified test technicians are listed
- Table 1 is for Alternating Current (AC) Voltages
- Table 2 lists MAD distances Direct Current (DC) systems
### Table 1. Minimum Approach Distances (MAD)

**Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection Alternating Current Systems**

(All dimensions are distance from energized electrical conductor or circuit part to employee).

<table>
<thead>
<tr>
<th>Nominal System Voltage Range, Phase-to-Phase</th>
<th>Exposed Movable Conductor</th>
<th>Exposed Fixed Circuit part</th>
<th>Restricted Approach Boundary; Includes Inadvertent Movement Adder</th>
<th>Prohibited Approach Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50 V</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>50 V - 300 V</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.0 m (3 ft. 6 in.)</td>
<td>Avoid contact</td>
<td>Avoid contact</td>
</tr>
<tr>
<td>301 V - 750 V</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.0 m (3 ft. 6 in.)</td>
<td>0.3 m (1 ft. 0 in.)</td>
<td>25 mm (0 ft. 1 in.)</td>
</tr>
<tr>
<td>751 V - 15 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.5 m (5 ft. 0 in.)</td>
<td>0.7 m (2 ft. 2 in.)</td>
<td>0.2 m (0 ft. 7 in.)</td>
</tr>
<tr>
<td>15.1 kV - 36 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.8 m (6 ft. 0 in.)</td>
<td>0.8 m (2 ft. 7 in.)</td>
<td>0.3 m (0 ft. 10 in.)</td>
</tr>
<tr>
<td>36.4 kV - 46 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>2.5 m (8 ft. 0 in.)</td>
<td>0.8 m (2 ft. 9 in.)</td>
<td>0.4 m (1 ft. 5 in.)</td>
</tr>
<tr>
<td>46.1 kV - 72.5 kV</td>
<td>3.0 m (10 ft. 4 in.)</td>
<td>2.5 m (8 ft. 0 in.)</td>
<td>1.0 m (3 ft. 3 in.)</td>
<td>0.7 m (2 ft. 2 in.)</td>
</tr>
<tr>
<td>72.6 kV - 121 kV</td>
<td>3.3 m (10 ft. 8 in.)</td>
<td>2.5 m (8 ft. 0 in.)</td>
<td>1.0 m (3 ft. 4 in.)</td>
<td>0.8 m (2 ft. 9 in.)</td>
</tr>
<tr>
<td>138 kV - 145 kV</td>
<td>3.4 m (11 ft. 0 in.)</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.2 m (3 ft. 10 in.)</td>
<td>1.0 m (3 ft. 4 in.)</td>
</tr>
<tr>
<td>161 kV - 169 kV</td>
<td>3.6 m (11 ft. 8 in.)</td>
<td>3.6 m (11 ft. 8 in.)</td>
<td>1.3 m (4 ft. 3 in.)</td>
<td>1.1 m (3 ft. 9 in.)</td>
</tr>
<tr>
<td>230 kV - 242 kV</td>
<td>4.0 m (13 ft. 0 in.)</td>
<td>4.0 m (13 ft. 0 in.)</td>
<td>1.7 m (5 ft. 8 in.)</td>
<td>1.6 m (5 ft. 2 in.)</td>
</tr>
<tr>
<td>345 kV - 362 kV</td>
<td>4.7 m (15 ft. 4 in.)</td>
<td>4.7 m (15 ft. 4 in.)</td>
<td>2.8 m (9 ft. 2 in.)</td>
<td>2.6 m (8 ft. 8 in.)</td>
</tr>
<tr>
<td>500 kV - 550 kV</td>
<td>5.8 m (19 ft. 0 in.)</td>
<td>5.8 m (19 ft. 0 in.)</td>
<td>3.6 m (11 ft. 10 in.)</td>
<td>3.5 m (11 ft. 4 in.)</td>
</tr>
<tr>
<td>765 kV - 800 kV</td>
<td>7.2 m (23 ft. 9 in.)</td>
<td>7.2 m (23 ft. 9 in.)</td>
<td>4.9 m (15 ft. 11 in.)</td>
<td>4.7 m (15 ft. 5 in.)</td>
</tr>
</tbody>
</table>

- For single-phase systems, select the range that is equal to the system’s maximum phase-to-ground voltage multiplied by 1.732.
- A condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.
<table>
<thead>
<tr>
<th>(1) Nominal Potential Difference</th>
<th>(2) Exposed Movable Conductor</th>
<th>(3) Exposed Fixed Circuit part</th>
<th>(4) Restricted Approach Boundary; Includes Inadvertent Movement Adder</th>
<th>(5) Prohibited Approach Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100 V</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>100 V – 300 V</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.0 m (3 ft. 6 in.)</td>
<td>Avoid contact</td>
<td>Avoid contact</td>
</tr>
<tr>
<td>301 V – 1 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.0 m (3 ft. 6 in.)</td>
<td>0.3 m (1 ft. 0 in.)</td>
<td>25 mm (0 ft. 1 in.)</td>
</tr>
<tr>
<td>1.1 kV – 5 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.5 m (5 ft. 0 in.)</td>
<td>0.5 m (1 ft. 5 in.)</td>
<td>0.1 m (0 ft. 4 in.)</td>
</tr>
<tr>
<td>5 kV – 15 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.5 m (5 ft. 0 in.)</td>
<td>0.7 m (2 ft. 2 in.)</td>
<td>0.2 m (0 ft. 7 in.)</td>
</tr>
<tr>
<td>15.1 kV – 45 kV</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>2.5 m (8 ft. 0 in.)</td>
<td>0.8 m (2 ft. 9 in.)</td>
<td>0.4 m (1 ft. 5 in.)</td>
</tr>
<tr>
<td>45.1 kV – 75 kV</td>
<td>3.0 m (10 ft. 4 in.)</td>
<td>2.5 m (8 ft. 0 in.)</td>
<td>1.0 m (3 ft. 2 in.)</td>
<td>0.7 m (2 ft. 1 in.)</td>
</tr>
<tr>
<td>75.1 kV – 150 kV</td>
<td>3.3 m (10 ft. 8 in.)</td>
<td>3.0 m (10 ft. 0 in.)</td>
<td>1.2 m (4 ft. 0 in.)</td>
<td>1.0 m (3 ft. 2 in.)</td>
</tr>
<tr>
<td>150.1 kV – 250 kV</td>
<td>3.6 m (11 ft. 8 in.)</td>
<td>3.6 m (11 ft. 8 in.)</td>
<td>1.6 m (5 ft. 3 in.)</td>
<td>1.5 m (5 ft. 0 in.)</td>
</tr>
<tr>
<td>250.1 kV – 500 kV</td>
<td>6.0 m (20 ft. 0 in.)</td>
<td>6.0 m (20 ft. 0 in.)</td>
<td>3.5 m (11 ft. 6 in.)</td>
<td>3.3 m (10 ft. 10 in.)</td>
</tr>
<tr>
<td>500.1 kV – 800 kV</td>
<td>8.0 m (26 ft. 0 in.)</td>
<td>8.0 m (26 ft. 0 in.)</td>
<td>5.0 m (16 ft. 5 in.)</td>
<td>5.0 m (16 ft. 5 in.)</td>
</tr>
</tbody>
</table>

- All dimensions are distance from energized electrical conductor or circuit part to employee.
- A condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.
Test Area Safety Check

- Required by OSHA 29 CFR1910.269 (0)
- Test operator in charge must verify prior to each series:
  - Barriers and safeguards are in place
  - Test status signals are operable
  - Test-power disconnects are available
  - Ground connections are identifiable
  - PPE is provided and used
  - Separation between signal, ground, and power cables
Training Requirements

- Trained prior to assignment to test area
- Receive Qualified Worker training
- Understand the hazards and means of mitigation
- Proficient in safe operation of test equipment
- Trained in hazardous energy control for electrical work
- Understand requirements for test area protection
- Trained in in-service care and use of PPE
Summary

- Electrical incidents occur during cable testing and fault location
- Electrical hazards (shock, arc & blast) must be understood by all techs
- Care and use of protective equipment is required
- Technicians must be trained in safe work practices for high voltage and high current testing in the field or test facilities
- Thorough understanding of verification and PPE grounding is required
- Must know how to conduct test area safety check
A Special Training Offer

As our way of saying thanks for registering for this webinar, we are pleased to offer a 10% savings on the courses listed below.

- Electrical Safety for Utilities
- NFPA 70E Electrical Safety
- Electrical Safety for Industrial Facilities
- Cable Splicing & Terminating, Medium-Voltage
- Cable Fault Location & Tracing, Medium-Voltage
- Certification Cable Testing & Diagnostics, Medium-Voltage

Visit [http://www.online.avotraining.com/webinar5](http://www.online.avotraining.com/webinar5) to register and use promo code: WEBINAR5

Must register and attend courses before November 30, 2017 to receive this special pricing.

Offer not valid with other discounts or promotions.
Save the Date for Our Next Webinar

Tuesday October 17, 2017 at 1pm – 2pm CDT

“Introduction to Substation Maintenance, Load Break Switches”

Presented by: Bob Fakelmann and Greg Richmond
AVO Training Institute, Instructors and Curriculum Advisors
Questions?

After more than 50 years, AVO Training remains a global leader in safety and maintenance training for the electrical industry. We deliver an engaging, hands-on experience for our clients in a professional, real-world environment.

We strive to provide industry relevant courses in a practical and flexible learning environment through an ongoing commitment to quality service, integrity, instruction, and client satisfaction.

Our goal is to convey practical job skills and career development for our clients and students by saving lives through a world-class learning experience.