Arc Flash, OSHA and NFPA 70E: Get Protected

Doug Tellin
Electrical Safety Specialists
ArcFlashpro.com
Electrical Safety

Safety Overall
- 1 out of 300
- 300 Recordable Injuries
- 1 Fatality

Electrical Safety
- 1 out of 10
- 10 Recordable Injuries
- 1 Fatality

Electrical Safety should be a MAJOR concern!

What we are going to Cover

- OSHA
  - General Duty Clause
  - David Wallis
  - OSHA’s Relationship with NEC, NFPA70E
  - Standards
  - OSHA’s Latest Approach
OSHA historically has encouraged companies to:
- De-energize circuits before working on them.
- Perform lockout/tagout procedures
- Develop ongoing safety programs including training and retraining for workers

Never work on live circuits unless it is absolutely necessary.
- OSHA has strict guidelines for working live circuits.
- Production or inconvenience is not justification for working energized.
- Not having the authority to shut off power, cannot be used as an excuse for workers.
• Was an arc flash hazard analysis performed?
• Were flash protection boundaries established?
• Were all other potential electrical hazards identified?
• Was a shock hazard analyses performed?
• Were shock hazard boundaries established?

• These are all Questions every EHS professional
  • should have an answer to.

The employer must show proof of the appropriate training and certifications for a person to be deemed qualified in OSHA’s Eyes
• This is achieved by training, even for the experienced electrician.
Inspector will "focus" on these four hazard areas:

- Falls
- Struck by
- Caught in/between
- Electrical

US Labor Department’s OSHA proposes $357,000 in fines against US Postal Service for electrical hazards at Boston mail processing facility

**BOSTON** - The U.S. Department of Labor’s Occupational Safety and Health Administration has cited the U.S. Postal Service for alleged willful and serious violations of safety standards following an inspection at the Boston Processing and Distribution Center. The Postal Service faces a total of $357,000 in fines, chiefly for exposing workers to electrical hazards.

"These citations and sizable fines reflect both the gravity of the hazards identified during this inspection, and the Postal Service’s knowledge of and systemic failure to address these hazards," said Assistant Secretary of Labor for OSHA Dr. David Michaels. "The dangers of electric shock, burns and explosions were real, present and ongoing. The Postal Service must take comprehensive and aggressive action to correct these conditions once and for all."

OSHA’s inspection, which began Jan. 28 in response to worker complaints, found that employees at the Boston center, including mechanics and technicians working with or near live electrical equipment or parts such as bar code readers and elevator control panels, were not provided with adequate training, safe electrical work practices, required personal protective equipment or insulated tools.

These conditions exposed the workers to the hazards of electric shock, arc flashes and arc blasts, and resulted in OSHA issuing the Postal Service five willful citations carrying $350,000 in proposed fines. OSHA defines a willful violation as one committed with plain indifference to or intentional disregard for employee safety and health.

OSHA also found that the Boston facility failed to have an authorized person conduct periodic inspections of its energy control procedures to prevent the unexpected startup of machinery during maintenance. This situation resulted in one serious citation, with a $7,000 fine. OSHA issues serious citations when death or serious physical harm is likely to result from hazards about which the employer knew or should have known."
Lack of protective equipment for Republic Steel plant electrician results in 1st and 3rd degree burns after arc flash

BUFFALO, New York – An electric technician at the Republic Steel Corp. steel manufacturing plant in Blasdell was removing wiring from a fan motor in an overhead crane on October 16, 2014, when an ungrounded electrical conductor touched a grounded surface causing an arc flash. The electric technician sustained third degree burns on her hand and first degree burns on her face.

An investigation by the Buffalo Area Office of the U.S. Department of Labor’s Occupational Safety and Health Administration found that Republic Steel failed to provide and ensure the use of effective face and hand protection by its employees.

"These injuries were avoidable. Republic Steel has a responsibility to make sure that its electric technicians are properly trained, equipped with and using personal protective equipment to protect from arc flash. In this case, that would include a face shield and rubber insulating gloves. The company should be especially aware of this, since OSHA cited Republic Steel earlier in 2014 for similar hazards at its Lorain, Ohio, facility," said Michael Scime, OSHA’s area director in Buffalo.

As a result of these conditions, OSHA cited Republic Steel for two repeat violations, with proposed penalties of $70,000 each for the lack of hand and face protection. The steel manufacturer was also cited for one serious violation, with a $7,000 fine, for failing to protect employees against contact with energized electrical equipment. Total proposed penalties are $147,000.
NFPA 70E 2018 has set the bar pretty high.

➢ Qualified workers within Limited Approach Boundary!
➢ Documented Proficiency in Safe Work Practices!
➢ Annual inspections of employee performance!
➢ Release of victims training Annually
➢ Electrical safety program audits every 3 years!
➢ Retraining every 3 years!

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NFPA70E Organization

Article 90 - Introduction
Article 100 - Definitions
Article 105 - Application of Safety-Related Work Practices
Article 110 - General Requirements for Electrical Safety-Related Work Practices
Article 120 - Establishing an Electrically Safe Work Condition
Article 130 - Work Involving Electrical Hazards

Source NFPA 70E 2018
ARTICLE 105 Application of Safety-Related Work Practices

105.3 Responsibility.

A. Employer Responsibility. The employer shall have the following responsibilities:

1. Establish, document, and implement the safety-related work practices and procedures required by this standard.
2. Provide employees with training in the employer’s safety-related work practices and procedures.

B. Employee Responsibility. The employee shall comply with the safety-related work practices and procedures provided by the employer.

New 2018

Source NFPA 70E 2018

15

ARTICLE 105 Application of Safety-Related Work Practices

105.4 Priority.

• Hazard elimination shall be the first priority in the implementation of safety related work practices.

New 2018

Source NFPA 70E 2018

16
110.1 Electrical Safety Program

(B) Inspection.
- The electrical safety program shall include elements to verify that newly installed or modified electrical equipment or systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

(C) Condition of Maintenance.
- The electrical safety program shall include elements that consider condition of maintenance of electrical equipment and systems.
The electrical safety program shall include a risk assessment procedure and shall comply with 110.1(H)1 through 110.1(H)3.

1. Elements of a risk assessment procedure. The risk assessment procedure shall address employee exposure to electrical hazards and shall identify the process to be used by the employee before work is started to carry out the following:
   1. Identify hazards
   2. Assess risks
   3. Implement risk control according to a hierarchy of risk control methods

2. Human Error.
   The risk assessment procedure shall address the potential for human error and its negative consequences on people, process, the work environment, and equipment.

New 2018
(H) Risk Assessment Procedure

3. Hierarchy of Risk Control Methods.

- The risk assessment procedure shall require that preventive and protective risk control methods be implemented in accordance with the following hierarchy:
  1. Elimination
  2. Substitution
  3. Engineering controls
  4. Awareness
  5. Administrative controls
  6. PPE

Source NFPA 70E 2018

(K) Auditing.

1. Electrical Safety Program Audit.

The electrical safety program shall be audited to verify that the principles and procedures of the electrical safety program are in compliance with this standard. Audits shall be performed at intervals not to exceed 3 years.

Source NFPA 70E 2018
(K) Auditing.

2. Field Work Audit.
   • Field work shall be audited to verify that the requirements contained in the procedures of the electrical safety program are being followed. When the auditing determines that the principles and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made. Audits shall be performed at intervals not to exceed 1 year.

Source NFPA 70E 2018

(K) Auditing.

3. Lockout/Tagout Program and Procedure Audit.
   • The lockout/tagout program and procedures required by Article 120 shall be audited by a qualified person at intervals not to exceed 1 year. The audit shall cover at least one lockout/tagout in progress. The audit shall be designed to identify and correct deficiencies in the following:
     1. The lockout/tagout program and procedures
     2. The lockout/tagout training
     3. Worker execution of the lockout/tagout procedure

4. Documentation.
   • The audits required by 110.1 (K) shall be documented.

New 2018
Source NFPA 70E 2018
110.2 Training Requirements.

(A)(1) Qualified Person.
• A qualified person shall be trained and knowledgeable in the construction and operation of equipment or a specific work method and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.
  a. Such persons shall also be familiar with the proper use of the special precautionary techniques, applicable electrical policies and procedures, PPE, insulating and shielding materials, and insulated tools and test equipment.

Source NFPA 70E 2018

110.2 Training Requirements.

(A)(1) Qualified Person.
  b. A person can be considered qualified with respect to certain equipment and tasks but still be unqualified for others.
  c. Such persons permitted to work within the LAB shall, at a minimum, be additionally trained in all of the following:
     1. Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment
     2. Skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts
     3. The approach distances specified in Table 130.4(D)(a) and Table 130.4(D)(b) and the corresponding voltages to which the qualified person will be exposed

Source NFPA 70E 2018
110.2 Training Requirements.

(A)(1) Qualified Person.
4. Decision-making process necessary to be able to do the following:
   a. Perform the job **safety planning**
   b. **Identify** electrical hazards
   c. **Assess the** associated risk
   d. Select the appropriate risk control methods from the **hierarchy of controls** including personal protective equipment

Source NFPA 70E 2018

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100 Definitions

**Qualified Person.**

One who has **demonstrated** skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved.

Source NFPA 70E 2018
Qualified Person.

The latest revision of the OSHA definition for qualified person (1910.399 8/07) includes the phrase “has demonstrated skills.”

To meet this requirement, the person has to actually demonstrate that he/she can perform the task.

110.2 Training Requirements.

(C) Emergency Response Training

(1) Contact Release.

- Employees exposed to shock hazards and those responsible for the safe release of victims from contact with energized electrical conductors or circuit parts shall be trained in methods of sale release. **Refresher training shall occur annually.**
Caution!
If a victim is being shocked by greater than **600v** do not remove victim from live circuit without specialized training and equipment. Disconnect power before entering the area.

Release of Victims from Electrical Shock

Release of Victims

1. **Remove Source of Electricity** Check the scene for safety turn of power or use non conductive tool or item if source power is not known
2. **Check for consciousness**
3. **Request Emergency Assistance**
4. **Emergency First-Aid**
   - CPR (cardiopulmonary resuscitation)
   - AED (automatic external defibrillator)

Source NFPA 70E 2018
110.2 Training Requirements.

(C) Emergency Response Training
(2) First Aid, Emergency Response, and Resuscitation.

a) Employees responsible for responding to medical emergencies shall be trained in first aid and emergency procedures.
   (Periodically)

b) Employees responsible for responding to medical emergencies shall be trained in cardiopulmonary resuscitation (CPR).

Source NFPA 70E 2018

110.2 Training Requirements.

(C) Emergency Response Training
(2) First Aid, Emergency Response, and Resuscitation.

c) Employees responsible for responding to medical emergencies shall be trained in the use of an automated external defibrillator (AED) if an employer’s emergency response plan includes the use of this device.

d) Training shall occur at a frequency that satisfies the requirements of the certifying body.

New 2018

Source NFPA 70E 2018
110.2 Training Requirements.

(C) Emergency Response Training

(3) Training Verification.

Employers shall verify at least annually that employee training required by 110.2(C) is current.

(4) Documentation. The employer shall document that the training required by 110.2(C) has occurred.

(A)(1)(e) Qualified Person.

• Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to verify the absence of voltage....

• The training shall include information that enables the employee to understand all limitations of each test instrument that might be used.
(A)(1)(f) Qualified Person.
• The employer shall determine through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the safety-related work practices required by this standard.

(A)(3) Retraining
An employee shall receive additional training (or retraining) if any of the following conditions exists:
(1) The supervision or annual inspections indicate that the employee is not complying with the safety-related work practices.
(2) New technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices that are different from those that the employee would normally use.
(3) The employee needs to review tasks that are performed less often than once per year.
(4) The employee needs to review safety-related work practices not normally used by the employee during regular job duties.
(5) The employee’s job duties change.
110.2 Training Requirements.


• The employer shall document that each employee has received the training required by 110.2(A).

• This documentation shall be made when the employee demonstrates proficiency in the work practices involved and shall be maintained for the duration of the employee’s employment.

• The documentation shall contain the content of the training, each employee’s name, and dates of training.

110.2 Training Requirements.

(A)(2) Unqualified Person

• Unqualified persons shall be trained in, and be familiar with, any electrical safety related practices necessary for their safety.

Source NFPA 70E 2018
Proper Use of Test Instruments

110.4 Test Instruments and Equipment

110.4(B) Rating.

- Test Instruments, equipment, and their accessories shall be as follows:
  1. Rated for circuits and equipment where they are utilized.
  2. Approved for the purpose.
  3. Used in accordance with any instructions provided by the manufacturer.

New 2018

Source NFPA 70E 2018
110.4 Test Instruments and Equipment

110.4 (D) Visual Inspection and Repair.
Test instruments and equipment and all associated:
• test leads
• cables,
• power cords
• probes
• connectors
shall be visually inspected for external defects and damage before each use.

Source NFPA 70E 2018

110.4 Test Instruments and Equipment

110.4 (E) Operation Verification.
• When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.

Source NFPA 70E 2018
110.4 Test Instruments and Equipment

110.4(A) Testing.
- Only **qualified persons shall** perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment operating at voltages equal to or greater than 50 volts.

OSHA 1910.334(c) “Test instruments and equipment”

1910.334(c)(2) "Visual inspection." Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before the equipment is used.
ANSI
This standard establishes an important four-category system for rating the electrical hazards electricians face when taking measurements on so-called “low voltage” equipment — up to 1000 volts.

Test Instruments and Equipment
Most digital multimeters (DMMs) display these ratings near the voltage/current input terminals. What is your meter CAT rating? Have you checked yours?
What are we going to cover

Verification of an Electrically Safe Work Condition

Establishing an Electrically Safe Work Condition.

120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

• Establishing and verifying an electrically safe work condition shall include all of the following steps, which shall be performed in the order presented, if feasible:

1. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

Source NFPA 70E 2018
120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

2. After Properly Interrupting the load current, open the disconnecting device(s) for each source.

Source NFPA 70E 2018

3. Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that draw out-type circuit breakers are withdrawn to the fully disconnected position.

Source NFPA 70E 2018
Establishing an Electrically Safe Work Condition.

120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

4. Release stored electrical energy.
5. Release or block stored mechanical energy.

CAUTION
Risk of electrical shock from energy stored in capacitors. Wait 5 minutes after shutdown of equipment before servicing.

New 2018

Source NFPA 70E 2018

6. Apply lockout/tagout devices in accordance with a documented and established procedure.

Source NFPA 70E 2018
120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

7. Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground.

• Before and after each test, determine that the test instrument is operating satisfactorily, through verification on a known voltage source.

Exception No. 1: An adequately rated permanently mounted test device shall be permitted to be used to verify the absence of voltage of the conductors or circuit parts at the work location, provided it meets all of the following requirements:

1. It is permanently mounted and installed in accordance with the manufacture's instructions and tests the conductors and circuit parts at the point of work.
2. It is listed and labeled for the purpose of verifying the absence of voltage.
3. It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground.
4. The test device is verified as operating satisfactorily on any known voltage source before and after verifying the absence of voltage.

New 2018
120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

7. Continued:
   • **Exception No. 2**: On electrical systems over 1000 volts, noncontact test instruments shall be permitted to be used to test each phase conductor.

8. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:
Establishing an Electrically Safe Work Condition

120.5 Process for Establishing and Verifying an Electrically Safe Work Condition.

8. Continued:
   a) Placement. Temporary protective grounding equipment (TPGE) shall be placed at such locations and arranged in such a manner to prevent each employee from being exposed to a shock hazard. The location sizing and application of TPGE shall be identified as part of the employee’s job planning.
   b) Capacity. TPGE shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.
   c) Impedance. TPGE and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electrical conductors or circuit parts.

Achieving an ESWC

1. Determine all sources of electricity
2. Properly interrupt the load
3. Open all disconnecting means
4. Visually verify open disconnects (When Possible)
5. Release stored electrical energy
6. Release or block stored mechanical energy
7. LOTO
8. Verify Meter CAT #, Physical Condition, and Known Power source
9. Verify absence of voltage
10. Verify meter known power source
11. Ground if determined necessary
120.1 Lockout/ Tagout Program
(A) General.
• Each employer shall establish, document, and implement a lockout/tagout program. The LOTO program shall specify LOTO procedures to safeguard workers to exposure form electrical hazards. The LOTO program and procedures shall also incorporate the following:
  1. Be applicable to the experience and training of the workers and conditions in the workplace.
  2. Meet the requirements of Article 120.
  3. Apply to fixed, permanently installed equipment, temporary installed equipment, and portable equipment.

(B) Employer responsibility.
• The employer shall be responsible for the following:
  1. Providing the equipment necessary to execute lockout/tagout procedures
  2. Providing LOTO training to workers in accordance with 110.2
  3. Auditing the LOTO program in accordance with 110.1
  4. Auditing execution of the LOTO procedures in accordance with 110.1
120.2 Lockout/Tagout Principles

(A) General.

• Electrical conductors and circuit parts shall not be considered to be in an electrically safe work condition until all of the requirements for Article 120 have been met.

• Safe work practices applicable to the circuit voltage and energy level shall be used in accordance with Article 130 until such time that electrical conductors and circuit parts are in an electrically safe work condition.

(B) Employee Involvement.

• Each person who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout/tagout process.
120.2 Lockout/Tagout Principles

(C) Lockout/Tagout Procedure.

- A lockout/tagout procedure shall be developed on the basis of the existing electrical equipment and system and shall use suitable documentation including up-to-date drawings and diagrams.

Source NFPA 70E 2018

Aluminum Manufacturer Faces $1.9M in OSHA Penalties Posted on July 24, 2017 by Trey Barrineau

An aluminum manufacturing company that produces products used in the glass and glazing industry is facing nearly $2 million in fines from the U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA).

Last week, Aluminum Shapes LLC of Delair, N.J., was hit with 51 safety and health violations and proposed penalties of $1,922,895 in the wake of an OSHA inspection that began in January 2017. It’s the latest in a long streak of OSHA citations for the company. Since 2011, the agency has inspected the facility eight times, issuing $516,753 in penalties for 60 violations. The most recent string of violation occurred between January and April of 2017, according to OSHA documents…….

§ Provide appropriate personal protective equipment; § Conduct air monitoring prior to permit-required confined space entry; § Have an attendant during permit-required confined space entry; § Complete a required confined space entry permit to identify, evaluate and control hazards in the space; § Provide confined space training; § Utilize proper lockout/tagout procedures; § Provide workers with locks and hardware to lock out equipment being serviced, maintained or repaired; § Lack of specific procedures for the use of blocking devices; § Utilize group lockout procedures, and; § Train workers in lockout/tagout.
If it has more than one source of energy (including non-lockable energy such as gravity, spring, thermal, kinetic, etc.) Then it needs a procedure.

110.2 Training Requirements

110.2 (B) Lockout/Tagout Procedure Training.

1. Initial Training.
   • Employees involved in or affected by the lockout/tagout procedures required by 120.2 shall be trained in the following:
     a) The lockout/tagout procedures
     b) Their responsibility in the execution and procedures

2. Retraining.
   • Retraining in the lockout/tagout procedures shall be performed as follows:
     a) When the procedures are revised
     b) At intervals not to exceed 3 years
     c) When supervision or annual inspections indicate that the employee is not complying with the lockout/tagout procedures

Don’t forget new or reassigned employees

Source NFPA 70E 2018
110.2 Training Requirements

110.2 (B) Lockout/Tagout Procedure Training.
3. Lockout/Tagout Training Documentation
   a) The employer shall document that each employee has received the training required by 110.2(B).
   b) The documentation shall be made when the employee demonstrates proficiency in the work practices involved.
   c) The documentation shall contain the content of the training, each employee’s name, and the dates of the training.

110.1 Electrical Safety Program

(K) Auditing.
3. Lockout/Tagout Program and Procedure Audit.
   • The lockout/tagout program and procedures required by Article 120 shall be audited by a qualified person at intervals not to exceed 1 year. The audit shall cover at least one lockout/tagout in progress. The audit shall be designed to identify and correct deficiencies in the following:
     1. The lockout/tagout program and procedures
     2. The lockout/tagout training
     3. Worker execution of the lockout/tagout procedure

4. Documentation.
   • The audits required by 110.1 (K) shall be documented.
120.4 Lockout/Tagout Procedures

120.4(A)(4) Simple Lockout/Tagout Procedure.
- All lockout/tagout procedures that involve only a qualified person(s) de-energizing one set of conductors or circuit part ... shall be considered a simple lockout/tagout.
- Simple lockout/tagout plans shall not be required to be written for each application.
- Each worker shall be responsible for his or her own lockout/tagout.

Source NFPA 70E 2018

120.4 Lockout/Tagout Procedures

120.4(A)(5) Complex Lockout/Tagout Procedure.
- A complex lockout/tagout plan shall be permitted where one or more of the following exist:
  1. Multiple energy sources
  2. Multiple crews
  3. Multiple crafts
  4. Multiple locations
  5. Multiple employees
  6. Multiple disconnecting means
  7. Particular sequences
  8. Job or task that continues for more than one work period

Source NFPA 70E 2018
120.4(5) Complex Lockout/Tagout Procedure.

b) All complex lockout/tagout procedures shall require a written plan of execution that identifies the person in charge.

d) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device ... when he or she begins and shall remove those devices when he or she stops working...
130.1 General.
1. When an electrically safe work condition must be established
2. Requirements for work involving electrical hazards such as the electrical safety-related work practices, assessments, precautions, and procedures when an electrically safe work condition cannot be established.

Source NFPA 70E 2018
130 Work Involving Electrical Hazards

130.2 Electrically Safe Work Conditions

• Energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:
  (1) The employee is within the limited approach boundary
  (2) The employee interacts with equipment where conductors or circuit parts are not exposed, but an increased likelihood of injury from an exposure to an arc flash hazard exists.

New 2018

Source NFPA 70E 2018

130 Work Involving Electrical Hazards

130.2(A)(1) Additional Hazards or Increased Risk.

• Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk
130 Work Involving Electrical Hazards

130.2(A)(2) Infeasibility.
• Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

130.2(A)(4) Normal Operating Condition
• Normal operation of electric equipment shall be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:

(1) The equipment is properly installed.
(2) The equipment is properly maintained.
130 Work Involving Electrical Hazards

130.2(A)(4) Normal Operating Condition

3. The equipment is used in accordance with the instructions included in the listing and labeling and in accordance with manufacturer’s instructions.

4. The equipment doors are closed and secured.

5. All equipment covers are in place and secured.

6. There is no evidence of impending failure.

Source NFPA 70E 2018

130 Work Involving Electrical Hazards

130.2(B)(1) When Required

• When energized work is performed as permitted in accordance with 130.2(A), an energized electrical work permit shall be required and documented under any of the following conditions:

(1) When work is performed within the restricted approach boundary

(2) When the employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists

Source NFPA 70E 2018
130 Work Involving Electrical Hazards

130.2(B)(3) Exemptions to Work Permit.

- Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Chapter 1 under any of the following conditions:
130 Work Involving Electrical Hazards

130.2(B)(3) Exemptions to Work Permit.
(1) Testing, troubleshooting, or voltage measuring
(2) Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed
(3) Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed
(4) General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

Source NFPA 70E 2018

What are we going to cover

• Shock Hazards
Electrical Shock Viewer Beware

SHOCK HAZARDS

(A) Touch Potential  (B) Step Potential  (C and D) Touch / Step Potential
# Shock Hazards

<table>
<thead>
<tr>
<th>Condition</th>
<th>Resistance (ohms)</th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>Dry</td>
<td>Wet</td>
<td></td>
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<tr>
<td>Finger Touch</td>
<td>40,000 – 1,000,000</td>
<td>4,000 - 15,000</td>
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<tr>
<td>Hand Holding Wire</td>
<td>15,000 - 50,000</td>
<td>3,000 - 6,000</td>
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<tr>
<td>Finger-Thumb Grasp</td>
<td>10,000 - 30,000</td>
<td>2,000 - 5,000</td>
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<tr>
<td>Palm Touch</td>
<td>3,000 - 8,000</td>
<td>1,000 - 2,000</td>
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<tr>
<td>Human Body</td>
<td>200 - 1,000</td>
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## Table 130.4(D)(a).

<table>
<thead>
<tr>
<th>Nominal System Voltage Range, Phase to Phase$^a$</th>
<th>(1) Limited Approach Boundary$^a$</th>
<th>(2) Exposed Movable Conductor$^a$</th>
<th>(3) Exposed Fixed Circuit Part</th>
<th>(4) Restricted Approach Boundary$^a$; Includes Inadvertent Movement Addler</th>
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</thead>
<tbody>
<tr>
<td>&lt;50 V</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Avoid contact</td>
</tr>
<tr>
<td>50 V–150 V$^a$</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></td>
</tr>
<tr>
<td>151 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></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></td>
</tr>
</tbody>
</table>
What are we going to cover

• Arc Flash
• Arc Blast

Equipment where Arc Events normally occur

Motor Control Centers (MCC’s)
Meters and Meter Sockets
Panel Boards
Switchgear (low and high voltage)
Transformers
Overhead Busses
Industrial Control Panels
• Over 2000 people are admitted into burn centers each year with severe electrical burns.

Majority of hospital admissions due to electrical accidents are from arc flash burns, not from shock.

Electrical Arc Flash/Blast

- Molten Metal
- Pressure Waves
- Sound Waves
- Shrapnel
- Rapid Expansion of Hot Air
- Intense Light

Copper Vapor: Solid to Vapor Expands by 67,000 times

35,000 °F
What are we going to cover

- Arc Flash Hazard Analysis
- Tables VS. Analysis
- Alerting Techniques
- Equipment labeling
- Boundaries

130.5 Arc Flash Risk Assessment

130.5(A) General

- An arc flash risk assessment shall be performed:
  1. To identify arc flash hazards
  2. To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health
  3. To determine if additional protective measures are required, including the use of PPE.

Source NFPA 70E 2018
130.5 Arc Flash Risk Assessment

130.5(B) Estimate of Likelihood and Severity.
- The estimate of the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health shall take into consideration the following:
  1. The design of the electrical equipment, including its overcurrent protective device and its operating time.
  2. The electrical equipment operating condition and condition of maintenance

New 2018

Source NFPA 70E 2018

130.5(C) Additional Protective Measures
- If additional protective measures are required they shall be selected and implemented according to the hierarchy of risk control identified in 110.1(H). When the additional protective measures include the use of PPE, the following shall be determined:
  1. Appropriate safety-related work practices
  2. The arc flash boundary
  3. The PPE to be used within the arc flash boundary

(D) Documentation. The results of the arc flash risk assessment shall be documented.

New 2018

Source NFPA 70E 2018
130.5 Arc Flash Risk Assessment

130.5(G) Incident Energy Analysis Method
• The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis.
• The incident energy analysis shall also be reviewed for accuracy at intervals not to exceed 5 years.

Source NFPA 70E 2018

130.5(H) Equipment Labeling
• Electrical equipment such as switch-boards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:
  1. Nominal system voltage
  2. Arc flash boundary
  3. At least one of the following:

Source NFPA 70E 2018
130.5 Arc Flash Risk Assessment

130.5(H)(3) Continued
- At least one of the following:
  a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or 130.7(C)(15)(b) for the equipment, but not both
  b. Minimum arc rating of clothing
  c. Site-specific level of PPE

---

Tables VS. Analysis

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

<table>
<thead>
<tr>
<th>Task</th>
<th>Equipment Condition</th>
<th>Likelihood of Occurrence*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading a panel meter while operating a meter switch.</td>
<td>Any</td>
<td>No</td>
</tr>
<tr>
<td>Performing infrared thermography and other non-contact inspections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>outside the restricted approach boundary. This activity does not</td>
<td></td>
<td></td>
</tr>
<tr>
<td>include opening of doors or covers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For ac systems, work on energized electrical conductors and circuit</td>
<td>Any</td>
<td>Yes</td>
</tr>
<tr>
<td>parts, including voltage testing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For dc systems, working on energized electrical conductors and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circuit parts of series-connected battery cells, including voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>testing. Removal or installation of CBs or switches.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source NFPA 70E 2018
Tables VS. Analysis

Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Arc-Flash PPE Category</th>
<th>Arc-Flash Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panelboards or other equipment rated 240 volts and below</td>
<td>1</td>
<td>485 mm (19 in.)</td>
</tr>
<tr>
<td>Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panelboards or other equipment rated greater than 240 volts and up to 600 volts</td>
<td>2</td>
<td>900 mm (3 ft)</td>
</tr>
<tr>
<td>Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-volt class motor control centers (MCCs)</td>
<td>2</td>
<td>1.5 m (5 ft)</td>
</tr>
<tr>
<td>Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-volt class motor control centers (MCCs)</td>
<td>4</td>
<td>4.3 m (14 ft)</td>
</tr>
<tr>
<td>Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-volt class switchgear (with power circuit breakers or fused switches) and 900-volt class switchboards</td>
<td>4</td>
<td>6 m (20 ft)</td>
</tr>
<tr>
<td>Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other 600-volt class (277 volts through 500 volts, nominal) equipment</td>
<td>2</td>
<td>1.5 m (5 ft)</td>
</tr>
<tr>
<td>Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Limited Approach Boundary - An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.
Restricted Approach Boundary - An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Source NFPA 70E 2018

Flash Protection Boundary (FPB)

FPB dependent on fault level and time duration of fuse or circuit breaker device. This is a calculated value which is printed on the HRC label and will vary at each equipment location.

RAB

Q + SH + AF PPE

V rated tools and handling equipment
V rated gloves required here when equipment is energized

12 Inches at 480V
26 Inches at 4,160V

LAB

Q + AF PPE

U + AF PPE

42 Inches at 480V
60 inches at 4,160V

1st degree burn potential

2nd to 3rd degree burn potential

Other voltages will decrease or increase these boundaries.
Minimum PPE $\leq 1.2 \text{ cal/cm}^2$

**WARNING**

Qualified Persons Only

**Arc Flash and Shock Hazards**
**Appropriate PPE Required**

<table>
<thead>
<tr>
<th>Arc Flash Protection Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 in</td>
</tr>
<tr>
<td>0.39 cal/cm$^2$</td>
</tr>
</tbody>
</table>

**AF Incident Energy @ Working Distance**

- 18 in

Recommended (minimum) PPE:
- Protective clothing, Nonmetallic (ASTM F1506) or Untreated Fiber (e.g., untreated cotton), Long sleeve shirt and long pants or coverall, Safety glasses/goggles, Hearing protection, Heavy-duty leather gloves or Rubber insulating gloves w/Leather protectors, Face shield (as needed)

**Location:** DISC 1

---

> 1.2 to 12 cal/cm$^2$

**WARNING**

Qualified Persons Only

**Arc Flash and Shock Hazards**
**Appropriate PPE Required**

<table>
<thead>
<tr>
<th>Arc Flash Protection Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>41 in</td>
</tr>
<tr>
<td>4.70 cal/cm$^2$</td>
</tr>
</tbody>
</table>

**AF Incident Energy @ Working Distance**

- 18 in

Recommended (minimum) PPE:
- Arc-rated (SR) clothing => estimated Incident Energy: Long sleeve shirt and pants/coverall, Flash suit (SR); SR face shield & talc latex or arc flash suit hood (SR); Arc outerwear as needed (e.g., jacket, parka, rainwear, hard hat liner), Heavy duty leather gloves, AR gloves, or rubber insulating gloves w/Leather protectors (SR); Hard hat, Safety glasses/goggles (SR); Hearing protection, Leather footwear.

**Location:** PNL A
> 12 to <40 cal/cm²

**WARNING**

Qualified Persons Only

Arc Flash and Shock Hazards
Appropriate PPE Required

**REVIEW SAFE WORK PRACTICES PRIOR TO WORK**

122 in
Arc Flash Protection Boundary

27.8 cal/cm²
AF Incident Energy @ Working Distance: 18 in

Recommended (minimum) PPE:
- Arc-rated/AR clothing
- Estimated Incident Energy: Long-sleeve shirt and pants/coveralls; arc flash suit (SR); AR arc flash suit hood; AR outerwear as needed (e.g., jacket, pants, rainwear, hard hat liner); AR gloves or rubber-insulating gloves w/ AR protectors (SR); Hard hat; Safety glasses/goggles (SR); Hearing protection; Leather footwear

<table>
<thead>
<tr>
<th>480 VAC</th>
<th>Shock Hazard</th>
<th>Glove Class</th>
<th>Limited Approach</th>
<th>Restricted Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>12 in</td>
<td>42 in</td>
<td>12 in</td>
<td></td>
</tr>
</tbody>
</table>

Location: DP1

---

≥40 to <999 cal/cm²

**DANGER**

Qualified Persons Only

Arc Flash and Shock Hazards
Appropriate PPE Required

**REVIEW SAFE WORK PRACTICES PRIOR TO WORK**

392 in
Arc Flash Protection Boundary

187.9 cal/cm²
AF Incident Energy @ Working Distance: 18 in

**Recommended (minimum) PPE**

Due to the explosive effect of some arc events, physical trauma injuries could occur. Greater emphasis on creating electrically safe work conditions is advised. Arc-rated (AR) clothing + estimated Incident energy: Arc Flash suit (SR); AR arc flash suit hood; AR gloves or rubber-insulating gloves w/ AR protectors (SR); Hard hat; Safety glasses/goggles (SR); Hearing protection; Leather footwear.

<table>
<thead>
<tr>
<th>480 VAC</th>
<th>Shock Hazard</th>
<th>Glove Class</th>
<th>Limited Approach</th>
<th>Restricted Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>12 in</td>
<td>42 in</td>
<td>12 in</td>
<td></td>
</tr>
</tbody>
</table>

Location: SWG 1 MAIN
Arc-rated PPE shall be worn at all times when the qualified employee is within the arc flash boundary.
Personal Protective Equipment

Improperly rated clothing can result in serious burn injuries!
Insulated Tools and Equipment

Article 130.7(D)(1) Insulated Tools and Equipment.

- Employees shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts where tools or handling equipment might make unintentional contact.

Questions?
More Information?

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