Safety Bulletin

Provided as a service of MCAA's Safety Excellence Initiative

Subject

Revisions to NFPA 70E (Standard for Electrical Safety in the Workplace)

Introduction

The National Fire Protection Association (NFPA) recently revised its *Standard for Electrical Safety in the Workplace*. The most current version is NFPA 70E – 2021.

Caution

This bulletin addresses work on HVAC equipment pushing 480 volts or less **only**. If your workers are exposed to equipment pushing higher voltages, please be sure to read the applicable parts of NFPA
70E – 2021.

Key Date

January 1, 2021 – NFPA 70E – 2021 became effective, replacing NFPA 70E – 2018.

Summary of Several Key Changes that Affect Mechanical Service Work

- Additional training and retraining must be performed at intervals not to exceed 3 years.
- Classroom training can now include interactive electronic or interactive web-based training components.
- More than one employer can be responsible for identifying hazardous conditions and creating safe work practices on multi-employer worksites.
- Lockout/tagout procedures must now meet the requirements of applicable codes, standards, and regulations.
- When work on equipment pushing 50 volts or more is not put into an electrically safe work condition, four new specified safety requirements apply.
- When using the incident energy analysis method for selecting PPE, footwear other than leather or dielectric must be tested before use to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure.
- When using the incident energy analysis method for selecting PPE, the arc rating of outer layers worn over arc-rated clothing, that are not part of a layered system, are not required to be equal to or greater than the estimated incident energy exposure.
- Four risk reduction methods are provided for testing for the absence of voltage when the estimated incident energy exposure is greater than the arc rating of commercially available arc rated PPE.
- Tools and handling equipment used within the restricted approach boundary must be insulated.

For additional information about this topic or to learn more about MCAA's Safety Excellence Initiative, contact Pete Chaney at 301 869 5800 or pchaney@mcaa.org.

- An elaborate new section on capacitor safety has been added to the standard addressing capacitors that exceed hazard thresholds that are less than 100 volts and greater than 100 joules of stored energy, greater than or equal to 100 volts and greater than 1.0 joule of stored energy, or greater than or equal to 400 volts and greater than 0.25 joules of stored energy.

General Information about NFPA 70E

- The acronym NFPA stands for the National Fire Protection Association. The organization develops codes and standards, including the *National Electrical Codes*.
- NFPA 70 refers to the National Electrical Codes.
- NFPA 70E, which is part of the *National Electrical Codes*, is the national standard for electrical safety in the workplace.
- NFPA 70E is revised every three (3) years.
- NFPA 70E is a voluntary standard, which was originally developed to address electrical workplace hazards involving industrial and power-generated switch gear operations. However, mechanical service companies have been held liable for failing to use the safe work practices presented in NFPA 70E to protect their workers from arc flash and electrical shock hazards.
- Plaintiff attorneys use the most current version of NFPA 70E to make the case that the hazards described in the standard are "recognized" industry hazards, and that a defendant should have known about the safe work practices described in the national consensus standard.
- OSHA does not have the authority to issue citations to employers for failure to comply with specific provisions of NFPA 70E. However, the agency does have the authority to issue General Duty Clause citations.
- The General Duty Clause is section 5(a)(1) of the Occupational Safety and Health Act of 1970. It states that each employer shall provide to each of his employees, employment, and a place of employment that is free from "recognized" hazards. The agency references NFPA 70E to make its case that the electrical hazards for which it is issuing the General Duty Clause citations are in fact "recognized" by a national industry consensus standard.
- OSHA's electrical safety standards do not address arc flash specifically. However, the agency has generic standards that it cites when it believes an employer has not provided its workers with adequate arc flash protection. The most common citations issued by OSHA for what it views as arc flash/and or electrical shock hazards follow.

Most Common OSHA Citations Affecting Mechanical Service Employers

When OSHA believes an employer has not provided its employees with adequate personal protective equipment and/or proper insulation for protection from arc flash and electrical shock, it typically issues the following citations.

- 29 CFR 1910.132(d)(1) – Personal Protective Equipment – Hazard Assessment and Equipment Selection – The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE). If such hazards are present, or likely to be present, the employer shall:

  (i) Select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;

(ii) Communicate selection decisions to each affected employee; and

(iii) Select PPE that properly fits each affected employee.

- 29 CFR 1910.355(a)(1) – Safeguards for Personal Protection (Electrical) – Use of Protective Equipment – Personal Protective Equipment

  (i) Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed.

  (ii) Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested as required by 1910.137.

  (iii) If the insulating capability of protective equipment may be subjected to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.)

  (iv) Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.

  (v) Employees shall wear protective equipment for the eyes or face wherever there is a danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

- 29 CFR 1910.355(a)(2) – Insulated Tools

  (i) When working near exposed energized conductors or circuit parts, each employee shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulation capacity of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.

When OSHA believes an employer has not provided its employees with adequate qualified level arc flash safety training it issues the following citations.

- 29 CFR 1910.332(b)(3) – Training – Additional Requirements for Qualified Persons – Qualified Persons (i.e., those permitted to work on or near exposed energized parts) shall, at a minimum, be trained in and familiar with the following:

  (i) The skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment;

  (ii) The skills and techniques necessary to determine the nominal voltage of exposed live parts; and

  (iii) The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.

- 29 CFR 1910.132(f)(1-4) – Personal Protective Equipment – Training

  (1) The employer shall provide training to each employee who is required by this section to use PPE. Each affected employee shall be trained to learn:

  (i) When PPE is necessary;

  (ii) What PPE is necessary;

  (iii) How to properly don, doff, adjust, and wear PPE;

  (iv) The limitations of the PPE; and

(v) The proper care, maintenance, useful life, and disposal of PPE.

(2) Each affected employee shall demonstrate an understanding of the training specified in paragraph (f)(1) of this section, and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE.

(3) When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required by paragraph (f)(2) of this section, the employer shall retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where:

(i) Changes in the workplace render previous training obsolete; or

(ii) Changes in the types of PPE to be used render previous training obsolete; or

(iii) Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill.

(4) The employer shall verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and that identifies the subject of the certification.

Key Changes

The following chart depicts key changes to NFPA 70E between 2018 and 2021 that affect mechanical service work on equipment pushing 480 volts or less.

NFPA 70E – 2018	NFPA 70E – 2021
1. The term "Balaclava" has been revised	
100. Definitions **Balaclava (Sock Hood).** An arc-rated hood that protects the neck and head except for the facial area of the eyes and nose.	**100. Definitions** **Balaclava.** An arc-rated head-protective fabric that protects the neck and head except for a small portion of the facial area.
2. The term "Conductor, Covered" has been revised	
100. Definitions **Conductor, Covered.** A conductor encased within material of composition or thickness that is not recognized by this *Code* as electrical insulation.	**100. Definitions** **Conductor, Covered.** A conductor encased within material of composition or thickness that is not recognized by *NFPA 70 National Electrical Code* as electrical insulation.
3. The term "Conductor, Insulated" has been revised	
100. Definitions **Conductor, Insulated.** A conductor encased within material of composition or thickness that is recognized by this *Code* as electrical insulation.	**100. Definitions** **Conductor, Insulated.** A conductor encased within material of composition or thickness that is recognized by *NFPA 70 National Electrical Code* as electrical insulation.

4. The term “Equipment, Arc-Resistant” has been added to the standard	
100. Definitions This definition does not exist.	**100. Definitions** **Equipment, Arc-Resistant.** Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.
5. The term “Receptacle” has been revised	
100. Definitions **Receptable.** A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.	**100. Definitions** **Receptable.** A contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.
6. The term “Shock Hazard” has been revised	
100. Definitions **Shock Hazard.** A source of possible injury or damage to health associated with current through the body caused by contact or approach to energized electrical conductors or circuit parts.	**100. Definitions** **Shock Hazard.** A source of possible injury or damage to health associated with current through the body caused by contact or approach to exposed energized electrical conductors or circuit parts.
7. The term “Working On” has been revised	
100. Definitions **Working On (energized electrical conductors or circuit parts).** Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of “working on”: Diagnostic (testing) is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; repair is any physical alteration of electrical equipment (such as	**100. Definitions** **Working On (energized electrical conductors or circuit parts).** Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of “working on”: *Diagnostic* (*testing*) is taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts. *Repair* is any physical alteration of

making or tightening connections, removing or replacing components, etc.).	electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing or replacing components, etc.).
8. This training section moved and changed to include "Additional Training"	
110.2 Training Requirements **(A) (3) Retraining.** Retraining in safety-related work practices and applicable changes in this standard shall be performed at intervals not to exceed 3 years. An employee shall receive additional training (or retraining) if any of the following conditions exist.	**110.6 Training Requirements** **(A) (3) Additional Training and Retraining.** Additional training and retraining in safety-related work practices and applicable changes in this standard shall be performed at intervals not to exceed 3 years. An employee shall receive additional training (or retraining) if any of the following conditions exist.
9. The "General" section in "Lockout/Tagout Principals" has been deleted	
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 of 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.	**120.2 Lockout/Tagout Principles** **(A) General.** This language has been deleted.
10. Lockout/tagout procedures must meet applicable codes, standards, and regulations	
120.2 Lockout/Tagout Principles **(C) Lockout/Tagout Procedures.** 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.	**120.2 Lockout/Tagout Principles** **(B) Lockout/Tagout Procedures.** 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. The procedure shall meet the requirements of appliable codes, standards, and regulations for lockout and tagging of electrical sources.

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11. Conditions established for a lock, by itself, to be considered a lockout device

120.2 Lockout/Tagout Principles

(C) Lockout Device. The lockout device shall meet the following requirements:

(1) A lockout device shall include a lock – either keyed or combination.

(2) The lockout device shall include a method of identifying the individual who installed the lockout device.

(3) A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock.

(4) Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

(5) Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnection means or unauthorized removal of the device.

(6) Lockout devices shall be suitable for the environment and for the duration of the lockout.

(7) Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

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(1) A lockout device shall include a lock – either keyed or combination.

(2) The lockout device shall include a method of identifying the individual who installed the lockout device.

(3) A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock, provided that all of the following conditions exits:

(a) Only one circuit or piece of equipment is deenergized.

(b) The lockout period does not extend beyond the work shift.

(c) Employees exposed to the hazards associated with reenergizing the circuit or equipment are familiar with this procedure.

(4) Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

(5) Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnection means or unauthorized removal of the device.

(6) Lockout devices shall be suitable for the environment and for the duration of the lockout.

(7) Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

12. Two steps to establishing & verifying an electrically safe work condition revised

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. (2) After properly interrupting the load current, open the disconnecting device(s) for each source. (3) Whenever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position. (4) Release stored electrical energy. (5) Release or block stored mechanical energy. (6) Apply lockout/tagout devices in accordance with a documented and established procedure. (7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is deenergized. 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 any known voltage source.	**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. (2) After properly interrupting the load current, open the disconnecting device(s) for each source. (3) Whenever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position. (4) Release stored electrical energy. (5) Block or relieve stored nonelectrical energy in devices to the extent the circuit parts cannot be unintentionally energized by such devices. (6) Apply lockout/tagout devices in accordance with a documented and established procedure. (7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to test for the absence of voltage. 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 any known voltage source.

13. The "General" section of "Work Involving Electrical Hazards" is substantially revised

130.1 General. Article 130 covers the following: (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. All requirements of this article shall apply whether an incident energy analysis is completed or if Table 130.7 (C) (15) (a), Table 130.7 (C) (15) (b), and Table 130.7 (C) (15) (c) are used in lieu of an incident energy analysis.	**130.1 General.** Article 130 covers 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. Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts are not put into an electrically safe work condition, and work is performed as permitted in accordance with 110.4, all of the following requirements shall apply: (1) Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition. (2) An energized electrical work permit shall be completed as required by 130.2. (3) A shock risk assessment shall be performed as required by 130.4. (4) An arc flash risk assessment shall be performed as required by 130.5

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14. “Alerting Methods” from 130.7 E Are Now referenced in “Working at or Close to the Limited Approach Boundary”	
130.4 (E) Limited Approach Boundary	**130.4 (F) Limited Approach Boundary**
(2) Working at or Close to the Limited Approach Boundary. When one or more unqualified persons are working at or close to the limited approach boundary, the designated person in charge of the work space where the electrical hazard exists shall advise the unqualified person(s) of the electrical hazard and warn him or her to stay outside of the limited approach boundary.	**(2) Working at or Close to the Limited Approach Boundary.** When one or more unqualified persons are working at or close to the limited approach boundary, the alerting methods in 130.7 (E) shall be applied to advise the unqualified person(s) of the electrical hazard and warn him or her to stay outside of the limited approach boundary.
15. Language has been added to Table 130.5 (G) regarding footwear and arc rated clothing	
Table 130.5 (G) Selections of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method is Used.	**Table 130.5 (G) Selections of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method is Used.**
The language does not exist.	Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure. The arc rating of outer layers worn over arc-rated clothing as protection from the elements or for other safety purposes, and that are not used as part of a layered system, shall not be required to be equal to or greater than the estimated incident energy exposure.
16. Language added regarding maximum voltage, length, and periodic testing of rubber insulating gloves	
130.7 (C) (7) Hand and Arm Protection	**130.7 (C) (7) Hand and Arm Protection**
(c) Maintenance and Use. Electrical protective equipment shall be maintained in a safe, reliable condition. Insulating equipment shall be inspected for damage before each day’s use and immediately following any incident that can reasonably be suspected of having caused damage. Insulating gloves shall be given an air test, along with the inspection. Electrical protective equipment shall be subjected to periodic electrical tests. Test voltages shall be in accordance with	**(c) Maintenance and Use.** Electrical protective equipment shall be maintained in a safe, reliable condition. Insulating equipment shall be inspected for damage before each day’s use and immediately following any incident that can reasonably be suspected of having caused damage. Insulating gloves shall be given an air test, along with the inspection. Maximum use voltages for insulating gloves shall not exceed that specified in Table 130.7 (C) (7) (a). The top

applicable state, federal, or local codes and standards. The maximum intervals between tests shall not exceed that specific in Table 130.7 (C) (7). Section (d) does not exist.	cuff of the protector glove shall be shorter than the rolled top of the cuff of the insulating glove by at least the distance specified in Table 130.7 (C) (7) (a) **(d) Periodic Electrical Tests.** Rubber insulating equipment shall be subjected to periodic electrical tests. Test voltages shall be in accordance with applicable state, federal, or local codes and standards. The maximum intervals between tests shall not exceed that specified in Table 130.7 (C) (7) (b).
17. Language added regarding arc-rating of outer layers of clothing	
130.7 (C) (9) Factors in Selection of Protective Clothing **(b) Outer Layers.** Garments worn as outer layers over arc-rated clothing, such as jackets or rainwear, shall also be made from arc-rated material.	**130.7 (C) (9) Factors in Selection of Protective Clothing** **(b) Outer Layers.** Garments worn as outer layers over arc-rated clothing, such as jackets, high visibility apparel, or rainwear, shall also be made from arc-rated material. The arc rating of outer layers worn over arc-rated clothing as protection from the elements or for other safety purposes, and that are not used as part of a layered system, shall not be required to be equal to or greater than the estimated incident energy exposure.
18. Footwear other than leather or dielectric footwear may be used under specified conditions	
130.7 (C) (10) Arc Flash Protective Equipment **(e) Foot Protection.** Heavy-duty leather footwear or dielectric footwear or both provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm^2 (16.75 J/cm^2).	**130.7 (C) (10) Arc Flash Protective Equipment** **(e) Foot Protection.** Leather footwear or dielectric footwear or both provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm^2 (16.75 J/cm^2). Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure or the minimum arc rating for the respective arc flash PPE category.

19. All tools and handling equipment used within the restricted approach boundary must be insulated	
130.7 (C) (15) (c) Protective Clothing and Personal Protective Equipment **(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. Insulated tools shall be protected from damage to the insulating material.	**130.7 (C) (15) (c) Protective Clothing and Personal Protective Equipment** **(D)(1) Insulated Tools and Equipment.** Tools and equipment used within the restricted approach boundary shall be insulated. Insulated tools shall be protected from damage to the insulating material.
20. Employees must avoid grounding locations where grounded vehicles and equipment can be elevated within a limited approach boundary	
130.9 (F) Vehicular and Mechanical Equipment **(3) Equipment Grounding.** If any vehicle or mechanical equipment is capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades, dielectric overshoe footwear, or insulation shall be taken to protect employees from hazardous ground potentials (step and touch potential).	**130.9 (F) Vehicular and Mechanical Equipment** **(3) Equipment Grounding.** If any vehicle or mechanical equipment is capable of having parts of its structure elevated within the limited approach boundary of exposed movable conductors of energized overhead lines and is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades, dielectric overshoe footwear, or insulation shall be taken to protect employees from hazardous ground potentials (step and touch potential).
21. Absence of voltage or identification of conductors must be verified when conductors that will be cut, removed, or rerouted are not within sight from the point of work	
Section 130.12 does not exist.	**130.12 Cutting, Removing, or Rerouting of Conductors** Where conductors are deenergized in order to cut, remove, or reroute them and the conductor terminations are not within sight from the point of work, such as where the conductors are remote from the source of the supply in a junction or pull box, additional steps to verify absence of voltage or identify

	the conductors shall be taken prior to cutting, removing, or rerouting the conductors.
22. New Article 360… "Safety-Related Requirements for Capacitors" added to the standard	
Article 360 does not exist.	**Article 360** **Safety-Related Requirements for Capacitors** **360.1 Scope.** This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with capacitors that present an electrical hazard. **360.2 Definitions.** **Arc Blast Hazard.** A source of possible injury or damage to health from the energy deposited into acoustical shock-wave and high-velocity shrapnel. **Bleed Resistor.** A resistor network connected in parallel with a capacitor's terminals that drains the charge after power has been disconnected. **Charge Transfer.** Improper discharging of capacitor networks that result in transferring from one capacitor to another charge instead of fully discharging the stored energy. **Dielectric Absorption.** The property of certain capacitors to recharge after being discharged. **Discharge Time.** The time required to discharge a capacitor to below a stored energy hazard threshold. **Ground Stick.** A device that is used to ensure that the capacitor is discharged by applying it to all terminals of the capacitor element. **Hazard Grounding (Low-Z).** The practice of discharging a capacitor through a low impedance, also called Low-Z (impedance) grounding.

	Hearing Protection Boundary. Worker distance at which a 1 percent probability of ear damage exists from a 20 kPa (3.0 psi) shock wave. **Lung Protection Boundary.** Worker distance at which a 1 percent probability of lung damage exists from a 70 kPa (10 psi) shock wave. **Soft Grounding (High-Z).** The practice of connecting a capacitor to ground through a power resistor to avoid the hazards related with hard grounding. **Time Constant.** The time it takes for voltage to drop by ~63 percent (1/e) during discharge. **360.3 Stored Energy Hazard Thresholds.** Appropriate controls shall be applied where any of the following hazard thresholds are exceeded: (1) Less than 100 volts and greater than 100 joules of stored energy (2) Greater than or equal to 100 volts and greater than 1.0 joule of stored energy (3) Greater than or equal to 400 volts and greater than 0.25 joules of stored energy **360.4 Specific Measures for Personnel Safety.** (A) **Qualification and Training.** The following qualifications and training shall be required for personnel safety. (1) Employees who perform work on electrical equipment with capacitors that exceed the energy thresholds in 360.3 shall be qualified and shall be trained in, and familiar with, the specific hazards and controls required for safe work. (2) Unqualified persons who perform work on electrical equipment with capacitors shall be trained in, and

	familiar with, any electrical safety-related work practices necessary for their safety. (B) Performing a risk assessment for capacitors. The risk assessment process for capacitors shall follow the overall risk assessment procedures in Chapter 1. If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.5 (H) (3). When additional protective measures include the use of PPE, the following shall be determined: (1) Capacitor voltage and stored energy for the worker exposure. An exposure shall be considered to exist when a conductor or circuit part that could potentially remain energized with hazardous stored energy is exposed. (2) Thermal Hazard. The appropriate thermal PPE shall be selected and used if the stored energy of the exposed part is greater 100 joules. (3) Shock Hazard. The appropriate shock PPE in accordance with 130.7 shall be selected and used if the voltage is greater than or equal to 100 volts. (4) Arc flash and arc blast hazard at the appropriate working distance. The appropriate protection for the arc flash and arc blast hazard shall be selected, as follows: (a) Arc flash PPE in accordance with 130.7 shall be selected and used if the incident energy exceeds 1.2 cal/cm^2 (5 J/cm^2) at the working distance. (b) Hearing protection shall be required where the stored energy exceeds 100 joules. (c) The lung protection boundary shall be determined if stored energy is

above 122 kJ. Employees shall not enter the lung protection boundary.

(d) Alerting techniques in accordance with 130.7 (E) shall be used to warn employees of the hazards.

(5) Required test and grounding method. Soft grounding shall be used for stored energy greater than 1000 joules. If capacitors are equipped with bleed resistors, or if using a soft grounding system, the required discharge wait time shall be determined where applicable.

(6) Develop a written procedure that captures all the required steps to place the equipment in an electrically safe work condition. Include information about the amount of stored energy available, how long to wait after de-energization before opening the enclosure, how to test for absence of voltage, and what to do if there is still stored energy present.

360.5 Establishing an Electrically Safe Work Condition for a Capacitor(s).

(A) Written Procedure. Where a conductor or circuit part is connected to a capacitor(s) operating at or above the thresholds in 360.3, a written procedure shall be used to document the necessary steps and sequence to discharge the capacitor(s) and place the equipment into an electrically safe work condition. The written procedure shall incorporate the results of the risk assessment performed in 360.5 (B) and specify the following at a minimum:

(B) Safe Work Practices. In order to place the capacitor(s) into an electrically safe work condition, a qualified person shall use the appropriate safe work practices and PPE and shall apply the following process for establishing and verifying an electrically safe work condition:

	(1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags. (2) After properly interrupting the load current, open the disconnecting device(s) for each source. (3) Whenever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position. (4) Apply lockout/tagout devices in accordance with a documented and established policy. (5) If bleed resistors or automatic discharge systems are applicable, wait the prescribed time for the capacitors to discharge to less than the thresholds in 360.3 and proceed to step (6). For systems without bleed resistors or automatic discharge systems, discharge the capacitors with an adequately rated grounding device (e. g. ground stick). Soft grounding shall be performed above 1000 joules, and remote soft grounding shall be performed above 100 kJ. (6) Verify that the capacitors are discharged. For capacitors less than 1000 joules, verification shall be permitted to be done either by testing or by grounding. For capacitors between 1000 joules and less than 100 kJ, verification shall be done using testing or soft grounding, then hard grounding. Above 100kJ, an engineered and redundant system shall be used for remote testing and grounding. An adequately rated portable test instrument shall be used to test between each capacitor terminal

	and from each terminal to ground to assure that the capacitor is deenergized. (7) Before and after each verification, determine that the test instrument is operating satisfactorily through verification on a known dc voltage source. If voltage remains, determine and correct the cause, and repeat step (5) to discharge the capacitors. Where recharging can occur due to dielectric absorption or induced voltages, all the capacitor terminals shall be connected together and grounded with bare or transparent-insulated wire. (8) For series capacitors the shorting wires shall be attached across each individual capacitor, and to case. For single capacitors or for a parallel capacitor bank, the grounding device shall be permitted to be left attached to the capacitor terminals for the duration of the work (e. g., a ground stick). **360.6 Grounding Sticks.** Grounding sticks shall be provided for qualified persons to safely discharge any residual stored energy contained in capacitors or to hold the capacitor potential at 0 volts. The grounding sticks shall be designed, constructed, installed, and periodically inspected so that the full energy and voltage of the capacitors can be safely discharged. (A) Visual Inspection. The ground stick shall be visually inspected for defects before each use. All mechanical connections shall be examined for loose connections. Resistors shall be visually inspected for cracks or other defects and electrically tested for proper resistance. The following shall occur if defects or contamination are found:

	(1) If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the ground stick is present, the tool shall be removed from service. (2) If the defect or contamination exists on the grounding stick, then it shall be replaced or repaired and tested before returning to service. (3) If the defect or contamination exists on the cable, then it shall be replaced or repaired and tested before returning to service. (B) Electrical Testing. All ground sicks shall be electrically tested as follows: (1) The ground stick cable shall be tested to verify that the impedance is less than 0.1 ohms to ground every 2 years. (2) The testing shall be documented. Exception: The test shall be performed annually if the ground stick is utilized outdoors or in other adverse conditions. (3) Soft grounding (High Z) ground sticks with resistors shall be measured and compared to the specified value before each use. (C) Storage and Disposal. Any residual charge from capacitors shall be removed by discharging before servicing or removal. (1) All uninstalled capacitors capable of storing 10 joules or greater at their rated voltage shall be short-circuited with a conductor of appropriate size. (2) When an uninstalled capacitor is discovered without the shorting conductor attached to the

	terminals, it shall be treated as energized and charged to its full rated voltage until determined safe by a qualified person.