Welcome NC Electricians!

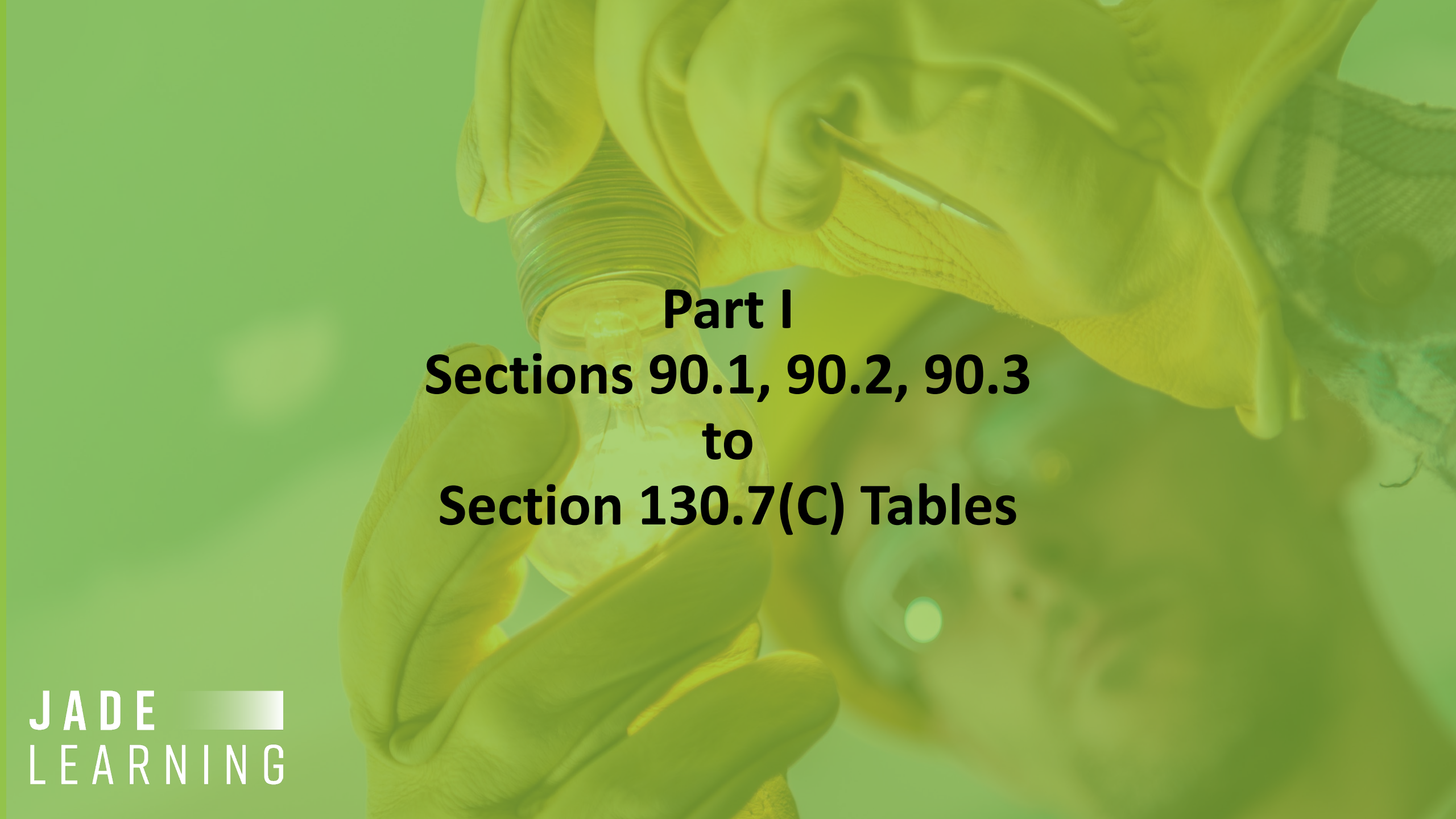
What Does North Carolina Require?

4 to 8 Hours of Continuing Education

- NC licenses [I, L, U, SP SFD] 8 hours of continuing education every year.
  Half of those must come from an in-person or VILT classroom session.

- NC licensees [SP-FA/LV, SP-EL, SP-PH, SP-WP, SP-ES, SP-SP] 4 hours of continuing education every year.
  Half of those must come from an in-person or VILT classroom session.

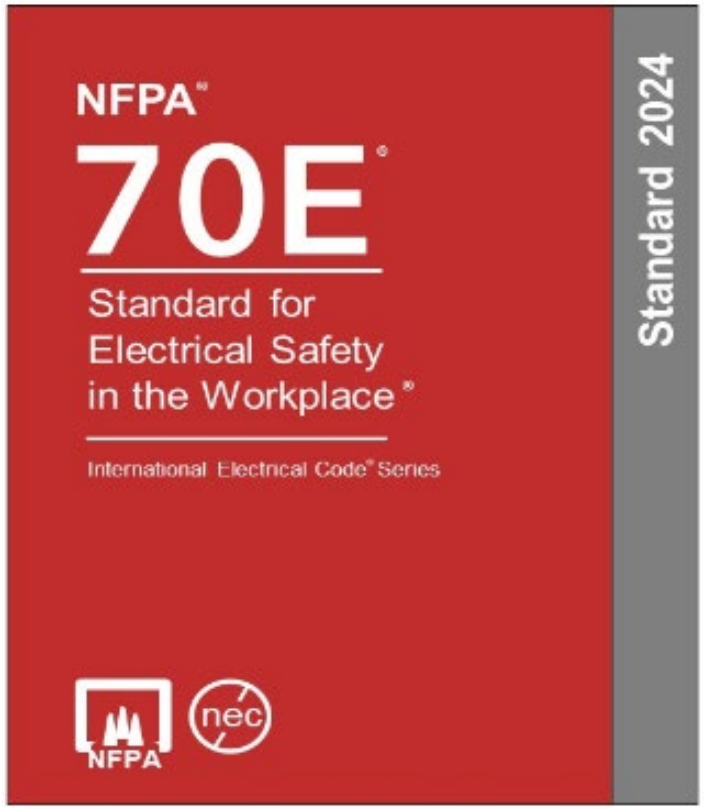
Today's class is worth 4 hours of classroom/VILT continuing education.



Part I
Sections 90.1, 90.2, 90.3
to
Section 130.7(C) Tables

JADE LEARNING

90.1 Scope.



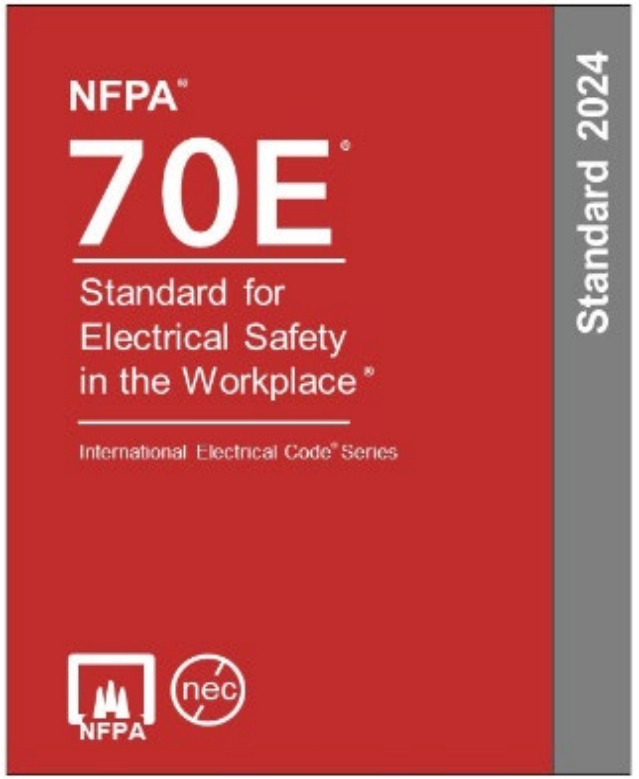
- Each NFPA 70E article begins with a **scope** to introduce the topics covered.

- **Article 90**, "Introduction," explains how to use and apply the 70E standard, including its overall arrangement.

90.2 Purpose.

*Includes practical requirements for reducing risk, guidance for determining hazards, details on regulations in place

- NFPA 70E provides guidance for a safe working environment for employees exposed to electrical hazards.



90.3 Workplaces Covered and Not Covered.

JADE LEARNING
A CERTUS COMPANY

(A) *Workplaces Covered*

Safety for employees, work practices, maintenance, and administrative controls. This Includes the following work associated with electrical conductors, electrical equipment, signaling and communications conductors, equipment, and raceways:

- Installation
- Removal
- Inspection
- Operation
- Maintenance
- Demolition

90.3 Workplaces Covered and Not Covered.

JADE LEARNING
A CERTUS COMPANY

Includes safe practices for tasks exposing employees to electrical hazards:

- Connecting conductors/equipment to electrical supply
- Performing installations for electric utility companies not related to their generating plants, etc.

NFPA 70E concepts are adapted to benefit other types of workers who are exposed to electrical hazards when the hazard is not recognized as part of their responsibilities.

90.3 Workplaces Covered and Not Covered.

JADE LEARNING
A CERTUS COMPANY

(B) *Workplaces Not Covered*

- Installations in ships, watercraft (except floating buildings), railway rolling stock, aircraft, and automotive vehicles (except mobile homes and RVs)
- Railway installations used exclusively for power generation, transmission, etc.
- Installations of communications equipment under the exclusive control of communications utilities

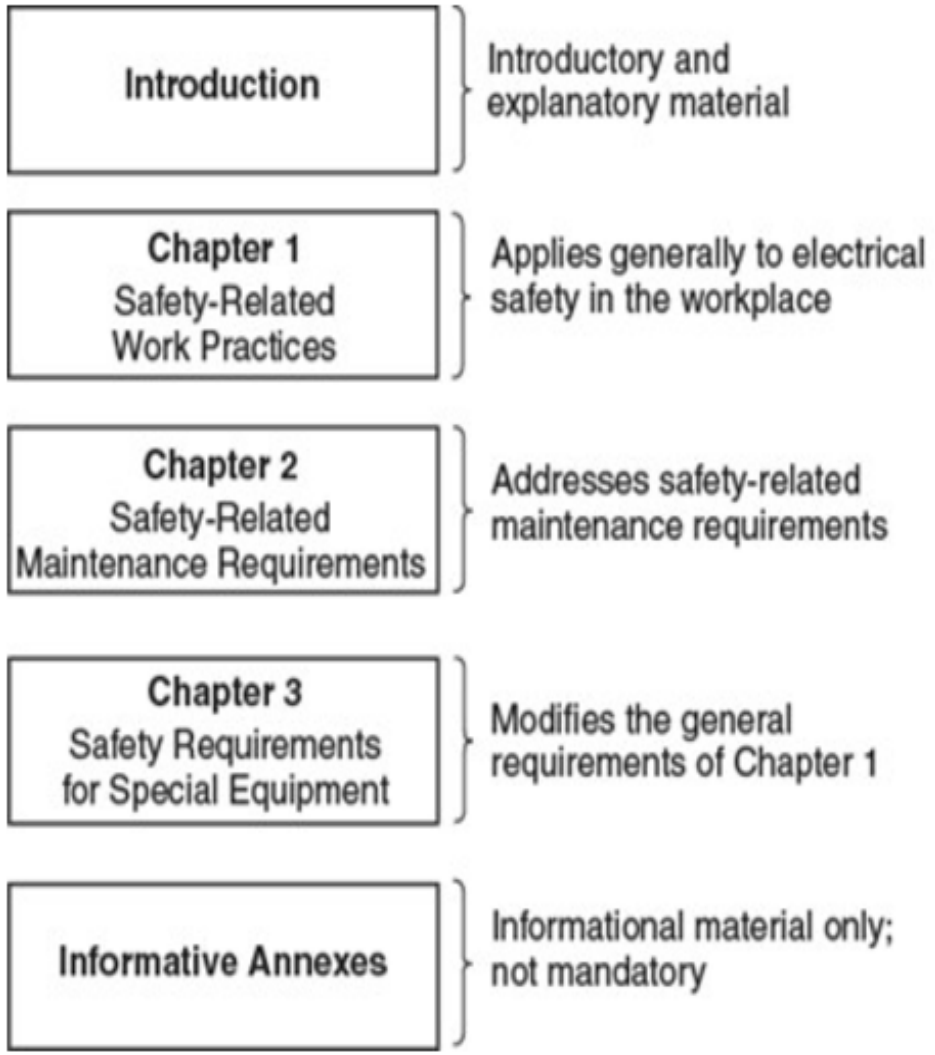
90.3 Workplaces Covered and Not Covered.

Not Covered, continued

Installations under the exclusive control of an electric utility if they involve:

- Service drops, service laterals, or associated metering
- Locations in easements or rights-of-way
- Property owned or leased by the utility for power-related operations
- Locations specified by written agreements or public service commissions

90.4 Standard Arrangement.



- Formal introduction to the document followed by three chapters
- Concludes with a group of Informative Annexes found at the end of the document
- *Informative Annexes*: intended for informational purposes; do not represent requirements from the NFPA 70E standard

90.5 Mandatory Rules, Permissive Rules, and Explanatory Material.

- **Mandatory Rules:** specifically required or prohibited actions characterized by "***shall***" or "***shall not***"
- **Permissive Rules:** allowed but not required actions; indicated by "***shall be permitted***" or "***shall not be required***"
- **Explanatory Material:** includes informational notes and references to other standards or sections of this standard; provided for guidance but ***not enforceable*** as requirements

Explanatory material is found throughout NFPA 70E and is ***not binding***.

90.6 Formal Interpretations.

- Formal interpretation procedures are found in the ***Regulations Governing the Development of NFPA Standards***.

- These interpretations are available to code users to promote uniformity of interpretation and application of NFPA 70E provisions.

100 Definitions. Accessible (as applied to equipment).

JADE LEARNING
A CERTUS COMPANY

Accessible (as applied to equipment) — Admitting close approach; ***not*** guarded by locked doors, elevation, or other effective means.

- Providing adequate access to equipment for operation, maintenance, and repairs.
- Ensuring that equipment can be effectively maintained, and potential issues can be promptly identified and addressed.

100 Definitions. Arc Rating.

Arc Rating — The value attributed to materials that describes their performance to exposure to an electrical arc discharge

Hazard, Arc Flash. (Arc Flash Hazard) —

A source of possible injury or damage to health associated with the release of energy caused by an electric arc

100 Definitions. Qualified Person.

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 the hazards and reduce the associated risk

105.3 Responsibility.

JADE LEARNING
A CERTUS COMPANY

(A) Employer Responsibility

- Develop, document, and implement safety-related work practices
  and procedures required by NFPA 70E
- Provide employees with specific training in the employer's safety-related work practices and procedures

(B) Employee Responsibility

Comply with the safety-related work practices and procedures provided by the employer

110.2 Electrically Safe Work Condition.

JADE LEARNING
A CERTUS COMPANY

(A) Policy:

emphasizes that an Electrically Safe Work Condition (ESWC) policy must adhere to the following two requirements:

1. Hazard elimination must be 1st priority when implementing safety-related work practices.

2. Electrically safe work condition practices must comply with 110.2(B).

110.2 Electrically Safe Work Condition.

JADE LEARNING
A CERTUS COMPANY

(B) When Required. Energized electrical conductors and circuit parts operating **at or above 50 volts** must be placed in an electrically safe work condition when either 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.

110.2 Electrically Safe Work Condition.

JADE LEARNING
A CERTUS COMPANY

(C) Requirements Until Established.

Electrical conductors and parts are not considered in an *Electrically Safe Work Condition* until all applicable requirements from NFPA 70E section 120.2, Lockout/Tagout Program, through section 120.6, Process for Establishing and Verifying an Electrically Safe Work Condition, have been met.

Until then, appropriate safe work practices must be followed.

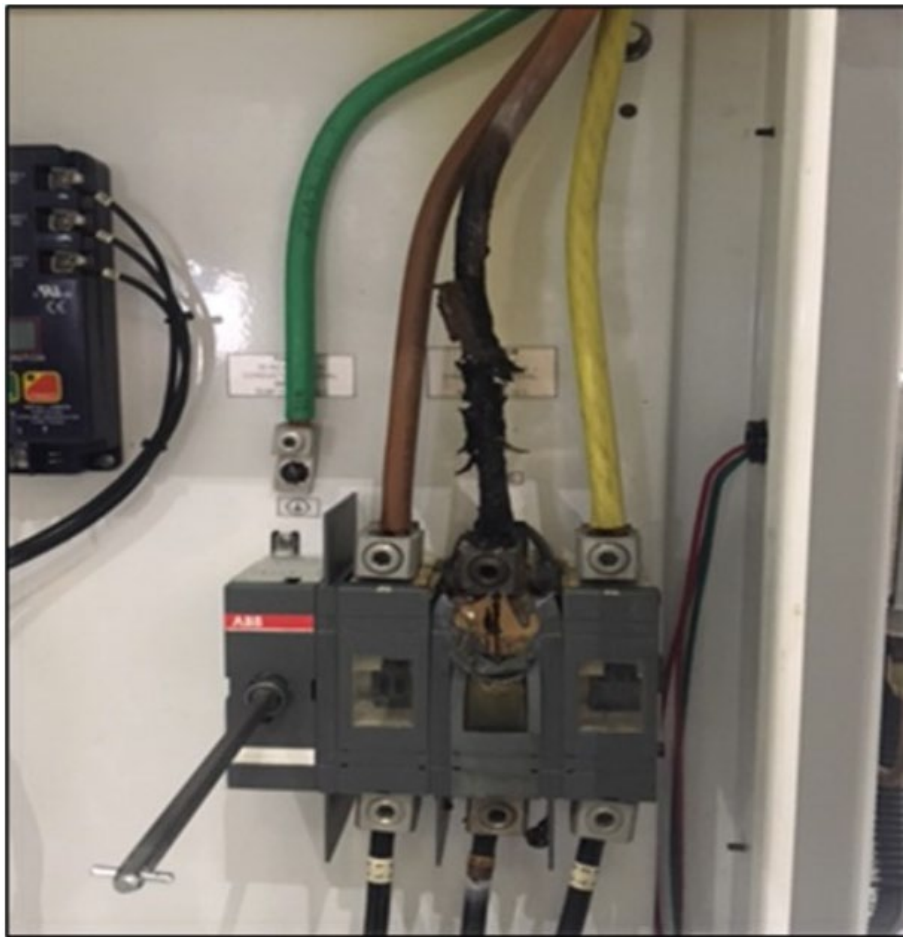
110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

An electrical safety program (ESP) is the employer's responsibility for establishing safety-related work practices and procedures on the job site. 110.3 outlines **12 steps** for properly implementing an ESP.

(A) General.

The employer **must implement** and **document** an ESP that directs activity appropriate to the risk associated with electrical hazards.



Visual Inspection

110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

(B) Inspection.

The ESP must verify that new or modified equipment and systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

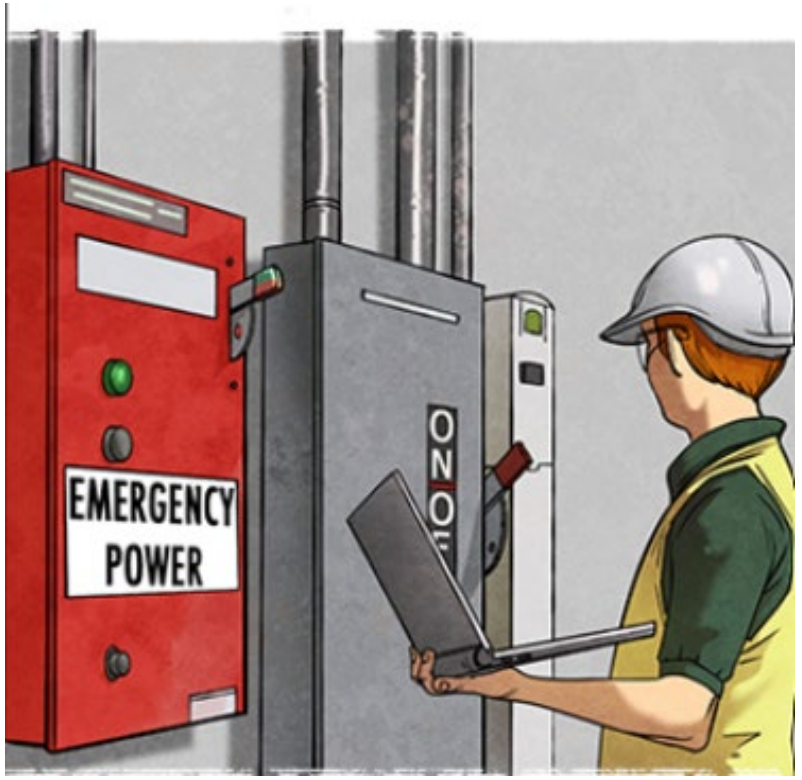
QR Codes are an acceptable way to view installation instructions for listed, labeled, or identified equipment.

110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

(D) Awareness and Self-Discipline.

- The ESP must include **awareness** of potential electrical hazards to employees who work on or near energized electrical equipment.
- The program must provide the **required self-discipline** for employees performing work around electrical hazards, and it must instill safety principles and controls.



(E) Electrical Safety Program Principles. The ESP must identify the principles upon which it is based.

110.3 Electrical Safety Program.

(F) Electrical Safety Program Controls.

The ESP must identify the controls by which it is measured and monitored.

(G) Electrical Safety Program Procedures.

The ESP must identify the procedures to be employed before work is started by employees exposed to electrical hazards.

110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

(H)(1) Elements of a Risk Assessment Procedure. Addresses employee exposure to electrical hazards and identifies the process to be used before work is started.

(1) Identify hazards

(2) Assess risks

(3) Implement risk control according to the hierarchy of risk control methods

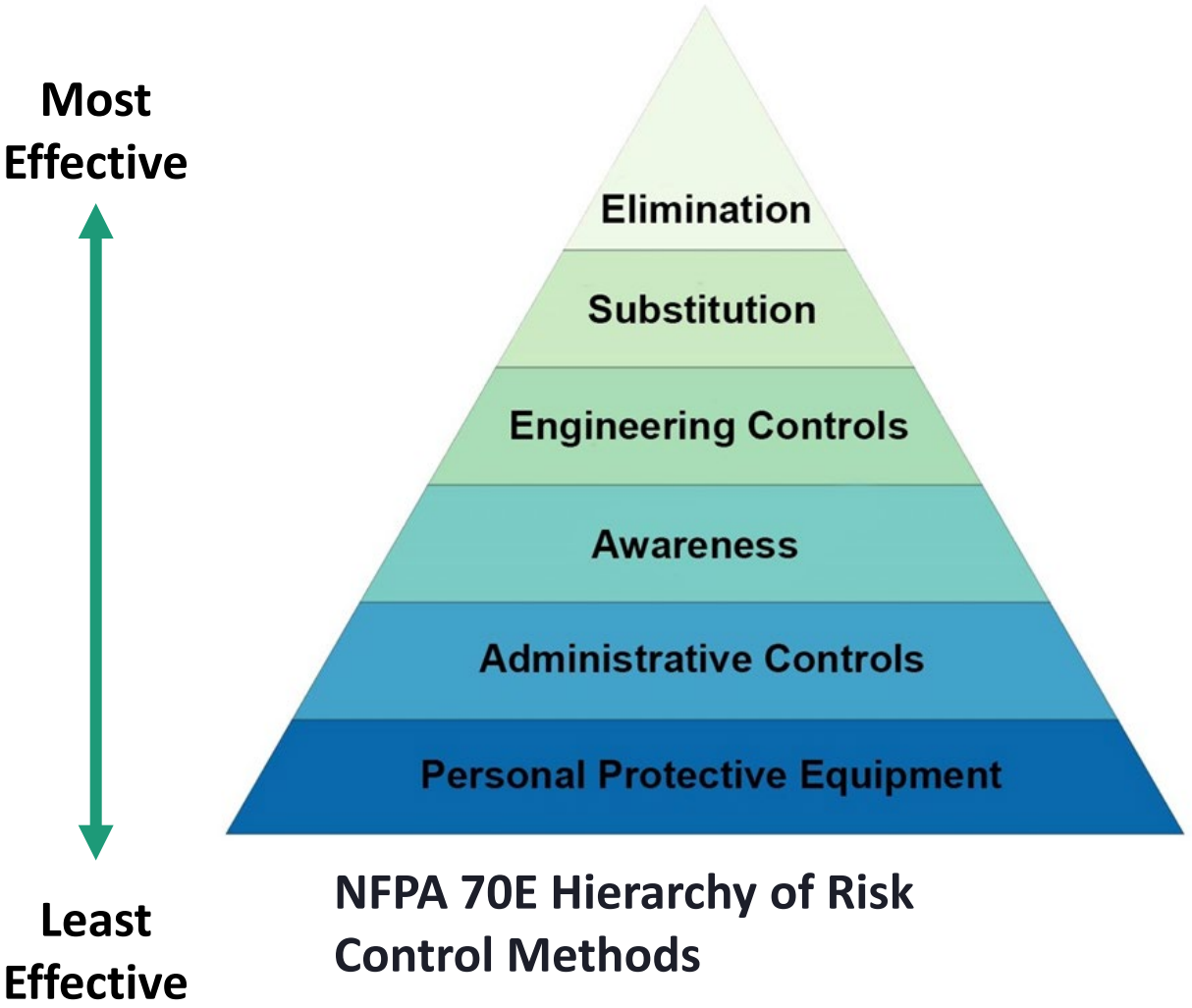
(H)(2) Human Error.
The risk assessment procedure addresses the potential for human error.

110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

(H)(3) Hierarchy of Risk Control Methods. Risk assessment requires that preventive and protective risk control methods be implemented in accordance with the following hierarchy:

- **Elimination**
- **Substitution**
- **Engineering controls**
- **Awareness**
- **Administrative controls**
- **PPE**



NFPA 70E Hierarchy of Risk Control Methods

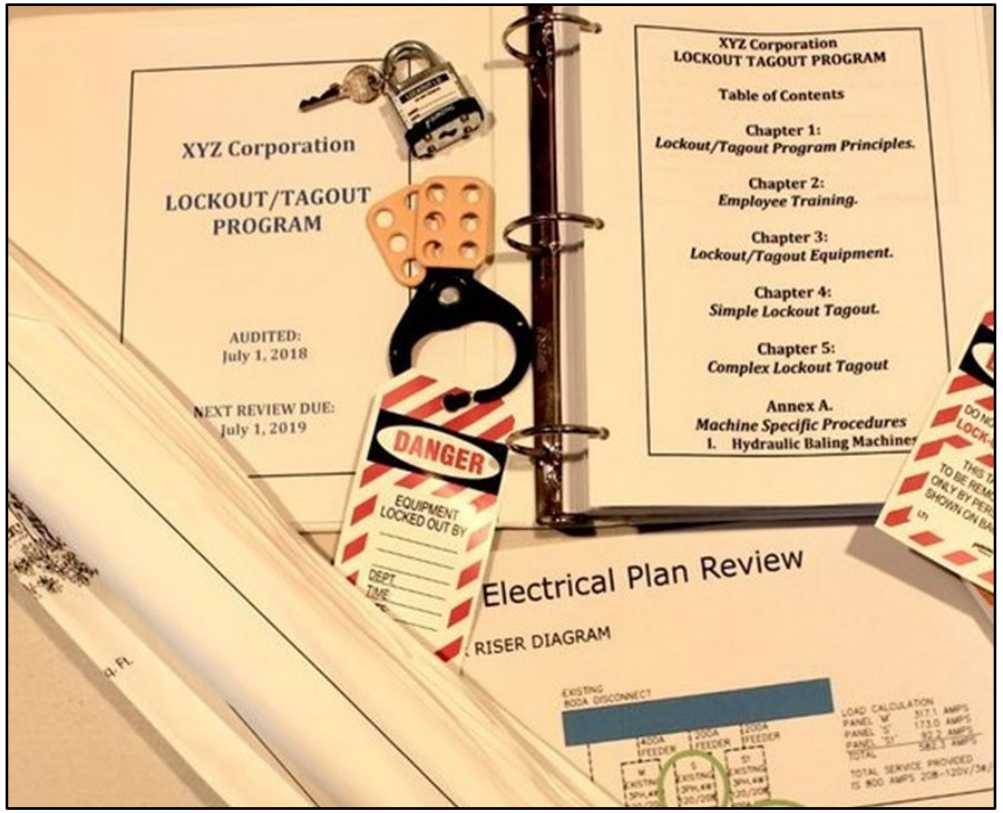
110.3 Electrical Safety Program.

JADE LEARNING
A CERTUS COMPANY

(I) Job Safety Planning and Job Briefing. The employee in charge must complete a job safety plan and conduct a job briefing with the employees involved.

(j) Incident Investigations. The electrical safety program must include means and methods to investigate electrical incidents.

(K) Lockout/Tagout Program. The electrical safety program must include the required lockout/tagout program in accordance with NFPA 70E 120.2(A).



110.3 Electrical Safety Program.

(L) (1) Electrical Safety Program Audit.
The electrical safety program must be audited to ensure compliance with the standard: audits conducted at least **every 3 years**.

(2) Field Work Audit.
Field work must be audited **annually** to confirm compliance with electrical safety program.

(3) Lockout/Tagout Program and Procedure Audit. The lockout/tagout program and procedures must be audited **annually** by a qualified person.

110.4 Training Requirements.

(A) Electrical Safety Training.

Employees exposed to electrical hazards **that cannot be effectively reduced to a safe level** must undergo training to recognize these hazards, understand the risks involved, and follow appropriate safety-related work practices and procedures.

Training comes in many forms, including classroom training.

110.4 Training Requirements.

JADE LEARNING
A CERTUS COMPANY

A qualified person must be trained and **knowledgeable** in the **construction and operation of equipment** or a specific work method and be trained to identify and avoid **electrical hazards** that might be present with respect to that **equipment** or work method.

Sections 110.4(A)(1)(a) through (f):

Must be knowledgeable in the use of *precautionary techniques, electrical policies, PPE, insulating materials, and insulated tools and test equipment.*

110.4 Training Requirements.

JADE LEARNING
A CERTUS COMPANY

Those working within the **limited approach boundary** must be trained to:

- distinguish exposed live conductors from other electrical equipment
- determine the voltage of exposed energized electrical conductors and parts.

- Employees must be trained to choose the **correct test instruments** and demonstrate how to verify the absence of voltage.
- They must understand the **limitations** of test equipment.
- Employers must determine that all employees are complying with **safety-related work practices**.

110.4 Training Requirements.

JADE LEARNING
A CERTUS COMPANY

(A)(2) Unqualified Persons: shall be trained in any electrical safety-related practices necessary for their safety.

Classroom Vs. on-the-job Training

(A)(3) Additional Training and Retraining: in safety-related practices and applicable changes in this standard shall be performed at intervals **not to exceed 3 years**.

(A)(4) Type of Training*:* must be conducted in the classroom, on-the-job, or a combination of both.

110.4 Training Requirements.

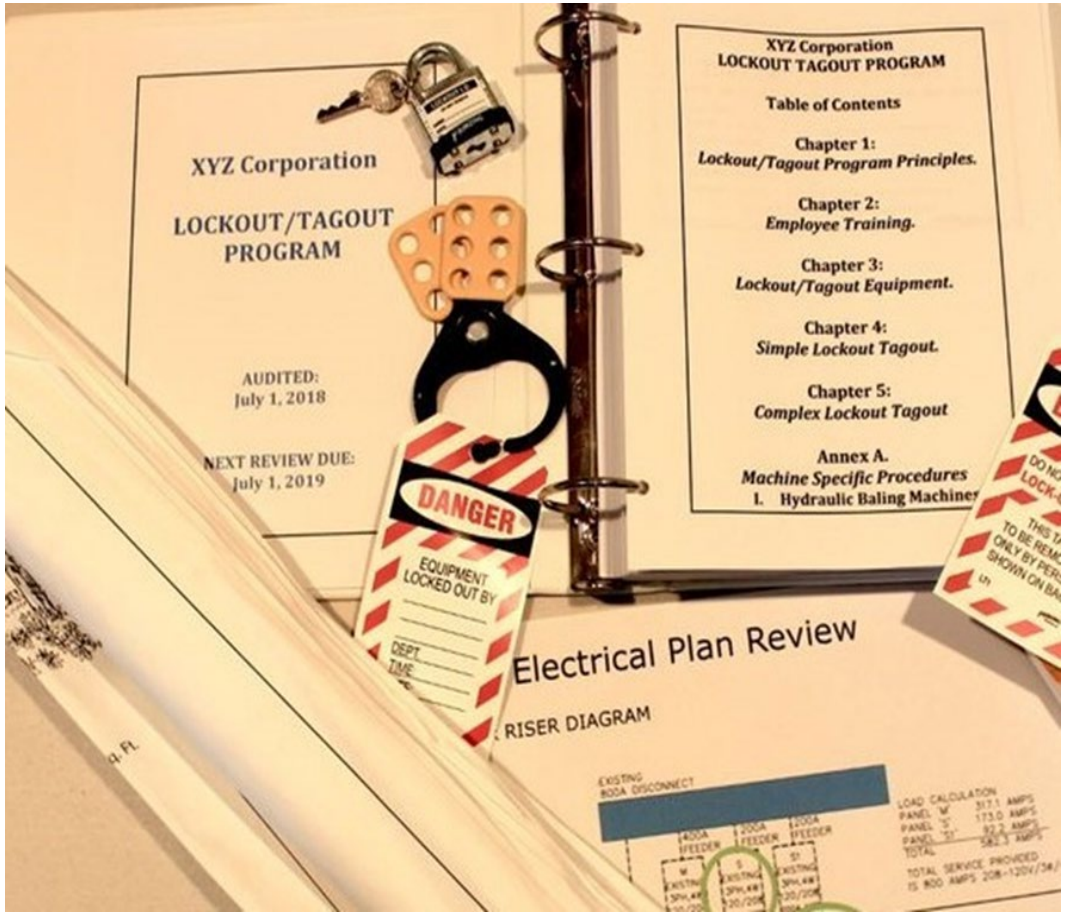
JADE LEARNING
A CERTUS COMPANY

(A)(5) Employer Safety Training Documentation*:*

The employer must document that each employee has received required training.

Documentation must:

- Be made when the employee demonstrates proficiency in relevant work practices.
- Be retained for the duration of the employee's employment.
- Include the content of the training, each employee's name, and dates.



110.4 Training Requirements.

JADE LEARNING
A CERTUS COMPANY

(B) Lockout/Tagout Procedure Training.

(1) Initial Training. Employees must be trained in lockout/tagout procedures, including their responsibility in the execution of the procedure.

(2) Retraining.
Retraining in lockout/tagout procedures must occur:

- whenever procedures are **revised**, but at intervals **not exceeding 3 years**.
- whenever there is an indication that employees are not complying with lockout/tagout procedures.

110.4 Training Requirements.

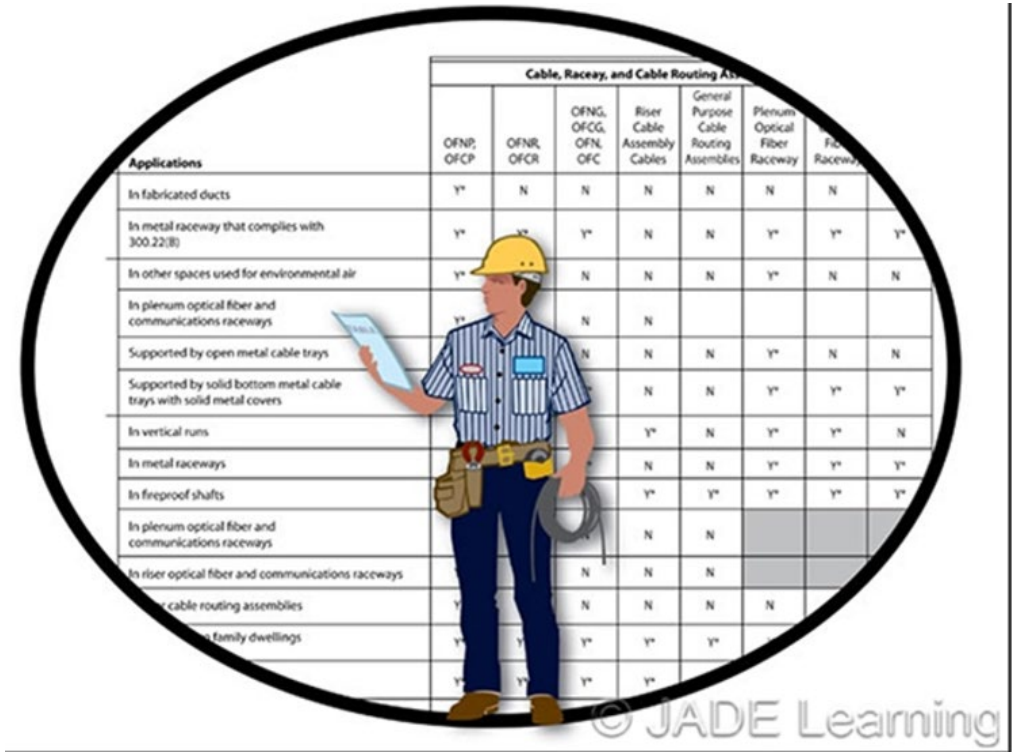
JADE LEARNING
A CERTUS COMPANY

(3) Lockout/Tagout Training Documentation.

The employer must document that each employee has received the required training.

This documentation must:

- Be made when the employee demonstrates proficiency in the relevant work practices.
- Include the content of the training, each employee's name, and dates of training.



110.4 Training Requirements.

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

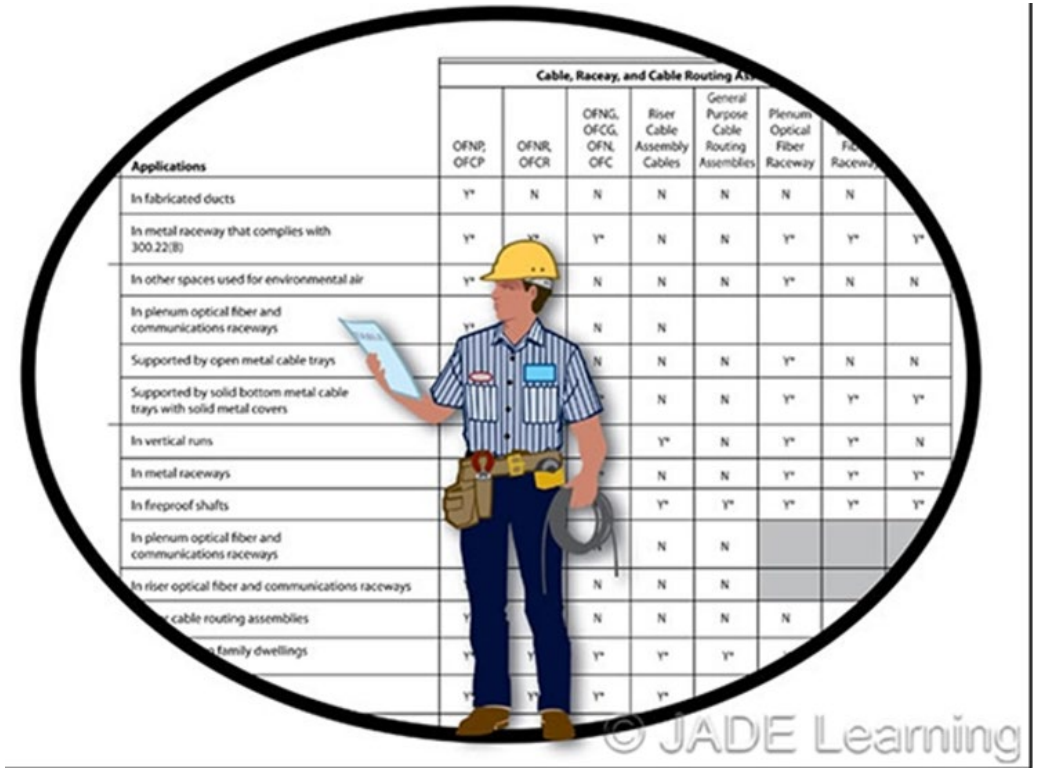
Contact Release.
Safe methods to separate the victim from the electrical source

Employees tasked with safely releasing victims from contact with energized parts must be trained in ***methods of safe release****.*

(2) First Aid, Emergency Response And Resuscitation.

(3) Training Verification.

(4) Documentation.



110.5 Host and Contract Employers' Responsibilities.

(A) Host Employer Responsibilities.

- Inform the contract employer of job site hazards.
- Provide the contract employer with necessary information for the assessments required in Chapter 1 of NFPA 70E.
- Report to the contract employer any contract employer–related NFPA 70E violations witnessed.

110.5 Host and Contract Employers' Responsibilities.

JADE LEARNING
A CERTUS COMPANY

(B) Contract Employer Responsibilities.

- Ensure employees follow safety-related work practices.
- Inform host employer of **special hazards** related to their work; notify them of any **new hazards**.
- Report any **corrective measures** taken regarding violations reported by the host employer/**steps** to prevent future violations.

(C) Documentation.

A documented meeting between the host employer and contract employer is required where the host employer has knowledge of hazards.

110.6 Test Instruments and Equipment.

JADE LEARNING
A CERTUS COMPANY

(A) Testing. Only **qualified persons** must perform tasks.

(B) Rating. Test instruments, equipment must be rated for circuits and equipment; approved for the purpose; used in accordance with any instructions provided by the manufacturer.

(C) Design.

(D) Visual Inspection and Repair. All test instruments and equipment must undergo visual inspection for external defects/damage. Damaged equipment must be **removed** from service.

(E) Operation Verification.

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

JADE LEARNING
A CERTUS COMPANY

(A)Handling and Storage.

Portable equipment must be handled and stored carefully to prevent damage.

Safe work practices involve handling tools as **directed by the manufacturer**, including proper methods for raising and lowering them.

NFPA 70E prohibits raising and lowering tools using their cords.

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

JADE LEARNING
A CERTUS COMPANY

(B) Grounding-Type Equipment.

- A flexible cord used with grounding-type utilization equipment **must contain** an equipment grounding conductor.
- Attachment plugs and receptacles **must not be connected or altered** in a way that interrupts the continuity of the equipment grounding conductor.
- Adapters that interrupt the continuity of the equipment grounding conductor **must not be used**.

Test instrument power cords are addressed in Section 110.7 (A) and (B).

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

(C) Visual Inspection and Repair of Portable Cord- and Plug-Connected Equipment and Flexible Cord Sets.

- Frequency of Inspection.
- Defective Equipment.
- Proper Mating.

Stationary cord-and-plug connected equipment

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

(D) Conductive or Wet Work Locations.

Portable cord-and-plug connected equipment **must be approved** for use in conductive or wet locations, as these environments pose significant dangers.

GFCI receptacle with red button for Reset and black button for Test

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

JADE LEARNING
A CERTUS COMPANY

(E) Connecting Attachment Plugs.

- Employee's **hands must be dry** when plugging and unplugging flexible cords and cord-and-plug connected equipment.
- P**rotective equipment must be used** when handling energized plug and receptacle connections.
- Locking-type connectors **must be properly secured** after they are connected.

(F) Manufacturer's Instructions.

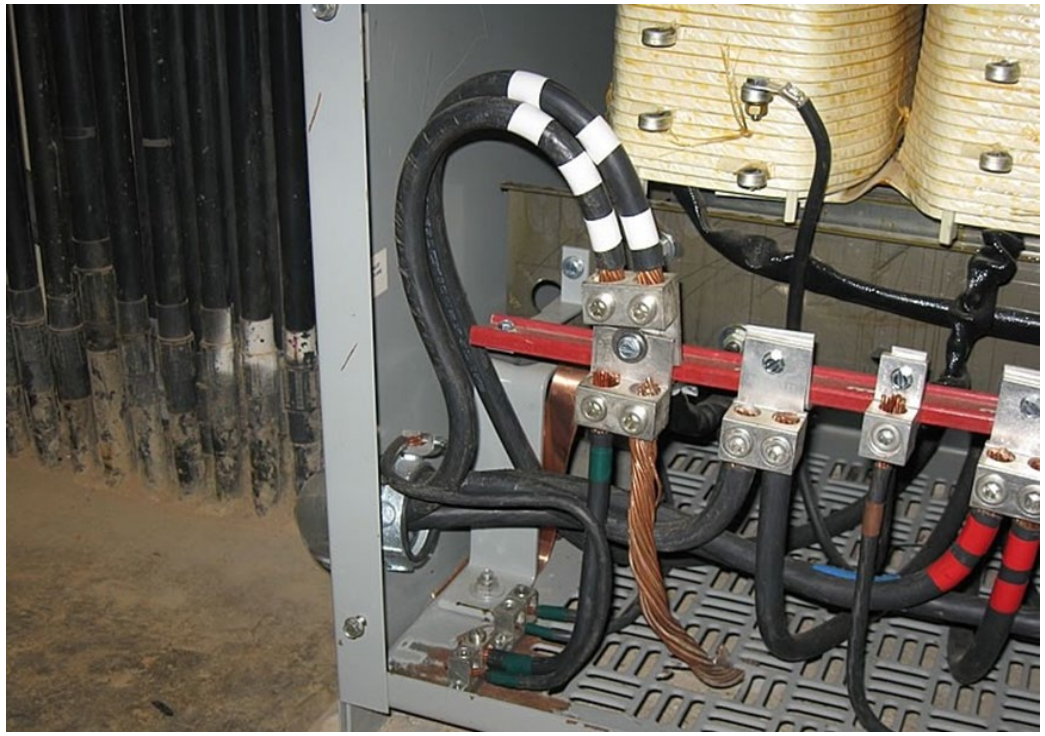
Attachment plugs of the locking type are inserted and twisted into locking receptacles.

110.8 Ground-Fault Circuit-Interrupter (GFCI) Protection.

(A) General. GFCI protection must be provided for employees where required by state, federal, or local codes.

(B) Maintenance and Construction.

- GFCI protection is required: cord-and-plug connected tools powered by 120-volt, 15-, 20-, or 30-amps circuits.
- Where greater than 120-volt, 15-, 20-, or 30-amps circuits, GFCI protection or an **assured equipment grounding conductor program** must be implemented.



An assured equipment grounding conductor program verifies all the grounding points inside all equipment.

110.8 Ground-Fault Circuit-Interrupter (GFCI) Protection.

(C) Outdoors.

- GFCI protection required for employees working outdoors
- *Assured equipment grounding conductor program* must be implemented

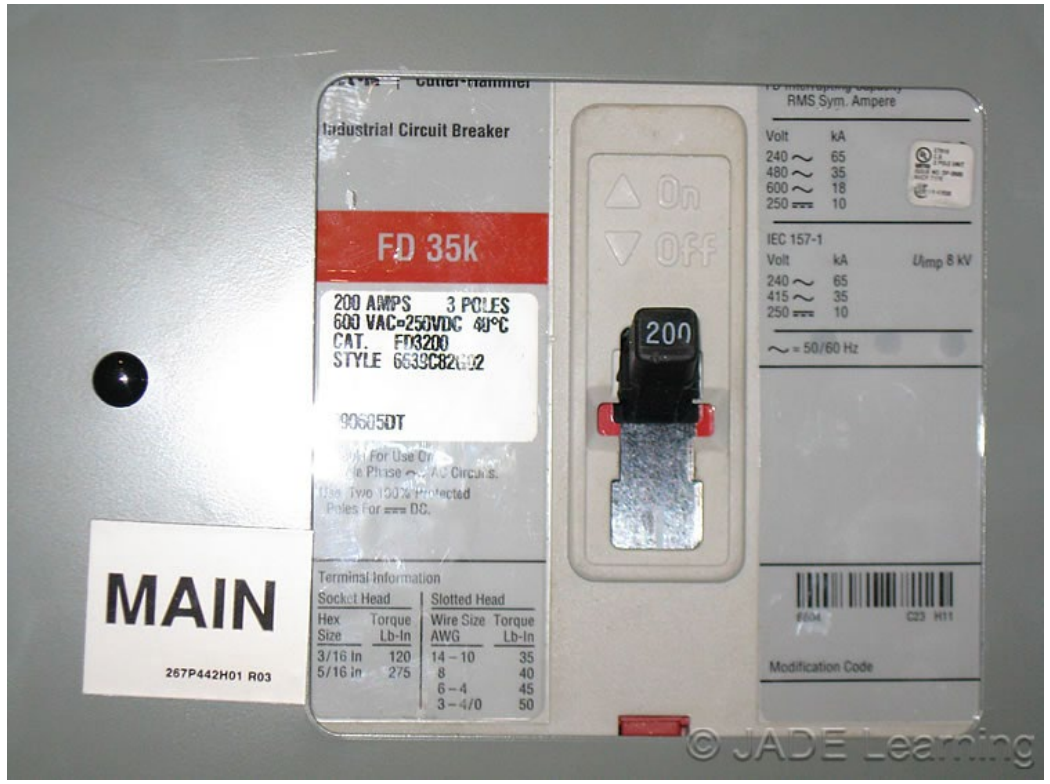
(D) Testing Ground-Fault Circuit-Interrupter Protection Devices.

GFCI protection devices must be tested in accordance with the **manufacturer's instructions.**

Outdoor GFCI Protection

110.9 Overcurrent Protection Modification; 110.10 Equipment Use.

Section 110.9: Overcurrent protection for circuits and their conductors ***must not be modified***, even temporarily, beyond what is ***permitted*** by applicable portions of electrical codes and standards dealing with overcurrent protection.



Section 110.10: Equipment must be used in accordance with the manufacturer's instructions.

The interrupting rating of a device cannot be less than the available fault current at that location.

120 Establishing an Electrically Safe Work Condition.

JADE LEARNING
A CERTUS COMPANY

- Equipment and systems are de-energized.
- Inoperable status is secured and advertised for everyone to see.
  This is known as ***lockout/tagout***.
- The priority in implementing safety-related work practices is to ***eliminate risk***.

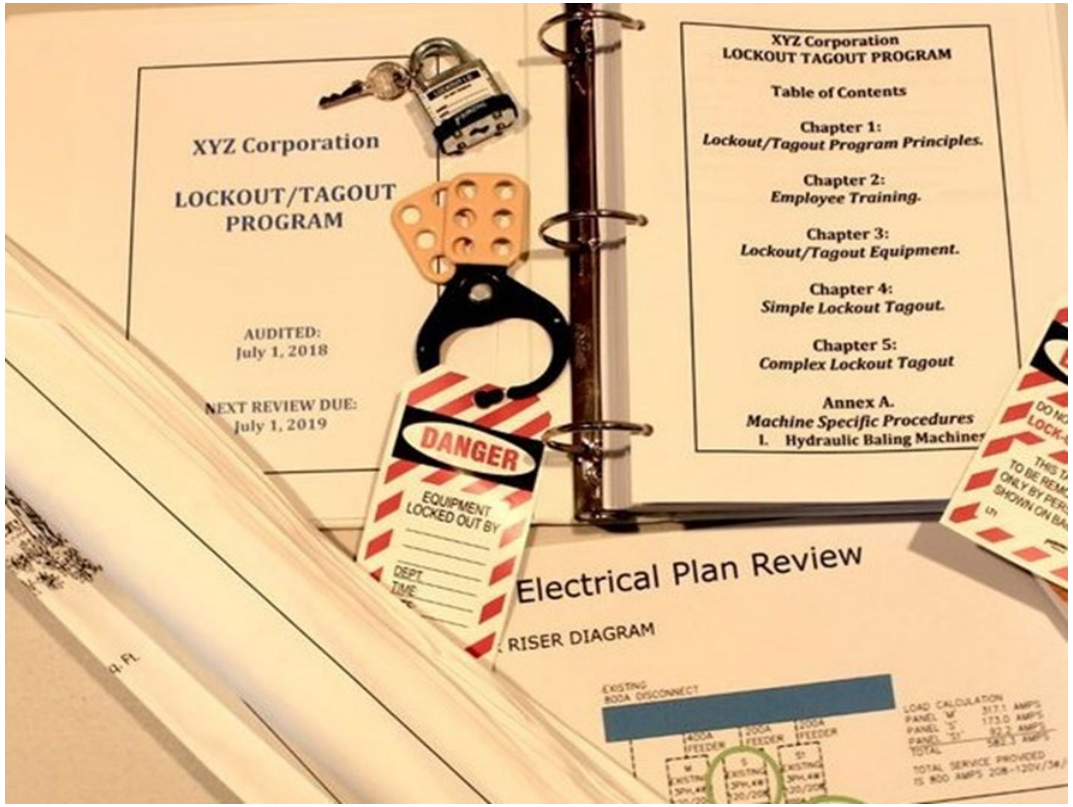
Conductors and circuit parts locked and tagged in the disconnected position are part of securing an electrically safe work condition.

120.2 Lockout/Tagout Program.

JADE LEARNING
A CERTUS COMPANY

(A) General. The employer is responsible for **establishing**, **documenting**, and **implementing** the lockout/tagout program.

- The lockout/tagout program must specify the **lockout/tagout procedures** to protect workers from electrical hazards.
- The lockout/tagout program must meet the requirements of 120.2 through 120.6.



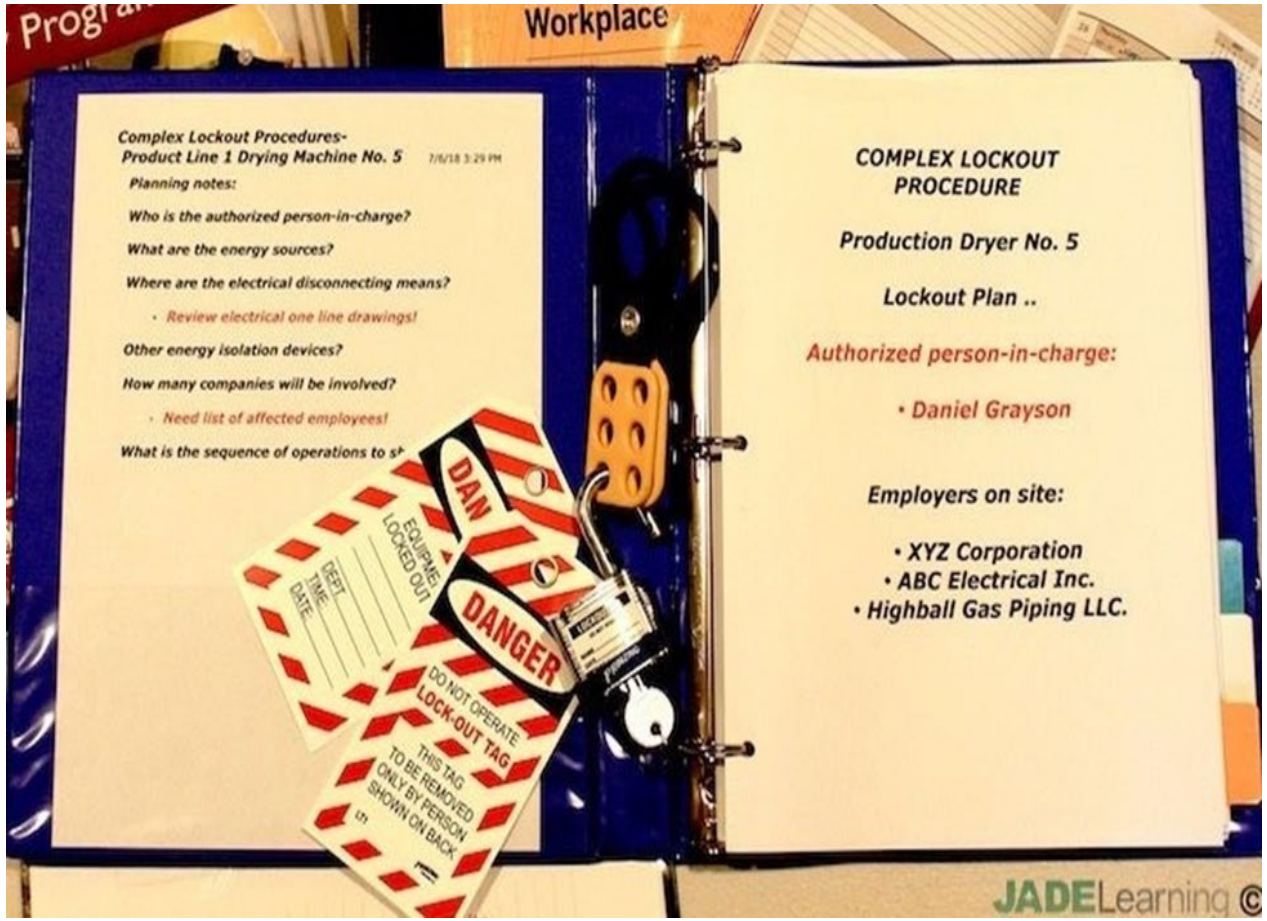
The lockout/tagout program must specify the procedures to protect workers from electrical hazards.

120.2 Lockout/Tagout Program.

JADE LEARNING
A CERTUS COMPANY

(B) Employer Responsibilities:

1. Providing all **equipment** necessary for lockout/tagout procedures
2. Providing **lockout/tagout training** to employees in accordance with 110.4(B)
3. Auditing the **lockout/tagout program** in accordance with 110.3(L)(3)
4. Auditing **execution of the lockout/tagout procedures** in accordance with 110.3(L)(3)



120.3 Lockout/Tagout Principles.

JADE LEARNING
A CERTUS COMPANY

(A) Employee Involvement. Employees exposed to sources of electrical energy must be involved with the company's lockout/tagout procedure.

(B) Lockout/Tagout Procedure.

- Must be based on the existing equipment and systems
- Must have current documentation
- Must comply with all relevant codes, standards, and regulations

(C) Control of Energy. Energy sources must be controlled to minimize employee exposure to hazards.

(D) Electrical Circuit Interlocks. Applicable drawings and diagrams must be up-to-date; documentation must be reviewed

120.3 Lockout/Tagout Principles.

JADE LEARNING
A CERTUS COMPANY

(E) Control Devices. Locks and tags must be installed only on the **disconnecting means.**

Pushbuttons, selector switches, and other control devices **must not be used** as primary isolating device for a circuit or equipment.

(F) Identification. Lockout/tagout devices must be **unique** from other devices used in the facility and readily **identifiable** as a lockout/tagout device.

Start, stop, directional, and other types of control switches are not acceptable as primary isolating devices of circuits and equipment.

120.3 Lockout/Tagout Principles.

(G) Coordination.

1. Employers must coordinate their lockout/tagout procedures so all requirements are addressed.
2. The procedure for controlling exposure to electrical hazards must be coordinated with procedures for controlling other **hazardous energy sources**.
3. Devices can be similar to lockout/tagout devices used for controlling other hazardous energy sources, but they must be used **solely** for this purpose.

120.3 Lockout/Tagout Principles.

(H) Forms of Control of Hazardous Electrical Energy.

The **two forms** of hazardous electrical energy control allowed by NFPA 70E include:

- **Simple lockout/tagout**, where the qualified person performing the work is in charge of the procedures.
- **Complex lockout/tagout**, where the designated person in charge has overall responsibility.

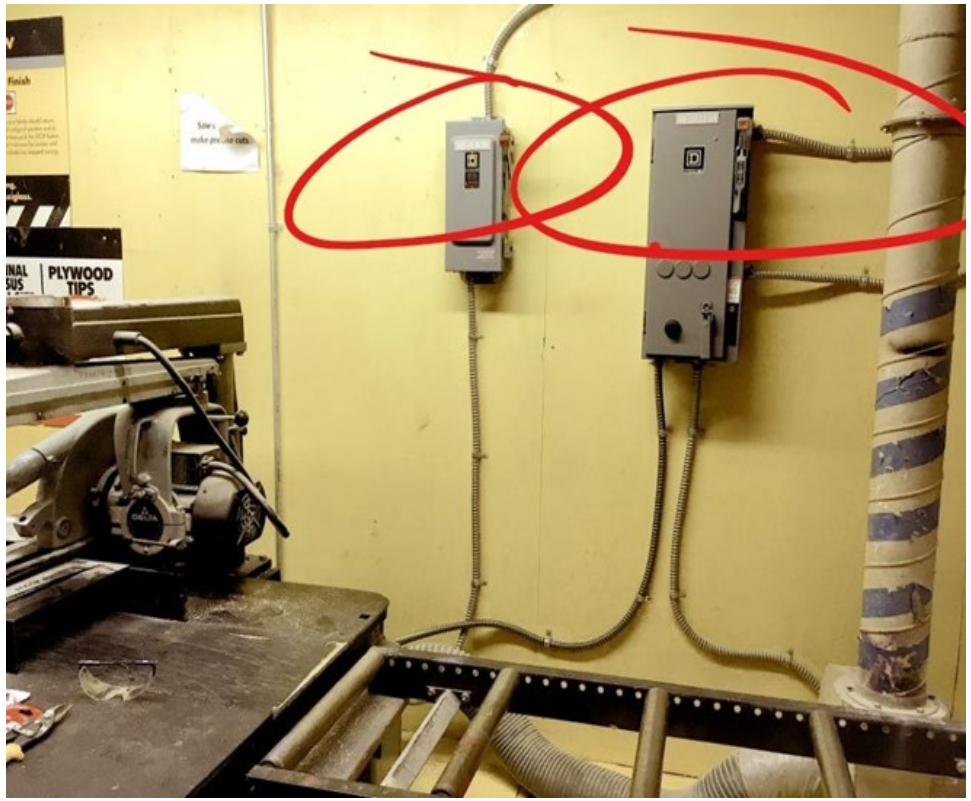
120.4 Lockout/Tagout Equipment.

JADE LEARNING
A CERTUS COMPANY

(A) Lock Application. Energy isolation devices for machinery or equipment installed after January 2, 1990, must be **capable of accepting** a lockout device.

(B) Lockout/Tagout Device. Employers must provide the necessary lockout/tagout components to execute the lockout/tagout requirements outlined in NFPA 70E.

Locks and tags must be **unique** from those used for other purposes and must not be used for **any other purposes**.



Two energy isolation devices (disconnects)

120.4 Lockout/Tagout Equipment.

JADE LEARNING
A CERTUS COMPANY

(C) Lockout Device. Must include a keyed or combination style lock.

- Must incorporate a way of identifying the person responsible for installing it.

- Can only be only a lock if it complies with the criteria covered (in detail) by 120.4 (C)

- It is readily identifiable as a lockout device.
- There is a way to identify who installed the lock.

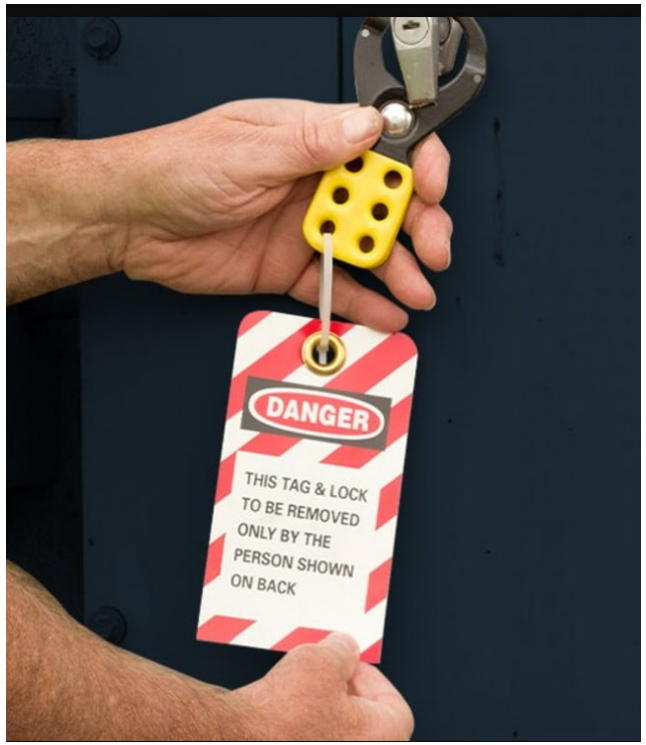
Refer to the Code handbook.

120.4 Lockout/Tagout Equipment.

JADE LEARNING
A CERTUS COMPANY

(D) Include a tag with a means of attachment. It must be readily identifiable as a tagout device and withstand its environment for the duration of the tagout event. *Attachment means must also comply with the following:*

- Withstand 50 lb. of force exerted at right angle to the disconnecting means surface.
- Attachable by hand and self-locking
- Nonreleasable
- Nonreusable
- Equivalent to an all-environmental tolerant nylon cable tie



120.5 Lockout/Tagout Procedures.

JADE LEARNING
A CERTUS COMPANY

(A) Planning. Lockout/Tagout planning must include the requirements from sections (A)(1) to 120.5(B)(14).

(1)Locating Sources. Up-to-date single-line drawings must be used to locate equipment and system power sources.

(2) Exposed Persons. The lockout/tagout plan must identify all individuals who could be exposed to an electrical hazard.

(3) Person In Charge. The plan must clearly identify the person in charge and his or her responsibility in the lockout/tagout procedure.

Sections 120.5 (A) (1) through (A) (3) apply to BOTH simple and complex lockout/tagout procedures.

120.5 Lockout/Tagout Procedures.

JADE LEARNING
A CERTUS COMPANY

(4) Simple Lockout/Tagout Procedure.

A lockout/tagout procedure involving one or more qualified persons deenergizing one set of conductors or circuit part sources solely for the purpose of safeguarding employees from electrical hazards.

- Each employee working under a simple lockout/tagout procedure is responsible for their own lockout/tagout.

Section 120.5 (A) (4) applies ONLY to simple lockout/tagout procedures.

Section 120.5 Complex Lockout/Tagout.

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(A) (5) Complex Lockout/Tagout.

Must be permitted wherever one or more of the following conditions exist:

- multiple energy sources
- multiple work crews at the job site
- multiple crafts
- multiple locations
- multiple employers with personnel performing the work, etc.

120.5 Lockout/Tagout Procedures.

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A CERTUS COMPANY

120.5(B), Elements of Control. 14 individual elements of control **[120.5(B)(1) through (B)(14)]**

Selected Elements:

- **De-energizing Equipment (Shutdown).** Establish who is responsible for controlling the switch to shut down the load.
- **Stored Energy.** Account for releasing all stored mechanical and physical energy in equipment.
- **Testing.** Test instruments and required PPE, check every exposed conductor or part before service; clarify retesting procedure, etc.
- **Lockout/Tagout Application.** Identify when and where lockout/tagout must be performed, and all aspects of the procedure.

See the Code handbook for complete content of this Section.*

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

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8 steps required:

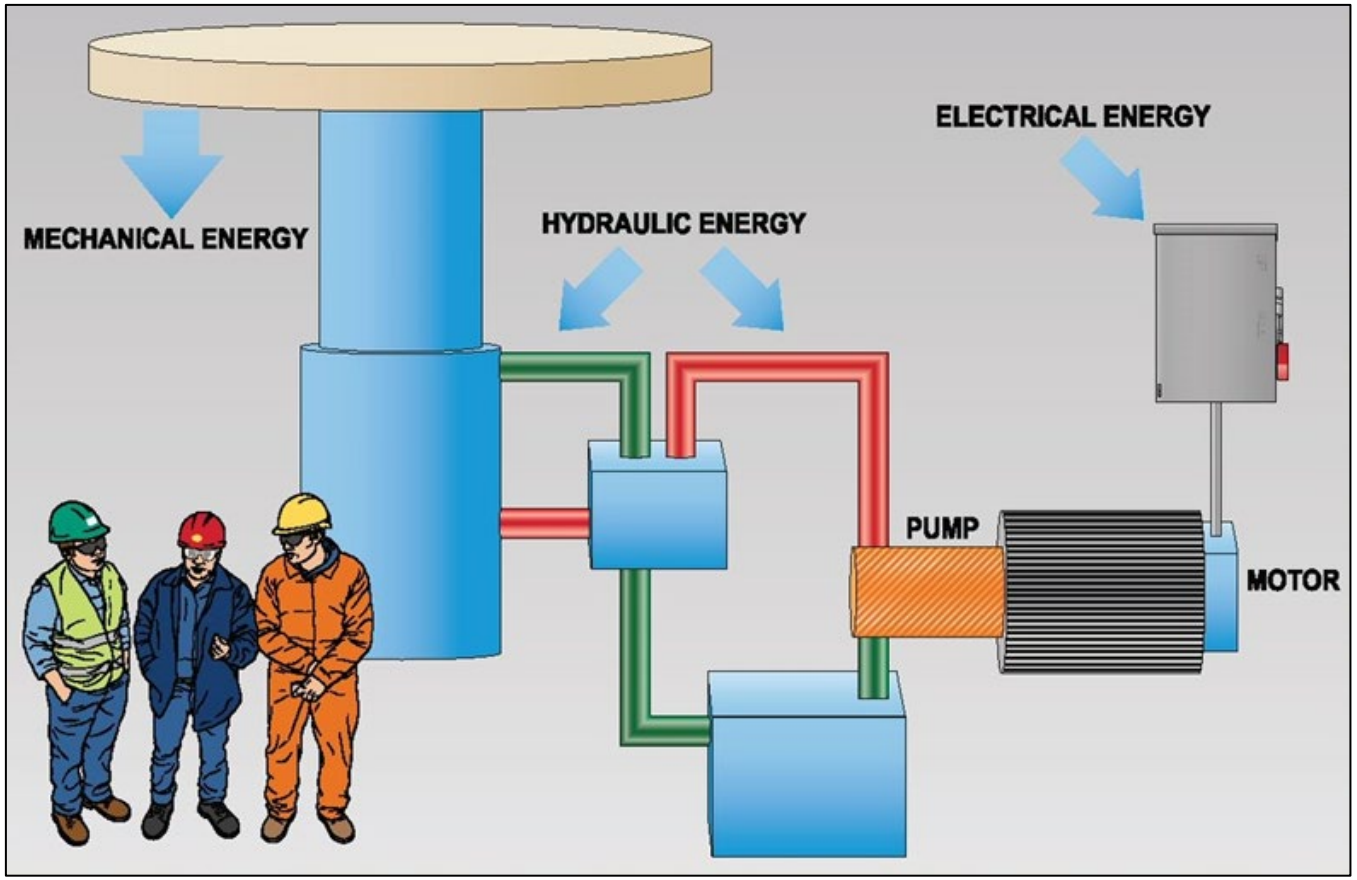
1. Determine all sources of electrical supply to the specific equipment.
2. Interrupt the load current according to the manufacturer's instructions, such as by using the equipment's on/off switch. Open the disconnect devices for each power source.
3. Verify that disconnect device blades are fully open/that drawout-type circuit breakers are withdrawn to the test.
4. Release all energy stored via any capacitors or other components capable of storing reserve energy after power interruption.

120.6 Establishing and Verifying an Electrically Safe Work Condition.

JADE LEARNING
A CERTUS COMPANY

5. Nonelectric energy must also be relieved or blocked. This must be done to the extent that circuit parts cannot be energized unintentionally later.

6. Initiate lockout/tagout procedures according to a documented and established lockout/tagout plan.



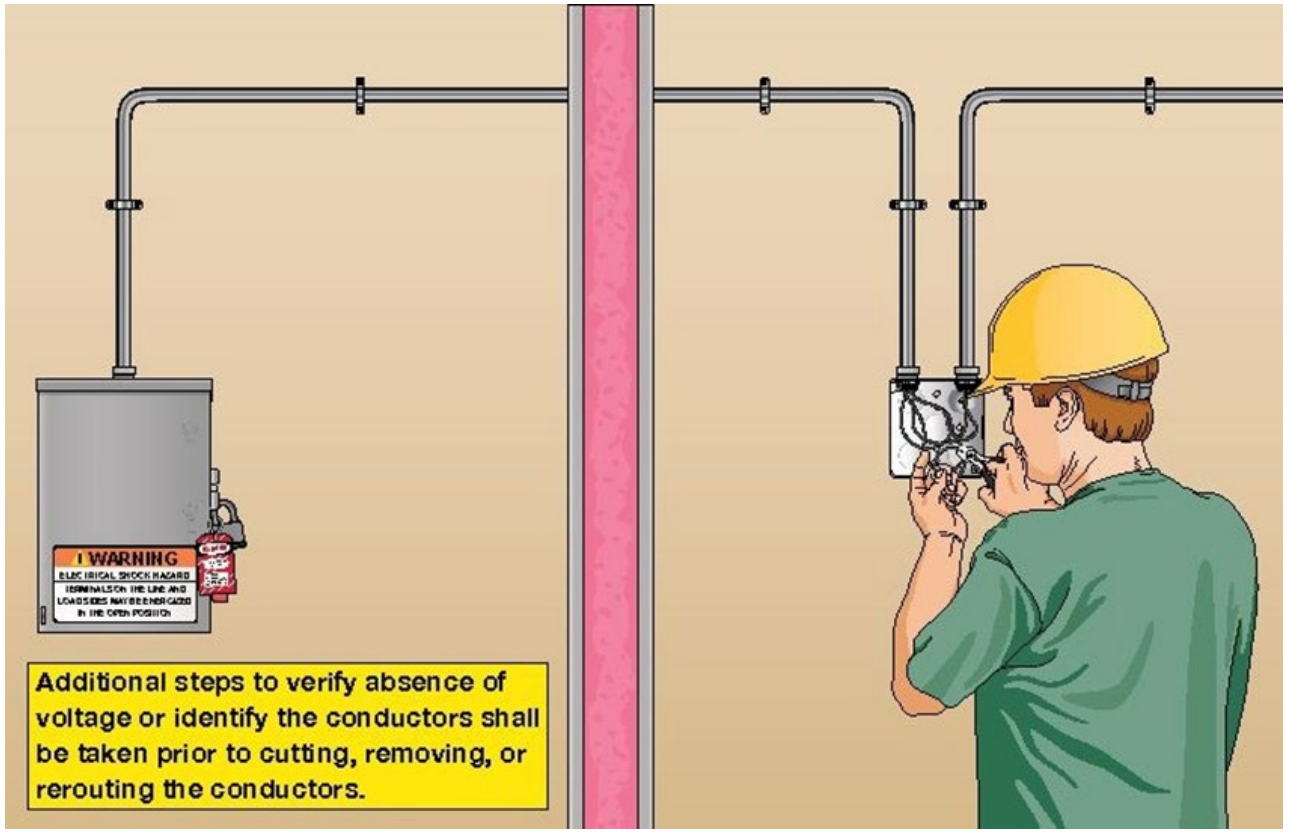
Nonelectric energy must also be relieved or blocked.

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

JADE LEARNING
A CERTUS COMPANY

7. Use adequately rated portable test instruments for confirming all phase conductors and circuit parts are free from voltage.

8. Ground all circuit conductors and circuit parts if there is any chance that induced voltage or stored electricity exists within the equipment being serviced.



130 Work Involving Electrical Hazards.

When energized conductors and circuit parts that operate at 50 volts or greater are not put into an electrically safe work condition, and the work is performed in accordance with Section 110.2(B), *Electrically Safe Work Condition—When Required,* all of the following requirements must be met:

- Qualified persons are the only persons allowed to perform work on electrical conductors and circuit parts not put into an electrically safe work condition.
- According to the requirements in Section 130.2, *Energized Electrical Work Permit,* an energized electrical work permit must be completed.
- According to the requirements in Section 130.4, *Electric Shock Risk* Assessment, an electric shock risk assessment must be performed.
- According to the requirements in Section 130.5, *Arc Flash Risk Assessment*, an arc flash risk assessment must be performed.

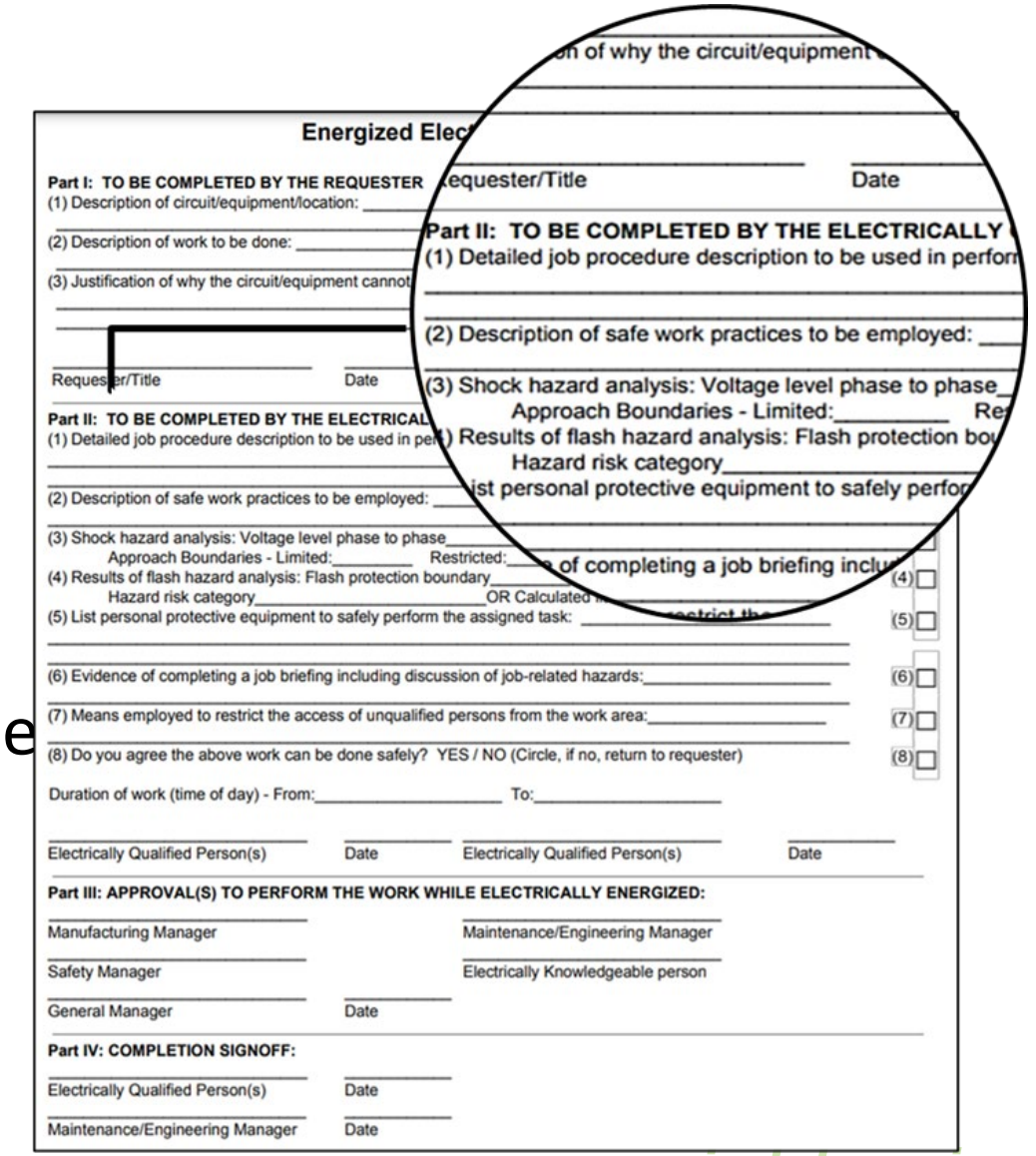
130.2 Energized Electrical Work Permit.

JADE LEARNING
A CERTUS COMPANY

(A) When Required. See 110.2 (B)

(B) (B) Elements of Work Permit. Work permit must include the following:

1. Description of the circuit/equipment to be worked on and location
2. Description of the work to be performed
3. Justification for why the work must be performed in an energized condition [see 110.2(B)].
4. A description of safe work practices being used [see 130.1].



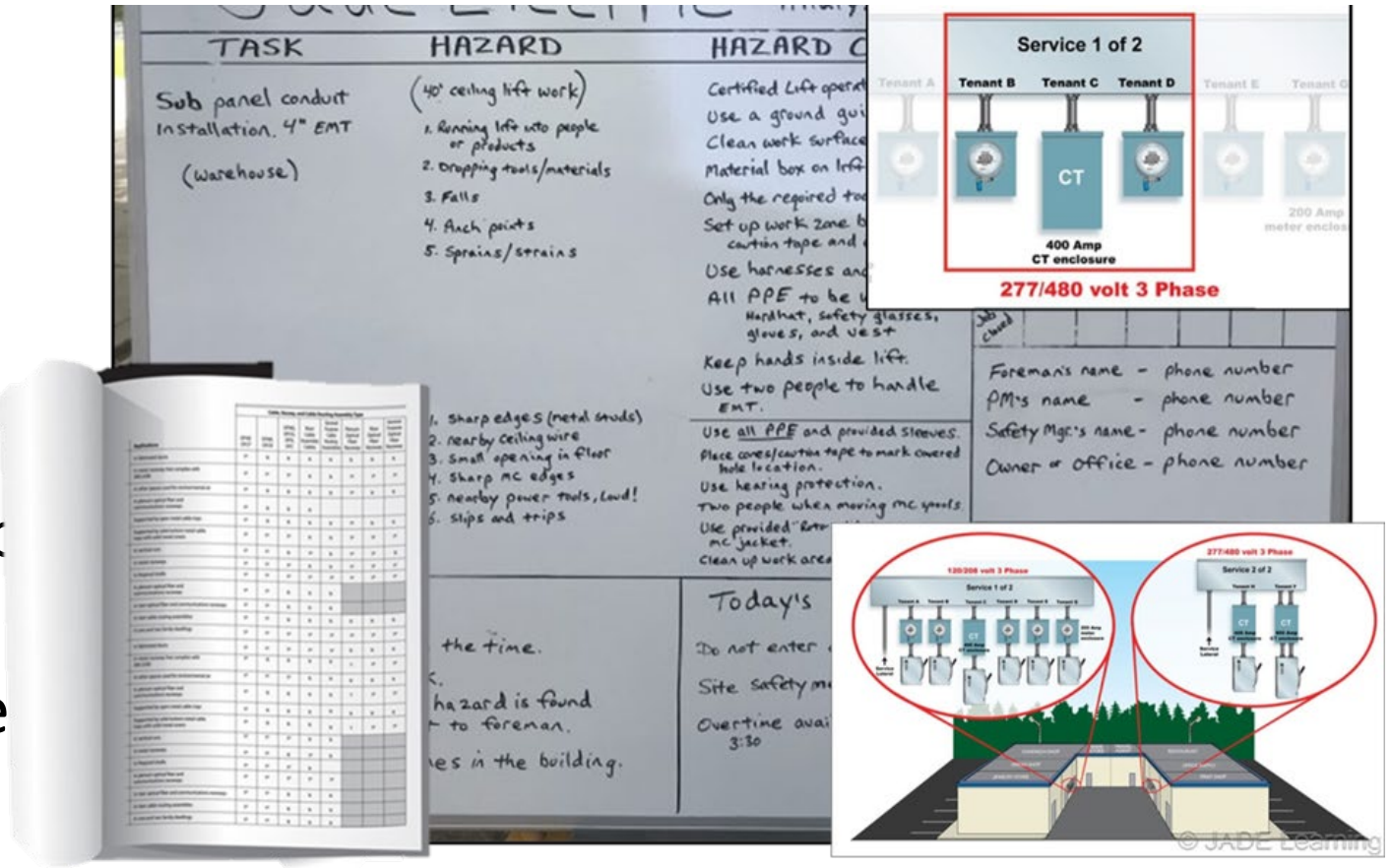
130.2 Energized Electrical Work Permit.

JADE LEARNING
A CERTUS COMPANY

5. Electric shock risk assessment results [see 130.4(A)], including:
   a. Voltage personnel will be exposed to.
   b. Limited approach boundary [see 130.4(F), Table 130.4(E)(a), and Table 130.4(E)(b)].
   c. Restricted approach boundary [see 130.4(G), Table 130.4(E)(a), and Table 130.4(E)(b)].
   d. Personal Protective Equipment (PPE) and other protective equipment required [see 130.4(F), 130.5(G), 130.7(C)(1) through (C)(15), and 130.7(D)].

130.2 Energized Electrical Work Permit.

6. Arc flash risk assessment results [see 130.5(A)].
7. All means used to restrict the entry of unqualified persons into work areas [see 130.8(O)].
8. Evidence of completion of a job briefing, including a discussion of any job-specific hazards [see 110.3(I)].
9. Energized work approval signatures.



An arc flash risk assessment and shock risk assessment must be performed for the work.

130.2 Energized Electrical Work Permit.

JADE LEARNING
A CERTUS COMPANY

(C) Exemptions to Work Permit.

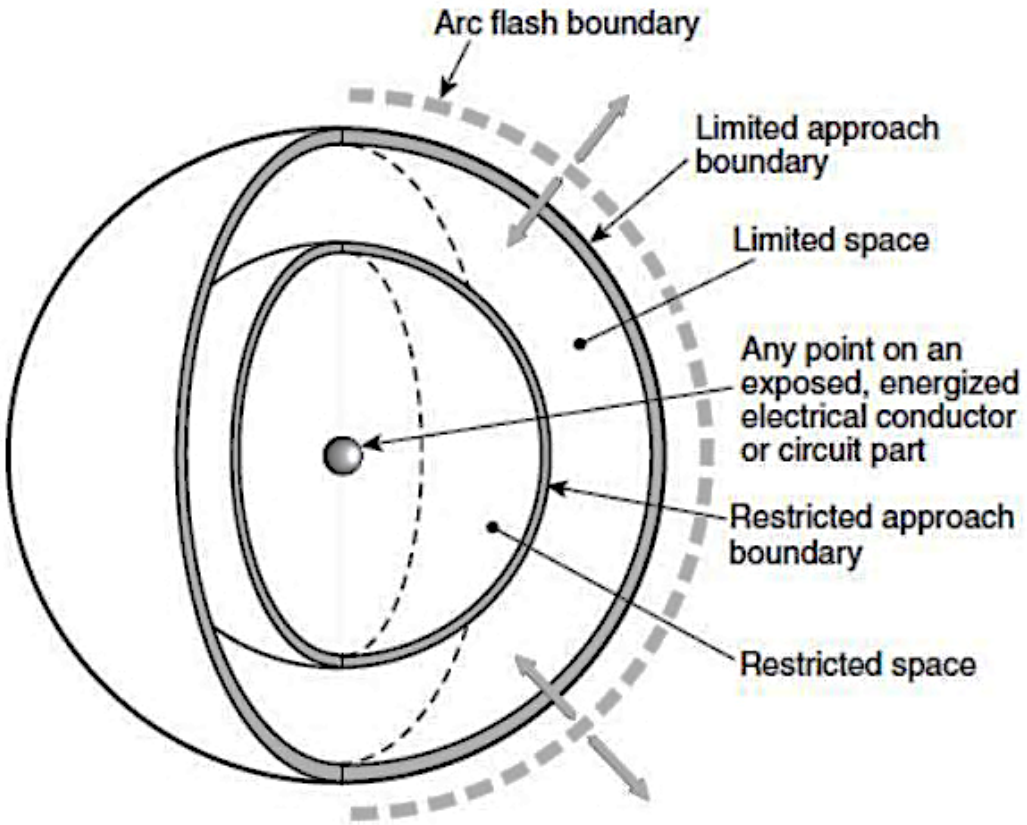
1. Testing, troubleshooting, or voltage measuring
2. Thermography, ultrasound, or visual inspections without crossing the restricted approach boundary
3. Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed
4. General housekeeping and miscellaneous non-electrical tasks without crossing the restricted approach boundary

130.4 Electric Shock Risk Assessment.

JADE LEARNING
A CERTUS COMPANY

Electric shock risk assessment guidelines provided in Sections 130.4(A to (G):

- Likelihood and severity of occurrence of injury or damage to health.
- The need for additional protective measures for personnel.
- Documentation requirements for a shock risk assessment.
- Shock protection boundaries.
- The limited approach boundary.
- The restricted approach boundary.

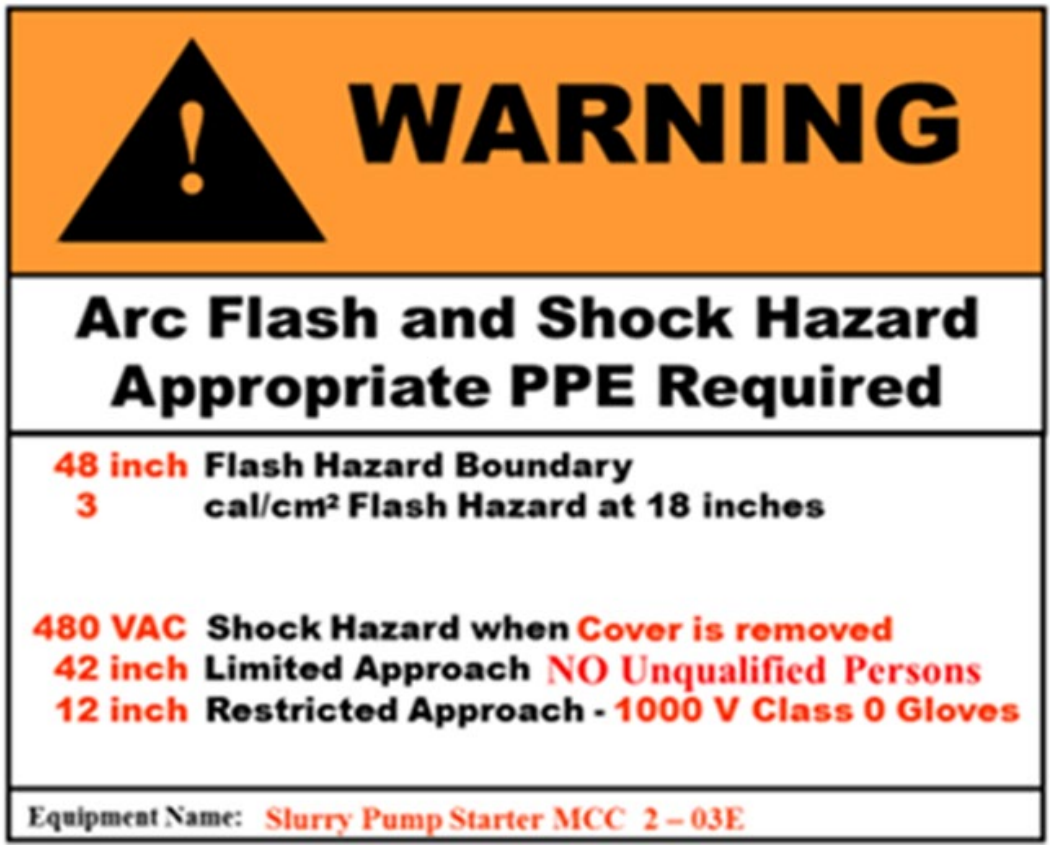


130.5 Arc Flash Risk Assessment.

JADE LEARNING
A CERTUS COMPANY

(A) General. An arc flash risk assessment must be performed:

- To identify arc flash hazards.
- To estimate the likelihood of occurrence of injury or damage and the potential severity of injury or damage.
- To determine if additional protective measures are required, including the use of PPE.



This equipment label warns workers that a flash hazard boundary exists within 48 inches of the equipment.

130.5 Arc Flash Risk Assessment.

JADE LEARNING
A CERTUS COMPANY

Sections ***130.5(B) through (H)*** provide the additional requirements for performing an arc flash risk assessment:

- Identify any additional protective measures needed based on the hierarchy of risk control identified in Section 110.3(H)(3).
- Determine the arc flash boundary.
- Determine arc flash personal protective equipment (PPE).
- Adhere to labeling requirements for electrical equipment such as switchboards, panelboards, control panels, meter socket enclosures, and motor control centers located in non-dwelling units.

130.5 Arc Flash Risk Assessment.

JADE LEARNING
A CERTUS COMPANY

Equipment must include :

- The nominal system voltage
- The arc flash boundary
- 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 Table 130.7(C)(15)(b) for the equipment, but not both*
  b. *Minimum arc rating of clothing*
  c. *Site-specific level of PPE*

Equipment labeling warns workers of dangerous electrical conditions.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(C) Personal Protective Equipment (PPE).

- **Section 130.7(C)(1)** requires workers within the restricted approach boundary to wear PPE according to Section 130.4.

[See the Informational Note concerning testing for voltage when incident energy exposure exceeds standard PPE ratings].

- **Section 130.7(C)(2)** requires that arc-rated clothing for workers must cover all other clothing capable of being ignited and allow for movement and visibility.
- **Sections 130.7(C)(3) through (C)(15)** address the types of PPE for protecting different parts of the body.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(C)(3), Head, Face, Neck, and Chin (Head Area) Protection.

Electrically nonconductive head protection is required where there is a danger of head injury from electric shock or burns or flying objects from electrical explosions.

An **Informational Note** states that arc flash protective requirements are addressed in 130.7(C)(10)(b) and (C)(10)(c).

Personal Protective Equipment (PPE) protects personnel from electrical hazards.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(4) Eye Protection.

(5) Hearing Protection.

(6) Body Protection.

Arc-rated clothing is required wherever there exists the possibility of exposure to an electric arc flash above the threshold incident energy level for a second-degree burn [1.2 cal/cm^2 (5 j/cm^2)].

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(7) Hand and Arm Protection.
Must be compliant with Sections 130.7(C)(7)(a), (C)(7)(b), and (C)(7)(c).

- Rubber insulating gloves with leather protectors and/or rubber insulating sleeves are required.
- The gloves **must be rated for the voltage** to which they will be exposed.

Rubber insulating gloves with leather protectors or rubber insulating sleeves are required wherever there is danger of hand or arm injury from electric shock.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(C)(8) Foot Protection.

Dielectric footwear must be worn wherever insulated footwear is used as electrical protection.

(9) Factors in Selection of Protective Clothing.

When protective clothing and equipment is required, it must be capable of protecting workers from both electric shock and arc flash hazards.

See additional guidelines in the NEC handbook.

Protective clothing must protect workers from both shock and arc flash hazards.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(10) Arc Flash Protective Equipment.

Arc flash suits must allow for rapid and easy removal by the user.

- Arc-rated hoods are required when incident energy exposure exceeds 12 cal/cm^2 (50.2 j/cm^2).
- Arc-rated face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area must be used.

An arc-rated balaclava can be used to protect the back of the head and neck.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(11) Clothing Material Characteristics.

Arc-rated clothing is required according to 130.7(C)(12) and 130.7(C)(14).

Fabrics, zipper tapes, and findings made from flammable synthetic materials that melt at temperatures below 600 degrees F cannot be used.

[Review this section's Informational Notes and Exception for more information on flammable materials and conditions where materials that melt can be permitted.]

130.7 Personal and Other Protective Equipment.

(12) Clothing and Other Apparel Not Permitted. Clothing and protective apparel that melt below 600°F or that are made from materials failing to meet flammability requirements are not permitted.

(13) Care and Maintenance of Arc-Rated Clothing and Arc-Rated Arc Flash Suits.

- Arc-rated apparel must be inspected before each use.
- Cleaning and repairs must be pursuant to the manufacturer's instructions.

The arc-rated arc flash suit must be inspected before each use.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(14) Standards for PPE.

- PPE must always conform to applicable state, federal, or local codes and/or standards.
- Suppliers or manufacturers of PPE must exercise product conformity with an appropriate product standard using one of the following methods:
    1. Self-declaration with a Supplier's Declaration of Conformity.
    2. Self-declaration under a registered quality management system and product testing by an accredited laboratory and a Supplier's Declaration of Conformity.
    3. Certification by an accredited independent third-party certification organization.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

For example, employees using rubber insulating gloves with a protection class ***designation of "00"*** would find the gloves approved for up to ***500 vac and 750 vdc***. A minimum distance would be required between the gauntlet and glove cuff of ***no less than ½ inch.***

This gauntlet extends no less than 2 inches past the cuff of this Class 2 glove.

TABLE 130.7(C)(7)(a) Maximum Use Voltage for Rubber Insulating Gloves

Class Designation of Glove or Sleeve	Maximum ac Use Voltage rms, volts	Maximum dc Use Voltage avg, volts	Distance Between Gauntlet and Cuff, minimum
00	500	750	13 mm (0.5 in.)
0	1,000	1,500	13 mm (0.5 in.)
1	7,500	11,250	25 mm (1 in.)
2	17,000	25,500	51 mm (2 in.)
3	26,500	39,750	76 mm (3 in.)
4	36,000	54,000	102 mm (4 in.)

130.7 Personal and Other Protective Equipment

Table 130.7(C)(7)(b), Rubber Insulating Equipment, Maximum Test Intervals: offers ***testing guidelines*** for the maintenance of rubber insulating equipment. Regular testing of equipment is required in accordance with the Table below:

TABLE 130.7(C)(7)(b) Rubber Insulating Equipment, Maximum Test Intervals

Rubber Insulating Equipment	When to Test
Blankets	Before first issue; every 12 months thereafter*
Covers	If insulating value is suspect
Gloves	Before first issue; every 6 months thereafter*
Line hose	If insulating value is suspect
Sleeves	Before first issue; every 12 months thereafter*

*New insulating equipment is not permitted to be placed into service unless it has electrically tested within the previous 12 months. Insulating equipment that has been issued for service is not new and is required to be tested in accordance with intervals in this table.

130.7 Personal and Other Protective Equipment

Table 130.7(C)(14), Informational Note: Standards for PPE. This table provides workers with up to 21 different document titles approved by NFPA 70E for expanding on electrical-safety-related topics, such as:

- *Standard Performance Specifications for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arc.*
- *Standard Specification for Personal Climbing Equipment.*
- *Standard Test Methods for Foot Protections*.

Table 130.7(C)(15)(a), Arc Flash PPE Categories for Alternating Current (ac) Systems. This table addresses arc-flash PPE categories 1-4, along with arc flash boundaries that must be adhered to around certain types of ac (alternating current) powered equipment.

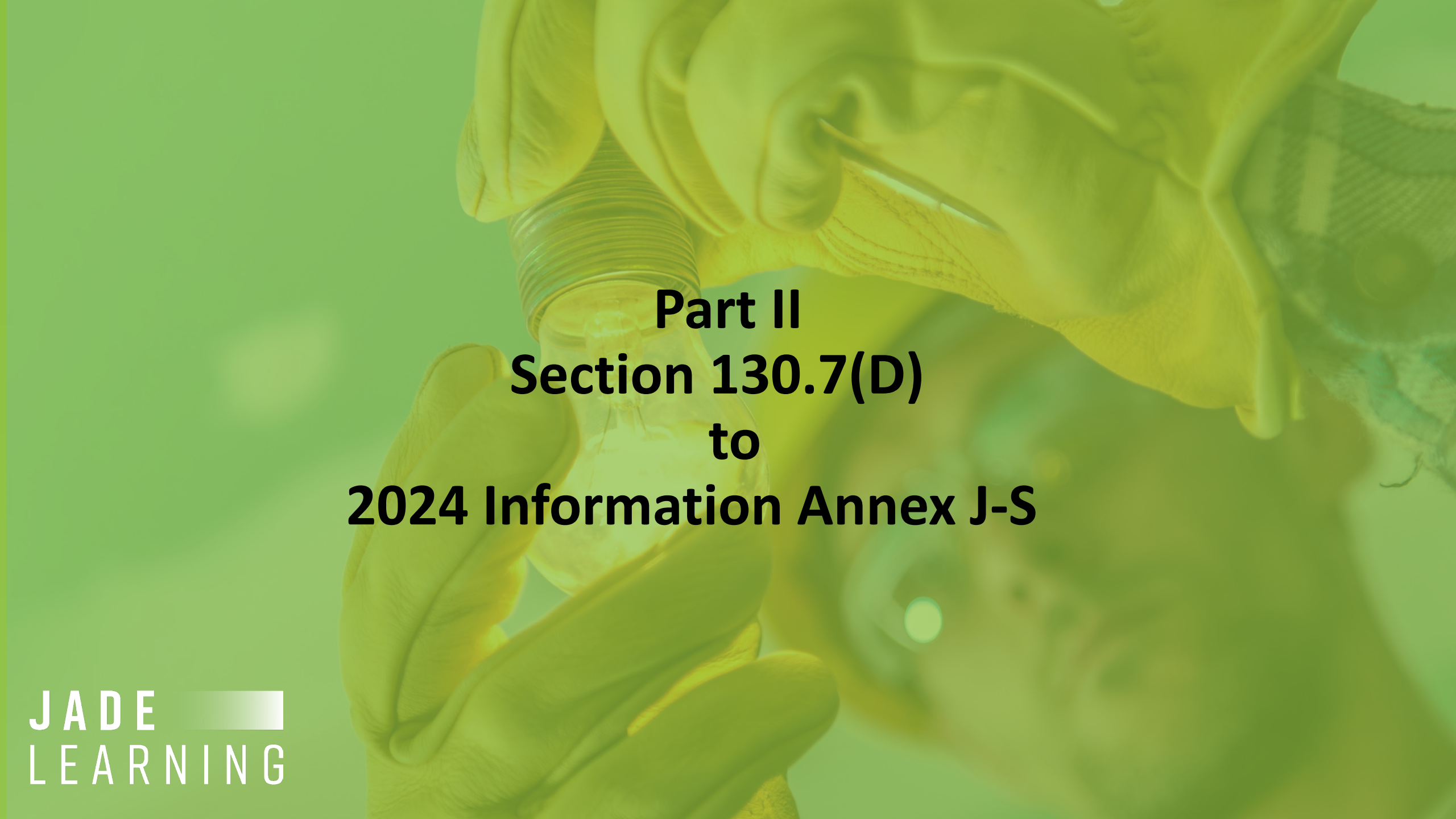
130.7 Personal and Other Protective Equipment

JADE LEARNING
A CERTUS COMPANY

Table 130.7(C)(15)(b) addresses arc-flash PPE categories 2-4, along with arc flash boundaries.

Table 130.7(C)(15)(c) lists for workers the appropriate type(s) of PPE to be used in Arc-Flash PPE Categories 1, 2, 3, and 4.

- As the arc-flash PPE category increases, the minimum arc rating for clothing also increases.
- Tables 130.7(C)(15)(a) and (b) specify the **arc-flash PPE category** applicable to the equipment being serviced, while Table 130.7(C)(15)(c) indicates what ***apparel is approved*** for that category.



Part II
Section 130.7(D)
to
2024 Information Annex J-S

JADE LEARNING

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

D(1) Insulated Tools and Equipment. Tools used within the restricted approach boundary must be **insulated and protected** from damage to the insulating material. Requirements for insulated tools and equipment:

(a) Requirements for Insulated Tools: must be rated for the applicable voltage, constructed to withstand the environment and use conditions, and inspected before use.

Insulated tools and a barrier rated to withstand up to 1000 volts.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(b) Fuse or Fuseholder Handling Equipment. When removing/installing a fuse where fuse terminals are live, fuse handling equipment must be rated for the appropriate voltage.

(c) Ropes and Handlines.

(d) Fiberglass-Reinforced Plastic Rods. Live-line tools using fiberglass-reinforced plastic rods or tubes must meet all applicable state, federal, or local codes.

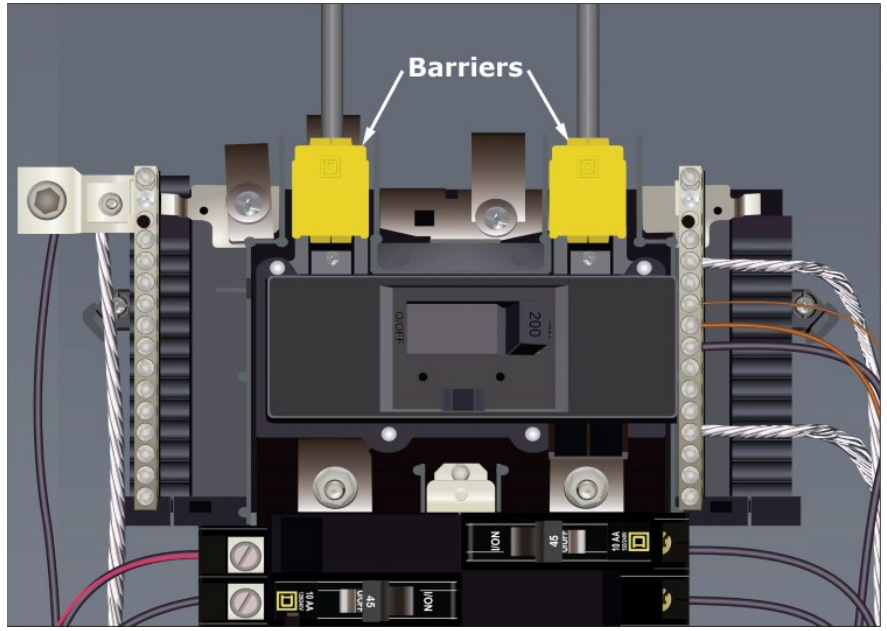
(e) Portable Ladders.

Fuse handling equipment such as a fuse puller must be rated for the appropriate voltage.

130.7 Personal and Other Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

(D)(2). Barriers: required for guarding energized electrical conductors and circuit parts operating at 50 volts or more. *Barriers must comply with Sections 130.7(D)(2)(a) – 130.7(D)(2)(c).*



(b) Voltage-Rated Plastic Guard Equipment.

(c) Physical or Mechanical Barriers.

Physical or mechanical barriers must be installed no closer than the restricted approach boundary specified in Tables 130.4(E)(a) and 130.4(E)(b).

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(A) Alertness.

Sections 130.8(A)(1)-(3) instruct all employees to exercise **alertness** when confronted with the following situations:

1. **Where Electrical Hazards Might Exist**.
2. **When Impaired**.
3. **Changes in Scope**.

(B) Blind Reaching. Employees should not reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

Blind Reaching

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(C) Illumination.

Employees must be provided adequate illumination to enter spaces with electrical hazards. They must not perform any task without adequate illumination.

(D) Conductive Articles Being Worn.

Conductive articles of jewelry and clothing must not be worn within the equipment's restricted approach boundary.

The metal parts of this watchband act as an electrical conductor when worn around energized electrical conductors or circuit parts.

130.8 Other Precautions for Personnel Activities.

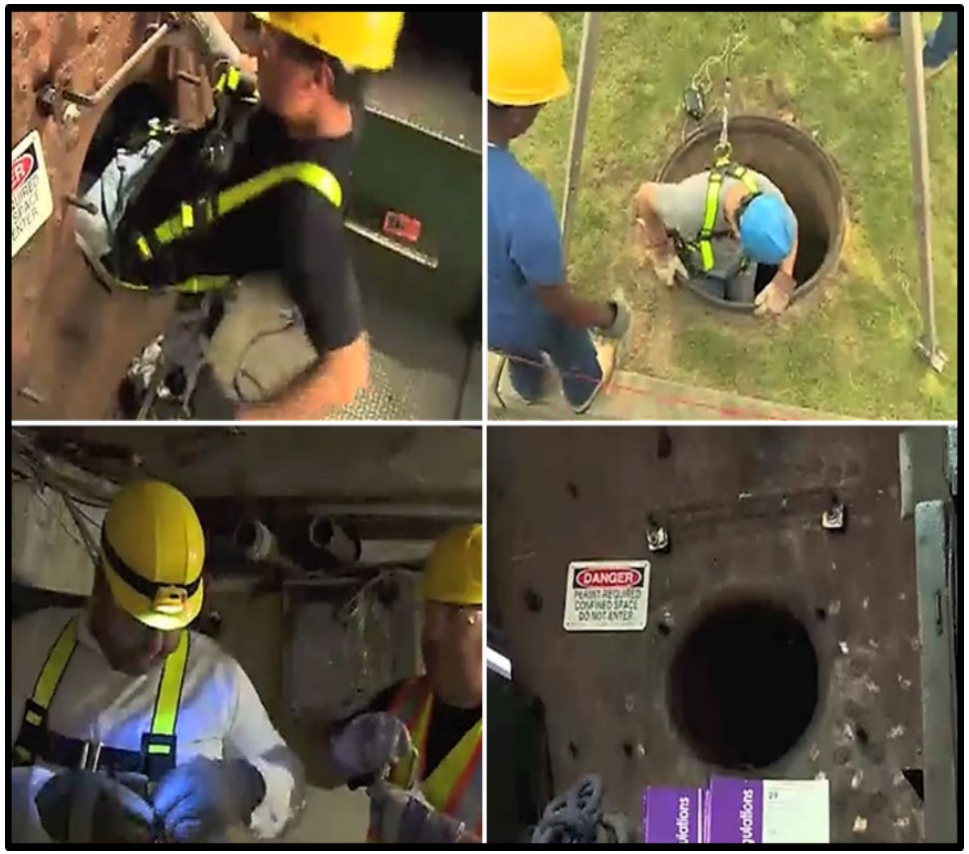
JADE LEARNING
A CERTUS COMPANY

(E) Conductive Materials, Tools, and Equipment Being Handled.

Conductive materials must be handled carefully and no closer to exposed conductors than permitted in 130.4 (F) to prevent accidental contact with energized conductors.

(F) Confined or Enclosed Work Spaces.

Employers must provide (and employees must use) protective shields, barriers, and insulating materials when working in confined or enclosed spaces.



Confined or Enclosed Work Spaces

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(G) Doors and Hinged Panels. Doors, hinged panels, and similar parts must be properly secured to prevent them from pushing employees into contact with any energized electrical conductors or circuit parts.

(H) Clear Spaces. All working space required by other codes and standards must be kept clear and must not be used for storage.

Loose Panel

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(I) Housekeeping Duties.

Employees must not perform housekeeping duties within the limited approach boundary unless safeguards are provided to prevent contact.
Electrically conductive cleaning materials are prohibited within the limited approach boundary.

(J) Occasional Use of Flammable Materials. Where flammable materials are present only occasionally, electric equipment capable of igniting them must not be permitted to be used, unless measures are taken to prevent hazardous conditions.

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(O) Alerting Techniques.

(1) Safety Signs and Tags.

- Safety signs, symbols, or tags must be used where necessary to warn employees about electrical hazards which may endanger them.
- Such signs and tags must meet the requirements of applicable state, federal, or local codes and standards.

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(2) Barricades.

- Barricades must be used in conjunction with safety signs where it is necessary to prevent/limit employee access.
- Where conductive barricades may increase the likelihood of hazard, a nonconductive barricade must be used.
- Barricades must be no closer than the **limited approach boundary** given in Tables 130.4(E)(a) and 130.4(E)(b).

130.8 Other Precautions for Personnel Activities.

JADE LEARNING
A CERTUS COMPANY

(3) Attendants.

- If signs and barricades do not provide sufficient warning, an attendant must be stationed to protect employees.
- The responsibility of the attendant assigned to manually alert employees is to prevent **unqualified employees from entering work areas** where they may encounter electrical hazards.
- The attendant must remain **in the work area** as long as there is potential for employees to be exposed to the electrical hazards.

Attendant

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

JADE LEARNING
A CERTUS COMPANY

(1) Uninsulated and Energized.

Precautions must be taken to prevent employee contact hen work is performed near uninsulated energized overhead lines.

If contact with uninsulated energized overhead lines is possible, they must be **de-energized** and **visibly grounded** at the point of work or suitably guarded.

Uninsulated overhead electrical lines present a hazard to workers.

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

JADE LEARNING
A CERTUS COMPANY

(B) Determination of Insulation Rating.
A qualified person must inspect the insulation of overhead lines before any work begins.

(C) De-energizing or Guarding.

Arrangements must be made with the authority regulating the overhead lines to **de-energize/ground** them at the point of work.

(D) Employer and Employee Responsibility. Both employers and employees share the responsibility of ensuring that all protective measures are taken.

Employees must use established work procedures and proper PPE.

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

(E) Approach Distances for Unqualified Persons. See the **limited approach boundary** of the lines, as presented in Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2.

(F) Vehicular and Mechanical Equipment When Elevating Equipment. Any vehicle or mechanical equipment structure being elevated near overhead lines must stay outside of the **limited approach boundary distances** provided in Table 130.4(E)(a)—column 2, or Table 130.4(E)(b)—column 2.

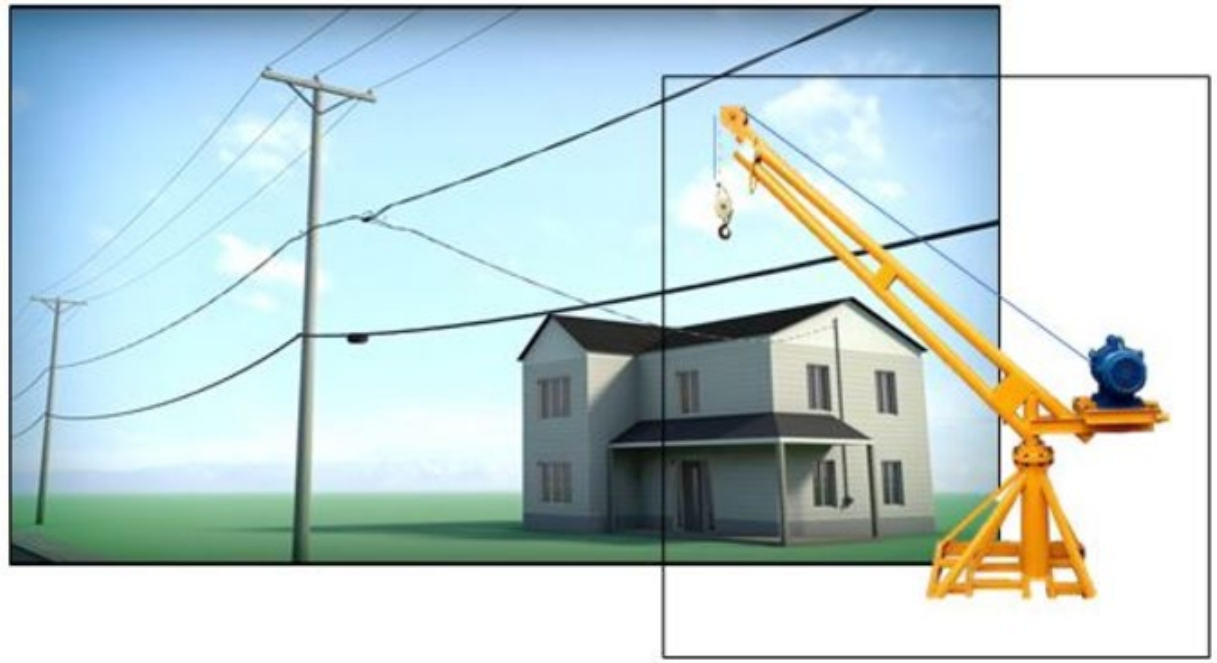
(2) Avoiding the Contact. Employees on the ground **must not contact** vehicles, mechanical equipment, or any of its attachments unless either of the conditions in **Sections 130.9(F)(2)(1)** or **(F)(2)(2)** apply.

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

JADE LEARNING
A CERTUS COMPANY

(3) Grounding the Equipment.

- Employees on the ground near elevated equipment **must avoid the grounding point** if there's a possibility of contact with the lines.
- Precautions, such as barricades, dielectric overshoes, or insulation, must be taken to protect employees from hazardous ground potentials (**step and touch potential**).



Safety-Related Maintenance 200.1 Scope.

JADE LEARNING
A CERTUS COMPANY

Chapter 2 covers practical ***safety-related maintenance requirements*** for electrical equipment and installations in workplaces as indicated by 90.3(A).

Maintenance: work performed to preserve or restore the condition of electrical equipment and installations for the safety of employees exposed to electrical hazards.

- Requirements identify ***only maintenance*** directly associated with employee safety.

- Employers choose the maintenance: Chapter 2 ***does not prescribe*** specific maintenance methods/test procedures for meeting the standard.

205 General Maintenance Requirements.

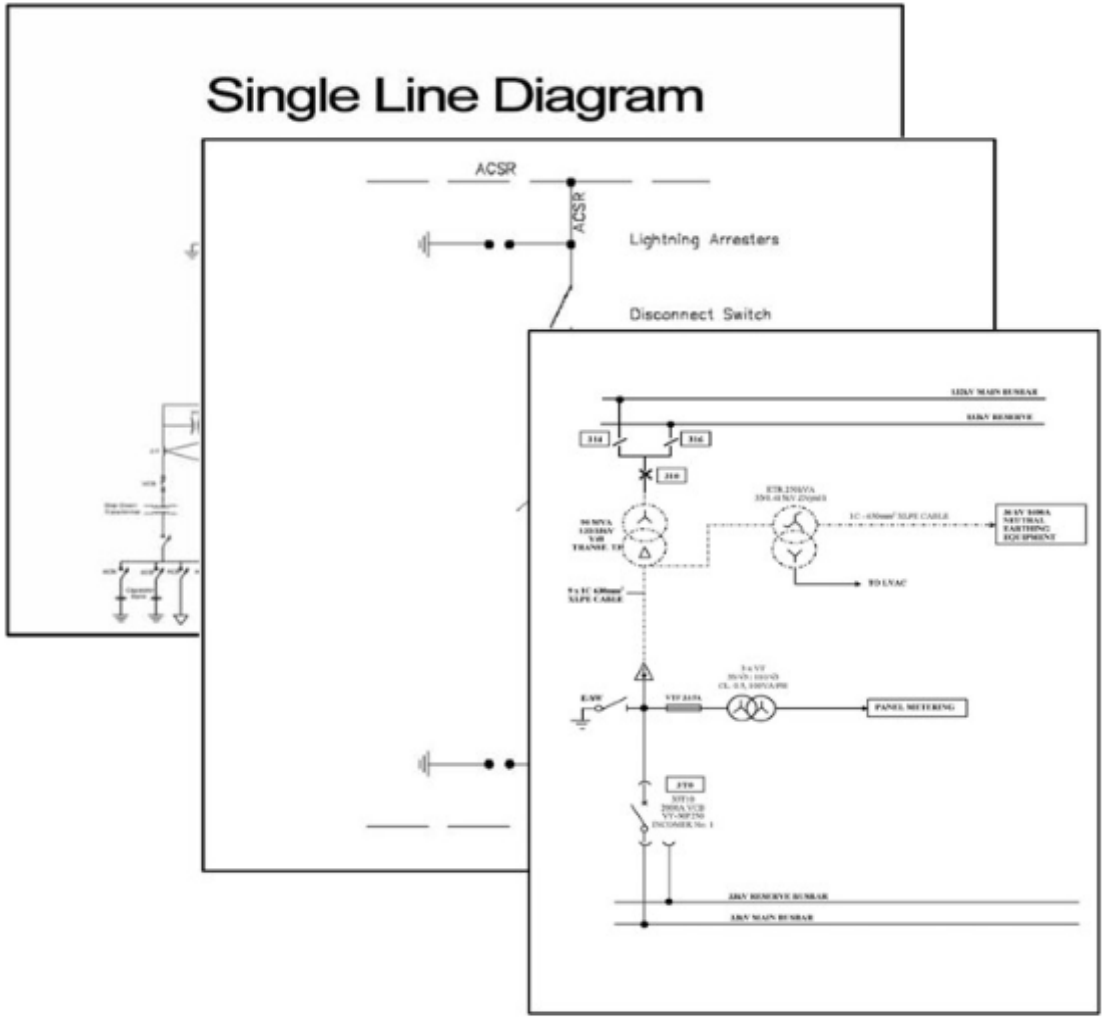
JADE LEARNING
A CERTUS COMPANY

205.2 Qualified Persons.

Employees who perform maintenance must be ***qualified persons*** and trained in procedures and/or testing methods included in the maintenance.

205.3 Single-Line Diagram.

Where a single-line diagram is kept for any electrical system,
it must be ***current and legible***
for those who may require it.



205 General Maintenance Requirements.

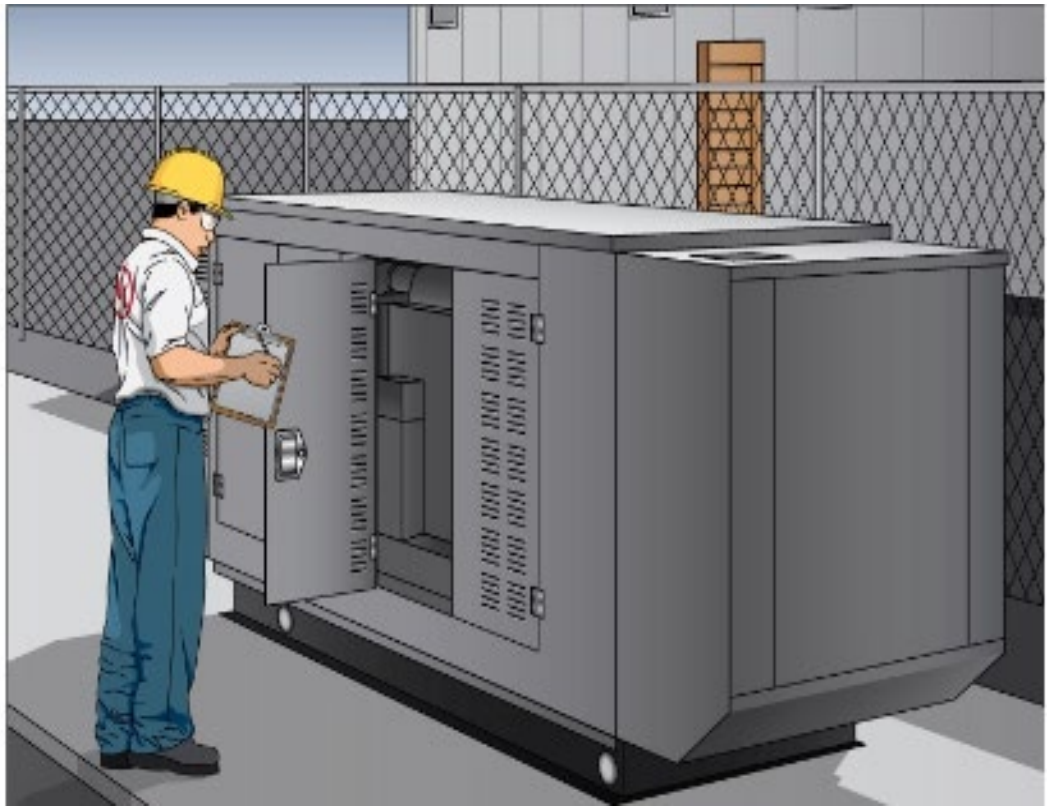
JADE LEARNING
A CERTUS COMPANY

205.4 General Maintenance Requirements.

Electrical equipment must be maintained according to the manufacturer's instructions or the industry standard to reduce safety risks.

205.5 Overcurrent Protective Devices.

Overcurrent devices must be maintained according to the manufacturer or the industry standard and documented.



Properly performed regular equipment maintenance can allow for years of safe and reliable service.

205 General Maintenance Requirements.

205.6 Spaces About Electrical Equipment. Applicable electrical codes as well as any other applicable standards declaring working space clearance requirements around electrical equipment must be followed.

205.7 Grounding and Bonding. Grounding and bonding components and connections **must be maintained** to ensure electrical continuity of all applicable equipment.

Grounding connections must be maintained.

205 General Maintenance Requirements.

JADE LEARNING
A CERTUS COMPANY

205.8 Guarding of Energized Conductors and Circuit Parts.

Enclosures must be maintained to guard against accidental contact with exposed energized conductors, circuit parts, and other electrical hazards.

Equipment covers and doors must be in place with fasteners and latches secured.

205.9 Safety Equipment.

Locks, interlocks, and other safety equipment must be maintained in proper working condition to accomplish the control purpose.

205 General Maintenance Requirements.

JADE LEARNING
A CERTUS COMPANY

205.10 Clear Spaces. All access and openings leading to and from equipment working spaces and any other recognized escape or egress passages must be kept **clear of obstructions.**

205.11 Identification of Components. Safety-related instructions for equipment operation or maintenance must be securely attached and maintained so **they remain legible**.

210 Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switches.

JADE LEARNING
A CERTUS COMPANY

210.1 Scope.

This article covers NFPA 70E recognized, safety-related maintenance requirements for:

- Substations
- Switchgear Assemblies
- Switchboards
- Panelboards
- Motor Control Centers
- Disconnect Switches

Article 210 maintenance standards apply to solar PV system disconnects

210 Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switches.

210.2 Enclosures.
Enclosures must be free of material that would expose employees to an electrical hazard.

210.3 Area Enclosures.
Fences, physical protection, enclosures, or other protective means must be regularly maintained.

Electrical enclosures keep employees away from electrical hazards

210 Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switches.

210.4 Conductors.

All current-carrying conductors, as well as buses, switches, disconnects, joints, terminations, and bracing, must be maintained to be able to **conduct (carry)** rated current without overheating; it must **withstand** the calculated available fault-current.

210 Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switches.

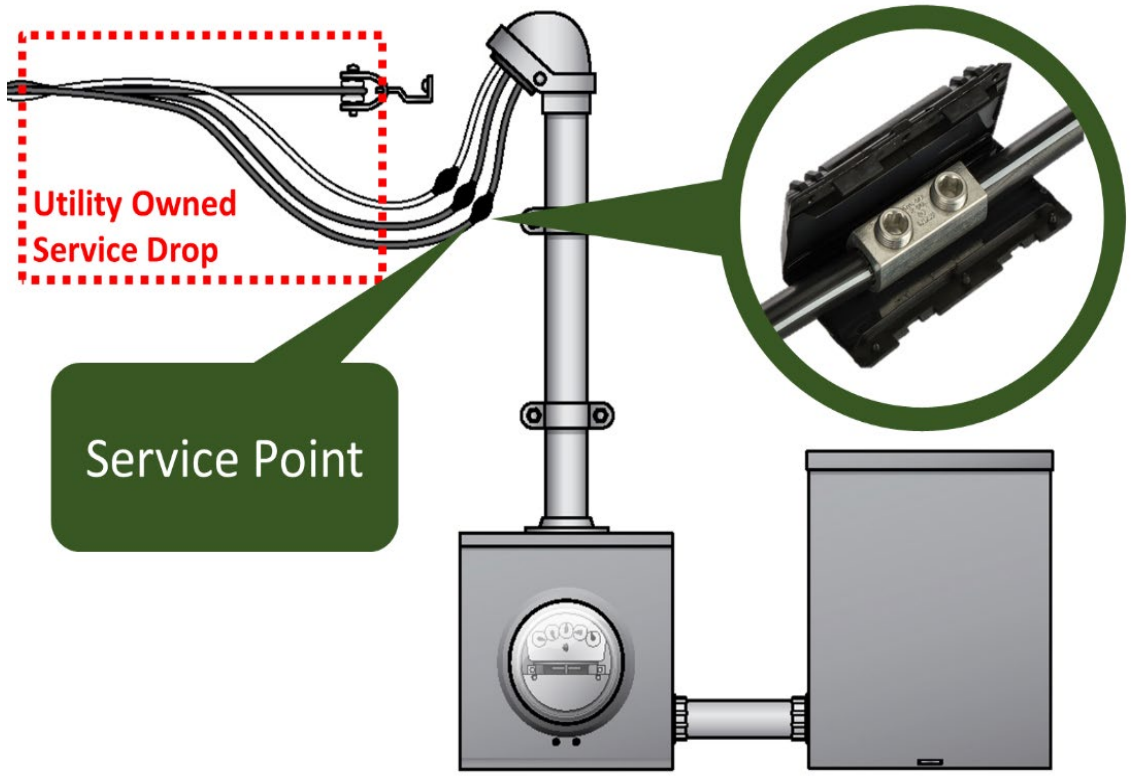
210.5 Insulation Integrity.
Integrity of a conductor's insulation must be maintained to support the **voltage impressed**.

210.6 Protective Devices. All protective devices installed for circuits and equipment must be maintained to **withstand or interrupt** available fault currents that may occur during a fault.

215 Premises Wiring.

215 outlines maintenance requirements—but ***only as they pertain to premises wiring***.

- **Premises wiring** refers to all wiring on the property ***after*** the utility provider's wiring ends *and the property owner's wiring begins.*
- **Service point** is the point where ownership of the wiring transfers from the utility provider to the property owner.



215 Premises Wiring.

215.2 Covers for Wiring System Components.

All wiring system component covers must be installed with all required hardware—**no openings** are uncovered or unprotected.

215.3 Open Wiring Protection.

All types of protection used to separate personnel from open wiring must be maintained to prevent unintentional contact.

215.4 Raceways and Cable Trays.

Raceways and cable trays must be maintained to provide physical protection and support for conductors.

Cable trays must be maintained to provide support and protection.

220 Controller Equipment.

JADE LEARNING
A CERTUS COMPANY

Scope. 220 covers required maintenance for controllers, including electrical equipment used for starting, stopping, directing motion, acceleration, and protection of rotating equipment.

The most common controller is the **motor controller**; it comes in different types:

- **AC (alternating current) motor controllers**
- **DC (direct current) motor controllers**
- **Stepper motor controllers**
- **Servo motor controllers**

A basic motor rotates to move light or heavy loads at various speeds and typically in two directions.

220 Controller Equipment.

JADE LEARNING
A CERTUS COMPANY

AC (alternating current) Motor Controllers.
They are commonly known as ***variable speed drives*** (VSD).
These drives adjust the ***frequency*** of the power supplied to the motor.

In the U.S., the standard electrical frequency is ***60 hertz*** (Hz).
By reducing that frequency to 30 Hz with a VSD, the motor's speed is ***decreased*** without increasing the required current or overheating the motor.

An ac motor controller

220 Controller Equipment.

JADE LEARNING
A CERTUS COMPANY

DC (direct current) Motor Controllers can be a simple two-wire brushed motor controller type that ***reduce voltage*** to slow motor speeds and ***reverse voltage*** to change rotation.

These controllers typically use ***pulse width modulation*** (PWM) for speed control.

A dc brushless motor controller.

220 Controller Equipment.

JADE LEARNING COMPANY

Stepper Motor Controllers.

They modify the **input signal** to the motor using pulse control. With electromagnets surrounding a central gear, the pulsed power allows rotation from one electromagnet to the next for **steps of movement**.

Servo Motor Controllers.

They usually consist of power, ground, and control wiring and can be **ac or dc driven**. Servo motors and controllers are used for applications requiring **precise movement**, such as robotics that demand micro-positioning of components. These motors can be fast with high torque and precise accuracy.

220.2 Protection and Control Circuitry.

All protection and control circuitry used for guarding workers against unintentional contact with exposed energized conductors and circuit parts must be maintained.

225 Fuses and Circuit Breakers.

JADE LEARNING
A CERTUS COMPANY

Fuse: a cartridge fuse, commonly found in a **30-amp** fused air-conditioning disconnect, is a tube or cylinder-shaped cartridge featuring exposed metal contacts on both ends and an insulated conductive filament inside.

The **filament** connects the exposed metal ends and is rated to withstand a predetermined amount of electrical current.

Inserted in series with the ungrounded conductor feeding the equipment, the fuse interrupts the conductive path whenever **damaging overcurrent** flows through the conductor.

Cartridge Fuse

225 Fuses and Circuit Breakers.

JADE LEARNING
A CERTUS COMPANY

225.2 Fuses.

Fuses must be maintained, which includes visual inspection to ensure the fuse cases, ferrules, and insulators are free from breaks or cracks.

The clips that secure fuses and contact the exposed metal parts can be regularly inspected to ensure adequate contact is maintained.

Current-limiting fuse holders must not be modified to accommodate non-current-limiting fuses, and vice versa.

Cartridge Fuse

225 Fuses and Circuit Breakers.

JADE LEARNING
A CERTUS COMPANY

Section 240.6(A) Fuses and Fixed Trip Circuit Breakers.

The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 240.6(A). Additional standard ampere ratings for fuses shall be 1, 3, 6, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

Section 240.4(B), Overcurrent Devices Rated 800 Amperes or Less.

The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the conditions in 240.4(B)(1) through (3) are met.

225 Fuses and Circuit Breakers.

JADE LEARNING
A CERTUS COMPANY

225.3 Molded-Case Circuit Breakers.

Molded-case circuit breakers must be maintained, including visual inspections to ensure the casing is free from cracks and the operating handles are not cracked or broken.

225.4 Circuit Breaker Testing After Electrical Faults.

Circuit breakers must be inspected and tested according to the manufacturer's instructions whenever they trip at fault current levels near their declared interrupting rating.

This molded case circuit breaker (MCCB) includes adjustable trip mechanisms enabling it to carry a smaller or larger number of amps.

230 Rotating Equipment.

JADE LEARNING
A CERTUS COMPANY

230.2 Terminal Boxes must be maintained to guard against unintentional contact with exposed energized conductors and circuit parts and other electrical hazards.

Maintaining an enclosure housing rotating equipment means ensuring the following:

- removable panels and covers are in place.
- hardware is tightly secured.
- Continuity of bonding is maintained between metal panels, covers, and the motor housing/is not weakened due to equipment vibration.

Terminal enclosures belonging to rotating equipment must prevent personnel from making unintentional contact with energized parts.

230 Rotating Equipment.

JADE LEARNING
A CERTUS COMPANY

230.3 Guards, Barriers, and Access Plates. All equipment guards, barriers, and access plates belonging to rotating equipment must be maintained to prevent employees from contacting moving or energized parts.

- Performing a visual inspection is an essential part of carrying out the NFPA 70E prescribed rotating equipment maintenance.

Threadlocker plays a big part in maintaining tight equipment hardware and parts.

235 Hazardous (Classified) Locations.

JADE LEARNING
A CERTUS COMPANY

235.1 Scope: hazardous (classified) locations [see informational notes]

235.2 Maintenance Requirements for Hazardous (Classified) Locations. Energized parts not permitted to be exposed—except for **intrinsically safe** and **nonincendive circuits**.

- Conduits, fittings, and enclosures must not have breaks.
- Bonding jumpers must be securely fastened and intact.

Employee safety-related maintenance is prescribed for electrical equipment with moving parts. Care must be taken when performing maintenance around moving parts.

235 Hazardous (Classified) Locations.

- All entries into fittings, boxes, or enclosures capable of compromising protection must be properly sealed.
- Closeup plugs, seals, breathers, and drains must be in place and secure.
- Maximum wattage and temperature ratings permitted for luminaires must be marked and legible and cannot be exceeded.

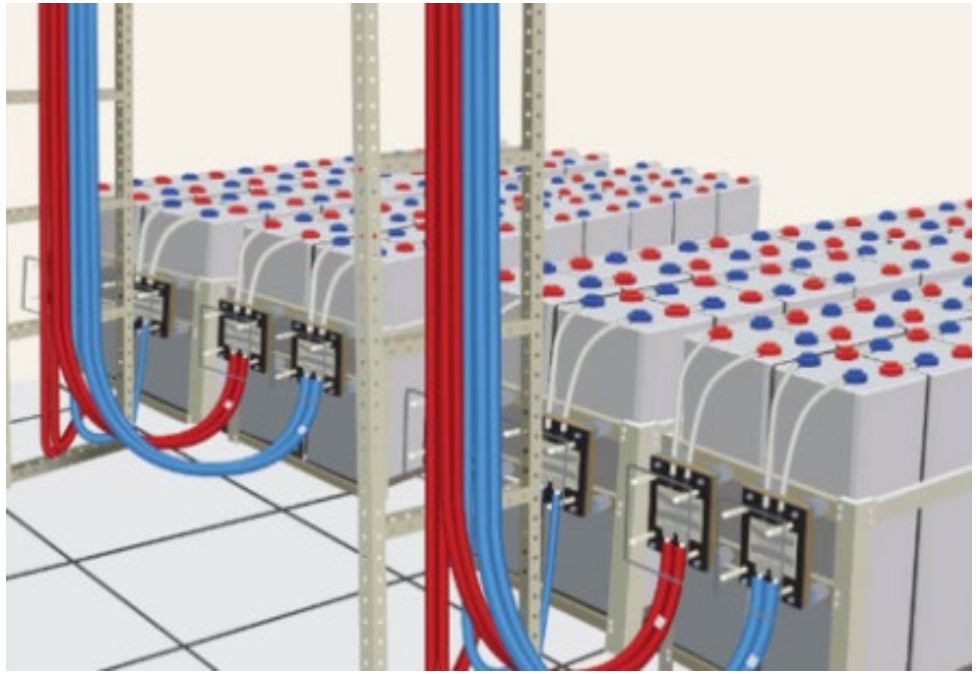
Bolts belonging to covers for fittings, boxes, or enclosures must be installed and tight.

240 Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

240.1 Scope: safety-related maintenance requirements for batteries and battery rooms.

Types of Batteries. Storage batteries consist of one or more rechargeable cells made from materials like lead-acid or nickel-cadmium.
Wet-cell (flooded) batteries need regular distilled water added due to water loss during normal use, while sealed batteries do not require water addition under normal conditions.



Batteries consist of one or more rechargeable cells connected in series, parallel, or a combination of both.

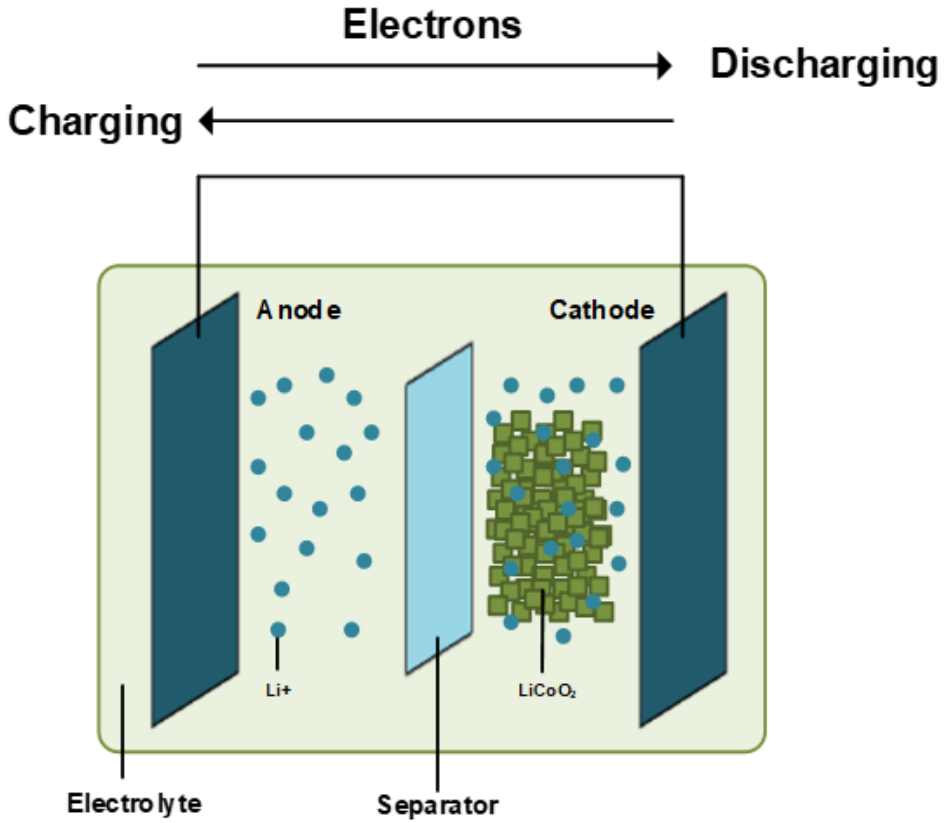
240 Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

Parts of a Battery. A battery consists of **cells** with 2 poles made of different conductive metals, one negatively charged, the other positively charged. These metals act as the **cathode** and **anode**, depending on current flow.

The substance between the cathode/anode is called the **electrolyte**; it insulates electrons but allows ions to move between the poles.

Movement of ions is part of the **chemical reaction** needed for batteries to store and release energy.



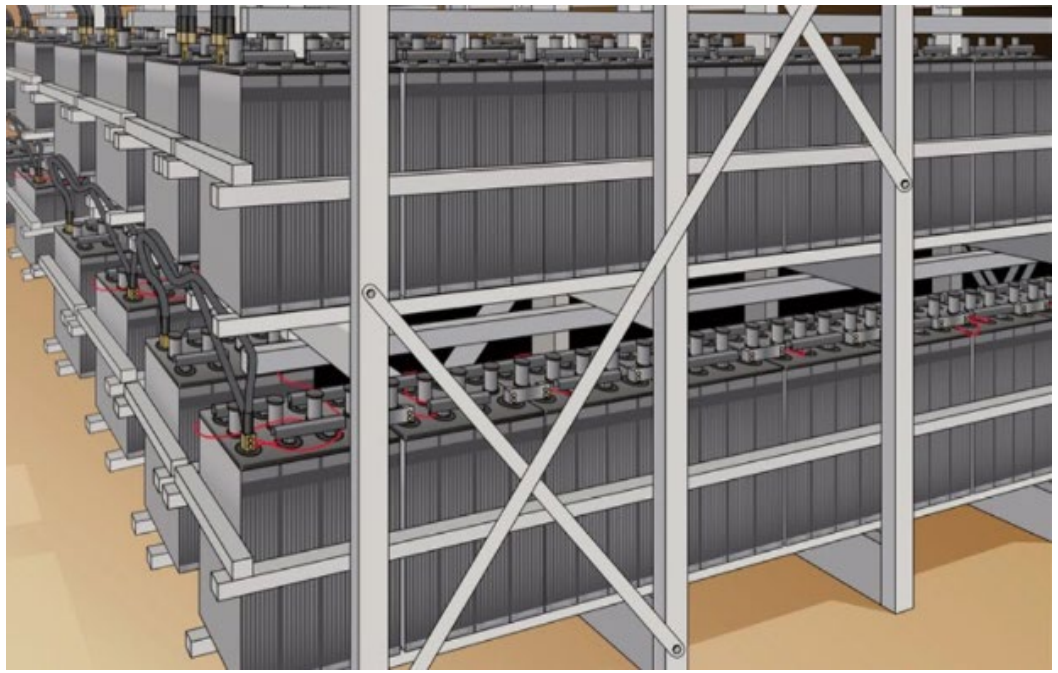
Parts of a Battery

240 Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

Battery Maintenance.

- Battery systems maintenance includes checking racking systems, casings, terminals, ventilation ports, cables, and terminations.
- Maintenance involves ensuring proper torque of cable connections, cleaning corrosion, and refilling.
- Lead-acid batteries release **hydrogen gas** during recharging, and proper ventilation prevents buildup of volatile gases around batteries and in battery rooms.



Battery maintenance involves checking cable termination torque to prevent loose connections from expanding and contracting metals and cleaning corrosion from terminals as needed.

240 Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

240.2 Ventilation.

When forced or natural ventilation systems are required by the battery system design and are present, they must be maintained to prevent buildup of explosive mixtures.

240.3 Eye and Body Wash Apparatus.

All apparatus performing eye and/or body wash functions in or around batteries or battery rooms must be maintained in operable condition.

This will require regular inspections and cleaning of wash station system parts.

Battery room eye and body wash apparatus must be maintained in operable condition.

245 Portable Electric Tools and Equipment.

JADE LEARNING
A CERTUS COMPANY

245.1 Scope.

This article addresses safety-related maintenance requirements for portable electric tools and portable electric equipment.

245.2 Maintenance Requirements for Portable Electric Tools and Equipment.

Attachment plugs, receptacles, cover plates, and cord connectors must be maintained so they meet specific following criteria.

Portable cord-and-plug connected electric tools includes any component with tool-like capabilities and equipped with a cord that connects to a utilization outlet.

245 Portable Electric Tools and Equipment.

JADE LEARNING
A CERTUS COMPANY

245.2 Maintenance Requirements for Portable Electric Tools and Equipment.

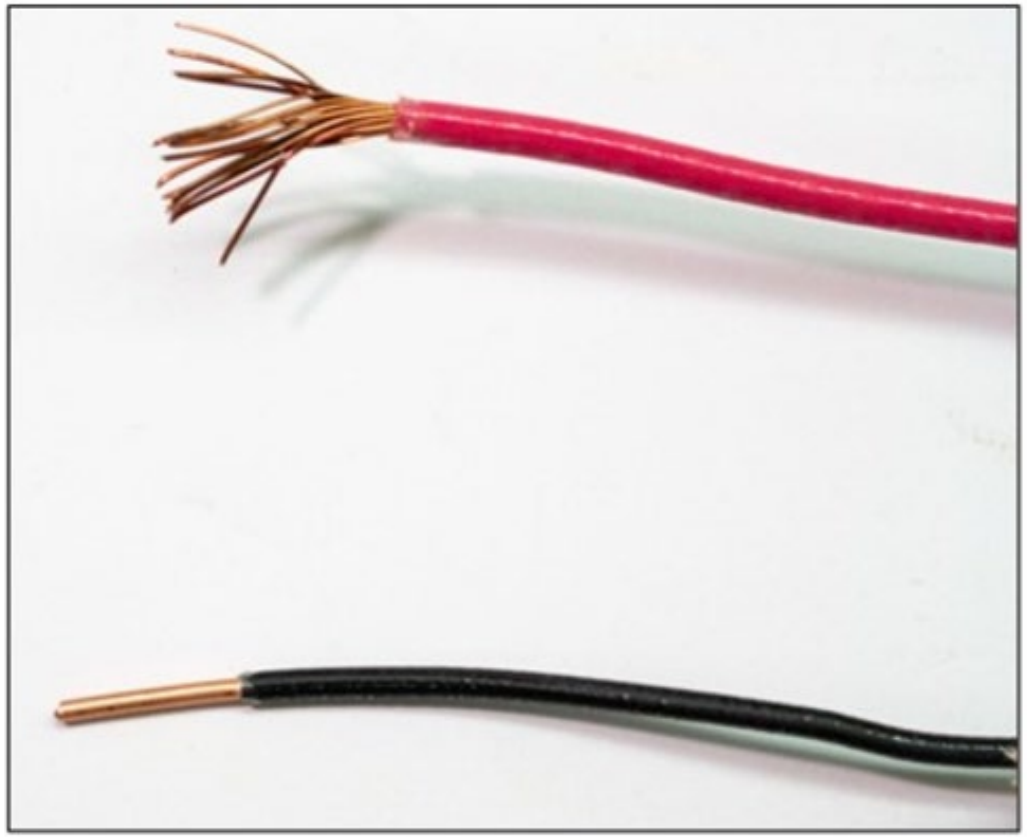
(1) No breaks, damage, or cracks exposing energized conductors and circuit parts.

(2) No missing cover plates.

(3) No stray strands or loose terminals.

(4) No missing, loose, altered, or damaged blades, pins, or contacts.

(5) Polarity is correct.



Stray conductor strands present a hazard to personnel.

250 Personal Safety and Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

250.1 Scope: maintenance of a worker's safety and protective equipment.

250.2 Maintenance Requirements for Personal Safety and Protective Equipment.

Personal safety and protective equipment for workers such as the following must be maintained in a safe working condition:

1. Grounding equipment
2. Hot sticks (live line tools)
3. Rubber gloves, sleeves, and leather protectors
4. Test instruments

Rubber gloves, sleeves, and leather protectors guard the hands and arms of employees working with energized electrical equipment.

250 Personal Safety and Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

5. Blanket and similar insulating equipment
6. Insulating mats
7. Protective barriers
8. External circuit breaker rack-out devices
9. Portable lighting units
10. Temporary protective grounding equipment
11. Dielectric footwear
12. Protective clothing
13. Bypass jumpers
14. Insulated and insulating hand tools

Protective clothing may include wearing PPE from head to toe.

250 Personal Safety and Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

250.3 Inspection and Testing

(A) Visual. A visual inspection must be performed to check for damages and defects before first using safety and protective equipment. Subsequent inspections must not exceed one year unless specified otherwise by applicable state, federal, or local codes.

(B) Testing.
For protective equipment and tools listed in Sections 250.2(1) through 250.2(14), the insulation used as primary protection against electrical shock must be verified by the appropriate test and visual inspection to verify its integrity before initial use. Verification and inspection shall in no case exceed 3-year intervals.

250 Personal Safety and Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

250.4 Safety Grounding Equipment.

(A) Inspection. Personal protective ground cable sets must be inspected for cuts and damage to the conductors. Inspections must be made before equipment is put into service and at intervals not to exceed one year thereafter.

(B) Testing.

Temporary protective grounding equipment that has undergone any repair must be tested before it is returned to service.

(C) Grounding and Testing Devices.

Devices used for grounding and testing of equipment must be stored in a clean and dry location.

The devices must be properly inspected and tested before each use.

250 Personal Safety and Protective Equipment.

JADE LEARNING
A CERTUS COMPANY

250.5 Test Instruments.

Test instruments and test leads used for verifying the absence of voltage on conductors and circuit parts must be maintained to preserve functional integrity.

Maintenance must include verification of functionality as described in Section 110.6(E), Test Instruments and Equipment—Operation Verification.

300 Introduction.

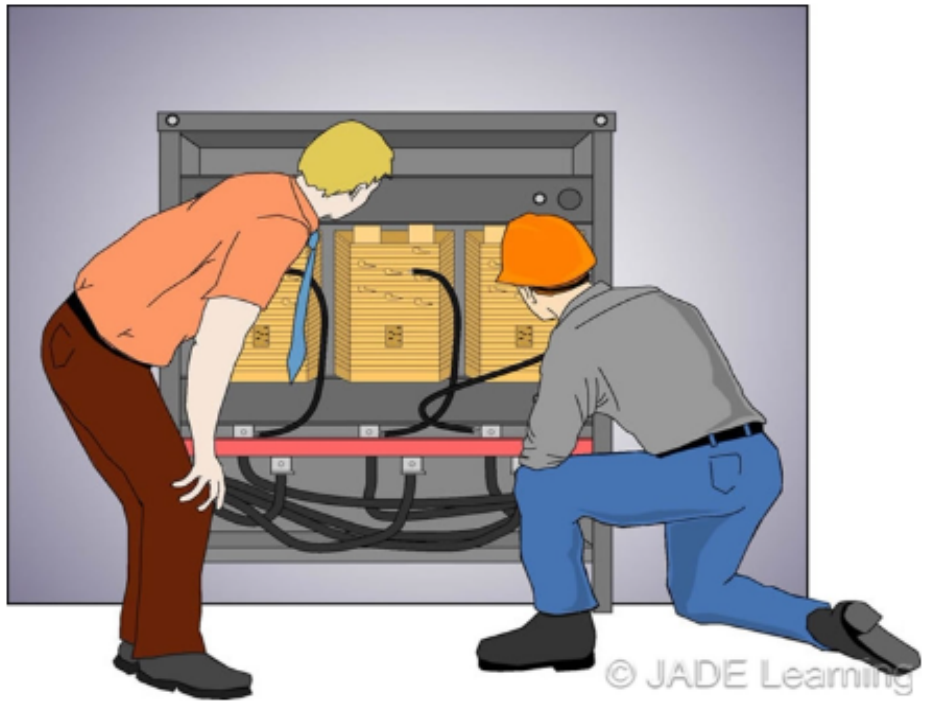
JADE LEARNING
A CERTUS COMPANY

300.1 Scope.

Chapter 3 covers special electrical equipment in the workplace and modifies the general requirements of Chapter 1.

300.2 Responsibility.

Employers are responsible for providing any safety-related work practices and employee training necessary for working on and around special electrical equipment.
Employees must follow those work practices.



The purpose of NFPA 70E is to provide a safe working area for employees working around electricity. Everyone plays a part in maintaining an electrically safe work environment!

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

310.1 Scope: electrical safety-related work practices surrounding the manufacturing, storing, transporting, installing, removing, and any other procedure(s) involved with electrolytic cells.

The **electrolytic cell** contains an anode, cathode, and electrolyte, and they are used to drive an oxidation-reduction reaction in a direction where it does not normally (spontaneously) occur.

Electrolytic Cell - Chlorine Electrolysis.

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

- **Voltaic cells** convert chemical (or light) energy into electrical energy by means of an oxidation-reduction reaction, but in the direction that occurs spontaneously (normally) in the cell.
- Electrolytic cells convert electrical energy to chemical energy, and voltaic cells convert chemical energy into electrical energy, so they are OPPOSITE of one another in their function.

Batteries act as electrolytic cells during charging.

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

310.3 Safety Training. (A) General. Chapter 3 training requirements apply to all employees exposed to cell line hazards.

(B) Training Requirements. Employees must be trained for electrical hazards associated with their respective job or task assignment.

310.4 Employee Training. Sections 310.4(A), Qualified Persons, and (B), Unqualified Persons, address the types of workers permitted to perform work within a cell line work zone and the training required in these areas.

A qualified person has the training and knowledge to do the job safely.

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

310.5 Safeguarding of Employees in the Cell Line Working Zone.

(A) General. Operation and maintenance of electrolytic cell lines may require employees to contact exposed energized surfaces.

The required approach distances in Table 130.4(E)(a) and Table 130.4(E)(b) do not apply to qualified persons working in the cell line working zone.

(B) Sign.

Permanent signs must clearly designate electrolytic cell areas.

A qualified person working in a cell line work zone is not subject to the approach distances required in Tables 130.4(E)(a) and 130.4(E)(b).

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

(C) Arc Flash Assessment. Requirements from **Section 130.5** do not apply to electrolytic cell line working zones.

(D) Safeguard. Safeguards must include one or a combination of the following:

1. Insulation
2. Personal protective equipment (PPE), including one or more of the following:

(1) Footwear for wet service	*(6) Sleeves for dry service*
(2) Gloves for wet service	*(7) Electrically insulated head protection*
(3) Sleeves for wet service	*(8) Protective clothing*
(4) Footwear for dry service	*(9) Eye protection with nonconductive frames*
(5) Gloves for dry service	*(10) Face shield (polycarbonate or similar nonmelting type)*

310 Safety-Related Work Practices for Electrolytic Cells.

JADE LEARNING
A CERTUS COMPANY

3. Barriers
4. Voltage equalization
5. Isolation
6. Safe work practices
7. Tools
8. Portable cutout-type switches
9. Cranes and hoists
10. Attachments
11. Pacemakers and metallic implants
12. Testing

A qualified person has the training and knowledge to do the job safely.

310 Safety-Related Work Practices for Electrolytic Cells.

310.6 Order of preference for the energy source for portable hand-held equipment:

1. Battery power
2. Pneumatic power
3. Portable generator
4. Nongrounded-type receptacle connected to an ungrounded source

Additional safety-related requirements:

(A) Portable electrical equipment
(B) Auxiliary nonelectric connections
(C) Welding machines
(D) Portable test equipment

When working around electrolytic cells, battery-operated tools are the preferred portable hand-held equipment.

320 Safety Requirements Related to Batteries and Battery Rooms.

320.1 Scope. Practical safeguarding of employees while working with exposed stationary storage batteries that exceed 100 volts, nominal, or exceed a short-circuit power of 1000 watts.

320.3 Safety Procedures. Batteries considered **special equipment** and covered in Section 320.3 have their own safety procedures:

(A) General safety hazards:

1. Exposure level thresholds while working around AC, DC, and thermal outputs are as follows:

(1) AC. 50-volts ac, and 5 milliamperes.
(2) DC. 100-volts dc, and 40 milliamperes
(3) Thermal. 1000-watts short-circuit power.

Exposed storage batteries over 100 volts are covered in Article 320 of NFPA 70E.

320 Safety Requirements Related to Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

2. Battery risk assessment procedures required before working on battery systems.
3. Personnel access and illumination requirements for battery rooms or enclosures.
4. Electrically conductive apparel worn around battery systems.
5. Abnormal battery conditions and abnormal condition warning systems and alarms.
6. Warning signs required around battery systems or battery voltage.

(B) Electrolyte hazards, such as battery activities involving the handling of liquid electrolytes and those that do not require handling liquid electrolytes.

320 Safety Requirements Related to Batteries and Battery Rooms.

JADE LEARNING
A CERTUS COMPANY

(C) Tools and equipment used for batteries:

1. Tool and equipment handles must be insulated —rated for the maximum voltage, used in accordance with 130.7(D)(1).
2. Battery terminals and electrical conductors must be kept clear of contact with tools, equipment, liquid containers, or foreign objects.
3. Nonsparking tools must be used when justified by the risk assessment procedure in Section 110.3(H).

(D) Battery cell ventilation openings must remain unobstructed.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

330.1 Scope:

safety-related work practices for maintaining lasers and their associated equipment.

Common types of lasers:

- Solid-state laser
- Gas laser
- Liquid laser
- Semiconductor laser

Laser hazard warning sign.

Common classes of visible-beam lasers:

- **Class 1:** Harmless to the eye/safe under all conditions.
- **Class 2:** Safe for unintentional momentary exposure.
- **Class 3R:** Potentially harmful to the eye during brief exposure.
- **Class 3B:** Harmful to the eye. Avoid exposure.
- **Class 4:** Harmful to eyes, skin, and flammable materials and can cause permanent damage upon immediate contact.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

330.3 Electrical Hazard Thresholds—Lasers.

Exposure levels must not exceed those identified in the following list unless appropriate controls are implemented:

(1) AC: 50 volts and 5 milliamperes

(2) DC: 100 volts and 40 milliamperes

(3) Capacitor stored energy:

a. Less than 100 volts and greater than 100 joules of stored energy.

b. Greater than or equal to 100 volts and greater than 1.0 joule of stored energy.

c. Greater than or equal to 400 volts and greater than 0.25 joule of stored energy

Blue-colored laser beams are typically much hotter than green lasers, but green lasers are visible at greater distances.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

330.4 (A) Personnel to Be Trained.

Employers must provide proper training for all personnel who work on or are near lasers or laser systems with user-accessible hazardous voltage, current, or stored energy, such as flashlamp-pumped lasers.

(B) Electrical Safety Training for Work on Lasers. Electrical safety training must include, but is not limited to, the following:

(1) Chapter 1 electrical safe work practices
(2) Electrical hazards associated with laser equipment
(3) Stored energy hazards, including capacitors and capacitor banks
(4) Ionizing radiation, including X-rays at voltages greater than 10 kV in a vacuum
(5) Assessing the listing status of electrical equipment and the need for field evaluation of nonlisted equipment

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

330.5 Safeguarding of Persons from Electrical Hazards Associated with Lasers and Laser Systems.

(A) Temporary Guarding.

Temporary guarding must be used to limit personnel exposure to any electrical hazard when the permanent laser enclosure covers are removed for maintenance and testing.

(B) Work Requiring an Electrically Safe Work Condition.

An electrically safe work condition in accordance with 120.2, 120.3, and 110.2(B) **is required** for all employees working on or around lasers where they may be exposed to electrical hazards.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

(C) Energized Electrical Testing.

An energized work permit is **not required** for performing energized electrical testing, troubleshooting, and voltage testing of lasers and laser systems.

(D) Warning Signs and Labels.

Electrical safety warning signs or labels are required on electrical equipment doors, covers, or protective barriers.

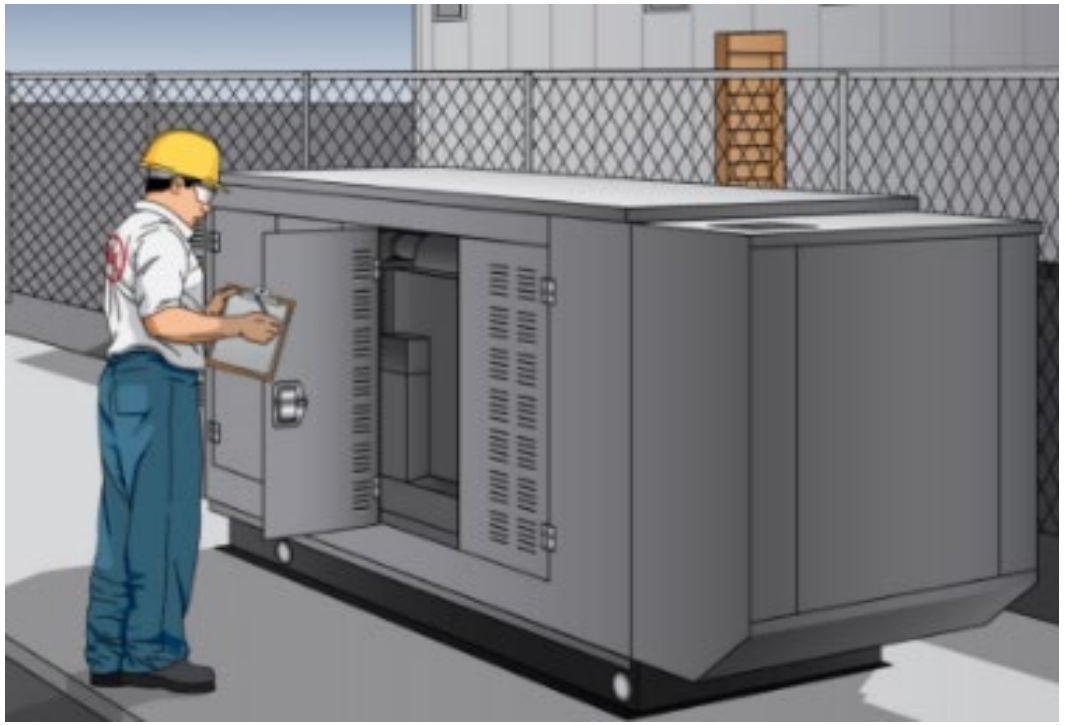
- They must warn personnel of hazards using effective words, colors, or symbols.
- Installed signs and labels must be permanently affixed and durable enough to withstand the environment involved.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

(E) Listing.

Before use, all laser and laser system electrical equipment with the potential to expose workers to electrical hazards must be listed by an approved listing agency or field evaluated by an approved field evaluation body (FEB).



Once equipment has been successfully field evaluated, a field label is applied. In many cases, a field label is accepted by the NFPA in lieu of a regular product listing.

330 Safety-Related Work Practices: Lasers.

JADE LEARNING
A CERTUS COMPANY

330.6 Responsibility for Electrical Safety.

All personnel with access to hazardous voltage, current, or stored energy must be responsible for the following:

1. Obtaining authorization for work with or on hazardous electrical equipment in lasers and laser systems
2. Use of Chapter 1 safety-related work practices
3. Reporting laser equipment failures, accidents, inadequate barriers, and inadequate signage to the employer

Laser hazard warning sign.

340 Safety-Related Work Practices: Power Electronic Equipment.

340.1 Scope: safety-related work practices around power electronic equipment:

1. Electric arc welding equipment.
2. High-power radio, radar, and television transmitting towers and antennas.
3. Industrial dielectric and radio frequency (RF) induction heaters.
4. Shortwave or RF diathermy devices.
5. Equipment that includes rectifiers and inverters such as:
- **a.** Motor drives
- **b.** Uninterruptible power supply systems
- **c.** Lighting controllers.

Article 340 covers this RF diathermy device.

340 Power Electronic Equipment.

JADE LEARNING
A CERTUS COMPANY

6. Generators producing sub-RF and RF fields.

7. Ionizing radiation field generators, including X-rays, magnetrons, klystrons, thyratrons, vacuum tubes, etc.

8. Nonionizing radiation field generating equipment:

- **a.** Antennas and RF transmission lines
- **b.** Radar equipment
- **c.** Industrial scientific and medical equipment
- **d.** RF induction and dielectric heaters
- **e.** Industrial microwave heaters and diathermy radiators
- **f.** Magnetic resonance imagers (MRIs)
- **g.** Large electromagnets

Article 340 covers this electric arc welding equipment.

340 Power Electronic Equipment.

JADE LEARNING
A CERTUS COMPANY

340.3 Application: guidance for safety personnel--safety-related work practices.

340.4 Electrical Hazard Thresholds.

Personnel must not be exposed to voltage/current levels beyond those identified in the following list unless appropriate controls are implemented:

1. DC (0 Hz to 1 Hz): 100 volts and 40 milliamperes
2. 60/50 Hz power: 50 volts and 5 milliampere
3. AC (1 Hz to 3 kHz): 50 volts and 3 milliamperes
4. AC (3 kHz to 100 kHz): 1 x f mA, f in kHz
5. AC (100 kHz to 3 MHz): 100 mA
6. AC (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz
7. AC (30 MHz to 110 MHz): 200 mA

340 Power Electronic Equipment.

JADE LEARNING
A CERTUS COMPANY

340.5 (A) Employer Responsibility.

The **employer** must be responsible for the following:

(1) Proper training and supervision, including:

a. Identification of associated hazards

b. Strategies to reduce the risk

c. Methods of avoiding the hazard

d. Necessity of reporting any incident that could have resulted in injury or damage to health

(2) Properly installed equipment

(3) Proper access to the equipment

(4) Availability of the correct tools for operation and maintenance

(5) Proper identification and guarding of dangerous equipment

340 Safety-Related Work Practices: Power Electronic Equipment.

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(6) Provision of complete and accurate circuit diagrams and other published information to the employee prior to the employee starting work

The circuit diagrams should be marked to indicate the components that present an electrical hazard.

(7) Maintenance of clear and clean work areas around the equipment to be worked on

(8) Provision of adequate and proper illumination of the work area

Article 340 covers this electric arc welding equipment.

340 Safety-Related Work Practices: Power Electronic Equipment.

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340.5(B) Employee Responsibility.

The **employee** must be responsible for the following:

(1) Understanding the hazards associated with the work
(2) Being continuously alert and aware of the possible hazards
(3) Using the proper tools and procedures for the work
(4) Informing the employer of malfunctioning protective measures, such as faulty or inoperable enclosures and locking schemes

340 Safety-Related Work Practices: Power Electronic Equipment.

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(5) Examining documents provided by the employer to identify the location of components that present electrical hazard
(6) Maintaining good housekeeping around the equipment and workspace
(7) Reporting any incident that resulted in, or could have resulted in, injury
(8) Using and appropriately maintaining the PPE and tools required to perform the work safely

350 Safety-Related Work Requirements: R&D Laboratories.

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350.1 Scope: installations equipped with custom/special electrical equipment, designated by management as areas for R&D or laboratories.

350.3 Application of Other Articles. The electrical system for R&D/laboratory applications must meet requirements from the remainder of this document*, except where they are amended by Article 350.

Examples include:

- Low-voltage—high-current power systems
- High-voltage—low-current power systems
- DC power supplies
- Capacitors
- Cable trays for signal cables and other systems, such as steam, water, air, drainage

350 Research and Development Laboratories.

350.4 Electrical Safety Authority (ESA).

Electrical Safety Authority (ESA) may be one of the following:

- An electrical safety committee
- Engineer
- Equivalent qualified individual

Each laboratory application can assign an ESA to ensure the use of appropriate electrical safety-related work practices and controls.

The ESA is permitted to delegate authority to an individual/organization within their control.

(A) Responsibility. The ESA must act in a manner similar to an authority having jurisdiction for R&D electrical systems and electrical safe work practices.

(B) Qualifications. The ESA must be competent in the NFPA 70E standard and electrical system requirements applicable to R&D laboratories.

350 Research and Development Laboratories.

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350.5 Specific Measures and Controls for Personnel Safety.

R&D system applications must designate a **competent person** to ensure appropriate electrical safety-related work practices and controls are being used.

***350.6* Approval Requirements.**

Equipment or systems used in the R&D area or in the laboratory must be ***listed*** or ***field evaluated*** prior to use.

Laboratories and R&D system applications require a competent person to ensure appropriate electrical safety-related work practices and controls are in use.

350 Research and Development Laboratories.

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350.7 Custom Built, Non-Listed Research Equipment, 1000 Volts or Less AC or DC.

(1) Equipment Marking. Equipment that is fabricated, designed, developed, etc. for research testing and evaluation of electrical systems, must be to list all voltages entering and leaving control cabinets, enclosures, and equipment.

All Caution, Warning, or Danger labels must be securely affixed to the outside of equipment or parts and describe the specific hazards and safety concerns.

NFPA 70E considers research and development (R&D) to be activities performed in installations designated for research or development using custom or special electrical equipment.

350 Research and Development Laboratories.

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(2) Equipment Documentation.

- Documentation must be available to personnel responsible for installing, operating, and maintaining custom built equipment.
- The documentation must describe operation, shutdown, safety concerns, and nonstandard installations.
- Schematics, drawings, and documentation that describe power feeds, voltages, currents, and parts used for constructing, maintaining, and operating the equipment must be provided.

University of Illinois, Research Laboratory—Electrical Safety in the Research Laboratory

350 Safety-Related Work Requirements: Research and Development Laboratories.

(3) Shutdown Procedures.
Safety requirements and emergency shutdown procedures included in equipment documentation must include **lockout/tagout (LOTO) requirements**.

(4) Specific Hazards.
Any specific hazards considered not to be electrical hazards but associated with the custom-built equipment must also be documented and made readily available.

350 Research and Development Laboratories.

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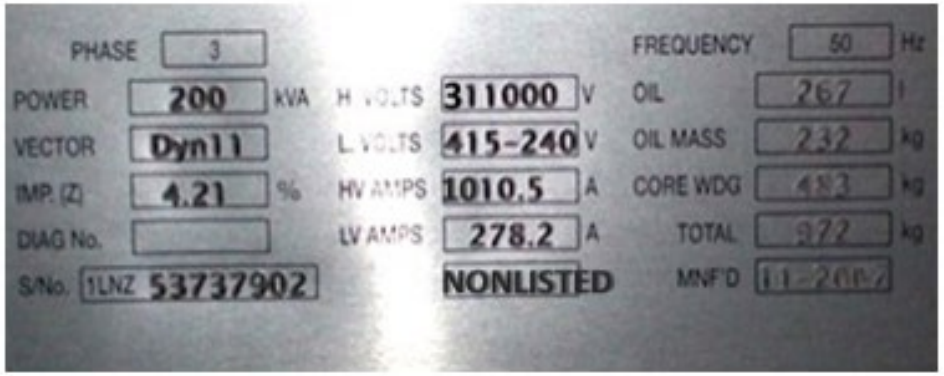
350.8 Custom Built, Unlisted Research Equipment, Over 1000 Volts AC or DC.

All custom built, unlisted research equipment operating at voltages above 1000 volts (ac or dc) must comply with all **requirements of 350.7.**

- The ESA must determine appropriate PPE and safe work practices for any research equipment requiring PPE beyond what is commercially available.



Custom built, unlisted research equipment operating at voltages over 1000 volts must comply with all requirements from Section 350.7.

360 Safety-Related Requirements for Capacitors.

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360.1 Scope: practical safeguarding of employees while working with **capacitors.**

360.3 Stored Energy Hazard Thresholds. Appropriate **controls** must 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/equal to 100 volts and greater than 1.0 joule of stored energy.

(3) Greater than/equal to 400 volts and greater than 0.25 joules of stored energy.

Low, medium, and high-voltage capacitors can contain explosive levels of electricity.

360 Safety-Related Requirements for Capacitors.

JADE LEARNING

360.4 Specific Measures for Personnel Safety.

(A) Qualification and Training. 360.4(A) requires the following qualifications and training:

- When working on equipment with capacitors exceeding energy thresholds from Section 360.3, employees must be familiar with the hazards and controls required.
- If an **unqualified person** is to work on electrical equipment with capacitors, they must be trained in all electrical safety-related work practices necessary

(B) Performing a Risk Assessment for Capacitors.
The risk assessment procedures in **Chapter 1** of NFPA 70E must be followed when work to be performed involves capacitors.

360 Safety-Related Requirements for Capacitors.

JADE LEARNING
A CERTUS COMPANY

360.5 (A) Written Procedure.

A written procedure is required to document the steps/sequence for discharging a capacitor(s) and placing equipment into an electrically safe work condition.

The written procedure must include the results of the risk assessment performed in 360.5(B) and specify the following 8 safe work practices used for placing capacitor(s).

Charging and Discharging the
(Power Output, Voltage Sen

Equipment List

Qty	Items
1	PASCO 750 Interface
1	Voltage Sensor
1	AC/DC Electronics Laboratory
2	Banana Plug Patch Cord
	330 microfarad (μF) Capacitor; 1000 Ohm Resistor

Introduction

The purpose of this activity is to measure the voltage across a
discharged through a resistor that is in series with the capacito
the change in voltage across the capacitor. Use the "Output" fu
charge and then discharge the capacitor through the resistor. F
capacitor based on your data and compare to the printed value

Background

When a DC voltage source is connected across an uncharged c
the rate at which the capacitor charges up decreases as time pr
first, the capacitor is easy to charge because there is very little
on the plates. But as charge accumulates on the plates, the volt
source must "do more work" to move additional charges onto
because the plates already have charge of the same sign on the
result, the capacitor charges exponentially, quickly at the begi
more slowly as the capacitor becomes fully charged. The char
given by:

Where a conductor is connected to a capacitor operating at or above the stored energy hazard thresholds found in Section 360.3, a written procedure is required to document the steps and sequence needed for discharging the capacitor.

360 Safety-Related Requirements for Capacitors.

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(B) Safe Work Practices.

To place the capacitor(s) into an electrically safe work condition, a qualified person must use appropriate safe work practices and PPE and must apply the following process for establishing and verifying an electrically safe work condition:

(1) Review all applicable, up-to-date drawings, diagrams, and identification tags to determine all possible sources of electrical supply to the specific equipment.

(2) Open all disconnect devices belonging to each power source after interrupting the load current to the equipment.

360 Safety-Related Requirements for Capacitors.

JADE LEARNING
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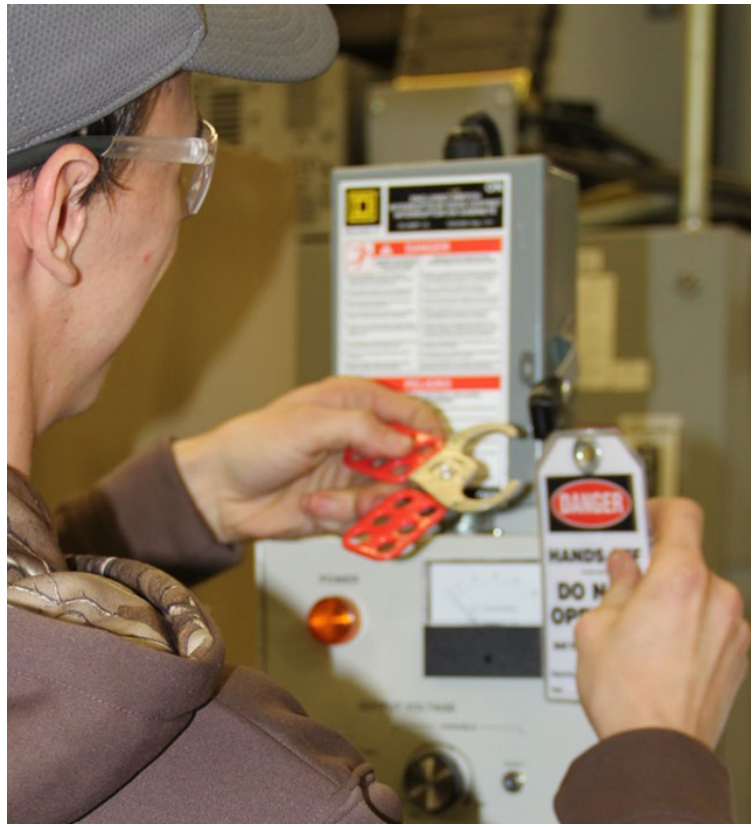
(3) Check that all blades in disconnecting devices are fully disengaged or that draw out type circuit breakers are withdrawn to their fully disconnected position, wherever this can be performed for disconnect devices.

(4) According to the documented and established policy, apply appropriate lockout/ tagout devices.



360 Safety-Related Requirements for Capacitors.

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(5) Where bleed resistors or automatic discharge systems are applicable, wait for capacitors to discharge to below thresholds given in Section 360.3, then proceed to step (6).

Where systems are not equipped with bleed resistors or automatic discharge systems to discharge capacitors, discharge the capacitors with an adequately rated grounding device.

Soft grounding is required above 1000 joules (.28 watt-hours), and remote soft grounding is required above 100 kj (28 watt-hours).

360 Safety-Related Requirements for Capacitors.

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(6) Discharging of capacitors must be verified.

For capacitors less than 1000 joules, verification procedures can include testing or grounding of capacitors.

For capacitors above 100 kJ, an engineered and redundant system must be used for remote testing and grounding of capacitors.

(7) When test instruments are used for testing the absence of voltage, the operation of the test instrument must be verified on a known dc voltage source before and after each absence of voltage procedure is performed.

360 Safety-Related Requirements for Capacitors.

JADE LEARNING
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(8) For series capacitors, the shorting wires must be attached across each individual capacitor at the capacitor terminals and its grounded case.

When de-energizing single capacitors or a parallel capacitor bank, the grounding device used must be permitted to be left attached to the capacitor terminals for the duration of the work
(e.g., a ground stick).

360 Safety-Related Requirements for Capacitors.

JADE LEARNING
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360.6 Ground Sticks.
Ground sticks must be provided for qualified persons to safely **discharge residual stored energy** from capacitors or to hold the capacitor voltage potential at **0 volts**.

These ground sticks must be designed, constructed, installed, and periodically tested so they are able to safely withstand the full energy and voltage of capacitors during discharge.

Ground (grounding) sticks allow current-carrying conductors to be intentionally bonded to one another and grounded to earth while they are de-energized to act as a safety precaution should the conductor(s) be unintentionally re-energized.

Informative Annexes

A.1 General. Annex A publications are intended to serve as additional information.

A.2 NFPA Publications. The NFPA is responsible for NFPA 70E, Standard for Electrical Safety in the Workplace, NFPA 70, National Electrical Code, and the following electrical publications discussed in 70E:

- NFPA 1, Fire Code.
- NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.
- NFPA 790, Standard for Competency of Third-Party Field Evaluation Bodies.

NFPA publications referenced in the 70E standard.

Informative Annexes

A.3.1 ANSI Publications.
The American National Standards Institute (ANSI) oversees Standards and Conformity Assessment Activities for **products**, **materials**, and **installations** in the United States.

The titles of the ANSI publications referred to in NFPA 70E can be located in this annex.

B. Reserved.
While this space is reserved for future use, no reference material occupies Informative Annex B of NFPA 70E, 2024 Edition.

Informative Annexes

C. Limits of Approach.

C.1 Preparation for Approach.

Observing a safe approach distance away from exposed energized circuit conductors and parts is an effective means of maintaining electrical safety.

C.2 Basis for Distance Values in Tables 130.4(E)(a) and 130.4(E)(b).

Limited approach boundary distances used for shock prevention, found in Tables 130.4(E)(a) and 130.4(E)(b), provide workers with recognized limited approach distances from exposed energized ac and dc electrical conductors and circuit parts.

The basis for determining these distances is addressed in **Informative Annex C**.

Informative Annexes

D. Incident Energy and Arc Flash Boundary Calculation Methods.

This annex summarizes calculation methods for calculating arc flash boundaries and incident energy.

The calculation methods for determining safe boundary distances from equipment with hazards are meant to protect workers from harmful incident energy and arc flash explosions.

These hazards can occur when energized phase conductors come into contact with conductors of different potentials or grounded surfaces.

Informative Annexes

E. Electrical Safety Program. This provides workers with examples of the following:

- **Typical Electrical Safety Program Principles**
- **Typical Electrical Safety Program Controls**
- **Typical Electrical Safety Program Procedures**

Refer to Informative Annex E for NFPA recognized electrical safety program tenets. Electrical safety program procedures include electrical safety planning.

F.1 Introduction to Risk Management.

Risk management is the logical, systematic process used to manage the risk associated with any activity, process, function, or product including safety, the environment, quality, and finance.

The risk management process and principles can be used by organizations of any type or size.

Informative Annexes

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G. Sample Lockout/Tagout Program provides workers with sample lockout/tagout program procedures that can serve as a plumbline when workers are developing such a program in their own workplace.

H. Guidance on Selection of Protective Clothing and Other Personal Protective Equipment (PPE) can aid workers as they select appropriate PPE and other protective equipment for their task(s).

I. Job Briefing and Job Safety Planning Checklist offers examples for consideration for workers developing job briefing and job safety planning checklists.

Informative Annexes

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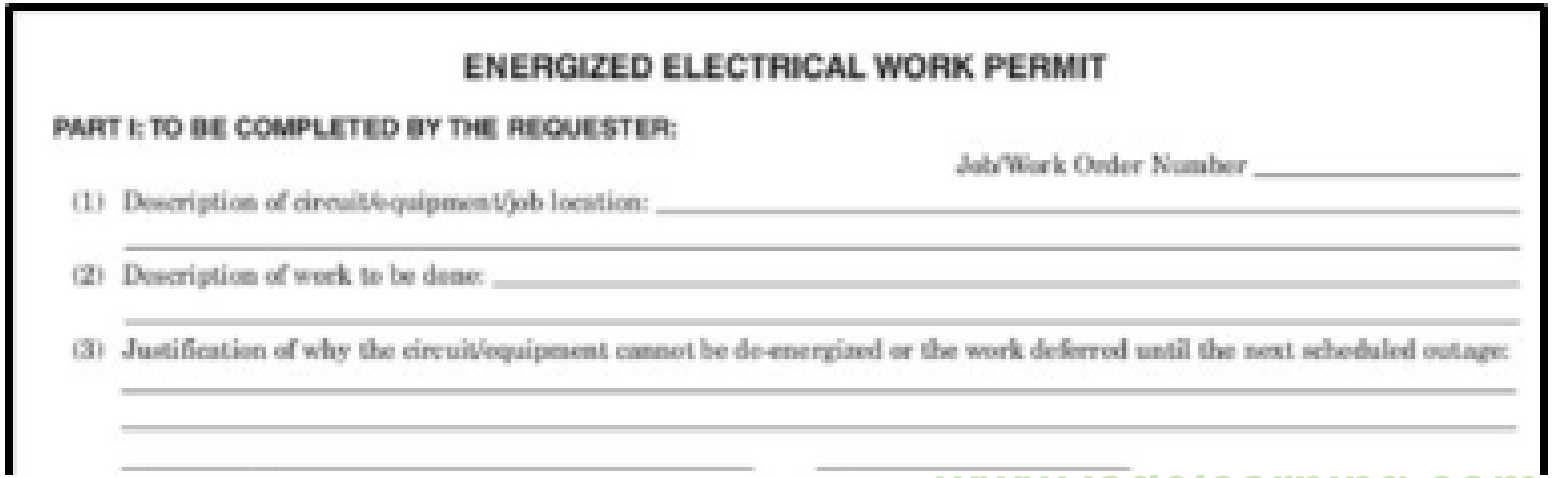
J. Energized Electrical Work Permit.

Figure J.1 provides workers with an example of an energized electrical work permit.

Figure J.2 illustrates the items workers should consider when determining whether an energized electrical work permit is necessary for their task or job.



ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

(1) Description of circuit/equipment/job location: _____

(2) Description of work to be done: _____

(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____

Informative Annexes

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K. General Categories of Electrical Hazards.

This annex provides workers with the categories recognized by the NFPA as the most common areas within the electrical industry to report accidents resulting in injury or death.

Electrical burns and **electrical shock** make up the two general categories of **electrical injuries** reported to the Bureau of Labor Statistics (BLS) in the United States.

Conduction of electrical current through the body in this case caused electrical current to flow through the tissue of the human body and exit both feet, where in contact with an electrically grounded surface. This type of current usually disintegrates tissue at entry and exit locations on the human body.

Informative Annexes

L. Typical Application of Safeguards in the Cell Line Working Zone.

This annex addresses safeguards considered adequate for personnel safety in electrolytic areas where electrical hazards exist.

M. Layering of Protective Clothing and Total System Arc Rating.

This annex informs workers that layering arc-rated clothing can effectively meet the required arc rating when those clothing layers have been tested together to determine their total composite rating.

Informative Annexes

N. Example Industrial Procedures and Policies for Working Near Overhead Electrical Lines and Equipment.

When working near overhead electrical lines, this annex provides workers an example of an NFPA-recognized industrial procedure for their work.

O. Employee Safety-Related Design Concepts and Facility Owner Responsibilities

addresses some procedure(s) proven effective for risk assessment, and the parties responsible for the assessment.

Informative Annexes

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P. Aligning Implementation of This Standard with Occupational Health and Safety Management Standards presents American National Standards Institute (ANSI) and International Organization for Standardization (ISO) publications providing comprehensive guidance on the elements of an effective health and safety management system for the workplace.

Q. Human Performance and Workplace Electrical Safety looks at human performance on the job site and variables affecting performance results. This Annex addresses how human performance can be applied to workplace electrical safety.

Informative Annexes

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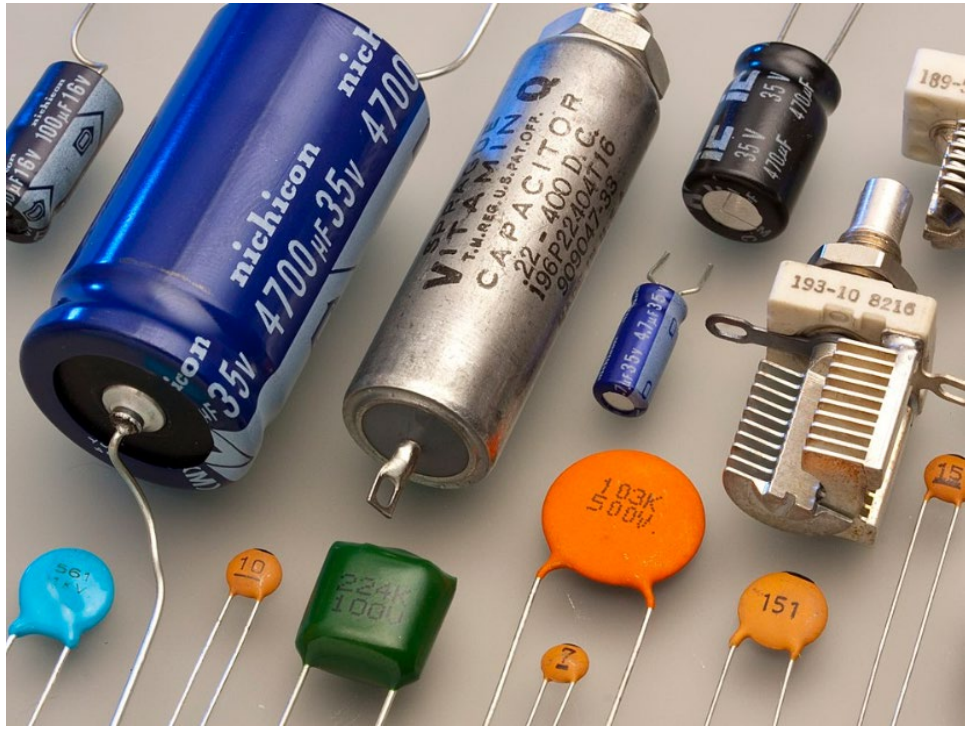
R. Working with Capacitors addresses qualifications for working with capacitors, training of unqualified persons around capacitors, the shock hazards associated with capacitors, general capacitor information, and much more.



S. Assessing the Condition of Maintenance contains seven sections that describe methods proven to be effective at obtaining useful information for assessing the condition of maintenance of electrical equipment and systems.

THANK YOU FOR ATTENDING!

Questions?
For additional instructor support, please contact instructor@jadelearning.com

For questions about your continuing education, please contact registrar@jadelearning.com

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