

CF SAFETY AND HEALTH PROGRAM

Electrical Safety Program

1.0 INTRODUCTION

Electricity is a serious workplace hazard, capable of causing both employee injury and property damage. It is the policy of the University of Missouri (MU), Campus Facilities (CF) to protect all employees, students, and other personnel from potential electrical hazards. This will be accomplished through compliance with the work practices described herein along with effective application of engineering controls, administrative controls, and the use of personal protective equipment.

The MU CF Electrical Safety Program is founded on the principle of avoiding energized work unless it is absolutely necessary. Live parts will be de-energized before an employee works on or near them unless one of the following conditions applies:

- **De-energizing introduces additional or increased hazards.** Examples of “additional or increased” hazards would include interruption of life support equipment, deactivation of emergency alarm systems, or shutdown of hazardous location ventilation systems. This work requires an energized work permit.
- **De-energized is not possible due to equipment design. Energized work permit is required. Examples of this would be an emergency generator transfer switch.**
- **De-energizing is not possible due to operational limitations.** Examples of this situation would include testing and troubleshooting of electrical circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.
- **Live parts are operating at less than 50 volts to ground and there is no increased exposure to electrical burns or to explosion due to electrical arcs.**

Live parts are to be de-energized in accordance with the CF Lockout/Tagout Program. If live parts are not placed in an electrically safe condition, the work practices described in this document must be used to protect employees.

When working on or near live parts (including testing and troubleshooting) the appropriate Personal Protective Equipment shall be selected from the NFPA 70E Table, 130.7(C)(16) in conjunction with either 130.7 (C) (15) (A) (b) or 130.7 (C) (15) (B) Arc Flash Hazard for Alternating (ac) and Direct

Current (dc) Systems (Appendix D of this document). If unable to determine the necessary level of protection using these tables, an Arc Flash Electrical Analysis must be performed by an Electrical Engineer.

2.0 PURPOSE

This program has been established in order to:

- Ensure the safety of employees who may work on or near electrical systems.
- Ensure that CF personnel understand and comply with safety standards related to electrical work.
- Ensure that CF personnel follow uniform practices during the completion of electrical work.

3.0 SCOPE

This program applies to all work performed by Campus Facilities employees regardless of job site location.

4.0 REFERENCES

- NFPA 70E, “Standard for Electrical Safety in the Workplace”, 2015 edition
- OSHA 29 CFR 1910.331 through 1910.335, “Electrical Safety-Related Work Practice
- Campus Facilities Lockout/Tagout Program

5.0 RESPONSIBILITIES

5.1 Safety Coordinator

- Receive Energized Work Permits (after work has been completed), and route to committee for review.
- In special circumstances may convene electrical safety committee when necessary.
- Evaluate work being performed to determine compliance with this program.
- Provide or assist in task specific training for electrical work qualifications.
- Recordkeeping of all electrical work permits and training records.
- Periodically review and update this written program.
- Provide or coordinate general training for CF on the content of this program.
- Evaluate the overall effectiveness of the electrical safety program on a periodic basis.
- Assist department supervisors in implementing the provisions of this program.

5.2 Managers

- Determine the applicability of the electrical safety program to activities conducted within their respective areas of jurisdiction.
- Designate individuals responsible for the implementation of the electrical safety program within their areas.
- Actively support this program as part of the CF overall safety effort.

- Provide or assist in task specific training for electrical work qualifications.

5.3 Supervisors

- Ensure employees comply with all provisions of the electrical safety program.
- Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training.
- Develop and maintain a listing of all qualified employees under their supervision.
- Ensure employees are provided with and use appropriate protective equipment.

5.4 Employees

- Follow the work practices described in this document, including the use of appropriate protective equipment and tools.
- Attend all training required relative to this program.
- Immediately report any concerns related to electrical safety to supervision.

5.5 Electrical Safety Committee

- Meet on a periodic basis to review electrical safety issues at CF.
- Review all energized electrical work permits (after work has been completed).
- Promote consistency in how electrical tasks are completed within the various work units of CF.
- Recommend methods of controlling electrical hazards through the application of engineering.

6.0 DEFINITIONS

The following terms are defined in order to allow a better understanding of this program:

- **Arc rating:** The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in (cal/cm²) and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (Ebt) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or Ebt whichever is the lower value.
- **Arc Flash suit:** A complete Arc-rated clothing and equipment system that covers the entire body, except for the hands and feet. (Such a suit typically includes pants, jacket, arc-rated hood with a face shield).
- **Arc-rated apparel:** Arc resistant apparel; describes a broad category of clothing designed to protect employees from electrical arc events during completion of energized tasks
- **Electrically safe work condition:** A state in which the conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.
- **Energized:** Electrically connected to or having a source of voltage.
- **Exposed (as applied to energized electrical conductors or circuit parts):** Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitable guarded, isolated, or insulated.

- **Flash protection boundary:** When an arc flash hazard exist, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur..
- **Incident energy:** The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. Incident energy is typically expressed in calories per square centimeter (cal/cm²).
- **Incident energy analysis:** A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.
- **Limited approach boundary:** An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exist.
- **PPE:** An acronym for “Personal Protective Equipment”.
- **Qualified person:** One who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installation and has received safety training to identify and avoid the hazards.
- **Restricted approach boundary:** An approach limit at a distance from an exposed energized electrical conductors or circuit within which there is an increased likelihood of electrical shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit parts. (due to electrical arc-over combined with inadvertent movement) for personnel working in close proximity to the live part.
- **Unqualified person:** Any person who does not meet the definition of a qualified person.
- **Working near (live parts):** Any activity within a Limited Approach Boundary. Not listed
- **Working on (energized electrical conductors or circuit parts):** Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of “working on”: *Diagnostic (testing)* is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical changes to the equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.)

7.0 TRAINING

- 7.1 Employees who are exposed to an electrical hazard must be trained initially and attend refresher training every 3 years.
- 7.2 The level of electrical safety training provided is dependent on whether the employee is classified as a “qualified person” or “unqualified person”. Unqualified workers will be trained on electrical hazards that may be in their areas of responsibility.
- 7.3 A “qualified person” shall be trained and knowledgeable in all of the following topics:
- Construction and operation of equipment on which work is assigned.
 - Skills and techniques necessary to distinguish exposed energized parts from other parts of electrical equipment.
 - Skills and techniques necessary to determine the nominal voltage of exposed live parts.
 - The approach distances specified in this document and the corresponding voltages to which the qualified employee will be exposed.

- The process necessary to determine the degree and extent of electrical hazards along with the PPE and job planning necessary to perform the task safely.

7.4 A person can be considered qualified with respect to certain equipment and methods but unqualified for others.

7.5 An “unqualified person” shall be trained in the inherent hazards of electricity and any related work practices that are necessary for their safety.

7.6 Training for qualified and unqualified persons will be coordinated by the CF Safety Coordinator and the department managers and supervisors. Training will be customized to reflect the scope of work performed within CF.

7.7 Training must be provided before the employee is assigned duties that involve work near or on electrical systems.

7.8 Training records shall be maintained in the CF TED data base.

8.0 WORKING ON OR NEAR LIVE PARTS >50 Volts

8.1 Energized Electrical Work Permit

8.1.1 If live parts are not placed in an electrically safe condition, work to be performed shall be considered energized electrical work and will be performed by written permit, risk Assessment has been completed and a the job briefing checklist has been completed only unless 8.1.3 applies.

8.1.2 A copy of the “*CF Energized Electrical Work Permit*”, “Risk Assessment “ and Job Briefing checklist” *can be found in **Appendix A*** of this document. The intent of this permit is to ensure that all appropriate safety precautions including a Risk Assessment are taken prior to starting energized electrical work.

8.1.3 Work related to testing, troubleshooting, and voltage measuring may be completed without a permit provided appropriate safe work practices and PPE are used.

8.1.4 The permit is to be originated by the individual requesting that the energized work be completed. The requestor is responsible for completing Part I of the permit.

8.1.5 The qualified persons completing the task are responsible for completing Part II of the permit.

8.1.6 Two Campus Facilities managers or supervisors that have received NFPA 70E training must approve the permit prior to beginning the work.

8.1.7 The permit must be posted outside the flash boundary where the work is taking place for the duration of the task.

8.1.8 Copies of all energized electrical work permits must be provided to the CF Safety Coordinator upon completion of the task.

8.2 Approach Boundaries to Live Parts

8.2.1 Observing a safe approach distance from exposed energized parts is an effective means of maintaining electrical safety. As the distance between an individual and live parts increases, the potential for an electrical injury decreases.

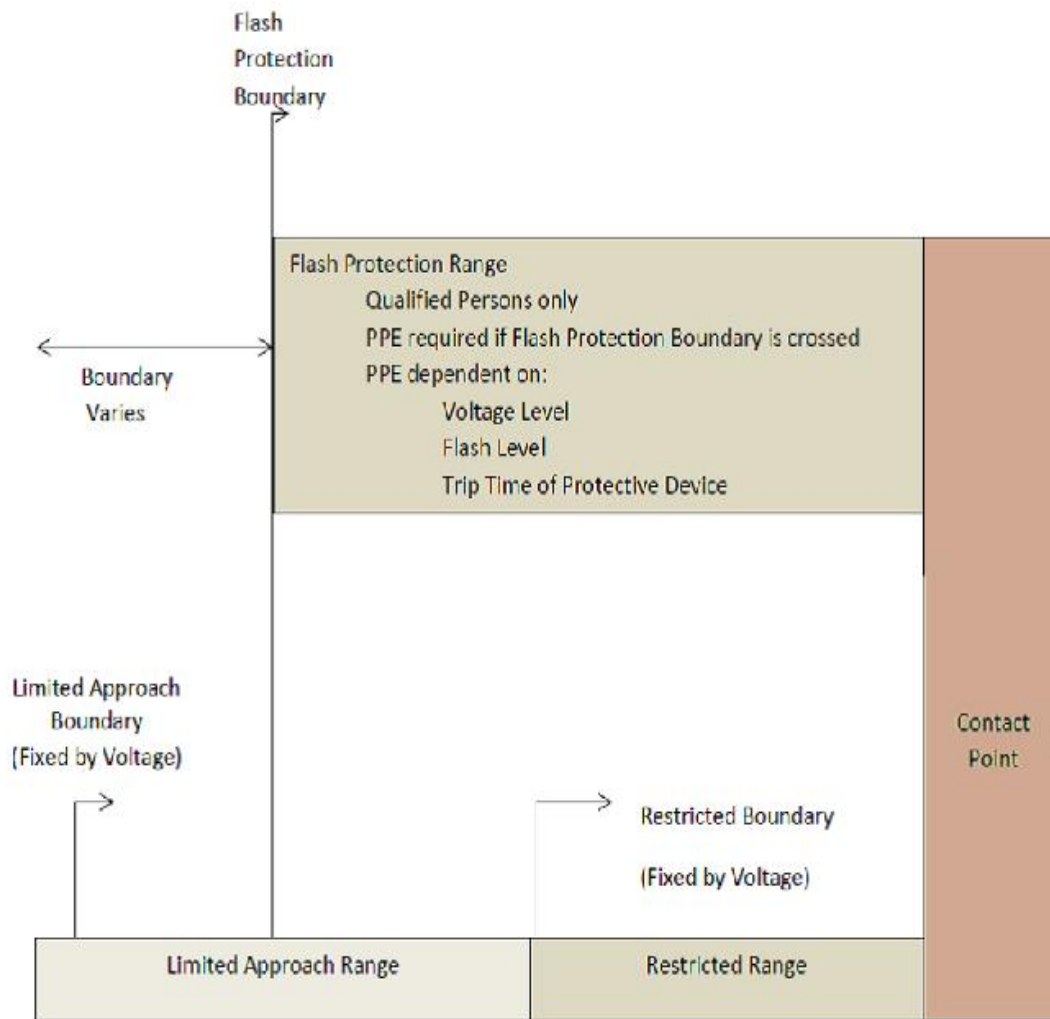
8.2.2 Safe approach distances will be determined for all tasks in which approaching personnel are exposed to live parts.

8.2.3 Safe approach distances to fixed live parts can be determined by referring to **Appendix B**, "*Approach Boundaries to Live Parts for Shock Protection*". This appendix can be used to identify the Limited and Restricted Approach Boundaries associated with various system voltages.

8.2.4 Unqualified persons may only cross the Limited Approach Boundary when they are under the direct supervision of a qualified person.

8.2.5 Qualified persons may not cross or take any conductive object closer than the Restricted Approach Boundary unless one of the following condition apply:

- The qualified person is insulated or guarded from the energized parts and no uninsulated part of the qualified person's body crosses the Restricted Approach Boundary.
- The energized parts are insulated from the qualified person and from any other conductive object at a different potential.



Limited Approach Range: Qualified or Unqualified Persons*

* Only if accompanied by Qualified Person

Revised 5-22-2015

8.3 Other Precautions for Personnel Activities:

- 8.3.1 Employees shall not reach blindly into areas that might contain exposed live parts.
- 8.3.2 Employees shall not enter spaces containing live parts unless illumination is provided that allows the work to be performed safely.
- 8.3.3 Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) shall not be worn when working on or near energized parts.
- 8.3.4 Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents accidental contact with live parts. Such materials and equipment include, but are not limited to, long conductive objects such as ducts, pipes, tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
- 8.3.5 When an employee works in a confined space or enclosed space (such as a manhole or vault) that contains exposed live parts, the employee shall use protective shields, barriers, or insulating materials as necessary to avoid contact with these parts. Doors, hinged panels, and the like shall be secured to prevent them from swinging into employees.
- 8.3.6 Melting or flammable materials such as pens or pencils, lighters shall not be taken within the approach boundary.

9.0 PERSONAL PROTECTIVE EQUIPMENT

9.1 General Requirements

- 9.1.1 Employees working in areas where electrical hazards are present shall be provided with, and shall use appropriate protective equipment that is designed and constructed for the specific body part to be protected and for the work to be performed.
- 9.1.2 CF will provide electrical protective equipment required by this program at no cost to employees. Such equipment shall include rated Arc Flash apparel, eye protection, head protection, hand protection, insulated footwear, and face shields where necessary. ***CF is not responsible for providing under layers.***
- 9.1.3 All protective equipment shall be maintained in a safe, reliable condition by the employee to whom it is issued.

- 9.1.4 Employees shall wear nonconductive protection for the eyes, head, face, neck, and chin whenever there is danger of injury from exposure to electric arcs or flashes or from flying objects resulting from an electrical explosion.
- 9.1.5 Employees shall wear rubber insulating gloves where there is danger of hand and arm injury due to contact with live parts or possible exposure to arc flash burn.
- 9.1.6 Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required. Insulated soles shall not be used as primary electrical protection.
- 9.1.7 Arc-rated face shields shall be used for electrical work. Safety glasses or goggles must always be worn underneath face shields.
- 9.1.8 Additional illumination may be needed when using tinted face shields as protection during electrical work.

9.2 Flash Protection Boundary

- 9.2.1 Personal protective equipment shall be provided to and used by all employees working within the “Flash Protection Boundary”.
- 9.2.2 For systems that are 600 volts or less, the Flash Protection Boundary shall be a minimum of four feet. *The formula in **Appendix C** can be used to determine the exact Flash Protection Boundary for systems under 600 volts.*
- 9.2.3 For systems that are above 600 volts, the Flash Protection Boundary shall be determined through engineering analysis.
- 9.2.4 The specific protective equipment to be worn within the Flash Protection Boundary can be determined by either of the following two methods in conjunction with the decision tree (**Appendix H** of this document):
 - (1) Complete a detailed incident energy analysis under engineering supervision that determines the incident exposure energy of each employee. Appropriate protective clothing can then be selected based on the calculated exposure level and NFPA 70E Table H.3 (b). Criteria for completing such an analysis can be obtained from the CF Safety Coordinator.
 - (2) *Determine the hazard level of the task by referring to NFPA 70E Table 130.7 (C) (15) (A) (b) and 130.7(C) (15) (B), “Hazard/Risk Category Classifications” (**Appendix D** of this document). Appendix D also includes Use of Rubber Insulating Gloves and Insulated/Insulating Hand Tools. Once the hazard level of the task has been determined, the required PPE can then be ascertained (**Appendix E** of this document).*
- 9.2.5 CF departments shall develop and maintain a listing of the specific PPE requirements for each energized electrical task conducted by their employees.

9.3 Arc rated Apparel & Underlayers

- 9.3.1** Arc-rated apparel shall be visually inspected before each use. Arc-rated apparel that is contaminated or damaged shall not be used. Protective items that become contaminated with grease, oil, flammable liquids, or combustible liquids shall not be used.
- 9.3.2** The garment manufacturer's instructions for care and maintenance of arc-rated apparel shall be followed.
- 9.3.3** When arc-rated apparel is worn to protect an employee, it shall cover all ignitable clothing and allow for movement and visibility.
- 9.3.4** Arc-rated apparel must cover potentially exposed areas as completely as possible. Arc-rated shirt sleeves must be fastened and arc-rated shirts/jackets must be closed at the neck.
- 9.3.5** Non-melting, flammable garments (i.e. cotton, wool, rayon, silk, or blends of these materials) may be used as underlayers beneath arc-rated apparel.
- 9.3.6** Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers next to the skin. (An incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted).
- 9.3.7** Arc-rated garments worn as outer layers over arc-rated apparel (i.e. jackets or rainwear) must also be made from arc-rated material.
- 9.3.8** Flash suits must permit easy and rapid removal by the user.

9.4 Rubber Insulating Equipment

- 9.4.1** Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.
- 9.4.2** Insulating equipment must be inspected for damage before each day's use and immediately following any incident that could have caused damage.
- 9.4.3** An air test must be performed on rubber insulating gloves before each use.
- 9.4.4** Insulating equipment found to have defects that might affect its insulating properties must be removed from service until testing indicates that it is acceptable for continued use.

- 9.4.5 Where the insulating capability of protective equipment is subject to damage during use, the insulating material shall be protected by an outer covering of leather or other appropriate material.
- 9.4.6 *Rubber insulating equipment must be tested according to the schedule contained in **Appendix G Table 130.7 (C)(7)(c)** and/or manufacturer's guidelines.*
- 9.4.7 Rubber insulating equipment must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that may cause damage.
- 9.4.8 Repairs to rubber insulating equipment shall only be performed by a certified facility.

9.5 Insulated tools and materials

- 9.5.1 Only insulated tools and equipment shall be used within the Limited Approach Boundary of exposed energized parts.
- 9.5.2 Insulated tools shall be rated for the voltages on which they are used.
- 9.5.3 Insulated tools shall be inspected and tested per manufacturer's recommendations.
- 9.5.4 Repairs to insulated tools shall only be performed by a certified facility.
- 9.5.5 Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
- 9.5.6 Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.
- 9.5.7 Ropes and hand lines used near exposed energized parts shall be nonconductive.
- 9.5.8 Portable ladders used for electrical work shall have nonconductive side rails.

10.0 ALERTING TECHNIQUES

- 10.1 Barricades shall be used in conjunction with safety signs to prevent or limit access to work areas containing live parts and Flash Protection Boundary. Conductive barricades shall not be used where they may cause an electrical hazard. Barricades shall be placed no closer than the Limited Approach Boundary.
- 10.2 If signs and barricades do not provide sufficient protection, an attendant will be assigned to warn and protect pedestrians. The primary duty of the attendant shall be to keep unqualified persons out of the work area where an electrical hazard exists.

The attendant shall remain in the area as long as there is a potential exposure to electrical hazards.

11.0 CONTRACT EMPLOYEES

- 11.1** Safety programs used by contractors on CF jobsites must meet or exceed all applicable guidelines of this Safety Program.
- 11.2** Contractors will be required to comply with applicable Safety and Health regulations such as OSHA, NFPA, EPA.
- 11.3** Contractors may be required to submit copies of their Safety Program to CF upon request.

12.0 ENFORCEMENT

Compliance with safety rules is considered a condition of employment for Campus Facilities employees. Supervisors and/or individuals in the CF Personnel Department reserve the right to issue disciplinary action to any CF employee, up to and including termination, for failure to follow the guidelines of this program.

Energized Electrical Work Permit Appendix A

Part I: To be completed by requestor or supervisor of the job	
Job Location:	
Job Location Contact (Name & Title):	Phone:
Description of Circuit & Equipment:	
Justification of why the circuit cannot be de-energized or the work delayed until the next scheduled outage:	
Part II: To be completed by the qualified person (s) completing the work.	
1. Detailed description of work procedure:	
2. Description of safe work practices to be employed:	
3. Voltage exposure:	
4. What is the PPE category or results of incident energy analysis?	
5. What are the flash protection boundaries?	
6. PPE required to perform work:	
7. Method used to restrict access to area:	
8. Hazard Assessment Completed? Yes / No	
9. Do you agree the above work can be done safely? Yes / No	
Qualified person signatures: _____	Date: _____
_____	Date: _____
_____	Date: _____
Part III: To be completed by supervisors	

Approvals: _____ Date: _____ Approvals: _____ Date: _____	
Note: Attach additional pages as necessary. This completed form shall be kept for two years after completion of work.	

Appendix B: Approach Boundaries to Live Parts for Shock Protection for Alternating-Current Systems

(All dimensions are distance from live part to employee)

Nominal System Voltage (phase to phase)	Limited Approach Boundary (fixed circuit parts only)	Restricted Approach Boundary (includes inadvertent movement adder)	
Less than 50 V	Not Specified	Not Specified	
50 V to 150 V	3 feet, 6 inches	Avoid Contact	
151V to 750 V	3 feet, 6 inches	1 foot	
751 V to 15 kV	5 feet	2 feet, 2 inches	
Over 15 kV or movable conductor	See NFPA 70 E Table 130.4(D)(a)		

See Table 130.4(D)(b) for Direct-Current systems

- **Limited Approach Boundary:** Distance from an exposed live part within which a shock hazard exists. An unqualified person may not cross this boundary unless they are continuously escorted by a qualified person.
- **Restricted Approach Boundary:** Distance from an exposed live part within which there is an increased risk of shock (due to electrical arc-over combined with inadvertent movement) for personnel working in close proximity to the live part. This boundary may only be crossed by a qualified person who is safely insulated or guarded from the live parts.
- **Flash Protection Boundary (not listed in table):** Distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur. This boundary may only be crossed by a qualified person wearing the appropriate PPE. For systems that are 600 volts or less, the Flash Protection Boundary shall be a minimum of four feet. An engineering analysis must be performed to determine the Flash Protection Boundary for systems that are above 600 volts.

Appendix C: Formula for Calculation of Flash Protection Boundary

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

OR

$$D_c = [53 \times MVA \times t]^{1/2}$$

Where:

D_c = Distance in feet from an arc source for a second-degree burn

MVA_{bf} = Bolted fault capacity available at point involved (in mega volt-amps)

MVA = Capacity rating of transformer (mega volt-amps). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25.

t = Time of arc exposure (in seconds).

Examples:

#1 Transformer 1000 kVA = 1.0 mVA, and breaker trip setting instantaneous of 0.1 seconds

$$D_c = (53 \times 1 \times 0.1)^{1/2}$$

$$D_c = (5.3)^{1/2}$$

$$D_c = 2.3 \text{ feet}$$

#2 Transformer 1000kVA = 1.0 mVA, and breaker trip setting at short time delay of 0.5 seconds

$$D_c = (53 \times 1 \times 0.5)^{1/2}$$

$$D_c = (26.5)^{1/2}$$

$$D_c = 5.1 \text{ feet}$$

Flash Protection Boundary increases with breaker trip setting

APPENDIX D

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130.7

ARTICLE 130-WORK INVOLVING ELECTRICAL HAZARDS

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

Equipment	Arc Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated >240 V and up to 600 V Parameters: Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	900mm (3 ft)
600-V class motor control centers (MCCs) Parameters: Maximum of 65 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	15 111 (5 ft)
600-V class motor control centers (MCCs) Parameters: Maximum of 42 kA short-circuit current available; maximum of 0.33 sec (20 cycles) fault clearing time; working distance 455 mm (18 in.)	4	4.3 m (14ft)
600-V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.5 sec (30 cycles) fault clearing time; working distance 455 mm (18 in.)	4	6m (20 ft)
Other 600-V class (277 V through 600 V, nominal) equipment Parameters: Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.)	4	12m (40ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.)	4	12m (40ft)
Arc-resistant switchgear Type 1 or 2 [for clearing times of <0.5 sec (30 cycles) with a perspective fault current not to exceed the arc resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of mc-resistant-type construction, tested in accordance with IEEE C37.20.7. 1 kV through 15 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36in.)	<i>N/A</i> (doors closed)	<i>N/A</i> (doors closed)
	4 (doors open)	12m (40ft)

Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.)	4	12m (40ft)
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Note: For equipment rated 600 volts and below, and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category I.

Table 130.7(C)(15)(B) Arc-Flash Hazard PPE Categories for Direct Current (dc) Systems

Equipment	Arc Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources 100 V > Voltage < 250 V Parameters: Voltage: 250 V Maximum arc duration and working distance: 2 sec @ 455 mm (18 in.)		
Short-circuit current < 4 kA	1	900 mm (3 ft)
4 kA ≤ short-circuit current < 7 kA	2	1.2 m (4 ft)
7 kA ≤ short-circuit current < 15 kA	3	1.8 m (6 ft)
Storage batteries, dc switchboards, and other dc supply sources 250 V ≤ Voltage ≤ 600 V Parameters: Voltage: 600 V Maximum arc duration and working distance: 2 sec @ 455 mm (18 in.)		
Short-circuit current 1.5 kA	1	900 mm (3 ft)
1.5 kA ≤ short-circuit current < 3 kA	2	1.2m (4ft)
3 kA::: short-circuit current < 7 kA	3	1.8 m (6ft.)
7 kA ::: short-circuit current < 10 kA	4	2.5 m (8 ft)

Note: Apparel that can be expected to be exposed to electrolyte must meet both of the following conditions:

- (1) Be evaluated for electrolyte protection in accordance with ASTM F1296, Standard Guide for Evaluating Chemical Protective Clothing
- (2) Be arc-rated in accordance with ASTM F1891, Standard Specification for Arc Rated and Flame Resistant Rainwear, or equivalent

(16) Protective Clothing and Personal Protective Equipment (PPE). Once the arc flash PPE category has been identified from Table 130.7(C)(15)(A)(b) or Table 130.7(C)(15)(B), Table 130.7(C)(16) shall be used to determine the required PPE for the task. Table 130.7(C)(16) lists the requirements for PPE based on arc flash PPE categories 1 through 4. This clothing and equipment shall be used when working within the arc flash boundary.

Informational Note No. 1: See Informative Annex H for a suggested simplified approach to ensure adequate PPE for Electrical Workers within facilities with large and diverse electrical systems.

Informational Note No. 2: The PPE requirements of this section are intended to protect a person from arc flash hazards. While some situations could result in burns to the skin, even with the protection described in Table 130.7(C)(16), burn injury should be reduced and survivable. Due to the explosive effect of some arc events, physical trauma injuries could occur. The PPE requirements of this section do not address protection against physical trauma other than exposure to the thermal effects

Use of Rubber Insulating Gloves and Insulated/Insulating Hand Tools

Tasks Performed on Energized Equipment	Rubber Insulating Gloves	Insulated/Insulating Hand Tools
Panelboards or Other Equipment Rated 240 V and Below – Note 1		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
Circuit breaker (CB) or fused switch operation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Remove/install CBs or fused switches	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	Y	Y
Panelboards or Switchboards Rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) – Note 1		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
CB or fused switch operation	Y	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard	Y	Y
600 V Class Motor Control Centers (MCCs) – Note 2 (except as indicated)		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
Reading a panel meter while operating a meter switch	N	N
CB or fused switch or starter operation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	Y	Y

Insertion or removal of individual starter “buckets” from MCC – Note 3	Y	N
Application of safety grounds, after voltage test	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts) – Note 3	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts) – Note 3	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the motor control center	Y	Y
600 V Class Switchgear (with power circuit breakers or fused switches) – Note 4		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
Reading a panel meter while operating a meter switch	N	N
CB or fused switch operation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	N	N
Application of safety grounds, after voltage test	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Other 600 V Class (277 V through 600 V, nominal) Equipment – Note 2 (except as indicated)		
Lighting or small power transformers (600 V, maximum)		
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Application of safety grounds, after voltage test	Y	N

Revenue meters (kW-hour, at primary voltage and current) Insertion or removal	Y	N
Cable trough or tray cover removal or installation	N	N
Miscellaneous equipment cover removal or installation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Application of safety grounds, after voltage test	Y	N
Insertion or removal of plug-in devices into or from busways	Y	N
NEMA E2 (fused contactor) Motor Starters, 2.3 kV Through 7.2 kV		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
Reading a panel meter while operating a meter switch	N	N
Contactor operation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	Y	Y
Insertion or removal (racking) of starters from cubicles, doors open or closed	N	N
Application of safety grounds, after voltage test	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Insertion or removal (racking) of starters from cubicles of arc- resistant construction, tested in accordance with IEEE C37.20.7, doors closed only	N	N
Metal Clad Switchgear, 1 kV Through 38 kV		
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	N	N
Reading a panel meter while operating a meter switch	N	N
CB operation	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Work on control circuits with energized electrical conductors	Y	Y

and circuit parts 120 V or below, exposed		
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	N	N
Application of safety grounds, after voltage test	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening voltage transformer or control power transformer compartments	N	N
Arc-Resistant Switchgear Type 1 or 2 (for clearing times of <0.5 sec with a perspective fault current not to exceed the arc resistant rating of the equipment)		
CB operation with enclosure door closed	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	N	N
Insertion or removal of CBs from cubicles with door open	N	N
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	Y	Y
Insertion or removal (racking) of ground and test device with door closed	N	N
Insertion or removal (racking) of voltage transformers on or off the bus door closed	N	N
Other Equipment 1 kV Through 38 kV		
Metal-enclosed interrupter switchgear, fused or unfused		
Switch operation of arc-resistant-type construction, tested in accordance with IEEE C37.20.7, doors closed only	N	N
Switch operation, doors closed	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	N	N
Outdoor disconnect switch operation (hookstick operated)	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	Y	N

Insulated cable examination, in manhole or other confined space

Y

N

Insulated cable examination, in open area

Y

N

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130.7

ARTICLE 130-WORK INVOLVING ELECTRICAL HAZARDS

Informational Note No. 3: The arc rating for a particular clothing system can be obtained from the arc-rated clothing manufacturer.

Table 130.7(C)(16) Continued

Table 130.7(C)(16) Personal Protective Equipment (PPE)

PPE Category	PPE
1. Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm² (see Note 1) Arc-rated long –sleeve shirt and pants or arc-rated coverall Arc-rated face shield (see Note 2) or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard Hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves (see Note 3) Leather footwear (AN)	
2. Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (see Note 1) Arc-rated long-sleeve shirt or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield (see Note 2) and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard Hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves (see Note 3) Leather footwear	
3. Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (see Note 1) Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves (see Note 1) Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather Footwear	

PPE Category	PPE
4. Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm² (see Note 1)	Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves (see Note 1) Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather Footwear

An: as need (optional). AR: as required. SR: selection required.
Notes:

1. Arc rating is defined in Article 100
2. Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or alternatively, an arc-rated arc flash suit hood is required to be worn.
3. If Rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.

(D) Other Protective Equipment.

1. **Insulated Tools and Equipment.** Employees shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts where tools or handling equipment might make accidental contact. Insulated tools shall be protected from damage to the insulating material.

Informational Note: See 130.4(B), Shock Protection Boundaries

- a. Requirements for Insulated Tools. The following requirements shall apply to insulated tools:
 1. Insulated tools shall be rated for the voltages on which they are used.
 2. Insulated tools shall be designed and constructed for the environment to which they are expose and the manner in which they are used.
 3. Insulated tools and equipment shall be inspected prior to each use. The inspection shall look for damage to the insulation or damage that can limit the tool from performing its intended function or could increase the potential for an incident (e.g., damaged tip on a screwdriver).

Appendix E

Protective Clothing and Personal Protective Equipment

NFPA70E
2015 Edition
Table 130.7(C)(16)

Table 130.7(C)(16) Protective Clothing and Personal Protective Equipment (PPE)

Hazard/Risk Category	Protective Clothing and PPE
PPE Category 1	
Arc-rated Clothing, Minimum Arc Rating of 4 (Note 1)	Arc-rated long-sleeve shirt (Note 3) Arc-rated pants (Note 3) Arc-rated coverall (Note 4) Arc-rated face shield or arc flash suit hood (Note 7) Arc-rated jacket, parka, or rainwear (AN)
Arc-rated Protective Equipment	Hard Hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather gloves (AN) (Note 2) Leather work shoes (AN)
PPE Category 2	
Arc-rated Clothing, Minimum Arc Rating of 8 (Note 1)	Arc-rated long-sleeve shirt (Note 5) Arc-rated pants (Note 5)

<p>Arc-rated Protective Equipment</p>	<p>Arc-rated coverall (Note 6)</p> <p>Arc-rated arc flash suit hood (Note 10)</p> <p>Arc-rated jacket, parka, or rainwear (AN)</p> <p>Hard Hat</p> <p>Safety glasses or safety goggles (SR)</p> <p>Hearing protection (ear canal inserts)</p> <p>Leather gloves (AN) (Note 2)</p> <p>Leather work shoes</p>
<p>PPE Category 3</p>	
<p>Arc-rated Clothing, Minimum Arc Rating of 25 (Note 1)</p> <p>Arc-rated Protective Equipment</p>	<p>Arc-rated long-sleeve shirt (AR) (Note 8)</p> <p>Arc-rated pants (AR) (Note 8)</p> <p>Arc-rated coverall (AR) (Note 8)</p> <p>Arc-rated arc flash suit jacket (AR) (Note 8)</p> <p>Arc-rated arc flash suit pants (AR) (Note 8)</p> <p>Arc-rated arc flash suit hood (Note 8)</p> <p>Arc-rated jacket, parka, or rainwear (AN)</p> <p>Hard Hat</p> <p>Arc-rated hard hat liner (AR)</p> <p>Safety glasses or safety goggles (SR)</p> <p>Hearing protection (ear canal inserts)</p> <p>Arc-rated gloves (Note 2)</p> <p>Leather work shoes</p>
<p>PPE Category 4</p>	
<p>Arc-rated Clothing, Minimum Arc Rating of 40 (Note 1)</p>	<p>Arc-rated long-sleeve shirt (AR) (Note 9)</p> <p>Arc-rated pants (AR) (Note 9)</p>

Arc-rated coverall (AR) (Note 9)
Arc-rated arc flash suit jacket (AR) (Note 9)
Arc-rated arc flash suit pants (AR) (Note 9)
Arc-rated arc flash suit hood (Note 9)
Arc-rated jacket, parka, or rainwear (AN)

Hard Hat

Arc-rated hard hat liner (AR)

Safety glasses or safety goggles (SR)

Hearing protection (ear canal inserts)

Arc-rated gloves (Note 2)

Leather work shoes

Arc-rated Protective Equipment

AN = As needed (optional)

AR = As required

SR = Selection required

Notes:

1. See Table 130.7(C)(11). Arc rating for a garment or system of garments is expressed in cal/cm².
2. If rubber insulating gloves with leather protectors are required by Table 130.7(C)(9), additional leather or arc-rated gloves are required.
3. The arc-rated shirt and pants used for Hazard/Risk Category 1 shall have a minimum arc rating of 4.
4. Alternate is to use arc-rated coveralls (minimum arc rating of 4) instead of arc-rated shirt and arc-rated pants.
5. Arc-rated shirt and arc-rated pants used for Hazard/Risk Category 2 shall have a minimum arc rating of 8.
6. Alternate is to use arc-rated coveralls (minimum arc rating of 8) instead of arc-rated shirt and arc-rated pants.
7. A face shield with a minimum arc rating of 4 for Hazard/Risk Category 1 or a minimum arc rating of 8 for Hazard/Risk Category 2, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or, alternatively, an arc-rated arc flash suit hood), is required.
8. An alternate is to use a total arc-rated clothing system and hood, which shall have a minimum arc rating of 25 for Hazard/Risk Category 3.
9. The total clothing system consisting of arc-rated shirt and pants and/or arc-rated coveralls and/or arc flash coat and pants and hood shall have a minimum arc rating of 40 for Hazard/Risk Category 4.
10. Alternate is to use a face shield with a minimum arc rating of 8 and a balaclava (sock hood) with a minimum arc rating of 8 and which covers the face, head and neck except for the eye and nose areas.

Appendix G: Inspection Schedule for Rubber Insulating Equipment

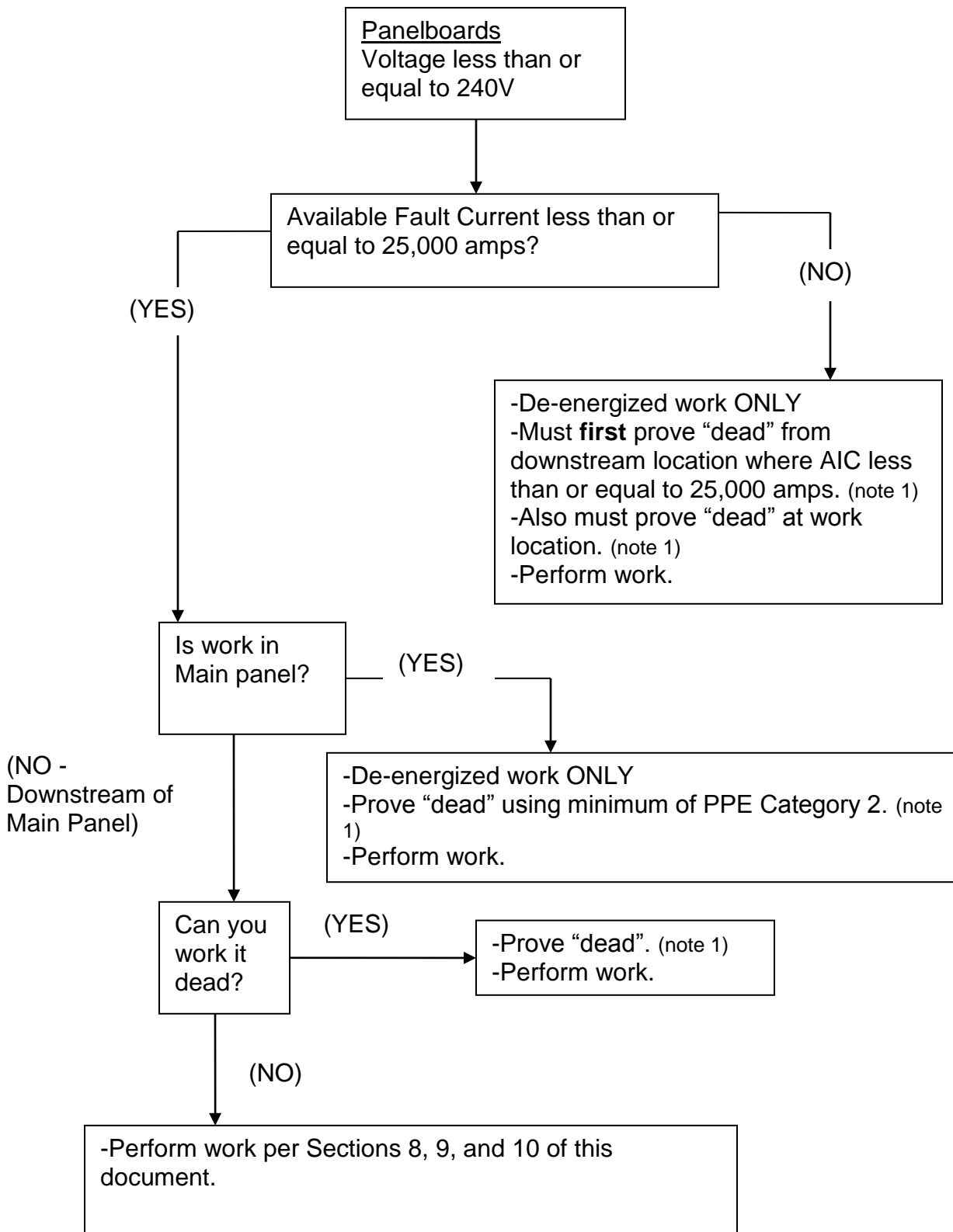
Table 130.7(C)(7)(c) Rubber Insulating Equipment, Maximum Test Intervals

Rubber Insulating Equipment	When to Test	Governing Standard for Test Voltage*
Blankets	Before first issue; every 12 months thereafter**	ASTM F479
Covers	If insulating value is suspect	ASTM F478
Gloves	Before first issue; every 6 months thereafter**	ASTM F496
Line Hose	If insulating value is suspect	ASTM F478
Sleeves	Before first issue; every 12 months thereafter**	ASTM F496

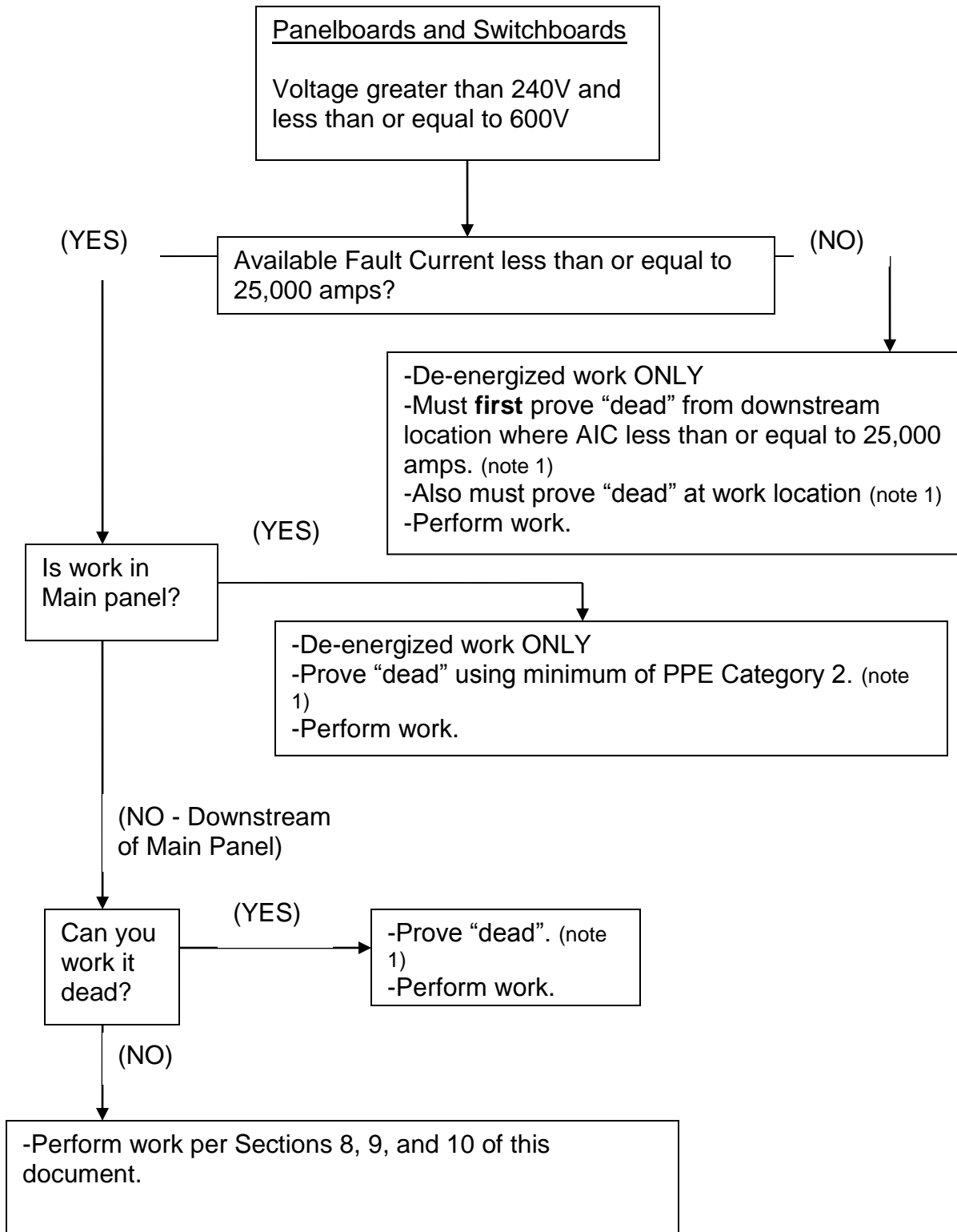
* ASTM F478, *Standard Specification for In-Service Care of Insulating Line Hose and Covers*; ASTM F479, *Standard Specification for In-Service Care of Insulating Blankets*; ASTM F496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves*.

** If the insulating equipment has been electrically tested but not issued for service, it is not permitted to be placed into service unless it has been electrically tested within the previous 12 months.

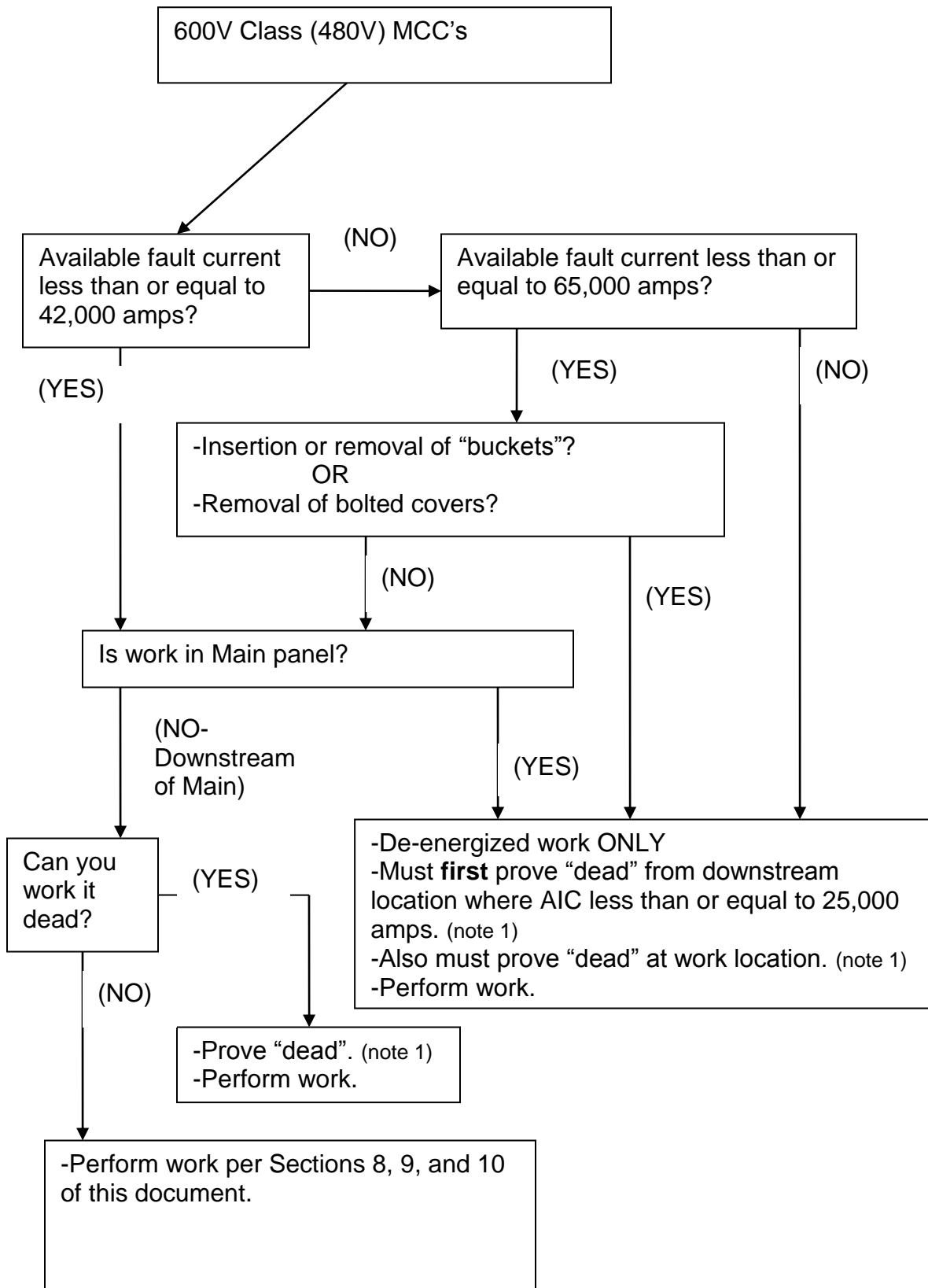
Appendix H



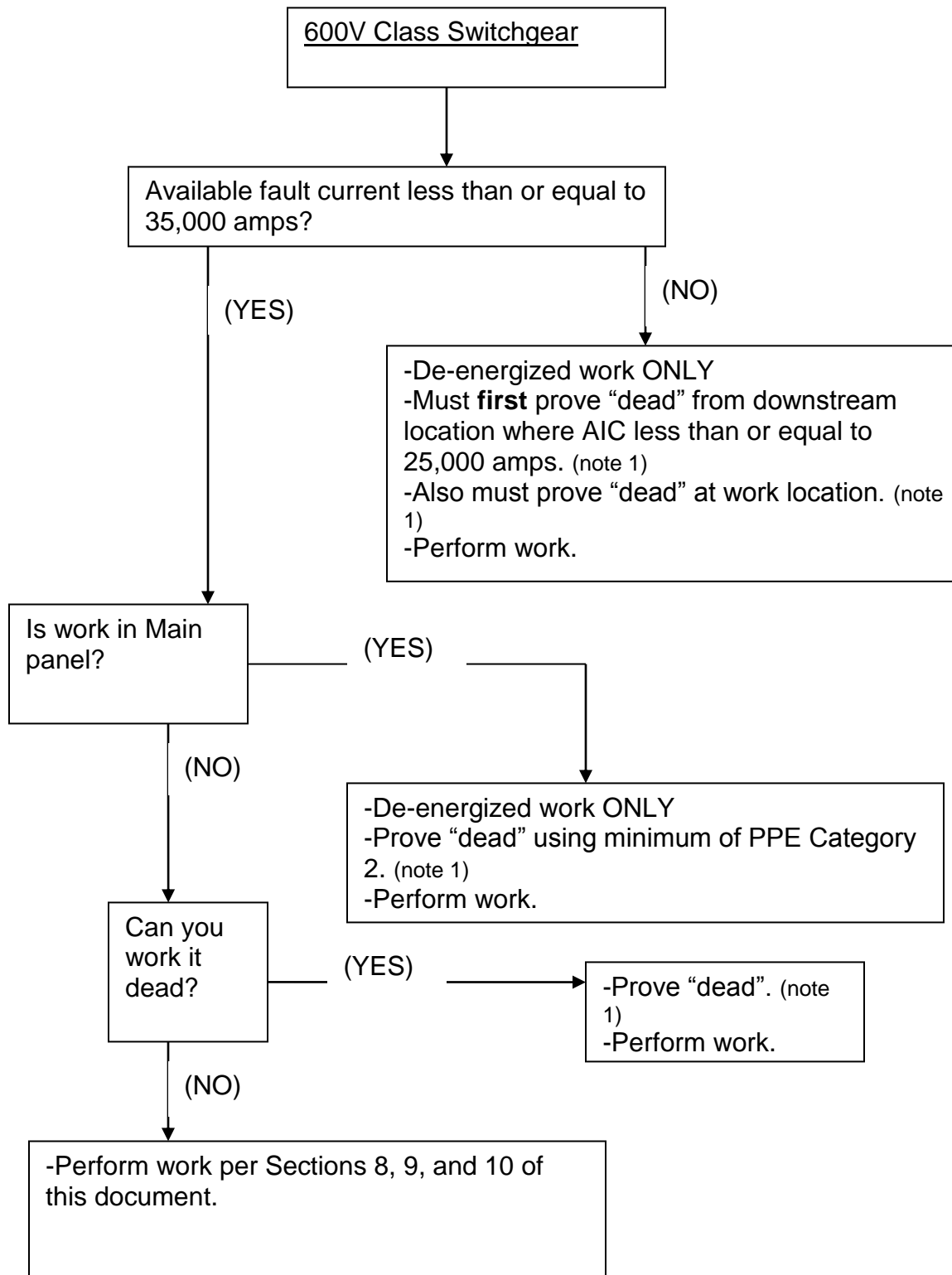
Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



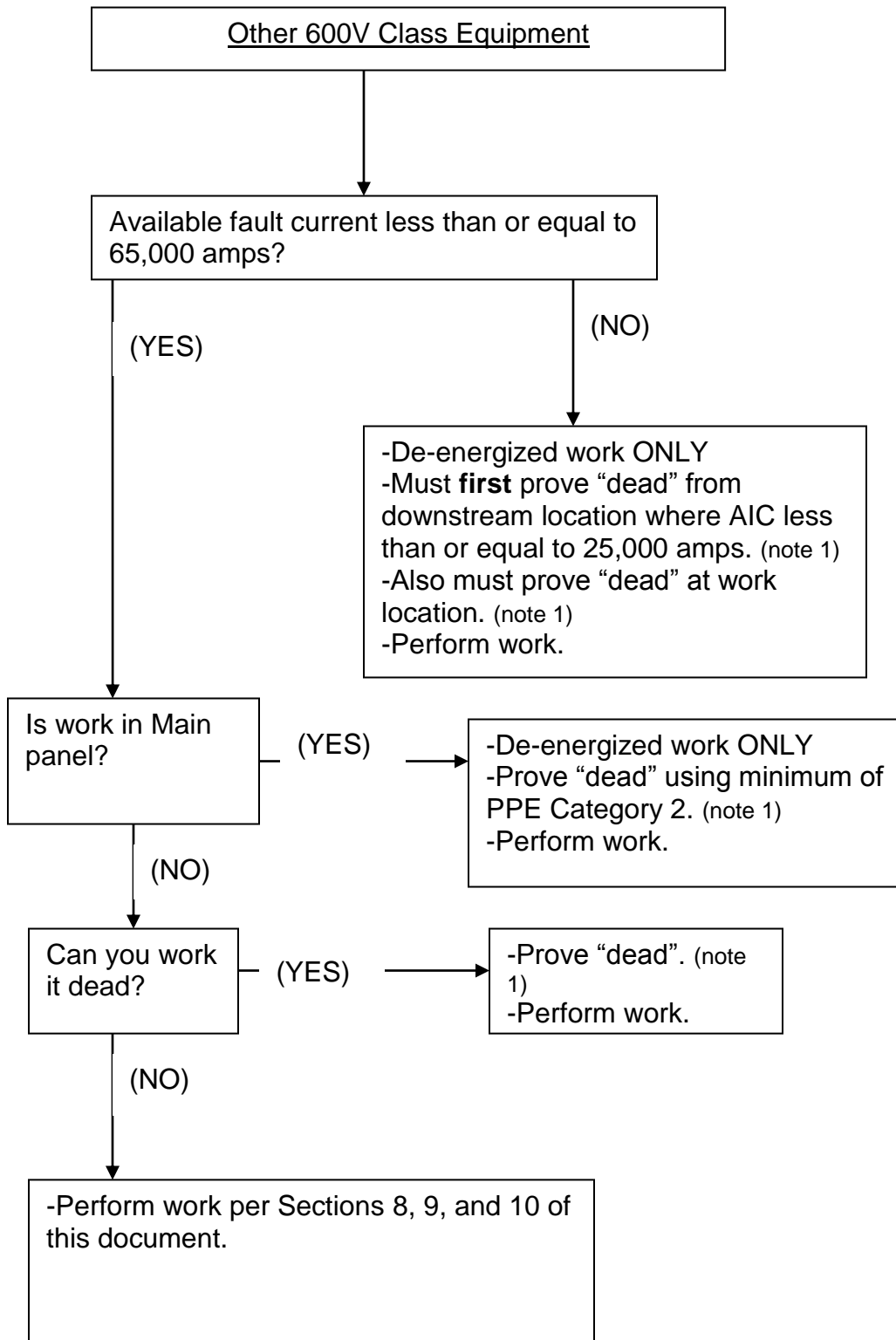
Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



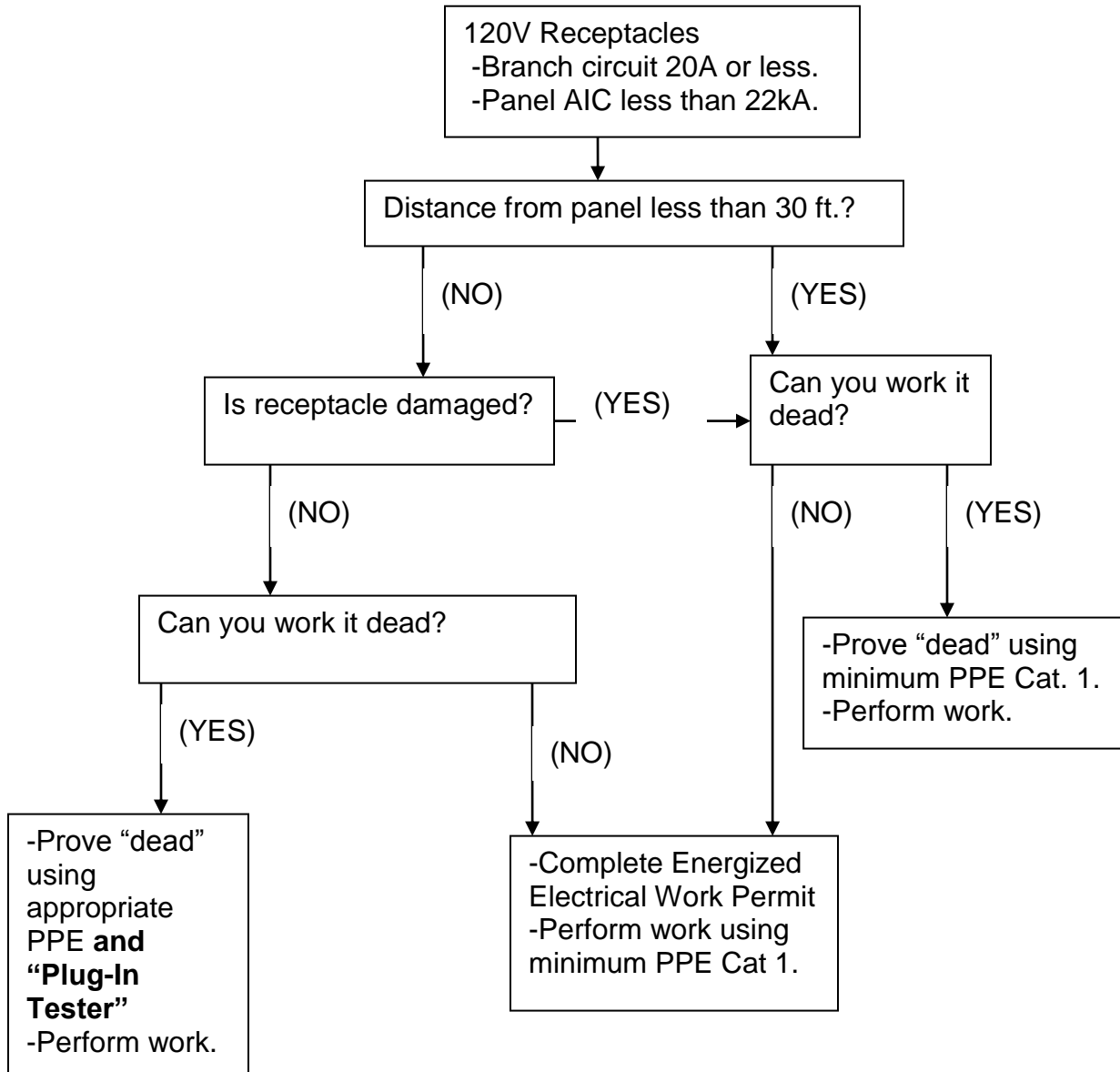
Note 1 - “Prove Dead” requires PPE appropriate for location and task. Use section 9 of this document.



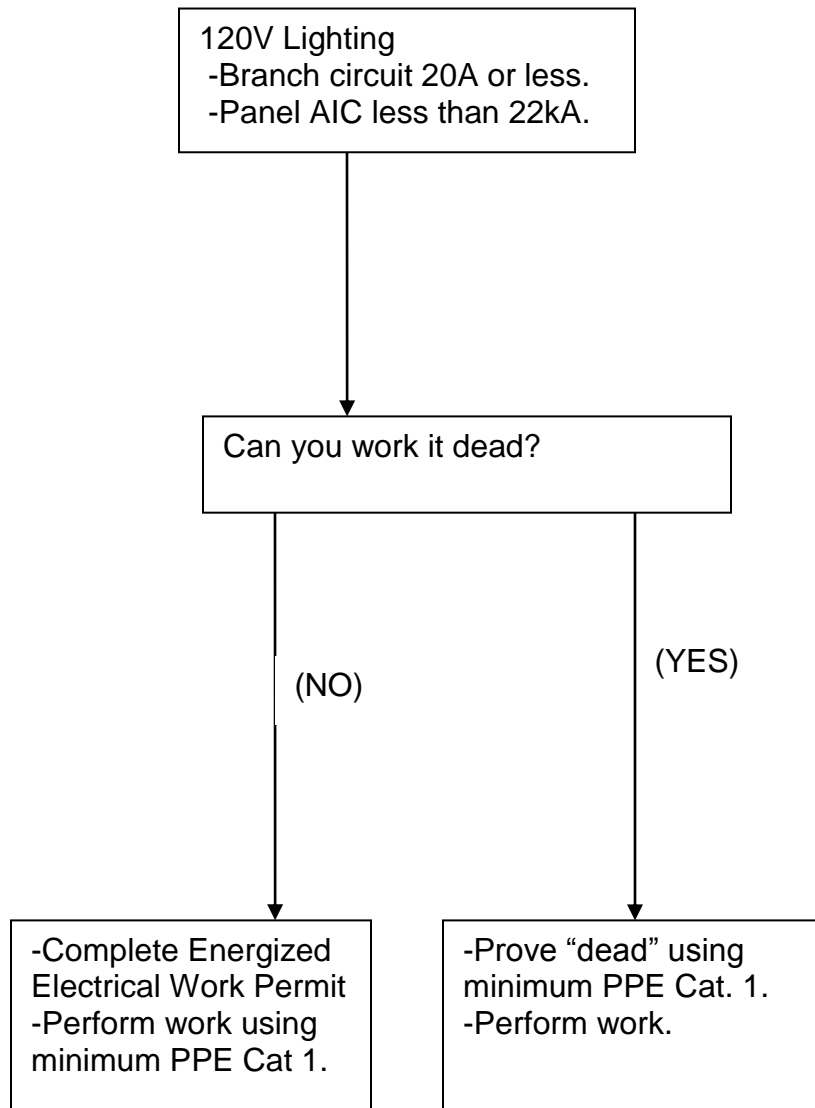
Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



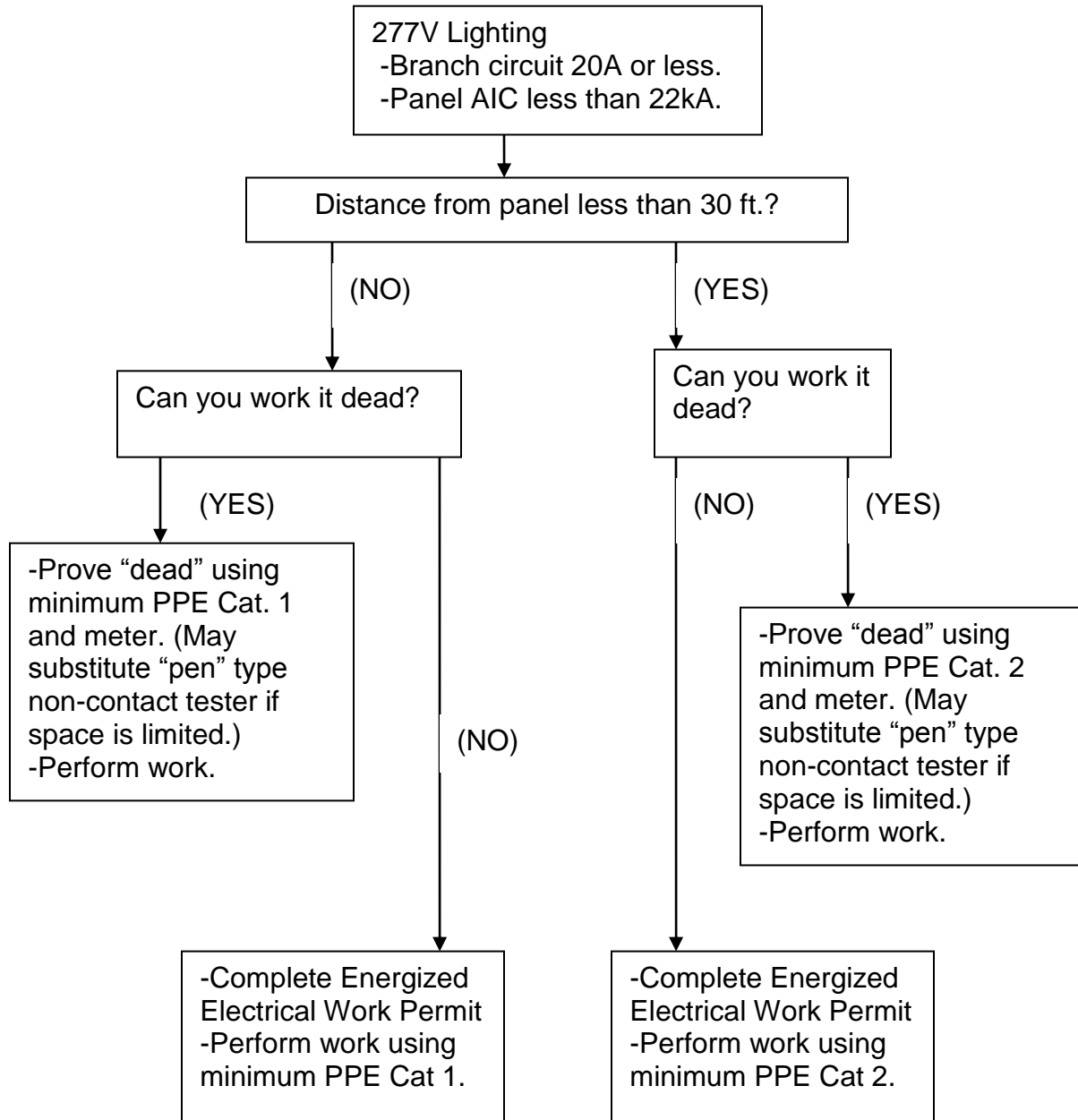
Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



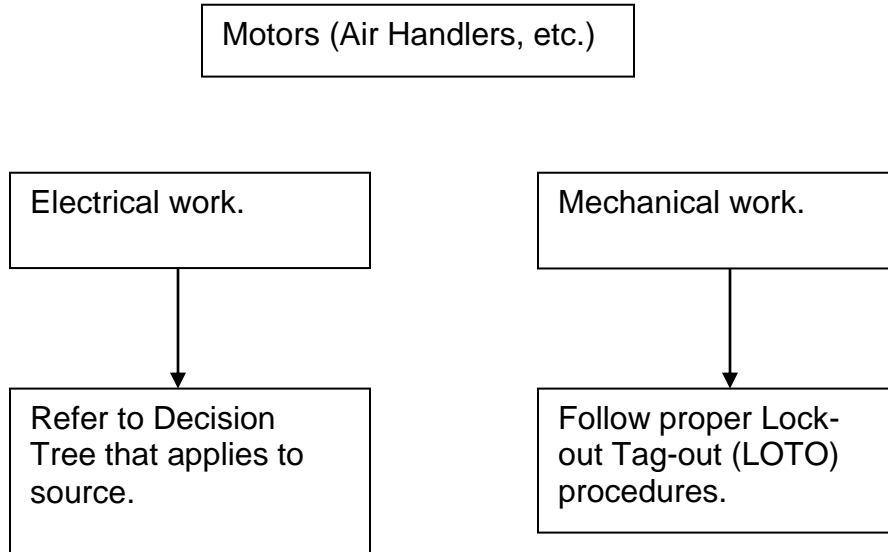
Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



Note 1 - "Prove Dead" requires PPE appropriate for location and task. Use section 9 of this document.



Note 1 - “Prove Dead” requires PPE appropriate for location and task. Use section 9 of this document.



Note 1 - “Prove Dead” requires PPE appropriate for location and task. Use section 9 of this document.