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1.0 Introduction

1.1 Purpose

The purpose of this program is to establish minimum standards to protect employees against electrical shock, burns, electrocution and other electrical safety hazards as well as ensure compliance with regulatory requirements applicable to electrical systems. **This program does not cover all requirements related to installation methods and procedures specifically learned through an apprenticeship program.**

1.2 Scope

This program applies to all Emory employees, including Emory Healthcare (EHC), faculty, staff, students and visitors who perform work on or near electrical equipment.

1.3 Definitions

Arc Flash. The light and heat produced from an electric arc supplied with sufficient electrical energy to cause substantial damage, harm, fire or energy.

Arc Flash Risk Assessment. A study investigating a worker's potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash boundary and the appropriate levels of personal protective equipment.

Boundary, Arc Flash. When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5J/cm^2).

Boundary, Limited Approach. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

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

De-energized. Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Energized. Electrically connected to, or is, a source of voltage.

Qualified Person. One who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. See Appendix F for more information.

Unqualified Person. A person who is not a qualified person.

Working Distance. The distance between a person's face and chest area and a prospective arc source.

Working On (energized electrical conductors or circuit parts). Intentionally coming in contact with energized electrical conductors or circuit parts with hands, feet or other

body parts with tools, probes or with test equipment regardless of the personal protective equipment a person is wearing.

1.4 Responsibilities

Environmental Health and Safety Office (EHSO) and applicable hospital/clinic Safety Management Group

As the administrative department for the Electrical Safety Program, EHSO and the applicable hospital/clinic Safety Management Group are responsible for:

- Reviewing and updating the Electrical Safety Program, every three years.
- Coordinating or providing general training on the contents of this program.
- Evaluating the overall effectiveness of the Electrical Safety Program.
- Reviewing the standards and regulations and helping to determine their applicability to work being performed at Emory.

Directors, Supervisors, Managers and Principal Investigators (PIs)

Directors, supervisors, managers and PIs have primary responsibility for the management and enforcement of the Electrical Safety Program in their areas. They must be knowledgeable about the work to be performed and the hazards involved to determine who is qualified to perform the work. They are responsible for:

- Ensuring employees comply with all provisions of the program. Compliance is documented by conducting annual field audits.
- Establishing, documenting and implementing safe work practices and procedures.
- Developing and maintaining a list of qualified electrical workers under their supervision.
- Ensuring employees are trained to their assigned electrical tasks and maintaining documentation of such training.
- Ensuring that electrical equipment is labeled appropriately.
- Ensuring that employees exposed to live electrical hazards are provided with appropriate protective equipment.
- Ensuring that electrical safety equipment and personal protective equipment are performance tested per the manufacturer's recommendations.
- Assisting in the investigation of all injuries and incidents involving electrical work.
- Attending all required training.

Employees

All employees are responsible for complying with the rules set forth by this program. They must ensure that they:

- Follow the work practices described in this document, including the use of appropriate protective equipment and completion of pre-use inspections.
- Attend all required training.
- Integrate safe electrical design practices and safe work procedures into research design, equipment selection and apparatus development.
- Immediately report any concerns related to electrical safety to a supervisor, manager, or PI.

Contractors

Contractors are responsible for ensuring their employees are instructed in the hazards of the job. They must also ensure that:

- They comply with all local, state and federal safety requirements.
- They provide all necessary tools, personal protective equipment and electrical safety equipment for their employees to perform the tasks that they have been assigned.
- Their employees perform a walkthrough of any affected areas with an Emory representative and remove all tools and equipment after the work has been completed.
- All of their employees and sub-contractors who perform work on Emory property have been suitably trained to perform the tasks that they have been assigned.

1.5 Training Requirements

- Training is provided to all Emory employees who work on or near energized electrical circuits. This training shall be given before the employee is assigned duties involving work around or on electrical systems. Unqualified worker training is available online through ELMS. Qualified worker training is provided by a third-party contractor. EHSO reserves the right to audit all training secured outside of EHSO to ensure compliance with applicable standards.
- Training on newly installed electrical equipment is provided by the equipment manufacturer/installation company.
- **Refresher** training is required to be completed **every three years** to inform employees to changes in the standard and ensure employees maintain safe work practices, skills and knowledge. Additional **retraining** is required whenever:
    - The supervisor or annual inspections indicate the employee is not complying with the safety-related work practices.
    - New technology, new types of equipment or changes in procedures necessitate the use of safety-related work practices that are different from those that the employee has been trained on.
    - The employee must employ safety-related work practices that are not normally used during his or her regular job duties.
    - The employee has been involved in an accident or near-miss incident while working on or near electrical equipment and refresher training is recommended.
- The level of electrical safety training provided is dependent on whether the employee is classified as a “qualified person” or “unqualified person”.
- Training will consist of both classroom and on-the-job training.
- Unqualified workers working near exposed parts of electrical circuits operating at or above 50 volts must be trained in the following, **every three years**:
    - The hazards of electricity.
    - Relationship between electrical hazards and possible injury.
    - Safety-related work practices necessary for their safety.
- Training for qualified workers will be conducted by persons who have the knowledge, training and experience to train employees and evaluate their competence.
- In addition to electrical safety related work practices, qualified workers receive training on emergency procedures, including methods to release victims from

contact with exposed energized electrical conductors or circuit parts, first aid and emergency procedures such as resuscitation. **NOTE:** Training in approved methods of resuscitation, including cardiopulmonary resuscitation and automatic external defibrillator (AED) use, shall be **re-certified at a frequency that satisfies the requirements of the certifying body**.

- Qualified persons working on or near exposed energized parts shall be trained and knowledgeable in the following:
    - Construction and operation of equipment on which work is assigned.
    - Skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment.
    - Skills and techniques necessary to determine the nominal voltage of exposed live parts.
    - How to safely work on energized circuits, including:
        - Clearance distances specified for working on or near exposed energized parts and the corresponding voltages to which the qualified person will be exposed.
        - Appropriate safety equipment and tools necessary to safely perform work in accordance with OSHA and NFPA 70E.
    - Decision-making process necessary to be able to do the following:
    - Perform the job safety planning.
    - Identify electrical hazards.
    - Assess the associated risk.
    - Select the appropriate risk control methods from the hierarchy of controls including personal protective equipment.

1.6 Recordkeeping Requirements

Records include but are not limited to:

- Training records will document that an employee demonstrates proficiency in the work practices involved and will be retained for the duration of the employee's employment.
    - Training records will include the content of the training (course syllabus, course curriculum, outline, table of contents or training objectives), the employee's name and dates of training.
    - For training secured outside of EHSO, records are retained by the department securing the training and must be made available upon request.
    - Each work unit will maintain a record of all electrical training provided to their employees along with a listing of all employees classified as qualified persons.
    - All trainings provided by EHSO are available in the Emory Learning Management System (ELMS).
- Job Briefings by Qualified Worker will be maintained by the Department of the Qualified Worker.
- Electrically Safe Standard Operating procedures will be maintained by the Department.
- Energized Electrical Work Permits should be maintained by the Department of the Qualified Worker.
- Risk assessments including shock and arc flash should be maintained by the Department where the electrical hazard(s) exist.

- Field audits should be maintained by the Department of the procedures and work practices audited.
- Job Briefings with contractors where knowledge of electrical hazards were shared should be maintained by the Department where the work occurred.
- Records should be maintained for one year in order to be reviewed during the annual field audit.

1.7 Program Evaluation

- The written Electrical Safety Program shall be re-evaluated every three years and revised if necessary by EHSO. This evaluation will include a program audit to verify that the principles of this program are in compliance with applicable standards.
- Field work shall be audited annually to verify that the procedures of the Electrical Safety Program are being followed. Field audits are the responsibility of the Directors, Supervisors, Managers and PIs.

1.8 Incident Investigations

Ensure all incidents, including near miss or close call incidents, are reported to the department manager or supervisor and an incident report is completed in PeopleSoft Self-Service.

2.0 Electrical Installations

2.1 General Requirements

- Ensure all electrical installations conform to standards and regulations in place at the time of construction, renovation or repair including the National Electric Code (NEC), local electrical codes and OSHA.
- Keep electrical equipment free from recognized hazards that are likely to cause death or serious physical harm.
- Effectively close unused openings in boxes, raceways, cabinets, equipment cases or housings to afford protection that is substantially equivalent to the wall of the equipment.
- Ensure the width and depth of the working space around electrical equipment complies with the National Electrical Code at the time of construction.
- Ensure all 125V, single-phase, 15 & 20 ampere receptacles installed in bathrooms or on rooftops have ground-fault circuit interrupter (GFCI) protection.
- Ensure that all 125V, single-phase, 15 & 20 ampere receptacles exterior to the building have GFCI protection.

2.2 General Wiring Design and Protection

New electrical wiring and modification, extension or replacement of existing wiring must conform to the requirements of the NEC, OSHA and the following:

- Do not attach the grounded conductor to any terminal or lead so as to reverse designated polarity.
- Do not use the grounding terminal or grounding-type device on receptacles, cord connector or attachment plug for any purpose other than grounding.
- Ensure that conductors entering boxes, cabinets or fittings are protected from abrasion.

- Close all openings through which conductors enter, including unused openings in cabinets, boxes and fixtures.
- Provide covers approved for that purpose over all pull boxes, junction boxes and fittings. If metal covers are used, they must be grounded.
- Ensure that pull boxes and junction boxes for electrical systems provide the nominal voltage on the enclosure. The boxes must be closed by suitable covers and securely fastened in place.
- Locate switchboards and panel-boards that have exposed live parts in permanently dry locations and ensure they are accessible to **qualified persons** only.
- Ensure panel-boards are mounted in cabinets, cutout boxes or other approved enclosure and are dead front unless accessible to **qualified persons** only. Exposed blades of knife switches must be dead when open.
- Receptacles installed in damp or wet locations must be suitable for the location.
- Cabinets, cutout boxes, fittings, boxes and panel-board enclosures that are installed in damp or wet locations must be weatherproof.
- Fixtures, lamp holders, lamps, rosettes and receptacles may have no live parts normally exposed to employee contact.
- Multi-plug receptacle adapters that may not maintain ground continuity or may overload circuits must not be used. If additional receptacles are needed in a work location, additional circuits and/or receptacles must be installed. Multi-plug power strips with over-current protection are acceptable for use with electronic equipment if they are used to reduce line noise or to provide surge or over-current protection.
- Electrical equipment, wiring methods and installations of equipment in hazardous classified locations must be intrinsically safe, approved for the location or safe for the location. Hazardous classified locations are areas where flammable liquids, gases, vapors or combustible dusts or fibers exist or could exist in sufficient quantities to produce an explosion or fire.

2.3 Requirements for Temporary Wiring

- Temporary wiring under 600 volts, including flexible cords, cables and extension cords may only be used during and for renovation, maintenance, repair or experimental work. Remove all temporary wiring when the project is complete.
- Temporary wiring for decorative lighting cannot exceed 90 days.
- Ensure ground-fault protection (e.g., ground-fault circuit interrupters or GFCI) is provided on all temporary-wiring circuits, including extension cords.
- Ensure that all equipment and tools connected by cord and plug are grounded unless they are double insulated.
- Ensure feeders originate in an approved distribution center, such as a panel board that is rated for the voltage and currents the system is expected to carry.
- Ensure branch circuits originate in an approved power outlet or panel board.
- Neither bare conductors nor earth returns may be used for the wiring of any temporary circuit.
- Receptacles must be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit must contain a separate equipment-grounding conductor and all receptacles must be electrically connected to the grounding conductor.

- Ensure that flexible cords and cables are of an approved type and suitable for the location and intended use. They may only be used for pendants, wiring of fixtures, connection of portable lamps or appliances, elevators, hoists, connection of stationary equipment where frequently interchanged, prevention of transmission of noise or vibration, data processing cables or where needed to permit maintenance or repair.
- Ensure that flexible cords are used only in continuous lengths without a splice or tap.
- Ensure that flexible cords and cables are connected to devices and fittings so that strain relief is provided that will prevent pull from being directly transmitted to joints or terminal screws.
- Install suitable disconnecting switches or plug connects to permit the disconnection of all ungrounded conductors.
- Ensure lamps for general illumination are protected from accidental contact or damage, by providing a suitable guard, such as a cover or sleeve.
- Hand lamps supplied by flexible cord must be equipped with a handle of molded composition or other approved material and must be equipped with a substantial bulb guard.
- Protect flexible cords and cables from accidental damage.
- Avoid sharp corners and projections.
- Protect flexible cords and cables from damage when they pass through doorways or other pinch points.

2.4 Equipment Labeling

- Ensure each disconnecting means is clearly labeled to indicate the circuit's function and point of origination unless it is located and arranged so the purpose is evident.
- Label all installations with the nominal system voltage, arc flash boundary, and at least one of the following:
    - Available incident energy and the corresponding working distance or arc flash PPE category in Table 130.7(C)(15)(a) or 130.7 (C)(15)(b) for the equipment but not both.
    - Minimum arc rating of clothing.
    - Site-specific level of PPE.
- Ensure that all labels and markings are durable enough to withstand the environment to which they may be exposed.

2.5 Guarding of Live Parts

- Guard all live parts of electric equipment operating at 50 volts or more against accidental contact.
- Proper guarding can be achieved by use of an approved cabinet or other approved enclosure, by location in a room or vault that is accessible to **qualified persons only**, by elevating the equipment by eight feet or more above working surface or by using partitions or screens to prevent contact by unqualified persons.
- If electric equipment is located in an area where it is potentially exposed to physical damage, ensure the enclosure or guard is of sufficient strength to prevent such damage.

- Mark entrances to rooms and other guarded locations that contain exposed live parts with signage forbidding entry by unqualified personnel.

2.6 Working Space about Electrical Equipment

- Provide and maintain sufficient access and working space around all electric equipment to allow ready and safe operation or maintenance of the equipment.
- Working clearances may not be less than 30 inches in front of electric equipment.
- Working space may not be used for storage.

Table 1.0: Working Clearances (OSHA 1910.303 Table S-1 and S-2)

Nominal Voltage to Ground	Minimum Clear Distance for Condition [2,3]		
	A	B	C
0 – 150V	3 ft.[1]	3 ft.[1]	3 ft.
151 – 600V	3 ft.[1]	3.5 ft.	4 ft.
601 – 2500V	3 ft.	4 ft.	5 ft.
2501 – 9000V	4 ft.	5 ft.	6 ft.
9001 – 25000V	5 ft.	6 ft.	9 ft.
Over 25 – 75 kV[4]	6 ft.	8 ft.	10 ft.
Above 75 kV[4]	8 ft.	10 ft.	12 ft.

Notes:

1. Minimum clear distances may be 2.5 ft. for installations built before April 16, 1981.
2. Conditions A, B, and C are as follows:
    a. Condition A – Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts.
    b. Condition B – Exposed live parts on one side and grounded parts on the other side.
    c. Condition C – Exposed live parts on both sides of the work space (not guarded as provided in Condition A) with the operator between.
3. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on deenergized parts on the back of enclosed equipment, a minimum working space of 30 in. horizontally shall be provided.
4. Minimum depth of clear working space in front of electric equipment with a nominal voltage to ground above 25,000 volts may be the same as that for 25,000 volts under Conditions A, B, and C for installations built before April 16, 1981.

3.0 Standard Operating Procedures (SOPs) and Safe Work Practices

3.1 General Requirements

- Qualified workers must assess the tasks to be performed and note whether the work can be performed with the equipment in the de-energized state. This is accomplished through job safety planning and job briefing. The job safety plan shall be completed by a qualified worker, documented and include:
    - A description of the job and the individual tasks.
    - Identification of the electrical hazards associated with each task.
    - A shock risk assessment for tasks involving a shock hazard.
    - An arc flash risk assessment for tasks involving an arc flash hazard.

  - Work procedures involved, special precautions and energy source controls.
- All live parts to which an employee may be exposed will be de-energized using approved lockout/tagout procedures, unless:
  - De-energizing introduces additional or increased hazards. Examples include, interruption of life support equipment, deactivation of emergency alarm systems, shutdown of fume hood ventilation systems or removal of illumination for an area.
  - De-energizing is not possible due to equipment design or operational limitations. Examples include testing that can only be performed with the electrical circuit energized and work on circuits that form an integral part of a continuous process that would need to be completely shut down in order to permit work on one circuit or piece of equipment.
  - Live parts operate at less than 50 volts to ground and there is no increased exposure to electrical burns or to explosion due to electric arcs.
- Consult Emory's *Energy Control Program (Lockout/Tagout)* for the requirements to de-energize and re-energize equipment.
- If the electric equipment has been de-energized but has not been locked out, tagged out, or tested for the absence of power, the equipment will be treated as if it is still energized.
- If work must be performed while equipment is energized, follow procedures for energized electrical work described in this program in *Section 5.1*.

3.2 Portable Electrical Equipment and Extension Cords

The following requirements apply to the use of cord and plug connected equipment and flexible cord sets (extension cords).

- Handle portable equipment in a manner that will not cause damage.
- Do not use the flexible electric cords connected to equipment for raising or lowering the equipment.
- Do not fasten cords with staples or hang in a manner that could damage the outer jacket or insulation.
- Only use extension cords to provide temporary power.
- Ensure any flexible cord used with grounding-type utilization equipment contains an equipment grounding conductor.
- Before each use, visually inspect portable cord and plug connected equipment and extension cords for external defects such as loose parts, deformed or missing pins or damage to outer jacket or insulation and for possible internal damage such as pinched or crushed outer jacket. Remove any defective cord from service until it is repaired and tested to ensure it is safe for use. **NOTE:** Cord and plug connected equipment and extension cords that remain connected once they are put in place and are not exposed to damage are not required to be visually inspected until they are relocated.
- When an attachment plug is to be connected to a receptacle (including any on a cord set) check the relationship of the plug and receptacle contacts to ensure they are of the proper mating configuration.
- Ensure that extension cords are of the three-wire type. Extension and flexible cords must be designed for hard or extra hard usage (i.e., types S, ST and SO).

The rating or approval must be visible.

- Job-made extension cords are not recommended. However, they may only be built by **qualified persons** and must be **tested and certified prior to use**. Job-made extension cords may only be constructed using parts approved for this use.
- Use ground-fault circuit interrupter (GFCI) protection when using extension cords on renovation or construction sites or where work is performed in damp or wet locations.
- Do not run flexible cords through windows, doors or walls unless protected from damage and then only on a temporary basis.
- Do not run flexible cords above ceilings or inside or through walls, ceilings or floors. Cover cords with a cord protector or tape when they extend into a walkway or other path of travel to avoid creating a trip hazard.
- Extension cords used with grounding-type equipment must contain an equipment-grounding conductor (i.e., the cord must accept a three-prong or grounded plug).
- Do not alter attachment plugs and receptacles in any way that would interrupt the continuity of the equipment grounding conductor. Additionally, these devices may not be altered to allow the grounding pole to be inserted into current connector slots. Clipping the grounding prong from an electrical plug is prohibited.
- Flexible cords may only be plugged into grounded receptacles. The continuity of the ground in a two-prong outlet must be verified before use with a flexible cord and it is recommended that the receptacle be replaced with a three-prong outlet. Adapters that interrupt the continuity of the equipment grounding connection may not be used.
- All portable electric equipment and flexible cords used in highly conductive work locations, such as those with water or other conductive liquids or in places where employees are likely to contact water or conductive liquids, must be approved for those locations.
- Do not use electric equipment in the presence of flammable materials unless measures are taken to prevent hazardous conditions from developing. Such material include, but are not limited to, flammable gases, vapors or liquids, combustible dust and ignitable fibers and flyings.
- Employee's hands must not be wet when plugging and unplugging flexible cords and cord and plug connected equipment, if energized equipment is involved.
- If the connection could provide a conducting path to employees hands (for example, if a cord connector is wet from being immersed in water) the energized plug and receptacle connections must be handled only with insulating protective equipment.
- Locking-type connectors must be properly locked into the connector.
- Lamps for general illumination must be protected from breakage and metal shell sockets must be grounded.
- Temporary lights must not be suspended by their cords unless they have been designed for this purpose.
- Portable lighting used in wet or conductive locations, such as tanks or boilers, must be operated at no more than 120 volts or must be protected by Ground Fault Circuit Interrupters (GFCI's). **NOTE:** Extension cords are considered to be

temporary wiring and must also comply with the section on — Requirements for Temporary Wiring in this program.

4.0 Electric Power and Lighting Circuits

4.1 Routine Opening and Closing of Circuits

- Use load rated switches, circuit breakers or other devices specifically designed as disconnecting means for the opening, reversing or closing of circuits under load conditions.
- Do not use cable connectors not of the load-breaker type, fuses, terminal lugs and cable splice connections for opening, reversing or closing circuits under load conditions except in an emergency.

4.2 Reclosing Circuits After Protective Device Operates

- After a circuit is de-energized by a circuit protective device (e.g., circuit breaker or similar) the circuit may not be manually re-energized until it has been determined that the equipment and circuit can be safely energized.
- The manual re-closing of circuit breakers or re-energizing circuits by replacing fuses without verifying that the circuit can be safely energized is prohibited.
- When it can be determined that the over-current device operated because of an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is re-energized.
- Over-current protection of circuits and conductors may not be modified even on a temporary basis.

5.0 Safe Work Practices for Working on or Near Energized Parts

5.1 Energized Electrical Work Permit

- If live parts are not placed in an electrically safe condition, work to be performed is considered energized electrical work (See Appendix G, *Energized Electrical Work Permit Flow Chart*). The *Energized Electrical Work Permit* must be completed before the work can be performed.
- The permit is originated by the individual requesting that the energized work be completed. The requestor completes Section I of the permit.
- The **qualified persons** completing the task are responsible for completing Section II of the permit.
- Obtain approval signatures from the authorizing or responsible manager prior to commencing work.
- **Qualified persons** completing the task are responsible for conducting a job briefing before the start of each job involving energized electrical work. The job briefing must include the following:
    - Associated electrical hazards.
    - Work procedures.
    - Special precautions.
    - Energy source controls.
    - Emergency response.
    - PPE requirements.
    - Other work in the immediate area.

- All energized work requires at least two qualified persons.
- The completed permit will be maintained for one year.

NOTE: The following electrical work is allowed to be performed without an energized electrical work permit if the qualified worker performing the work uses appropriate safe work practices and PPE:

- Testing, troubleshooting, or voltage measuring.
- Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed.
- 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.
- General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed.

5.2 Testing, Troubleshooting and Voltage Measuring

- Work-related testing, troubleshooting and voltage measuring may be completed without an energized electrical permit, provided appropriate safe work practices and PPE are used.
- **Only qualified persons** can perform testing, troubleshooting and voltage measuring within the limited approach boundary of energized electrical conductors or circuit parts operating at 50 volts or more.
- Ensure that test instruments, equipment and their accessories are rated for the circuits and equipment to which they will be connected and designed for the environment in which they will be used.
- Visually inspect all test instruments and equipment (including all associated test leads, cables, power cords, probes and connectors) for external defects and damage before each use. If there is a defect or evidence of damage, tag the item out of service and do not return it to service until it has been repaired and tested rendered safe for use.

5.3 Approach Boundaries to Live Parts

- Determine safe approach distances for all tasks in which approaching personnel are exposed to live parts.
- Safe approach distances to fixed live parts can be determined by referring to NFPA 70E Table 130.4(D)(a) “Shock Protection Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems found in Appendix A and Table 130.4(D)(b), “Shock Protection Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Direct-Current Voltage Systems” found in Appendix B. These tables can be used to identify the limited and restricted approach boundaries with various system voltages.
- Unqualified persons may only cross the limited approach boundary when they are under the direct supervision of a qualified person. Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.
- Qualified persons may not cross or take any conductive object closer than the Restricted Approach Boundary unless one of the following conditions applies:
  - The qualified person is insulated or guarded from the live parts. If

there is a need for an uninsulated part of the qualified person's body to contact exposed live parts, a combination of 130.4(D)(a) and 130.4(D)(b)shall be used to protect the uninsulated body parts.
    - The live parts are insulated from the qualified person and from any other conductive object at a different potential.
    - The qualified person is insulated from any other conductive object.

5.4 Arc Flash Risk Assessment

- Complete a detailed arc flash risk assessment under engineering supervision that:
    - Identifies arc flash hazards.
    - Estimates the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health which takes into consideration:
    - The design of the electrical equipment including overcurrent protective device(s) and its operating time.
    - The electrical equipment operating condition and condition of maintenance.
    - Additional Protective Measures. When the additional protective measures include the use of PPE, the following shall be determined:
        - Appropriate safety-related work practices.
        - The arc flash boundary.
        - PPE to be used within the arc flash boundary.
- Until an arc flash risk assessment can be made, a qualified electrical worker should use NFPA 70E Table 130.7(C)(15)(a), "Arc Flash Hazard PPE Categories for AC Systems" or 130.7(C)(15)(b) "Arc Flash Hazard PPE Categories for DC Systems" found in Appendix C & Appendix D respectively, to determine the applicable arc flash PPE category.
- Once the arc flash PPE category has been determined, choose the required PPE for the task from NFPA 70E Table 130.7(C)(15)(c) "PPE" found in Appendix E.

6.0 Personal Protective Equipment

6.1 General Requirements

- Work units/departments will provide electrical protective equipment required by this program at no cost to employees, such as arc-rated apparel, eye protection, head protection, hand protection, hearing protection, insulated footwear and face shields.
- Maintain all protective equipment in a safe, reliable condition.
- Wear nonconductive head protection whenever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from an electrical explosion.
- Wear nonconductive protection for the 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.
- Wear protective equipment for the eyes whenever there is a danger of injury from electric arcs, flashes or from flying objects resulting from an electrical explosion.

- 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. The following ratings can be found on voltage rated gloves:

Table 2.0: Glove Class and Voltage

Class	Maximum Use Voltage
Class 00	500 volts
Class 0	1000 volts
Class 1	7500 volts
Class 2	17,000 volts
Class 3	26,500 volts
Class 4	36,000 volts

- Where insulated footwear is used as protection against step and touch potential, dielectric overshoes are required. Do not use insulated footwear as the primary protection. The integrity of the insulating quality of such footwear cannot be established easily after the worker has been wearing them in the working environment.
- Do not use face shields without an arc rating for electrical work. Safety glasses or goggles must always be worn underneath face shields.
- Additional illumination may be needed when using tinted face shields as protection during electrical work.
- Wear hearing protection whenever there is a danger of noise overexposure resulting from an electrical explosion.

6.2 Arc-rated Apparel

- Visually inspect arc rated apparel before each use.
- Do not use arc rated apparel that is contaminated or damaged.
- Do not use protective items that become contaminated with grease, oil, flammable liquids or combustible liquids.
- Follow the garment manufacturer's instructions for care and maintenance of arc rated apparel.
- When arc rated apparel is worn to protect an employee, ensure it covers all ignitable clothing and allow for movement and visibility.
- Ensure arc rated apparel covers potentially exposed areas as completely as possible.
- Fasten arc rated shirt sleeves and close arc rated shirts/jackets at the neck.
- Non-melting, flammable garments (i.e. cotton, wool) may be used as underlayers beneath arc rated apparel.
- Meltable fibers such as acetate, nylon, polyester, polypropylene and spandex are not permitted in fabric underlayers next to the skin. (An incidental amount of elastic used on non-melting fabric underwear or socks is permitted).
- When arc rated apparel is required, garments worn as outer layers over arc rated apparel (i.e. jackets or rainwear) must also be made from arc rated material.
- Flash suits must permit easy and rapid removal by the user.

6.3 Rubber Insulating Equipment

- Rubber insulating equipment includes protective devices such as gloves,

sleeves, blankets and matting.

- Inspect insulating equipment for damage before each day's use and immediately following any incident that could have caused damage. Perform an air test on rubber insulating gloves along with the inspection.
- Remove from service any insulating equipment found to have defects that might affect its insulating properties such as holes, tears, punctures, embedded foreign object, ozone cutting or checking or any change in texture including swelling, softening, hardening or becoming sticky or inelastic until testing indicates that it is acceptable for continued use.
- Where the insulating capability of protective equipment is subject to damage during use, protect the insulating material with an outer covering of leather or other appropriate material. **NOTE:** At Emory, protectors must be worn over rubber gloves.
- Clean insulating equipment as needed to remove foreign substances.
- Store rubber insulating equipment in an area protected from light, temperature extremes, excessive humidity, ozone and other substances and conditions that may cause damage.
- Do not attempt repairs to rubber insulating equipment. All damaged gloves must be replaced.
- Have rubber insulating equipment tested according to the schedule in Table 3.0 below:

Table 3.0: Rubber Insulating Equipment Testing Schedule

Type of Equipment	When to Test
Rubber insulating line hose	Upon indication that the insulating value is suspect and after repair
Rubber insulating covers	Upon indication that insulating value is suspect and after repair
Rubber insulating blankets	Before first issue and every 12 months thereafter; upon indication that the insulating value is suspect; after repair.
Rubber insulating gloves	Before first issue and every 6 months thereafter; upon indication that the insulating value is suspect; after repair; and after use without protectors.
Rubber insulating sleeves	Before first issue and every 12 months thereafter; upon indication that the insulating value is suspect; and after repair.

NOTE: If the insulating equipment has been electrically tested but <u>not</u> issued for service, it may <u>not</u> be placed into service <u>unless</u> it has been electrically tested within the previous 12 months.

- Do not use insulating equipment that fails to pass visual inspections or electrical tests except as follows:
    - Rubber insulating line hose may be used in shorter lengths if the defective portion is cut off.
    - Rubber insulating blankets may be repaired with a compatible patch as long as the physical and electrical properties equal or exceed those of the blanket.
    - Rubber insulating blankets may be salvaged by cutting and removing the defective area from the undamaged portion of the blanket if the

undamaged area remaining is greater than 22 inches by 22 inches for Class 1, 2, 3 and 4 blankets.

- Repaired insulating equipment must be retested before it may be returned to service. The tests must be documented in writing and indicate the type(s) of test(s) performed, equipment tested (specifically by referencing an applied marking, serial number or similar), date, name of tester and the results of the tests. These test results must be maintained in a permanent log.

6.4 Insulated Tools and Equipment

- Only use insulated tools and equipment within the Restricted Approach Boundary of exposed energized parts.
- Ensure insulated tools are rated for the voltages on which they are used.
- Ensure insulated tools are designed and constructed for the environment to which they are exposed and the manner in which they are used.
- Use fuse or fuse holder handling equipment, insulated for the circuit voltage, to remove or install a fuse if the fuse terminals are energized.
- Ensure ropes and handlines used near exposed energized parts are nonconductive.
- Use portable ladders with nonconductive side rails for all electrical work.

6.5 Live-Line Tools

- Visually inspect live-line tools and wipe them clean before use each day. If a defect or contamination could adversely affect the insulating quality of the mechanical integrity of the tool, remove it from service and have it tested before returning to service.
- Live-line tools shall be examined, cleaned, repaired, if necessary, and electrically tested every two years.

6.6 Alerting Techniques

- Use barricades in conjunction with safety signs to prevent or limit access to work areas containing live parts.
- Do not use conductive barricades where they might cause an electrical hazard.
- Place barricades no closer than the limited approach boundary or arc flash boundary, whichever is greater.
- Barricade placement should not impede exit of employees within the boundary.
- If signs and barricades do not provide sufficient protection, assign an attendant to warn and protect pedestrians and keep unqualified persons out of the work area where an electrical hazard exists until there is no longer a potential for employees to be exposed to the electrical hazards.

6.7 Other Precautions for Personnel Activities

- Do not reach blindly into areas that might contain exposed live parts.
- Do not enter spaces containing live parts unless illumination is provided that allows the work to be performed safely.
- Do not wear 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) when working near exposed live parts.

- Ensure conductive material, equipment and tools that are in contact with any part of an employee's body are 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.
- Only use portable ladders that have nonconductive side rails when the ladder or the employee could contact exposed energized parts.
- Use protective shields, barriers or insulating materials when working in a confined or enclosed space (such as a manhole or vault) that contains exposed live parts.
- Secure doors, hinged panels and the like to prevent them from swinging into employees. Work performed within confined spaces must comply with *Emory's Confined Space Program*.

7.0 Overhead Power Lines

- When work is to be performed near overhead lines, contact the utility company to have the lines de-energized and grounded, when possible.
- If de-energizing and grounding the lines is not possible, use other protective measures such as guarding, isolating or insulating before work is started.
- Protective measures must prevent direct contact by the qualified person or indirect contact through conductive materials, tools or equipment.
- All other persons, and any conductive object used by employees, may not approach closer than the minimum distance specified in the Table 4.0 below:

Table 4.0: Approach Distances for Qualified Employees (Alternating Current)

Voltage Range (Phase to Phase)	Minimum Approach Distance
300V and less	Avoid contact
300V to 750V	1 ft. 0 in.
750V to 2kV	1 ft. 6 in.
2kV to 15kV	2 ft. 0 in.
15kV to 37kV	3 ft. 0 in.
37kV to 87.5kV	3 ft. 6 in.
87.5kV to 121kV	4 ft. 0 in.
121kV – 140kV	4 ft. 6 in.

8.0 Vehicular and Mechanical Equipment

- Use a spotter at all times when working near overhead lines.
- Maintain a minimum distance of 10 ft. between energized overhead lines and all vehicles or mechanical equipment capable of having parts or structures elevated (e.g. cranes, mobile scaffolds, elevating platforms, dump trucks, lift trucks, etc.).
- If the voltage of the overhead line is greater than 50kV, increase the clearance by 4 inches for every 10 kV over 50kV.
- The clearance requirement may be reduced under the following conditions:
    - The vehicle is in transit with its structure lowered. The clearance may be reduced to 4 feet when near energized lines operating at less than 50 kV. Increase the clearance 4 in for every 10 kV over 50 kV.

  - Insulating barriers, rated for the voltage of the line being guarded, are installed to prevent contact with the lines and the barriers may not be part of an attachment to the vehicle or its raised structure. The clearance may be reduced to the distance allowed by the design of the insulating barrier.
  - The equipment is an aerial lift insulated for the voltage involved and the work is performed by a **qualified person**. The clearance between the un-insulated portion of the lift and the power line may be reduced to the distance given in the Table 4.0.
- Persons working on the ground are not allowed to contact the vehicle or mechanical equipment or any of its attachments, unless:
  - The person uses protective equipment rated for the voltage.
  - The equipment is located so that no uninsulated part of its structure can provide a conductive path to persons on the ground. Do not allow equipment to approach closer to the line than 10 feet for voltages less than 50 kV. Increase the clearance 4 inches for every 10 kV over 50 kV.
- When any vehicle or mechanical equipment is intentionally grounded, persons may not stand near the point of grounding when there is any possibility of contact with overhead energized lines. Additional precautions (e.g., such as the use of barricades or insulation) must be taken as necessary to protect persons from hazardous ground potential that can develop within a few feet or more outward from the grounding point.

9.0 References

- National Fire Protection Association (NFPA) 70E: Standard for Electrical Safety in the Workplace, 2018 edition.
- Occupational Safety and Health Administration (OSHA) Standard – 1910 Subpart S – Electrical.

10.0 List of Associated Documents

- Energized Work Permit
- SAF-361, Confined Space Program
- SAF-367, Energy Control Program (Lockout/Tagout)

Appendix A: Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating Current Systems

Voltage Range (Phase to Phase)	Limited Approach Boundary		Restricted Approach Boundary (includes inadvertent movement adder)
	Exposed Movable Conductor	Exposed Fixed Circuit Part	
<50V	Not specified	Not specified	Not specified
50V – 300V	10 ft.	3 ft. 6 in.	Avoid contact
301V – 750V	10 ft.	3 ft. 6 in.	1 ft. 0 in.
751V – 15kV	10 ft.	5 ft. 0 in.	2 ft. 2 in.
15.1kV – 36kV	10 ft.	6 ft. 0 in.	2 ft. 9 in.
36.1kV – 46kV	10 ft.	8 ft. 0 in.	2 ft. 9 in.
46.1kV – 72.5kV	10 ft.	8 ft. 0 in.	3 ft. 6 in.
72.6kV – 121kV	10 ft. 8 in.	8 ft. 0 in.	3 ft. 6 in.
138 kV – 145kV	11 ft. 0 in.	10 ft. 0 in.	3 ft. 10 in.
161kV – 169kV	11 ft. 8 in.	11 ft. 8 in.	4 ft. 3 in.
230 kV – 242kV	13 ft. 0in.	13 ft. 0 in.	5 ft. 8 in.
345kV – 362kV	15 ft. 4 in.	15 ft. 4 in	9 ft. 2 in.
500kV – 550kV	19 ft. 0 in.	19 ft. 0 in.	11 ft. 10 in.
765kV – 800kV	23 ft. 9 in.	23 ft. 9in.	15 ft. 11 in.

Source: From table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems(NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix B: Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct-Current Voltage Systems

Voltage Range (Phase to Phase)	Limited Approach Boundary		Restricted Approach Boundary (allowing for accidental movement)
	Exposed Movable Conductor	Exposed Fixed Circuit Part	
<100V	Not specified	Not specified	Not specified
100V – 300V	10 ft.	3 ft. 6 in.	Avoid contact
301V – 1kV	10 ft.	3 ft. 6 in.	1 ft. 0 in.
1.1kV – 5kV	10 ft.	5 ft. 0 in.	1 ft. 5 in.
5kV – 15kV	10 ft.	5 ft. 0 in.	2 ft. 2 in.
15.1kV – 45kV	10 ft.	8 ft. 0 in.	2 ft. 9 in.
45.1kV – 75kV	10 ft.	8 ft. 0 in.	3 ft. 6 in.
75.1kV – 150 kV	10 ft. 8 in.	10 ft. 0 in.	3 ft. 10 in.
150.1kV – 250kV	11 ft. 8 in.	11 ft. 8 in.	5 ft. 3 in.
250.1kV – 500kV	20 ft. 0 in.	20 ft. 0 in.	11 ft. 6 in.
500.1kV – 800kV	26 ft. 0 in.	26 ft. 0 in.	16 ft. 5 in.

Source: From table 130.4(D)(b) Shock Protection Approach Boundaries to Energized Electrical Conductor or Circuit Parts for Direct-Current Voltage Systems (NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix C: Arc Flash Hazard PPE Categories for Alternating Current 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	19 inches
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	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	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	14 ft
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	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	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	40 ft
Metal-clad switchgear, 1kV through 15kV Parameters: Maximum of 35kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time: working distance 910 mm (36 in.)	4	40 ft
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 arc-resistant-type construction, tested in accordance with IEEE C37.20.7, 1 kV through 15 kV	N/A (doors closed)	N/A (doors closed)
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 (doors open)	40 ft
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	40 ft

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 1.
Source: From table 130.7(C)(15)(a) Arc Flash Hazard PPE Categories for Alternating Current Systems (NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix D: Arc Flash Hazard PPE Categories for Direct Current 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	2	3 ft
4 kA ≤ short-circuit current < 7 kA	2	4 ft
7 kA ≤ short-circuit current < 15 kA	3	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	2	3 ft
1.5 kA ≤ short-circuit current < 3 kA	2	4 ft
3 kA ≤ short-circuit current < 7 kA	3	6 ft
7 kA ≤ short-circuit current < 10 kA	4	8 ft

Source: From table 130.7(C)(15)(b) Arc Flash Hazard PPE Categories for Direct Current Systems(NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix E: Personal Protective Equipment (PPE)

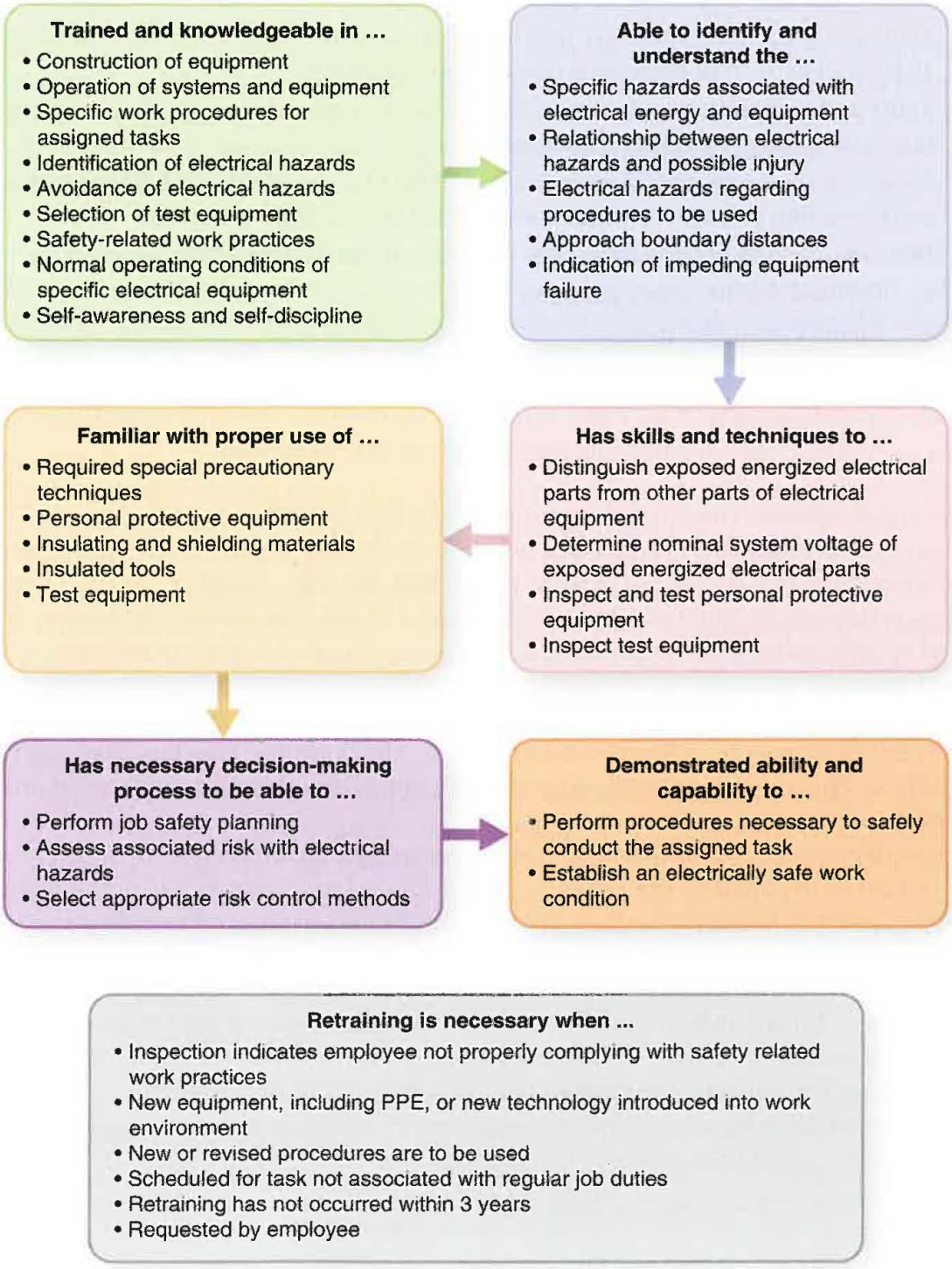
PPE Category	PPE
1	**Arc-rated Clothing, Minimum AR of 4 cal/cm^2 (See Note 1)** • Arc rated long sleeve shirt and pants or AR coverall • Arc rated face shield (see Note 2) or AR suit hood • Arc rated jacket, parka, rainwear or hard hat liner (AN) **Protective Clothing** • Hard Hat • Safety glasses or goggles (SR) • Hearing protection (ear canal inserts) • Heavy duty leather gloves (See Note 3) • Leather footwear (AN)
2	**Arc-rated (AR) Clothing, Minimum AR of 8 cal/cm^2 (See Note 1)** • Arc rated long sleeve shirt and pants or AR coverall • Arc rated face shield (see Note 2) or AR suit hood • Arc rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Clothing** • Hard Hat • Safety glasses or goggles (SR) • Hearing protection (ear canal inserts) • Heavy duty leather gloves (See Note 3) • Leather footwear (AN)
3	**Arc-rated (AR) Clothing so that the System Arc Rating Meets the Required Minimum AR of 25 cal/cm^2 (See Note 1)** • Arc rated long sleeve shirt and pants (AR) • Arc rated coverall (AR) • Arc rated arc flash suit jacket (AR) • Arc rated arc flash suit pants (AR) • Arc rated arc flash suite hood • Arc rated gloves (See Note 3) • Arc rated jacket, parka, rainwear or hard hat liner (AN) **Protective Clothing** • Hard Hat • Safety glasses or goggles (SR) • Hearing protection (ear canal inserts) • Leather footwear
4	**Arc-rated (AR) Clothing so that the System Arc Rating Meets the Required Minimum AR of 40 cal/cm^2 (See Note 1)** • Arc rated long sleeve shirt and pants (AR) • Arc rated coverall (AR) • Arc rated arc flash suit jacket (AR) • Arc rated arc flash suit pants (AR) • Arc rated arc flash suite hood • Arc rated gloves (See Note 3) • Arc rated jacket, parka, rainwear or hard hat liner (AN) **Protective Clothing** • Hard Hat • Safety glasses or goggles (SR) • Hearing protection (ear canal inserts) • Leather footwear

AN: as needed (optional). AR: as required. SR: selection required.

Notes:
(1) Arc rated clothing is also flame resistant.
(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.

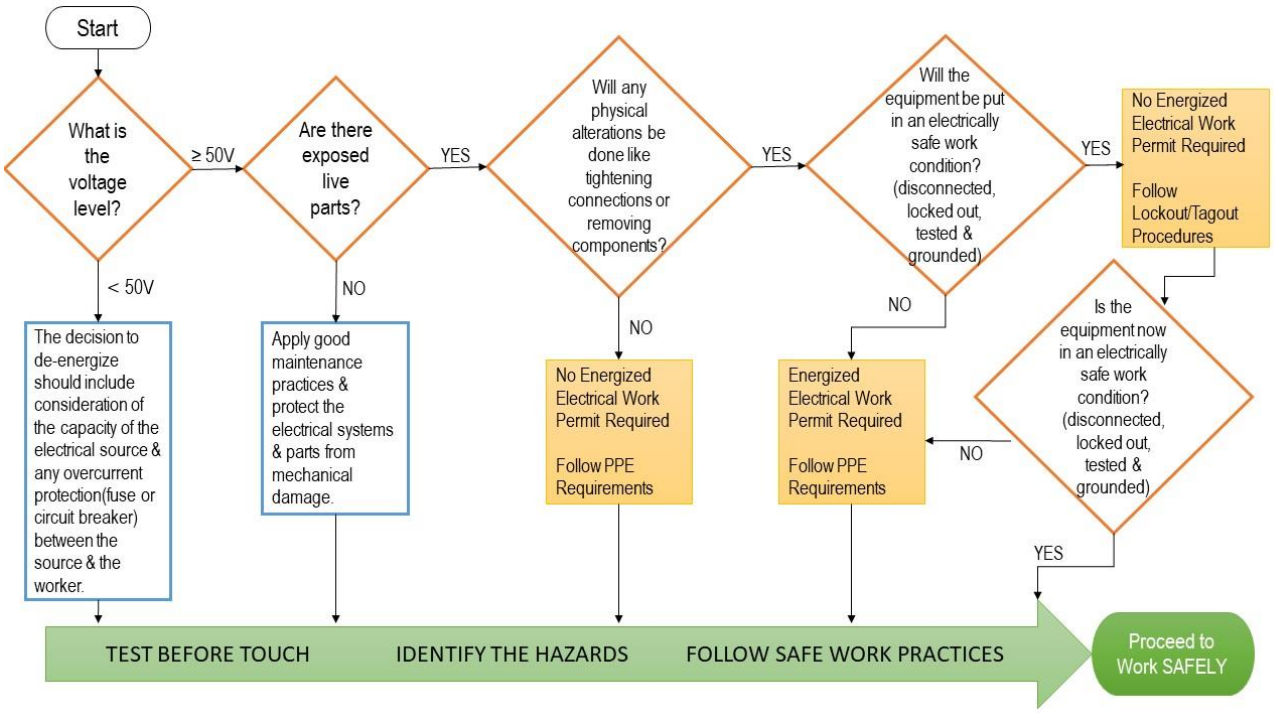
Source: From table 130.7(C)(15)(c) Personal Protective Equipment (PPE) (NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix F: Traits of a "Qualified" Person



Source: From Exhibit 110.3 (NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018 edition*).

Appendix G: Energized Electrical Work Permit Flow Chart



Source: From Figure J.2 (NFPA 70E *Standard for Electrical Safety in the Workplaces, 2018*