CHAPTER 4 ISOLATION OF HAZARDS

4.1 HIGH-VOLTAGE EQUIPMENT ISOLATION REQUIREMENTS

Energized parts of high-voltage (above 600 V ac or dc) equipment and circuits shall be isolated from surfaces exposed to personnel by two acceptable, independent energy barriers, one of which shall be designed to survive any credible failure mode. Two acceptable barriers are required between all ungrounded conducting parts that extend from high-voltage energy sources or enclosures to areas or devices that are accessible to personnel. A safety barrier may be used for the outer limited approach boundary.

4.2 LOW-VOLTAGE EQUIPMENT ISOLATION REQUIREMENTS

Energized parts of low-voltage (600 V ac or dc and below) equipment and circuits shall be isolated from personnel by an acceptable energy barrier.

4.3 ENERGY BARRIERS AND SAFETY BARRIERS

Barriers are isolating features that provide protection against direct contact from any usual direction of access. They are features that minimize effects on personnel by electric shock, arcs and arc-fault.

4.3.1 **Energy barriers** depend on physical integrity, insulation, or conduction to either contain or shunt the energy away from personnel.
Safety barriers depend on separating personnel from the energy source by time and distance.

4.3.2 Energized parts of electrical equipment and circuits shall be guarded against accidental human contact through the use of either energy barriers, safety barriers, or both. When electrical systems and equipment are in an operating mode, all barriers shall be permanently in place and functioning.
When electrical systems and equipment are in a test or maintenance mode and permanent energy barriers are removed, approved temporary safety barriers may be substituted or added to protect personnel, provided the requirements of this Electrical Safety Program, Section 2.0 are satisfied. Electrical equipment under test with permanent energy barriers removed shall be energized only with approved test procedures performed by qualified personnel and a safety watch.

4.3.3 Energy Barriers

The design objective of energy barriers is to prevent an unwanted transfer of energy between an energy source and a target. Acceptable energy barriers shall be designed with adequate physical integrity to withstand the maximum credible energy that can be delivered by the energy sources to which the barriers are exposed. Energy barriers may be:

A. Insulating - Having adequate clearance in air, oil, or some other insulating medium.

B. Conducting - Such as an effectively grounded metal enclosure.

4.3.4 Safety Barriers

Safety barriers shall be designed to restrict the time and manner in which Qualified Personnel may gain access to energy sources and to prevent or inhibit access by unqualified personnel. Safety barriers may be either of permanent or temporary construction as follows.

A. Permanent safety barriers (such as rooms, vaults, partitions, or screens) shall have sufficient structural integrity to withstand all electrical and mechanical failure modes of the enclosed energy source(s). Their access doors shall be lockable.

B. Temporary safety barriers (such as safety ropes and tapes, snow fences, or approved wooden barricades) shall be spaced far enough from unguarded live parts to prevent accidental contact by unqualified personnel. Minimum clearances specified in NFPA 70E, Table 130.4(C)(a) for AC and 130.4(C)(b) for DC shall be permitted for Limited Approach areas that are accessible to Qualified Personnel only. All temporary safety barriers shall be provided with either warning devices as required by paragraph 4.13 or approved safety signs. See paragraph 4.18 for arc effects.

4.4 HIGH-CURRENT EQUIPMENT

Regardless of operating voltage, non-type-tested equipment and circuits rated in excess of 50 A. shall be guarded by at least one energy barrier capable of surviving any credible fault. Examples of ways to mitigate hazards are as follows:

A. Electric-arc welding equipment and its use shall comply with Section 5.0 of this PPPL Environment, Safety, and Health Manual and Article 630 of the NEC.

B. Protect workers from arcs in conductor joints and between conductors (including ultraviolet eye burns). See paragraph 4.18, “Arc Effects.” The use of arc-resistant clothing shall be required.

C. Protect workers from the effects of fields on magnetic materials such as loose tools and inductively heated surfaces. See Chapter 9 regarding security and credit cards in high fields.

D. Conductors shall be secured to prevent hazardous movement during a short circuit or ground fault as explained in Chapter 7.

4.5 LISTED or LABELED EQUIPMENT

A. Commercially available equipment having a representative sample successfully tested to verify the adequacy of its design by a Nationally Recognized Testing Laboratory (NRTL) is considered listed or labeled equipment.
Listed - labeled equipment is approved per NEC Articles 110-2/3.
All listed or labeled equipment shall be installed in accordance with the recommended manufactures instructions, and industry codes referenced in Chapter 3, paragraph 3.2, and shall not be required to be inspected unless modified or used differently from the manufacturer’s instructions.

B. Unlisted and non labeled equipment shall be inspected and analyzed as per NEC 110.3, and approved by the Authority Having Jurisdiction
PPPL’s Electrical Equipment Inspection Program shall be utilized to ensure code and standard compliance.

4.6 COMPLIANCE CRITERIA FOR NEW AND EXISTING ELECTRICAL SYSTEMS

A. All new high-voltage equipment installations are required to meet the isolation criteria of paragraphs 4.1 and 4.3.

B. High-voltage equipment installations that are in operation prior to May 1, 1995, are not required to meet the requirements of paragraph A. However, significant revisions or modifications to the installed equipment shall require that the entire system be analyzed and upgraded to meet the criteria of paragraphs 4.1 or 4.2 and 4.3.

4.7 PROTECTIVE RUBBER PRODUCTS

4.7.1 The use of protective rubber gloves is mandatory when testing, troubleshooting, working on, or safeing energized circuits above 50 volts, until the circuits have been positively de-energized. Positively de-energized criteria are specified in paragraph 3.3.3 in Chapter 3. Guidelines for the selection, care, inspection, testing, storage, and

the use of gloves and other protective equipment for electrical work are in ASTM Specification F 1236. Employees shall visually inspect and air-test all protective rubber gloves before use as indicated below.

A. FIELD CARE AND INSPECTION OF GLOVES

1. General: Insulating equipment shall be visually inspected for damage before each use and given an air test along with the inspection. Gloves shall be returned to Electrical Safety for testing if any defects are found.

2. Perform Visual Inspection
   a. Check for nicks, holes, tears, punctures, abrasions, or cuts.
   b. Ozone cracks, pitting, burns
   c. Imbedded foreign objects
   d. Texture changes: swelling, softening, hardening, sticky, or inelastic
   e. Other defects such as color changes in insulating material, oil, grease.

3. Perform air test
   a. Roll the cuff tightly toward the palm in such a manner that air is entrapped inside the glove. A visual inspection shall be performed for defects listed above and for leakage of air.

4. Storage of gloves and rubber products
   a. Gloves shall be stored in as cool, dark, and dry an area as possible.
   b. The location shall be free from ozone, chemicals, oils, solvents, damaging vapors or fumes, and away from sunlight and electrical discharges.
   c. Gloves shall be stored in their natural shape inside their protectors in the storage bag furnished with the gloves.

5. Glove Protectors
   a. Shall be worn over insulating gloves except for class "o" when good finger dexterity is required.

6. Rubber gloves used without protectors must be returned to Electrical Safety and retested after use.
7. When using rubber gloves without protectors personnel must use one class level higher than required for the voltage level being worked on.

4.7.2 The maximum use voltage recommended at PPPL for each class of glove is designated as follows:

Class	Maximum Voltage
0	600 Volts
1	5,000 Volts
2	15,000 Volts
3	20,000 Volts

4.7.3 The Electrical Safety Specialist ("Electrical Safety") in the Safety Division coordinates and documents the testing of protective rubber products and the application of the ASTM Specifications listed below. The frequency of tests for each product category is as follows:

Product	ASTM Spec.	Frequency (months)
Gloves	F496-02a	6
Sleeves	F496-02a	12
Blankets	F479-95920010	12
Line Hose	F478-92 & this Section 2.0	12
Covers	F478-92 & this Section 2.0	12

4.7.4 Rubber insulating floor matting manufactured to ASTM standard D178 is available three-eighths inch thick with anti-skid backing and non-oil resistant, corrugated surface, initially rated at 50 kV. Matting is manufactured in widths of 24, 30, 36, and 48 inches. The application should determine both the need and width. A PPPL in-service retest specification cannot be established since no industry-consensus retest standard exists at this time. Floor mats in front of High Voltage equipment shall be provided by the home cost center. Electrical Safety shall provide Blankets for use by electricians.

4.8 INSULATED HAND-TOOLS

Criteria for the use of insulated hand tools are specified in paragraph 3.3.4 (E) in Section 2, Chapter 3. Damaged tools shall be replaced when the indicator insulation is showing through the outer jacket insulation.

4.9 LOCAL LIGHTING SWITCHES

General-use snap switches that are permitted by NEC, Article 404.14 and 404.15 are to be used on inductive loads such as electric-discharge lamps and ballasts operated over 120 V and shall be clearly and permanently identified for the purpose, i.e., listed and externally labeled for the intended nominal operating voltage.

4.10 GUARDING OF LIVE PARTS

4.10.1 Live parts of equipment designed to operate above 50 V, but less than 600 V (ac or dc), shall be guarded in accordance with Article 110-27 of the NEC. Terminal boxes and control enclosures having circuits operating above 50 volts shall be guarded by barriers or cover plates requiring a screwdriver or similar tool for their removal. These barriers or cover plates shall be clearly marked to indicate the circuit voltage.

4.10.2 Live parts of equipment designed to operate over 600 V are considered high voltage and shall be guarded and labeled in accordance with Chapter 1, Section III, Over 600 Volts, Nominal, Articles - 110.30 thru 110.40 of the NEC.

4.10.3 High-voltage parts may be located within a vault, room, or closet, or in an area surrounded by a wall, screen, or fence. To ensure that the parts are de-energized prior to entry, either a Kirk®-type key interlock system shall control the availability of the door key or the door shall be equipped with a "fail-safe" electrical interlock. See Chapter 5, Personnel Safety Interlocks (PSI) Systems for guidelines.

4.11 HIERARCHY OF HAZARD-REDUCTION METHODS

Some hazard-reduction methods are more efficient than others. They range from the most preferred to the least acceptable method in the following sequence:

4.11.1 Design safety features utilizing energy barriers and other protective devices, which are incorporated into the design to minimize personnel-safety hazards and risks of damage to equipment.

4.11.2 Safety barriers such as rooms, grounded-metal screens, snow fences, safety tapes, insulated gloves, and insulated tools are used to separate personnel from hazards not eliminated by design features.

4.11.3 Warning devices alert personnel to the presence of hazards. Examples include annunciators, audible alarms, indicating lights, and instrumentation such as voltmeters.

4.11.4 Administrative controls include management direction and control over operations, maintenance, inspections, surveillance, and other activities that pose potential safety hazards. Examples include written procedures and verbal instructions.

4.12 REQUIREMENTS BY AREA SAFETY CLASSIFICATIONS

4.12.1 General-Access Areas

Areas that do not present any hazards to personnel when equipment and systems are functioning normally. These areas are accessible to all personnel.

General-access areas shall meet the following criteria:

A. There are no exposed live electric parts or mechanical hazards that may cause injury in the event of accidental contact by any personnel.

B. There is no hazard to personnel in the event of equipment faults such as an explosion of capacitors.

C. “CAUTION” signs shall be placed at metal-enclosed switchgear, unit substations, power transformers, and Class E pull boxes where located in General-Access areas.

4.12.2 **Limited-Access Areas**

Areas that are kept locked and are accessible only by authorized personnel.

A. Limited-Access areas have exposed live parts over 50 V and/or have insulated conductors that are not guarded in accordance with NEC 110-27 or NEC 110-34.

B. “WARNING” signs shall be placed on the entrances to Limited-Access areas

C. Limited-Access areas shall:

1. Be kept locked when authorized or Qualified Personnel are not present.
2. Have keys that are available to authorized or Qualified Personnel.
3. Be identified by warning signs.
4. Have unguarded live parts positively de-energized before unauthorized or unqualified personnel may enter for any reason. Exception: When performing observations while supervised by an Authorized / Qualified Person.

4.12.3 **Interlocked-Access Areas**

A. Interlocked-Access areas are potentially dangerous areas having experimental devices with unguarded live parts operating above 600 V and having 50 J or more of stored energy. Personnel access to these areas is restricted while hazardous equipment is operating or hazardous environmental conditions exist.

B. “DANGER” signs shall be placed on the entrances to Interlocked-Access areas from General-Access areas or Limited-Access areas.

C. Interlocked-Access areas with energy-storage devices, when opened by normal procedures, may revert to Limited-Access areas.

4.13 TEMPORARY HAZARDOUS OPERATIONS IN GENERAL-ACCESS AREAS: PERSONNEL PROTECTION

Whenever conditions are introduced into a General-Access area such that it no longer meets the criteria for General-Access, the following precautions shall be taken:

4.13.1 Access to the area shall be guarded by a safety-barrier rope or fence placed around the perimeter of the temporarily hazardous area. Distances for limited and restrictive boundaries for Alternating Current Systems shall be as specified in NFPA 70E Table 130.4 (C)(a) and for Direct Current Systems Table 130.4(C)(b).
An Arc Flash Hazard Analysis shall also be consulted.

4.13.2 Adequate disconnects shall be provided in the immediate vicinity of the hazardous area so that the hazardous operation can be quickly de-energized.

4.13.3 Standard “DANGER - (state voltage) - AUTHORIZED PERSONNEL ONLY” safety signs shall be clearly displayed.

4.13.4 A Safety Watch shall be provided for the area and only Qualified Personnel shall be allowed inside the area.

4.13.5 Temporary grounding conductors shall be used to connect all ungrounded panels and exposed metal structures of portable test equipment to the nearest suitable grounding cable or bus. Due to the phenomenon of “skin effect,” grounding conductors in extension cords should not be relied upon for this purpose. Such equipment shall be grounded with braid, ribbon-type, or stranded copper conductor. See paragraph 4.15.5 for additional information.

4.13.6 Approval of the cognizant engineer or Accountable Technical Individual (ATI) shall be obtained before energizing equipment.

4.13.7 The area shall meet requirements of a general-access area when the Safety Watch leaves.

4.13.8 A Hazard Analysis shall be performed and an approved procedure describing the temporary operation shall be written by the cognizant engineer and concurred with by the cognizant Division Head or Responsible Line Manager (RLM) and the Safety Division Electrical Safety Specialist or designee.

4.14 TEMPORARY HAZARDOUS OPERATIONS IN OTHER THAN GENERAL-ACCESS AREAS: PERSONNEL PROTECTION

The cognizant engineer or lead technician may permit temporary operations, with personnel in a limited-access or an interlocked area, under the following conditions:

4.14.1 The cognizant engineer or lead technician has determined with approval from the cognizant Division Head or RLM that it is absolutely necessary to enter and troubleshoot or test equipment in an energized condition.

4.14.2 At least two trained, qualified persons shall be assigned to the temporary operations, both of whom are completely familiar with emergency procedures and one of whom shall be designated as Safety Watch.

4.14.3 A statement defining the reasons for entry shall be recorded in the operating log of an interlocked area or otherwise posted at the entrance(c) to an area. The statement shall include the names of all personnel permitted entry and shall designate a Safety Watch. The number of personnel authorized to enter shall be restricted to the minimum essential to do the work including the Safety Watch.

4.14.4 An Electrical Hazard Analysis and JHA shall be performed and the work shall be thoroughly planned beforehand by the cognizant engineer or lead technician and the technical personnel assigned to the temporary operations. An approved procedure shall be used.

4.14.5 Current operational restrictions of the device or system being tested shall not be exceeded.

4.14.6 Readily accessible emergency egress shall be provided (e.g., blocked-open door, kick-out panel, or other means concurred with by the Safety Division Electrical Safety Specialist or designee).

4.14.7 All emergency-shutdown pushbuttons (E-STOPs) related to the systems within the interlocked area shall be satisfactorily tested in accordance with Chapter 5, paragraph 5.8.4, before the temporary operations begin.

4.15 GROUNDING

4.15.1 The general requirements for grounding and bonding of electrical-wiring systems and equipment are covered in NEC Article 250 with the following exceptions and additions:

A. Isolated equipment-grounding conductors traceable to a single-point ground may be used in experimental-device power, control, and diagnostic systems, after a technical specification and fault analysis have been provided by the cognizant engineer to the Safety Division Electrical Safety Specialist or designee for review and approval.

B. In addition to the equipment grounding conductor which is routed with its associated circuit,

1. A bonding conductor shall be installed between the facility ground grid and fixed electrical equipment operated between 480 V and 2 kV.
2. A redundant bonding conductor should be installed on such equipment operated over 2 kV.
3. The bonding conductor preserves at least one low-impedance path to the power source should a grounding-conductor connection disconnect. The bonding conductors reduce potential differences between equipment and conductive surfaces of the working area.

C. Guidelines for ac power substation grounding practices, including procedures for calculating maximum step-and-touch potentials, are in IEEE Standard 80. Recommended practices for grounding industrial and commercial power systems are in IEEE Standard 142. Recommended grounding practices for emergency-power and standby-power systems are in IEEE Standard 446.

D. Requirements for effective lightning protection systems are in NFPA-780 and UL-96A.

E. Requirements for the control of static electricity may be found in NFPA-77.

4.15.2 Equipment supplied from an energy-storage unit is capable of delivering high-level potential wave fronts to its cases or enclosures. Considering skin-effect in a grounding conductor, particular care shall be exercised to provide proper low-impedance return-path grounding. The potential between enclosures and nearby building ground shall be limited to less than 50 V, even under fault conditions. The path to ground from circuits, equipment, and conductor enclosures shall:

A. Be permanent and continuous.

B. Have capacity to conduct safely any fault current likely to be imposed on it but in no case shall it be smaller than indicated in NEC Table 250-122 or equivalent for frequencies above 60Hz.

C. Have sufficiently low impedance to limit the voltage to ground and to facilitate the operation of the circuit-protective devices in the circuit.

D. Be designed to prevent excessive voltage between structures and equipment accessible to personnel. The paths of grounding conductors to the grounding electrode(s) shall be separated based on class as required by NEC Article 250.

4.15.3. When a control or metering console, rack, or other enclosure having a single ground connection interfaces with remote high-voltage equipment, an extremely hazardous condition could prevail if the grounding conductor is removed either accidentally or deliberately. The

possibility of accidental loss of a grounding connection shall be virtually eliminated by physical arrangement or mechanical construction. If a ground is intentionally removed for any purpose, the power system shall be positively de-energized and shall be locked-out and tagged-out in accordance with PPPL ESH-016 tagging procedures using the criteria for positively de-energized circuits and equipment specified in Chapter 3, paragraph 3.3.2.

> Exception: For certain tests, if it is absolutely necessary to turn on the high voltage with the ground removed, it may be done only with the specific prior approval of the Cognizant Engineer or Accountable Technical Individual (ATI) of the device or system, who then becomes directly responsible for personnel safety during these tests. The tests shall follow the requirements of paragraph. 4.14.

4.15.4 To meet NEC splicing requirements for grounding electrode conductors (NEC Article 250-50 and 250-64c) when neither exothermic welding nor listed grounding conductor connections are feasible, the PPPL silver brazing process shall be considered an approved alternative when it is performed by a person who is qualified in the technique.

4.16 WORKING ON GROUNDED METAL SURFACES

Grounded metal surfaces of electrical enclosures, tanks, vacuum or pressure vessels, structures, etc., are well grounded and considered good conductors relative to other floor surfaces such as dry concrete or vinyl tile. Before stepping onto metal surfaces or entering into metal enclosures, the following precautions shall be taken:

4.16.1. Ground-fault circuit interrupters (GFCIs) shall be provided for portable electrical equipment in use by personnel. GFCI's shall be tested prior to use.

4.16.2 Portable hand-lamp cords shall have step-down transformers to restrict lamp operating voltage to 50 V ac or less. The operating voltage of a typical portable hand-lamp is 24 Volts.

4.16.3 Shoes shall be visually inspected to ensure they are made with rubber soles and heels, which have not picked up any metal objects such as pins, nails, or tacks.

4.17 CLEARANCES

Adequate clearances are required to safely perform construction, operation, and maintenance tasks. The following documents define safe access, working, and egress clearances which will reduce shock hazards:

> A. Around electrical equipment operated at 600 V and below when exposed parts are energized - NEC Article 110-26.

B. Around electrical equipment operated above 600 V, either energized or de-energized - NEC Article 110-34.

C. Means of exit from rooms and spaces where electrical-supply conductors or equipment are installed - NESC Rule 113: Electrical equipment inside switchgear rooms - NESC Section 18, Rule 180.

D. Outside, overhead electrical-supply and communication lines - NESC Section 23 and OSHA 29 CFR 1926.950 through 1926.960.

E. Outside, underground (UG) electrical-supply and communication lines and equipment:

1. UG conduit systems - NESC Rule 320B.

2. Manholes, hand holes, and vaults - NESC Rule 323.

3. Direct-burial cables - NESC Rule 352 through 354.

4.18 ARC FLASH EFFECTS

Clearances sufficient to reduce shock hazards may not be adequate to avoid the hazards of electric arcs that occur over greater distances. The effects include overpressure and thermal stress. Non-ionizing radiation in the visible and ultraviolet spectrum may be present in sufficient amounts to be a concern in very large arcs. If a task involves the live-line work method performed on high energy circuits operated over 250 Volts or non-type-tested high current circuits, an arc flash hazard analysis shall be included in the procedures required in paragraph 3.3.4 in Chapter 3.
Sample calculations of arc flash protection boundaries may be found in NFPA 70E 2012, Informative Annex D

To minimize risk during a switching operation, ensure that all protective energy barriers are in place and secured and the proper PPE (Personal Protective equipment) including AR clothing is worn. Stand to the side of the enclosure and open or close the device with a smooth and continuous motion on its operating handle. An erratic motion may cause unnecessary and potentially damaging arcing across blade contacts. PPPL policy shall be to perform switching operations in a de-energized state or remotely when possible.

4.19 LOCKOUT/TAGOUT PROCEDURES

Generic lockout/tagout (LO/TO) procedures are described in ESH-016.

ES&HD 5008, Section 2, Chapter 3, paragraph 3.3.2, identifies the proper steps to positively de-energize energy isolation devices in electric circuits. Use the isolation criteria in Chapter 4 together with verified single-line diagrams and circuit directories to decide how many and what kind of isolation devices are appropriate to the risk.

4.20 SAFETY SIGNS/TAGS

Authorized persons with jurisdiction over electrical systems and equipment having live parts shall ensure appropriate facility safety signs and tags are used to alert employees to possible hazards or special alignment of system components. Criteria for the use of signs are in ESH-002. Criteria for the use of tags are in ESH-001. All tags are to be filled out completely and are not to be removed without the consent of the cognizant person or their supervisor. Danger tags shall not be removed without the consent of the cognizant individual or in his absence his supervisor along with safety shall walk the system down prior to removal of a Danger tag.

4.21 AS-BUILT DRAWINGS

Drawings, that are important for safe operation or maintenance of electrical systems or equipment, shall be kept up-to-date, as-built or as-installed. Single line diagrams and panelboard circuit-directories are considered important electrical drawings. It is the policy of this Laboratory that the AC Power Section shall be advised of all proposed changes to switchboards, panel-boards, lighting or receptacle panels, and other load centers that are typically shown on either the single line diagrams or panel-board circuit-directories. Failure to comply with the above will result in de-energization and tagging out of the unauthorized changes.

4.22 DEACTIVATING AND DECOMMISSIONING

A. When equipment is deactivated (shut down with no definite plans for future use), the following precautions shall be taken:

1. Circuits shall be positively de-energized, and individual capacitors shall be shorted.

2. “Out of Service” signs shall be conspicuously applied to equipment involved to provide guidance in the event of an emergency.

3. All nonessential safety signs should be removed from the equipment.

B. In addition to the above, when equipment is decommissioned, all cables shall be removed as per NEC. If cables are to be abandoned for future use, they shall be left in a safe condition so that no live part is exposed in compliance with PPPL Policy No. P-046. A safe condition exists when power, lighting, and NEC Class 1 non-power limited cables are abandoned for future use in place have:

1. Both ends of each conductor properly taped or properly secured on enclosed terminal blocks.

2. A NOTICE tag at both ends of power cables. Use a CAUTION tag if conductors are subject to common mode failure with adjacent active energized

cables. All other circumstances use a NOTICE tag per procedure ESH-001. Where practical, conductors and cables may be gathered together as one or more bundles using one tag per bundle

3. Note the location of the other end of the cable on the tag and what procedure number authorized its decommissioning and disconnection. Also note that the cable is Out-Of-Service (OOS).

4.23 SAFE REMOVAL OF ELECTRICAL EQUIPMENT / WIRING

The safe removal of Electrical equipment and associated wiring requires a well thought out method for removing the hazards associated with some adjacent equipment that may be energized. An assessment of all the work and the associated hazards that may be present is required prior to commencing the work. All personnel must be familiar with the hazards present and have been trained in the tasks that are to be performed. Below are the minimum requirements for the removal of electrical equipment.

A. Prerequisites for de-energizing, disconnection, and removal of equipment.

1. A JHA or hazard assessment shall be conducted by the cognizant person, Safety Division representative, and AC Power, to establish special safety/job requirements.

2. Shock Protection Boundaries shall be established as per 70E 130.2(c).

3. An Arc Flash Hazard Analysis shall determine the Arc Flash Boundary as per 70E 130.3

4. A procedure shall be issued identifying the equipment to be removed, and sources of power and de-energizing steps to be taken prior to the equipment removal sequence. The associated drawings, for the work shall be provided, and a pre-job walkdown with the technical staff to review special safety/job requirements shall be performed prior to the start of work.

5. All wires are to be considered energized until they have been tested and removed following the guidelines in paragraph 3.3.2 of chapter 3.

B. Minimum requirements for the de-energizing and removal of wiring and equipment

1. Locate and identify power sources to equipment to be removed.

2. See paragraph 3.3 of Chapter 3 for added requirements for testing on energized equipment.

3. Verify testing equipment is working before and after testing.

4. Check to see if the equipment to be removed has a ground wire attached. If not, ground the equipment prior to removal of all other existing wiring.

5. Turn off power at the source and test wires at the load end for the absence of voltage. Disconnect/cut the wires immediately at both ends and tape the ends. The rule is to test all cables prior to cutting or removing. DO NOT REMOVE GROUND WIRES until all other wires have been removed.

6. Insulate all cut or removed cable ends. Construction schedules may leave jobs incomplete, therefore ends of cables shall be taped so that no "un-insulated pigtails" are out in the field.

7. If cables are to remain in cable trays or conduits, the taped ends of the cables must have a tag attached to each end of the cable. See paragraph 4.22 B of Chapter 4, tagging instructions. Approval of the Associate Laboratory Director for Engineering and Infrastructure is required to abandon cables in place. The foregoing is required by PPPL Policy P-046.

8. When all cables have been removed from the equipment, the only cable remaining shall be the equipment ground wire which is the last wire to be removed.

9. All changes to panelboards at PPPL must be coordinated through the AC Power Section. See para 4.21 above for as-built drawings. All circuits that have been disconnected shall be labeled as spare in the circuit index and a copy sent to AC Power for drawing and panel schedule updates.