



**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**ELECTRICAL SAFETY PROGRAM**

**Applicable to: All FMD Organizations**

**Date Effective: 7/1/2014**

**Issue No.: 1**

**Revision: 0**

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**A. Purpose**

1. To establish a written electrical safety program that promotes a safe and healthy work environment.
2. To provide an awareness of the potential electrical hazards and possible injuries to all employees.
3. To provide techniques to identify, assess, and mitigate electrical hazards
4. To provide guidelines for the performance of electrical work on all University Building Systems and Equipment.

**B. Scope**

1. The provisions of this program apply to all FMD employees and contractors working for FMD involved in electrical work.
2. Administrative personnel are covered under the "General Equipment Requirements" paragraph for electrical safety covered in the Duke University Safety Manual.
3. Electrical Safety Procedures shall be used in conjunction with Lockout-Tagout (LOTO) Procedures, Method and Procedure (MAP), Job Hazard Analysis (JHA), Risk Mitigation (RM), Standard Operating Procedures (SOP), and Confined Space Entry Procedures when applicable.

**C. Policy**

1. FMD shall take all reasonable measures to provide a safe workplace. All FMD operations shall be performed in a manner, which will prevent any undesirable effects to FMD and/or Duke employees, assets, the local community, and the environment. The provisions of this program and all applicable standards shall be followed to ensure the safety of personnel performing service or maintenance activities to equipment, machines, or systems.
2. Failure to follow the requirements of the Electrical Safety Program shall be cause for disciplinary action.

**D. Definitions**

1. **Boundary, Arc-Flash:** Specified distance from an arc-flash hazard, with incident energy > 1.2 cal/cm<sup>2</sup> that a person can receive a second degree burn to unprotected skin. Individual shall be wearing specified arc-rated fire retardant PPE to enter.
2. **Boundary, Limited Approach:** Specified distance from exposed conductors or parts that a person shall be qualified to enter.
3. **Boundary, Prohibited Approach:** Specified distance from exposed conductors or parts that a person shall be qualified, wearing specified gloves, and have a documented procedural plan for the associated tasks to enter.
4. **Boundary, Restricted Approach:** Specified distance from exposed conductors or parts that a person shall be qualified, trained in energized electrical work, wearing specified gloves, and have a documented procedural plan for the associated tasks to enter.
5. **Electrical Engineer/Electrical Technician:** A "qualified person" that is capable of performing tests utilizing voltages greater than 50 volts within a controlled engineering/test area. This person is also capable of calculating incident energy available.
6. **Engineering/Test Area:** A controlled area where electrical testing or monitoring are performed utilizing specialized equipment and tools. Testing may be above, or below, 50 volts on guarded and unguarded equipment and materials.
7. **Exposure:** Electrical conductors or parts that are not suitably guarded, isolated, or insulated and are capable of possible shock and/or arc flash hazards
8. **Grounding:** A conducting connection, intentional or accidental, between an electrical circuit or equipment and the Earth or some conducting body that serves as the Earth.
9. **Ground-Fault Circuit-Interrupter:** A device intended to protect people from electrical shock. It de-energizes a circuit within a prescribed period of time when it detects a pre-set current to ground.

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10. **Hazardous Voltage:** As used in this standard, this term identifies any electrical circuitry that is operating at more than 50 volts, either phase to ground or phase to phase and is capable of a current flow of greater than 0.005 ampere.
11. **Hazard, Arc-Flash:** Condition associated with the possible release of energy caused by an electric arc. A condition may exist when energized electrical conductors or parts are exposed or when an individual is interacting with the equipment or device in a manner that could cause an electric arc. Equipment operating automatically that has been properly installed and maintained is not likely to pose an arc-flash hazard.
12. **Hazard, Shock:** Condition associated with the possible release of energy caused by contact with or within proximity of energized electrical conductors or parts.
13. **Incident Energy:** The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per centimeter squared (cal/cm<sup>2</sup>).
14. **Energized Electrical Work:** As used in this standard, the term refers to any work on or in near proximity to exposed (unguarded, uncovered, or uninsulated) hazardous voltage (> 50 volts).
15. **Energized Electrical Work Permit:** A written document that contains all the provisional elements in this program that shall be approved by the qualified person(s) that will be performing the work, the supervisor/engineer, and next level director/designee.
16. **Near Proximity:** Once you break the plane of a cabinet, panel, box, enclosure, etc. with hand or tool you are in near proximity, if the cabinet contains exposed energized conductors or parts.
17. **Qualified Person:** An individual that:
  - a. Has knowledge related to the construction and operation of electrical equipment / devices.
  - b. Has been trained to recognize the hazards associated with the energized electrical work.
  - c. Has been trained in electrical safety-related work practices
  - d. Has been trained in the methods to establish safe working conditions.
  - e. Has been trained to recognize and determine the degree and extent of the electrical hazard along with the requirements for entrance inside the shock / arc-flash boundaries and the precautionary measures to prevent entrance from unqualified persons.
  - f. Has been trained in the proper selection and use of protective clothing.
  - g. Has been trained in the proper selection and use of personal protective equipment (PPE)
  - h. Has been trained and demonstrated the skills required to perform the specific work task being contemplated. An individual may be qualified to work on certain equipment / devices, but unqualified to work on other equipment / devices. An individual may be qualified to perform certain duties if the employee undergoing on-the-job training demonstrates an ability to perform duties safely at his/her level of training.
  - i. Has been trained in First Aid, CPR, AED, Bloodborne Pathogens.
  - j. Has been trained in the methods necessary to release individuals that are in contact with energized conductors or parts.
18. **Safety Backup:** The primary responsibility of the safety backup is to be able to immediately summon rescue help and assist in rescue efforts. The safety backup shall not perform any work while backing up the primary qualified person. A safety backup is defined as an individual who:
  - a. Has been trained to recognize the hazards associated with the energized electrical work.
  - b. Has been trained in electrical safety-related work practices.
  - c. Has been trained in First Aid, CPR, AED, Bloodborne Pathogens.
  - d. Has been trained in the methods necessary to release individuals that are in contact with energized conductors or parts.
  - e. Has emergency response / communication (radio, cell phone, etc.) equipment available.
19. **Unqualified Person:** An individual that has little or no training to recognize the hazards associated with electrical equipment / devices or has not the demonstrated skills required to perform work on certain

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equipment / devices. Unqualified persons shall not be permitted to enter inside the limited or arc-flash boundary.

**E. Electrical Work Procedures (Attachment A)**

**STEP 1**

Determine Tasks Required to Perform Electrical Work

- a. Identify whether task(s) will create a shock or arc-flash hazard.

**STEP 2**

- a. Identify Environmental Conditions or Obstructions that Create Additional Hazards to the Work
- b. Utilize Table 1 – Working Spaces to verify that working space has adequate clearances and entrances/exits.
- c. Verify that working space has adequate lighting to perform tasks. Employees shall not enter spaces containing exposed energized conductors or parts unless illumination is provided that enables the employees to perform the work safely. Portable lighting shall be secured such that it cannot engage exposed energized conductors or parts. Employees shall not reach blindly into areas which might contain energized conductors or parts.
- d. When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized conductors or parts, the supervisor or equivalent shall provide, and the employee shall use, protective shield, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Refer to FMD Confined Space Entry Safety Program for complete requirements.
- e. Boundaries shall be maintained around all electrical equipment to permit ready and safe operation and maintenance of such equipment.
- f. All reasonable precautions shall be taken to see that unauthorized persons are prohibited from tasks that might bring them inside the defined boundaries or into contact with energized hazardous voltage circuits. These precautions should include posting signs or placing barriers to restrict access where energized electrical work is being performed. Barricade tape shall indicate DANGER and shall be red in color. If signs and barricades do not provide sufficient warning and protection, an attendant may be posted to verbally warn and protect unauthorized persons.
- g. Identify flammable materials within vicinity of working space. If possible, temporarily relocate flammable materials to an area outside of the working space that does not impede entrance/exit to the associated working space.
- h. Identify wet (i.e. standing liquids) and/or damp locations within the working space

**STEP 3**

Determine if Equipment / Device Can Be De-Energized

- a. All equipment / devices shall be de-energized unless the exposure of energized conductors or parts can be justified. Energized electrical work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards, increased risk, or where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations. Exposure shall be permitted for the following situations:
  - 1) Equipment / device is less than 50V
  - 2) Inspections
  - 3) Diagnostics / Troubleshooting
    - a) Infrared scanning, voltage/amp readings, rotation verification, circuit tracing
  - 4) If shutdown of equipment / device introduces additional hazards or increased risk:
    - a) Interruption of life support or data storage systems for patients or animals
    - b) De-activation of emergency alarm systems
    - c) Shutdown of ventilation equipment in hazardous locations

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**STEP 4**

Determine if Electrical Energized Work Permit is Required

- a. Utilize Attachment B - Electrical Energized Work Permit for the following situations:
  - 1) Work that involves the modification, changing, installation, or removal of any conductor or part inside the equipment / device while energized conductors or parts are exposed
  - 2) Work that involves the racking of an over-current protective device or MCC bucket while the bus is energized
  - 3) Work that has the potential of entering into the limited approach boundary of un-insulated overhead conductors

**STEP 5**

Determine Shock / Arc-Flash Boundaries

- a. If equipment / device is labeled, utilize shock / arc-flash boundaries indicated on label.
- b. If equipment / device is not labeled, utilize Table 2 – Shock Hazard Approach Boundaries for Unlabeled Equipment / Devices to determine the limited, restricted, and prohibited shock protection approach boundaries
- c. If equipment / device is not labeled, utilize Attachment C – Arc-Flash Boundary / Hazard Assessment Diagrams for Unlabeled Equipment / Devices
- d. When working within the limited approach boundary, the proper protective equipment shall be utilized to prevent electric shock. When working within the arc-flash boundary, the proper protective clothing shall be utilized to prevent/reduce injury caused by an electric arc

**STEP 6**

Determine Available Arc-Flash Incident Energy / Hazard Risk Category

- a. If equipment / device is labeled, utilize incident energy / hazard category indicated on label
- b. If equipment / device is not labeled, utilize Attachment C – Arc-Flash Boundary / Hazard Assessment Diagrams for Unlabeled Equipment/Devices to determine arc-flash hazard risk category
- c. No work shall be performed on equipment / devices with an incident energy > 40 Cal/cm<sup>2</sup> or hazard category > CAT 4

**STEP 7**

Determine if/when Additional Personnel are Needed

- a. Additional Qualified Person(s).
- b. Safety Backup.

**STEP 8**

Verify Personnel, Including Contractors, are Trained and Qualified to Perform the Tasks

**STEP 9**

Conduct Job Briefing Prior to Electrical Work Being Performed

- a. The briefing shall cover such subjects as the hazards associated with the work, sequence of operations / procedures to be followed, energy control measures, personal protective equipment to be utilized, emergency shutoff procedures, and point out locations of the nearest fire extinguisher, fire alarm initiating device and the nearest telephone / radio.
- b. An additional briefing meeting shall take place if changes to the scope of work occur that may lead the person outside of an electrically safe work condition or introduce additional hazards or increased risks

**STEP 10**

Perform Electrical Work

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**F. Other Requirements / Procedures**

1. Portable ladders shall have non-conductive side rails.
2. Ropes and pull cables, utilized or attached to equipment / devices within the limited approach boundary, shall be non-conductive
3. Only qualified persons shall defeat electrical safety interlocks, and then only temporarily while working on the equipment. The interlock system shall be returned to its operating condition immediately upon completion of work.
4. Flexible portable cord-and-plug connected equipment shall be visually inspected for external defects and damage each time prior to use. Damaged cords shall be tagged as defective and removed from service until repairs are made to ensure equipment is safe to use.
5. Conductive apparel and articles of jewelry and clothing (such as watch bands, bracelets, rings, key chains, necklaces, metallic aprons, cloth with conductive thread, or metal headgear) shall not be worn inside the limited approach boundary.
6. Housekeeping duties shall not be performed, within the limited approach boundary, unless adequate safeguards have been provided. Electrically conductive materials and solutions shall not be used on energized electrical conductors or parts. Employees shall not vacuum, blow, or otherwise disturb metallic shavings, cuttings, or filings or conductive dust in the proximity of energized conductors or parts.
7. Electric Power and Lighting Circuits
  - a. Only load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means should be used for the opening, reversing, or closing of circuits under load conditions.
  - b. When operating electrical load-rated switches, circuit breakers, or other devices, always stand to the hinged side of the device.
  - c. After a circuit is de-energized by a circuit protective device, the circuit should not be manually re-energized until a best effort has been made to determine that the equipment and circuit can be safely energized. If it can be determined that the operation was caused by an overload rather than a fault condition, the circuit may then be re-energized.
  - d. Over-current protection of equipment and conductors shall not be modified unless the modification is recommended through formal analysis for coordination purposes or for incident energy reduction. Temporary modifications, to perform work, shall only be permitted to reduce incident energy and shall be returned to its operating condition immediately upon completion of work.
8. Test Equipment
  - a. Only qualified persons shall perform inspections or diagnostic / troubleshooting work on energized electric circuits or equipment.
  - b. Test instruments and all associated test leads, cables, probes, and connectors shall be visually inspected for external defects and damage each time prior to use.
  - c. Damaged equipment shall be tagged as defective and removed from service until repairs and tests are made to ensure the equipment is safe to use.
  - d. Current-carrying parts of tools, probes, leads, clips and other equipment shall be rendered non-conductive with insulating material by the manufacturer of such equipment and a Nationally Recognized Testing Laboratory to have a voltage rating equal to or greater than the system voltage to be worked on.
  - e. Electrical insulating tape shall not be applied in the field to current-carrying parts for the purpose of working on energized electrical equipment or conductors.
  - f. Test instruments and their accessories shall be rated for the circuits and equipment to which they will be connected and should be designed for the environment that they would be use.
  - g. The operation of test equipment shall be verified before and after an absence of voltage test is performed

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**G. Protective and Other Protective Equipment**

1. Personal protective equipment shall be used in accordance with applicable regulatory standards.
2. Personal protective equipment shall be stored and maintained per manufacturer recommendations.
3. Head Protection
  - a. Insulating head protection rated for the voltage shall be worn when there is a potential for contact of the head with energized electrical conductors or parts. ANSI Z89.1-1997 helmets Class E rated 20,000V are preferred.
  - b. Face shields shall be arc-rated and shall have wrap-around design to protect the face, chin, beard, forehead, ears, neck, and hair.
  - c. An arc-rated balaclava shall be used, in conjunction with an arc-rated face shield, within the arc-flash boundary, where incident energy exposures exceed 8 cal/cm<sup>2</sup> or instances where the face shield does not fully wrap around the beard and hair.
  - d. In lieu of an arc-rated balaclava and face shield, an arc-rated suit hood may be utilized. Hoses intended for the use of supplemental outside air shall be arc-rated.
  - e. Safety glasses shall be worn at all times shall be worn when working inside the arc-flash boundary
  - f. Ear canal inserts or earmuffs shall be worn when working inside the arc-flash boundary
4. Body Protection
  - a. Where incident energy exposures exceed 1.2 cal/cm<sup>2</sup>, arc-rated fire resistant (FR) clothing shall be worn when working within the minimum safe approach distances identified in the appropriate energized electrical work procedure or permit.
  - b. All body parts and flammable material inside the arc-flash boundary shall be protected. Arc-rated clothing shall always be the outermost layer. (i.e. arc-rated rainwear, arc-rated high visibility vests, arc-rated harnesses, arc-rated winter wear)
  - c. A visual inspection of the clothing shall be performed prior to each use to ensure that they are free from defects (cuts, tears, holes, etc.).
  - d. Whenever visual inspection of clothing indicates it is damaged or has been contaminated with grease, oil, or other flammable liquids or materials, the clothing shall be immediately marked or tagged and removed from service for repair or cleaning
5. Hand and Arm Protection
  - a. Rubber insulating gloves shall be worn while working inside the limited approach boundary and where there is a possibility of inadvertent contact with energized electrical conductors or parts. When the nominal voltage is less than 50 volts and there is no additional hazard of contact with energized conductors or parts, no electrical PPE is required for use by a "Qualified Person".
    - 1) Gloves shall be rated for the voltage(s) involved. When the nominal voltage is 50 volts or greater the following chart shall be referenced:

Class of Glove	Maximum Voltage for Use
00	500 V
0	1,000 V
1	7,500 V
2	17,000 V
3	26,500 V
4	36,000 V

- 2) Gloves shall be used with non-flammable, non-melting leather protectors with minimal thickness of 0.03in. Use of insulated gloves is permitted under limited-use conditions where small equipment and part manipulation necessitate unusually high finger dexterity.

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- 3) Extra care shall be taken in the visual examination of the rubber gloves used without protectors prior to each use and extra care shall be taken to avoid handling sharp objects.
- 4) Gloves shall be tested for proper insulating values before first issue and every six (6) months thereafter or more often as wear dictates. If gloves have been tested but not issued for service, they shall not be placed into service unless it has been electrically tested within the previous twelve (12) months. All gloves shall be listed in the periodic maintenance program and have the certification date ink-stamped on the gloves indicating when the gloves were last inspected.
- 5) The user of rubber insulating gloves shall perform a visual and a roll up pressure inspection of the gloves prior to each use to ensure they are free from defects (cuts, tears, holes, foreign objects, etc.) If the user determines that any rubber-insulating glove is defective they shall immediately destroy the glove by cutting off at least one (1) finger and tag the glove as out-of-service.
- b. Insulating sleeves rated for the voltage shall be worn when there is a potential for contact of the arms or shoulders with energized electrical conductors or parts. Insulating sleeves shall meet the following:
  - 1) Insulating sleeves shall be PPE tested before first issue and every 12 months thereafter for proper insulating values. PPE tested sleeves shall be stored for a maximum of 12 months before first issue;
  - 2) All sleeves shall have the certification date (PPE test date) ink-stamped on the sleeve indicating when the sleeve was last electrically and mechanically tested for insulation integrity;
  - 3) The user of electrical insulating sleeves shall perform a visual inspection of the sleeves prior to each use to ensure they are free from defects (cuts, tears, holes, foreign objects, etc.);
  - 4) Whenever visual inspection of an electrical insulating sleeve indicates it is damaged or that the insulating value is suspect, the electrical insulating sleeve shall be immediately marked or tagged and removed from service.
6. Foot Protection
  - a. Where incident energy exposures exceed 4 cal/cm<sup>2</sup> heavy duty leather work shoes shall be worn. For wet conditions (less than 1 inch standing liquid) or instances where there is a potential for contact with energized electrical conductors or parts, insulating overshoes shall be worn. Overshoes shall be rated for the voltage(s) involved. EH shoes meeting the electrical hazard (EH) requirements of ASTM F2413 shall be utilized as a primary source for electrical shock protection.
7. Insulated Tools
  - a. Insulated tools shall be utilized when working inside the limited approach boundary.
  - b. All tools utilized shall be rated for the voltage(s) involved and shall have the double triangle symbol.
  - c. A visual inspection of the rubber-insulating material shall be performed prior to each use to ensure that they are free from defects (cuts, tears, holes, etc.).
  - d. Whenever visual inspection of insulated tools indicates they are damaged (i.e. visible yellow for two-color configurations) or that the insulating value is suspect, the insulated tool shall be immediately marked or tagged and removed from service.
8. Rubber Insulating Floor Mats
  - a. When used to reduce the exposure of qualified persons to shock hazards, rubber insulating floor mats shall be used only for temporary application and shall be stored in an approved manner.
  - b. Specific requirements for rubber insulating mats are as follows:
    - 1) Mats shall be rated for the voltage(s) involved;
    - 2) A visual inspection of mats shall be performed prior to each use to ensure they are free from defects (cuts, tears, holes, foreign objects, etc.);
    - 3) Mats shall be PPE tested before first issue and every 12 months thereafter for proper insulating values. PPE tested mats shall be stored for a maximum of 12 months before first issue;
    - 4) When visual inspection of electrical insulating mats indicates they are damaged or that the insulating value is suspect, the electrical insulating mat shall be immediately marked or tagged and removed from service.

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9. Rubber Insulating Blankets
  - a. When used, rubber-insulating blankets shall be installed over energized conductors or parts to temporarily reduce the exposure of qualified persons to shock hazards.
  - b. Unless specifically rated, rubber-insulating blankets do not provide arc flash, or blast protection.
  - c. Specific requirements for rubber-insulating blankets are as follows:
    - 1) Rubber insulating blankets shall be rated for the voltage(s) involved;
    - 2) A visual inspection of rubber-insulating blankets shall be performed prior to each use to ensure they are free from defects (cuts, tears, holes, foreign objects, etc.);
    - 3) Rubber-insulating blankets shall be PPE tested before first issue and every 12 months thereafter for proper insulating values. PPE tested blankets shall be stored for a maximum of 12 months before first issue;
    - 4) Whenever visual inspection of rubber insulating blankets indicates they are damaged or that the insulating value is suspect, the rubber insulating blanket shall be immediately marked or tagged and removed from service.
10. Arc-Flash Protection Blankets
  - a. When used, arc/flash protection blankets shall be installed to redirect the arc flash, or blast of energized conductors or parts that are not being worked on, but, are located in the area of the work and that may inadvertently fault during the time the work is being performed.
  - b. Arc-flash protection blankets shall be installed in accordance with the manufacturer's instructions.
  - c. Arc-flash protection blankets do not provide electrical insulation.
11. Fiberglass Reinforced Plastic Rods
  - a. Fiberglass rods shall be utilized for all clamp sticks, switch sticks, static discharge sticks, grounding sticks, and rescue hooks.
  - b. All fiberglass rods shall be rated for the voltage(s) involved.
  - c. Rescue hooks shall be utilized where an Electrical Energized Work Permit is required

**H. Contractors**

1. All electrical work performed by Contractor(s) shall be coordinated through a FMD Project Manager or other FMD representative.
2. Prior to electrical work being performed, a documented job briefing with the Contractor(s) shall take place.
3. Contractors performing electrical work shall have First Aid, AED, CPR and Bloodborne Pathogens training.
4. Contractors shall provide a written certification of electrical safety training of any employee who will perform energized electrical work.
5. Contractors shall wear the appropriate PPE when exposed to energized conductors or parts and when performing energized electrical work.
6. Contractors are required to obtain all applicable permits prior to starting any electrical work, including an Energized Electrical Work Permit, etc.
7. Only those Contract employees that are qualified and trained are authorized to work on energized electrical systems and equipment.
8. Contractors shall not rely only on FMD's electrical programs and processes to satisfy legal requirements. They should also follow their own company rules applicable to electrical work. It is the responsibility of each Contractor to identify and comply with all laws and regulations applicable to the particular work.

**I. Training**

1. Employees such as electricians, general maintenance mechanics, electrical engineers, HVAC technicians, and other facilities personnel who face a risk of electrical shock, burns, or related injuries or are responsible for taking action in case of an emergency shall be trained on the following:.

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- a. Electrical Safety Related Work Practices, First Aid, CPR, AED, and Bloodborne Pathogens.
  - 1) Electrical Safe Work Practices, including methods of release, and Bloodborne Pathogens training intervals shall not exceed 12 months.
  - 2) CPR/First Aid training is required once every two years per American Heart Association standards. Certify annually.
  - 3) Hepatitis B shots are also required unless an employee opts out by signing a form.
  - 4) Individuals shall be current with Lockout/Tagout training and procedures to establish a safe work condition
- 2. Employees (unqualified) that work around, but not on, electrical installations shall be trained in the inherent danger of electricity and the possible injuries that can occur.
- 3. All training shall be documented and records maintained.

**J. Records Retention**

- 1. All completed Energized Electrical Work Permit Forms shall be retained for one month from their use.
- 2. All completed job briefings with the Contractor shall be retained per Duke University standard.
- 3. Training records shall be retained per the Duke University standard.

**K. References:**

- 1. NFPA 70 National Electric Code
- 2. NFPA 70E Standard for Electrical Safety in the Workplace
- 3. FMD Lockout/Tagout Program
- 4. OSHA 1910.147 Control of Hazardous Energy
- 5. OSHA 1910.331-335 Electrical Safety Related Work Practices
- 6. OSHA 1910.137 ASTM D 120 - 95 Standard Specifications for Rubber Insulating Gloves
- 7. OSHA 29 CFR 1910 Subpart S "Safety-Related Work Practices"
- 8. NIOSH 83-125 Guidelines for Controlling Hazardous Energy During Maintenance and Servicing
- 9. ASTM F 496 "Specification for In-service Care for Insulating Gloves"
- 10. ASTM F 1236 "Standard Guide for Visual Inspection of Electrical Protective Rubber Products".
- 11. FMD Electrical Work Procedures
- 12. FMD Energized Electrical Work Permit
- 13. FMD Arc-Flash Boundary / Hazard Assessment for Unlabeled Equipment / Devices (NFPA 70E – Table 130.7(C)(15)(a))
- 14. Table 1 – Working Space (NFPA 70 – 110.26)
- 15. Table 2 – Shock Hazard Approach Boundaries for Unlabeled Equipment / Devices (NFPA 70E – Table 130.4)
- 16. Table 3 – Protective Clothing and Personal Protective Equipment (NFPA 70E – Table 130.7(C)(16))

**L. Attachments:**

- A. Electrical Work Procedures - Summary
- B. FMD Energized Electrical Work Permit
- C. Hazard Assessment Diagrams for Unlabeled Equipment
- D. Table 1 – Working Clearances
- E. Table 2 – Shock Boundaries for Unlabeled Equipment
- F. Table 3 - Protective Clothing and Protective Equipment

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**ATTACHMENT A - ELECTRICAL WORK PROCEDURES**

**Area: All FMD Organizations**

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**STEP 1**

**Determine Tasks Required to Perform Electrical Work**

**STEP 2**

**Identify Environmental Conditions or Obstructions that Create  
Additional Hazards or Increased Risk to the Work**

**STEP 3**

**Determine if Equipment / Device Can Be De-Energized**

**STEP 4**

**Determine if Electrical Energized Work Permit Required**

**STEP 5**

**Determine Shock / Arc-Flash Boundaries**

**STEP 6**

**Determine Available Arc-Flash Incident Energy / Hazard Risk Category**

**STEP 7**

**Determine if Additional Qualified Person and/or Safety Backup are Required**

**STEP 8**

**Verify Personnel, Including Contractors, are Trained and Qualified to Perform the Tasks**

**STEP 9**

**Conduct Job Briefing Prior to Electrical Work Being Performed**

**STEP 10**

**Perform Electrical Work**



**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**ATTACHMENT B - ENERGIZED ELECTRICAL WORK PERMIT**

**Area: All FMD Organizations**

**Date Effective: 7/1/2014**

**SECTION I – Justification**

Per NFPA 70E, energized electrical work shall be permitted where the employer can demonstrate that de-energizing introduces additional or increased hazards or where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations. Provide justification as to why the specified equipment/circuit cannot be de-energized or work deferred until the next scheduled outage.

Customer : \_\_\_\_\_ Date: \_\_\_\_\_

**SECTION II – Background / Information**

Work Order #: \_\_\_\_\_ Start Date: \_\_\_\_\_ End Date: \_\_\_\_\_

Equipment / Circuit Description & Location: \_\_\_\_\_

Primary Source Description & Location: \_\_\_\_\_

Alternate Source Description & Location (If Applicable): \_\_\_\_\_

Emergency Source Description & Location (If Applicable): \_\_\_\_\_

General Description of Work: \_\_\_\_\_

Risk or Potential Failure: \_\_\_\_\_

System Affected: \_\_\_\_\_ Impact to System: \_\_\_\_\_

**SECTION III – Emergency Action**

In the event of an electrical emergency call 911 or 684-2444. Provide detailed information to the emergency operator letting them know it is an electrical emergency, the specifics of the emergency, and the location of the emergency. Note any additional requirements / information:



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**ATTACHMENT B - ENERGIZED ELECTRICAL WORK PERMIT**

Area: All FMD Organizations

Date Effective: 7/1/2014

**SECTION IV - Procedures**

Detailed Sequence of Operation to Perform Work (Attach Additional Procedures if Necessary):

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Risk Mitigation Plan: \_\_\_\_\_

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**SECTION V – Hazard Analysis**

Results of Arc Flash Hazard Analysis		Results of Shock Hazard Analysis	
Flash Hazard Boundary:	(inches)	Nominal Voltage:	(volts)
Flash Hazard at 18 inches:	(cal/cm <sup>2</sup> )	Insulated Glove Class/Rating:	
Risk Category:		Limited Approach Boundary:	(inches)
		Restricted Approach Boundary:	(inches)
		Prohibited Approach Boundary:	(inches)

For Unlabeled Equipment / Devices, refer to Attachment C - Arc-Flash Boundary / Hazard Assessment Diagrams for Unlabeled Equipment / Devices and Table 2 – Shock Hazard Approach Boundaries for Unlabeled Equipment/Devices

Means Employed to Restrict Access to Work Area: \_\_\_\_\_

Additional Hazards (Project Conditions, Environmental, Obstructions, Etc.) \_\_\_\_\_

Hazard Control Practices: \_\_\_\_\_



**Duke University - Facilities Management Department  
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**ATTACHMENT B - ENERGIZED ELECTRICAL WORK PERMIT**

Area: All FMD Organizations

Date Effective: 7/1/2014

**SECTION VI – Equipment Requirements**

Personal Protective Equipment (PPE)	Required	Checked	Personal Protective Equipment (PPE)	Required	Checked
Hard Hat (Type I, Class E)			Safety Glasses/Goggles		
Arc-Rated Suit Hood			Hearing Protection		
Arc-Rated Face Shield			Insulated Gloves		
Balaclava Hood			Leather Gloves		
Hair Net/Beard Net			Insulated Tools		
Arc-Rated Suit			Category III Meter		
Arc-Rated FR Clothing			AED		
Natural Fiber Clothing			Other		

Refer to Table 3 – Protective Clothing and Personal Protective Equipment

**SECTION VII – Approvals**

**Electrically Qualified Persons That Understand and Agree to the Above**

Qualified Person: \_\_\_\_\_ Date: \_\_\_\_\_

Qualified Person: \_\_\_\_\_ Date: \_\_\_\_\_

**Management Approvals to Perform the Work While Electrically Energized**

FMD Supervisor/Engineer: \_\_\_\_\_ Date: \_\_\_\_\_

FMD Next Level Director/Designee: \_\_\_\_\_ Date: \_\_\_\_\_

Contractor Supervisor (If Applicable): \_\_\_\_\_ Date: \_\_\_\_\_

Other: \_\_\_\_\_ Date: \_\_\_\_\_

Note to Contractors: Whatever legal requirements exist for electrical energized work, nothing in this permit process relieves the Contractor from following all the Contractor's own rules applicable to electrically energized work. The Contractor shall not rely on Duke's Electrical Safety program to meet any of the Contractor's safety or regulatory requirements.

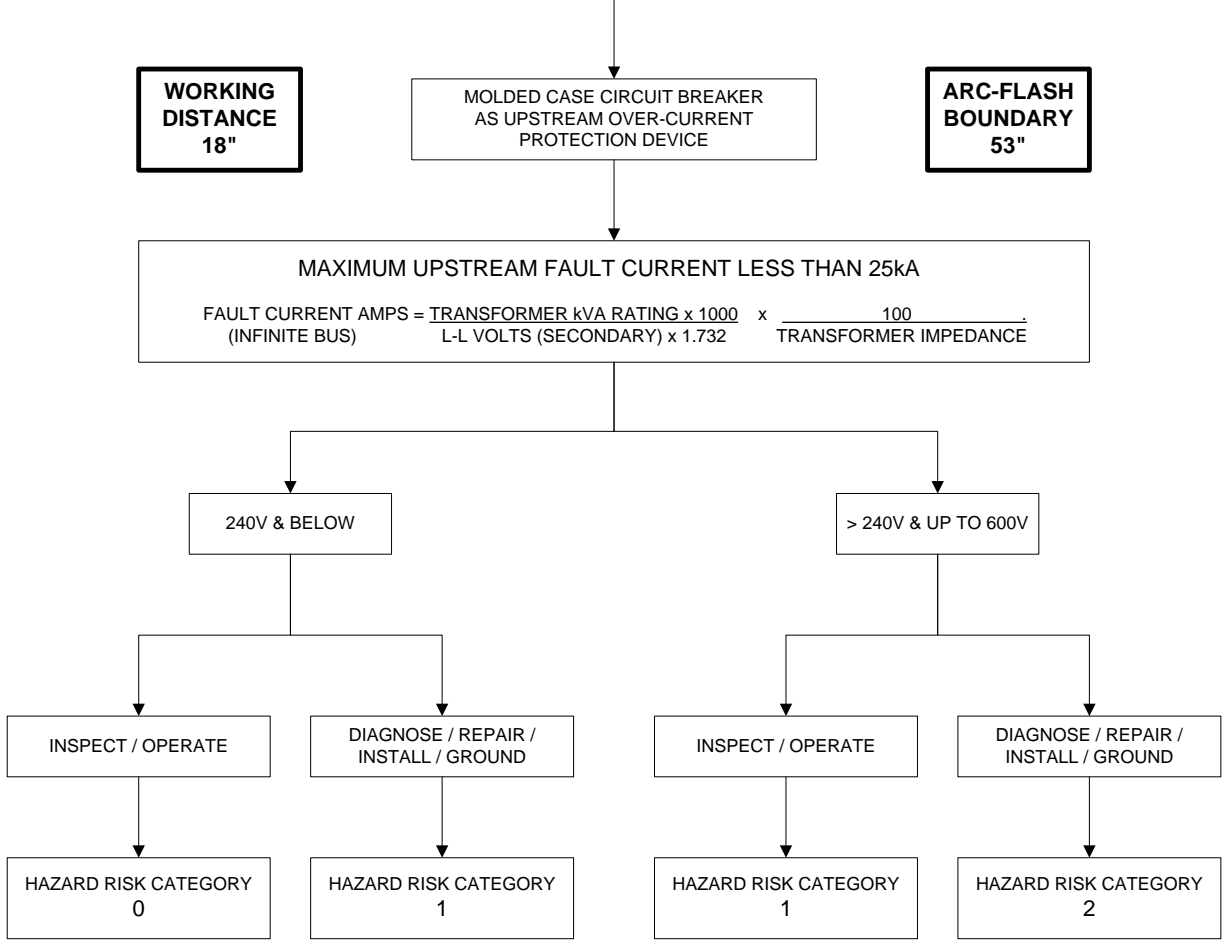
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**Environmental Safety and Health Program**

**ATTACHMENT C – ARC-FLASH BOUNDARY / HAZARD**  
**ASSESSMENT DIAGRAMS FOR UNLABELED EQUIPMENT / DEVICES**  
**(NFPA 70E – Table 130.7(C)(15)(a) )**

**Area: All FMD Organizations**

**Date Effective: 01 July 2014**

- AC PANELBOARDS (400A & BELOW) (WITH INTERNAL MOLDED CASE CIRCUIT BREAKERS)
- MISCELLANEOUS AC EQUIPMENT (VARIABLE FREQUENCY DRIVES, MOTOR STARTERS, CONTACTORS, SAFETY SWITCHES, DRY-TYPE TRANSFORMERS, CONTROL PANELS, ACCESS PANELS, JUNCTION BOXES, LIGHTS, LIGHTING CONTROLLERS, UNINTERRUPTIBLE POWER SUPPLIES, LIGHT SWITCHES, RECEPTACLES, BUSWAYS, CABLE TRAY, ETC.)



GENERAL NOTES / ASSUMPTIONS TO DIAGRAM

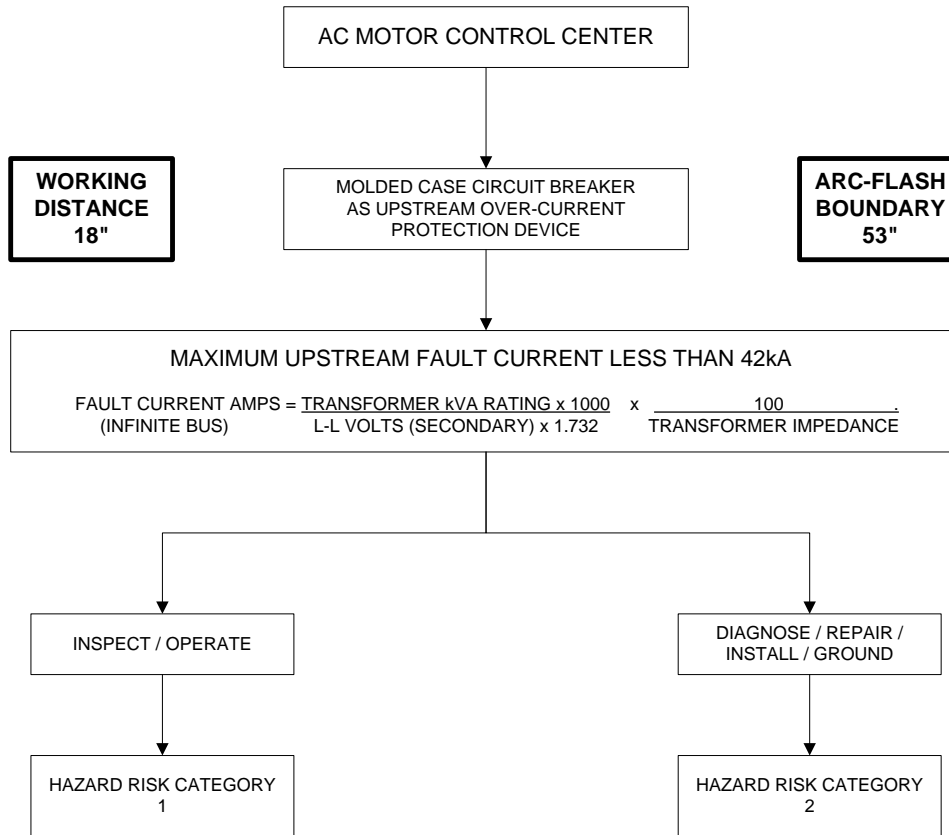
- IF ANY BRANCH OF THIS DIAGRAM IS NOT SATISFIED, AN ARC-FLASH ANALYSIS SHALL BE PERFORMED
- TYPICAL CLEARING TIME FOR MOLDED CASE CIRCUIT BREAKER = 1.5 CYCLES (IEEE 1015-2006)
- ELECTRICAL ENERGIZED WORK PERMIT IS REQUIRED FOR WORK THAT INVOLVES THE MODIFICATION, CHANGING, INSTALLATION, OR REMOVAL OF ANY COMPONENT INSIDE THE EQUIPMENT / DEVICE WHILE ENERGIZED CONDUCTORS OR PARTS ARE EXPOSED
- AN ADDITIONAL QUALIFIED PERSON AND A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE REMOVAL OF A BOLTED COVER GREATER THAN 30" X 60" IN SIZE

**Duke University - Facilities Management Department  
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**ATTACHMENT C – ARC-FLASH BOUNDARY / HAZARD  
ASSESSMENT DIAGRAMS FOR UNLABELED EQUIPMENT / DEVICES  
(NFPA 70E – Table 130.7(C)(15)(a) )**

Area: All FMD Organizations

Date Effective: 01 July 2014



GENERAL NOTES / ASSUMPTIONS TO DIAGRAM

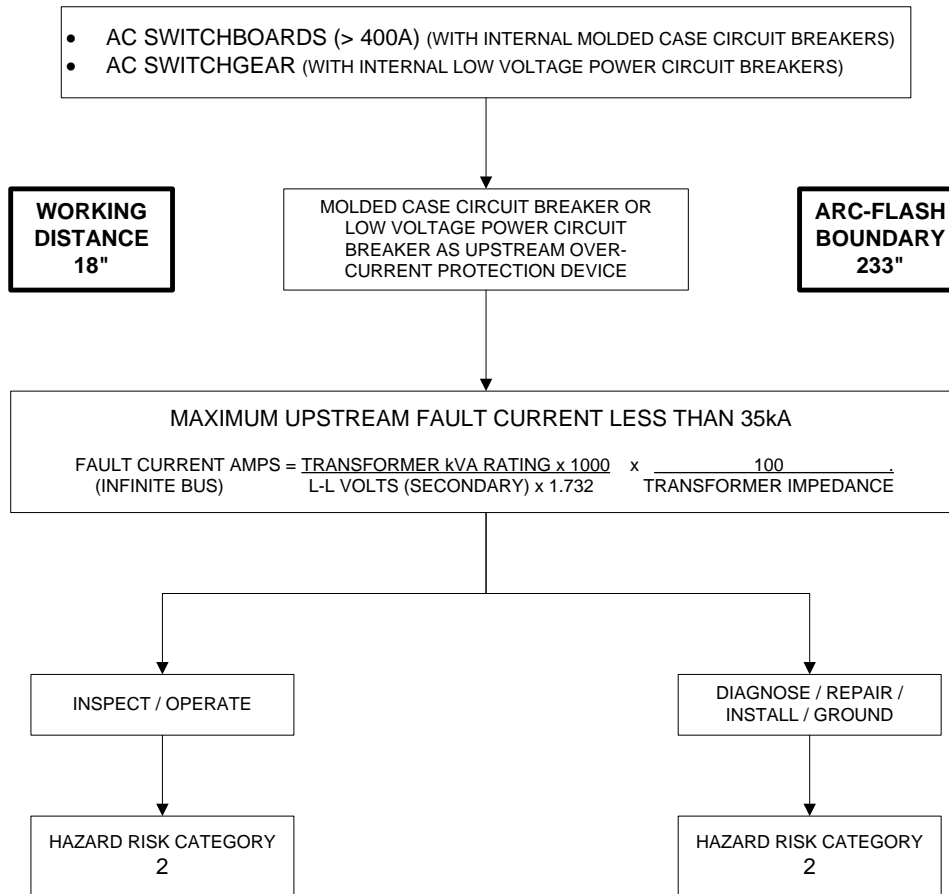
- IF ANY BRANCH OF THIS DIAGRAM IS NOT SATISFIED, AN ARC-FLASH ANALYSIS SHALL BE PERFORMED
- TYPICAL CLEARING TIME FOR MOLDED CASE CIRCUIT BREAKER = 1.5 CYCLES (IEEE 1015-2006)
- ELECTRICAL ENERGIZED WORK PERMIT IS REQUIRED FOR WORK THAT INVOLVES THE MODIFICATION, CHANGING, INSTALLATION, OR REMOVAL OF ANY COMPONENT INSIDE THE EQUIPMENT / DEVICE WHILE ENERGIZED CONDUCTORS OR PARTS ARE EXPOSED
- ELECTRICAL ENERGIZED WORK PERMIT IS REQUIRED FOR WORK THAT INVOLVES THE INSERTION OR REMOVAL OF A MCC BUCKET WHILE BUS IS ENERGIZED
- AN ADDITIONAL QUALIFIED PERSON AND A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE REMOVAL OF A BOLTED COVER GREATER THAN 30" X 60" IN SIZE

**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**ATTACHMENT C – ARC-FLASH BOUNDARY / HAZARD  
ASSESSMENT DIAGRAMS FOR UNLABELED EQUIPMENT / DEVICES  
(NFPA 70E – Table 130.7(C)(15)(a) )**

Area: All FMD Organizations

Date Effective: 01 July 2014



GENERAL NOTES / ASSUMPTIONS TO DIAGRAM

- IF ANY BRANCH OF THIS DIAGRAM IS NOT SATISFIED, AN ARC-FLASH ANALYSIS SHALL BE PERFORMED
- TYPICAL CLEARING TIME FOR MOLDED CASE CIRCUIT BREAKER = 1.5 CYCLES (IEEE 1015-2006)
- TYPICAL CLEARING TIME FOR LOW VOLTAGE POWER CIRCUIT BREAKER = 3 CYCLES (IEEE 1015-2006)
- ELECTRICAL ENERGIZED WORK PERMIT IS REQUIRED FOR WORK THAT INVOLVES THE MODIFICATION, CHANGING, INSTALLATION, OR REMOVAL OF ANY COMPONENT INSIDE THE EQUIPMENT / DEVICE WHILE ENERGIZED CONDUCTORS OR PARTS ARE EXPOSED
- ELECTRICAL ENERGIZED WORK PERMIT IS REQUIRED FOR WORK THAT INVOLVES THE RACKING OF AN OVER-CURRENT PROTECTIVE DEVICE WHILE BUS IS ENERGIZED
- AN ADDITIONAL QUALIFIED PERSON AND A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE REMOVAL OF A BOLTED COVER GREATER THAN 30" X 60" IN SIZE



**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**ATTACHMENT C – ARC-FLASH BOUNDARY / HAZARD  
ASSESSMENT DIAGRAMS FOR UNLABELED EQUIPMENT / DEVICES  
(NFPA 70E – Table 130.7(C)(15)(a) )**

**Area: All FMD Organizations**

**Date Effective: 01 July 2014**

- AC METAL-CLAD SWITCHGEAR
- AC METAL ENCLOSED SWITCHGEAR
- AC NEMA E2 FUSED CONTACTORS / MOTOR STARTERS
- MISCELLANEOUS AC EQUIPMENT (SAFETY SWITCHES, TRANSFORMERS, METERS, ACCESS PANELS, JUNCTION BOXES, MANHOLES, CABLES, ETC.)

**WORKING  
DISTANCE  
36"**

**ARC-FLASH  
BOUNDARY  
422"**

**MAXIMUM UPSTREAM FAULT CURRENT LESS THAN 35kA**

$$\text{FAULT CURRENT AMPS (INFINITE BUS)} = \frac{\text{TRANSFORMER kVA RATING} \times 1000}{\text{L-L VOLTS (SECONDARY)} \times 1.732} \times \frac{100}{\text{TRANSFORMER IMPEDANCE}}$$

INSPECT / OPERATE

DIAGNOSE / REPAIR /  
INSTALL / GROUND

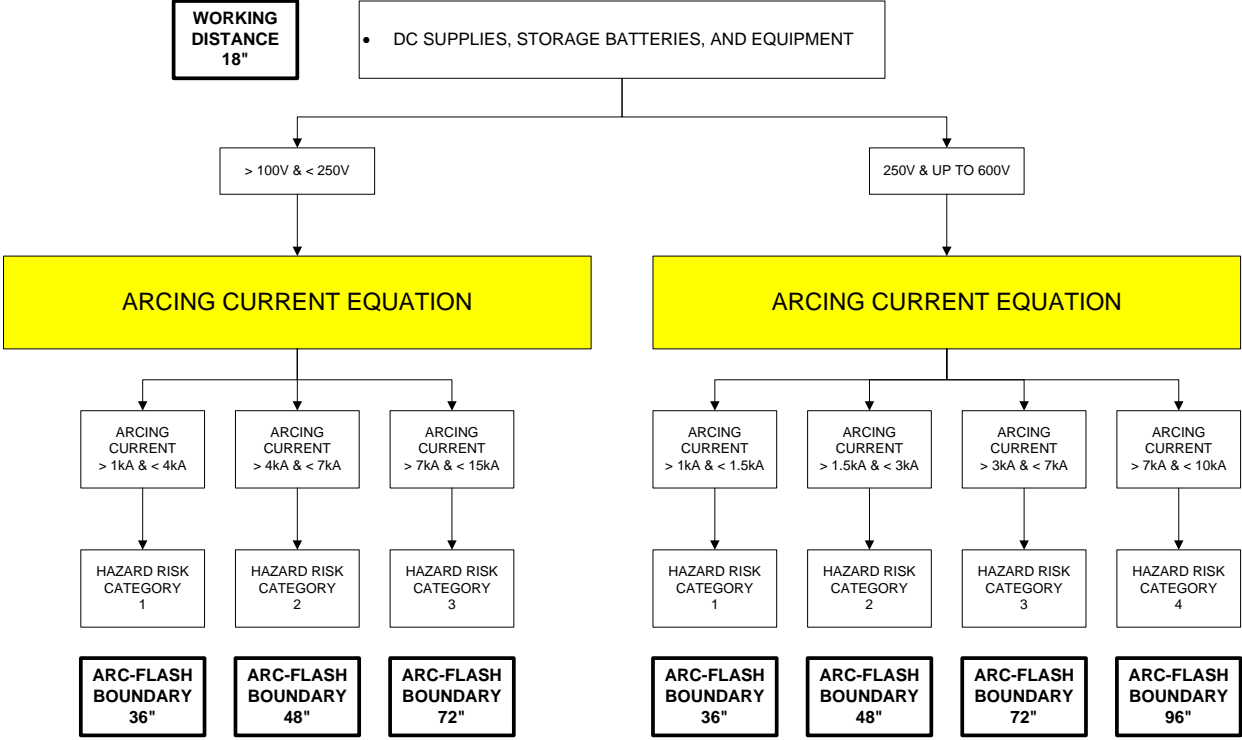
HAZARD RISK CATEGORY  
4

HAZARD RISK CATEGORY  
4

GENERAL NOTES / ASSUMPTIONS TO DIAGRAM

- UTILIZE EXISTING ARC-FLASH ANALYSIS RESULTS INDICATED ON LABELS
- A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE MODIFICATION, CHANGING, INSTALLATION, OR REMOVAL OF ANY COMPONENT INSIDE THE EQUIPMENT / DEVICE WHILE ENERGIZED CONDUCTORS OR PARTS ARE EXPOSED
- A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE RACKING OF AN OVER-CURRENT PROTECTIVE DEVICE WHILE BUS IS ENERGIZED
- AN ADDITIONAL QUALIFIED PERSON AND A SAFETY BACKUP IS REQUIRED FOR WORK THAT INVOLVES THE REMOVAL OF A BOLTED COVER GREATER THAN 30" X 60" IN SIZE

**Duke University - Facilities Management Department**  
**Environmental Safety and Health Program**  
**ATTACHMENT C – ARC-FLASH BOUNDARY / HAZARD**  
**ASSESSMENT DIAGRAMS FOR UNLABELED EQUIPMENT / DEVICES**  
**(NFPA 70E – Table 130.7(C)(15)(a) )**  
**Area: All FMD Organizations**      **Date Effective: 01 July 2014**





**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**TABLE 1 - WORKING SPACES (NFPA 70 – 110.26)**

**Area: All FMD Organizations**

**Date Effective: 7/1/2014**

**DEPTH OF WORKING SPACE**

**Minimal Depth of Working Spaces (0-600V)**

Nominal Voltage Range	Minimal Clear Distance		
	Condition 1	Condition 2	Condition 3
0 - 150V	900 mm (3 ft)	900 mm (3 ft)	900 mm (3 ft)
151 - 600V	900 mm (3 ft)	1m (3-1/2 ft)	1.2 m (4 ft)

**Minimum Depth of Working Space (Above 600V)**

Nominal Voltage Range	Minimal Clear Distance		
	Condition 1	Condition 2	Condition 3
601 - 2,500V	900 mm (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)
2,501 - 9,000V	1.2 m (4 ft)	1.5 m (5 ft)	1.8 m (6 ft)
9,000 - 25,000V	1.5 m (5 ft)	1.8 m (6 ft)	2.8 m (9 ft)
25,001 - 75,000V	1.8 m (6 ft)	2.5 m (8 ft)	3.0 m (10 ft)
Above 75,000V	2.5 m (8 ft)	3.0 m (10 ft)	3.7 m (12 ft)

**Condition 1** - 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 materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.

**Condition 2** - Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls shall be considered as grounded.

**Condition 3** - Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.



**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**TABLE 1 - WORKING SPACES (NFPA 70 – 110.26)**

**Area: All FMD Organizations**

**Date Effective: 7/1/2014**

<b><u>WIDTH OF WORKING SPACE</u></b>	
<b>Nominal Voltage Range</b>	<b>Minimum Width</b>
0 - 600V	750 mm (30 in)
Above 600V	750 mm (36 in)
Work space shall permit at least a 90 degree opening of the equipment doors or hinged panels	
<b><u>HEIGHT OF WORKING SPACE</u></b>	
<b>Nominal Voltage Range</b>	<b>Minimum Height</b>
0 - 600V	2 m (6-1/2 ft) or Height of Equipment Whichever is Greater
Above 600V	2 m (6-1/2 ft)
<b><u>ENTRANCES TO WORKING SPACE</u></b>	
<b>Amperage Range</b>	<b>Minimum Requirements</b>
0 - 1200A	One (1) Entrance Opening in the Direction of Egress
Above 1200A	Two (2) Entrances at Opposite Ends of the Working Space Both Opening in the Direction of Egress
	OR
	One (1) Entrance Opening in the Direction of Egress with Unobstructed Path from Working Space
	OR
	One (1) Entrance Opening in the Direction of Egress with Twice the Required Working Space



**Duke University - Facilities Management Department  
Environmental Safety and Health Program**

**TABLE 2 – SHOCK HAZARD APPROACH BOUNDARIES FOR  
UNLABELED EQUIPMENT / DEVICES (NFPA 70E – 130.4)**

**Area: All FMD Organizations**

**Date Effective: 7/1/2014**

**ALTERNATING CURRENT SYSTEMS**

Nominal Voltage Range	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 50V	Not Specified	Not Specified	Not Specified	Not Specified
50 to 300V	3.0m (10ft - 0in)	1.0m (3ft - 6in)	Avoid Contact	Avoid Contact
301 to 750V	3.0m (10ft - 0in)	1.0m (3ft - 6in)	0.3m (1ft - 0in)	25mm (0ft - 1in)
751 to 15kV	3.0m (10ft - 0in)	1.5m (5ft - 0in)	0.7m (2ft - 2in)	0.2m (0ft - 7in)
15.1 to 36kV	3.0m (10ft - 0in)	1.8m (6ft - 0in)	0.8m (2ft - 7in)	0.3m (0ft - 10in)
36.1 to 46kV	3.0m (10ft - 0in)	2.5m (8ft - 0in)	0.8m (2ft - 9in)	0.4m (1ft - 5in)
46.1 to 72.5kV	3.0m (10ft - 0in)	2.5m (8ft - 0in)	1.0m (3ft - 3in)	0.1m (2ft - 2in)
72.6 to 121kV	3.3m (10ft - 8in)	2.5m (8ft - 0in)	1.0m (3ft - 4in)	0.8m (2ft - 9in)

**DIRECT CURRENT SYSTEMS**

Nominal Voltage Range	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 100V	Not Specified	Not Specified	Not Specified	Not Specified
100 to 300V	3.0m (10ft - 0in)	1.0m (3ft - 6in)	Avoid Contact	Avoid Contact
301 to 1kV	3.0m (10ft - 0in)	1.0m (3ft - 6in)	0.3m (1ft - 0in)	25mm (0ft - 1in)
1.1kV to 5kV	3.0m (10ft - 0in)	1.5m (5ft - 0in)	0.7m (2ft - 2in)	0.2m (0ft - 7in)



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**TABLE 3 – PROTECTIVE CLOTHING AND PERSONAL  
PROTECTIVE EQUIPMENT (NFPA 70E - Table 130.7(C)(16))**

**Area: All FMD Organizations**

**Date Effective: 7/1/2014**

	<u>CAT 0</u> Min. FW 4.5 oz/yd <sup>2</sup>	<u>CAT 1</u> Min. AR 4 cal/cm <sup>2</sup>	<u>CAT 2</u> Min. AR 8 cal/cm <sup>2</sup>	<u>CAT 3</u> Min. AR 25 cal/cm <sup>2</sup>	<u>CAT 4</u> Min. AR 40 cal/cm <sup>2</sup>
<b>PROTECTIVE CLOTHING</b>					
Untreated Fiber Shirt (Long Sleeve)	X				
Untreated Fiber Pants (Long)	X				
<b>ARC-RATED CLOTHING</b>					
Insulated Hard Hat		X	X	X	X
Face Shield		X	X	X	X
Balaclava		(If Applicable)	X	X	X
- or -					
Suit Hood		X	X	X	X
Shirt (Long Sleeve)		X	X	X	X
Pants (Long)		X	X	X	X
- or -					
Coverall		X	X	X	X
Suit Jacket (Long Sleeve)				X	X
Suit Pants (Long)				X	X
Jacket, Parka, Rainwear	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
<b>PERSONAL PROTECTIVE EQUIPMENT</b>					
Safety Glasses or Safety Goggles	X	X	X	X	X
Hearing Protection	X	X	X	X	X
Insulated Gloves	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
Heavy Duty Leather Gloves	X	X	X	X	X
Insulated Sleeves	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
Leather Work Shoes		X	X	X	X
Insulated Overshoes	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
Insulated Tools	X	X	X	X	X
Insulated Floor Mats	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
Insulated Blankets	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)
Arc-Flash Blankets	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)	(If Applicable)