UNIVERSITY OF ROCHESTER
ENVIRONMENTAL HEALTH & SAFETY

Policy No.: OS001	**Approved by: Mark Cavanaugh**
Title: Energized Electrical Safety Program	**Date: 8/24/2020**
Revision No.: 7	**Page 1 of 34**
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I. PURPOSE

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

The University's Energized Electrical Safety Program is founded on the *principle of avoiding and not permitting energized work unless it is absolutely necessary*. Energized electrical conductors or circuit parts will be de-energized before an employee works on or near them unless one of the following conditions applies:

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

Energized electrical conductors or circuit parts are to be de-energized in accordance with the University's Lockout/Tagout Program. If live parts are not placed in an electrically safe condition, the work practices described in this document must be used to protect employees. Work on live parts or circuits requires the issuance of a *Live Work Permit*, except as noted in Section V.B.2, Limited Long Term Energized Electrical Work Permit.

II. PERSONNEL AFFECTED

This program applies to all properties owned by the University, and work performed by university employees and contractors regardless of job site location.

III. DEFINITIONS

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

1. **Arc Flash Hazard:** A dangerous condition associated with the possible release of energy caused by an electric arc.
2. **Arc Flash protection boundary:** An approach limit at a distance from a prospective arc source within which a person could receive a second-degree burn if an electrical arc flash were to occur. See Appendix B.
3. **Arc rating:** The maximum incident energy resistance demonstrated by a material (or a layered system of materials) prior to "breaking open" or at the onset of a second-degree skin burn. This rating is assigned to electrical protective clothing and is normally expressed in calories per square centimeter (cal/cm^2).
4. **Electrically safe work condition:** A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with the University policy, tested to ensure the absence of voltage, and grounded if determined necessary.
5. **Energized:** Electrically connected to or having a source of voltage.
6. **Energized Electrical Work Permit:** Used for all approved non-routine live work.
7. **Exposed (as applied to live parts):** Capable of being inadvertently touched or approached from closer than a safe distance by a person. It is applied to parts that are not suitably guarded, isolated, or insulated.
8. **Flash hazard analysis:** A study investigating a worker's potential exposure to arc-flash energy, conducted prior to commencing work for the purpose of injury prevention and the determination of safe work practices along with appropriate levels of PPE.
9. **Flash suit:** A complete Fire Resistive (FR) clothing and equipment system that covers the entire body, except for the hands and feet. (Such a suit typically includes pants, jacket, and a "bee-keeper" style hood fitted with a face shield).
10. **FR apparel:** Flame-resistant apparel; describes a broad category of clothing designed to protect employees from electrical arc events during completion of energized tasks.
11. **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 square centimeter (cal/cm^2).
12. **Limited approach boundary:** An approach limit at a distance from an exposed live part within which a shock hazard exists. See Appendix B.
13. **Limited Long Term Energized Electrical Work Permit:** Allows specified live work to be performed by a qualified individual. The permit is good for up to one year and will be renewed annually, as appropriate. Routine work only.
14. **Live parts:** Energized conductive components.
15. **Prohibited approach boundary:** An approach limit at a distance from an exposed live part within which work is considered the same as making contact with the live part. See Appendix B.

16. **PPE:** An acronym for "Personal Protective Equipment".

17. **Qualified person:** Through training and experience understands the requirements of this program plus, OSHA and NFPA 70E. A person who:
    - Has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations
    - Has received safety training to recognize and avoid the hazards involved
    - Has received training to recognize the appropriate level of PPE required
    - Has shown competency in inspecting and maintaining PPE.
    - Has exhibited proficiency for specific procedures, i.e. Lock Out Tag Out
    - Has worked on the specific voltage or calorie level before
    - Can distinguish exposed live parts from other parts
    - Can determine the nominal voltage of live parts
    - Understands clearance distances for the voltages he/she will be exposed to

    Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, PPE, insulating and shielding materials, and insulated tools. A person may be "task qualified" – qualified to use certain equipment, but not on equipment of a different nature. The supervisor must determine if someone is qualified.
18. **Restricted approach boundary:** An approach limit at a distance from an exposed live part within which there is an increased risk of shock (due to electrical arc-over combined with inadvertent movement) for personnel working in close proximity to the live part.
19. **Unqualified person:** Any person who does not meet the definition of a qualified person.
20. **Working On:** (energized electrical conductors or circuit parts). Coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the Personal Protective Equipment a person is wearing.

IV. RESPONSIBILITIES

A. UNIVERSITY FACILITIES DIRECTORS

1. Shall be responsible for the ownership, rollout and implementation of the Energized Electrical Safety Program within their departments.
2. Shall function as the Host Employer in relationship with contractors and shall:
    - Attend all required training.
    - Inform contractors of known hazards covered by this standard.
    - Provide adequate information about the facility so the contractor can make informed safety assessments.
    - Provide the contractor with a copy of this program and require a copy of the contractor's electrical safety program and training.

- Report observed contract-employer-related violations of this standard to their manager and/or director.

3. Support the general regulatory compliance programs, and assure that Facility/Departmental Policies are followed.
4. Provide resources and personnel necessary to develop, maintain, and annually verify and update this program as a whole, including a database system to maintain written procedures.
5. Provide resources and personnel to assure all of their employees have received necessary training and instruction regarding their assigned roles and responsibilities to comply with this program.

B. SUPERVISOR

1. Determine the applicability of the electrical safety program to activities conducted within their respective areas of jurisdiction
2. Designate individuals responsible for the implementation of the electrical safety program within their areas.
3. Actively support this program as part of the University of Rochester overall safety effort.
4. Oversee the Limited Long Term Energized Electrical Work Permit process.
5. Identify tasks that require Live/Energized Work Permits and submit permit requests.
6. Issue Limited Long Term Energized Work Permit based on operational needs and route to the area manager and then the Electrical Safety Committee for review and approval.
7. Maintain records of all electrical work permits
8. Determine if a person and/or contractor is qualified to perform electrical work.
9. Ensure employees comply with all provisions of the electrical safety program.
10. Conduct periodic site inspections and document observations.
11. Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training.
12. Develop and maintain a listing of all qualified employees under their supervision,
13. Ensure employees are provided with and use appropriate protective equipment.
14. Conduct annual assessments/audits of each employee under their responsibility in the program.
15. Perform job hazard assessments, develop work plans and conduct safety meetings.
16. Report unsafe conditions and seek mitigation assistance.
17. Attend all required training.

C. CONTRACT EMPLOYER

1. Must follow the electrical safety program
2. Provide a copy of their company's electrical safety program
3. Communicate all potential hazards to the hiring and/or project manager
4. Ensure employees follow safe work practices.
5. Alert host employer of unique or unanticipated hazards presented by contractor's work.
6. Inform host employer of any hazards encountered that host employer did not mention.
7. Correct reported violations.
8. Provide documentation on qualifications of contract staff who will be working on electrical equipment.

D. ENVIRONMENTAL HEALTH & SAFETY OCCUPATIONAL SAFETY UNIT

1. Provide program update awareness.
2. Assist with training annually.
3. Periodically review and update this written program.
4. Provide general training for work units on the content of this program and work with training contractor to include the University specific program.
5. Assist university facility work units in implementing the provisions of this program.
6. Conduct a program audit at least every three years.

E. OPERATIONS and AREA MANAGERS

1. Determine the applicability of the electrical safety program to activities conducted within their respective areas of jurisdiction.
2. Designate individuals responsible for the implementation of the electrical safety program within their areas.
3. Actively support this program as part of the University of Rochester overall safety effort.
4. Oversee the Limited Long Term Energized Electrical Work Permit process.
5. Maintain records of all electrical work permits.

F. TRADES SUPERVISORS

1. Determine if a person and or contractor is qualified to perform electrical work.
2. Attend all required training.
3. Ensure employees comply with all provisions of the electrical safety program.
4. Conduct periodic site inspections and document observations.
5. Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training
6. Develop and maintain a listing of all qualified employees under their supervision.

7. Ensure employees are provided with and use appropriate protective equipment.
8. Identify tasks that require Live/Energized Work Permits and submit permit requests.
9. Issue Limited Long Term Energized Electrical Work Permit based on operational needs and route to the area manager and then the Electrical Safety Committee for review and approval.
10. Conduct annual assessments/audits of each employee under their responsibility in the program.
11. Perform job hazard assessments, develop work plans and conduct safety meetings.
12. Report unsafe conditions and seek mitigation assistance.

G. EMPLOYEES

1. Consistently demonstrate safe workman like practices.
2. Maintain a safe work environment for yourself and others.
3. Adhere to the guidelines and work practices as described in OSHA, NFPA 70e and this written program.
4. Attend all training required relative to this program.
5. Immediately report any concerns related to electrical safety to supervision.

H. ELECTRICAL SAFETY COMMITTEE CHAIRPERSON

1. The responsibility for designating the Electrical Safety Committee Chairperson resides jointly with the EH&S Chief Safety Officer and the Sr. Associate Vice President of Facilities.
2. Shall be a Director level employee.
3. Shall be responsible for organizing the team, scheduling the semiannual program review meetings, taking meeting minutes and assigning tasks to perform updates to the program.
4. Shall be responsible for ensuring that the program review and updates are completed by the Electrical Safety Committee and EH&S.

I. ELECTRICAL SAFETY COMMITTEE

1. Shall be comprised of members from River Campus, Medical Center, Utilities & Energy Management and Environmental Health & Safety.
2. Meet semiannually to review program, its implementation, new and existing issues.
3. Review all Live Energized Electrical Work Permits submitted for approval.
4. Promote consistency in how electrical tasks are completed within the various work units at the University.
5. Ensure that this electrical safety program is audited on a frequency as determined appropriate by the committee. Where discrepancies are found, the committee shall agree on appropriate revisions and corrections.

6. Establish and follow through on all initiatives, including, but not limited to training.
7. Investigate and debrief any electrical safety injury/incident or near miss to identify root cause and any improvement opportunities.

V. PROCEDURES

A. TRAINING

1. Employees must perform all electrical work within the guidelines for their training at all times.
2. The level of electrical safety training provided is dependent on whether the employee is classified as a "qualified person" or "unqualified person".
3. A "qualified person" shall receive technical training upon initial assignment and at least every three years thereafter. Program refresher training shall be conducted annually. They shall be trained and knowledgeable in all of the following topics:
    a. Construction and operation of equipment on which work is assigned.
    b. Emergency Procedures. Employees exposed to shock hazards shall be trained in methods of release of victims from contact with exposed energized electrical conductors or circuit parts. Employees shall be trained and certified in First aid, AED CPR, in accordance with the American Heart Association recommended frequency.
    c. Proper use of insulating tools and test equipment, including selection of an appropriate voltage-detector and demonstration on how to use the device to verify absence of voltage, including interpretation of indications provided by the device. The training shall include device limitations.
    d. Proper use of PPE, including arc flash, insulation, and shielding materials.
    e. Ability to distinguish exposed energized conductors and circuits from other parts of equipment, by demonstrating the proper use of a meter.
    f. Ability to determine nominal voltage of exposed live parts.
    g. Understanding of the required approach distances, of both arc flash and shock.
4. A person can be considered qualified with respect to certain equipment and methods but still be considered unqualified for others. The supervisor shall maintain appropriate documentation of the employee's qualifications.
5. Although not qualified in this program, an "unqualified person" shall be trained in the inherent hazards of electricity and any related work practices that are necessary for their safety. Affected personnel shall receive annual awareness training. Awareness training does not qualify these people to do any electrical work of any type.
6. Occupational Safety will assist the work unit supervisor in coordinating

training for qualified and unqualified persons**.** Training for employees, whether experienced or new to the job, must be provided before duties are assigned that involve work near or on electrical systems.

7. Each employee shall receive additional training (or retraining) under any of the following conditions:
    a. If supervision or annual inspections indicate that the employee is not complying with the proper safety related work practices.
    b. If new technology, equipment, or changes in procedure necessitate changes in safety-related work practices.
    c. If work practices not normally used during regular job duties must be employed.
    d. For tasks that are performed less often than once a year.
8. Each University work unit shall maintain a record of all electrical training provided to their employees along with a listing of all employees classified as qualified persons.

B. WORKING ON OR NEAR LIVE PARTS

1. Live/Energized Electrical Work Permit
    a. When live parts are not placed and verified to be in an electrically safe condition, work to be performed on them shall be considered energized electrical work and will be performed by written permit only, unless the work is authorized by that person's *Limited Long Term Energized Electrical Work Permit*
    b. A copy of the University's "*Energized Electrical Work Permit*" can be found in Appendix A of this document. The intent of this permit is to ensure that all appropriate safety precautions are taken prior to starting energized electrical work.
    c. The permit is to be originated by the supervisor requesting that the energized work be completed. The requestor is responsible for completing Section I of the permit.
    d. The qualified persons completing the task are responsible for completing Section II of the permit.
    e. All Energized Work Permits should be initiated by the Trades Supervisor, who then reviews it with the operations/area manager followed by a cross departmental review. The supervisor then reviews the permit with the individual(s) doing the work before work commences.
    f. In the event of an emergency condition requiring an Energized Work Permit, and the review requirements above cannot be met, the on-call supervisor and the on-call manager will then notify the director and with approval initiate the permit, review the work plan, and discuss it with another member of the Electrical Safety Committee, who will provide verbal authority to conduct the work and sign off on the

permit the next business day. The manager and supervisor will sign the permit as will the individual(s) performing the work.

g. The permit must be posted in the area where the energized work is taking place for the duration of the task. Copies of all energized electrical work permits must be kept on file in the individual's department.

h. Work related to testing, troubleshooting, and voltage measuring may be completed without a permit provided appropriate safe work practices and PPE are used. The individual performing such work must have a Limited Long Term Energized Electrical Work Permit on file (see next section).

2. **Limited Long Term Energized Electrical Work Permit (see Appendix H)**
   a. Allows specified live work to be performed by a qualified individual.
   b. It includes the performance of routine tasks including testing, troubleshooting, voltage measuring and repairs provided appropriate safe work practices and PPE are used, as specified on the individual's long term permit.
   c. Copies of all limited long term energized electrical work permits must be kept on file in the individual's department.
   d. The permit is good for up to one year.
3. **Approach Boundaries to Live Parts**
   a. Observing a safe approach distance from exposed energized parts is an effective means of maintaining electrical safety. As the distance between an individual and live parts increases, the potential for an electrical injury decreases.
   b. Before setup, safe approach distances will be determined by the qualified person for all tasks in which approaching personnel are exposed to live parts. See Appendix B**,** *"Approach Boundaries to Live Parts for Shock Protection"*.
   c. Unqualified 3rd party persons are not allowed to cross the restricted approach boundary.
   d. Qualified persons may not cross or take any conductive object closer than the Restricted Approach Boundary unless one of the following conditions apply:
      i. The qualified person is insulated or guarded from the live parts and no un-insulated part of the qualified person's body crosses the Prohibited Approach Boundary.
      ii. The live parts are insulated from the qualified person and from any other conductive object at a different potential.
   e. Crossing the Prohibited Approach Boundary is considered the same as making contact with energized parts. Qualified persons may only cross this boundary when all of the following precautions have been taken:

i. The qualified person has specific training to work on energized parts.
ii. The qualified person has obtained an approved Energized Electrical Work Permit.
iii. The qualified person uses PPE appropriate for working on energized parts that are rated for the voltage and energy level involved.

4. **Other Precautions to Ensure Staff Safety**
   a. Lockout/Tagout shall be implemented at all times.
   b. Employees shall not reach blindly into areas that might contain exposed live parts. i.e. switch gear, panels etc.
   c. Employees shall not enter spaces containing live parts unless illumination is provided and permits to perform live work have been issued that allow the work to be performed safely.
   d. Conductive articles of PPE, jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses, etc.) shall not be worn whenever and wherever work is performed on electrical equipment or circuits.
   e. Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents accidental contact with live parts. Such materials and equipment include, but are not limited to, long conductive objects such as ducts, pipes, tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
   f. When an employee works in a confined space or enclosed space (such as a manhole or vault) that contains exposed live parts, the employee shall use protective shields, barriers, or insulating materials as necessary to avoid contact with these parts. Doors, hinged panels, and the like shall be secured to prevent them from swinging into employees.
   g. When working in a confined space, the University Confined Space Program shall be adhered to.
   h. Only properly rated and approved tools shall be used. Non-rated tools, including 4 in 1 screwdrivers are prohibited. See Appendix J for approved tool

C. PERSONAL PROTECTIVE EQUIPMENT (PPE)

These items and their reasoning must be reviewed with all participants in the program.

1. **General Requirements**
    a. Employees working in areas where electrical hazards are present shall be provided with, and shall use, protective equipment (Arc Flash Gear) that is designed and constructed for the specific body part to be protected and for the work to be performed.
    b. Such equipment shall be a minimum of 12 calorie rated, and 40 calorie rated Arc Flash apparel only, eye protection, head protection, hearing protection, hand protection, insulated footwear, and face shields as necessary.
    The University is not responsible for providing under layers, but the employee must wear compatible under layers made of white cotton. See Appendix E.
    c. The employee to whom it is issued shall maintain all protective equipment in a safe, reliable condition. Employees shall store arc flash gear in the special storage bag provided.
    d. Any additional electrical PPE purchased by employees must be approved by the supervisor.
    e. Employees shall wear nonconductive protection for the head, eyes, face, neck, chin, hand and arms whenever there is danger of contact with live parts or from injury from exposure to electric arcs or flashes or from flying objects resulting from an electrical explosion.
    f. Employees shall wear hearing protection whenever performing live work.
    g. Heavy-duty electrically rated boots or dielectric overshoes (per ANSI Z41 and ASTM F2413-05) provide some arc flash protection to the feet and shall be used for all tasks involving energized electric. Insulated soles shall not be used as primary electrical protection.
    h. Face shields with an arc rating will be used for electrical work. Safety glasses with side shields or goggles must always be worn underneath face shields.
        i. Additional illumination may be needed when using tinted face shields as protection during electrical work.
2. **Flash Protection Boundary**
    a. Personal protective equipment shall be provided to and used by all qualified employees working within the “Flash Protection Boundary”.
    b. For systems that are above 600 volts, the Flash Protection Boundary shall be determined through engineering analysis. Arc Flash consulting firms will be employed as necessary.
    c. For systems that are 600 volts or less there are three methods for determining the Flash Protection Boundary. The preferred order of which method shall be utilized is:
        i. Incident Energy Analysis method, as part of the overall arc flash

study. The analysis shall be performed by a qualified person. Arc Flash consulting firms may be employed.

ii. The PPE category method, utilizing the tables in Appendix E.

iii. Calculating the boundary using the formula in Appendix C.

d. The specific protective equipment to be worn within the Flash Protection Boundary shall be determined by using Incident Energy Analysis Method and selecting the PPE with NFPA Table 130.5, shown in Appendix D.

i. Complete a detailed flash hazard analysis utilizing an engineering consulting firm or under engineering supervision that determines the incident exposure energy of each employee. Appropriate protective clothing will be selected based on the calculated exposure level.

ii. It is the Project Manager's responsibility to ensure new buildings and installations have an arc flash study performed and documented. The project manager is also responsible for ensuring all installations are below 40 calories, anything greater than that will need approval from the Senior Associate Vice President of University Facilities and Services.

iii. The detailed arc flash hazard analysis shall be reviewed and performed every 5 years, or earlier whenever a major system change occurs.

e. As an alternative secondary method, for systems that are 600 volts or less, the specific protective equipment to be worn within the Flash Protection Boundary can be determined by using the Arc Flash PPE Category Method using NFPA Tables 130.7(C)(15)(a), 130.7(C)(15)(b), 130.7(C)(15)(c), shown in Appendix E. This method can only be used if the specific task to be performed appears in the tables and the system meets the listed criteria for short circuit current magnitude and fault clearing times.

i. To utilize Table 130.7(C)(15)(a), fault current at the equipment must be known. To determine the fault current without a system model/engineering analysis, the fault current can be calculated at the transformer secondary lugs and assumed as the fault current for the whole system. This can be calculated using the calculation in Appendix E.

ii. The Arc Flash PPE Category table shall be reviewed re-utilized every 5 years, or earlier whenever a major system change occurs.

f. The University work units shall develop and maintain a listing of the specific PPE requirements for each energized electrical task conducted by their employees using the form found in Appendix F of this

document.

3. **Arc Flash Labels**
    a. Arc Flash Labels shall be posted at all major electrical equipment that are likely to require examinations, adjustment, servicing, maintenance or operation while energized.
    b. Arc Flash labels shall be created in accordance with the example labels in Appendix M. Examples are shown for both the Incident Energy Analysis and PPE Category Methods.
4. **Flame-Resistant (FR) Apparel & Under layers**
    a. FR apparel shall always be a minimum of 12 calorie rated. And rated for 40 calories when required for arc flash levels.
    b. FR apparel (See Appendix E of this document) shall be visually inspected before each use. FR apparel that is contaminated or damaged shall not be used. Protective items that become contaminated with grease, oil, flammable liquids, or combustible liquids shall not be used.
    c. The garment manufacturer's instructions for care and maintenance of FR apparel shall be followed.
    d. When FR apparel is worn to protect an employee, it shall cover all ignitable clothing and allow for movement and visibility.
    e. FR apparel must cover potentially exposed areas as completely as possible. FR shirtsleeves must be fastened and FR shirts/jackets must be closed at the neck.
    f. Non-melting, flammable garments (i.e. cotton, wool, rayon, silk, or blends of these materials) should be used as under layers beneath FR apparel.
    g. Fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric under layers next to the skin.
    h. Garments containing metal or other conductive materials shall not be worn.
    i. FR garments worn as outer layers over FR apparel (i.e. jackets or rainwear) must also be made from FR material.
5. **Rubber Insulating Equipment**
    a. Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.
    b. Insulating equipment must be inspected for damage before each day's use and immediately following any incident that could have caused damage.
    c. Where the insulating capability of protective equipment is subject to damage during use, an outer covering of leather or other appropriate material shall protect the insulating material.
    d. Rubber insulating equipment must be tested according to the schedule contained in Appendix G.

e. Rubber insulating equipment must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that may cause damage.
f. No repairs to rubber insulating equipment shall be attempted.

6. **Electrically insulated tools and materials (provided by the University)**
   a. Only insulated tools and equipment shall be used within the Limited Approach Boundary of exposed energized parts.
   b. Insulated tools shall be rated for the voltages on which they are used.
   c. Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
   d. Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse.
   e. Ropes and hand lines used near exposed energized parts shall be nonconductive.
   f. Portable ladders shall be nonconductive.
7. **Test and Inspection Protocol for PPE Equipment**
   a. All PPE clothing and equipment must be visually inspected by the user before each use and taken out of service if any defects are noted.
   b. A physical inspection and air test must be performed on rubber insulating gloves before each use. Each person in the program must be trained in this by their supervisor.
   c. Insulating equipment found to have defects that might affect its insulating properties must be removed from service until testing indicates that it is acceptable for continued use.
   d. Equipment, tools, and clothing will be subjected to annual inspection. These inspections shall be documented on the *Test and Inspection Protocol* standard form used at the University. See Appendix K.

D. ALERTING TECHNIQUES

1. Barricades shall be used in conjunction with safety signs to prevent or limit access to work areas containing live parts. If a barricade must be used within the limited approach boundary it must be non-conductive. Barricades shall be placed no closer than the Limited Approach Boundary.
2. If signs and barricades do not provide sufficient protection, attendants will be assigned to warn and protect pedestrians. The primary duty of the attendant shall be to keep nonessential people out of the work area where an electrical hazard exists. The attendant shall remain in the area as long as there is a potential exposure to electrical hazards. The attendant shall remain outside of the Limited Approach Boundary.

E. CONTRACT EMPLOYEES

1. Contractor safety programs must at a minimum meet the requirements of the University Electrical Safety program.
2. Contractors will be required to comply with all applicable University, Federal, State and local environmental, safety and health regulations.
3. Contractors are required to meet the training requirements of NFPA 70E prior to beginning work at the University of Rochester and provide documentation to show compliance.
4. Contractors are required to submit copies of their Safety Program to PPM upon request.

VI. REFERENCES

1. NFPA 70E, "Standard for Electrical Safety in the Workplace", 2018 edition
2. OSHA, 29 CFR 1910.331 through 1910.335, "Electrical Safety-Related Work Practices"
3. OSHA, 29 CFR 1910.147, "The Control of Hazardous Energy"
4. OSHA, 29 CFR 1910.132, "Personal Protective Equipment"
5. OS002 Control of Hazardous Energy (Lockout/Tagout)
6. IH009 Confined Space Program
7. Personal Protective Equipment Program

VII. APPENDICES/FORMS

Appendix A: Energized Electrical Work Permit – All Non Routine Tasks
Appendix B: Approach Boundaries to Live Parts for Shock Protection: NFPA 70E Tables 130.4 (D)(a), 130.4(D)(b)
Appendix C: Incident Energy and Arc Flash Boundary Calculations NFPA 70E Informative Annex D
Appendix D: Incident Energy Analysis Method PPE Selection: NFPA 70E Table 130.5 (G)
Appendix E: Arc Flash PPE Category Method & PPE Selection: NFPA Tables 130.7(C)(15)(a), 130.7(C)(15)(b), 130.7(C)(15)(c)
Appendix F: PPE Requirements for Energized Tasks
Appendix G: Inspection Schedule for Rubber Insulating Equipment
Appendix H: Limited Long Term Energized Electrical Work Permit – Routine Tasks
Appendix I Flame Resistant Clothing Care and Maintenance
Appendix J: Arc Flash PPE and Insulated Tools
Appendix K: Test and Inspection Protocol for PPE Equipment
Appendix L: Resources
Appendix M: Arc Flash and Shock Risk Assessment Labels

VIII. REVISION HISTORY

Date	Revision No.	Description
2/06/2008	New	New Policy
1/25/2012	1	Policy revised and updated
6/1/2012	2	Appendix H changed, Appendix M updated
8/14/2013	3	Policy reviewed and revised
8/26/2019	4	Policy updated to reflect new 70e standard
11/8/2019	5	Edit references and appendices to match
6/15/2020	6	PPE Cat method details added
8/24/2020	7	Responsibilities expanded

Appendix A: Energized Electrical Work Permit – All Non Routine Tasks

Part I: To be completed by the requestor or supervisor of the job	
Description of Circuit & Equipment:	Job # and Location:
Description of Work to Be Done:	
Justification of why the circuit cannot be de-energized or the work delayed until the next scheduled outage: Requester/Title:_____ Signature:	
Part II: To be completed by the qualified person(s) completing the work	**Check when Complete**
(1) Detailed description of procedure to be used in performing the above work:	____
(2) Description of safe work practices to be employed:	
(3) Voltage exposure (shock hazard analysis):	
(4) Determination of shock protection boundaries:	
(5) Results of flash hazard analysis:	
(6) Determination of flash protection boundaries:	
(7) PPE required to safely perform the task:	
(8) Method used to restrict access to the work area:	
(9) Do you agree the above work can be done safely? YES ___ (proceed to Part III) NO __(return to requestor) Qualified Person(s): _____ Date: _____ Qualified Person(s): _____ Date: Qualified Person(s): Date:	
(10) Supervisor has reviewed this with the qualified person(s) performing the task? YES _____ Supervisor: Date:	
Part III: To be completed by members of The University Electrical Safety Committee	
Approvals: **Name** **Job Title** **Date** _____ _____ _____ _____ _____ _____	

Note: ***Route Permit to Electrical Safety Committee***. A minimum of two committee members must approve energized work. .All permits must be retained by the employees' department.

Appendix B: Approach Boundaries to Live Parts for Shock Protection NFPA 70E Tables 130.4 (D)(a), 130.4(D)(b)

Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V[d]	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
751 V–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–36 kV	3.0 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.8 m (2 ft 9 in.)
36.1 kV–46 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
46.1 kV–72.5 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
138 kV–145 kV	3.4 m (11 ft 0 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
161 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.3 m (4 ft 3 in.)
230 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	1.7 m (5 ft 8 in.)
345 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	2.8 m (9 ft 2 in.)
500 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.6 m (11 ft 8 in.)
765 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	4.9 m (15 ft 11 in.)

Notes:
(1) For arc flash boundary, see 130.5(A).
(2) All dimensions are distance from exposed energized electrical conductors or circuit part to employee.
[a]For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.
[b]See definition in Article 100 and text in 130.4(D) (2) and Informative Annex C for elaboration.
[c]*Exposed movable conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.
[d]This includes circuits where the exposure does not exceed 120 volts nominal.

Table 130.4(D)(b) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct-Current Voltage Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
Nominal Potential Difference	Exposed Movable Conductor*	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
301 V–1 kV	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
1.1 kV–5 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.5 m (1 ft 5 in.)
5 kV–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–45 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
45.1 kV– 75 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
75.1 kV–150 kV	3.3 m (10 ft 8 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
150.1 kV–250 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.6 m (5 ft 3 in.)
250.1 kV–500 kV	6.0 m (20 ft 0 in.)	6.0 m (20 ft 0 in.)	3.5 m (11 ft 6 in.)
500.1 kV–800 kV	8.0 m (26 ft 0 in.)	8.0 m (26 ft 0 in.)	5.0 m (16 ft 5 in.)

Note: All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.
**Exposed movable conductor* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

- **Limited Approach Boundary:** Distance from an exposed live part within which a shock hazard exists. An unqualified person may not cross this boundary unless a qualified person continuously escorts them.

- **Restricted Approach Boundary:** Distance from an exposed live part within which there is an increased risk of shock (due to electrical arc-over combined with inadvertent movement) for personnel working in close proximity to the live part. This boundary may only be crossed by a qualified person who is safely insulated or guarded from the live parts.

- **Prohibited Approach Boundary:** Distance from an exposed live part within which work is considered the same as making contact with the live part. This boundary may only be crossed by a qualified person who has specific training to work on energized parts; has obtained an approved Energized Electrical Work Permit; and uses PPE appropriate for working on energized parts which are rated for the voltage and energy level involved. (Note: A permit is not required for work related to testing, troubleshooting, and voltage measuring).

- **Flash Protection Boundary (not listed in table):** Distance from exposed live parts within which a person could receive a second-degree burn if an electrical arc flash were to occur. This boundary may only be crossed by a qualified person wearing the appropriate PPE. For systems that are 600 volts are less, the Flash Protection Boundary shall be a minimum of four feet. An engineering analysis must be performed to determine the Flash Protection Boundary for systems that are above 600 volts.

Appendix C: Incident Energy and Arc Flash Boundary Calculations: NFPA 70E Informative Annex D

Informative Annex D Incident Energy and Arc Flash Boundary Calculation Methods

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. Informative Annex D summarizes calculation methods available for calculating arc flash boundary and incident energy. It is important to investigate the limitations of any methods to be used. The limitations of methods summarized in Informative Annex D are described in Table D.1.

D.2 Ralph Lee Calculation Method.

D.2.1 Basic Equations for Calculating Arc Flash Boundary Distances. The short-circuit symmetrical ampacity, I_{sc}, from a bolted three-phase fault at the transformer terminals is calculated with the following formula:

[D.2.1(a)]

$$I_{sc} = \{[MVA\ \text{Base} \times 10^6] \div [1.732 \times V]\} \times \{100 \div \%Z\}$$

where I_{sc} is in amperes, V is in volts, and $\%Z$ is based on the transformer *MVA*.

A typical value for the maximum power, P (in MW) in a three-phase arc can be calculated using the following formula:

[D.2.1(b)]

$$P = [\text{maximum bolted fault, in } MVA_{bf}] \times 0.707^2$$

[D.2.1(c)]

$$P = 1.732 \times V \times I_{sc} \times 10^{-6} \times 0.707^2$$

The arc flash boundary distance is calculated in accordance with the following formulae:

[D.2.1(d)]

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

[D.2.1(e)]

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

where:

D_c = distance in feet of person from arc source for a just curable burn (that is, skin temperature remains less than 80°C).
MVA_{bf} = bolted fault *MVA* at point involved.
MVA = *MVA* rating of transformer. For transformers with *MVA* ratings below 0.75 *MVA*, multiply the transformer *MVA* rating by 1.25.
t = time of arc exposure in seconds.

The clearing time for a current-limiting fuse is approximately ¼ cycle or 0.004 second if the arcing fault current is in the fuse's current-limiting range. The clearing time of a 5-kV and 15-kV circuit breaker is approximately 0.1 second or 6 cycles if the instantaneous function is installed and operating. This can be broken down as follows: actual breaker time (approximately 2 cycles), plus relay operating time of approximately 1.74 cycles, plus an additional safety margin of 2 cycles, giving a total time of approximately 6 cycles. Additional time must be added if a time delay function is installed and operating.

The formulas used in this explanation are from Ralph Lee, "The Other Electrical Hazard: Electrical Arc Flash Burns," in *IEEE Trans. Industrial Applications*. The calculations are based on the worst-case arc impedance. *(See Table D.2.1.)*

D.2.2 Single-Line Diagram of a Typical Petrochemical Complex. The single-line diagram *(see Figure D.2.2)* illustrates the complexity of a distribution system in a typical petrochemical plant.

Table D.1 Limitation of Calculation Methods

Section	Source	Limitations/Parameters
D.2	Lee, "The Other Electrical Hazard: Electrical Arc Flash Burns"	Calculates incident energy and arc flash boundary for arc in open air; conservative over 600 V and becomes more conservative as voltage increases
D.3	Doughty, et al., "Predicting Incident Energy to Better Manage the Electrical Arc Hazard on 600 V Power Distribution Systems"	Calculates incident energy for three-phase arc on systems rated 600 V and below; applies to short-circuit currents between 16 kA and 50 kA
D.4	IEEE 1584, *Guide for Performing Arc Flash Calculations*	Calculates incident energy and arc flash boundary for: 208 V to 15 kV; three-phase; 50 Hz to 60 Hz; 700 A to 106,000 A short-circuit current; and 13 mm to 152 mm conductor gaps
D.5	Doan, "Arc Flash Calculations for Exposure to DC Systems"	Calculates incident energy for dc systems rated up to 1000 V dc

Appendix D: Incident Energy Analysis Method PPE Selection: NFPA 70E Table 130.5 (G)

Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

Incident energy exposures equal to 1.2 cal/cm² up to 12 cal/cm²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)[b]
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear
Incident energy exposures greater than 12 cal/cm²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated arc flash suit hood
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Arc-rated gloves or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear

SR: Selection of one in group is required.
AN: As needed.
[a]Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.
[b]Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.
[c]Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.

PPE Requirements can be found in Appendix E
Additional Information:

• V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
• V-rated Tools are tools that are rated and tested for the maximum line-to-line voltage upon which work will be done.
• 2(*) means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazard/Risk Category requirements of ***Appendix E.***
• Y = Yes (required)
• N = No (not required)

Notes:

(1) 25kA short circuit current available, 0.03 second (2 cycle) fault clearing time.

(2) For < 10kZ short circuit current available, the hazard/risk category required may be reduced by one number.

Appendix E: Arc Flash PPE Category Method & PPE Selection: NFPA 70E Table 130.7 (C)(15)(a), 130.7 (C)(15)(b), 130.7 (C)(15)(c)

Calculation for fault current at the transformer secondary lugs:

Fault Current (A) = (TR kVA / (1.73 x TR Secondary L-L kV)) / (TR Impedance %)

Example Calc.: *Fault Current of 500kVA 4.16kV-208V, 5.75% transformer = (500kVA/ (1.73 x 0.208)) / (0.0575) = 24,136 A = 24.14kA*

NOTE: when comparing fault current to the 130.7(C)(15)(a) & (b) table maximum allowable values, the value must be under a 10% margin.

Table 1:

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

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available 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, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	N/A (doors closed) 4 (doors open)	N/A (doors closed) 12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (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.

Informational Note to Table 130.7(C)(15)(a): The following are typical fault clearing times of overcurrent protective devices:
(1) 0.5 cycle fault clearing time is typical for current limiting fuses when the fault current is within the current limiting range.
(2) 1.5 cycle fault clearing time is typical for molded case circuit breakers rated less than 1000 volts with an instantaneous integral trip.
(3) 3.0 cycle fault clearing time is typical for insulated case circuit breakers rated less than 1000 volts with an instantaneous integral trip or relay operated trip.
(4) 5.0 cycle fault clearing time is typical for relay operated circuit breakers rated 1 kV to 35 kV when the relay operates in the instantaneous range (i.e., "no intentional delay").
(5) 20 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay for motor inrush.
(6) 30 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay without instantaneous trip.

Informational Note No. 1: See Table 1 of IEEE 1584TM, *Guide for Performing Arc Flash Hazard Calculations*, for further information regarding Notes b through d.

Informational Note No. 2: An example of a standard that provides information for arc-resistant switchgear referred to in Table 130.7(C)(15)(a) is IEEE C37.20.7, *Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults.*

Table 2:

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

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than or equal to 100 V and less than or equal to 250 V Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 4 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 4 kA and less than 7 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 7 kA and less than 15 kA	3	1.8 m (6 ft)
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than 250 V and less than or equal to 600 V Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 1.5 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m (6 ft.)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m (8 ft)

Notes

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

(a) Be evaluated for electrolyte protection

Informational Note: ASTM F1296, *Standard Guide for Evaluating Chemical Protective Clothing*, contains information on evaluating apparel for protection from electrolyte.

(b) Be arc-rated

Informational Note: ASTM F1891, *Standard Specifications for Arc Rated and Flame Resistant Rainwear*, contains information on evaluating arc-rated apparel.

(2) A two-second arc duration is assumed if there is no overcurrent protective device (OCPD) or if the fault clearing time is not known. If the fault clearing time is known and is less than 2 seconds, an incident energy analysis could provide a more representative result.

Informational Note No. 1: When determining available fault current, the effects of cables and any other impedances in the circuit should be included. Power system modeling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can be obtained from the battery manufacturer. See Informative Annex D.5 for the basis for table values and alternative methods to determine dc incident energy. Methods should be used with good engineering judgment.

Informational Note No. 2: The methods for estimating the dc arc-flash incident energy that were used to determine the categories for this table are based on open-air incident energy calculations. Open-air calculations were used because many battery systems and other dc process systems are in open areas or rooms. If the specific task is within an enclosure, it would be prudent to consider additional PPE protection beyond the value shown in this table. Research with ac arc flash has shown a multiplier of as much as 3× for arc-in-a-box [508 mm (20 in.) cube] versus open air. Engineering judgment is necessary when reviewing the specific conditions of the equipment and task to be performed, including the dimensions of the enclosure and the working distance involved.

Table 3:

Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

Arc-Flash PPE Category	PPE
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm² (16.75 J/cm²)[a]** Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield[b] or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves[d] Leather footwear (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²)[a]** Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves[d] Leather footwear
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (104.7 J/cm²)[a]** Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves[d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Leather footwear
4	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm² (167.5 J/cm²)[a]** Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves[d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Leather footwear

AN: As needed (optional). AR: As required. SR: Selection required.

[a]*Arc rating* is defined in Article 100.

[b]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.

[c]Other types of hearing protection are permitted to be used in lieu of or in addition to ear canal inserts provided they are worn under an arc-rated arc flash suit hood.

[d]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.

Appendix F: PPE Requirements for Energized Tasks

Trade Group: ___________________________

Description of Task	Equipment	Voltage	Incident Energy	Specific PPE To Be Worn

Appendix G: Inspection Schedule for Rubber Insulating Equipment

Type of Equipment	When to Test
Rubber insulating line hose	Upon indication that insulating value is suspect
Rubber insulating covers	Upon indication that insulating value is suspect
Rubber insulating	Before first issue and every 12 months thereafter (*)
Rubber insulating gloves	Before first issue and every 6 months thereafter (*)
Rubber insulating sleeves	Before first issue and every 12 months thereafter (*)
Leather Protectors	Before first issue and every 12 months thereafter

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

Appendix H: Limited Long Term Energized Electrical Work Permit – Routine Tasks

LIMITED LONG TERM ENERGIZED ELECTRICAL WORK PERMIT – Routine Tasks
To Be Updated Annually

QUALIFIED EMPLOYEE: _____

EMPLOYEE JOB TITLE: _____

Tasks Qualified for: _____

_____

Hazard Category 2 Qualified for unless otherwise specified: _____

VOLTAGE LEVEL LIMIT: _____

TECHNICAL TRAINING REQUIRED every three years NFPA 70E Date Received: _____
ANNUAL TRAINING REQUIRED: NFPA 70E Date Received: _____
Electrical Safety Program Date Received: _____

PPE INSPECTION: DATE: _____

FR PANTS/SHIRTS: _____ FR HOOD: _____

FR JACKET: _____ VOLTAGE RATED GLOVES: _____

VOLTAGE RATED TOOLS: _____

(AGREE WITH ABOVE CONDITIONS)

EMPLOYEE: _____ Date: _____

SUPERVISOR: _____ Date: _____

OPERATIONS/AREA MANAGER: _____ Date: _____

Appendix I: Flame Resistive Clothing Care and Maintenance

- Machine wash with like colors
- Tumble dry and remove promptly
- No chlorine bleach
- No starch
- No fabric softeners
- No products containing hydrogen peroxide

Note: Failure to launder these garments properly could affect the flame resistance.

Appendix J: Arc Flash PPE and Insulated Tools

Face Shield, Hard Hat, Hood, and Safety Glasses

Glove Kits

Insulating rubber gloves are necessary for every electrical worker's complete safety. To insure safety, leather protectors provide needed protection from cuts, abrasions, and punctures. To keep these safety items in top condition, proper storage is very important. Proper storage extends the service life of gloves. Folds and creases strain natural rubber and cause it to cut from ozone prematurely. By storing rubber gloves in the right size bag and never forcing more than one pair into each bag, equipment will lie flat and last longer.

GK011BL9

TEN-FOUR™ Glove Dust
A cooling, frictionless powder that absorbs moisture and perspiration when wearing rubber gloves. It is available in the shop.

Basic Electrician's Kit

Insulated Hand Tools

Rated for exposure up to 1000VAC and dielectrically tested at 10,000VAC. These tools meet or exceed current ASTM F1505-01 and IEC 900 Standards for Insulated Hand Tools. These tools will help you to be compliant with OSHA 29 CFR1910 Subpart S, and NFPA 70E 2004.

The insulating material used is impact resistant and flame retardant. Two-color insulation makes inspection easier, which adds to the overall safety. If the yellow under layer is showing, the tool may no longer be insulated properly and should be considered for electrical retesting.

Kit, as pictured: 9PCS. INCLUDES: 3/16 X 4", 3/16 X 6", 1/4 X 6" SLOTTED SCREWDRIVERS; #1 X 3", #2 X 4" PHILLIPS SCREWDRIVER; 7" NEEDLE NOSE PLIER; 7-1/2" DIAGONAL CUTTING PLIER; 9" LINESMAN'S PLIER; AND COMBINATION STRIPPER / CRIMPER PLIER. IN A ROLL.

Appendix K: Test and Inspection Protocol for PPE Equipment:

Shirts, Workpants, and Coveralls:

- Rips and Tears
- Holes
- Threadbare
- Worn spots
- Missing or loose fasteners
- Shirts and Coveralls have the Meliora logo on chest and Bulwark triangle on the sleeve.

Gloves:

- Electrically tested before first use and every 6 months thereafter.
- Visual inspection for damage or wear before each use.
- Perform an air test on rubber insulating gloves before each use.
- Glove rotation with vendor/supplier

Hardhats:

- Must be electrically rated for the type of work
- Support mechanism properly adjusted and in good repair
- Support mechanism mounted correctly so the brim is forward.
- Hat has no cracks or notable scratches.
- Hat has no decals or painting other than prescribed identifiers.
- Hat is pliable. Test by pressing in on the sides to ensure some flex.
- Hat is no more than 5 years old. See manufacture date on underside of brim.

Face Shield:

- Must be electrically rated for the type of work
- Support mechanism is in good repair and fits the hard hat properly.
- Shield is certified for HRC-2.
- Shield has no cracks or notable scratches.
- Shield has no decals applied.

Dielectric Footwear:

- Soles must be kept clean and free of oil, paint, and other materials that can insulate the shoe from ground.

NEVER USE ANY EQUIPMENT THAT DOES NOT PASS INSPECTION. MARK AS DEFECTIVE AND DISCARD. SEE SUPERVISOR OR MANAGER FOR REPLACEMENT.

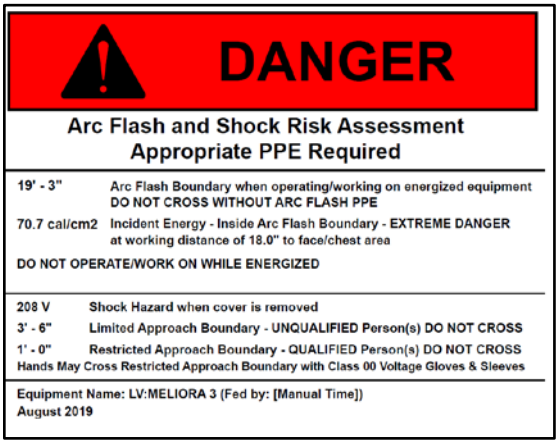
Appendix L: Resources

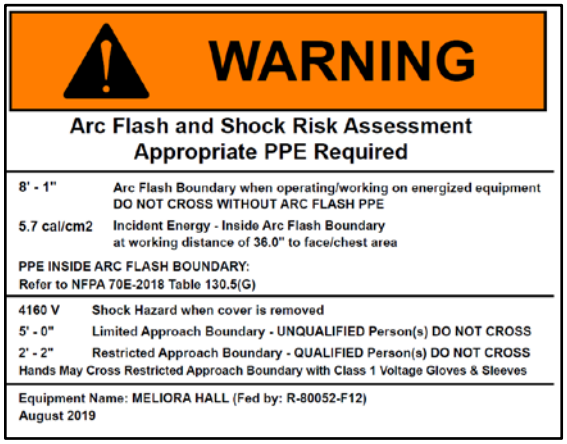
ELECTRICAL SAFETY COMMITTEE

EH&S Occupational Safety	275-3241
UF&S MC Operations	275-4810
CUP	
MCFO	273-4567
UF&S RC Operations	273-2100
U&E Mgmt UF&S	273-4609
UF&S RC Operations	273-5810

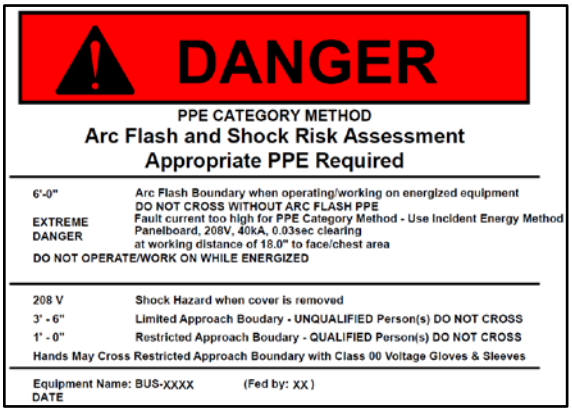
Appendix M: Arc Flash and Shock Risk Assessment Labels

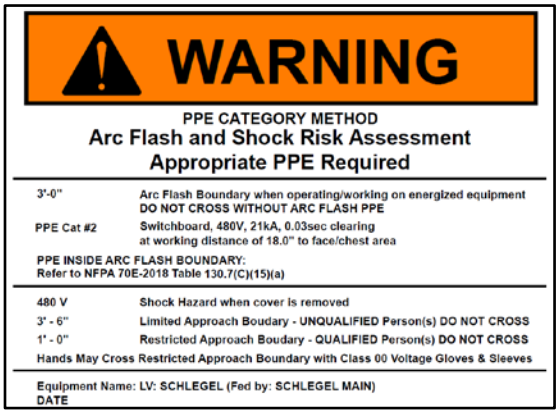
LABEL EXAMPLES 1: INCIDENT ENERGY ANALYSIS METHOD:





LABEL EXAMPLES 2: PPE CATEGORY METHOD:





Note: AF boundary calculated using NFPA 70E Informative Annex D, when PPE category method was not applicable to determine AF boundary.