**Laboratory Standard Operating Procedure**

**Appendix A:**

**Electrical Apparatus Used or Fabricated in Laboratory/Research Areas – Risk Assessment**

*Please fill out the form and then print it on your local printer and place in your Laboratory and Research Safety Plan.*

Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Principal Investigator\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Person/s completing this risk assessment\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Title of person/s completing this risk assessment\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Room and Building\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Check to Acknowledge)

Section 1:

 Does the person conducting this assessment have knowledge of how the tool operates and its use (qualified)?

Section 2: Does the task or equipment involve:

 Modifications to an electrical device;

 Conducting/creating electrical experiments/research/exercises;

 Conducting battery experiments/research/exercises;

 Have home-made/shop-made/lab-made equipment from component parts (includes self-assembled systems comprised of commercial test equipment from different manufacturers with voltage sources 50 volts or higher);

 Operating equipment that has any exposed conductors/circuit parts operating at 50 Volts or higher.

- Does not include utilizing common electrical devices used as originally intended by the manufacturer. Such items include but aren’t limited to those bought at any department store, appliances, hot plates, power strips, wood/metal wooding machines, refrigerators, microwaves, ovens, computers, televisions, etc.

Section 3: Determine if interaction with live parts is necessary.

**NOTE: In a lab environment live work is only permitted when:**

* **Deenergizing is not possible due to equipment design or operational limitations. Examples of this situation would include diagnostic work such as voltage measurements, troubleshooting, and testing of electrical equipment.**
* **Live parts are operating at less than 50 volts and there is no increased exposure to electrical burns or to explosion due to electrical arcs.**

Will there be interaction with live parts?

* No. There are no tasks that require any interaction with live parts AND/OR the equipment will be disconnected from power source (i.e Lockout Tagout) before troubleshooting/servicing/maintenance.
* Yes, list all tasks where the person/s are required to interact with live parts:

-i.e. during normal operation, testing/troubleshooting, etc.

|  |  |
| --- | --- |
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|  |  |
|  |  |

Section 4: If equipment is “used” (not purchased new from the manufacturer within the last 12 months), determine if there are any known issues/problems with the equipment:

 No known issues/problems  Yes: Has issues/problems.

If Yes, explain issue/problems and corrective actions to fix:

Section 5: Perform a **visual** inspection of the equipment to look for physical damage:

(Physical damage could be an indication of impending equipment malfunction, further examination is required to ensure safety)

 No damage  Yes: Has damage.

If Yes, explain damage and corrective actions to fix:

Section 6: Perform a visual inspection and continuity test with a multimeter to ensure equipment is properly grounded to prevent shock.

|  |  |
| --- | --- |
| Not properly grounded. Explain what will be done to ensure proper grounding of equipment: | * Yes: properly grounded.   Check all that apply:   * Equipped with a 3-prong plug. * A portable GFCI outlet is used. * Equipment is connected to a wall outlet that is a GFCI. * Equipment is connected to a circuit breaker that is designed to operate as a GFCI. * Equipment is hard wired into a building electrical panel that has a proper ground established. *Verified by OPP electrician/or electrician*. |

Section 7: Determine if additional safety devices/equipment can be installed on/with the equipment to reduce hazard (i.e. DC Isolation Monitors).

 None required/Not Applicable  Yes: If yes, explain what additional devices will be utilized:

Section 8: Distinguish live parts from other parts of equipment:

* Not necessary: All live parts are enclosed during operation.
* Live parts may be exposed during operation.
  + Explain how will these parts be distinguished (color, notes, labels, signs, etc):

Section 9: Determine how to insulate/guard/enclose/limit access to energized electrical conductors/circuits/parts 50 volts or higher in the system to reduce/eliminate exposure during operation:

* Not Necessary: No exposed parts during operation.

 Necessary. Explain:

* + *NOTE: Only non-conductive devices can be used to* *insulate/guard/enclose/limit access to energized electrical conductors/circuits/parts*.

Section 10: Determine the nominal system voltage and maximum system voltage output possible (if applicable):

* What is the nominal voltage? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* What is the maximum system voltage output possible (if applicable)?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + *PPE requirements may change depending on voltage exposure.*

 Is the system and all its components (i.e. plugs, wires, connectors) designed/rated to withstand the voltage?

Section 11: Determine distances to exposed live parts during tasks. If tasks (troubleshooting/testing, etc) are required to be conducted within the Restricted Approach Boundary of an exposed live part/circuit, then shock protection PPE (voltage rated gloves, etc) is required.

See ***Appendix B***.

* List the distances:
  + Limited Approach Boundary \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Restricted Approach Boundary \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Section 12: Determine the appropriate PPE for each task (i.e. normal operation, servicing/maintenance, troubleshooting, etc):

* Electrical installations in laboratory or research areas often contains custom or specially designed electrical equipment that may have unique and varying electrical safety related hazards. Arc flash PPE and/or shock protection PPE may be necessary depending on the hazard/s associated with the task, equipment design and voltage. As part of your PPE risk assessment also follow any PPE guidance documented by the manufacturer of the equipment (typically -found in owner’s manual/operation manual).

-Section 11 (above) helps determine if/when Shock Protection PPE is required.

-Appendix C, D and E serves as guidance for determining if an arc flash risk exists as well as providing the types of PPE for that risk.

**NORMAL OPERATION:**

|  |  |  |
| --- | --- | --- |
| Safety Glasses | Arc Flash Face Shield |  |
| Leather Gloves | Arc Flash Balaclava |  |
| * Voltage Rated Rubber Gloves   (NOTE: gloves are required to be sent to a 3rd party every 6 months to ensure they are still in a non-conductive state. Alternatively a new pair of gloves can be purchased every 6 months and the old pair discarded.) Contact Safety Officer for 3rd party information. |  |  |
| Arc Flash Clothing |  |  |

**SERVICE/MAINTENANCE/TROUBLESHOOTING:**

|  |  |  |
| --- | --- | --- |
| Safety Glasses | Arc Flash Face Shield |  |
| Leather Gloves | Arc Flash Balaclava |  |
| * Voltage Rated Rubber Gloves   (NOTE: gloves are required to be sent to a 3rd party every 6 months to ensure they are still in a non-conductive state. Alternatively a new pair of gloves can be purchased every 6 months and the old pair discarded.) Contact Safety Officer for 3rd party information. |  |  |
| Arc Flash Clothing |  |  |

Section 13: Determine the proper insulated tools needed:

* No insulated tools are required because there are no tasks that require interaction with live parts.
* Yes, interaction with live parts may be necessary such as testing/troubleshooting. The following tools are required to be insulated (pliers, sockets, strippers, crimpers, wrenches, etc):
  + List the tools below:

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |

Section 14: Determine the appropriate voltage rated test instruments to utilize that require interaction with live parts:

* No test instruments are required
* Yes, test instruments are required:
* List the test instruments below:

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |

Section 15: Determine and identify appropriate **emergency** shutdown/shutoff procedures:

1. Explain emergency shutdown procedure if tool has a failure (smoking, etc):
2. Explain emergency shutdown procedure if the building experiences a fire alarm/evacuation:

Section 16: Determine the appropriate energy isolation procedures to use in order to perform **servicing/maintenance** on the equipment (i.e. Lockout/Tagout (LOTO) procedures):

* Cord and plug powered equipment.
  + Cord must be unplugged before servicing/maintenance can begin. To ensure that the tool cannot be re-energized the cord must be kept under the continuous control of the person performing the servicing/maintenance (i.e. kept within reach of the person performing the servicing/maintenance).
* Hard-wired powered equipment (circuit breaker/disconnect lever).
* If so, does the person performing the servicing/maintenance have LOTO training?

Generic Steps:

* + Step 1 – Identify the energy source/s
  + Step 2 – Notify others in the lab that you are servicing/maintaining the equipment
  + Step 3 – Shutdown equipment (how it is typically shutdown)
  + Step 4 – Isolate equipment (open circuit breaker/disconnect)
  + Step 5 – LOTO equipment (attach lock and tag to circuit breaker/disconnect)
  + Step 6 – Release stored energy
  + Step 7 – Verify isolation (try to start equipment and/or test for voltage)
  + Step 8 – Perform servicing/maintenance
  + Step 9 – Release from LOTO

**Section 17:**

** Attach the task specific procedures / processes / instructions / SOP’s to this form.**

**Appendix B**

**Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts**

**(All dimensions are distance from fixed live part to employee)**

**Alternating Current (AC)**

|  |  |  |
| --- | --- | --- |
| **Nominal System Voltage** | **Limited Approach Boundary** | **Restricted Approach Boundary** |
| Less than 50 V | Not Specified | Not Specified |
| 50 V to 150 V | 3 feet, 6 inches | Avoid Contact |
| 151 V to 750 V | 3 feet, 6 inches | 1 foot |
| 751 V to 15 kV | 5 feet | 2 feet, 2 inches |
| *Over 15 kV or a movable conductor (a condition in which the distance between the conductor and a person is not under the control of the person)*  *See NFPA 70 E Table 130.4 (D)(a)-* Contact EHS (Tony Cygan: ajc28@psu.edu) to obtain a copy of this reference material | | |

**Direct Current (DC)**

|  |  |  |
| --- | --- | --- |
| **Nominal Potential Difference** | **Limited Approach Boundary** | **Restricted Approach Boundary** |
| Less than 50 V | Not specified | Not specified |
| 50 V - 300 V | 3 feet, 6 inches | Avoid Contact |
| 301 V - 1 kV | 3 feet, 6 inches | 1 foot |
| *Over 1 kV or a movable conductor (a condition in which the distance between the conductor and a person is not under the control of the person)*  *See NFPA 70 E Table 130.4 (D)(b)-* Contact EHS (Tony Cygan: [ajc28@psu.edu](mailto:ajc28@psu.edu)) to obtain a copy of this reference material | | |

Definitions

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

**Appendix C**

**Arc flash Hazard Identification –**

**Alternating Current Equipment (AC) and Direct Current Equipment (DC) (page 1 of 3)**

|  |  |  |
| --- | --- | --- |
| **Task** | **Equipment Condition** | **Arc Flash PPE Required** |
| Operation of a circuit breaker, switch, contactor, or starter | All of the following:  **Note: All of the following requirements must be met to satisfy the “no arc flash PPE required” scenario:**   1. Covers/panels that enclose the circuit breaker (CB), switch, contactor, or starter are in place, and secure. 2. No visual damage to the enclosure of the circuit breaker (CB), switch, contactor, or starter. 3. No visual damage to the circuit breaker (CB) switch, switch, contactor, or starter. 4. No visual damage to the wires/conduits at entry/exit points to the enclosure. 5. No knockouts missing. 6. No evidence of water/liquid damage (puddling, rust, chemicals). 7. No evidence of heat/fire damage (discoloration). 8. No bolts, screws, fasteners missing. 9. No exposed live parts of the enclosure (proper blanks used to cover empty circuit breaker locations)   If conditions in 1-9 are found to be satisfactory, a circuit breaker (CB), switch, contactor, or starter can be used to turn off/on a circuit without PPE.  **\*\*\*\*\*\*\*\*\*Resetting a tripped breaker\*\*\*\*\*\*\*\*\***  If conditions in 1-9 are found to be satisfactory and circuit breaker operation training has been completed, a tripped circuit breaker can be reset WITHOUT PPE ONLY IF after investigation reveals a probable cause of the trip (overloaded circuit). ADDITIONALLY, the circuit breaker is only permitted to be reset only 1 time.  A person who has been qualified to troubleshoot an electrical circuit (i.e. electrician) must be notified if the breaker trips a 2nd time. | No |

**Appendix C**

**Arc flash Hazard Identification –**

**Alternating Current Equipment (AC) and Direct Current Equipment (DC)**

**(page 2 of 3)**

|  |  |
| --- | --- |
| **Task** | **Arc Flash PPE Required** |
| 1.) Reading a panel meter while operating a meter switch | No |
| 2.) For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing | Yes |
| 3.) For dc systems: Work on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing | Yes |
| 4.) Voltage testing on individual battery cells or individual multi-cell units | No |
| 5.) Removal or installation of circuit breakers or switches | Yes |
| 6.) Examination of insulated cable with no manipulation of cable. | No |
| 7.) Examination of insulated cable with manipulation of cable. | Yes |
| 8.) Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts | No |
| 9.) Removal of battery conductive intercell connector covers. | Yes |
| 10.) Removal of battery non-conductive intercell connector covers. | No |
| 11.) Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers. | Yes |
| 12.) Opening a panelboard hinged door or cover to access dead front overcurrent devices. | No |
| 13.) Perform infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers. | No |
| 14.) Application of temporary protective grounding equipment after voltage test. | Yes |
| 15.) Working on control circuits with exposed energized electrical conductors and circuit parts,  -125 volts ac or dc, or below without any other exposed energized equipment over 125 volts ac or dc, including opening of hinged covers to gain access. | No |
| 16.) Work on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 V | Yes |
| 17.) Insertion or removal of individual starter buckets from motor control center (MCC) | Yes |
| 18.) Insertion or removal (racking) of circuit breakers or starters from cubicles, doors open or closed | Yes |
| 19.) Insertion or removal of plug-in devices into or from busways | Yes |
| 20.) Work on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center | Yes |
| 21.) Insertion and removal of revenue meters (kW-hour, at primary voltage and current) | Yes |
| 22.) For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack | No |
| 23.) For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack | No |
| 24.) For dc systems, work on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source. | Yes |
| 25.) Opening voltage transformer or control power transformer compartments | Yes |

**Appendix C**

**Arc flash Hazard Identification –**

**Alternating Current Equipment (AC) and Direct Current Equipment (DC)**

**(page 3 of 3)**

|  |  |  |
| --- | --- | --- |
| **Task** | | **Arc Flash PPE Required** |
| 26.) Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV | | Yes |
| 27.) Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV | | Yes |
| 28.) Maintenance and testing on individual battery cells or individual multi-cell units in an open rack. | Yes, Only if equipment condition considered to be “abnormal”. SEE NOTE AT END OF THIS TABLE | |
| 29.) Arc-resistant switchgear Type 1 or 2 (for clearing times of less than 0.5 sec with a prospective 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.  -insertion or removal (racking) of circuit breakers from cubicles;  -Insertion or removal (racking) of ground and test device; or  -Insertion or removal (racking) of voltage transformers on or off the bus. | Yes,  Only if equipment condition considered to be “abnormal”. SEE NOTE AT END OF THIS TABLE | |
| 30.) Insertion or removal of individual cells or multi-cell units of a battery system in an open rack. | Yes, Only if equipment condition considered to be “abnormal”. SEE NOTE AT END OF THIS TABLE | |

NOTE:

Equipment condition considered to be “normal” if all of the following circumstances apply:

* + 1. The equipment is properly installed in accordance with the manufacturer’s recommendations and applicable industry codes and standards.
    2. The equipment is properly maintained in accordance with the manufacturer’s recommendations and applicable industry codes and standards.
    3. The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacture’s instruction.
    4. Equipment doors are closed and secured.
    5. Equipment covers are in place and secured.
    6. There is no evidence of impending failure such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.

**Appendix D (Page 1 of 2)**

**Arc flash hazard PPE categories for**

**Alternating Current (AC) Equipment**

|  |  |
| --- | --- |
| **Equipment** | **Arc Flash PPE Category** |
| Panelboards or other equipment rated 240 V and below  *Parameters:*  *Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum working distance 18 in.* | 1 |
| Panelboards or other equipment rated greater than 240 V and up to 600 V  *Parameters:*  *Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum working distance 18 in.* | 2 |
| 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 18 in.* | 2 |
| 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 18 in.* | 4 |
| 600-volt class switchgear (with power circuit fuses or fused switches) and 600-volt class 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 18 in.* | 4 |
| Other 600-volt class equipment (277 volts through 600 volts nominal)  *Parameters:*  *Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum working distance 18 in.* | 2 |

**Arc Flash Boundary**

For AC systems that are 600 volts or less, the arc flash boundary shall be a minimum of 20 feet or the entire room if a boundary of 20 feet cannot be obtained (i.e. room is smaller than 20 feet). If the equipment has an NFPA 70E label attached its stated arc flash boundary should be used.

**Appendix D (Page 2 of 2)**

**Arc flash hazard PPE categories for**

**Direct Current (DC) Equipment**

|  |  |  |
| --- | --- | --- |
| **Equipment** | **Arc Flash PPE Category** | **Arc-Flash Boundary** |
| Storage batteries, dc switchboards, and other dc supply sources 100 volt or greater but less than or equal to 250 volts.  *Parameters:*  *Maximum arc duration and minimum working distance: 2 sec @ 18 in.* | | |
| Available fault current less than 4 kA | 2 | 3 feet |
| Available fault current greater than or equal to 4 kA and less than 7 kA | 2 | 4 feet |
| Available fault current greater than or equal to 7 kA and less than 15 kA | 3 | 6 feet |
| Storage batteries, dc switchboards, and other dc supply sources greater than 250 volts and less than or equal to 600 volts.  Parameters:  Maximum arc duration and minimum working distance: 2 sec @ 18 in. | | |
| Available fault current less than 1.5 kA | 2 | 3 feet |
| Available fault current greater than or equal to 1.5 kA and less than 3 kA | 2 | 4 feet |
| Available fault current greater than or equal to 3 kA and less than 7 kA | 3 | 6 feet |
| Available fault current greater than or equal to 7 kA and less than 10 kA | 4 | 8 feet |

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 3x for arc-in-a-box versus open air.

**Appendix E: Personal Protective Equipment**

|  |  |
| --- | --- |
| **PPE Category** | **PPE** |
| 1 | **Arc Rated Clothing, Minimum Arc Rating of 4 cal/cm2**  Arc-rated long-sleeve shirt and pants or Arc- rated coveralls  Arc-rated face shield (see Note 2) or arc flash suit hood  Arc-rated jacket, parka, rainwear or hard hat liner (AN)  **Protective Equipment**  Hard hat  Safety glasses or safety goggles  Hearing protection (ear canal inserts)  Heavy duty leather gloves with rubber insulating gloves (see note 1)  Leather footwear (AN) |
| 2 | **Arc Rated Clothing, Minimum Arc Rating of 8 cal/cm2**  Arc-rated long-sleeve shirt and pants or arc-rated coveralls  Arc-rated flash suit hood or arc-rated face shield (note 2) AND arc-rated balaclava  Arc-rated jacket, parka, rainwear, or hard hat liner (AN)  **Protective Equipment**  Hard hat  Safety glasses or safety goggles  Hearing protection (ear canal inserts)  Heavy duty leather gloves with rubber insulating gloves (see note 1)  Leather footwear |
| 3 | **Arc Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm2**  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 1  Arc-rated jacket, parka, rainwear or hard hat liner (AN)  **Protective Equipment**  Hard hat  Safety glasses or safety goggles  Hearing protection (ear canal inserts)  Rubber insulating gloves  Leather footwear |
| 4 | **Arc Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm2**  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 1  Arc-rated jacket, parka, rainwear or hard hat liner (AN)  **Protective Equipment**  Hard hat  Safety glasses or safety goggles  Hearing protection (ear canal inserts)  Rubber insulating gloves  Leather footwear |

AN: As Needed AR: As Required

Notes:

1. 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.
2. Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or, **alternatively**, an arc-rated arc flash suit hood is required to be worn.