Procedure

Arc Flash Operational Procedure

Policy

1. Purpose

Arc Flash is a high consequence, low likelihood serious hazard event which could cause personnel injury, equipment damage and loss of productivity to business. Sydney Water (SWC) has identified the need to increase awareness and provide safety guidelines to minimize the risk of injury to persons from an arc flash event. This document provides the minimum PPE requirements in relation to the Arc Flash categories that have been previously defined and to reinforce the requirement for carrying out risk assessments before electrical work.

Other measures such as administrative and engineering controls will be defined in technical specifications and other documents.

2. Scope

This procedure applies to all direct employees, all contractors and all persons who enter any Sydney Water electrical switchrooms or are working near live high energy electrical equipment at all Sydney Water sites.

High energy electrical equipment is defined as high voltage electrical equipment and low voltage electrical equipment nominally rated at 400amps or greater.

3. Minimum Requirements Summary

Category 2 PPE, (without the face shield and gloves but with standard eye and hearing protection), shall be the minimum requirement to enter any electrical switchroom beyond the arc flash Cat 1 blue line.

Category 2 PPE (without the face shield and gloves but with standard eye and hearing protection) shall also be the minimum PPE when working within 2 meters of any live high energy electrical switchboard/starter in a common area(this does not apply when staff / visitors are transiting past high energy electrical equipment in common areas).

Risk assessments which consider arc flash risk shall be completed and risk mitigation measures shall be applied before any/all work within all Sydney Water electrical switchrooms.

Risk assessments and risk mitigation measures shall be applied before any/all work on or within 2 metres of high energy electrical equipment in common areas, eg. VSD’s, pump starters, HV kiosks, etc.

All electrical switchboards to have all electrical panels and doors secured correctly at all fastening points.

All Sydney Water switchrooms shall have all supplementary furniture removed to discourage loitering within electrical switchrooms. All supplementary furniture to be moved away from high energy electrical equipment located in common areas.

Minimum amount of time possible to be spent in electrical switchrooms and/or near live switchboards in common areas.

4. Procedure in detail

4.1 Risk

Arc flash is an electric arc with thermal energy dissipated as radiant, convective, and conductive heat that occurs when there is an electrical short circuit fault event.

Arc flash is sometimes a high consequence event however it is always rare or very unlikely the event will occur while a person is in close proximity.

Sydney Water has completed an arc flash calculations project in 2023-24, to determine incident energy for most HV & LV switchboards throughout SWC sites, calculated for each electrical circuit at the point of each circuit breaker or node (ie. Inside the panel). Arc flash incident energy varies at each location in switchboard/electrical panel, and this incident energy is calculated based on power system fault levels, electrode configuration, bus gaps, duration of arcing fault (settings on protection devices) , working distance and operating scenario.

In most switchrooms coloured floor markings have been painted (or taped) around the switchboards to indicate the category of risk within that area.

The full information of the above project can be found in the files / reports completed in this link Accepted Reports– Arc Flash Identification and Mitigation and also in MAximo.

The report classified the Arc Flash Hazard incident energy levels into six categories as the Australian Energy Council guidelines. The floor markings installed indicate these categories around the switchboards:

- Category 0 – Incident Energy Level 0 cal/cm^2 – No colour applied
- Category 1 – Incident Energy Level up to 4 cal/cm^2 - Blue
- Category 2 – Incident Energy Level from 4-8 cal/cm^2 - Yellow
- Category 3 – Incident Energy Level from 8-25 cal/cm^2 - Orange
- Category 4 – Incident Energy Level from 25-40 cal/cm^2 - Red
- Dangerous / Above category 4 – Incident Energy Level above 40 cal/cm^2 - Purple

4.2 Risk Assessment

All work tasks which need to be carried out on or near SWC electrical switchboards require a risk assessment be completed as per current SWC requirements. This assessment may generate requirement for further safe work method statements and additional controls and risk mitigations for the particular task.

For all tasks within a switchboard or any task/operation likely to expose a person to a higher category of arc flash fault, a risk assessment shall be completed, and risk mitigations put in place with the following criteria being met.

Sydney Water require:

- Category 2 PPE, (without the face shield and gloves but with standard eye protection), shall be the minimum requirement to enter any electrical switchroom unless you remain outside the Cat 1 arc flash zone
- Category 4 PPE shall be worn for any risk assessed as Cat 3 and above
- Other mitigation measures as required by the particular risk assessment, this could include full Cat 2 PPE including face shield and gloves, rubber mats, blast barriers or other measures as required.

The risk of an arc flash incident should be incorporated within the overall risk assessment and should take into account the hazard category (as required).

If there is little or no interactions with the particular electrical switchboards, then the risk of arc flash will be correspondingly reduced; further guidance (if required) for this topic can be obtained from the HV electrical team regardless of the voltage level of the equipment involved.

For mitigation measures which involve PPE, please refer to the section 4.3.

Appendix 2 contains a table on likelihood for common operating and work tasks which can be used a guide. This table is sourced from NFPA70E.

4.3 PPE Application

Category 2 PPE without the face shield and gloves, shall be the minimum requirement to enter any arc flash boundary area near an electrical switchboard. Category 2 PPE without the face shield and gloves shall also be considered minimum PPE when working within 2 meters of any live high energy electrical switchboard or motor starter in a common area.

This requirement for Cat 2 PPE will apply to staff carrying out work on non-electrical equipment such as pump housings, pipework, other equipment cabinets or non-energised electrical equipment where they are within 2 metres of HV or LV high energy switchboards.

Arc flash PPE will not be required when transiting past high energy electrical equipment in common areas however the minimum amount of time possible should be spent in these areas.

Note the operation of circuit breakers, switches and contactors, with doors closed, is considered operating work and is in a low-risk category. Reduced Cat 2 PPE as described above is considered appropriate. Operating of non-arc rated equipment or old electrical switchboards may require further risk assessments. Where a risk assessment indicates exposure to increased risk, full Cat 2 PPE **including** face shield and gloves or Cat 4 PPE may be required and shall be used.

Personnel within the vicinity (2 metres) or inside a marked arc flash boundary of HV or high energy LV switchboard shall wear appropriate PPE as specified in this procedure. Ordinary cotton clothing or synthetic clothing must not be worn as this can melt and adhere to bare skin or catch fire in an arc flash event.

The below constitutes minimum PPE:

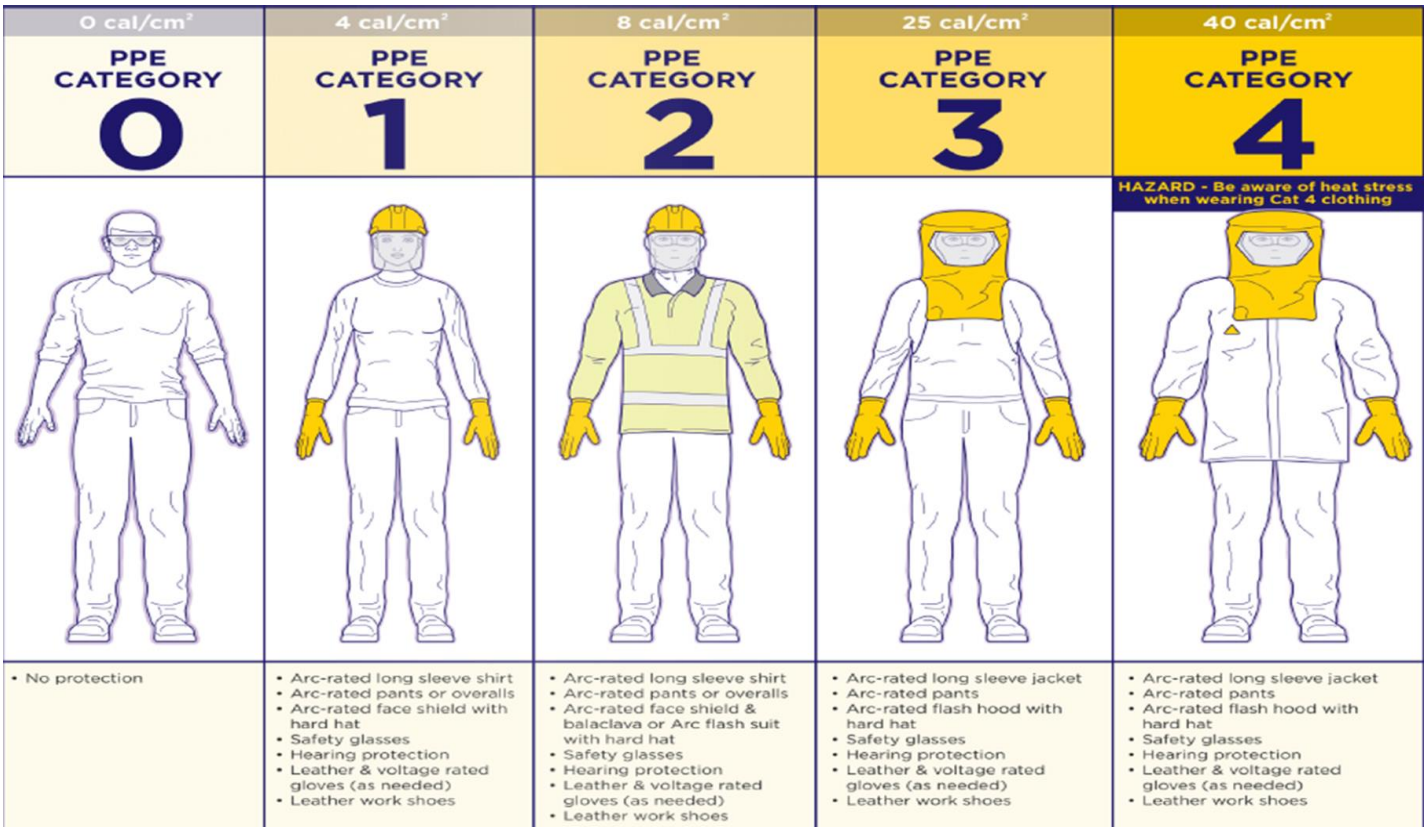
- **Hazard Category Cat 1 and Cat 2**
  When entering electrical switchrooms or working within 2 metres of high energy electrical equipment, Cat 2 rated PPE (without the face shield and gloves but with standard eye and hearing protection).

  When working exposed to Category 1 and 2 hazards, full Cat 2 rated PPE including face shield, gloves and hearing protection is required.

  The application of reduced Cat 2 PPE is intended to be applied in conjunction with existing SWC requirements for eye protection, hearing protection, hard hat and safety boots on all sites. These requirements shall remain unchanged.

- **Hazard Category Cat 3 and Cat 4**
  When exposed to Category 3 and 4 hazards, Cat 4 rated PPE shall be used.

- **Hazard Category - Above Cat 4**
  Working when exposed to “Dangerous” category areas shall be avoided and conducted as an absolute last resort with prior approval only. Work in category “dangerous” rated areas should follow the SWC live electrical work policy for approval.



PPE category table sourced from Australian Energy Council Guidelines

4.4 Secure Electrical Panels

All fasteners on all panels and doors shall be fully tightened and secured as designed. If any are unable to be fastened as designed, a work order shall be raised for repair of the fastener. Considerable pressure and force can be developed during an arc flash event and securing panels and doors properly significantly reduces the risk of the panel and doors from being thrown open during an arc flash event.

4.5 Supplementary Furniture

All supplementary furniture located within an electrical switchroom or within 2 metres of high energy electrical equipment located in common access areas is to be removed. This is discouraging any un-necessary additional time being spent within the risk areas near electrical equipment.

4.6 Time Near Electrical Assets

All efforts should be made to limit exposure time within electrical switchrooms or near high energy electrical boards in common areas. The likelihood of an event is extremely low and the risk can be reduced further by limiting time near electrical assets.

Complete the intended work within the room or near electrical equipment and then leave the area.

4.7 Lock Out Tag Out (LOTO)

Verification of LOTO will involve sighting the isolation point prior to starting work. For the purposes of LOTO entry into a switchroom may be granted provided the person who is not wearing Cat 2 PPE remains outside the Cat 1 blue line markings.

Additional Information

5. Definitions

Term	Definition	Source
Arc Flash	Is defined as a voltage breakdown of air gap resistance resulting in the formation of an arc of highly concentrated radiant thermal energy.	SWC
Arc Flash Hazard	A dangerous condition associated with the possible release of energy caused by an arc flash.	SWC
AS/NZS	Australian Standard / New Zealand Standard.	SWC
Circuit	A circuit comprises live conductors, protective conductors (if any), a protective device and associated switchgear, control gear and accessories.	AS/NZS 3000
Circuit Breaker	A switch suitable for opening a circuit automatically.	AS/NZS 3000
Contactor	A wire or other form of conducting material suitable for carrying current.	AS/NZS 3000
Electrodes	Any conductive material which forms the anode or cathode of an electric arc.	AEC
Energised	Connected to a source of electrical supply.	AS/NZS 3000
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)	SWC
High Energy Low Voltage	Arbitrary figure estimated by local SME's. In this instance deemed to be any electrical equipment above 400amps rating.	SWC
Incident Energy	The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.	SWC
Live	Energised or subject to hazardous induced or capacitive voltage.	AS/NZS 3000
LV	Exceeding Extra-low voltage, but not exceeding 1000V a.c. or 1500V d.c.	SWC
Node	A point in a circuit where two or more circuit elements are connected.	SWC
PPE	Personal Protective Equipment.	SWC
SME	Subject Matter Expert.	SWC
Switchboard	An assembly of circuit protective devices, with or without switchgear, instruments or connecting devices, for distribution to, and protection of, one or more submains or final subcircuits.	AS/NZS 3000
Switchgear	Equipment for controlling the distribution of electrical energy, or for controlling or protecting circuits, machines, transformers, or other equipment.	AS/NZS 3000

6. Context

6.1 Accountabilities

Position	Accountabilities
HV Team	• To review and modify every 12 months or as required.

6.2 Training and Competencies

Position	Training or competency
Production Officers of HV sites.	SWC High Voltage Electrical Induction on Beakon
Any worker entering a site containing HV assets in a shared location.	SWC High Voltage Electrical Induction on Beakon.

6.3 References

Sydney Water will adopt the recommended actions from this operational procedure as mandatory from 31st August 2024 for all people entering electrical switchrooms or working near any high energy electrical switchboards at all Sydney Water sites.

6.4 Attachments

Attachment	Title
1	Appendix 1 – Safety as far as is reasonably practicable
2	Appendix 2 – Table 130.5 from NFPA70E Likelihood of arc flash incident

7. Ownership

Role	Title
Group	HV Team
Owner	Electrical Mechanical Services Leader
Author	David Keegan

7.1 Change History

Version	Issue Date	Approved by	Brief description of change and consultation
2	13/03/2025	D. Keegan	Updated section 4.3 and minor changes
1	24/01/2024	D. Keegan	New document

Appendix 1 SFAIRP

A1.1 Safety as Far As Is Reasonably Practicable Justification

Sydney Water ref: D0002299

ARC Flash Identification and Mitigation

This memo is based on significant work completed as part of SWC Project 20036234 – Arc Flash Identification and Mitigation.

A high-level interpretation of the results is provided, and the proposed recommendations are submitted for review.

Key information

This memo is based on the significant work completed as part of SWC Project 20036234 – Arc Flash Identification and Mitigation.

The memo is instigated by anecdotal information from plant managers, operators and staff who interact with electrical equipment as to the recommendations and implementations for definitive actions arising out of the analysis already completed.

The memo serves to clarify the interpretation of the reports and to provide practicable recommended procedures for the situation identified in these reports.

The full information of the above project can be found in the files / reports completed for SWC Project 20036234 – Arc Flash Identification and Mitigation and this memo only serves to clarify this information and provide clear recommendations going forward.

Discussion

The work completed as part of part of SWC Project 20036234 – Arc Flash Identification and Mitigation was comprehensive and included (but not limited to):

- Arc Flash studies for particular SWC sites.
- Arc Flash Operational Guideline (draft – not implemented).
- Associated Arc Flash Labels installed at various SWC sites.
- Associated Arc Flash Floor tapes installed at various SWC sites.
- Associated presentations.

The Arc Flash Reports for the following sites include the arc flash energy for each significant electrical circuit at each site using formulas derived from IEEE 1584 2028 as executed by SKM Power tools (v9.0.07).

The status of each site is included as an Excel file in Appendix A of the report.

Interpretation

The arc flash incident energy calculated for each circuit is an estimate of arc flash energy at that particular point with due reference to the type of enclosure that the electrodes are located within and the particular fault levels and the settings of the protection devices.

All Arc Flash Hazard incident energy levels are broadly categorised into six levels:

- Dangerous / Above category 4 – Incident Energy Level above 40 cal/cm^2.
- Category 4 – Incident Energy Level from 25-40 cal/cm^2.
- Category 3 – Incident Energy Level from 8-25 cal/cm^2.
- Category 2 – Incident Energy Level from 4-8 cal/cm^2.
- Category 1 – Incident Energy Level up to 4 cal/cm^2.
- Category 0 – Incident Energy Level 0 cal/cm^2.

IEEE 1584 2028 as executed by SKM Power tools (v9.0.07) takes into account the fault level at the particular circuit level as limited by the protection available with respect to the configuration of electrodes in an open enclosure. It does not take into account the arc rating of the equipment per se, and all calculations are based on an enclosure with the cubicle doors (if present) or covers as open.

Accordingly, even within the particular switchboards where circuits can be in the immediate vicinity of each other, there is a wide range of energy levels.

SWC has a significant quantity of electrical switchboards and equipment and there are further factors in assessing the safety of switchboards particular to SWC:

- SWC has equipment ranging from 415V through to 33kV.
- SWC a range of switchgear of all designs and models (may be type tested to differing standards and levels).SWC has equipment of different ages from over 40 years ago to the present.
- SWC has equipment manufactured to a range of different standards including different standards for arc testing.SWC has a range of equipment in differing levels of condition.

Accordingly, even if the arc flash energy is of the same value, the actual risk will be different due to other factors as described above (and potentially other considerations).

This can lead to confusion as to the appropriate approach in addressing the risk associated with each switchboard.

Risk and Safety

It is to be noted that the consequence of circuits with a higher arc flash energy / category is more significant than circuits with a lower arc flash energy, if an arc fault occurs.

This does not mean that mean that the risk is the same for this energy level / category across all the different sites as the risk is a consideration of the combination of the aforementioned factors. For instance, if the arc flash category is the same for a circuit in an old poorly maintained switchboard as compared with a new type tested design switchboard, then the risk will be less for the new switchboard.

Existing SWC Controls

SWC as an organisation places the highest value on safety for all its personnel and accordingly have many practices which contribute already to arc flash safety.

The main existing practices below are taken into account when the considering the recommendations (listed under the hierarchy of controls; first two levels not applicable to electrical equipment):

Isolate:

The current SWC specification requires that all HV switchboards shall be type tested for arc fault containment (AFLR) and accordingly under normal operation, protection is provided for personnel in the vicinity of HV switchboards. This aspect of the specification has been in place for 10-15 years and hence switchgear purchased within this period will generally have this feature.

For HV switchboards, there is a current policy to purchase equipment which can be switched remotely via remote switching panels and that the policy includes remote racking capabilities for withdrawable equipment.

For 415V switchgear the current SWC specification requires all major MCC and switchboard to have doors which are interlocked with isolators, and this means that the panel / cubicle is effectively isolated before the door is open. Furthermore, each major LV switchboard / MCC is manufactured to form 3 (a or b) or higher and each compartment is effectively isolated from each circuit type (busbar, cable, main circuit). This type of specification has been in place for 10-15 years and hence switchgear purchased within this period will generally have these features. This means that the incident energy of the arc flash will be mitigated by such an arrangement and the circuit is effectively disengaged when the doors are to be opened for maintenance / repairs.

SWC also has a policy that work on equipment is only allowed when it is adequately isolated and earthed (if required) and this is implemented via a permit system; see administrative controls.

Engineer:

There is a current directive to implement arc flash detection in HV switchgear.

Administrative:

SWC implements a permit system to allow work on electrical equipment; generally, this means that electrical systems are isolated and earthed (as required) prior to any work on electrical equipment which has a certain amount of risk during the particular tasks.

SWC implements a system of risk assessment and safe work method statements (SWMS) prior to any significant work.

SWC implements a system of toolbox talks and workplace brief prior to any significant work.

As part of the permit system, switching of HV equipment via remote switching panels (where available) is implemented.

PPE:

SWC implements a regime of PPE for entry and work (of any kind) on any of its sites. This PPE consist of safety glasses, safety boots, head protection, high vis clothing; currently this clothing is not required to be fire retardant.

Recommendations

SWC as an organisation places the highest value on safety for all its personnel and accordingly the below recommendations are considered to be formulated to ensure all personnel are provided with safety as far as is reasonably practicable (SFAIRP).

The below recommendations have been formulated with due reference to:

- Practicability
- Ease of implementation
- Human factors

Due to the factors detailed above, the proposed recommendations may be considered to be unnecessary for some sites. However, in the interest of maintaining uniformity of guidelines and for ease of implementation, the following are recommended for uniform dissemination and implementation.

The main augmentation / changes to existing practices are provided below for consideration and implementation (listed under the hierarchy of controls; first two levels not applicable to electrical equipment):

Isolate:

No current changes or augmentation is considered to be required.

A greater emphasis / training to be provided to ensure that all doors and covers for all types of switchgear to be adequately closed and fastened (see Administrative).

Engineer:

The current directive to implement arc flash detection in HV switchgear is endorsed and encouraged.

A new directive to implement arc flash detection in main LV switchgear and MCCs.

Administrative:

All existing procedures are endorsed.

Minor augmentation is considered to be suitable:

A general visual assessment of the HV and LV switchboard with regards to doors / covers being closed to be part of any risk assessment in carrying out any task in the vicinity of HV and LV switchgear. This is also to form part of any risk assessment and SWMSs and forms part of the toolbox / before work briefings.

If works is to be completed in the common cable zone of LV voltage switchgear, it may become necessary to isolate the other circuits located in this cable zone. A risk assessment is to be completed when this is required. As per current procedures, only qualified electrical staff are allowed to work in this area with the door open.

PPE:

It is to be noted that many circuits in many switchboards across different locations are classified as category 3 and above (IEEE 1584 2028 as executed by SKM Power tools (v9.0.07).

Although in the majority of cases there are factors which mitigate this risk, there is still a need to ensure at a general level that all staff are protected to the level of safety as far as is reasonably practicable (SFAIRP).

Accordingly, the following changes / augmentation is recommended.

All general PPE for staff working in the vicinity of HV and LV switchboards to be upgraded to category 2 fire resistance with the exception that standard safety glasses can still be worn. This will apply to staff carrying out work on non-energised equipment and non-electrical work in the general area.

Category 4 PPE is expected where risk assessments show exposure to category 3 or higher arc flash hazard is present while carrying out work tasks. Its important to note operating work is different to work tasks.

No visitors to be allowed in the vicinity of HV and LV switchboards with non-cotton (nylon) based clothing.

Appendix 2 NFPA70E Table 130.5(C) Likelihood of Arc Flash Incident

The purpose of this table is to aid in determining the likelihood of an arc flash incident occurring. If a likelihood exists, hazard control options other than PPE must be used first. PPE should only be used after all other means of employee protection have been exhausted. **PPE is considered the least effective control for employee protection and should not be the first or only hazard control used.**

Task	Equipment Condition	Likelihood of Occurrence*
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.	Any	No
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.	Any	No
Examination of insulated cable with no manipulation of cable.	Any	No
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack.	Any	No
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	Any	No
For ac systems, work on energized electrical conductors and circuit parts, including voltage testing.	Any	Yes
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing.	Any	Yes
Removal or installation of CBs or switches.	Any	Yes
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.	Any	Yes
Application of temporary protective grounding equipment, after voltage test.	Any	Yes
Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts.	Any	Yes

Insertion or removal of individual starter buckets from motor control center (MCC).	Any	Yes
Insertion or removal (racking) of circuit breakers (CBs) or starters from cubicles, doors open or closed.	Any	Yes
Insertion or removal of plug-in devices into or from busways.	Any	Yes
Examination of insulated cable with manipulation of cable.	Any	Yes
Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center.	Any	Yes
Insertion or removal of revenue meters (kW-hour, at primary voltage and current).	Any	Yes
Removal of battery conductive intercell connector covers.	Any	Yes
For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.	Any	Yes
Opening voltage transformer or control power transformer compartments.	Any	Yes
Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV.	Any	Yes
Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.	Any	Yes
Operation of a CB, switch, contactor, or starter.	Normal	No
Voltage testing on individual battery cells or individual multi-cell units.	Normal	No
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.	Normal	No
Opening a panelboard hinged door or cover to access dead front overcurrent devices.	Normal	No
Removal of battery nonconductive intercell connector covers.	Normal	No
Maintenance and testing on individual battery cells or individual multi-cell units in an open rack.	Abnormal	Yes

Insertion or removal of individual cells or multi-cell units of a battery system in an open rack.	Abnormal	Yes
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.	Abnormal	Yes
Insertion or removal (racking) of CBs from cubicles; Insertion or removal (racking) of ground and test device; or Insertion or removal (racking) of voltage transformers on or off the bus.	Abnormal	Yes

Equipment condition is 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 manufacturer’s instructions.
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.

***Where this table identifies “No” as an estimate of likelihood of occurrence, it means that an arc flash incident is not likely to occur. Where this table identifies “Yes” as an estimate of likelihood of occurrence, it means that additional protective measures are required to be selected and implemented according to the hierarchy of risk control identified in NFPA 70E 110.1(H).**