Electrical Arc Flash - Risk-Based Application of PPE

Guideline

May 2025

VICTORIA State Government

Melbourne Water
Enhancing Life and Liveability

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Acronyms and Abbreviations

Term	Definition
ACB	Air Circuit Breaker
ALARP	As low as reasonably practicable
Cat	Category – of arc flash incident energy (0, 1, 2, 3, 4 or Dangerous)
ELV	Extra Low Voltage
G2G	Good To Go – Melbourne Waters dynamic risk assessment
HSE	Health Safety & Environment
HV	High Voltage
HV COP	HV Community of Practice
ICA	Internal Arc Classification
LV	Low Voltage
MCB	Miniature Circuit Breaker
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
RCD	Residual Current Device
TRA	Task Risk Assessment
V	Volts

1. Purpose

This document was developed to provide practical guidance, per task activity, on where a risk based reduction of default PPE may be considered. The aim is to provide an immediate practical enhancement to risk management.

This guide will assist in risk assessments for those activities and the selection of appropriate mitigation measures such as de-energisation and PPE.

The simple adoption of PPE based solely on the calculated value (potential) may not always be a practical solution for improving safety. It may even increase the likelihood of initiating an arc event due to:

- impaired visibility;
- loss of dexterity;
- fatigue due to heat;
- physical access constraints (e.g. hard hat with arc flash visor within a small compartment);
- reduced perception of risk leading to complacency.

Risk is a combination of:

- potential to do harm should an event occur; and
- the likelihood of that harm occurring.

2. Scope

The scope of this guideline is the PPE selection for arc flash risks associated with battery systems, Low Voltage and High Voltage electrical equipment. It applies to all areas where Melbourne Water own or operate electrical assets.

This guideline **does not** include non PPE mitigation considerations; refer to AM PLA Arc Flash Management Plan for those details.

2.1 Audience

- Operators of electrical equipment undertaking operational activities
- Maintainers of electrical equipment undertaking maintenance and repair activities
- Capital works installers of equipment

3. Process

3.1 Related Standards and Documents

Table 1: Key standards referenced within this document

Melbourne Water standards/documents • This document: H&S GUI Electrical Arc Flash – Risk-Based Application of PPE • AM PLA Arc Flash Management Plan • AM GUI Arc Flash Assessment Guideline **Industry standards/documents** • AEC Electrical Arc Flash Hazard Management Guideline March 2019 **Australian, international and ISO standards** • AS/NZS 5139 Electrical Installations – Safety of battery systems for use with power conversion equipment	

We encourage innovation for a positive outcome

If you feel there is a better way to go about managing this guideline, please contact Melbourne Water so we can integrate your ideas into the next revision of this standard.

3.2 Background

3.2.1 What is an Arc Flash

An arc flash is an electrical short circuit through the air. As air has a high impedance the associated currents are less than a bolted short circuit. It is a different risk to electrocution although this can occur if parts of the body become a part of the conducting path of the arc flash. The risk applies to both HV and LV and some ELV installations.

Arc flash occurrences are rare but can happen with or without personnel present. During an arc flash, an enormous amount of radiant energy can be released, which can result in hazardous flames, molten material and an ionised gases arc blast. This can result in severe burns, cause damage to the eyes due to the flash. It can also produce a pressure wave that can cause damage to hearing and even fracture bones. The pressure wave can also send loose materials such as pieces of molten metal and other objects flying through the air which can puncture the skin.

3.2.2 PPE Protection Against Arc Flash

An arc flash study calculates the incident heat energy that would be experienced by a person working at a specified distance from live (exposed) electrical equipment. These incident energies are a measure of the potential hazard. This measure can then be used to determine the level of Personal Protective Equipment (PPE) that could be worn by the person to prevent incurable burns. Refer to Appendix 3 for details on PPE types. The working distance is where a

person is expected to be stood. The energy reduces over distance and reaches an acceptable level at the arc flash boundary where it is considered acceptable to be without PPE.

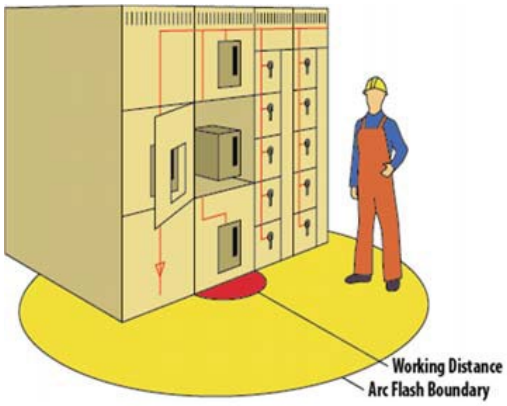

Figure 1: Working distance and arc flash boundary diagram

Table 2: Incident energy PPE categories

Hazard PPE Category	PPE requirement	Associated incident energy
0	Base on ALARP principles, Melbourne Water has adopted a minimum PPE for use even when incident energy is low.	Energy is less than 1.2 cal/cm^2 at the working distance
1	Some PPE required, See	Up to 4 cal/cm^2
2	Increasing PPE requirements	Up to 8 cal/cm^2
3	Increasing PPE requirements	Up to 25 cal/cm^2
4	Typically highest PPE	Up to 40 cal/cm^2
DANGEROUS	Typically recognised as no available PPE available for this duty, (some slightly higher ratings are entering the marketplace)	Greater than 40 cal/cm^2

3.3 Practical Application of PPE Working Group

Melbourne Water established a working group to consider the practical application of PPE. The working group consisted of HV operators, HV and LV maintenance technicians, safety team (HSE), Asset Management and HV Community of Practice (HV COP).

It was considered that the label stated PPE was based on the potential (incident energy) and did not take into account likelihood with resultant risk. The outcome of that working group was that an improved safety approach, based on specific individual risk assessment, was appropriate. The format would be specific risk assessments and raised awareness, rather than automatic mandatory adoption of the arc flash label stated PPE. The accepted approach is:

- default position is to utilise PPE as stated on the arc flash labelling;
- utilise mandatory PPE requirements, with no exceptions, for some activities;

- vary the default position where the activity has permitted exceptions that allow for PPE reduction. Any such reduction requires a specific risk assessment;

The working group considered the form of any risk assessment and determined:

- generic risk assessment of switchboard type would not be suitable given it could not take into account the latest known configuration, history and condition. The risk assessment should be specific to an individual switchgear.

- reviewing the current condition and known history was best done at the time of the planned activity to ensure currency.

- the risk assessment should be reviewed dynamically as the activity progressed e.g. typically starting with all covers closed, once cover is open allowing visual inspection, checking for de-energised, after confirmed de-energised, etc.

- the format of the risk assessment would vary G2G, written etc.

- a risk assessment guide was needed (this document).

- training / awareness of arc flash, its initiators and consequences was required to enable personnel to undertake risk assessment

- some activity risk assessments would require peer or senior review

Based on the findings of the working group, tables have been produced to give guidance on activity versus PPE selection. The HV COP has been authorised by MWC Chief Safety Officer to review, amend and approve the tables. Those approved tables are detailed in the following sections.

3.4 Table - Risk-Based Application of PPE for HV Equipment

Before commencing any task the following risk assessment process should be followed:

- Confirm the potential for harm - this is detailed on the arc flash labelling.
- For the intended activity, confirm the default minimum requirements and any permitted exceptions for PPE possible reduction using table 3.
- Assess the potential causes for harm occurring whilst undertaking the task. See Appendix 1 – *Typical Arc Flash Initiator Checklist – High Voltage.*
- Assess the risk and select appropriate PPE.

Table 3: Typical HV switchboard minimum PPE requirements

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Any activity where all covers are not closed, secured and category is DANGEROUS	Work cannot proceed whilst the potential consequence remains present.	A written TRA must be undertaken by the person undertaking the works in conjunction with MWC Operating Authority.	This would never be considered as routine work and any exemption approval is unlikely to be given.
When entering electrical switch rooms or operating controls mounted on the front of a switchboard with covers closed and secured.	MWC Minimum PPE	None	
HV switchgear racking in front of panel (compartment door closed and secured)	As per arc flash labelling, subject to minimum Cat 4	None	Whilst it is recognised that an IAC board should contain arc flash, it is current MWC preference to wear Cat 4 regardless of actual category.
HV switchgear removal / insertion of breaker /contactor (compartment door open)	As per arc flash labelling	Gloves may be removed whilst disconnecting / reconnecting umbilical cable	The breaker compartment should only be open for the duration of the necessary works within it. At all other times it should be closed.
Opening/ closing HV breaker /contactor in front of panel	As per arc flash labelling, minimum Cat 4	None	Compartment shall be closed. Whilst it is recognised that an IAC board should contain arc flash, it is current MWC practice to wear Cat 4. This shall be worn regardless of actual category.

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
HV breaker compartment, breaker / contactor withdrawn, visual inspection	As per arc flash labelling	A written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works and sighted by Melbourne Water representative (MWC/ Service Provider).	The breaker now having been removed removes a major risk item. The breaker compartment should only be open for the duration of the necessary works within it. At all other times it should be closed.
HV breaker compartment, breaker / contactor withdrawn, specific internal tasks e.g. guide adjustments, shutter mechanisms etc.	As per arc flash labelling	A written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works and sighted by Melbourne Water representative (MWC/ Service Provider).	The breaker now having been removed removes a major risk item. The breaker compartment should only be open for the duration of the necessary works within it. At all other times it should be closed.
Protection & control compartment - visual inspection / working/ testing within	As per arc flash labelling	A written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works and sighted by Melbourne Water representative (MWC/ Service Provider). Subject to MW Minimum PPE.	It is recognised that working within this compartment has been standard industry practice. The risk posed when its door is open is an unquantifiable theoretical risk associated with the power sections of the switchboard. Dexterity, detailed visual requirements and physical space restrictions meant that increased PPE was not practical and given the expected likelihood is not in any case warranted.

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Cable compartment access	As per arc flash labelling	A written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works and sighted by Melbourne Water representative (MWC/ Service Provider). Subject to MW Minimum PPE	Often these cannot be accessed without being already earthed but to cover any eventuality this should not be assumed.
HV contactor testing whilst outside compartment (umbilical connected)	As per arc flash labelling	A written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works and sighted by Melbourne Water representative (MWC/ Service Provider). The immediate area in front of the compartment made restricted to all by temporary barriers and signage. Once the contactor is placed to the other side of the open compartment and the person not remaining in front of the open door the risk is reduced. The hinge side should be used such that it forms a barrier between the tester and the open compartment.	In some locations the contactor is currently withdrawn from the compartment with umbilical connected. This umbilical connection requires the door to remain open. It was considered necessary to be able to revert to reduced PPE once the contactor was placed to the other side of the open compartment and the person not remaining in front of the open door.

3.5 Table - Risk-Based Application of PPE for LV Equipment

Before commencing any task the following risk assessment process should be followed:

- Confirm the potential for harm - this is detailed on the arc flash labelling. Where a site does not have labelling installed, see appendix 5 for Low Voltage default assumption to be utilised.

- For the intended activity, confirm the default minimum requirements and any permitted exceptions for PPE possible reduction using table 4.
- Assess the potential causes for harm occurring whilst undertaking the task. See Appendix 2 – Typical Arc Flash Initiator Checklist – Low Voltage.
- Assess the risk and select appropriate PPE.

Table 4: Typical LV switchboard minimum PPE requirements

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Any activity where all covers are not closed, secured and category is DANGEROUS	Work cannot proceed whilst the potential consequence remains present.	A written TRA must be undertaken by the person undertaking the works in conjunction with the MWC Operating Authority	This would never be considered as routine work and any exemption approval is unlikely to be given.
When entering electrical switch rooms but not interacting with a switchboard / Motor Control Centre	MW Minimum PPE	None	
When operating controls mounted on the front of a switchboard / Motor Control Centre stop /start/ hand auto/	MW Minimum PPE	None	This is seem as minimum starting point for initial improved safety. Would looking for next step potentially being PPE 1
After protection trip operating controls mounted on the front of a switchboard / Motor Control Centre	As per arc flash labelling subject to MW Minimum PPE plus leather gloves	For Electrical qualified personnel only, a written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works.	Protection trip is not a normal thing. The ability to contain arc flash may be unknown, particularly for older boards.

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Light and power board protection reset (MCB's /RCD's). Outer door open (if fitted) escutcheon in place	MW Minimum PPE plus leather gloves	None	
LV switchgear Racking in front of panel (compartment door closed and secured)	As per arc flash labelling	None	
LV switchgear Racking in front of panel (door open)	As per arc flash labelling	None	
LV switchgear Removal / insertion of breaker (door open)	As per arc flash labelling	A written Task Risk Assessment (TRA) should be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA shall be undertaken by the person undertaking the works with a peer review.	The breaker being now having been removed removes a major risk item.
Opening/ closing LV equal or greater than 800A MCCB / ACB/ Fused switch in front of panel(not after a protection trip)	Minimum category 1	None	Compartment shall be closed and secured. Normal operation
Opening / closing LV less than 800A MCCB / ACB/ Fused switch in front of panel (not after a protection trip)	MW Minimum PPE plus leather gloves	None	Compartment shall be closed and secured. Normal operation

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Any ACB compartment, breaker withdrawn, visual inspection. Cover open	As per arc flash labelling	A written Task Risk Assessment (TRA) should be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works.	The breaker being now having been removed removes a major risk item.
Any ACB compartment, breaker withdrawn, specific internal tasks e.g. guide adjustments, operating mechanisms etc.	As per arc flash labelling	Written Task Risk Assessment (TRA) should be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works.	The breaker being now having been removed removes a major risk item. Upstream isolation should be undertaken where practical
Isolation proving, cover open	minimum PPE 2 category, Cat 1 may be worn if arc flash labelling is at 1 or 0	Where incident energy is higher than Category 2 a risk assessment should be undertaken by the individual performing the proposed works	
Cableway compartment access	MW Minimum PPE	Risk assessment should be undertaken by the individual performing the proposed works to understand how in service compartments may pose a risk and uprate PPE as necessary	
Undertaking tasks, other than isolation proving, within a compartment	MW Minimum PPE	Risk assessment should be undertaken by the individual performing the proposed works to understand how in service compartments may pose a risk and uprate PPE as necessary	

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Extra low voltage compartments, PLC, Instrumentation and control compartments	MW Minimum PPE	Risk assessment should be undertaken by the individual performing the proposed works to understand how in service compartments may pose a risk and uprate PPE as necessary	

3.6 Table - Risk-Based Application of PPE for Battery Systems

The Electricity Safety Regs 2019 part 2 212 States that a battery system must be installed, altered, repaired or maintained in accordance with AS/NZS 5139 Electrical installations – Safety of battery systems for use with power conversion equipment. The Regulations state the whole of AS/NZS 5139 applies.

AS/NZS 5139 section 6.3.2.1 Arc flash, states that when working on battery systems, the correct level of PPE based on the potential arc flash energy for the battery system shall be selected and worn within the arc flash boundary. The word "potential" effectively rules out any risk assessment-based selection of reduced PPE.

Table 5: Typical battery systems minimum PPE requirements

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Any activity on a battery system that the operating output voltage is 12V or less. Or for higher voltages where the rated storage is less than one kilowatt hour.	None	N/A	AS 5139 defines a battery system as having: • nominal operating voltage greater than 12Vdc; and • An individual or combined rated storage equal to or greater than one kilowatt hour The system operating voltage is the combination of individual batteries
Testing of battery voltages / internal resistance test across terminals	As per arc flash labelling subject to MW Minimum PPE plus leather gloves	None	Electricity Safety Regs 2019 call on entirety of AS/NZS 5139 which in turn mandates PPE based on the potential arc flash energy for the battery system. This shall be selected and worn within the arc flash boundary.

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Swapping out of batteries / Replacing connections if corroded	As per arc flash labelling subject to MW Minimum PPE plus leather gloves	None	Electricity Safety Regs 2019 call on entirety of AS/NZS 5139 which in turn mandates PPE based on the potential arc flash energy for the battery system. This shall be selected and worn within the arc flash boundary.
Visual battery inspection	As per arc flash labelling subject to MW Minimum PPE plus leather gloves	For Electrical qualified personnel only, a written Task Risk Assessment (TRA) shall be undertaken, before proceeding, to determine if reduced PPE is appropriate. The TRA should be undertaken by the person undertaking the works.	Not considered work as no contact expected.
Connecting new circuits at the distribution point	As per arc flash labelling subject to MW Minimum PPE plus leather gloves	None	Electricity Safety Regs 2019 call on entirety of AS/NZS 5139 which in turn mandates PPE based on the potential arc flash energy for the battery system. This shall be selected and worn within the arc flash boundary.

Activity	Default minimum requirements	Permitted exceptions for PPE reduction	Comments
Unlabelled sites	As per estimated arc flash energy subject to MW Minimum PPE plus leather gloves. See Appendix 3 for specific PPE details	None	Safety step forward until actual value calculated. A lookup table is available to determine required PPE. This table is based on Doan method (referenced in AS/NZS 5139) and an estimated typical battery short circuit contribution. You may consider splitting the battery circuits so that reduced PPE (as determined by the look up table) may be selected. The full PPE must be worn until any split is completed. This principal may also applied to labelled sites.

4. References

Document title
AM PLA Arc Flash Management Plan
AM GUI Arc Flash Assessment Guideline
Generic Form 3 4 swbd arc flash H&S_TEM_Risk_Assessment
Typical DC battery arc fault Doan method V1.xlsx
AS/NZS 5139:2019 Electrical installations – Safety of battery systems for use with power conversion equipment
Electricity Safety (General) Regulations 2019
Electricity Safety (Management) Regulations 2019
AEC Electrical Arc Flash Hazard Management Guideline March 2019

5. Appendices

Appendices
Appendix 1 – Typical Arc Flash Initiator Checklist - HV
Appendix 2 – Typical Arc Flash Initiator Checklist - LV

Appendices
Appendix 3 – Unlabelled Battery Systems PPE Look up Tables (Derived from Doan Method)
Appendix 4 – PPE for Arc Flash Categories
Appendix 5 - Unlabelled Low Voltage equipment - Default category to be assumed

6. Stakeholder Consultation

Stakeholders
HV Community of Practice
HSE
Arc flash working Group (temporary group formed to perform practicality review)
Programmed

7. Document History

Date	Reviewed/ Actioned By	Version	Action
May 2025	Principal, Electrical	3	3.4 & 3.5, additional guidance on process to be followed; Added appendix 5 -Low Voltage default assumption for when no label; updated index to make it easier to find tables.
January 2025	Senior Safety & Assurance Advisor	2	Added Inflo ID number and updated responsibilities for future reviews (as advised by Electrical Principal)
January 2025	Principal, Electrical	1	First issue

Appendix 1 – Typical Arc Flash Initiator Checklist - HV

This appendix lists typical arc flash initiators verses activity tasks. The list is not exhaustive but is intended to cover the most common tasks.

Table 6: High Voltage switchgear Typical arc flash initiator checklist

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
1	Operating	Opening/ closing HV breaker in front of panel	Internal fault initiates arc flash occurs that is not contained or safely vented to place where persons are not potentially present	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Arc energy released resulting in injury
2	Operating	Visual reading / reset of protection relays , meter displays etc. (covers secured)	Internal fault initiates arc flash occurs that is not contained or safely vented to place where persons are not potentially present	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Arc energy released resulting in injury
3	Visual inspection	Entering electrical HV to visually inspect HV asset when all covers are secured	Internal fault initiates arc flash occurs that is not contained or safely vented to place where persons are not potentially present	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Arc energy released resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
4	Visual inspection	HV compartment, breaker/ contactor withdrawn, visual inspection	Internal fault initiates arc flash within compartment at spouts	Not considered credible	
5	Visual inspection	Protection & control compartment - visual inspection within.	working within this compartment requires its door to be open and is industry practice. There is an unquantifiable theoretical risk associated with the power sections of the switchboard as IAC certification has all covers closed.	Internal fault in power section initiates an arc flash. Some of that energy could indirectly make its way to protection & control compartment	Non direct arc energy released resulting in injury
6	Visual inspection	Cable compartment access	Often these cannot be accessed without being already earthed but to cover any eventuality this should not be assumed	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	
7	Racking activity	HV switchgear racking in front of panel (door closed and secured)	Internal fault initiates arc flash occurs that is not contained or safely vented to place where persons are not potentially present	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Indirect arc energy released resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
8	Racking activity	HV switchgear removal / insertion post/ pre racking of breaker (door open)	Internal fault initiates arc flash within compartment at spouts	Fault on busbar elsewhere on board	Arc energy released resulting in injury
9	Working on HV asset	HV breaker compartment, breaker withdrawn, specific internal tasks e.g. guide adjustments, shutter mechanisms etc.	Internal fault at spouts initiates an arc flash within the compartment	Not considered credible	Arc energy released resulting in injury
10	Working on HV asset	HV breaker compartment, breaker withdrawn, specific internal tasks e.g. guide adjustments, shutter mechanisms etc.	Internal fault elsewhere on switchboard initiates an arc flash the effects of which reach the open compartment	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Arc energy potentially reaches person resulting in injury
11	Working on HV asset	Cable compartment access to install (rest of switchboard remains energised)	Internal fault elsewhere on switchboard initiates an arc flash the effects of which reach the open cable compartment	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	Arc energy potentially reaches person resulting in injury
12	Working on other assets	Entering electrical HV switch rooms for cleaning, painting, changing luminaire's etc.	Internal fault initiates arc flash occurs that is not contained or safely vented	Internal fault when covers not secured or switchgear design does not meet Internal Arc Classification (IAC) for protection of users (A-F switchgear front (F-front) only; A-FL	

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
			to place where persons are not potentially present	switchgear front and side (F-front, L-lateral) only; A-FLR all sided switchgear (F-front, L-lateral, R-rear) protection for users)	
13	Testing	Protection & control compartment testing within.	working within this compartment requires its door to be open and is industry practice. There is an unquantifiable theoretical risk associated with the power sections of the switchboard as IAC certification has all covers closed.	Internal fault in power section initiates an arc flash. Some of that energy could indirectly make its way to protection & control compartment	Non direct arc energy released resulting in injury
14	Testing	Cable compartment access to test cables	Often these cannot be accessed without being already earthed but to cover any eventuality this should not be assumed	Not effectively isolated prior to works and remains / becomes energised	Arc energy released resulting in injury
15	Testing	HV contactor / breaker testing whilst outside compartment	Where there is no external testing bed for such devices, the contactor is currently withdrawn from the compartment with umbilical connected. This umbilical connection requires the door to remain open.	Enclosure door open to facilitate umbilical connection to the withdrawn contactor when a non-related internal fault occurs elsewhere on switchboard	Arc energy released resulting in injury

Appendix 2 – Typical Arc Flash Initiator Checklist - LV

This appendix lists typical arc flash initiators verses activity tasks. The list is not exhaustive but is intended to cover the most common tasks.

Table 7: Low Voltage switchgear Typical arc flash initiator checklist

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
1	Operating	operating panel mounted switches, isolation device, stop/start pushbuttons, resets etc with covers closed and secured	Arc flash occurring that is not contained within the compartment	Compartment door fixings not secured or board is not designed to contain arc	Arc energy could be that limited by the main incomer protection device / resulting in injury
2	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live.	Arc flash on load side of the isolation device being tested	isolating device did not perform full isolation . In the act of testing for isolated a short circuit occurs at the isolation device load side or downstream components	Arc energy could be that limited by the main incomer protection device / resulting in injury
3	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash at line side of compartment being tested protective device	Testing performed on **line side o**ff isolating device. The act of testing a short circuit occurs	Arc energy could be that limited by the main incomer protection device / resulting in injury
4	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash at line side of compartment being tested protective device	non testing related fault occurs on **load side of main incomer** that causes **arc to travel** along busbar to the compartment line side of its protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
5	Testing for isolated	Testing for isolated in a non-incomer compartment, after the	arc flash at line side of compartment being tested protective device	non testing related fault occurs on **line side of main incomer** that causes arc to	

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
		isolation device has been opened. Rest of switchboard live		cross over to load side and then **travel along** busbar to the compartment line side of its protective device**. Not considered credible**	
6	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being tested ;physical separations between compartments that are deemed sufficient to restrict plasma flow	fault in another compartment load side only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under test compartment	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury
7	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being tested, due to physical separations between compartments that are NOT deemed sufficient to restrict plasma flow	fault in another compartment **load side** only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under test compartment	Arc energy could be that limited by the main incomer protection device with little or no reduction due to physical path / resulting in injury
8	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being tested due to physical separations between compartments that are NON EXISTANT deemed	fault in another compartment **load side only** that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
			sufficient to restrict plasma flow	openings in sidewalls and reaches the under test compartment	
9	Testing for isolated	Testing for isolated in a non-incomer compartment, after the isolation device has been opened. Rest of switchboard live	arc flash at line side of compartment being tested protective device	non testing related fault occurs on **bus bar** that causes arc to travel to line side of compartment being tested protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
10	Testing for isolated	Testing for isolated in the incomer compartment, after the isolation device has been opened. Line connection live.	arc flash on load side of the isolation device being tested	isolating device did not perform full isolation . In the act of testing for isolated a short circuit occurs at the isolation device load side or downstream components	Arc energy could be that limited by the upstream protection device / resulting in injury (assumed because it failed to isolate that it won't work)
11	Testing for isolated	Testing for isolated in the incomer compartment, after the isolation device has been opened. Line connection live	arc flash at line side of isolation device	Testing performed on line side of isolating device. The act of testing a short circuit occurs	Arc energy could be that limited by the upstream protection device / resulting in injury
12	Testing for isolated	Testing for isolated in the incomer compartment, after the isolation device has been opened. Line connection live	arc flash at line side of isolation device	non testing related fault occurs on line side of main incomer	Arc energy could be that limited by the upstream protection device / resulting in injury
13	Testing for isolated	Testing for isolated in the incomer compartment, after the isolation device has been opened. Upstream supposedly isolated	arc flash at line side of isolation device	Testing performed on line side of isolating device. The act of testing a short circuit occurs. Upstream isolating device did not perform full isolation .	Arc energy could be that limited by the upstream protection device / resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
14	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device has been opened but prior to confirmation testing. Rest of switchboard live	arc flash on load side of the isolation device	isolating device did not perform full isolation . In the act of visual inspection a short circuit occurs at the isolation device load side or downstream components. Possibly caused by unintended disturbance to components	Arc energy could be that limited by the main incomer protection device / resulting in injury
15	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash at line side of compartment being tested protective device	non testing related fault occurs on **load side of main incomer** that causes **arc to trave**l along busbar to the compartment line side of its protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
16	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being inspected ;physical separations between compartments that are deemed sufficient to restrict plasma flow	fault in another compartment load side only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under inspection compartment	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury
17	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being tested, due to physical separations between compartments that are NOT deemed sufficient to restrict plasma flow	fault in another compartment **load side** only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
				openings in sidewalls and reaches the under test compartment	
18	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device has been opened. Rest of switchboard live	arc flash plasma enters compartment being tested due to physical separations between compartments that are **NON EXISTANT** deemed sufficient to restrict plasma flow	fault in another compartment **load side only** that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under test compartment	Arc energy could be that limited by the main incomer protection device with little or no reduction due to physical path / resulting in injury
19	Visual inspection	visual inspection of components in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash at line side of compartment being tested protective device	non testing related fault occurs on **bus bar** that causes arc to travel to line side of compartment being tested protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
20	Visual inspection	visual inspection of components in incomer compartment after the incomer isolation device has been opened but prior to confirmation testing. Line side live	arc flash at load side of incomer isolation device	isolating device did not perform full isolation . In the act of visual inspection a short circuit occurs at the isolation device load side or downstream components. Possibly caused by unintended disturbance to components	Arc energy could be that limited by the upstream line side protection device / resulting in injury
21	Visual inspection	visual inspection of components in incomer compartment after the incomer isolation device	arc flash at line side of incomer	non considered credible	

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
		confirmation testing. Line side live			
22	Visual inspection	visual inspection of components in incomer compartment after the incomer isolation device confirmation testing. Line connection isolated	arc flash	unauthorised removal of upstream isolation	compartment becomes live. Arc energy could be that limited by the upstream line side protection device / resulting in injury
23	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash at line side of compartment being worked	Inadvertent contact with bus bar system e.g. screwing though backplane and making contact with busbars	Arc energy could be that limited by the main incomer protection device / resulting injury
24	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash at line side of compartment being worked protective device	non work related fault occurs on **load side of main incomer** that causes **arc to travel** along busbar to the compartment line side of its protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
25	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash plasma enters compartment being worked ;physical separations between compartments that are deemed sufficient to restrict plasma flow	fault in another compartment load side only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under work compartment	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
26	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash plasma enters compartment being worked, due to physical separations between compartments that are NOT deemed sufficient to restrict plasma flow	fault in another compartment **load side** only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under test compartment	Arc energy could be that limited by the main incomer protection device with little or no reduction due to physical path / resulting in injury
27	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash plasma enters compartment being worked due to physical separations between compartments that are NON EXISTANT deemed sufficient to restrict plasma flow	fault in another compartment **load side only** that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the under test compartment	Arc energy could be that limited by the main incomer protection device with little or no reduction due to physical path / resulting in injury
28	Replacing components	replacing components (other than the isolation device) in a non-incomer compartment after the isolation device confirmation testing. Rest of switchboard live	arc flash at line side of compartment being worked protective device	non testing related fault occurs on **bus bar** that causes arc to travel to line side of compartment being tested protective device	Arc energy could be that limited by the main incomer protection device / resulting in injury
29	Replacing components	replacing components (other than the isolation device) in incomer compartment after the isolation device confirmation testing. Line connection live	arc flash at line side of isolation device	inadvertent contact with line side e.g. dropped tool	Arc energy could be that limited by the upstream protection device / resulting in injury

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
30	Replacing components	replacing any components (including the isolation device) in incomer compartment after the upstream isolation confirmation testing. Line connection has been proven to be isolated	arc flash	unauthorised removal of upstream isolation	compartment becomes live. Arc energy could be that limited by the main incomer upstream protection device with some further reduction due to physical path / resulting in injury
31	Cableway	Working in cable way	arc flash plasma enters cableway (non-incomer)	fault in another compartment load side only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the cableway	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury
32	Cableway	Working in cable way	arc flash plasma enters cableway (next to incomer)	fault in incomer compartment load side only that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any obstacles such as openings in sidewalls and reaches the cableway	Arc energy could be that limited by the main incomer protection device with some further reduction due to physical path / resulting in injury
33	Cableway	Working in cable way	arc flash plasma enters cableway (next to incomer)	fault incomer compartment line side that causes arc flash within that compartment, plasma may ejected out of compartment through air, past any	Arc energy could be that limited by the main incomer **upstream** protection device with some further reduction

Risk No.	Activity type	Description of activity	Potential risk	Potential cause	Consequence / Impact
				obstacles such as openings in sidewalls and reaches the cableway	due to physical path / resulting in injury
34	Racking	Manual racking incomer or bus tie breaker, with **compartment door closed**	arc flash	breaker not being open, test materials left in place , misalignment mechanical failure	Arc energy could be that limited by the upstream protection device / resulting in injury
35	Racking	Manual racking incomer or bus tie breaker, with compartment door open	arc flash	breaker not being open, test materials left in place , misalignment mechanical failure	Arc energy could be that limited by the upstream protection device / resulting in injury

Appendix 3 – Unlabelled Battery Systems PPE Look up Tables (Derived from Doan Method)

Melbourne Water has elected to utilise the Ammerman method, to minimise over-conservatism in its detailed arc flash calculation. However given its relative simplicity, the Doan method has been used to produce typical PPE tables as an interim position for the selection of PPE.

To use the tables following steps are undertaken:

Step 1 - identify voltage of individual battery

Step 2 – identify number of individual strings (parallel batteries)

Step 3 – identify number of batteries in a string (no of batteries in series)

Step 4 – identify installation type (1 if in Open Air, 1.5 in Room, 3 in Enclosure)

Step 4 - select appropriate table and read value.

Table 8: 12V batteries, installed within an enclosure, arc flash typical arc flash details based on typical equipment details (Doan method)

In Enclosure (3) **12V batteries utilised**

Cat 0	
Cat 1	
cat 2	
Cat 3	
Cat 4	
Dangerous	

					12V		
Tarc(S)	2	D (cm)	45		Ibf (A)	2100	
Individual Battery Voltage	No of batteries per string	No of strings	System voltage	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
12	1	1	12	3	0.37	25	45
12	2	1	24	3	0.75	35	45
12	3	1	36	3	1.12	43	45
12	4	1	48	3	1.49	50	45
12	5	1	60	3	1.87	56	45
12	6	1	72	3	2.24	61	45
12	7	1	84	3	2.61	66	45
12	8	1	96	3	2.99	71	45
12	9	1	108	3	3.36	75	45
12	10	1	120	3	3.73	79	45
12	11	1	132	3	4.11	83	45
12	12	1	144	3	4.48	87	45
12	13	1	156	3	4.85	90	45
12	14	1	168	3	5.23	94	45
12	15	1	180	3	5.60	97	45
12	16	1	192	3	5.97	100	45
12	17	1	204	3	6.35	103	45
12	18	1	216	3	6.72	106	45
12	19	1	228	3	7.09	109	45
12	20	1	240	3	7.47	112	45
12	21	1	252	3	7.84	115	45
12	22	1	264	3	8.21	118	45
12	23	1	276	3	8.59	120	45
12	24	1	288	3	8.96	123	45
12	25	1	300	3	9.33	125	45
12	26	1	312	3	9.71	128	45
12	27	1	324	3	10.08	130	45
12	28	1	336	3	10.45	133	45
12	29	1	348	3	10.83	135	45
12	30	1	360	3	11.20	137	45
12	31	1	372	3	11.57	140	45
12	32	1	384	3	11.95	142	45
12	33	1	396	3	12.32	144	45
12	34	1	408	3	12.69	146	45
12	35	1	420	3	13.07	148	45
12	36	1	432	3	13.44	151	45

Individual Battery Voltage	No of batteries per string	System voltage	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
12	1	12	2	3	0.75	35	45
12	2	24	2	3	1.49	50	45
12	3	36	2	3	2.24	61	45
12	4	48	2	3	2.99	71	45
12	5	60	2	3	3.73	79	45
12	6	72	2	3	4.48	87	45
12	7	84	2	3	5.23	94	45
12	8	96	2	3	5.97	100	45
12	9	108	2	3	6.72	106	45
12	10	120	2	3	7.47	112	45
12	11	132	2	3	8.21	118	45
12	12	144	2	3	8.96	123	45
12	13	156	2	3	9.71	128	45
12	14	168	2	3	10.45	133	45
12	15	180	2	3	11.20	137	45
12	16	192	2	3	11.95	142	45
12	17	204	2	3	12.69	146	45
12	18	216	2	3	13.44	151	45
12	19	228	2	3	14.19	155	45
12	20	240	2	3	14.93	159	45
12	21	252	2	3	15.68	163	45
12	22	264	2	3	16.43	166	45
12	23	276	2	3	17.17	170	45
12	24	288	2	3	17.92	174	45
12	25	300	2	3	18.67	177	45
12	26	312	2	3	19.41	181	45
12	27	324	2	3	20.16	184	45
12	28	336	2	3	20.91	188	45
12	29	348	2	3	21.65	191	45
12	30	360	2	3	22.40	194	45
12	31	372	2	3	23.15	198	45
12	32	384	2	3	23.89	201	45
12	33	396	2	3	24.64	204	45
12	34	408	2	3	25.39	207	45
12	35	420	2	3	26.13	210	45
12	36	432	2	3	26.88	213	45

Individual Battery Voltage	No of batteries per string	System voltage V	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
12	1	12	3	3	1.12	43	45
12	2	24	3	3	2.24	61	45
12	3	36	3	3	3.36	75	45
12	4	48	3	3	4.48	87	45
12	5	60	3	3	5.60	97	45
12	6	72	3	3	6.72	106	45
12	7	84	3	3	7.84	115	45
12	8	96	3	3	8.96	123	45
12	9	108	3	3	10.08	130	45
12	10	120	3	3	11.20	137	45
12	11	132	3	3	12.32	144	45
12	12	144	3	3	13.44	151	45
12	13	156	3	3	14.56	157	45
12	14	168	3	3	15.68	163	45
12	15	180	3	3	16.80	168	45
12	16	192	3	3	17.92	174	45
12	17	204	3	3	19.04	179	45
12	18	216	3	3	20.16	184	45
12	19	228	3	3	21.28	189	45
12	20	240	3	3	22.40	194	45
12	21	252	3	3	23.52	199	45
12	22	264	3	3	24.64	204	45
12	23	276	3	3	25.76	208	45
12	24	288	3	3	26.88	213	45
12	25	300	3	3	28.00	217	45
12	26	312	3	3	29.12	222	45
12	27	324	3	3	30.24	226	45
12	28	336	3	3	31.36	230	45
12	29	348	3	3	32.48	234	45
12	30	360	3	3	33.60	238	45
12	31	372	3	3	34.72	242	45
12	32	384	3	3	35.84	246	45
12	33	396	3	3	36.96	250	45
12	34	408	3	3	38.08	253	45
12	35	420	3	3	39.20	257	45
12	**36**	**432**	**3**	**3**	**40.32**	**261**	**45**

Table 9: 12V batteries, installed within a room (no enclosure), arc flash typical arc flash details based on typical equipment details (Doan method)

						In Room (1.5)			12V batteries utilised																							
							12V																									
		Tarc (S)	2	D (cm)	45		Ibf (A)	2100																								
		Individual Battery Voltage	No of batteries per string	No of strings	System voltage (V)	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm		Individual Battery Voltage	No of batteries per string	System voltage	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm		Individual Battery Voltage	No of batteries per string	System voltage V	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm		Individual Battery Voltage	No of batteries per string	System voltage V	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
Cat 0		12	1	1	12	1.5	0.19	18	45		12	1	12	2	1.5	0.37	25	45		12	1	12	3	1.5	0.56	31	45		12	1	12	3	1.5	0.56	31	45
Cat 1		12	2	1	24	1.5	0.37	25	45		12	2	24	2	1.5	0.75	35	45		12	2	24	3	1.5	1.12	43	45		12	2	24	3	1.5	1.12	43	45
cat 2		12	3	1	36	1.5	0.56	31	45		12	3	36	2	1.5	1.12	43	45		12	3	36	3	1.5	1.68	53	45		12	3	36	3	1.5	1.68	53	45
Cat 3		12	4	1	48	1.5	0.75	35	45		12	4	48	2	1.5	1.49	50	45		12	4	48	3	1.5	2.24	61	45		12	4	48	3	1.5	2.24	61	45
Cat 4		12	5	1	60	1.5	0.93	40	45		12	5	60	2	1.5	1.87	56	45		12	5	60	3	1.5	2.80	69	45		12	5	60	3	1.5	2.80	69	45
Dangerous		12	6	1	72	1.5	1.12	43	45		12	6	72	2	1.5	2.24	61	45		12	6	72	3	1.5	3.36	75	45		12	6	72	3	1.5	3.36	75	45
		12	7	1	84	1.5	1.31	47	45		12	7	84	2	1.5	2.61	66	45		12	7	84	3	1.5	3.92	81	45		12	7	84	3	1.5	3.92	81	45
		12	8	1	96	1.5	1.49	50	45		12	8	96	2	1.5	2.99	71	45		12	8	96	3	1.5	4.48	87	45		12	8	96	3	1.5	4.48	87	45
		12	9	1	108	1.5	1.68	53	45		12	9	108	2	1.5	3.36	75	45		12	9	108	3	1.5	5.04	92	45		12	9	108	3	1.5	5.04	92	45
		12	10	1	120	1.5	1.87	56	45		12	10	120	2	1.5	3.73	79	45		12	10	120	3	1.5	5.60	97	45		12	10	120	3	1.5	5.60	97	45
		12	11	1	132	1.5	2.05	59	45		12	11	132	2	1.5	4.11	83	45		12	11	132	3	1.5	6.16	102	45		12	11	132	3	1.5	6.16	102	45
		12	12	1	144	1.5	2.24	61	45		12	12	144	2	1.5	4.48	87	45		12	12	144	3	1.5	6.72	106	45		12	12	144	3	1.5	6.72	106	45
		12	13	1	156	1.5	2.43	64	45		12	13	156	2	1.5	4.85	90	45		12	13	156	3	1.5	7.28	111	45		12	13	156	3	1.5	7.28	111	45
		12	14	1	168	1.5	2.61	66	45		12	14	168	2	1.5	5.23	94	45		12	14	168	3	1.5	7.84	115	45		12	14	168	3	1.5	7.84	115	45
		12	15	1	180	1.5	2.80	69	45		12	15	180	2	1.5	5.60	97	45		12	15	180	3	1.5	8.40	119	45		12	15	180	3	1.5	8.40	119	45
		12	16	1	192	1.5	2.99	71	45		12	16	192	2	1.5	5.97	100	45		12	16	192	3	1.5	8.96	123	45		12	16	192	3	1.5	8.96	123	45
		12	17	1	204	1.5	3.17	73	45		12	17	204	2	1.5	6.35	103	45		12	17	204	3	1.5	9.52	127	45		12	17	204	3	1.5	9.52	127	45
		12	18	1	216	1.5	3.36	75	45		12	18	216	2	1.5	6.72	106	45		12	18	216	3	1.5	10.08	130	45		12	18	216	3	1.5	10.08	130	45
		12	19	1	228	1.5	3.55	77	45		12	19	228	2	1.5	7.09	109	45		12	19	228	3	1.5	10.64	134	45		12	19	228	3	1.5	10.64	134	45
		12	20	1	240	1.5	3.73	79	45		12	20	240	2	1.5	7.47	112	45		12	20	240	3	1.5	11.20	137	45		12	20	240	3	1.5	11.20	137	45
		12	21	1	252	1.5	3.92	81	45		12	21	252	2	1.5	7.84	115	45		12	21	252	3	1.5	11.76	141	45		12	21	252	3	1.5	11.76	141	45
		12	22	1	264	1.5	4.11	83	45		12	22	264	2	1.5	8.21	118	45		12	22	264	3	1.5	12.32	144	45		12	22	264	3	1.5	12.32	144	45
		12	23	1	276	1.5	4.29	85	45		12	23	276	2	1.5	8.59	120	45		12	23	276	3	1.5	12.88	147	45		12	23	276	3	1.5	12.88	147	45
		12	24	1	288	1.5	4.48	87	45		12	24	288	2	1.5	8.96	123	45		12	24	288	3	1.5	13.44	151	45		12	24	288	3	1.5	13.44	151	45
		12	25	1	300	1.5	4.67	89	45		12	25	300	2	1.5	9.33	125	45		12	25	300	3	1.5	14.00	154	45		12	25	300	3	1.5	14.00	154	45
		12	26	1	312	1.5	4.85	90	45		12	26	312	2	1.5	9.71	128	45		12	26	312	3	1.5	14.56	157	45		12	26	312	3	1.5	14.56	157	45
		12	27	1	324	1.5	5.04	92	45		12	27	324	2	1.5	10.08	130	45		12	27	324	3	1.5	15.12	160	45		12	27	324	3	1.5	15.12	160	45
		12	28	1	336	1.5	5.23	94	45		12	28	336	2	1.5	10.45	133	45		12	28	336	3	1.5	15.68	163	45		12	28	336	3	1.5	15.68	163	45
		12	29	1	348	1.5	5.41	96	45		12	29	348	2	1.5	10.83	135	45		12	29	348	3	1.5	16.24	166	45		12	29	348	3	1.5	16.24	166	45
		12	30	1	360	1.5	5.60	97	45		12	30	360	2	1.5	11.20	137	45		12	30	360	3	1.5	16.80	168	45		12	30	360	3	1.5	16.80	168	45
		12	31	1	372	1.5	5.79	99	45		12	31	372	2	1.5	11.57	140	45		12	31	372	3	1.5	17.36	171	45		12	31	372	3	1.5	17.36	171	45
		12	32	1	384	1.5	5.97	100	45		12	32	384	2	1.5	11.95	142	45		12	32	384	3	1.5	17.92	174	45		12	32	384	3	1.5	17.92	174	45
		12	33	1	396	1.5	6.16	102	45		12	33	396	2	1.5	12.32	144	45		12	33	396	3	1.5	18.48	177	45		12	33	396	3	1.5	18.48	177	45
		12	34	1	408	1.5	6.35	103	45		12	34	408	2	1.5	12.69	146	45		12	34	408	3	1.5	19.04	179	45		12	34	408	3	1.5	19.04	179	45
		12	35	1	420	1.5	6.53	105	45		12	35	420	2	1.5	13.07	148	45		12	35	420	3	1.5	19.60	182	45		12	35	420	3	1.5	19.60	182	45
		12	36	1	432	1.5	6.72	106	45		12	36	432	2	1.5	13.44	151	45		12	36	432	3	1.5	20.16	184	45		12	36	432	3	1.5	20.16	184	45

Table 10: 2V batteries, installed within an enclosure, arc flash typical arc flash details based on typical equipment details (Doan method)

In Enclosure (3) **2V batteries utilised**

Cat 0	Tarc (S)	2		Working Distance (D) cm	45	Ibf (A)	8000	
Cat 1	Individual Battery Voltage	No of batteries per string	No of strings	System voltage	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
cat 2	2	1	1	2	3	0.24	20	45
Cat 3	2	2	1	4	3	0.47	28	45
Cat 4	2	3	1	6	3	0.71	35	45
Dangerous	2	4	1	8	3	0.95	40	45
	2	5	1	10	3	1.19	45	45
	2	6	1	12	3	1.42	49	45
	2	7	1	14	3	1.66	53	45
	2	8	1	16	3	1.90	57	45
	2	9	1	18	3	2.13	60	45
	2	10	1	20	3	2.37	63	45
	2	11	1	22	3	2.61	66	45
	2	12	1	24	3	2.84	69	45

Individual Battery Voltage	No of batteries per string	System voltage	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
2	1	2	2	3	0.47	28	45
2	2	4	2	3	0.95	40	45
2	3	6	2	3	1.42	49	45
2	4	8	2	3	1.90	57	45
2	5	10	2	3	2.37	63	45
2	6	12	2	3	2.84	69	45
2	7	14	2	3	3.32	75	45
2	8	16	2	3	3.79	80	45
2	9	18	2	3	4.27	85	45
2	10	20	2	3	4.74	89	45
2	11	22	2	3	5.21	94	45
2	12	24	2	3	5.69	98	45

Individual Battery Voltage	No of batteries per string	System voltage V	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
2	1	2	3	3	0.71	35	45
2	2	4	3	3	1.42	49	45
2	3	6	3	3	2.13	60	45
2	4	8	3	3	2.84	69	45
2	5	10	3	3	3.56	77	45
2	6	12	3	3	4.27	85	45
2	7	14	3	3	4.98	92	45
2	8	16	3	3	5.69	98	45
2	9	18	3	3	6.40	104	45
2	10	20	3	3	7.11	110	45
2	11	22	3	3	7.82	115	45
2	12	24	3	3	8.53	120	45

Table 11: 2V batteries, installed within a room (no enclosure), arc flash typical arc flash details based on typical equipment details (Doan method)

In Room (1.5) 2V batteries utilised

Cat 0
Cat 1
cat 2
Cat 3
Cat 4
Dangerous

Tarc (S)	2	D (cm)	45		Ibf (A)	8000	
Individual Battery Voltage	No of batteries per string	No of strings	System voltage	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
2	1	1	2	1.5	0.12	14	45
2	2	1	4	1.5	0.24	20	45
2	3	1	6	1.5	0.36	24	45
2	4	1	8	1.5	0.47	28	45
2	5	1	10	1.5	0.59	32	45
2	6	1	12	1.5	0.71	35	45
2	7	1	14	1.5	0.83	37	45
2	8	1	16	1.5	0.95	40	45
2	9	1	18	1.5	1.07	42	45
2	10	1	20	1.5	1.19	45	45
2	11	1	22	1.5	1.30	47	45
2	12	1	24	1.5	1.42	49	45

Individual Battery Voltage	No of batteries per string	System voltage	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
2	1	2	2	1.5	0.24	20	45
2	2	4	2	1.5	0.47	28	45
2	3	6	2	1.5	0.71	35	45
2	4	8	2	1.5	0.95	40	45
2	5	10	2	1.5	1.19	45	45
2	6	12	2	1.5	1.42	49	45
2	7	14	2	1.5	1.66	53	45
2	8	16	2	1.5	1.90	57	45
2	9	18	2	1.5	2.13	60	45
2	10	20	2	1.5	2.37	63	45
2	11	22	2	1.5	2.61	66	45
2	12	24	2	1.5	2.84	69	45

Individual Battery Voltage	No of batteries per string	System voltage V	No of strings	Installation type	Incident energy Cal/cm2	Arc Flash Boundary cm	Working Distance cm
2	1	2	3	1.5	0.36	24	45
2	2	4	3	1.5	0.71	35	45
2	3	6	3	1.5	1.07	42	45
2	4	8	3	1.5	1.42	49	45
2	5	10	3	1.5	1.78	55	45
2	6	12	3	1.5	2.13	60	45
2	7	14	3	1.5	2.49	65	45
2	8	16	3	1.5	2.84	69	45
2	9	18	3	1.5	3.20	73	45
2	10	20	3	1.5	3.56	77	45
2	11	22	3	1.5	3.91	81	45
2	12	24	3	1.5	4.27	85	45

Appendix 4 – PPE for Arc Flash Categories

This appendix lists typical arc flash initiators versus activity tasks. The list is not exhaustive but is intended to cover the most common tasks.

MWC MINIMUM PPE	4 cal/cm² PPE CATEGORY 1	8 cal/cm² PPE CATEGORY 2	25 cal/cm² PPE CATEGORY 3	40 cal/cm² PPE CATEGORY 4
				HAZARD - Be aware of heat stress when wearing Cat 4 clothing 
- Non-conductive eye protection - Natural fibre, flame retardant or 'PPE 2' clothing - Safety helmet (non-vented preferred) - Fully enclosed footwear	- Arc-rated long sleeve shirt - Arc-rated pants or overalls - Arc-rated face shield with hard hat - Safety glasses - Hearing protection - Leather & voltage rated gloves (as needed) - Leather work shoes	- Arc-rated long sleeve shirt - Arc-rated pants or overalls - Arc-rated face shield & balaclava or Arc flash suit with hard hat - Safety glasses - Hearing protection - Leather & voltage rated gloves (as needed) - Leather work shoes	- Arc-rated long sleeve jacket - Arc-rated pants - Arc-rated flash hood with hard hat - Safety glasses - Hearing protection - Leather & voltage rated gloves (as needed) - Leather work shoes	- Arc-rated long sleeve jacket - Arc-rated pants - Arc-rated flash hood with hard hat - Safety glasses - Hearing protection - Leather & voltage rated gloves (as needed) - Leather work shoes

Figure 2: Australian Energy Council Arc Flash Management Guideline 2019, with amendment of PPE category 3 image to further differentiate jacket from shirt. MWC have also added MWC MINIMUM PPE. Copyright image reproduced with permission from Australian Energy Council

Appendix 5 – Unlabelled Low Voltage equipment - Default category to be assumed

It is recognised that many switchboards will not yet have arc flash labelling installed. Therefore, as an interim measure, the following table has been produced. The table is based on already completed sites calculated results and the suggested values given in *AS/NZS 4836 2023 Safe working on or near low voltage and extra low voltage electrical installations and equipment table B1*.

Table 12: Assumed PPE category for unlabelled Low voltage switchboards

Upstream Device	Assumed Category
Low Voltage Fuse	Where upstream device for single phase 230Vac is a fuse ≤ 150A MWC min PPE can be reasonably assumed
	Where upstream device for 3 phase 415Vac is a fuse ≤ 63A MWC min PPE can be reasonably assumed
	Where upstream device is a LV fuse ≤ 800A CAT 2 can be reasonably assumed
	Where upstream device is a LV fuse > 800A CAT 4 can be reasonably assumed
Low Voltage Circuit Breaker	Where upstream device for single phase 230Vac is a circuit breaker ≤ 80A MWC min PPE can be reasonably assumed
	Where upstream device is an LV circuit breaker ≤ 250A CAT 2 can be reasonably assumed
	Where upstream device is an LV circuit breaker >250A but ≤ 1250A CAT 4 can be reasonably assumed
	Where upstream device is an LV circuit breaker > 1250A Dangerous category can be reasonably assumed
Transformer (i.e. where there is no protective device between the transformer and the supplied equipment)	Where upstream device is a transformer ≥ 315KVA with no known LV protection in between it and the point being considered, CAT 2 can be reasonably assumed
	Where upstream device is a transformer >315kVA but < 750KVA with no known LV protection in between it and the point being considered, CAT 4 can be reasonably assumed
	Where upstream device is a transformer ≥ 750KVA with no known LV protection in between it and the point being considered, Dangerous category can be reasonably assumed