Specification

Engineering Standard E-SPE-STD-007 Power System Modelling and Arc Flash Analysis

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Ver No.	Description	Document Owner		Document Approver		
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This Engineering Standard was endorsed by an RPEQ on behalf of Seqwater.						

Contents

1. Purpose

This document is part of a suite of Seqwater Engineering Standards which are in alignment with the Seqwater Quality Management System. Their purpose is to provide a consistent approach to the development, modification, and management of Seqwater infrastructure that is fit for purpose, economic over the life of the asset, and meets Seqwater's Work Health and Safety obligations.

This Standard Specification provides the minimum requirements for conducting power system modelling and arc-flash analysis, specifically related to arc-flash incident energy calculation and risk assessment. It further outlines the specific requirements for:

- Development and management of power system model files
- Conducting arc-flash assessment and all pre-requisite studies
- Documenting and publishing study results
- Labelling of Arc Flash Hazard levels on switchboards and electrical equipment

This Standard Specification shall apply to arc-flash assessment on all HV and LV electrical equipment, connected to Seqwater site electrical networks, and shall be used in conjunction with the documents referenced herein.

Other Power System Analysis studies (such as Load Flow, Harmonic Analysis and Motor Starting) are not described in this Standard Specification but may be required by the Project Specification, and may be combined into a common PSA Model and Report.

The objective of this document is to provide a consistent and repeatable methodology for power system modelling and arc flash analysis such that arc flash risks can be identified and managed systematically across Seqwater's electrical infrastructure.

This document must be used in conjunction with the documents it references to assist in ensuring fit for purpose infrastructure. This Standard Specification is not intended to be relied on solely for design, supply, and installation works; advice from specialist engineers and/or manufacturers may be required on a case-by-case basis.

2. Scope

This Standard Specification applies to all Seqwater employees, contractors, suppliers and consultants working for or on behalf of Seqwater unless otherwise stated. It applies to all new assets and to all existing assets undergoing refurbishment or modification. It must be used in conjunction with other relevant Seqwater Engineering Standards and project specific documents to define the technical requirements for infrastructure design and construction.

Where single or discrete components of an existing non-compliant system are to be replaced, refurbished or modified, this standard should not automatically be applied to the entire system retrospectively, however consideration should be given, in consultation with relevant stakeholders, to the extent of the application of the standard outside of the components requiring replacement, refurbishment or modification, to ensure safe, economic, and fit for purpose infrastructure.

Seqwater Engineering Standards detail Seqwater's minimum requirements and recommendations to provide infrastructure that will be fit for purpose, and safe to operate and maintain. However, compliance with these requirements and recommendations does not remove, and cannot be relied on as meeting, the designer's overarching responsibility for ensuring infrastructure designed is fit for purpose and safe to construct, operate, maintain, and demolish. The designer must exercise appropriate due diligence to identify and manage hazards so far as is reasonably practicable.

Designers must also ensure compliance with relevant Australian Legislation, Standards, Codes and Guidelines (including those produced by Water Services Association of Australia). Where no Australian Standard exists for a particular application, work must conform to the most current version of an industry accepted international standard.

Deviation from meeting the minimum requirements in this Standard Specification requires written agreement from Seqwater as per the deviation process detailed in Procedure X-PRO-STD-008 Asset Standards Management and Application. That process includes completion of an X-TMP-STD-022 Asset Standards Deviation Request Form and submission by the Seqwater Project Representative to the Seqwater Engineering Mailbox. Where noted in this Standard Specification that Seqwater approval, agreement, or acceptance shall/must be sought, such approval, agreement or acceptance must be gained through the Seqwater Asset Standard Deviation process, as outlined above.

Responsibility for ensuring compliance with Seqwater Engineering Standards lies with those engaged in the management and execution of design, construction, and modification of Seqwater infrastructure. This includes modifications to the functional design of the infrastructure including technical changes made which would extend an asset outside of its design operating envelope and/or approved operation and maintenance practices.

Any ambiguities or conflicts identified between specific requirements within this Standard and project documents, another Seqwater Engineering Standard or Australian Legislation, Standards, Codes or Guidelines, these must be brought to the attention of the Seqwater Document Owner, via the Engineering Mailbox, for clarification. Where it is proposed to proceed without meeting the requirements of this standard, agreement must be obtained via the Deviation Process, as outlined above.

Seqwater undertakes regular updates of its Engineering Standards. Before utilising this Engineering Standard, the complete list of Seqwater Engineering Standards should be reviewed to ensure currency and applicability of standards to be applied to the works. These can be accessed on the Waternet Seqwater Engineering Standards page. Instructions for downloading Standards are also provided on the Waternet Seqwater Engineering Standards page.

3. Power System Analysis

Power System Analysis (PSA) is an engineering basis approach to study power system networks. The PSA and arc-flash report for each site shall include all (HV and LV) electrical equipment connected to the site network directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope, including sufficient detail of the DNSP (Energex) assets so far as they impact fault level, arc flash incident energy, and electrical and protection design for the Seqwater electrical assets or as specified otherwise in the project scope of work.

The power system arc flash analysis for each Seqwater site shall, as a minimum, consist of the following components:

- Fault Current Calculation report (Short circuit analysis).
- Protection coordination analysis.
- Arc-flash incident energy analysis.

The Project Documentation will define which reports are to be delivered under the Contract.

3.1. Responsibility

The PSA works, arc flash analysis and arc flash label development shall be conducted by, or under the direct supervision of, a registered professional engineer of Queensland (RPEQ) who takes full professional responsibility for the work. In addition, it is a fundamental requirement that the responsible RPEQ and any supervised personnel conducting or checking the work have knowledge in power system analysis and protection systems, experience in the software tools and computation methods used, and awareness of the relevancy of data and information necessary to perform such analysis accurately.

All revisions of the report issued to Seqwater, including both preliminary revisions for review and the final issue, shall include the name of the author, name of the checker, and the name, RPEQ number, date and signature of the RPEQ responsible for the work.

3.2. Engineering software

SKM Power Tools® for Windows™ (PTW) version 9.0.0.4 or later shall be used to perform all modelling and power system analysis. The PTW software package used shall, as a minimum, be licensed to perform the following:

- Short-circuit analysis.
- Protection coordination.
- Arc-flash analysis.

The exact version of PTW used shall be specifically stated in the PSA arc-flash engineering report. Additionally, to support the calculation results and report conclusions, all reports and single line diagrams (obtained from the PTW software) shall be included in the engineering report in the form of appendices.

3.3. Power System Analysis methodology

The PSA relevant to this document shall be developed using the following engineering steps:

- Data collection of the installation and site validation of data.
- Modelling of electrical single line diagrams including protective devices.

- Maximum and minimum short circuit calculation.
- Production of Time Current Curves (TCC) and coordination study.
- Arc-flash hazard analysis.
- Preparation of equipment arc flash labelling (where requested by Seqwater).

3.4. Data collection

The contractor shall be responsible for collecting and validating all available site electrical installation data, relevant to modelling and analysing equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope. This data collection shall include, but not be limited to the following:

- Existing SLD's and verify the accuracy of the drawings.
- Existing Seqwater and manufacturer documentation.
- Transformer, motor (≥37kW) and generator name plate details (e.g. voltage, tap settings, ampacity, kW or kVA, electrical machines impedances and so on).
- Mode of operation for on-site generator(s) - standby only or designed for operation in parallel with grid supply.
- Circuit breaker and relay test reports.
- Datasheets for motors, generators and switchboards.
- Copies of any previous PSA studies or PTW models where available.
- Cable schedules showing cable size, type, insulation, route length and installation details (e.g. routing and support method, in conduit, cable ladder, etc).
- Protective devices ratings, settings, trip unit type, and make/model.
- CT ratios, and specifications (accuracy, class, protection or metering application, etc).
- HV and LV motor characteristics.
- Mode of operation for motors – for example, is a pair of pumps able to operate duty-duty or only duty-standby.
- Any additional engineering data that may influence in the calculation process for this specific site.

3.4.1. Site Data Verification

The contractor must conduct an inspection of the specified site to verify the accuracy of all data obtained for equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope. (Exception: Site data verification may be omitted for studies where all required information is explicitly issued by Seqwater as verified reliance information. For studies where some information is explicitly issued by Seqwater as verified reliance information, site data verification is required for the gaps in the verified reliance information for equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope.)

The contractor shall access sites and undertake all site works in accordance with Seqwater's site access procedures. In the first instance, the contractor should arrange such access, through their designated Seqwater contact.

Data collected on site shall be in the form of digital photos and/or notes in electronic format. Photos are the preferred method to record site data and as-found settings on devices. All source data, collected from site visits, shall be made available at the request of Seqwater. Photo file names shall include the date they were taken. Where this is not practical, photos shall be grouped into dated folders.

If during site verification any errors or inconsistencies are identified on the existing site documentation then the contractor must immediately notify Seqwater of such and advise the as found condition.

3.4.2. Power Utility Data

In addition to the Seqwater site data, the contractor shall also obtain the power utility prospective short circuit current at the point of common coupling (PCC); for input into the power system model, including:

- Utility supply nominal voltage,
- Prospective short circuit current level at point of supply (minimum and maximum) for three phase and single phase to ground faults
- System X/R ratios if available.
- The relevant protective device / settings managed by the power utility at the PCC shall also be sourced for protective device coordination purpose.
- Seqwater shall be consulted in the first instance as the protective device information / settings may already be available in the central database. If the power utility protective device information / settings cannot be confirmed by Seqwater the contractor shall obtain this information from the supply authority.

The information obtained from the power utility shall be appended to the PSA report.

3.5. Power system model

Using the input data obtained for the specified site (section 3.4), the contractor shall construct a power system model in the PTW software.

The PTW model shall use bus names and device names that correspond as closely as practicable to the existing site equipment numbering. Suffixes may be used to differentiate multiple buses in the PTW model that form part of the same equipment. (E.g. transformer HV and LV sides.) An example is provided in Appendix A.

It should be noted that the power system one-line model developed in PTW software does not aim to replace the single line diagram of the plant.

The final model shall be provided to Seqwater, inclusive of all libraries, suitable to be re-used by other service providers.

3.5.1. Power system model assumptions

The following assumptions are considered acceptable for the purpose of constructing power system models for PSA arc-flash calculations.

- LV asynchronous motors - to simplify the building of the power system network modelling without compromising the final calculation accuracy, it is acceptable to group (lump) together multiple LV small asynchronous motors (≤ 37kW) and their connection cables to represent an equivalent motor of the installation. This approach is detailed in Australian Standard AS 3851.
- In the absence of documentation for cable sizes or where determination of the cable size is not feasible through a site inspection, it is a reasonable engineering approach to estimate the cable size based on the protective device ratings. However, it is important to know the cable installation type to apply this engineering assumption by conducting site inspections. In the first instance, the contractor shall liaise with the Principal to determine whether or not a shutdown can be planned in a timely manner so that cable sizes can be confirmed either by lug sizes or by measurement of overall cable diameter.

- LV cable impedances may be modelled using AC resistance and AC reactance values in AS/NZS 3008.1.1. Cable AC resistance shall be selected based on the cable rated temperature.
- LV cable current carrying capacity may be determined using data and derating factors in AS/NZS 3008.1.1.
- Final subcircuit non-rotating loads supplied by a circuit protective device rated at 32A or less may be aggregated into a lumped load (unless necessary for design).
- Single phase 230VAC switchboards supplied by a circuit protective device rated at 32A or less do not need to be separately modelled in PTW (unless necessary for design). The load may be aggregated with the upstream switchboard.
- UPSs, LV harmonic filters and non-regenerative LV VFDs that are separately wall mounted and supplied by a CB/fuse ≤32A, may be modelled as a lumped load.
- UPSs, LV harmonic filters and non-regenerative LV VFDs that are built into an MCC or switchboard may be modelled as a lumped load.
- DC systems do not need to be separately modelled in PTW. Rectifier loads may be aggregated with the upstream AC switchboard.

Note that the aforementioned assumptions are specific to PSA for arc-flash calculation, and may be not sufficient for other studies or design purposes.

One of the objectives of the PTW modelling is to identify all locations with an incident energy exceeding 1.2cal/cm^2 at the applicable working distance. If arc flash calculations indicate or imply an incident energy exceeding 1.2cal/cm^2 at the location of a lumped or unmodelled load, the lumped/unmodelled loads shall be separately added into the model to confirm the specific location of such arc flash hazards.

Any additional assumptions made by the contractor must first be presented to and approved by the Principal.

All assumptions shall be listed within the assumptions section of the site PSA report.

3.5.2. PTW Model Management

Seqwater maintains a suite of site PTW model files for major sites in REX. Models are organised as one separate project for each site network, each containing their own unique device library.

When a contractor is required to carry out power system analysis at an existing site, the contractor shall request the existing site PTW model from the Seqwater Project Manager. The Seqwater Project Manager will request the existing site PTW model (if available) from Seqwater Engineering and issue it to the contractor.

Models are reserved on a “One model, one user” basis to ensure the integrity of the information contained within. Where there are multiple simultaneous projects on one site, the model will be issued for updating to only one project at a time. Any further simultaneous projects must coordinate site power system changes with the original project holding the model, in consultation with Seqwater Engineering.

PTW model files issued to the contractor by Seqwater are for information only and shall not be relied on by the contractor for site data. In particular, where there are concurrent projects at the same site, the model issued by Seqwater may not reflect the latest constructed or planned works. The contractor shall independently check the accuracy and completeness and suitability of the model against site data and other records as per section 3.4 for equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope.

Where the existing PTW model does not accurately reflect the existing installation, the contractor shall update the PTW model to reflect the existing site power system (for equipment directly in project scope and any part of the

system that could influence or be influenced by the equipment directly in project scope) before starting on any modifications forming part of the project. Where there is no existing PTW model, the contractor shall create the PTW model of the existing site (for equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope). Commentary regarding model development shall be provided in the PSA report to clearly articulate what has been done.

The updated PTW system model, all protective device libraries and other relevant information shall be provided to Seqwater in native format after Seqwater has accepted all reports related to the PSA of the site.

The site model shall be provided as a zip file of the entire PTW project folder for the site, including the PTW project file, associated project database files, PTW drawing(s), PTW report(s) and PTW library.

The model PTW project file and overall zip file shall be named with the following naming format:

E-PTW-[Area/Facility Code]-001 – [Area/Facility Description] - [Date in YYYYMMDD format] - [Revision Description]

E.g. E-PTW-SLO-001 – Lowood Intake RWPS – 20230208 – AS FOUND

The revision description shall describe the status of the model using one of the options below:

- AS FOUND
- PLANNING
- DESIGN
- AS CONSTRUCTED

The model for a network that spans multiple facilities shall be named based on the facility with the majority of electrical infrastructure.

The PTW model shall include a title block on the main single line diagram in PTW, including the details of the site name, PTW revision date, PTW model revision description, author name, company name and document number reference for the corresponding PSA report.

PSA reports shall include a reference to the applicable PTW file name including revision date and description.

3.5.3. PTW Library Management

The devices preinstalled in the PTW library are unlikely to include all the devices needed, particularly for protection relays.

Where the site includes devices that are not present or not correctly modelled in the existing PTW library, the contractor shall create/update the device in the PTW library.

Changes made by the contractor to the PTW library will be documented in a Memorandum which shall be appended to the PSA report. This shall be inclusive of the vendor published TCC and adjustable parameters in a condensed form. Submission of entire manuals is not acceptable.

3.6. Power study scenarios

Many of Seqwater's sites are capable of being fed from multiple sources of supply. This may include multiple supply connections to the power utility or supply from onsite stand-by generation sources.

Seqwater sites may include one of more of the following typical arrangements for on-site generation:

- Permanent solar or hydro generator operating in parallel with the grid

- Permanent standby diesel generator
- Designated connection point for a transportable diesel generator

Additionally, there may be multiple options for switching of HV ring networks, or options to feed switchboard from one or more transformers in parallel.

The PSA study shall consider all the relevant scenarios that may affect the plant prospective short-circuit current, protection settings and the arc-flash incident energy calculation results.

Where the site includes a standby generator connection point, the study shall consider the typical generator intended for use with the connection point.

PSA studies shall model and report on both (i) the existing site network and protection settings, and (ii) the proposed site network incorporating recommended or designed changes.

The existing and proposed network, each under applicable supply scenarios, shall be modelled in PTW using the PTW Scenario Management tool. The base scenario shall be the existing or as-built site network under normal supply conditions.

3.7. Arc-Flash and Power System Analysis Report

The contractor shall produce and provide to Seqwater a Power System Analysis Report for equipment directly in project scope and any part of the system that could influence or be influenced by the equipment directly in project scope. This report shall include the outputs from the short circuit study, protection grading analysis, and arc-flash calculations; in accordance with the specific requirements outlined in the standard.

As a minimum, the report shall contain the details outlined in Appendix D.

The report shall be provided to Seqwater for review and acceptance prior to the production and application of equipment specific labelling (per section 0).

4. Short Circuit Analysis Study

The contractor shall conduct all short-circuit calculations in compliance with IEC 60909 with voltage factors set as per section 4.1.

Calculations shall be conducted for the scenarios identified (per section 3.6) using the PTW software. For each scenario, the maximum and minimum short-circuit current levels shall be calculated and published in accordance with the following sections:

4.1. Maximum and minimum short-circuit currents

The maximum and minimum short-circuit currents shall be calculated using the corresponding voltage factors (C_{max} and C_{min}) as defined in Australian Standard AS 3851:1991, Tables 5.1 and Table 5.2. respectively. These values are summarised in Table 1 below.

Additionally, the maximum and the minimum short-circuit currents shall be calculated, as follows:

- **Maximum short-circuit current** shall be determined with maximum operating levels of generation plant able to run under the power study scenario and with all the electrical network in service, except standby equipment with mechanical/electrical interlocks designed to never run in parallel with duty equipment. “Normally open”

points which are only closed to maintain supply during rearrangement of the system shall be assumed to be open. The maximum fault level calculated in accordance with AS 3851:1991, clause 5.2 might be exceeded for short period of times when these points are closed. The minimum equivalent external source impedance (e.g. power utility) shall be used which corresponds to the maximum short-circuit contribution from the external source.

- **Minimum short-circuit current** – Shall be determined with outages of motor plant and minimum generation viable for the scenario. For a mains supply scenario, the maximum equivalent external source impedance (e.g. power utility) shall be used which correspond to the minimum short-circuit contribution from the external source. Resistance (R_L) of circuits (overhead lines and cables) shall be adjusted to 150% (copper, aluminium and aluminium alloys) of the resistance at a temperature of 20° C as per Australian Standard AS 3851:1991.

Table 1 – Maximum and minimum voltage factors

Voltage Range	C_{min}	C_{max}
0 V – 650 V	0.94	1.06
650 V – 36 kV	0.90	1.09

4.2. Variable Frequency Drives

The variable frequency drive (VFD) contribution to the fault shall be determined based on the manufacturer data. However, it is noted that under typical installations, the variable frequency drive will not contribute to the fault. The contractor shall ascertain as to whether the variable frequency drive is of the regenerative type or not as this will have implications to the fault current contribution on the line side of the variable frequency drive.

Where the installation is an existing installation, the contractor shall obtain all details pertaining to the variable frequency drive in question. On new installations, the assessment shall be based on the VFD manufacturer's data corresponding to the make and model nominated on the design drawings.

Short circuit studies which have the variable frequency drives configured in the bypass mode will not be accepted unless the contractor can demonstrate that this is how the actual installation is configured. Generally, the bypass mode is only applicable on soft start installations only and thus is not applicable on variable frequency drive installations.

All input data pertaining to the variable frequency drive as part of the short circuit study shall be provided as appendices to the PSA report.

4.3. Short Circuit Calculation Results

The short circuit calculation results shall be summarised, within the PSA report, in tabulated format. Refer to Table 2 an example of the calculation results to be incorporated in the relevant section of the project specific power system report.

Table 2 – Example - Short-circuit (SC) calculation summary

Equipment	Bus	Rated Voltage (kV)	3 Ph Peak Short Circuit current (I_p) (kA)	3 Ph Symmetrical Short Circuit Breaking current (I_b) (kA)	Minimum Short Circuit (I_k"min)		Maximum Short Circuit (I_k"max)	
					3 Ph (kA)	1 Ph (kA)	3 Ph (kA)	1 Ph (kA)
SWBD-01	BUS-001	11	16.5	15	4.5	4	6.5	5.5
SWBD-02	BUS-002	11	12.5	14	3.5	3	5	4.5

4.3.1. Equipment rating and protection pickup verification

Based on the calculated minimum and maximum short circuit currents calculated, the contractor must ensure that each protection device and associated switchboards are correctly rated for its application in the system by confirming that:

- Breaker interrupt capacity is adequate to interrupt the maximum expected fault level
- Switchboard fault current withstand rating is adequate for the maximum expected fault level
- Protection device is correctly set to operate for minimum expected fault level

Where equipment ratings are satisfactory on the basis of manufacturer approved cascade configuration, this should be noted by the contractor in the PSA report. Manufacturer cascade tables must be provided as Appendices to the PSA report.

For all new installations, the use of cascade protection shall be limited to MCB's only. That is to mean that a MCCB will enhance the fault rating of the downstream MCB's.

Table 3 – Example of equipment rating verification table

Equipment	Bus	Rated Voltage (kV)	Maximum Short Circuit Current (I_k"max)		Equipment Short Circuit Withstand (I_{cw})		Compliance Check	
			3 Ph (kA)	1 Ph (kA)	3 Ph (kA)	Time (s)	$I_{cw} > I_k$"	Pass
SWBD-01	BUS-001	11	4.5	4	20	1	Yes	Yes

Table 4 – Example of protective device verification table – per switchboard

Protective Device ID	Maximum Short Circuit Current (I_k"max) kA	Protective Device Rated Breaking Capacity (I_{cu}) kA	Compliance Check	
			$I_{cu} > I_k$"	Pass
Q1	4.5	25	Yes	Yes

5. Protection Coordination Study

The contractor shall conduct a protection coordination study to ensure correct protection system grading and reliable power system operation is achieved.

The following section outlines the specific requirements, to be completed by the contractor, and the required outputs from this study.

5.1. Protection Setting Schedule - as-found

It is essential that all adjustable device settings are confirmed by the contractor during the site inspection; in accordance with the data collection requirements outlined in section 3.4.

Following verification, the contractor shall produce a protective device setting schedule showing as-found settings, manufacturer, model and type for each protection device for the specified site. This shall include the utility (Energex) incomer protective device/s upstream of the PCC.

This as-found setting schedule must be published in the PSA report to indicate the study input data. Settings that are not user settable, or that are factory defaults, should be clearly identified as such.

Where changes to protection settings are required, the proposed settings that are different to the existing settings should be highlighted.

The protection setting schedule shall include the minimum information (where applicable to device type) shown in Table 5 below.

Table 5 – Example Protection Setting Schedule – LV Installation

Device ID	Device Type	Manufacturer, Model, Trip Unit	Trip Rating	Element	Identifier	As-Found Setting	Proposed Settings
Q1	ACB	Schneider, MTZ2, Micrologic 6.0X	1600A	Ir	Long time pickup	1 (xxA)	**2 (xxA)**
				tr	Long time delay	15 sec	**5 sec**
				Isd	Short time pickup	1.2 (xxA)	**1.5 (xxA)**
				Tsd	Short time delay	0.1 sec	0.1 sec
				I^2t	On/Off	On	On
				Ii	Instantaneous	15 (xxA)	15 (xxA)

5.2. Time current characteristic curves (TCCs)

The time grading between relays located on each protected zone of the power system shall be demonstrated as part of the PSA report. The PTW generated time current curves shall be included within the PSA report appendices and shall include the following minimum information for each device by type.

Protection relays:

- CT ratio.
- Relay manufacturer /type.
- Long-time O.C phase settings.
- IDMT selected curve.
- Instantaneous settings.

LV ACB sensor:

- Long-time protection pick-up.
- Long-time protection time delay.
- Short-time protection pick-up.
- Short-time protection time delay.
- Short-time protection - I^2t curve ON/OFF (as required on a case-by-case basis).
- Instantaneous protection pick-up (as required on a case-by-case basis).
- Ground fault protection pick-up (as required on a case-by-case basis).
- Ground fault protection time delay (as required on a case-by-case basis).
- Ground fault protection - I^2t curve ON/OFF (as required on a case-by-case basis).

Fuses:

- Fuse Manufacturer
- Fuse Class (e.g. Gg)
- Fuse Rating

To demonstrate satisfactory grading throughout the power system, the relevant elements of the power system associated with the protective devices shall be plotted on the same log-log graph as protective devices immediately upstream and downstream. To ensure clarity, the plotting of more than three successive protective device's TCCs on a single log-log graph shall not be acceptable.

In addition to the protection device TCC's, other relevant elements of the power system that should also be graphed include, but are not limited to, the following:

- Power cable and bus damage curves
- Transformer thermal withstand capability
- Transformer inrush transient current
- Motor start up transient current
- Incident Energy Level curves
- Worst Case Arcing fault line
- SLD out of PTW showing the relevant faulted point

The log-log graph reference voltages shall be for the relevant bus voltage associated with the protective devices.

Sufficient TCC curves must be provided to demonstrate grading throughout the scope of the study, including for any existing equipment that may be impacted by the project.

An example of the TCC required presentation is shown in Figure 1 below.

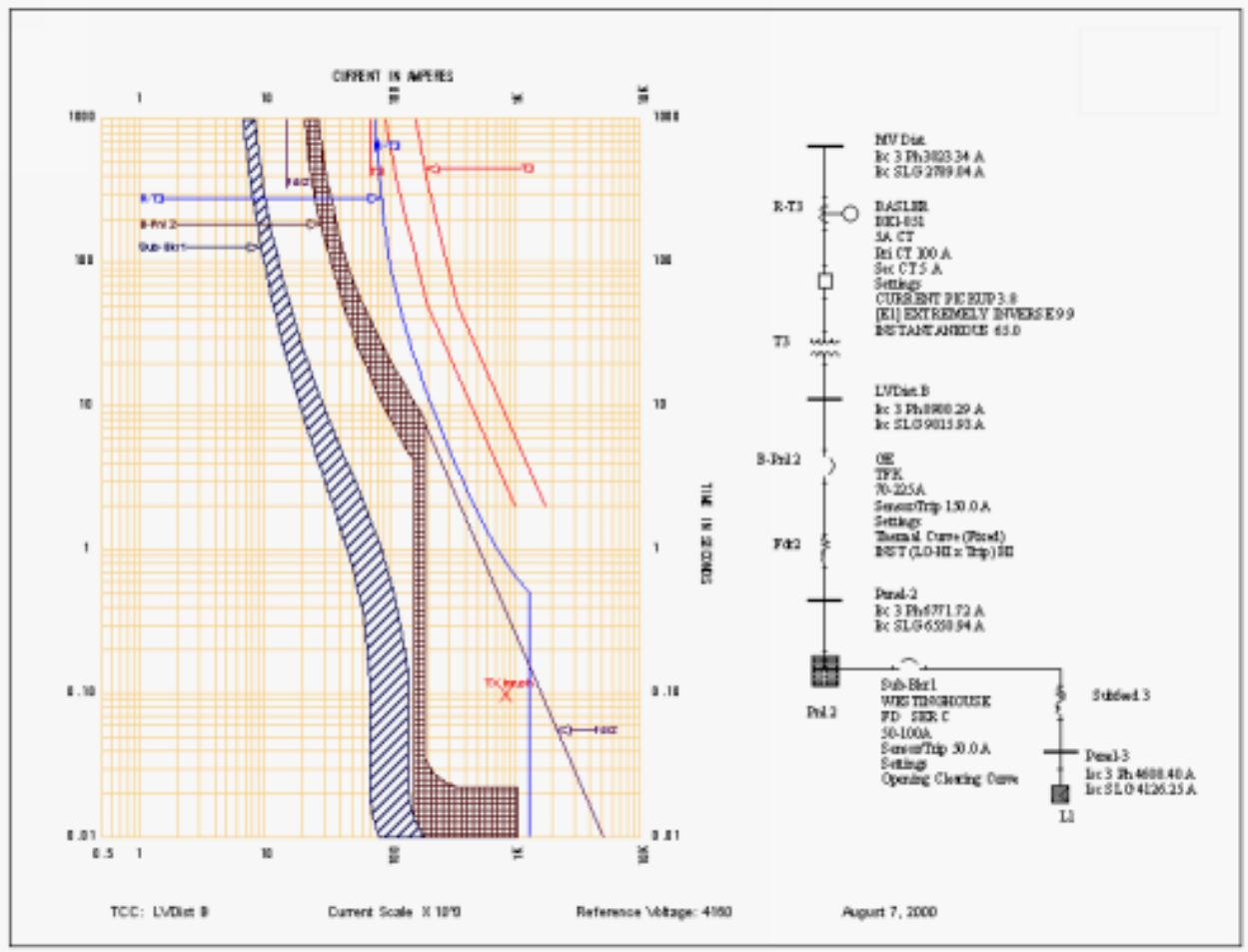


Figure 1 – Example of TCC

5.3. Protection Grading Analysis

Protective devices shall maintain selectivity; that is, only those circuit-breakers whose operation are required to isolate a fault within a protected zone of the power system should trip. This is also known as “discrimination” or “time grading”. Where time-based grading is used, instead of unit protection schemes (such as differential protection), then a grading analysis must be performed by the contractor; to confirm satisfactory grading.

In performing the protection grading analysis, the contractor shall utilise as-found protection settings to generate TCC’s for each device; in accordance with section 5.2. The TCC’s shall be evaluated by the contractor to ensure that adequate discrimination exists between upstream and downstream devices. Analysis should include both 3-phase and earth fault scenarios.

The contractor shall also confirm that equipment such as cable, transformers and generators are adequately protected by the selected protective device settings. This shall be demonstrated by inclusion and comparison with the relevant equipment damage curves.

5.4. Recommended Settings

Any proposed changes of the existing protection settings shall be detailed on a revised settings schedule and included within the PSA report recommendations.

The as-found and proposed settings shall be tabulated in the same settings schedule but within separate cells and with the changes shown in red colour to clearly communicate where a change has been proposed from the as-found settings. Please refer to Table 5 for an example which may be used to comply with this requirement.

Recommendations for protection setting changes must consider equipment ratings and loadings. Commentary on the proposed changes shall be provided to justify why a change to the existing protection settings is recommended.

In instances where protection coordination cannot be adequately achieved, the contractor shall advise Seqwater of such and advise the reasons why the proposed settings can be accepted and how compliance with AS/NZS 3000 and Energex requirements is proposed to be achieved.

5.4.1. Coordination and Reliability of Supply

A practical method of reducing arc flash incident energy is to modify the protective device selection/settings for faster operation at a given arc flash fault current, while maintaining time and current coordination between protective devices.

Optimising the protection settings can require a trade-off between arc flash incident energy and maintaining a high degree of discrimination for reliability of supply.

Seqwater operates water supply electrical infrastructure with differing criticality and reliability requirements.

When developing protection settings, the contractor shall evaluate and document in the PSA report both the reliability of supply considerations and arc flash safety considerations.

New installations must achieve discrimination between upstream and downstream protective devices while minimising the arc flash incident energy.

For existing installations where it is proposed to modify protection settings that will reduce supply reliability to achieve an arc flash incident energy reduction, or vice versa, this shall be supported with a risk assessment by the contractor involving Seqwater stakeholders.

6. Arc-Flash Analysis Study

An arc flash or fault happens when electric current flows through air gaps between conductors, essentially, arc-flash is a short-circuit. An arc-flash event often occurs when racking in a breaker, performing switching, having insulation failure, touching a test probe to the wrong surface or slipped (non-insulated) tools. In its most basic form, an arc is made up of four elements, as follows:

- Thermal energy dissipated as radiant, convective, and conductive heat.
- Acoustical energy (sound).
- Pressure waves.
- Ejection of debris and shrapnel.

An arc flash may result in severe burns, damage to eyesight, damage to hearing, puncture wounds, internal injuries and death. The pressure waves may propel tools and loose materials such as metal pieces. Additionally, liquid metal droplets and metal oxide dust are created by atomisation from such high levels of energy. The severity of the arc flash is essentially determined by the fault current and the overcurrent protection device operating time.

The following section outlines the requirements for conducting the Arc-flash hazard analysis and deliverables to be provided by the contractor.

6.1. Arc Flash Calculations

In Australia, no specific Australian Standard exists for quantitative arc flash analysis. As this is the case, industry best practice for arc flash analysis is to use the IEEE 1584 standard to estimate incident energies and arc flash boundaries. This is also the methodology referenced by *AS/NZS 4836 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment.*

Calculations in accordance with IEEE 1584 standard (latest edition) shall be undertaken using the PTW software to calculate the following:

- The worst-case arc-flash incident energy (Cal/cm^2) at working distance. The incident energy shall be calculated using the typical Working Distances defined for the given voltage and class of equipment.
- The arc-flash boundary. The arc-flash boundary is an approach limit at a distance from an arc source at which the incident energy equals 1.2 Cal/cm^2.

To determine the worst-case incident energy at each fault location (section 6.2) the arc flash calculations must be conducted for each scenario, for both the as-found and proposed protective device settings.

6.2. Assessment locations

6.2.1. General

Unless otherwise specified in the project scope or agreed by the Principal, and considering the inclusions and exclusions in sections 6.2.2 and 6.2.3, the contractor shall calculate and publish the worst-case arc-flash incident energy calculations for all:

- Fault locations included in the project scope electrical equipment
- Fault locations within a site that could have a change in arc flash energy as a result of the project scope or protection setting changes

6.2.2. Fault Location Inclusions

Arc flash assessment must as a minimum be conducted at the following equipment:

- High voltage switchboards and RMUs
- High voltage VFDs
- Transformer HV and LV terminal boxes
- Generator LV breaker compartment and connection terminal box
- Three phase low voltage Switchboard, Motor Control Centre, Distribution Board
- Vendor supplied motor control panels
- Single phase LV Switchboard >32A
- Equipment mounted outside switchboards that could be interacted with while energized and may have arc flash hazards, including:

- LV Field isolators
- LV VFDs installed outside switchboard/MCC
- UPSs installed outside switchboard/MCC
- Harmonic filters installed outside switchboard/MCC

For switchboards, MCCs, distribution boards, kiosk substations and similar equipment that include an incoming protective device, the arc flash assessment shall simulate faults at locations both upstream and downstream of the main incoming protective device (i.e. locations (1 – Incoming Supply) and (2 – Main Busbar or distribution blocks) as indicated in Figure 2.

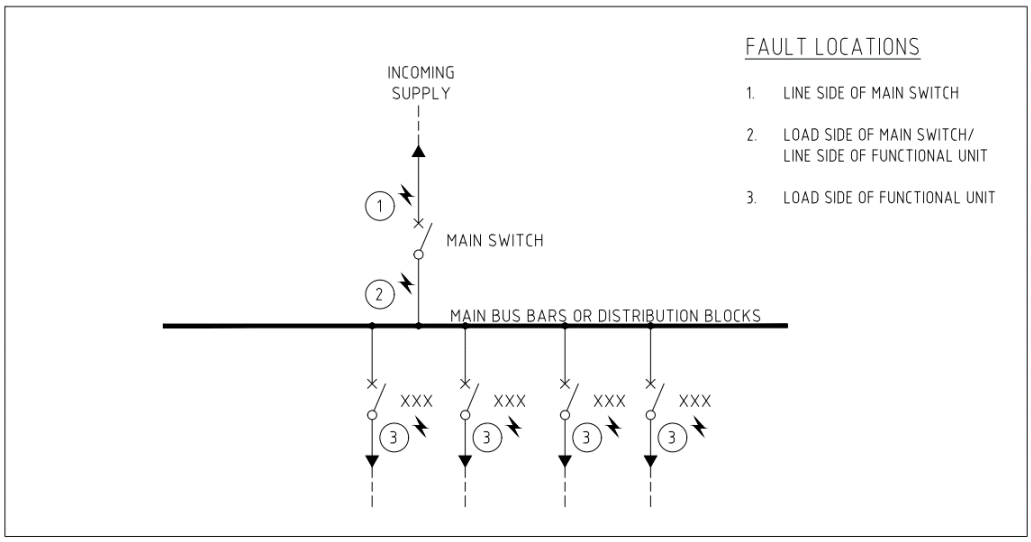


Figure 2 – Fault locations

Note that while Location 2 shall be modelled in PTW for equipment that includes an incoming protective device, the Location 2 results will only be relevant to arc flash hazard assessment and labelling where it is very unlikely that the Location 2 arcing fault will propagate to Location 1, as detailed in section 0

Arc-Flash Hazard Labelling.

For applicable VFDs, UPS, harmonic filters and similar equipment, arc flash assessment must be conducted at the incoming terminals (Location 1) and applied to the equipment as whole.

An additional fault location is applicable to distribution board sections and control sections within existing MCCs that are fully segregated with sheet metal from the main busbars and main power circuits, to the extent that it is very unlikely that an arcing fault in the DB/control section would propagate to the main bus, and very unlikely that work in the DB/control section could initiate a fault in the remainder of the switchboard. These shall be assessed as a separate piece of equipment in addition to the main MCC. If such a distribution section has its own incomer protective device inside the cell, it shall be assessed for Location 1 line side of the distribution section incoming protection device and Location 2 load side of the incomer protective device. If the distribution section does not have an incoming protective device in the same cell, it shall be assessed as Location 1 at the incoming terminals to the distribution section. This location is not applicable to new MCCs and switchboards, that should include a separate enclosure for small power distribution and controls completely away from the MCC/switchboard arc flash boundary.

6.2.3. Fault Location Exclusions

To simply the assessment, in general the potential arcing fault at the load side of each outgoing unit (Location 3 in Figure 2) need not be assessed. It is assumed that an arcing fault in this location can propagate to the line side of the outgoing unit, with the same fault current and duration at the load side of the main switch (Location 2). The Location 2 fault is expected to be more severe (longer duration if protection correctly coordinated) and therefore conservatively higher arc flash energy than an arcing fault that occurs in Location 3 only.

The contractor may also exclude the following from the arc flash assessment:

- Individual VFDs, UPSs or harmonic filters mounted within a switchboard or MCC
- Motor terminal boxes
- Switchboards or control enclosures containing voltages no greater than 50VDC or 50VAC
- Load side of the protective device of a motor starter cell, feeder cell
- Load side of variable frequency drives
- Single phase switchboards ≤ 32A
- The following equipment, where supplied by a circuit breaker or fuse rated at ≤ 32A:
    - LV Field isolator
    - LV VFD
    - UPS
    - Harmonic filter
    - SCADA/PLC Panel.

6.3. Calculation Methods

6.3.1. IEEE-1584 Calculation Method

The contractor shall apply the IEEE-1584 (latest edition), empirically derived model for the arc-flash incident energy calculations. Where discrepancies exists between this Seqwater standard (E-SPE-STD-007) and the latest edition of IEEE-1584, the contractor shall notify Seqwater in writing.

6.3.2. Single-Phase AC Systems

The IEEE-1584 empirical method specifically excludes incident energy calculation for single-phase AC systems.

Where calculation of incident energy is required for single-phase ac systems, the contractor shall perform conservative incident energy calculation in accordance with the guidance provided in IEEE-1584, Section 4.11 Single-phase systems.

6.3.3. DC Systems

Incident energy analysis shall be carried out for all DC systems with a rated voltage exceeding 50 VDC.

The IEEE-1584 empirical method specifically excludes incident energy calculation for DC systems.

Where calculation of incident energy is required for DC systems up to 1000V, the contractor shall provide estimation of arc-flash incident energy in accordance with the Maximum Power Method outlined in NFPA 70E.

6.3.4. The Lee Method

The contactor shall utilise the Lee calculation method for systems where voltage exceeds 15 kV or where the gap between conductors is outside the range of the empirical model developed in the IEEE 1584-2018.

6.4. IEEE-1584 Arc Flash Analysis Process

Using the PTW software, the contractor shall perform an arc-flash analysis in conjunction with a short-circuit and protective device coordination study. The protective device clearing time, in response to arcing current, must be applied during the analysis process.

The contractor must ensure that the appropriate calculation parameters are applied, in accordance with the equipment class and the physical installation parameters.

6.4.1. Step 1 - Collect the system and installation data

The collection of the electrical system data is the initial step in the arc-flash analysis. These documents should be obtained during the site data collection process outlined in section 3.4.

6.4.2. Step 2 – Determine the system mode of operation

The electrical installation may have more than one mode of operation with different switching configuration arrangements. The worst-case scenario shall be considered for the mode(s) of operation that provides both the maximum and the minimum available short-circuit currents. Conduct the incident energy calculation for all defined modes of operation in the power system to determine the highest incident energy and arc-flash boundary result for each arcing location. It is common to calculate the arcing location at each equipment bus (e.g. MCCs, switchboard, distribution-board, etc.).

6.4.3. Step 3 – Determine the bolted fault system

The arc-fault study should be based upon an up-to-date fault-current (short-circuit) study for the facility. The study should consider both the system data and modes of operating / configuring the system.

The fault-levels shown in the arc flash calculation tables for the site-specific report should be based upon the PTW, IEC 60909 fault level calculation module.

Arc fault calculations shall be carried out at both the minimum fault level and maximum fault level for all scenarios.

6.4.4. Step 4 – Determine typical gap and enclosure size

IEEE 1584-2018 provides typical bus gaps and enclosure sizes for different classes of equipment.

It is recommended to use actual bus gaps and enclosure sizes based on drawings or site assessment where this information is available, in particular for “Location 1” faults.

Explanatory Note: Location 2 faults have been generalised to cover arcing faults occurring on the switchboard main bus or the line side of outgoing units, therefore can have many different dimensions for the same equipment, therefore making typical dimensions more practical. By contrast, Location 1 faults refer to a specific location at the incomer which is easier to model accurately. Additionally, Location 1 faults are usually higher incident energy and therefore more critical to model accurately.

6.4.5. Step 5 – Determine the equipment electrode configuration

In the arc-flash hazard calculation process, the equipment conductor and enclosure arrangement being assessed should match the electrode configuration (s) defined in IEEE 1584-2018.

The appropriate parameters for the equipment under assessment should be applied based on the as-built vendor drawings.

Some equipment may have multiple electrode configurations present. Select the “worst case” electrode configuration present in the equipment that will give the highest incident energy, excluding locations that are extremely unlikely to generate an arcing fault.

Withdrawable switchgear may have a different electrode configuration depending on the operational state of the equipment when the arcing fault occurs. (Refer to IEEE1584-2018 Annex C.) The arc flash study shall select one electrode configuration for each switchgear based on the “worst case” electrode configuration that will give the highest incident energy, excluding configurations that are extremely unlikely to generate an arcing fault. Conditions for excluding HCB for withdrawable air circuit breakers include:

- Racking of air circuit breaker behind closed door, or
- Air circuit breaker equipped with fail safe mechanical trip interlocks (cannot be inserted or withdrawn in with CB closed) and automatic safety shutters which cover the bus bar connections with circuit breaker in racked out position.

Enable the PTW options “For VCBB, also run VCB, report Worst incident energy/arc flash boundary” and “For HCB, also run VCB+VCBB, report Worst incident energy/arc flash boundary”.

6.4.6. Step 6 – Determine the working distance

The working distance is used in the calculation process for the arc-flash incident energy. The arc-flash protection is typically based on the incident energy level on the workers head and torso (i.e. NOT the incident energy on the hands or arms).

In performing the incident energy calculations, the contractor shall select the working distance corresponding to relevant equipment class; as defined in IEEE 1584.

For any equipment not covered by the typical working distances in IEEE 1584 , the justification for the working distance selected shall be documented in the report.

6.4.7. Step 7 – Calculation of arcing current

The arcing current is directly correlated to the bolted fault, gap between conductors, electrode configuration and system voltage. The available bolted fault through each protective device is derived from the short-circuit contribution from active sources such as electrical rotating machines. The total arcing current at given location is calculated based upon the total bolted fault current available at that location.

The arcing current is calculated using the PTW software.

6.4.8. Step 8 – Determine the arc duration

The arc duration is defined as the time it takes the upstream energizing source(s) of arcing current to stop providing current or energy to the arc fault. The fault clearing time is the time required for the protective device to break the fault current and to extinguish any arc. When multiple sources are present, the arc duration depends on the time it takes the last protective device to clear the arc current.

For the calculation of incident energy, the fault clearing time of all protective devices is required. If the total protective device clearing time is longer than two seconds (2 secs); It is assumed that a person exposed to an arc flash will move away, if physically possible, within 2 secs.

Arcing duration shall be determined using the PTW software, where protection device settings have been entered and verified within the system model.

Fuses

Where fuses are installed, the fuse fault clearing time curve must be used. These curves may include both melting and total clearing time; in this case, the total clearing time that represents the worst-case duration should be used. Where only the fuse average melting time is available, add 10% of time plus 0.004 sec to determine the total clearing time. If the total clearing time at the arcing fault is less than 0.01 sec, then 0.01 sec shall be used for the time.

LV Circuit Breakers

For circuit-breakers with integral trip units the manufacturer's time-current curves should include both tripping and clearing times. If the curves show only the trip unit's operating time, a circuit-breaker operating time (typically 0.05 sec or three cycles) should be added.

O/C Relays and Circuit Breakers

For relay-operated circuit-breakers the time-current curves will only show the relay operating times. The circuit-breaker fault clearing time must be added to the relay operating time plus any additional time delays (e.g. lock-out

relays, manufacturer tolerances, any other additional time delay considerations). The interrupting time is the sum of the circuit-breaker opening time and arcing time.

6.4.9. Step 9 – Calculate the incident energy

Incident energy shall be calculated using the PTW software.

6.4.10. Step 10 – Determine the arc-flash boundary

Incident energy shall be calculated using the PTW software.

6.4.11. Step 11 – Determine Required PPE Category

The Arc-flash PPE levels at Seqwater, have been rationalised to three Seqwater-specific categories as follows:

- **CAT 0** No arc flash rating. May be selected for incident energy up to 1.2 Cal/cm^2
- **CAT 2** – Rated for incident energy up 7.9 Cal/cm^2
- **CAT 4** – Rated for incident energy up to 40 Cal/cm^2

The CAT 2 limit is set at 7.9 Cal/cm^2 to align with the existing (as at 2024) 7.9 Cal/cm^2 standard issue Seqwater electrical worker shirt.

PPE CAT 1 and PPE CAT 3 are not currently used at Seqwater.

Locations with incident energy greater than 40 Cal/cm^2 are beyond the rating of Seqwater PPE CAT 4. Such locations are denoted “EXTREME INCIDENT ENERGY” in place of a PPE category and require a documented arc flash risk assessment tailored to the activity and endorsed by the Electrical Supervisor, usually necessitating upstream isolation prior to entering the arc flash boundary.

Note that these PPE categories are specific to Seqwater, for use with the arc flash analysis methodology defined in this specification based on the NFPA70E incident energy analysis method and IEEE1584. The Seqwater PPE categories do not correspond to the categories used in NFPA70E for the NFPA70E arc flash PPE category method.

Note that high voltage switching operations require minimum CAT 4 PPE, even if the calculated incident energy is lower, according to the requirements of PRO-00006 Electrical – High and Low Voltage Procedure.

6.4.12. Publishing of Arc flash Study results and PPE categories

The calculation results, derived from PTW software, shall be included in the relevant appendices of the arc-flash analysis report. An example of the required register format, including the minimum data required, is given in Appendix C.

For each site, the contractor shall also publish a summary of the arc flash results in a tabulated arc flash register. The register shall be incorporated in the arc flash analysis report for each specific site and also provided in an excel spreadsheet format.

The bolted fault, protective device arcing fault, trip delay time, breaker opening time, arc flash boundary and incident energy shall be calculated and provided in the report at both minimum and maximum fault levels for each applicable operating scenario. The worst case (highest) arc flash boundary and incident energy for each calculation location under any operating scenario shall also be calculated and provided in the report. It should be noted that in some cases the minimum fault level will result in a higher incident energy and arc flash boundary than the maximum fault level, due to slower operation of protection at lower fault currents.

6.5. Initial Analysis of Arc flash results

Based on the calculation results, the contractor shall conduct an assessment of the existing as-found incident energy levels for each item of electrical plant. This assessment shall, as a minimum, take into consideration both the calculated arc-flash incident energy and the corresponding PPE category required for access to the equipment.

7. Site Arc-Flash Risk Reduction

7.1. Hierarchy of controls

For all equipment and tasks that expose workers to incident energy greater than 1.2 cal/cm² (or for a residual risk level greater than "Low") contractor shall consider mitigation options that are practicable.

Preference for selection of mitigation measures shall be in accordance with the hierarchy of controls as follows:

- **Elimination:** Removing the hazard entirely
- **Substitution:** Replacing a severe hazard with something safer
- **Engineering Controls:** Reduce risk through engineering controls
- **Administrative Controls:** Developing formal procedures and processes for managing risks. Training and educating workers on the hazards and providing information for making safe decisions.
- **Personal Protective Equipment:** Equipping workers with clothing and equipment designed to reduce risk and limit the severity of injuries.

Typical examples of these measures are outlined in the following sections.

7.1.1. Elimination

Elimination is the most effective and preferred control method.

Arc flash hazards can be eliminated for certain work tasks by de-energising and positively isolating all sources of electrical energy to the equipment. However, the hazard will still be present during the process of de-energising and proving dead.

Elimination will not be possible for all tasks and equipment, in which case the other controls further down the hierarchy become more important.

7.1.2. Substitution

Is there any opportunity to replace or change equipment or materials to lower the risk from the arc flash hazard. Substitution is the second most effective way to control hazards, which involves removing something that produces a hazard (similar to elimination) and replacing with something that does not produce or lowers the likelihood of the hazard event occurring.

For example, would replacing an existing switchboard with a high arc flash hazard with an arc fault contained switchboard that poses little or no arc flash hazard risk be feasible and cost effective.

7.1.3. Engineering Controls

Engineering controls that provide permanent reduction in arc flash risk, but these controls must be monitored and reviewed from time to time.

- Measures to reduce Arc flash incident energy, by reducing fault current, such as:
    - Configuration of boards (open bus-ties).
    - Use of current limiting reactors.
    - Using of current limiting protection devices. Current limiting protective devices reduce incident energy by clearing the fault faster and by reducing the current seen by the arc source.

- Measures to reduce incident energy by reducing arc duration (trip time), such as:
    - Reduce protection settings (if practicable)
    - Introduce maintenance mode protection settings that, when enabled, can lower protection operating times
    - Install faster operating switchgear / protection devices
    - Implement a bus differential Scheme (faster than ZSI)
    - Implement protection tripping from arc-flash and overcurrent detection systems
- Measures to reduce worker exposure to arc flash sources
    - Implement facilities for remote breaker switching and racking
    - Installation of isolation points upstream of switchboard
    - Split duty and standby loads across two separate switchboards or on two separate buses with a bus tie where a single switchboard is used
- Reduce the Likelihood of an arc flash occurring, by measures such as:
    - IP2X compliant panels. Installing finger-safe components, covers, and insulating barriers reduces exposure to energised parts
    - Insulation of busbars
- Contain or redirect the arc flash energy away from personnel, such as:
    - Install Arc fault rated low voltage switchboards which have been verified for fault containment on both the line and load side of the main incomer. Care must be taken when nominating arc fault contained switchboards from the line side as there are limitations to how fast the upstream protective device needs to operate for the line side arc fault containment to be within the tested limitations. Typically, the upstream protective device needs to operate within 300ms.
    - Install Arc fault rated high voltage switchboards which have been verified for fault containment. These typically either vent downwards into the cable trench or at the top of the switchboard cubicle.

7.1.4. Administrative Controls

Standard administrative controls are described in PRO-00006 Electrical – High and Low Voltage Procedure. Where additional administrative controls need to be implemented, the contractor shall consult with Seqwater and articulate the need in the PSA report. Administrative controls do not remove hazards, rather limit or prevent people's exposure to the hazards, such as:

- Restricting access to switch rooms and switchboards to Authorised Personnel only
- Apply signage and arc flash labels to electrical equipment advising personnel of the arc flash energy levels and PPE recommendations
- Authorised Personnel to have training in the hazards and procedures associated with working within an electrical switch room
- All personnel not directly involved in switching operations to vacate area when switching occurs
- Formal risk assessments shall be conducted prior to conducting work on or near electrical equipment
- Removal of furniture and equipment from locations in front or adjacent to switchgear
- Ensuring plant single line diagram and arc flash registers are maintained and updated when changes occur
- Ensure plant labelling and identification match electrical drawings.

- Carry out routine plant maintenance such as:
    - Routine inspection, maintenance and testing.
    - Thermography (infra-red scanning) of panels.
    - Check integrity of panel fasteners/locks/interlocks.
    - Noise and Partial Discharging (PD) test.
    - Dust ingress protection (pressurised or air-conditioned switch rooms).
- Development of Operation and Maintenance Procedures
- Use of insulated tools.
- Use of calibrated, tested and appropriately rated test equipment.
- Use of Permit To works systems

7.1.5. Personal Protective Equipment

The purpose of arc flash PPE is to reduce the energy reaching the skin and thereby reduce the severity of burns injuries. PPE should be selected considering the magnitude of the arc flash incident energy, the arc flash boundary, and the probability of an arc flash occurring during the work in question. PPE requirements shall be defined on equipment labelling as per section 0.

7.2. Target Incident Energy

New or altered electrical equipment, or projects that affect incident energy at existing electrical equipment, should be designed to limit incident energy as far as practicable and no higher than the values listed in Table 6. These values are also the long-term planning objective for all existing switchboards.

For any existing equipment within the project or affected by the project that exceeds the limits defined in Table 6, unless specified otherwise by Seqwater, the contractor must revisit the protection co-ordination study and consider / recommend other technically feasible methods to reduce the incident energy level.

Table 6 – Target incident energy

Description	Maximum incident energy	Arc Fault Containment Required
Switchboard/MCC in locked switchroom or switchyard restricted to electrical personnel only	40 cal/cm^2 (CAT 4) at incomer 7.9 cal/cm^2 (CAT 2) at non-incomer circuits	Yes – if >10kA or >1.2cal/cm^2 at incomer line side
Switchboard/MCC accessible by non-electrical personnel	7.9 cal/cm^2 (CAT 2) at incomer	Yes – if >10kA or >1.2cal/cm^2 at incomer line side
Light and power distribution board or minor switchboard	1.2 cal/cm^2 (CAT 0) at incomer	No

8. Arc-Flash Hazard Labelling

Electrical equipment, that are likely to require access for examination, adjustment, servicing, manual operation, or maintenance while energized must be fitted with arc-flash and shock hazard labelling. Such equipment may include but not be limited to:

- LV switchboard
- HV switchboard
- Kiosk transformers with accessible LV breaker / distribution compartments
- LV/HV Variable Frequency Drive (VFD) cabinets
- Distribution boards

Upon acceptance of the final arc-flash PSA results, and unless otherwise specified in the scope of work, the contractor shall supply Seqwater with electronic native file and pdf labels for each item of equipment in accordance with the following sections.

For projects including construction or modification of electrical equipment, or otherwise as specified in the scope of work, the contractor shall supply and affix new arc flash hazard labels to equipment requiring updated labels as a result of the project scope.

8.1. Arc Flash Hazard Position

Each piece of equipment assessed requires one or more labels depending on whether there is physical separation of incomer and non-incomer sections sufficient to limit propagation of an arc flash from one to the other.

For equipment with such physical separation, the incomer and non-incomer circuits are considered separate positions with separate labels.

The number and location of labels shall be as specified below for different categories of electrical equipment:

8.1.1. LV switchboards with Form 4A or Form 4B separated incomer protective devices to AS/NZS 61439 or AS/NZS 3439 -

For such switchboards, conditional on being in fair condition or better (See Table 13), it may be considered very unlikely for an arcing fault in an outgoing cell to propagate to the incomer line side. The results obtained for location (1) shall be applied to the incomer cell(s)/tier(s) (Position: “INCOMER”) and the results for location (2) shall be applied for outgoing functional units as a group (Position: “NON-INCOMER CIRCUITS”.)

8.1.2. Form 2bi LV distribution boards with an incomer MCCB where the line side is fully insulated and phase barriered

For such switchboards, conditional on being in fair condition or better, it may be considered very unlikely for an arcing fault at the outgoing circuits to propagate to the incomer line side.

If the location (1) incident energy is ≥1.2cal/cm², the results obtained for location (1) shall be applied to the incomer MCCB, Position: “INCOMER” and the results obtained for location (2) shall be applied for all outgoing MCBs as a group, Position: “NON-INCOMER CIRCUITS”

For simplicity, if incomer line side incident energy is <1.2cal/cm² , apply the incomer line side incident energy to both the incomer and non-incomer positions and produce one common label, “INCOMER AND NON-INCOMER CIRCUITS”.

8.1.3. Distribution section within MCC

For MCCs containing a miniature circuit breaker distribution section separated with sheet metal in accordance with section 6.2.2, create a separate label(s) for the distribution section position in addition to the label(s) for the main MCC incomer and non-incomer circuits.

If the distribution section is Form 2bi with an incomer MCCB in the same cell, where the line side is fully insulated and phase barriered, and the switchboard is in fair condition or better, create labels for the distribution section incomer (Position: e.g. “DB SECTION MAIN SWITCH ONLY”) and the distribution section outgoing circuits (Position: DB SECTION OUTGOING CIRCUITS ONLY”). (Similarly to standalone Form 2bi LV distribution boards, if the DB section incomer line side incident energy is <1.2cal/cm² , simplify by applying the DB section incomer line side incident energy to both the DB incomer and DB non-incomer positions and produce one common label, “DB SECTION ONLY”.)

Otherwise, produce one label for the “DB SECTION ONLY”. If the switchboard is in fair condition or better, this will be based on the incident energy at the incoming terminals to the DB section. If the switchboard is in poor condition or worse, this will be based on the line side incident energy of the MCC incomer.

8.1.4. HV switchboards that are Internal Arc Classified (IAC) to IEC 62271-200

Such switchboards shall be assessed to determine whether they have been designed and constructed with segregation sufficient to make it very unlikely for an arcing fault on outgoing units to propagate to the incomer line side, noting that this is not guaranteed by the IAC certification alone – IAC applies to switchboard as a whole, not between internal sections of the switchboard).

If such segregation exists, the incident energy and arc flash boundary results obtained for location (1) shall be applied to the incomer tier(s) (Position: “INCOMER”) and the incident energy and arc flash boundary results for location (2) shall be applied for all outgoing tier(s) as a group. (Position: “NON-INCOMER CIRCUITS”)

If such segregation does not exist, the incident energy and arc flash boundary results obtained for location (1) shall be applied to both the incomer and outgoing tiers. (Position: INCOMER and NON-INCOMER CIRCUITS”)

The arc flash analysis report shall include the justification for selecting segregated or common INCOMER and NON-INCOMER arc flash positions.

8.1.5. HV switchboards that are not Internal Arc Classified (IAC) to IEC 62271-200

The incident energy and arc flash boundary results obtained for location (1) shall be applied to both the incomer and outgoing tiers. (Position: INCOMER and NON-INCOMER CIRCUITS”)

8.1.6. Equipment with multiple incomers

Switchboards and incomers with multiple sources of supply (e.g. two transformers, or mains and generator) shall be labelled at all incomers. All incomers on the same switchboard shall show the same incident energy, arc flash boundary and PPE category based on the worst-case incomer.

(Exception: Secondary UPS feeds to switchboards with <1.2cal/cm^2 incident energy need not be separately labelled.)

8.1.7. MCC control tiers and low current, low incident energy equipment

Equipment rated at ⩽ 32A and assessed as <1.2 cal/cm² with boundary < 0.5m in general do not require arc flash hazard labelling. Where necessary to positively identify such equipment as suitable for access with CAT 0 PPE, such as at a control tier on the end of an MCC, install a Type 4 label.

(Note that the Type 1 and Type 2 labels apply for equipment >32A, even if it has <1.2 cal/cm² incident energy.)

8.1.8. Switchboards without separation of incomer and non-incomer circuits, and other equipment

For equipment not otherwise described above, it is assumed that there is a risk of an arc flash at the non-incomer circuits propagating to an incomer line side arc flash. Produce one label based on the incident energy at Location 1, i.e., based on fault clearing time of upstream protective device.) (Position: “ALL”, or as relevant to the equipment)

8.1.9. Switchboards and equipment in poor condition

If the switchboard or equipment is in poor condition or worse (see 8.4.9.15) , it is assumed that there is a risk of an arc flash at the non-incomer circuits propagating to an incomer line side arc flash. Produce one label based on the incident energy at Location 1, i.e., based on fault clearing time of upstream protective device.) (Position: “ALL”, or as relevant to the equipment.)

8.2. Label Information

The standard “Arc-flash hazard” labels must be produced in accordance with the Seqwater template TEM-00371 Engineering Standard E-TMP-STD-007 Arc Flash Hazard Label Template.

Information that is necessary to complete the Arc Flash Hazard label as documented herein shall be available in the Arc Flash Hazard Analysis Report.

Table 7 – Label types

Equipment	Label Types Required
Low voltage and high voltage switchboards and equipment, with < 40 Cal/cm^2 incident energy	Type 1 DANGER ARC FLASH AND SHOCK HAZARD + Type 2 PPE REQUIRED
Low voltage and high voltage switchboards and equipment, with ≥ 40 Cal/cm^2 incident energy	Type 1 DANGER ARC FLASH AND SHOCK HAZARD + Type 3 EXTREME ARC FLASH INCIDENT ENERGY
Low voltage equipment rated at ⩽ 32A with <1.2 Cal/cm^2 incident energy, and arc flash boundary < 0.5 m, only where necessary to positively identify such equipment as suitable for access with CAT 0 PPE	Type 4 COMPACT CAT 0
Switchrooms and locations with CAT 2 or higher equipment	Type 5 PPE CATEGORIES

8.3. Type 1 Label – DANGER ARC FLASH AND SHOCK HAZARD

The appropriate number of DANGER labels shall be produced to accompany the Type 2 and Type 3 labels.

Figure 3: Example of Label Type 1 – DANGER ARC FLASH AND SHOCK HAZARD

8.4. Type 2 Label – PPE REQUIRED

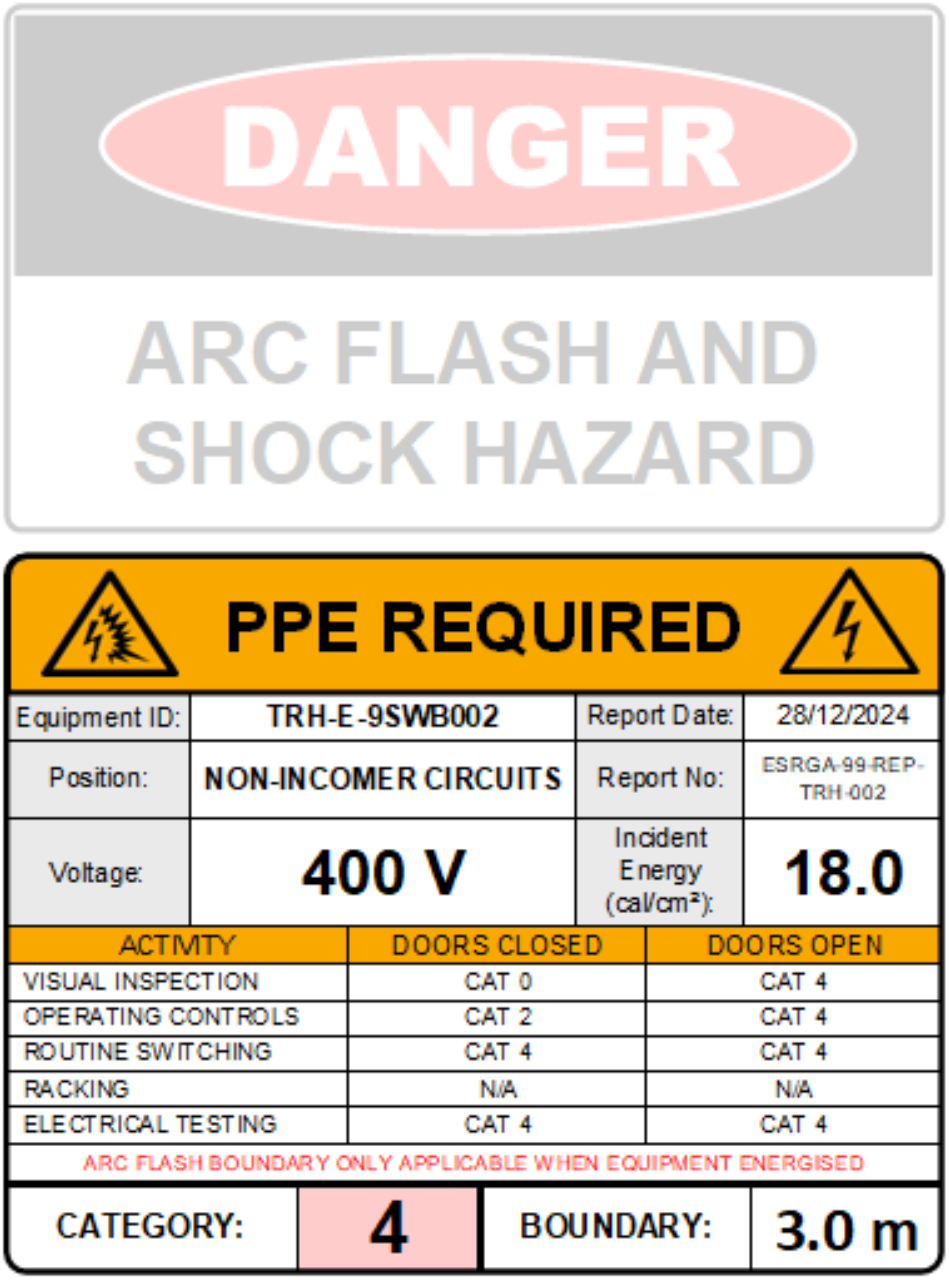


Figure 4: Example of Label Type 2 - PPE REQUIRED

8.4.1. Equipment ID

Show the equipment number of the assessed equipment.

8.4.2. Position Field

Show which part of the equipment the label is applicable to, e.g.:

- INCOMER
- NON-INCOMER CIRCUITS
- INCOMER AND NON-INCOMER CIRCUITS
- DB SECTION MAIN SWITCH ONLY
- DB OUTGOING CIRCUITS ONLY
- DB SECTION ONLY

8.4.3. Voltage

Show the highest voltage present behind the equipment door.

8.4.4. Report Date

Show the date of the PSA report that has been used to create the labels.

8.4.5. Report No.

Show the document number of the PSA report that has been used to create the labels.

8.4.6. Incident Energy

Show the incident energy applicable to that position, in cal/cm², round up to the next highest 0.1 cal/cm², based on the worst-case operating scenario, i.e. the highest values.

8.4.7. Category

For LV equipment with incident energy up to 40 Cal/cm², the "Category" field in the bottom left corner of the Type 2 arc flash label shall show the PPE category corresponding to the calculated incident energy. (Noting that this may differ from some of the activity-based doors open / doors closed PPE requirements.)

For HV equipment with incident energy up to 40 Cal/cm², the "Category" field in the bottom left corner of the Type 2 arc flash label shall be "CATEGORY: 4".

8.4.8. Boundary

Show the calculated arc flash boundary applicable to that position, in metres, rounded up to the next highest 0.1m, based on the worst-case operating scenario, i.e. the highest values.

8.4.9. Activity by Doors Closed and Doors Open

This part of the label lists the PPE required for various activities, with equipment doors open or closed.

The table shall be completed with CAT 0, CAT 2, CAT 4 or N/A as per the tables and PPE selection notes below.

Where an activity is not possible for that equipment/position, select "N/A".

The minimum personal protective equipment applicable to various work activities as listed in this specification are based on recommendations from:

- AS/NZS 4836:2023 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment,

- NFPA70E Electrical Workplace Safety (United States), and
- the Australian Energy Council Arc Flash Hazard Management Guidelines

The guidance in these documents has been interpreted to align with Seqwater work practices, assets and risk management framework. (Seqwater risk assessment REX reference D23/186987.)

Table 8 – PPE by Activity for LV equipment in fair condition with incident energy < 40 Cal/cm²

<table>
<tr><th rowspan="2">Activity</th><th colspan="2">LV Switchboard position that is rated for Arc Fault Containment; (in fair condition or better)</th><th colspan="2">LV Switchboard position that is not rated for Arc Fault Containment, or other LV equipment
(in fair condition or better)</th></tr>
<tr><th>DOORS CLOSED</th><th>DOORS OPEN</th><th>DOORS CLOSED</th><th>DOORS OPEN</th></tr>
<tr><td>VISUAL INSPECTION</td><td rowspan="3">CAT 0</td><td rowspan="5">CAT 0/2/4 based on incident energy</td><td>CAT 0</td><td rowspan="5">CAT 0/2/4 based on incident energy</td></tr>
<tr><td>OPERATING CONTROLS</td><td>Refer 8.4.9.7</td></tr>
<tr><td>ROUTINE SWITCHING</td><td rowspan="3">CAT 0/2/4 based on incident energy</td></tr>
<tr><td>RACKING</td><td rowspan="2">CAT 0/2/4 based on incident energy</td></tr>
<tr><td>ELECTRICAL TESTING</td></tr>
</table>

Table 9 – PPE by Activity for LV equipment in poor condition or worse with incident energy < 40Cal/cm²

<table>
<tr><th rowspan="2">Activity</th><th colspan="2">LV Switchboard or equipment
(in poor condition)</th></tr>
<tr><th>DOORS CLOSED</th><th>DOORS OPEN</th></tr>
<tr><td>VISUAL INSPECTION</td><td rowspan="5">CAT 0/2/4 based on incident energy</td><td rowspan="5">CAT 0/2/4 based on incident energy</td></tr>
<tr><td>OPERATING CONTROLS</td></tr>
<tr><td>ROUTINE SWITCHING</td></tr>
<tr><td>RACKING</td></tr>
<tr><td>ELECTRICAL TESTING</td></tr>
</table>

Table 10 – PPE by Activity for HV equipment in fair condition with incident energy < 40Cal/cm²

Activity	IAC A-FLR or B-FLR HV Switchboard (in fair condition or better)		Other HV Switchboard / Equipment (in fair condition or better)	
	DOORS CLOSED	DOORS OPEN	DOORS CLOSED	DOORS OPEN
VISUAL INSPECTION	CAT 0	CAT 4	CAT 0	CAT 4
OPERATING CONTROLS			Refer 8.4.9.7	
ROUTINE SWITCHING	CAT 4		CAT 4	
RACKING				
ELECTRICAL TESTING				

Table 11 – PPE by Activity for HV equipment in poor condition or worse with incident energy < 40Cal/cm²

Activity	IAC AFLR HV Switchboard (in poor condition)	
	DOORS CLOSED	DOORS OPEN
VISUAL INSPECTION	CAT 4	CAT 4
OPERATING CONTROLS		
ROUTINE SWITCHING		
RACKING		
ELECTRICAL TESTING		

8.4.9.1. Doors Open or Closed Definition

"Doors Open" refers to the condition when there is no door or panel between a worker and live conductors or terminals. For example – open cell door at a motor control centre, or open escutcheon at a distribution board.

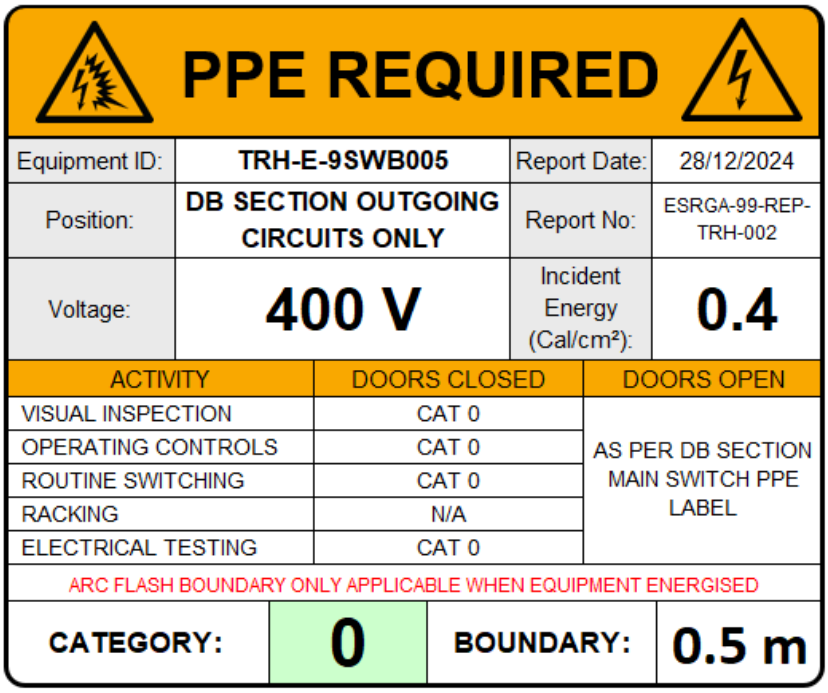
Doors closed refers to the condition where there is a dead front door or panel between a worker and live conductors or terminals. For example – motor control centre with cell doors closed, or a distribution board with the outer door open but inner escutcheon covering all live parts closed and secured.

8.4.9.2. Doors Open PPE Selection

For any activity that requires opening the equipment doors, there is a greater opportunity for the activity to cause an arc flash. The consequence of an arc flash is also considered likely be more severe based on there being no door or panel between the worker and live conductors or terminals. Select the PPE category corresponding to the incident energy at the location.

The “doors open” section must allow for the worst-case incident energy for all equipment within a common door/compartment.

For switchboards with incomer and non-incomer labels for the same door/compartment (i.e. form 2bi distribution boards with an insulated and phase barriered incomer MCCB in the same enclosure/cell as the outgoing circuits), DOORS OPEN PPE recommendations shall not be provided on the non-incomer circuits label. The DOORS OPEN section on the non-incomer circuits label shall refer to the DB section incomer label, e.g. “AS PER INCOMER PPE LABEL” for a standalone switchboard, or “AS PER DB SECTION MAIN SWITCH PPE LABEL” for a DB section in an MCC.



PPE REQUIRED

Equipment ID:	TRH-E-9SWB005	Report Date:	28/12/2024
Position:	DB SECTION OUTGOING CIRCUITS ONLY	Report No:	ESRGA-99-REP-TRH-002
Voltage:	400 V	Incident Energy (Cal/cm²):	0.4

ACTIVITY	DOORS CLOSED	DOORS OPEN
VISUAL INSPECTION	CAT 0	AS PER DB SECTION MAIN SWITCH PPE LABEL
OPERATING CONTROLS	CAT 0	
ROUTINE SWITCHING	CAT 0	
RACKING	N/A	
ELECTRICAL TESTING	CAT 0	

ARC FLASH BOUNDARY ONLY APPLICABLE WHEN EQUIPMENT ENERGISED

CATEGORY:	0	BOUNDARY:	0.5 m

Figure 5: Example of PPE REQUIRED Label for outgoing circuits sharing an enclosure with a separately labelled Main Switch

8.4.9.3. Arc Fault Containment Definition

Switchboards can be designed to provide increased security against the effect of internal arcing which may occur in service with all doors closed and all covers and internal barriers in place.

For LV switchboards (or parts thereof) to be consider arc fault containment type, they must be designed and tested to meet the internal arcing fault tests of AS/NZS 3439.1 Appendix ZD or AS/NZS 61439.1 Appendix ZD.

For HV switchboards to be consider arc fault containment type, they must be designed and tested as Internal Arc Classified (IAC) A-FLR to IEC 62271-200.

It is noted that Appendix ZD in AS/NZS 61439 specifically deals with arc fault containment testing by default where the arc is initiated on the load side of the protective device of each outgoing functional unit compartment of the assembly. Nevertheless, there are manufacturers who have undertaken arc fault containment testing of the main incoming unit where the fault has been initiated on the load side, or the line side and the load side. However, the line side tests are typically bound by how fast the upstream protective device needs to operate as it is independent to the protective device within the main incoming unit of the assembly. As such the contractor shall validate that the site specific upstream protective devices operate within the allowable disconnect times as shown

in the test certificates in order to deem the switchboard (assembly) as arc fault contained for the incomer line side.

For the purposes of risk categorisation and PPE labelling, Seqwater has adopted a conservative approach of considering a switchboard location arc fault contained if it has been designed and tested for a line side fault, as below:

- Switchboards that are tested only at the load side of outgoing circuits: Consider as not arc fault contained
- Switchboards that are tested at load side of outgoing circuits and the load side of the incomer: Consider as arc fault contained at non-incomer circuits positions if separated from the incomer, but not arc fault contained at the incomer position.
- Switchboards that are tested at the line side of the incomer and the load side of outgoing circuits: Consider as arc fault contained at non-incomer and incomer circuits positions.

For switchboards built after 2021 (AS/NZS 61439) a design verification report shall be obtained which clearly documents if and how the switchboard has been verified with all supporting test certificates appended to the design verification report. This report shall then be appended to the Arc Flash Hazard assessment report.

For switchboards built prior to 2021 (AS/NZS 3439 or AS/NZS 61439) type test certificate should be obtained which clearly documents if and how the arc fault containment has been tested. This certificate shall then be appended to the Arc Flash Hazard assessment report.

If any of the following conditions are true, the switchboard position shall not be considered arc fault contained:

- Switchboard is not an arc fault containment tested design, or
- Switchboard is operating in conditions outside of the tested design (e.g. upstream protection slower than test conditions), or
- Connections in the compartment tested, from the busbars to the protective device line side terminals, are not covered with substantial electrical insulation, at least complying with Clause 8.4.2.2 of AS/NZS 61439.1-2016, or
- Neither the design verification report (AS/NZS 61439) nor the type test certificate (AS/NZS 3439) are available.

Arc fault containment design switchboards are only effective when all doors are closed and all latching devices are fully secured. If the switchboard requires opening the arc tested doors to operate switchgear or controls, the position shall be considered as not arc fault contained for the purposes of risk categorisation and labelling. (E.g. distribution/control escutcheon requiring the arc tested door to be opened to operate circuit breakers.)

The justification for considering a switchboard position as arc fault contained or not shall be document in the arc flash analysis report and the comments section of the Arc Flash PPE Label Spreadsheet.

8.4.9.4. Visual Inspection with Doors Closed - Definition

While switchboard is in *normal equipment operating condition*[8.4.9.17], with door or escutcheon closed:

- Standing near electrical equipment and not interacting with it
- Walking past electrical equipment if no alternative route available
- Visual inspection of switchboard externally
- Checking status of external indication lamps
- Taking photos of switchboard exterior for data gathering exercises

- Reading meters and indication mounted on front of switchboard
- Opening hinged outer doors to access dead front escutcheon or inner doors
- Interacting with panel mounted meters, protection relays, motor starter keypads to scroll through information without changing the operational state of equipment.

8.4.9.5. Visual Inspection with Doors Closed – PPE Selection

It is considered very improbable that an arc flash will occur at the moment that a worker is conducting a visual inspection of equipment in normal operating condition. If the equipment is in fair condition or better, select CAT 0 PPE for Visual Inspection with Doors Closed.

8.4.9.6. Operating Controls with Doors Closed - Definition

While switchboard is in *normal equipment operating condition*[8.4.9.17], with door or escutcheon closed:

- Operating door/escutcheon mounted start/stop, speed, local/remote, button/keypad fault reset controls for motors and equipment designed for non-electrical personnel operator interaction
- Operating panel mounted meters, protection relays, motor starter keypads or selector switches to change the operational state of equipment.

This activity does not include switching of circuit breakers, fuse switches or isolators.

8.4.9.7. Operating Controls with Doors Closed – PPE Selection

Operating controls in normal operating condition is considered very improbable to result in an arc flash.

A reduced PPE category may be applicable for Operating Controls with Doors Closed. Select a PPE category as per Table 12.

Table 12 – PPE Selection for Operating Controls with Doors Closed

Equipment Condition	Equipment	Operating Controls with Doors Closed – PPE Required based on Incident Energy at position:			
		< 1.2 cal/cm²	≥1.2 cal cal/cm² < 7.9 cal cal/cm²	≥7.9 cal cal/cm² < 40 cal cal/cm²	> 40 cal/cm²
Fair or better	LV Switchboard position that is rated for Arc Fault Containment	CAT 0	CAT 0	CAT 0	Risk assess – see 8.5
	LV Switchboard position that is not rated for Arc Fault Containment, or other LV equipment	CAT 0	CAT 0	CAT 2	
	IAC AFLR HV Switchboard	CAT 0	CAT 0	CAT 0	
	Other HV Switchboard / Equipment	CAT 0	CAT 0	CAT 2	
Poor or worse	LV equipment	CAT 0	CAT 2	CAT 4	
	HV equipment	CAT 4	CAT 4	CAT 4	

8.4.9.8. Routine Switching with Doors Closed - Definition

While switchboard is in *normal equipment operating condition*[8.4.9.17], with door or escutcheon closed:

- Switching for routine operation or isolation/de-isolation at a circuit-breaker/isolator/fuse-switch

This activity does not include switching for restoration or commissioning after a fault.

8.4.9.9. Routine Switching with Doors Closed - PPE Selection

Routine switching has a very low likelihood of initiating an arc flash. Based on a risk assessment process Seqwater has elected to select arc flash PPE allowing for the chance of a catastrophic mechanical failure of the switching device, with the consequence partially mitigated in the case of arc-containment switchboards.

For equipment that is not arc-fault contained, select the PPE category corresponding to the incident energy at the location.

For equipment that is arc-fault contained, in fair condition or better, and has <40 Cal/cm² incident energy, select CAT 0 PPE.

8.4.9.10. Racking – Definition

Racking refers to moving withdrawable switchgear between the connected, test and isolated positions.

The “Racking” PPE requirements are not applicable to operating motorised remote racking from a safe location outside the arc flash boundary.

8.4.9.11. Racking – PPE Selection

There is an elevated risk of an arc flash occurring while undertaking racking.

Select the PPE category corresponding to the incident energy at the location.

8.4.9.12. Electrical testing – Definition

This activity includes:

- Using multimeter or test equipment for fault-finding
- Using multimeter or test equipment to test for dead
- Opening doors that could expose live exposed parts
- Opening bolted covers
- Switching circuit breakers, fuse switches or isolators for commissioning or restoration after a fault.

8.4.9.13. Electrical testing – PPE Selection

There is an elevated risk of an arc flash occurring while undertaking electrical testing.

Select the PPE category corresponding to the incident energy at the location.

8.4.9.14. HV Equipment – PPE Selection

High voltage switching and testing has a standardized CAT 4 PPE requirement for incident energy from 0 to 40 Cal/cm².

8.4.9.15. Equipment condition score – definition

For arc flash labelling purposes, equipment condition assessment shall be based on the Seqwater Asset Lifecycle Management scoring scheme as in Table 13. Equipment with a score of 1, 2 or 3 shall be considered “in fair condition or better”. Scores 4 shall be considered as “in poor condition or worse”.

Table 13 – Condition Scores

Seqwater / IIMM Definition			Seqwater Valuation Method		
Score	**Condition**	**Description**	**Condition**	**Description**	**% Useful Life**
1	Very Good	Only normal maintenance required	Asset "as new"	Excellent	95
2	Minor defects only	Minor maintenance required (4%)	Good	Asset is reliable, asset operates as intended and structural integrity is up to the standard expected of an operating asset	75
3	Maintenance required to return to an acceptable level of service	Significant maintenance required (10-20%)	Fair	Asset is reliable and operates as intended but early stages of deterioration are evident	50
4	Requires renewal	Significant renewal / upgrade required (20-40%)	Poor	Asset still operates but does not meet intended duty or does not appear sound	25
5	Asset unserviceable	Over 50% of asset requires replacement	Unserviceable	Asset not functioning or needs immediate attention	5

8.4.9.16. Equipment condition score – PPE Selection

Equipment in fair condition or better is assumed to present a very low probability of arc flash during visual inspection or operating controls, which may result in reduced PPE requirements as per Table 8 and Table 10. This PPE reduction does not apply to equipment in poor or very poor condition, as per Table 9 and Table 10.

8.4.9.17. Normal operating condition

Normal operating condition is a term used in NFPA 70 E. *Normal operating condition* requires all the following conditions to be satisfied:

- the equipment is properly installed
- the equipment is properly maintained
- the equipment is used in accordance with labelling and manufacturer's instruction's
- the equipment doors are closed and secured
- all equipment covers are in place and secured
- there is no evidence of impeding failure

8.5. Type 3 Label – EXTREME ARC FLASH INCIDENT ENERGY

For locations with incident energy exceeding 40 Cal/cm², the PPE requirements and additional controls shall be developed by means of a risk assessment involving the arc flash analysis RPEQ, Seqwater Engineering Representative and Seqwater Electrical Maintenance Representative. The risk assessment shall be appended to the PSA report.

A Type 3 label, "EXTREME ARC FLASH INCIDENT ENERGY" shall be produced for the position.

Complete the fields for Equipment ID, Position, Voltage, Report Date, Report No., Incident Energy and Boundary as per the instructions provided for the Type 2 Label.

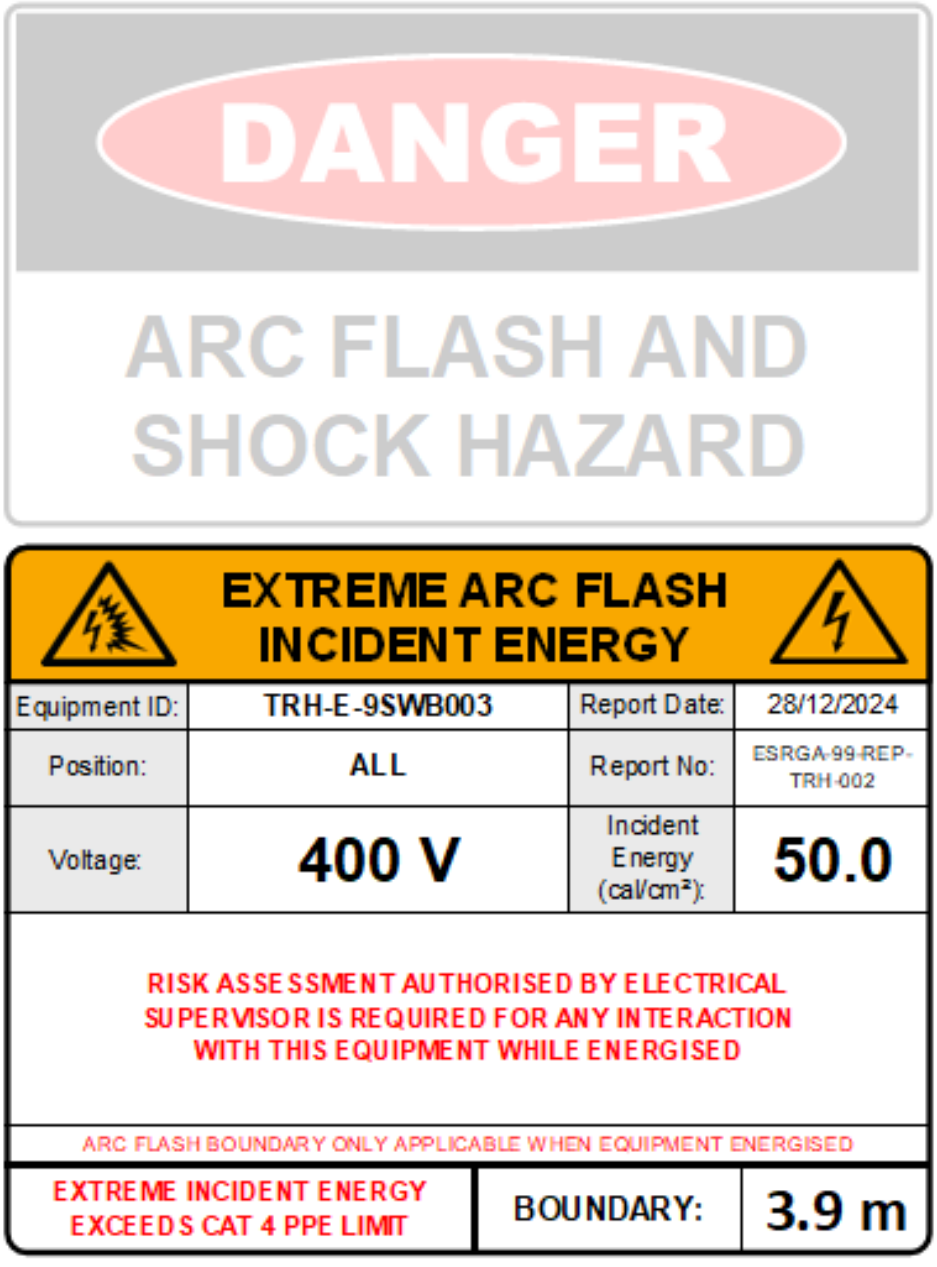


Figure 6: Example of Label Type 3 – EXTREME ARC FLASH INCIDENT ENERGY

8.6. Type 4 Label – COMPACT CAT 0

Where a Type 4 label is applicable and necessary (see 8.1.7), complete the fields for Equipment ID, Position, Voltage, Report Date, Report No. as per the instructions provided for the Type 2 Label.

The specific incident energy and boundary need not be shown – leave these as "LESS THAN 1.2 cal/cm²" and "<0.5m".

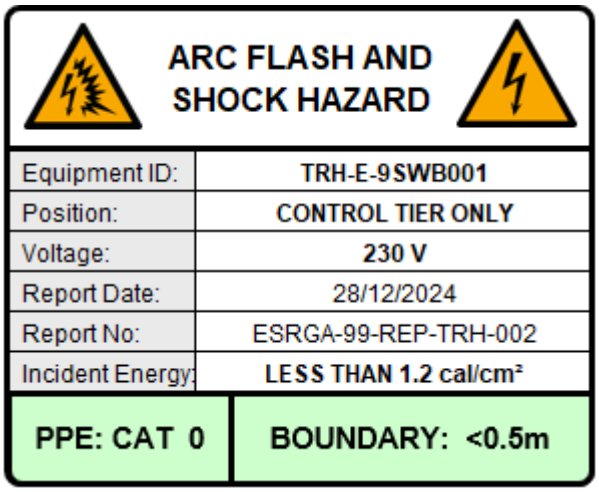
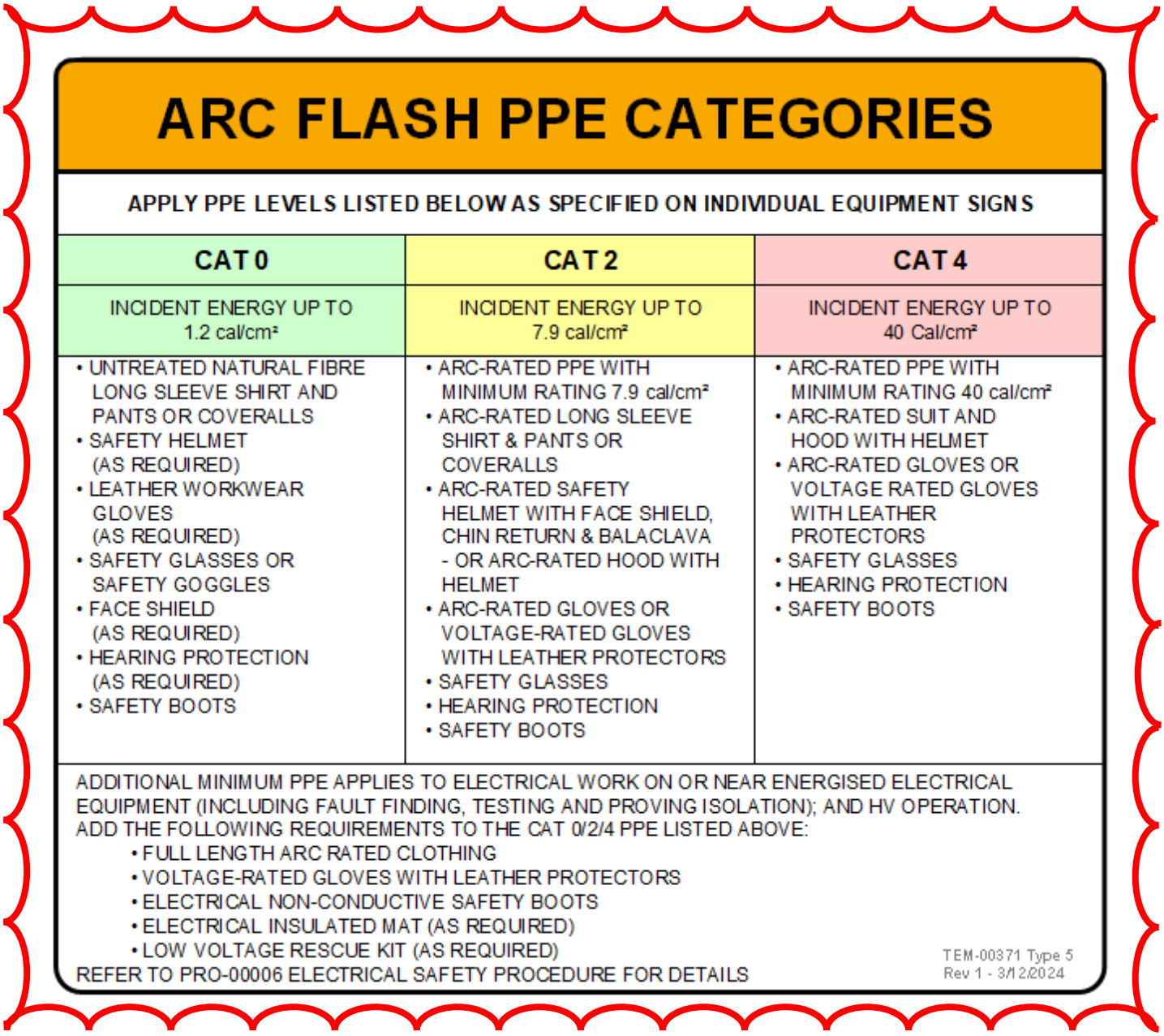


Figure 7: Example of Label Type 4 – COMPACT CAT 0

8.7. Type 5 Label – PPE CATEGORIES

The Type 5 label is a standard format to show the PPE applicable to each category. This label must be placed in a prominent location(s) near equipment requiring CAT 2 or higher PPE. This could be on the equipment itself (preferable), or if space is limited, on a nearby wall. One Type 5 label is sufficient for several pieces of electrical equipment within 10m of the Type 5 label.



ARC FLASH PPE CATEGORIES

APPLY PPE LEVELS LISTED BELOW AS SPECIFIED ON INDIVIDUAL EQUIPMENT SIGNS

CAT 0	CAT 2	CAT 4
INCIDENT ENERGY UP TO 1.2 cal/cm²	INCIDENT ENERGY UP TO 7.9 cal/cm²	INCIDENT ENERGY UP TO 40 Cal/cm²
• UNTREATED NATURAL FIBRE LONG SLEEVE SHIRT AND PANTS OR COVERALLS • SAFETY HELMET (AS REQUIRED) • LEATHER WORKWEAR GLOVES (AS REQUIRED) • SAFETY GLASSES OR SAFETY GOGGLES • FACE SHIELD (AS REQUIRED) • HEARING PROTECTION (AS REQUIRED) • SAFETY BOOTS	• ARC-RATED PPE WITH MINIMUM RATING 7.9 cal/cm² • ARC-RATED LONG SLEEVE SHIRT & PANTS OR COVERALLS • ARC-RATED SAFETY HELMET WITH FACE SHIELD, CHIN RETURN & BALACLAVA - OR ARC-RATED HOOD WITH HELMET • ARC-RATED GLOVES OR VOLTAGE-RATED GLOVES WITH LEATHER PROTECTORS • SAFETY GLASSES • HEARING PROTECTION • SAFETY BOOTS	• ARC-RATED PPE WITH MINIMUM RATING 40 cal/cm² • ARC-RATED SUIT AND HOOD WITH HELMET • ARC-RATED GLOVES OR VOLTAGE RATED GLOVES WITH LEATHER PROTECTORS • SAFETY GLASSES • HEARING PROTECTION • SAFETY BOOTS

ADDITIONAL MINIMUM PPE APPLIES TO ELECTRICAL WORK ON OR NEAR ENERGISED ELECTRICAL EQUIPMENT (INCLUDING FAULT FINDING, TESTING AND PROVING ISOLATION); AND HV OPERATION.
ADD THE FOLLOWING REQUIREMENTS TO THE CAT 0/2/4 PPE LISTED ABOVE:

- FULL LENGTH ARC RATED CLOTHING
- VOLTAGE-RATED GLOVES WITH LEATHER PROTECTORS
- ELECTRICAL NON-CONDUCTIVE SAFETY BOOTS
- ELECTRICAL INSULATED MAT (AS REQUIRED)
- LOW VOLTAGE RESCUE KIT (AS REQUIRED)

REFER TO PRO-00006 ELECTRICAL SAFETY PROCEDURE FOR DETAILS

TEM-00371 Type 5
Rev 1 - 3/12/2024

HOLD 1

TYPE 5 LABEL TO BE CONFIRMED, PENDING ONGOING REVIEW OF PRO-00006 ELECTRICAL SAFETY PROCEDURE.

CONTACT SEQWATER ENGINEERING BEFORE PRINTING THIS LABEL.

Figure 8: Example of Label Type 5 - ARC FLASH PPE CATEGORIES

8.8. Label Location

Label types 1, 2, 3 and 4 shall be affixed to the front doors of electrical switchboards and equipment.

For switchboards requiring one PPE label applicable to all positions (i.e. no separate INCOMER and NON-INCOMER label), the label should be affixed near the incomer.

Where a switchboard has more than one incomer, the arc flash labels must be installed to each incoming tier.

NON-INCOMER PPE labels, where applicable, should be affixed near the midpoint of the non-incomer tiers. It is not necessary to place a label on each individual non-incomer cell or tier.

Switchboards greater than 4m in length shall include additional copies of labels (e.g. duplicate NON-INCOMER labels) such that no part of the switchboard is more than 3m away from the relevant Type 2/3/4 label.

Prior to the installation of the label, the contractor shall confirm the position with the Principal.

The PPE REQUIRED label should preferably be located directly below the DANGER label. If space is limited, the PPE REQUIRED label may be placed at a nearby location on the same door as the DANGER label.

For equipment needing two PPE REQUIRED labels on the same door (i.e. some form 2bi distribution boards with different labels for INCOMER and NON-INCOMER CIRCUITS), the DANGER label should be installed with the INCOMER PPE REQUIRED label only and may be omitted from the NON-INCOMER CIRUICTS PPE REQUIRED label.

All labels shall be affixed to equipment at a height that can be easily read and, where practical, they should be situated such that the bottom of the label is 1.5 meters from the ground.

For kiosk substations, generator installations, and outdoor switchboards with dead front panels behind outer doors, the arc flash labels shall be installed to the internal equipment doors or compartments and not to the outer doors.

8.9. Interpretation of Arc Flash Labels

PRO-00006 Electrical – High and Low Voltage Procedure describes Seqwater's minimum requirements to control the risk associated with Low Voltage (LV) and High Voltage (HV) electricity. SPE-00439 (this Procedure) provides informational guidance on interpretation of arc flash labels, pending an update of the arc flash requirements in PRO-00006.

8.9.1. PPE Selection

In case of arc flash hazard, the main purpose of personal protective equipment is to reduce the severity of burn injuries to the worker.

Arc flash PPE shall be selected to match or exceed the category specified on the arc flash label for the work activity being undertaken. Activities outside of the scope of those listed on the label will require PPE to be selected considering the magnitude of the arc flash incident energy, the arc flash boundary, and the likelihood of an arc flash occurring during the work in question.

In all cases, the arc flash risks specific to the task and equipment must be considered in the relevant standard operating procedure (SOP), safe work method statement (SWMS) or Take 5. This may require additional PPE compared with the default minimum requirements on the label.

The incident energy and arc flash boundary are a predictive calculation based on the equipment at the time of the arc flash study. The study results rely on assumptions such as correct operation of upstream protection to

interrupt the fault. Risk assessments should consider any factors that may invalidate the data indicated on the arc flash label.

Incident energy calculations are based on a nominal working distance as shown in the arc flash study report. At closer distances, the incident energy will be higher. Increased PPE may be required for activities that require the worker to be especially close to potential sources of arcing faults.

PPE is considered the least effective risk control in the hierarchy of controls, and must be used in combination with other controls.

8.9.2. Work on Isolated Equipment

Minimum CAT 0 PPE is the standard arc flash requirement for working on equipment that is isolated, locked, tagged, proven dead, earthed if applicable, and not within the same enclosure as energised equipment nor within 3 m of exposed energised parts or conductors. Additional PPE may apply based on the activity being undertaken, as per the relevant procedure, safe work method statement (SWMS) or Take 5.

9. Reassessment

Arc flash hazard analysis shall be reassessed when the electrical installation changes, including but not limited to the following:

- Changes to protection settings.
- Plant upgrade.
- Inclusion of new electrical machines (e.g. power transformers, large electrical motors, power backup generator in parallel operation with mains supply).
- Utility's prospective fault increase at the PCC. This is particularly relevant for HV supply directly onto Seqwater's switchgear.
- Switchgear's bus switching reconfiguration due to project optimisation (e.g. operation of power transformer in parallel, temporary switching of capacitors and/or reactors during a specific period of plant operation).

Arc flash hazard analysis shall be periodically reviewed for accuracy at intervals not exceeding 5 years.

10. Roles and Responsbilities

Table 14 – Roles and Responsibilities

Role	Responsibility
Leaders	In addition to the responsibilities of a worker, ensure compliance with this Standard Specification by those they lead.
Workers / Employees	Be aware of and comply with this Standard Specification

11. Definitions and Abbreviations

The following definitions (Table 15) apply to this Standard Specification.

Additionally, the definitions in AS3851 apply to this Standard Specification.

Table 15 – Definitions

Term	Definitions
Arc-Blast	Rapid heating and expansion of air and molten metal resulting from an arc fault
Arc-Flash	An electric arc event with thermal energy dissipated as radiant, convective, and conductive heat
Arc-Flash Boundary	When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2. Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 for one second. (NFPA 70E)
Arc-Flash Hazard	A dangerous condition associated with the possible release of energy caused by an electric arc
Arc-Flash Hazard Calculation	The use of equations to compute the incident energy at a specific working distance and the arc-flash boundary
Arcing Fault Current	A fault current flowing through an electrical arc plasma
Arc Rated (AR) PPE	Clothing specified with an ATPV (Arc Thermal Performance Value) expressed in calories per centimetre squared. AR PPE with an ATPV has been specifically tested to provide protection against electrical arcing faults.
Assembly	Combination of one or more low voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, with all the internal electrical and mechanical interconnections and structural parts
Arc Thermal Performance Value	In arc testing, the incident energy on a material that results in a 50% probability that sufficient heat transfer through the tested specimen is expected to cause the onset of a second degree burn injury
Bolted Fault	A short-circuit condition that assumes zero impedance exists at the point of the fault
Circuit	A conductor or system of conductors through which an electric current flow
Clearing Time	The total time between the beginning of a specified overcurrent and the final interruption of the circuit at rated voltage
Contractor	An entity engaged by Seqwater to undertake work in accordance with an agreed contract and defined scope of work.
Control Panel	A type of a switchboard that may contain ELV and/or LV sources including switching control devices.

Term	Definitions
Electrode Configuration	The orientation and arrangement of the electrodes used in the testing performed for the model development. VCB Vertical conductors/electrodes inside a metal box/enclosure VCBB Vertical conductors/electrodes terminated in an insulating barrier inside a metal box/enclosure HCB Horizontal conductors/electrodes inside a metal box/enclosure VOA Vertical conductors/electrodes in open air HOA Horizontal conductors/electrodes in open air
Employees	Means persons employed directly by Seqwater in a permanent, temporary or casual capacity.
Energised	Electrically connected to, or is, a source of voltage
Extra-low voltage	Not exceeding 50 VAC or 120 VDC ripple free.
Fault Current	A current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two conductors
Gap	The spacing between bus bars or conductors at the arc location
High Voltage	Exceeding low voltage.
Incident Energy	The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electric arc event. Incident energy is typically expressed in joules per square centimetres (J/cm^2) or calories per square centimetre (Cal/cm^2).
Incident Energy Analysis	A component of an arc-flash risk assessment used to predict the incident energy of an arc flash for a specific set of conditions.
Initial symmetrical short-circuit current (I''_K)	R.M.S. value of the a.c. symmetrical component of a prospective (available) short-circuit current applicable at the instant of short-circuit if the impedance remains at zero-time value.
Leader	Means any Level 1, 2, 3 and 4 Leader with responsibility for managing a functional area of the business, including people management responsibilities within their functional area.
Limited Approach Boundary	An approach limit at distance from an exposed energised electrical conductor or circuit part within which a shock hazard exists.
Low voltage	Exceeding ELV but not exceeding 1000 VAC or 1500 VDC.
Manufacturer / Supplier / Vendor / Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
Nominal Voltage	A numerical value of a circuit or system for designating its voltage class

Term	Definitions
Owner / Principal / Seqwater	The entity that engages the contractor to undertake the work and takes custody of the outcome. The Owner may delegate responsibilities to other entities to act on its behalf (e.g. a consultant).
Peak short-circuit current (Ip)	Maximum possible value of the prospective short-circuit current. NOTE: The prospective short-circuit current reaches a peak in the first cycle. The magnitude of this peak varies according to the moment at which the short-circuit occurs. The maximum value generally occurs when the short-circuit starts at the zero crossing of the pre-fault voltage waveform.
Prospective short-circuit current	Current that would flow if the short-circuit current were replaced by an ideal connection of negligible impedance without any change of the supply. NOTES: The current in a multiphase short-circuit is assumed to be made simultaneously in all faulted phases. "Without any change of the supply" implies no operation of switchgear or current limiting switching devices such as current limiting fuses or circuit-breakers.
Seqwater Approval / Acceptance	Written sign-off gained via the deviation process, as detailed in X-PRO-STD-008 Asset Standards Management and Application.
Seqwater Engineering Standard	Includes Standard Procedures and Standard Specifications and associated supporting documents such as Standard Drawings, Guidelines, Lists, Datasheets, Manuals, Registers, and Templates.
Shall / must	Indicates a mandatory requirement
Short-circuit	Accidental or intentional connection, by a relatively low resistance or impedance, of two or more points in a circuit which are normally at different voltages.
Short-circuit current	Current resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit. NOTE: It is necessary to distinguish between the short-circuit current in the fault and the currents in the network branches.
Should	Indicates a recommendation
Switchboard	An assembly of circuit protective devices, with or without switchgear, instruments or connecting devices, suitably arranged and mounted for distribution to, and protection of, one or more submains or final subcircuits, or a combination of both.
Symmetrical short-circuit breaking current (I_b)	R.M.S. value of an integral cycle of the symmetrical a.c. component of the prospective short-circuit current at the instant of contact separation of the first pole of a switching device. NOTE: In accordance with AS 3851-1991, I_b is taken as the current in the fault and is not necessarily the current in the switching device.
Voltage factor (c)	Factor used in the determination of the equivalent source voltage
Worker(s)	Includes all permanent, temporary, and casual employees of Seqwater, and: • vocational and work experience placements • volunteers

Term	Definitions
	suppliers, contractors, and consultants temporarily engaged to do work for or on behalf of Seqwater.
Working Distance	The distance between the potential arc source and the face and chest of the worker performing the task

The following abbreviations (Table 16) apply to this Standard Specification.

Table 16 – Abbreviations

Abbreviation	Description
A	Ampere
AC	Alternating Current
a.c.	Alternating Current
ACB	Air Circuit Breaker
ATPV	Arc Thermal Performance Value
cal	Calories
CB	Circuit Breaker
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
DT	Definite Time
DNSP	Distribution Network Service Provider
EDO / EDOF	Expulsion Drop Out Fuse
ELV	Extra Low Voltage
FLC	Full Load Current
HV	High Voltage
Hz	Hertz
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IDMT	Inverse Definite Minimum Time
kA	Kilo Amperes

Abbreviation	Description
kV	Kilo Volt
kVA	Kilo Volt Amperes
LV	Low Voltage
MCC	Motor Control Centre
MV	Medium Voltage
NFPA	National Fire Protection Association, USA
O/C	Overcurrent
PCC	Point of Common Coupling
PPE	Personal Protective Equipment
PSA	Power System Analysis
PTW	Power Tools for Windows
REX	Seqwater Records Excellence Electronic Document and Records Management System
RMU	Ring Main Unit
RPEQ	Registered Professional Engineer of Queensland
STPU	Short Time Pick Up
SS	Soft Starter
SWBD	Switchboard
TBD	To Be Developed
TCC	Time Current Characteristic
TMS	Time Multiplier Setting
V	Volt
VFD	Variable Frequency Drive
VT	Voltage Transformer
X/R Ratio	Reactance to Resistance ratio
ZSI	Zone Selective Interlocking

12. References and Related Materials

The documents listed in Table 17 and Table 18, and the requirements therein, are relevant to this Standard Specification. In their latest editions, these documents form a part of this Standard Specification. Note that this is not an exhaustive list of documents relevant to the works.

Table 17 – Reference Seqwater Documentation

Description	Location
PRO-00006 Electrical – High and Low Voltage Procedure	REX
PRO-01617 Engineering Standard X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance Procedure	REX
PRO-01872 Engineering Standard X-PRO-STD-002 Engineering Drawing Numbers Procedure	REX
PRO-01873 Engineering Standard X-PRO-STD-001 Asset Standards Document Classification and Naming Structure Procedure	REX
PRO-01874 Engineering Standard X-PRO-STD-004 Development and Review of Asset Standards Procedure	REX
PRO-02187 Engineering Standard X-PRO-STD-007 Drawing & Spatial Data Standards Procedure	REX
PRO-02190 X-PRO-STD-006 Equipment Numbering and Naming Convention Procedure	REX
PRO-02205 Engineering Standard X-PRO-STD-008 Asset Standards Management and Application Procedure	REX
PRO-02253 Engineering Standard X-PRO-STD-014 Drawings Management Procedure	REX
SPE-00352 Engineering Standard E-SPE-STD-001 Electrical Design and Construction	REX
TEM-00224 Engineering Standard X-TMP-STD-022 Asset Standards Deviation Request Template	REX
TEM-00371 Engineering Standard E-TMP-STD-007 Arc Flash Hazard Label Template	REX

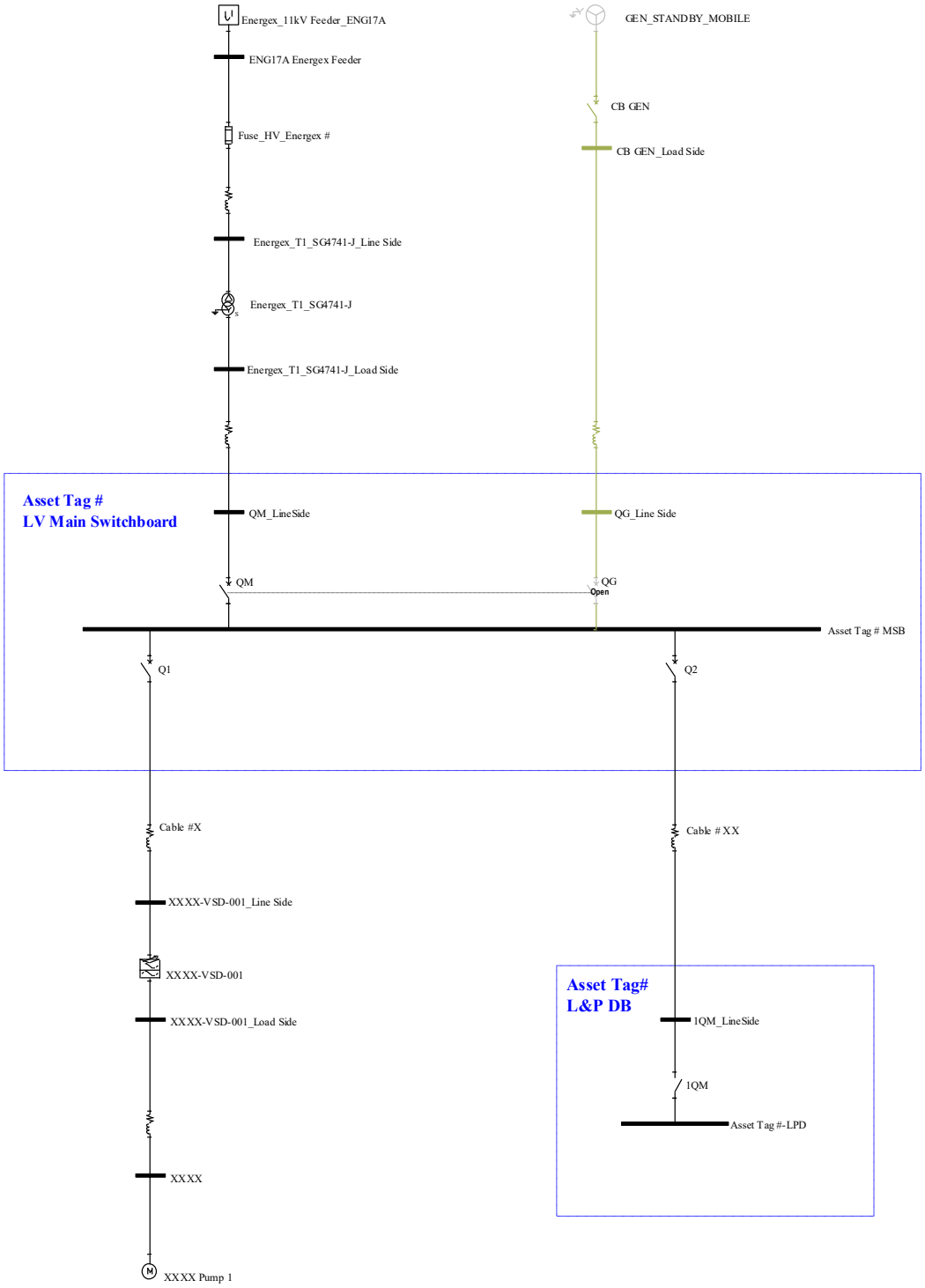
Table 18 – Reference External Standards, Specifications and Codes

Standard Number	Document Title
AS 2067	Substations and High Voltage installations exceeding 1 kV a.c.
AS 2467	Maintenance of electrical switchgear
AS/NZS 3000	Wiring Rules, Electrical Installations
AS 3008.1.1	Electrical Installations – Selection of Cables
AS 3851	The calculation of short-circuit currents in three-phase a.c. systems. Note: This standard is based upon IEC 60909
AS/NZS 4836	Safe working on or near low-voltage and extra-low voltage electrical Installations and equipment
AS/NZS 60076.5	Power Transformers Part 5 – Ability to withstand short-circuit
AS/NZS 61439	Low-voltage switchgear and controlgear assemblies - General rules
AS 62271	High voltage switchgear and control gear – A.C. metal-enclosed switchgear and control gear above 1 kV.
IEC 60255	Measuring Relays and Protection Equipment
IEEE 1584	Guide for performing arc-flash hazard calculations
IEEE 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE 399	Recommended Practice for Industrial and Commercial Power System Analysis
NFPA 70E	Standard for Electrical Safety in the Workplace
	Managing electrical risks in the workplace Code of Practice – Queensland Electrical Safety Office

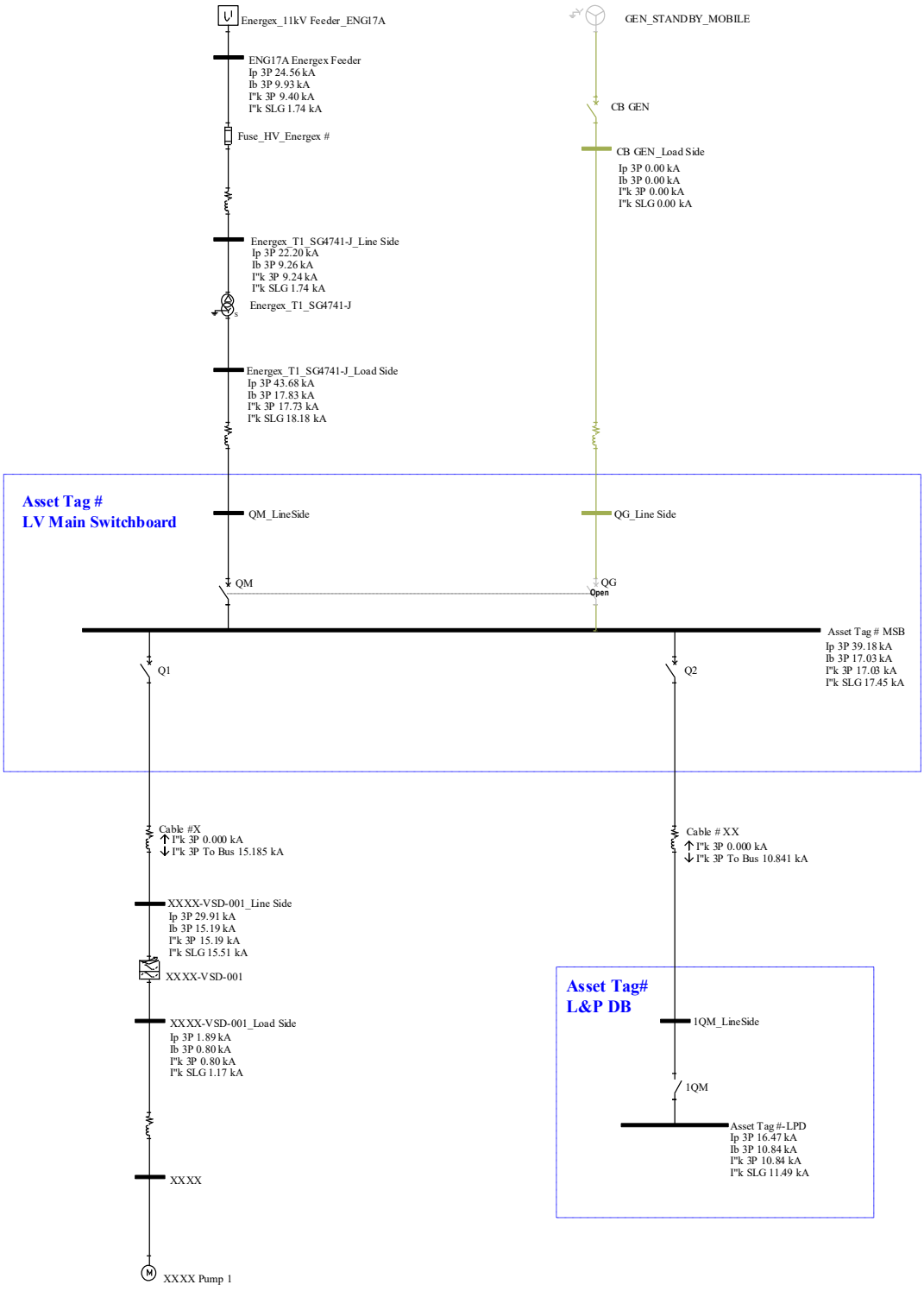
13. Changes from Previous Version

This Standard Specification will be regularly reviewed and updated, including the consideration of requested alterations, in accordance with Seqwater Procedure X-PRO-STD-004 Development and Review of Asset Standards.

Appendix A – Typical PTW Bus Naming Convention



Appendix B – Typical PTW Fault Study Data Block Output



Appendix C – Typical Arc Flash Hazard Register

The arc flash register shall be exported from the PTW arc flash module and appended to the back of the PSA report. An example PTW output is provided below as a guide.

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Equip Type	Electrode Config	Box Width (mm)	Box Height (mm)	Box Depth (mm)	Gap (mm)	Arc Flash Boundary (mm)	Working Distance (mm)	Incident Energy (cal/cm2)	PPE Level / Notes (*N)
1	1QM_LineSide	Q2	0.415	13.25	9.56	13.25	9.56	0.02	0.0000	PNL	VCB	305	356	254	25	244	457	0.44	Level 0
2	Asset Tag # MSB	QM	0.415	19.24	13.84	19.24	13.84	0.04	0.0000	PNL	VCB	305	356	254	25	481	457	1.30	Level 2
3	Asset Tag #-LPD	Q2	0.415	13.24	9.56	13.24	9.56	0.02	0.0000	PNL	VCB	305	356	254	25	244	457	0.44	Level 0
4	Energex_T1_SG4741-J_Line Side	Fuse_HV_Energex #	11.00	11.21	10.25	11.21	10.25	0.0162	0.0000	SWG	VCB	762	1143	762	152	293	914	0.20	Level 0
5	Energex_T1_SG4741-J_Load Side	Fuse_HV_Energex #	0.415	17.73	11.17	17.73	11.17	0.3264	0.0000	PNL	VCB	305	356	254	25	1564	457	8.57	Level 4 (*N3 Imin)
6	QM_LineSide	Fuse_HV_Energex #	0.415	17.03	10.74	17.03	10.74	0.3557	0.0000	PNL	VCB	305	356	254	25	1608	457	8.95	Level 4 (*N3 Imin)
7	XXXX-VSD-001_Line Side	Q1	0.415	17.37	12.54	17.37	12.54	0.011	0.0000	PNL	VCB	305	356	254	25	201	457	0.32	Level 0

Appendix D – Power System Report Template

This Appendix provides an example of the minimum information to be included in the power study report (power system modelling, short circuit, arc flash analysis).

The formatting provided in this template is an example only and may be adapted to suit the project requirements. Report requirements provided in the body of for reporting in the body of the specification take precedence over this template.

Cover Page

- Contractor Company Name
- Client: Seqwater
- Site name
- Project
- Document number
- Document title
- Revision number
- Revision Date
- Author Name
- Checker Name
- Approving RPEQ Name, RPEQ Number, Date and Signature
- PTW model file name

Contents

Include page numbers and list of Appendix.

1. Executive Summary

Provide a concise description with relevant results and recommendations. Example:

"This report presents the results of the power systems analysis undertaken for Seqwater Bundamba Pump Station (BPS) Plant located at 116 River Road, Bundamba in Ipswich, 35 km from Brisbane, Queensland. The power system analysis comprises the following:

- Fault study.
- Protection setting analysis.
- Arc flash assessments.

Based on the arc flash analysis results for the worse case plant operation scenario, site specific Working Instructions were developed to determine the work categories and PPE categories to be adhered to when working within the arc flash incident energy boundaries of the electrical switchboards."

In the executive summary, provide an arc flash study incident energy summary table with the following headings:

Asset ID	Asset	Fault Location	Incident Energy (cal/cm2)	Arc Flash Boundary (mm)	Arc Flash Category
FAC0044130	LV Main Switchboard SLL-E-MSB1	Line Side	0.84	366	0
		Load Side	0.84	366	0

Labelling indicated in the relevant appendices of this document shall be implemented to all electrical switchboards."

2. Introduction

In this section, provide a brief description of the specific site including location and section of the power system covered in this document. Example:

- Three-phase short-circuit calculation.
- Protection device settings.
- Arc Flash Analysis

3. Site Background

Brief summary of the site network and key switchboards and loads.

4. Purpose

In this section describe the main purpose of this document.

5. Reference Documents and Drawings

List all documents associated with specific site.

6. Definitions

For clarity of the audience reading this document provide relevant technical definitions that may be used in this document. Use tabulated format for each definition.

7. Abbreviations

For clarity of the audience reading this document provide relevant technical abbreviations used in this document. Use tabulated format for each acronym.

8. Methodology

Describe the methodology applied in the development of the power system study. Example:

“The power system studies were developed by conducting the following relevant engineering steps:

- Site data collection.
- Power System Modelling.
- Maximum and minimum short circuit calculation
- Protection relay settings.
- Protection relay grading curves.
- Arc-flash hazard analysis.

8.1 General

The PSA relevant to this document is developed based on the following engineering

methodologies:

- Engineering documentation (provided by Seqwater).
- Site data collection and photos taken of the installation.
- Assessment of the engineering documentation and data collected on site.
- Modelling of electrical single line diagrams including protective devices.
- Protection relay settings including relevant TCCs.
- Engineering analysis of the relevant sections of the power system.

8.2 Data Collection

The electrical installation data was collected during the Bundamba Pump Station site visit. Data collected on site was in the form of digital photos and/or notes in electronic format.

The following data inputs relating to the Bundamba BPS site was collected as described below:

- Energex fault contribution data (supplied by Seqwater).
- Network configuration SLD’s of the electrical infrastructure (supplied by Seqwater).
- Conductor type, insulation type/class and, installation details (e.g. routing and support method, in conduit, cable ladder, etc). Not all conductor details were available from site.
- Protective device settings, type and model.

8.3 Engineering Software and Model

The electrical engineering analysis software, SKM Power Tool® for Windows™ (PTW) version 9.0.0.4 was used to construct the power system model and perform the power system calculations for the following studies:

- Short-circuit analysis.
- Protection relay coordination.
- Arc-flash analysis.

The PSA reports and SLD's derived from the PTW software model "Bundamba Pump Station PTW Model September 2019" shall form part of this Report (detailed in appendices to support the calculation results.). "

9. Exclusions

The contractor conducting the power system analysis shall state in the specific site report details of the power system study that have been excluded from the scope of work. Prior approval, for the exclusion of any such items, must first be obtained from Seqwater. Describe all exclusions not covered in the report. Example:

- Hand calculation for arc flash hazards.
- Load flow report – it will be modelled but not reported in this particular case (out of SoW)."
- Transient Analysis
- Harmonic Analysis

10. Assumptions

List all assumptions made in this report.

11. Study Scenarios

In this section provide a brief description of the scenarios that will be studied in this report.

12. Equipment Overview

Include here a brief description of the equipment and varying loads in relation to the specific site.

Example sub-headings for this section:

12.1 HV Switchboard
12.2 VFDs
12.3 LV Pump Motors
12.4 Main Transformer
12.5 LV Switchboard
12.6 LV Distribution Boards

13. Short Circuit Analysis

13.1 Maximum and Minimum SC

In this section provides a summary of the short-circuit current evaluated at different main-bus of the switchboards. Example:

"The following tables summarize the fault calculation derived from the engineering software PTW, the detailed calculation results are attached in the relevant appendices of this report. The equipment rating indicated on the equipment nameplate details is well above the calculation results as shown on the following tables:"

Add the relevant summarized tables for the short-circuit calculation results.

13.2 Input Data

13.3 Calculation Results

14. Protective Coordination Analysis

Example sub-headings for this section:

14.1 Incomer

14.2 HV Pump

14.3 Main TXF

14.4 LV SWBD's & DBs

15. Arc Flash Assessment

15.1 Arc Flash Analysis Approach

In this section describe the purpose of conducting an arc flash analysis of the power system involving switchboards. Example:

"The purpose of conducting an arc-flash hazard analysis within a power distribution system is to determine the following:

- The arc-flash incident energy (cal/cm²).
- The arc-flash boundaries in a three-phase AC system to which workers may be exposed during their work or near electrical equipment.

Once the arc-flash incident energy and the arc-flash boundaries are calculated, this information can be used as a basis to develop strategies that have the goals of minimum burn injuries. Strategies include specifying:

- The rating of the Personal Protective Equipment (PPE)
- Working de-energised
- Following other engineering strategies techniques and work practices."

15.2 Arc flash results

Provide detailed arc flash analysis results for all scenarios, and the summary results containing all of the "worst case" information required for labelling, at key buses that will require arc flash hazard labels.

In this section also discuss the presentation format of the arc flash incident energy and the relevant location.

15.3 Arc flash result comments

Provide comments on any notable or elevated arc flash results.

15.4 Equipment Labelling

In this section describe the relevant labels to be affixed on electrical switchboards. Example:

"Based on the arc-flash results, the type of arc flash label for relevant switchboards are printed in the relevant appendices of this document."

Document the information and assumptions used to translate the raw incident energy analysis results into equipment labels.

15.5 Criterion for Reassessment

In this section, describe the relevant examples of instances where a reassessment of the Arc Flash Hazard Analysis will be required. Example:

"Arc flash hazard analysis shall be reassessed if the electrical installation changes, examples of these instances are as follows:

- Plant upgrade.
- Inclusion of new electrical machines (e.g. power transformers, large electrical motors, power backup generator in parallel operation with mains supply).
- Utility's prospective fault increase at the PCC. This is particularly relevant for HV supply directly onto Seqwater's switchgear.
- Switchgear's bus switching reconfiguration due to project optimisation (e.g. operation of power transformer in parallel, temporary switching of capacitors and/or reactors during a specific period of plant operation).
- In the absence of the any modifications that impact the power system, the arc-flash analysis of the plant should be revalidate every 10 years."

16. Conclusion

Finalise report with technical conclusion and use part of this conclusion to elaborate the EXECUTIVE SUMMARY on the front page of this document.

17. Recommendations

Provide recommendations to mitigate risks and correct non-compliance or issues found.

18. Appendices

Example Appendices:

APPENDIX A - PTW Single Line Drawings (showing worst case arc flash results)

APPENDIX B - PTW maximum short circuit results

APPENDIX C - PTW minimum short circuit results

APPENDIX D - Protection setting Schedule

APPENDIX E - Protection setting TCC

APPENDIX F - Arc flash results

APPENDIX G - Arc flash labels

APPENDIX H - Seqwater documentation

APPENDIX I - Reference Data

APPENDIX J - PTW Library changes