

BATTERY INSTALL GUIDELINES FOR ACCREDITED INSTALLERS



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These guidelines have been developed by Clean Energy Council. They represent latest industry best practice for the installation of battery systems and pre-assembled BESS. © Copyright 2017

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1 PREFACE

The installation of grid-connected energy systems - including batteries, is a relatively new and emerging field, and one in which there is a lack of definitive standards.

There are existing standards for the design and installation of stationary battery systems (refer *1.1 Existing Standards* below).

However, such standards were prepared for use with traditional lead acid and nickel cadmium battery chemistries, and do not address recent product innovations and other developments. Such developments include:

- Battery chemistries other than lead acid and nickel cadmium, such as:
 - Lithium (eg. lithium iron phosphate, lithium ferro phosphate, etc),
 - Flow (eg. zinc bromine, vanadium redox flow, etc); and,
 - Hybrid ion (eg. aqueous)
- Interconnected power conversion equipment (such as multi-mode inverters), which can result in energy storage being continually connected to the grid network, and may include photovoltaic or other energy sources
- Availability of pre-assembled integrated battery energy storage systems, manufactured as complete packages. Such systems include battery storage, inverters and other control equipment into a single assembly, with pre-engineered connections

This document provides guidance to designers and installers of energy storage and must be read in conjunction with existing relevant standards, codes, network service provider rules and other such requirements.

These guidelines, referencing Australian and international standards, apply to energy storage operating at both:

- Extra-low voltage (ELV); and,
- Low voltage (LV).

Additionally, these guidelines apply to the following energy system types:

- Grid-connected; and,
- Stand-alone.

For further information on applicability refer to:

- *2 SCOPE*
- *6 BATTERY SYSTEM HAZARDS - 6.1 General*

1.1 Existing Standards

There are several existing Australian Standards covering installation of stationary batteries in buildings. Whilst these standards have some common content, their scope and applicability vary as follows:

Standard	Scope	Notes
AS 2676 - Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings	This standard covers practices for the installation, maintenance, testing and replacement of lead acid and alkaline (eg. nickel-cadmium) secondary batteries installed in or on buildings. The scope includes batteries with a nominal voltage of at least 24VDC and a capacity exceeding 10A.h (at the 1 hr rate.)	To be read in conjunction with AS 3011 - Electrical installations - Secondary batteries installed in buildings
AS 3011 - Electrical installations - Secondary batteries installed in buildings	This standard covers the installation (including layout) and maintenance, of lead acid and alkaline (eg. nickel-cadmium) secondary batteries installed in or on buildings, structures or premises. The scope includes batteries with a nominal voltage of at least 24VDC and a capacity exceeding 10A.h (at the 1 hr rate.)	To be read in conjunction with AS 2676 - Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings
AS 4086 - Secondary batteries for use with stand-alone power systems Installation and maintenance	This Standard covers the installation, maintenance, testing and replacement of secondary batteries, having nominal voltages not exceeding 115 VDC, for use with stand-alone systems. Stand-alone systems are those that are not connected to the power distribution systems of an electricity supply authority. This Standard applies to all battery chemistries, including lead-acid and nickel-cadmium.	This standard is referenced by AS/ NZS 4509 - Stand-alone power systems – system design, safety & installation

Standard	Scope	Notes
AS/ NZS 4509 - Stand-alone power systems – system design, safety & installation	This standard sets out design, safety and installation requirements for stand-alone power systems used for the supply of extra-low (ELV) and/ or low voltage (LV) electric power to an electrical load.	This standard references AS 4086 - Secondary batteries for use with stand-alone power systems Installation and maintenance
AS/ NZS 4777.1 - Grid connection of energy systems via inverters - Installation requirements	This standard specifies the electrical and general safety requirements for inverter energy systems connected to the grid at low voltage. This standard includes requirements for connection of an inverter to an energy source – including battery storage. Such requirements include connections, cabling, overcurrent protection and isolation devices.	-

2 SCOPE

This document applies to the installation of battery systems up to the terminals of power conversion equipment (PCE), such as inverters, charge controllers, etc.

That is, the scope includes the following:

- Battery
- Battery Enclosure
- Cabling
- Switchgear (Protection & Isolation Devices)
- Auxiliary Equipment (eg. Battery Management System (BMS), and other equipment required by the manufacturer)

Additionally, this document covers the installation of pre-assembled integrated battery energy storage systems (BESS) which includes the battery system, cabling, switchgear, power conversion equipment and auxiliary equipment.

The scope of this document also includes installation of battery systems/ pre-assembled BESS as follows:

- A nominal voltage $\geq 12\text{VDC}$
- Rated capacity of $\geq 1\text{kWh}$ and $\leq 200\text{ kWh}$
 - C10 rating for lead acid batteries
 - 0.1C for lithium chemistries
 - Manufacturer's specified energy capacity, for other chemistries

Refer to *Figure 1, Figure 2, Figure 3 and Figure 4* for examples of the scope of these guidelines.

The scope does not include the following:

- Telecommunication Equipment
- Electric Vehicles
- Portable Equipment
- Sites with critical power supply requirements (eg. acute care hospitals, distributor sub-station support, etc)



Figure 1 Scope of these guidelines: The battery system including cabling up to PCE terminals



Figure 2 Scope of these guidelines: Installation of pre-assembled integrated battery energy storage systems (pre-assembled BESS)



Figure 3 Scope of these guidelines: Installation of pre-assembled integrated battery energy storage systems (pre-assembled BESS)



Figure 4 Scope of these guidelines: Installation of pre-assembled integrated battery energy storage systems (pre-assembled BESS)

3 REFERENCED DOCUMENTS

- AS 1170.4 Structural design actions - Earthquake actions in Australia
- AS 1319 Safety signs for the occupational environment
- AS 1926.1 Swimming pool safety - Safety barriers for swimming pools
- AS 2676.1 Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings – Vented cells
- AS 2676. 2 Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings – Sealed cells
- AS/ NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
- AS 3011.1 Electrical installations - Secondary batteries installed in buildings - Vented cells
- AS 3011.2 Electrical installations - Secondary batteries installed in buildings - Sealed cells
- AS 4086.2 Secondary batteries for use with stand-alone power systems - Installation and maintenance
- AS/ NZS 4509.1 Stand-alone power systems - Safety and installation
- AS/ NZS 4509.2 Stand-alone power systems - System design
- AS/ NZS 4777.1 Grid connection of energy systems via inverters – Installation requirements
- AS/ NZS 4777.2 Grid connection of energy systems via inverters – Inverter requirements
- AS/ NZS 5000.1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV
- AS/ NZS 5000.2 Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V
- AS 60950.1 Information technology equipment - Safety - General requirements
- AS 62040.1.1 Uninterruptible power systems (UPS) - General and safety requirements for UPS used in operator access areas
- AS 62040.1.2 Uninterruptible power systems (UPS) - General and safety requirements for UPS used in restricted access locations
- NZS 4219 Seismic performance of engineering systems in buildings
- IEC 62109-1 Safety Of Power Converters For Use In Photovoltaic Power Systems - Part 1: General Requirements
- IEC 62109-2 Safety Of Power Converters For Use In Photovoltaic Power Systems - Part 2: Particular Requirements For Inverters
- IEC 62619 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications

4 DEFINITIONS

Where possible, terms and definitions have been derived from AS/ NZS 3000, AS/NZ 5033, AS 4777, [DR] AS/ NZS 5139, other relevant standards, codes or industry terminology.

Some terms have been adapted in line with industry and market developments or translated into plain language; and, some terms are unique to this document.

- **Adjacent** – Within three meters, where each item is fully visible from both locations
- **Arc Flash** – An electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition
- **Authorised person** – A person in charge of the premises, or the licenced electrician/ contractor/ accredited person, or other such person appointed or selected by the person in charge of the premises to perform certain duties
- **Battery** – A unit consisting of one or more energy storage cells connected in series, parallel or both
- **Battery Cell** – A basic functional unit of a battery generally containing electrodes, electrolyte, terminals, etc.
- **Battery Energy Storage System (BESS)** – A system consisting of power conversion equipment (PCE), battery system (s), switchgear and other such equipment. A BESS may be manufactured as a complete package where all above components are integrated into a single assembly with pre-engineered connections (referred to as a “Pre-assembled BESS” in this document.)
- **Battery enclosure** – An enclosure containing a battery or batteries suitable for the installation location and associated components
- **Battery management system (BMS)** – An electronic device which safely manages a battery/ battery system by ensuring it is within its safe operating parameters. Such parameters generally include overcharge, overcurrent, over discharge, overheating, etc.
- **Battery module** – One or more batteries linked together, generally incorporating electronics for monitoring, cycling and/ or protection
- **Battery system** – A system comprising one or more cells, modules or battery systems. It may include a battery management system (BMS), auxiliary equipment and other supporting equipment. It does not include power conversion equipment (PCE).
- **Bunding/ bunds** – A physical system for the retention of potentially hazardous substances, eg. electrolyte
- **Combustible material** – a material that, in the form in which it is used and under the conditions anticipated, will ignite and burn
- **Contact, direct** – Contact with a conductor/ conductive parts that is live in normal service
- **Contact, indirect** – Contact with a conductor/ conductive parts that is not normally live but has become live under fault conditions (eg. due to a breakdown of insulation)
- **Damp situation** – A situation in which moisture is either permanently or intermittently present to the extent to impair the effectiveness and safety of an electrical installation
- **Dwelling, domestic** – An Australian or New Zealand building as specified in the National Construction Code (NCC) under Australian building classifications, as follows:

- Class 1, examples include:
 - Detached house
 - Terrace house
 - Town house
 - Villa unit
- Boarding house/ guest house/ hostel
(subject to specified conditions – refer to clause 1.3.2(b) of the National Construction Code 2015, Volume 2)
 - Class 2, examples include:
 - A building containing 2 or more sole-occupancy units each being a separate dwelling – such as an apartment block
 - Class 10, examples include:
 - A non-habitable building being a private garage, carport, shed, etc

Note that AS/ NZS 5033:2014 includes Class 3 as a domestic dwelling. However, this document and AS/ NZS 4777.1 does not include Class 3 as a domestic dwelling.

- Dwelling, non-domestic – An Australian or New Zealand building as specified in the National Construction Code (NCC) under Australian building classifications, that is not Class 1, Class 2 or Class 10.

Note that AS/ NZS 5033:2014 includes Class 3 as a domestic dwelling. However, this document and AS/ NZS 4777.1 does not include Class 3 as a domestic dwelling.

- Fire resistance level (FRL) – as defined in the National Construction Code (NCC), is the grading period in minutes for three criteria: structural adequacy, integrity and insulation
- Material Safety Data Sheet (MSDS) – See Safety Data Sheet (SDS)
- Port (of PCE) – Access to a device (eg. inverter) where electromagnetic energy or signals may be supplied or received
- Power conversion Equipment (PCE) – An electrical device that converts one kind of electrical power from a voltage or current source into another with respect to voltage, current and frequency (eg. inverters, charge controllers, etc)
- Readily available – capable of being reached for inspection, maintenance or repairs (without having to dismantle structural parts, cupboards, benches, etc)
- Readily accessible – capable of being reached quickly without having to remove obstructions, use of elevation equipment (eg. ladder); and not more than 2 metres above the ground/ floor/ platform
- Restricted access (to battery system/ pre-assembled BESS) - Access restricted, to authorised persons, to the following:
 - DC isolation devices
 - DC overcurrent devices
 - DC cabling (between batteries/ battery modules and DC overcurrent devices)
 - Live parts (eg. PCE input terminals, battery cell terminals, DC busbars, etc)

Access can be restricted:

- By a barrier, such as:

- A perimeter fence/ barrier/ door to a dedicated room with access only via a padlocked/ equivalently secured gate/ door; or,
- Enclosure (where the relevant parts are fully enclosed and are only accessible with the use of a tool (eg. screwdriver, key, etc)
- By location (eg. where there is no ready means of access)

Note that restricted access is not required to DC battery cabling between batteries/ battery module overcurrent and PCE. However, the general cable installation requirements of AS/ NZS 3000 shall apply.

- Risk assessment - A risk assessment builds knowledge and understanding about hazards and risks that have been identified so that informed decisions can be taken about controlling them.
- Safe work procedures – a part of a risk management process which outlines hazards, risks and control measures to be applied to ensure an activity is conducted in a way that satisfactorily reduces the risk of injury
- Stationary batteries – permanently installed batteries, not in use for a portable application
- Safety Data Sheet (SDS) – a document that provides critical information about hazardous materials. Typically such information includes the chemical's identity and ingredients, health and physical hazards, safe handling and storage procedures, emergency procedures and disposal considerations.

5 HOW TO USE THESE GUIDELINES

The purpose of this document is to provide guidance to battery installers and promote:

- Best practice
- Compliance with existing standards
- Familiarity with the methodology of the forthcoming standard AS/ NZS 5139 - Electrical Installations - Safety of battery systems for use with power conversion equipment
- System:
 - Safety
 - Reliability
 - Performance

To fully understand the proceeding clauses the following terms should be reviewed by referring to 4 **DEFINITIONS**:

- Battery system
- Battery energy storage system (BESS)
- Restricted access
- Dwelling
 - Domestic
 - Non-domestic
- Readily available

To comply with the requirements of this document, the following should occur:

1. Apply the clauses of 7 **INSTALLATION**:
 - 7.1 *General*
 - 7.2 *Location*
 - 7.3 *Battery System Accommodation*
2. Determine the hazards applicable to the battery system/ pre-assembled BESS according to the table in 6 **BATTERY SYSTEM HAZARDS** - 6.1 *General*
3. Apply the risk reduction methods specific to the battery system/ pre-assembled BESS in accordance with 8 **HAZARD REDUCTION METHODS**

Note: Only the risk reduction methods applicable to the battery system/ pre-assembled BESS need be applied. For example, where a battery installer intends to install a “hybrid ion” chemistry and where an explosive gas hazard is not found to be present, the risk reduction methods found in 8 **HAZARD REDUCTION METHODS** - 8.5 *Explosive Gas Hazard* need not apply

4. Apply the requirements of:
 - 9 **LABELS AND SAFETY SIGNAGE**

- 10 COMMISSIONING AND TESTING
- 11 DOCUMENTATION

6 BATTERY SYSTEM HAZARDS

6.1 General

There are numerous hazards associated with battery systems/ pre-assembled BESS, such as:

- Electrical
- Energy
- Fire
- Chemical
- Explosive Gas
- Mechanical

The following sections discuss the nature of each hazard.

Where a hazard is identified, as per the chemistry and overall battery system/ BESS design, risk reduction methods shall be applied to eliminate or reduce these risks to protect persons, property and livestock from:

- Electric shock
- Fire
- Physical injury

Risk reduction methods are specified in:

- 7 *INSTALLATION*
- 8 *HAZARD REDUCTION METHODS*

6.2 Hazard Classification

6.2.1 General

The following table displays hazards that apply to specific battery chemistry types.

Where a chemistry is not listed, a risk assessment shall be undertaken to determine which hazards apply to the specific battery system and the relevant risk reduction methods shall be applied.

In all cases, as per 7.1.2 *Safety Data Sheet (SDS)*, the installation of all battery systems and pre-assembled BESS shall be in accordance with the SDS applicable to the chemistry.

Battery Hazard	Lead Acid	Nickel Alkaline	Lithium	Flow	Hybrid Ion
Electrical	√	√	√	√	√
Energy	√	√	√	√	√
Fire	Note ¹	Note ¹	Note ¹	N/A	N/A
Chemical/ Toxic Gas	√	√	√	√	N/A
Explosive Gas	√	√	Note ²	√	N/A
Mechanical	√	√	√	√	√

This table has been adapted from [DR] AS/ NZS 5139 - Electrical installations - Safety of battery systems for use with power conversion equipment.

Notes:

- 1 - Lead acid, nickel alkaline and lithium chemistry types may represent a fire hazard. As per 7.1.2 *Safety Data Sheet (SDS)*, the SDS shall be consulted to determine if a fire hazard is present. In all cases, fire hazard risk reduction installation methods should be conducted in accordance with 8 *HAZARD REDUCTION METHODS - 8.3 Fire Hazard* - especially where the chemistry type may change to a more hazardous type over the life of the BESS.
- 2 - Typically, lithium chemistry types do not emit explosive gas during normal working conditions. However, some may release hydrogen under fault conditions (eg. lithium manganese). To determine if a lithium chemistry represents an explosive gas hazard the SDS shall be consulted as per 7.1.2 *Safety Data Sheet (SDS)*.

6.2.2 Electrical Hazard

6.2.2.1 General

The electrical risks associated with battery systems are dependent on the voltage of the battery system and other connected equipment – such as earthing, protection devices, etc.

6.2.2.2 Decisive Voltage Classification (DVC)

Decisive Voltage Classification (DVC), as defined in IEC 62109, informs the level of electric shock hazard. It also informs the designer/ installer on safety measures required for electrical protection, enclosures and interlocks.

Table 1 Summary of Decisive Voltage Classification (DVC) Ranges provides a summary of DVC levels.

DVC refers to the voltage level and the degree of separation of the relevant battery port from the grid or other energy source. It is the highest voltage that occurs continuously between two live parts during worst case conditions.

Where a battery system is within the DVC A (eg. 48V) range and is connected to a PCE port also within the DVC A range, it is considered relatively safe with respect to an electric shock hazard (although other types of hazards may be present).

However, where a battery system is within the DVC A (eg. 48V) range and is connected to a PCE port classified as DVC C (for example, a non-separated inverter connected to the grid) the entire battery system would be classified as DVC C.

The applicable DVC is always the highest classification of the equipment within, and connected to, a battery system, which may be greater than the voltage at the battery terminals.

Table 1 Summary of Decisive Voltage Classification (DVC) Ranges

Decisive Voltage Classification (DVC)	Limits of Working Voltage (V)		
	AC Voltage U_{ACL} r.m.s.	AC Voltage U_{ACPL} peak	DC Voltage U_{DCL} mean
A	≤ 25	≤ 35.4	≤ 60
B	≤ 50	≤ 71	≤ 120
C	> 50	> 71	> 120

Notes:

- Under fault conditions, DVC-A circuits are permitted to have voltages up to the DVC-B limits for a maximum of 0.2s
- For DC voltages greater than extra low voltage (120V ripple free) and not exceeding 1,500V, AS/ NZS 3000 defines this as low voltage
- Where a battery system has a nominal voltage of 48VDC (DVC-A) but exceeds 60VDC (but not exceeding 120VDC) under charging – including boost – conditions, it would be classified as DVC-B

6.2.2.3 *Battery System Short-Circuit Current/ Prospective Fault Current*

The prospective short circuit/ fault current may be significant in a battery system. This condition occurs where the impedance between conductors is almost zero and overcurrent protection does not operate.

This figure is important for selection of overcurrent protection, cabling, etc.

The short circuit/ prospective fault current should be obtained from the battery system manufacturer.

Alternately, the fault current may be calculated, based upon the internal resistance of the battery system, by using the formula in AS 2676.1, clause 2.5.

6.2.3 Energy Hazard

An energy, or arc flash, hazard occurs where there is a release of energy caused by electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Under such conditions, electrical energy is transferred into other forms of energy including heat, light and sound.

The severity of any such energy hazard depends on:

- Voltage
- Current
- Duration of event
- Proximity to the hazard; and,
- Obstructions near the hazard

Such a hazard may occur under the following scenarios:

- Accidental contact between battery terminals with a conductive tool – such as an uninsulated socket wrench, spanner, etc
- A dead short within connected PCEs
- A build-up of conductive material across conductors – such as fluid, metal shavings, etc
- Damage to cable insulation, resulting in electrical conductivity between copper conductors

In addition to other risk reduction methods, batteries and associated DC cabling shall:

- Be protected from mechanical damage; and,
- Access to battery systems and pre-assembled BESS shall be restricted to authorised persons.
(Refer to “Restricted Access” and “Authorised Persons” in 4 *DEFINITIONS*.)

6.2.4 Fire Hazard

The manufacturer’s SDS shall be assessed to determine if a fire risk is present as per 7.1.2 *Safety Data Sheet (SDS)*.

Note that a fire hazard is distinct from:

- An “energy” hazard as defined in 6.2.3 *Energy Hazard*
- An “explosive gas” hazard as defined in 6.2.5 *Explosive Gas Hazard*

A fire hazard may be present in any chemistry type.

A fire hazard may be present where the battery system chemistry is lithium. As per United Nations (UN) 38.3, abuses that may result in fire include:

- Low ambient pressure
- Overheating
- Vibration
- Shock
- External short circuit
- Impact
- Overcharge

- Forced discharge

6.2.5 Explosive Gas Hazard

Under certain conditions, some battery systems and pre-assembled BESS emit explosive gas which represents a hazard where an ignition source is present.

Ignition sources may include:

- Battery system isolation and overcurrent devices
- Switches internal to electrical components
- Fans
- Motors
- General electrical switches (eg. light & power)

Typically this hazard applies to acid and alkaline based chemistries, particularly lead acid.

Risk mitigation methods include:

- Ventilation
- Clearance from and/ or elimination of ignition sources

6.2.6 Chemical Hazard

There are many types of chemical hazards that a battery system may represent. Such hazards may concern one or more of the following:

- Health (to persons and animals)
- Physical (such as damage to equipment)
- Environment (including soil and water contamination)

Typically, stored chemical energy in the form of a fluid or gel electrolyte is the source of a chemical hazard.

To determine if a battery system represents such a hazard, the SDS shall be consulted.

A chemical hazard may occur:

- Under normal operating conditions (eg. venting of hydrogen gas when charging)
- Under fault or abuse conditions, including:
 - Mechanical (eg. impact, puncture, etc)
 - Thermal (eg. in excess of specified operating conditions)
 - Electrical (eg. forced discharge)

Examples of hazard statements from existing, commercially available, energy storage SDS's are as follows:

- May be corrosive to metals
- Harmful if swallowed and/ or inhaled
- Possible emission of toxic fumes when involved in fire
- May cause severe irritation, burns and ulceration to skin and eyes
- May damage fertility or the unborn child
- May cause damage to organs through prolonged or repeated exposure
- Very toxic to aquatic life with long lasting effects
- May cause long-term adverse effects in the environment

Risk reduction methods vary according to the nature of the chemical hazard.

However, general methods include:

- Providing restricted access to battery systems
- Providing physical barriers, such as bollards, where battery systems may be subject to physical damage – such as in a garage
- Use of bunding to retain harmful substances in the event of spillage and/ or discharge
- Use of personal protective equipment, spill kits and safe work procedures when handling, repairing, maintaining, installing and inspecting battery systems

6.2.7 Mechanical Hazard

All battery systems represent a mechanical hazard. This hazard relates to the following:

- Weight
- Sharp edges/ corners
- Moving parts (eg. Pumps in flow batteries)
- Limited balance points (eg. Tall and thin battery profiles)

Mechanical hazards may be due to:

- Inappropriate battery accommodation and arrangement
- An external force – such as a seismic earthquake

When installing battery systems, consideration shall be given to:

- Type
- Quantity
- Profile; and,
- Size

The following sections reduce the risk of mechanical hazards:

- *7.3 Battery System Accommodation*
- *8 HAZARD REDUCTION METHODS - 8.6 Mechanical Hazard*

7 INSTALLATION

7.1 General

7.1.1 Manufacturer's Instructions

The installation of all battery systems shall be in accordance with manufacturer's instructions.

7.1.2 Safety Data Sheet (SDS)

The installation of all battery systems shall be in accordance with the safety data sheet applicable to the battery chemistry and battery system/ pre-assembled BESS.

7.1.3 Restricted Access

Restricted access shall be provided to battery systems to prevent access by unauthorised persons.

Restricted access may be achieved by the following:

- A dedicated battery room
- A dedicated enclosure
- A fenced off, and secure, section of a larger room

A pre-assembled integrated BESS may inherently include a suitable enclosure.

Refer to 4 *DEFINITIONS* a definition of "Restricted Access."

7.1.4 Environmental Effects

Pre-assembled BESS shall have an IP rating appropriate for the environment in which they are installed in accordance with AS/ NZS 3000.

All equipment exposed to the outdoor environment shall be at least IP 54 and UV resistant. Higher ratings should be considered for tropical locations.

Connection of wiring, conduit and glands to IP rated equipment and/ or enclosures shall be installed so the minimum IP rating is maintained.

7.1.5 External Influences

BESS and battery systems shall be able to operate safely and function properly in the conditions in which they are likely to be exposed. Particular situations include:

- Solar radiation (direct sunlight)
- Ambient temperature
- External heat sources
- Presence of water or high humidity
- Presence of solid foreign bodies
- Presence of corrosive or polluting substances
- Impact
- Vibration
- Other mechanical stresses
- Presence of flora and fauna

7.1.6 Voltage Limits

For domestic installations, battery system DC voltages shall not exceed 600V.

For non-domestic installations, DC voltages should not exceed 1500V.

7.1.7 Product Standards

At all times, batteries and battery modules should meet relevant product standards, which may include:

- Lead Acid
 - AS/ NZS 4029.2
 - IEC 60896
 - AS 3731
 - IEC 60896
 - IEC 62485
 - IEC 60095
 - IEC 60254
- Nickel Cadmium
 - AS 3731
 - IEC 60896
 - IEC 62485
- Lithium
 - IEC 62619
 - IEC 62620
 - IEC 62133

- Flow
 - [DR] IEC 62932
- Aqueous Ion
 - IEC 61427-2

Pre-assembled BESS shall meet relevant product standards, which may include:

- AS 62040.1.1
- AS 62040.1.2
- IEC 62109
- AS/ NZS 4777.2; and,
- Requirements of AS/ NZS 4509

7.2 Location

7.2.1 General

The following location requirements apply to battery systems and pre-assembled BESS.

The following shall apply:

- Be installed in accordance with the manufacturer's specifications – including ambient minimum and maximum temperatures as per *7 INSTALLATION - 7.1.1 Manufacturer's Instructions* and *7 INSTALLATION - 7.1.5 External Influences*

Refer to *Figure 5* and *Figure 6* for examples.

2.1.5 Environmental requirements	
Available operating temperature	–10 to 45 °C (14 to 113 °F)
Optimal operating temperature	15 to 30 °C (59 to 86 °F)
Storage temperature	–30 to 60 °C (–22 to 140 °F)
Humidity	5 to 95% (non-condensing)
Altitude	Below 2000 m (6562 ft)

Figure 5 Example manufacturer's specifications (temperature, humidity, altitude)

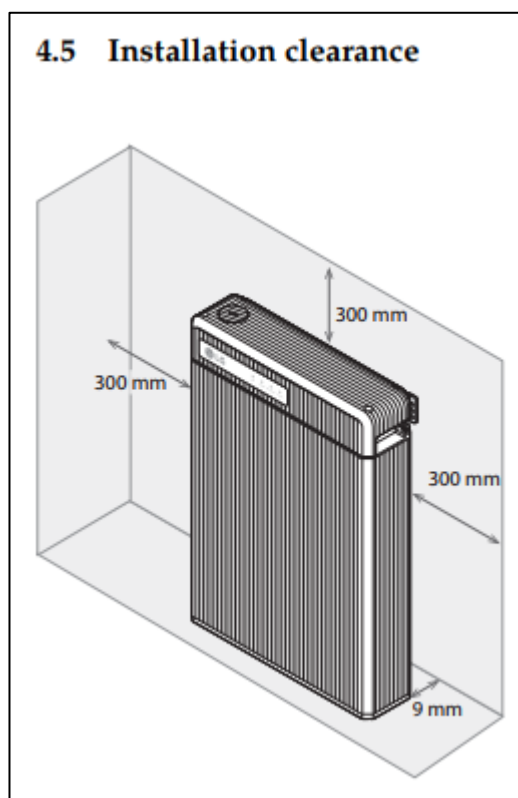


Figure 6 Example manufacturer's specifications (clearance)

- IP & UV rating be suitable for the environment as per *7 INSTALLATION - 7.1.4 Environmental Effects*
- Protected against physical damage and other environmental and external factors (eg. Impact from vehicles, high humidity, etc) as per *7 INSTALLATION - 7.1.5 External Influences*
- Not be installed:
 - In ceiling cavities
 - In ceiling spaces; or,
 - On roofs
- Not be installed in restricted locations for switchboards, as per AS/ NZS 3000
- Not be installed in damp situations, as defined by AS/ NZS 3000, including:
 - Baths, showers and other fixed water containers
 - Swimming pools, paddling pools and spa pools or tubs
 - Fountains and water features
 - Saunas
 - Refrigeration rooms
 - Sanitization and general hosing-down operations

The following should apply:

- Not be located near heat sources such as sunlight, space heaters, etc, as per 7

INSTALLATION - 7.1.5 External Influences

- Not be installed near combustible materials
- Not be located where electrolyte spillage contaminates water supply
- Not be installed under floors of a building envelope

7.2.2 Domestic

Battery systems and pre-assembled BESS shall not be installed in the following:

- Habitable rooms, as defined by the **National Construction Code (NCC)**, including:
 - Bedroom
 - Living Room
 - Lounge Room
 - Music Room
 - Television Room
 - Kitchen
 - Dining Room
 - Sewing Room
 - Study
 - Playroom
 - Family Room
 - Home Theatre
 - Sunroom
 - Spaces occupied frequently or for extended periods

Subject to all other requirements in these guidelines, suitable locations for battery systems and pre-assembled BESS for domestic installations may include:

- Garages
- Storage Rooms
- Battery Rooms
- Verandas

7.2.3 Non Domestic

Unless otherwise explicitly specified by the **National Construction Code (NCC)** or other relevant Australian Standards, the following applies to battery systems and pre-assembled BESS installed in non-domestic buildings:

- Where a battery system is installed in a (non-domestic) building and:

- Exceeds 24 volts, and;
- Exceeds 10 ampere hours

Separation of equipment (battery system/ pre-assembled BESS to building) shall satisfy a Fire Resistance Level (FRL) of not less than 120/ 120/ 120.

This may be achieved through the following:

- The battery system is installed in a plant room or separate battery room; and, the walls of the room are constructed from:
 - Layers of fire resistant plasterboard
 - Concrete, masonry or similar

7.3 Battery System Accommodation

7.3.1 General

Battery systems shall be located in areas that prevent access by unauthorised persons as per 7 *INSTALLATION - 7.1.3 Restricted Access*.

Battery systems and pre-assembled BESS shall be installed in one of the following:

- A dedicated room
- A dedicated enclosure; or
- A fenced off, and secure, section of a larger room

A pre-assembled BESS may inherently include a suitable enclosure.

Refer to 4 *DEFINITIONS* for definitions of “battery enclosure” and “restricted access.”

Battery accommodation shall ensure battery systems are readily available.

Refer to 4 *DEFINITIONS* for a definition of “readily available.”

Battery system accommodation shall comply with the requirements of:

- 7 *INSTALLATION - 7.2 Location*
- 8 *HAZARD REDUCTION METHODS*
 - 8.1 *Electrical Hazard*
 - 8.2 *Energy Hazard*
 - 8.3 *Fire Hazard*
 - 8.4 *Chemical Hazard*
 - 8.5 *Explosive Gas Hazard*
 - 8.6 *Mechanical Hazard*

7.3.1.1 **Battery System Room**

Where battery systems are installed in dedicated rooms, requirements apply to the room layout and floor area. The requirements of AS 3011.1, clause 2.2.2 and AS/ NZS 4509.1, Appendix C shall apply.

7.3.1.2 **Battery System Enclosure**

The following requirements should apply for battery system enclosures:

- Be clean, dry, adequately ventilated and provide suitable protection against environmental effects as *per 7 INSTALLATION - 7.1.4 Environmental Effects*
- Be insect and vermin proof
- Allow for sufficient clearance to provide access for installation, inspection, maintenance and repairs
- Not be near conductive objects capable of falling across battery terminals and causing a short circuit

PCE and other equipment should not be located in the same enclosure as the battery system.

Where the battery system emits hydrogen, PCE, isolators and other sources of ignition shall not be located in the same enclosure as per *8.5.3 Location of Ignition Sources*.

7.3.1.3 **Fenced off Section of Larger Room**

Where battery systems are installed in a fenced off section of a larger room, requirements apply to the construction, height, material and apertures of the fence. The requirements of AS/ NZS 4509.1, clause 7.3.4 shall apply.

8 HAZARD REDUCTION METHODS

8.1 Electrical Hazard

8.1.1 General

Where battery systems include accessible live parts and terminals provision shall be made to prevent:

- Direct contact; and,
- Indirect contact

Exposed components shall be insulated and/ or shrouded and mechanically protected, including:

- Terminals
- Inter battery system cabling
- Connections (a small hole for testing probes may be provided above each terminal)

Where a battery system voltage exceeds DVC-A, it shall:

- Be fitted with isolating switches, plugs or links to separate it into sections not exceeding DVC-A
- Be installed to sectionalise the battery into voltage blocks not exceeding DVC-A.

Barriers shall extend a minimum of 50 mm out from the exposed side of the battery and a minimum of 400 mm above the top of the container. Refer to AS 3011.1, Appendix A for further examples.

8.1.1.1 *Pre-assembled BESS*

Where a battery system is incorporated into a pre-assembled integrated BESS, manufactured as a complete package and complies AS 62040.1.1 the following clauses need not apply:

- 8.1.2 *Isolation*
- 8.1.3 *Overcurrent Protection*
- 8.1.4 *Battery System Output Wiring*

8.1.2 Isolation

8.1.2.1 *General*

An isolation device shall be installed between a battery system and PCE; and shall meet the following requirements:

- Be capable of being secured in the open position

- Be non-polarised
- Be DC rated
- Be rated for voltage and current under normal and fault conditions
- Operate simultaneously on both poles
- Comply with AS/ NZS 60947.3
- Comply with the general requirements for isolation and switching in AS/ NZS 3000
- Remain in place if the PCE is removed, where the PCE is a grid-connected inverter with battery storage, as per AS/ NZS 4777.1, clause 4.5
- Not be a semi-conductor (solid-state) device

A combined isolation and overcurrent protection device may be used - subject to compliance with all isolation and overcurrent requirements.

8.1.2.2 **Parallel Battery Systems**

Where multiple battery systems are connected in parallel, each battery system shall have an isolator.

8.1.2.3 **Location**

The isolation device shall be:

- Installed as close as practicable to the battery system
- Readily available

Where the battery system represents an explosive gas hazard, restrictions apply on the location of isolators, as per *8.5.3 Location of Ignition Sources*.

An isolation device should be adjacent to the PCE to which it is connected.

Where the PCE is a grid-connected inverter, an isolation device shall be adjacent to the inverter port to which it is connected.

8.1.3 Overcurrent Protection

8.1.3.1 **General**

Overcurrent protection shall be installed between a battery system and PCE; and meet the following requirements:

- Be non-polarised
- Be DC rated
- Be rated for voltage and current under normal and fault conditions

- Be rated to protect battery system cabling
- Comply with the general requirements in AS/ NZS 3000
- Meet relevant product standards (eg. AS 1775, AS 3947.3, etc)
- Must not be a semi-conductor (solid-state) device

Overcurrent protection should be selected from the following:

- Circuit breakers
- HRC fuses

A battery system which does not have either output conductor connected to earth shall have overcurrent protection installed in all live conductors.

All battery systems should have overcurrent protection installed in all live conductors.

Battery systems should comprise a single string of cells, where not managed by a BMS or similar (eg. a string of lead acid cells).

8.1.3.2 **Parallel Battery Systems**

Where multiple battery systems are connected in parallel, each battery system shall have separate overcurrent protection.

8.1.3.3 **Location**

The overcurrent device shall be:

- Installed as close as practicable to the battery system (to minimise the length of unprotected cable)
- Readily available

Where the battery system represents an explosive gas hazard, restrictions apply on the location of overcurrent protection, as per section 8.5.3 *Location of Ignition Sources*.

8.1.4 Battery System Output Wiring

8.1.4.1 **General**

Battery system output cables shall meet the following requirements:

- Be DC rated
- Have a voltage rating equal to or exceeding the DVC
- Have a fault and normal operating current greater than the overcurrent protection device, including operation time of the device
- Be multi-stranded

- Be clearly identified (eg. "BATTERY") at intervals not exceeding 2 metres
- Where cabling is in a wiring enclosure (eg. conduit), the wiring enclosure shall be labelled as above.
- Cable identification shall be durable, permanent, legible, indelible and visible
- Selected as to minimise the risk of short circuit and earth faults (eg. double-insulated)
- Be mechanically protected by PVC conduit or equivalent protection (where cabling exceeds 2 meters)
- Comply with the general requirements of AS/ NZS 3000, particularly "Selection and Installation of Wiring Systems"

Battery system output cables should meet the following requirements:

- Be as short as possible
- Be double insulated
- Be double insulated where the battery system voltage exceeds DVC-A

Where not installed in conduit, cables should be effectively clamped and sufficient support should be provided throughout the length of cables to minimise sag, and prevent undue strain from being imposed on the cables or on battery terminals or other parts of the installation.

Cables shall not be bent through a radius less than the minimum bending radius specified by the cable manufacturer.

Segregation shall be provided between the following circuits:

- AC and DC
- DVC-A DC and \geq DVC-B DC

8.1.4.2 ***Parallel Battery Systems***

Where multiple battery systems are connected in parallel, each battery system should have cables connecting strings of equal resistance (eg. of equal length and cross-sectional area; and, conductor material) – except where the charge/ discharge regime is controlled by a BMS or similar.

8.1.4.3 ***Voltage Drop***

The maximum voltage drop between the battery system terminals and the PCE:

- Shall be less than 5%
- Should be less than 2%

DC voltage drop can be calculated as per:

- AS/ NZS 4509.2, Appendix C2
- AS 4086.2, Appendix A5; or,

- AS 2671, clause 2.6

Typically, the current carrying capacity will determine the cross sectional area of DC cable, rather than voltage drop – especially where voltage levels do not exceed DVC-A.

8.1.5 Earthing

8.1.5.1 General

There are four categories of earthing arrangements for battery systems:

- Floating/ separated (ie. Not earthed and not referenced to earth)
- Direct earthed
- Resistive earthed
- Connected to a non-separated inverter (ie. Reference to the grid and therefore to earth by the inverter's internal connections)

The PCE and battery system manufacturer's instructions on earthing arrangements shall be followed.

Examples of earthing arrangements are in *Figure 7*, *Figure 8*, *Figure 9* and *Figure 10*.

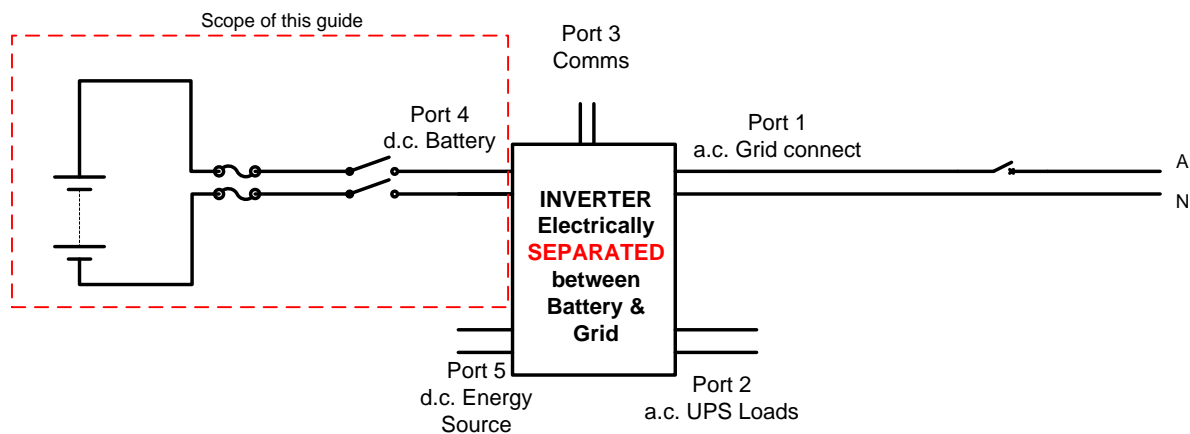


Figure 7 Battery connected to an inverter providing separation from the grid

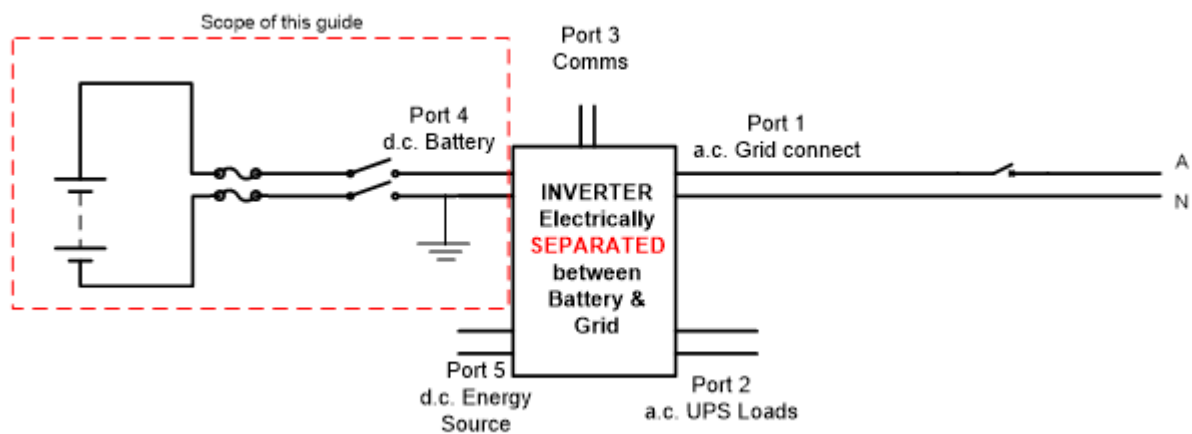


Figure 8 Battery connected to an inverter providing separation from the grid with a direct earth connection

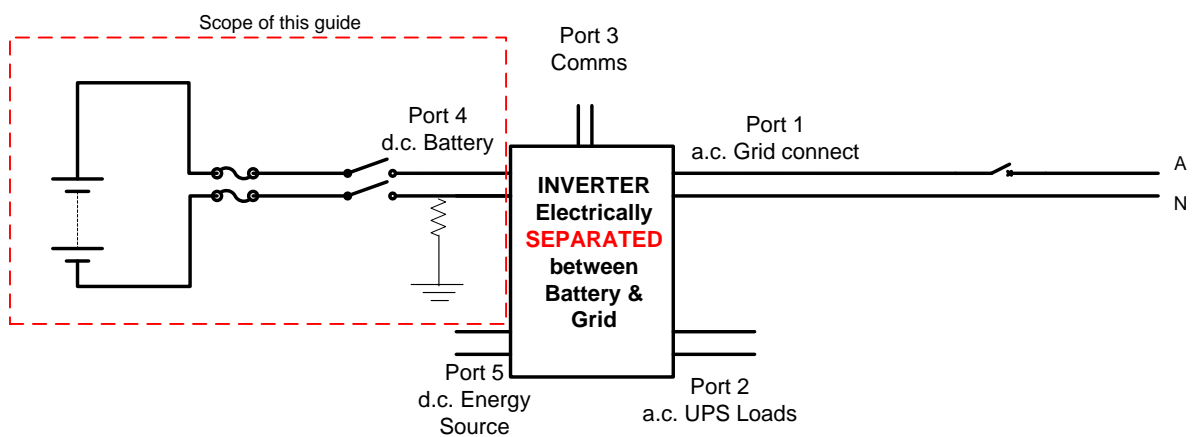


Figure 9 Battery connected to an inverter providing separation from the grid with resistive earth connection

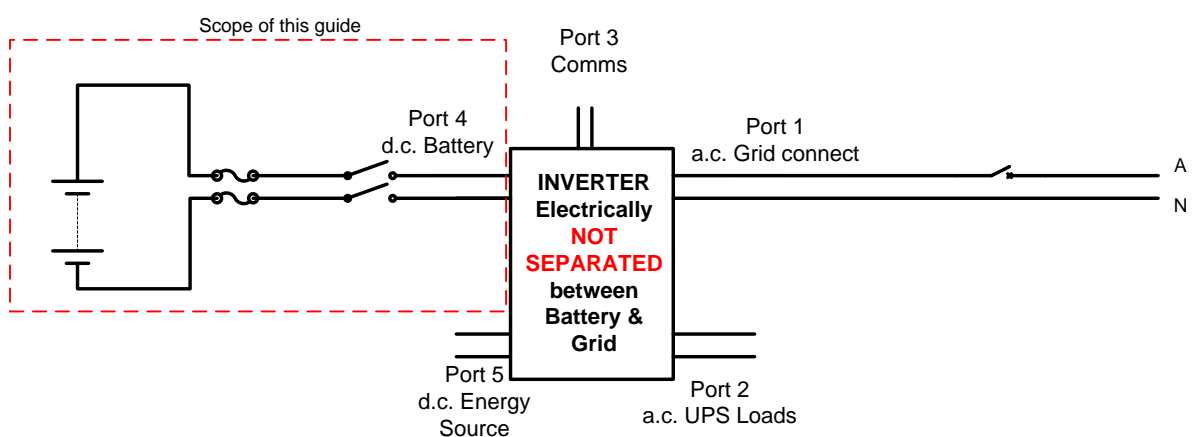


Figure 10 Battery connected to a non-separated inverter i.e. no separation between the battery and the grid (eg. transformerless)

8.1.5.2 *Earth Fault Alarm*

Where unearthed battery systems, including pre-assembled BESS, exceed DVC-A an earth fault alarm should be installed which, on an earth fault, causes an action to be initiated to correct the earth fault.

The following conditions should also apply:

- Repeat operation at least at hourly intervals until the earth fault is corrected
- Be placed in an area that shall be noticed
- Be reliable (eg. audible signal and/ or light powered from a constant source)

It may take the form of:

- Visual alarm (eg. light)
- Audible signal
- Fax
- SMS
- Email

A set of operational instructions shall be provided to the customer that includes the actions to take when the alarm operates.

8.1.5.3 *Equipotential Bonding*

If the battery system enclosure and/ or battery system stand is metallic and the battery system is operating at voltages exceeding DVC-A, the enclosure and/ or stand should be earthed in accordance with AS/ NZS 3000.

8.2 Energy Hazard

Battery systems represent an inherent arc flash hazard which cannot be eliminated.

The following measures reduce the risk of an arc flash hazard:

- Battery output cabling shall be selected as to minimise the risk of short circuit faults (eg. double-insulated), as per *8.1.4 Battery System Output Wiring - 8.1.4.1 General*
- DC cable shall be protected from mechanical damage as per *8.1.4 Battery System Output Wiring - 8.1.4.1 General*
- Terminals, inter-cell connectors and outgoing busbars shall be insulated or shrouded as per *8 HAZARD REDUCTION METHODS - 8.1 Electrical Hazard - 8.1.1 General*
- Access to battery systems shall be restricted to authorised persons as per *7.1.3 Restricted Access*
- Overcurrent protection shall be placed as close as practicable to the battery system as per *8.1 Electrical Hazard - 8.1.3 Overcurrent Protection - 8.1.3.3 Location*

- Isolators shall be installed as per *8.1 Electrical Hazard - 8.1.2 Isolation*
- Where a battery system voltage exceeds DVC-A, it shall be fitted with isolating switches, plugs or links to separate it into sections not greater than DVC-A as per *8.1 Electrical Hazard - 8.1.1 General*
- Standard operating procedures should be developed to facilitate safe work procedures
- Personal Protection Equipment (PPE) should be used when working on battery systems

8.3 Fire Hazard

The following measures reduce the risk of a fire hazard.

- The following risk reductions measures shall apply:
- DC cable shall be protected from mechanical damage as per *8.1.4 Battery System Output Wiring - 8.1.4.1 General*
- Battery Systems shall be mechanically protected as per *7 INSTALLATION - 7.1.4 Environmental Effects*
- Protection shall be provided against fire initiated or propagated by components of the electrical installation as per AS/ NZS 3000
- Shall be installed such that the minimum and maximum temperatures are not exceeded for safe operation as per manufacturer's specification as per *7 INSTALLATION - 7.1.1 Manufacturer's Instructions*
- Shall meet national and local requirements with respect to FRL & separation between battery system and any buildings
- Where the battery system requires a BMS for safe operation, one shall be installed that is compatible with the chemistry and overall system; and provides protection against abuse conditions, including:
 - Excess temperature
 - Minimum temperature
 - Overcurrent
 - Over voltage
 - Over discharge
- Protection against mechanical damage shall be provided to withstand abuse conditions, including:
 - Crushing
 - Impact
 - Vibration
 - Shock
 - Puncturing

The following risk reduction measures should apply:

- Be installed on a non-combustible surface (eg. brick, concrete, etc)

- Installation of a hard-wired smoke alarm, with battery back up
- Not be installed under floors of a building envelope
- Not be installed within 1 metre of a neighbouring property, building or dividing fence
- Not be installed within 1 metre of any access/ egress area
- Not installed near combustible material

8.4 Chemical Hazard

8.4.1 General

The following general requirements apply to reducing the risk of chemical hazards:

- The battery manufacturer SDS shall be consulted and installation instructions shall be followed
- Battery systems shall be located in areas designed to prevent access by unauthorised persons, as per clause 7.1.3 *Restricted Access*
- Where subject to physical damage, mechanical protection shall be provided to the battery system to minimise the risk of such, resulting in electrolyte leakage, including:
 - Crushing
 - Impact
 - Puncturing

Mechanical protection may be achieved via the use of a suitable battery system enclosure and/ or bollards.

Use of mechanical protection shall ensure battery systems and pre-assembled BESS are readily available.

An example of protection through a bollard barrier can be found in *Figure 11*.



Figure 11 Battery system mechanically protected by a bollard in a garage

Where electrolyte may leak or spill, the following should be installed to restrict the spread:

- Electrolyte-resistant material or coatings; or,
- Suitable drip trays, bunds or sumps

Where electrolyte is corrosive and vents:

- Exhaust air should not pass over battery system terminals or other electrical devices
- Fumes should be vented outside

8.4.2 Safe Work Procedures

Safe work procedures should be developed to address potential chemical hazards which may include:

- Cracked or damaged battery casings
- Spillage of electrolyte
- Inhalation of, and physical exposure to, electrolyte
- What to do in the event of a fire

8.4.3 Personal Protective Equipment

The following equipment may be required for safe handling of battery systems and protection of authorised persons:

- Combination overalls or dust coat (acid resistant)
- Bib Apron
- Gloves
- Face shield or goggles
- Running water or water containers for rinsing eyes and skin in case of electrolyte spillage
- Bicarbonate of soda for acid spills, or boric acid for alkaline electrolyte spills, or other suitable neutralising agent recommended by the manufacturer

8.5 Explosive Gas Hazard

8.5.1 General

Battery systems and pre-assembled BESS that represent an explosive gas hazard shall be installed in accordance with risk reduction methods as per 8.5 Explosive Gas Hazard.

Typically, battery systems that represent an explosive gas hazard produce hydrogen during charging, especially during boost and overcharging, conditions. This includes chemistries such as lead acid and nickel cadmium.

However, the battery system and pre-assembled BESS manufacturer SDS shall be consulted to determine if an explosive gas hazard is present as per 7.1.2 *Safety Data Sheet (SDS)*.

8.5.2 Ventilation

8.5.2.1 *General*

The average hydrogen concentration by volume in a battery room or enclosure shall be less than 2%.

8.5.2.2 *Flooded (vented) and Sealed Valve-Regulated Lead Acid Cells*

Ventilation shall be provided for all lead acid battery system chemistries.

8.5.2.3 *Rate of Ventilation (Lead Acid)*

The minimum exhausted ventilation rate required to maintain hydrogen concentration below 2% is calculated by the following equation:

$$qv = 0.006nI$$

where

$$qv = \text{the minimum exhaust ventilation rate, in litres per second}$$

n = the number of battery cells

I = the charging rate, in amperes (refer to 8.5.2.4 *Charging Rate*)

Where multiple parallel battery systems are present, the total ventilation rate is the sum of all battery systems.

8.5.2.4 **Charging Rate**

8.5.2.4.1 *General*

Battery charging shall occur to minimise conditions, as listed in the battery manufacturer's specifications, that result in excessive explosive gas emission, such as overcurrent and overvoltage conditions.

8.5.2.4.2 *Flooded Lead Acid Battery Systems*

The charging rate for vented cells is:

- The maximum output rating of the charging source (eg. solar array); or,
- The rated output of the overcurrent protection device of the charging source

8.5.2.4.3 *Sealed Valve Regulated Lead Acid Battery Systems*

The charging rate for valve-regulated battery systems differs according to the following conditions:

- Condition 1**
If the charger does not have an automatic overvoltage cut-off, the charging current shall be based on the rate for flooded lead acid battery systems (refer to 8.5.2.4.2 *Flooded Lead Acid Battery Systems*)
- Condition 2**
If the charger does have an automatic overvoltage cut-off (set at the battery manufacturer's recommended level) the charging rate is:
0.5A per 100Ah at the 3hr rate of discharge of battery capacity

8.5.2.5 **Method of Ventilation**

8.5.2.5.1 *General*

Natural ventilation should be used, in preference to mechanical ventilation, due to the potential failure of fans or other such equipment.

Ventilation paths shall be designed to minimise the risk of vented gas entering equipment.

8.5.2.5.2 Natural Ventilation

Where natural ventilation is used, the minimum size of inlet and outlet apertures is determined from the following equation:

$$A = 100qv$$

where

A = the minimum area of the apertures, in square centimetres

qv = the minimum exhaust ventilation rate, in litres per second

With natural ventilation, an air velocity of at least 0.1 m/s is assumed to flow through the apertures.

Where apertures are circular and the diameter is known, the area of a circle can be determined as per the following formula:

$$A = \frac{1}{4} \pi d^2$$

where

A = Area

d = Diameter

8.5.2.5.3 Mechanical Ventilation

Where mechanical ventilation is used, the minimum flow rate is determined by 8.5.2.3 *Rate of Ventilation (Lead Acid)*.

If mechanical ventilation is used, an airflow sensor shall be installed to initiate an alarm to indicate fan failure.

Mechanical ventilation should be of a type that is not a source of ignition.

8.5.2.5.4 Arrangement of Ventilation

The following applies to the arrangement and layout of the ventilation systems for battery rooms and enclosures:

- Battery enclosures should be designed to prevent the formation of pockets of gas
- Ventilation shall be provided by means of holes, grilles or vents so that air sweeps across the battery
- Exhaust air should not pass over other electrical equipment as per 8.4 *Chemical Hazard - 8.4.1 General*
- Inlet and outlet vents should:
 - Consist of:
 - A number of holes spaced evenly along the side of the enclosure; or,

- A slot running along the side of the room or enclosure; and,
 - Be on laterally opposite sides of enclosures; and,
 - Where required, prevent entry of vermin through the installation of a coarse screen
- Ventilation inlets should:
 - Be at a low level
 - Be no higher than the tops of the individual battery cells
- Ventilation outlets should:
 - Be at the highest level in the battery enclosure

8.5.2.6 **7.5.2.6 Nickel Cadmium**

For nickel cadmium battery systems, all the requirements of 8.5.2 *Ventilation* apply.

However, recommended charging rate (I) used in the ventilation rate in 8.5.2.3 *Rate of Ventilation (Lead Acid)* is 1.5A per 100 A.h. at the 3hr rate of discharge of battery capacity.

8.5.2.7 **Other Battery System Chemistries**

For battery system chemistries other than lead acid and nickel cadmium, the manufacturer's instruction of ventilation rates shall be followed.

8.5.3 Location of Ignition Sources

8.5.3.1 **General**

Arc-producing devices shall not be located in areas where hydrogen concentrations can become significant, such as directly above battery cells.

8.5.3.2 **Exclusion Zones**

A minimum horizontal separation of 500mm shall be provided between the battery and all other equipment from 100mm below battery terminals except where there is a solid separation barrier.



8.5.3.3 **Socket Outlets**

Socket outlets shall not be installed in battery enclosures.

Where a battery system is installed in a dedicated room, or fenced off area of a larger room, all socket outlets shall comply with the following:

- Be located at least 1800mm from the battery system or battery enclosure
- For socket outlets installed within 5m of the battery enclosure, the outlet shall be a minimum of 100mm below the top of the battery or battery vent

8.5.3.4 **Luminaires**

Luminaires shall not be installed:

- Directly over a cell
- Within 200mm of a battery system

8.5.3.5 **Other Equipment**

Control equipment, such as those used for exhaust fans, shall be located more than 1800mm from the battery system and a minimum of 100mm below ventilation apertures.

8.6 **Mechanical Hazard**

8.6.1 **General**

Battery system accommodation shall comply with the requirements of 7.3 *Battery System Accommodation*.

For ground mounted battery systems/ pre-assembled BESS, such as those in a dedicated room, the ground structure and type shall be designed to withstand the prevailing weight.

For wall-mounted battery systems/ pre-assembled BESS, the structural integrity of the wall shall be able to withstand the prevailing weight.

The supporting surface of any enclosure shall have adequate structural strength to support the battery system/ pre-assembled BESS weight and its support structure

Battery stands, supports and enclosures should protect battery systems/ pre-assembled BESS from damage due to seismic (earthquake) activity and should comply with AS 1170.4 (Australia) and NZS 4219 (New Zealand).

Battery systems/ pre-assembled BESS should not be installed at a height exceeding 2 m above a floor or platform.

8.6.2 Moving Parts

Where a battery system/ pre-assembled BESS consist of moving parts, such as pumps, such equipment shall be provided with protection to prevent inadvertent contact.

Preventing inadvertent contact may be achieved through the use of shields or barriers.

9 LABELS AND SAFETY SIGNAGE

The following provides guidance on the safety signs associated with battery systems. .

Labelling may also be required in accordance with:

- AS/ NZS 5033 - Installation and safety requirements for photovoltaic (PV) arrays
- AS/ NZS 4777.1 - Grid connection of energy systems via inverters Installation requirements

Worked labelling examples can be found on the Solar Accreditation website in the “**Technical Information**” section within the “Installer Area” (log in required) on the Solar Accreditation (www.solaraccreditation.com.au) website.

9.1 Energy Storage and Battery Type UN Number

Sites with battery systems shall include a circular green reflector sign at least 70mm in diameter with the letters “ES” adjacent to the meter box and main switchboard as to be readily visible to approaching emergency workers.

Additionally, the UN number of the battery chemistry shall be listed as per the following:

UN Number	Battery Chemical Type
UN 3480	Lithium ion (including ion polymer)
UN 3090	Lithium metal batteries
UN 2794	Flooded lead acid battery
UN 2800	Valve regulated lead acid battery
UN 3496	Nickel-metal hydride battery
UN 2794	Nickel cadmium battery
UN 36292	Sodium ion batteries

Refer to *Figure 12* and *Figure 13* for examples.

9.2 Battery System Location

Where a battery system may be difficult to locate, such as in large buildings, a plan or site map shall be placed at the main metering panel and fire panel indicating where it can be found.

Refer to *Figure 14* for an example.

Where battery systems are accessible within:

- A dedicated battery room
- A dedicated enclosure
- A fenced off, and secure, section of a larger room

A sign shall be adjacent to the enclosure or on all doors to the room/ section of a larger room indicating that “restricted access” is only permitted for authorised persons.

Refer to *Figure 15* for an example.

9.3 Voltage and Current

A sign stating the following shall be mounted adjacent to battery enclosures or all doors to the room/ fenced off section of a larger room:

- Battery System Location
- Potential short-circuit current rating
- Maximum DC voltage

The above sign shall be adjacent to the battery system isolator. Where the sign is not adjacent an additional one shall be installed.

Refer to *Figure 16* for an example.

Where battery system voltages exceed 600V, the above signage shall include the words “Hazardous DC Voltage.”

Note that further details can be found in AS/ NZS 4777.1, clause 6.5(a).

Refer to *Figure 14* for an example.

9.4 Explosive Gas Hazard

A battery system that represents an explosive gas hazard shall have a sign installed which includes the words “Danger, Risk of Battery Explosion.”

The sign shall be adjacent to the enclosure or on all doors to the room/ section of a larger room.

Refer to *Figure 18* for an example.

9.5 Chemical Hazard

A battery system that represents a chemical hazard shall include an appropriate sign applicable to the specific risk.

For example, such a sign may refer to:

- Electrolyte burns
- Toxic fume emissions

The sign shall be adjacent to the enclosure or on all doors to the room/ section of a larger room.

Refer to *Figure 19* and *Figure 20* for examples.

9.6 Energy Hazard

All battery systems contain an inherent energy hazard that cannot be eliminated.

Battery systems should include a general sign to indicate an energy hazard.

The sign shall be adjacent to the enclosure or on all doors to the room/ section of a larger room.

Refer to *Figure 21* for an example.

9.7 Isolation Devices

Battery system isolators shall be labelled with the following words:

- Battery System Isolator

Refer to *Figure 22* for an example.

9.8 Overcurrent Devices

Battery system overcurrent protection devices shall be labelled with the following words:

- Battery System Circuit Breaker
- Battery System Circuit Breaker and isolating switch; or
- Battery System Fuse; or
- Battery System Switch Fuse and Isolator

Refer to *Figure 23* for an example.

9.9 Battery System Cables

Battery system cabling (or conduit where cabling is enclosed), shall be labelled “BATTERY” at intervals not exceeding 2 metres.

Refer to *8.1.4 Battery System Output Wiring* for further details.

9.10 Shutdown Procedure

All BESS shall include a shutdown procedure detailing the shutdown procedure to safely shut down the system.

This procedure shall be specific to the BESS that is installed as generic labelling may not be accurate or appropriate.

The shutdown procedure shall be located:

- At the main switchboard; and,
- At the distribution board (where a BESS terminates into such); and,
- Adjacent to equipment to be operated (eg. battery overcurrent protection)

Refer to *Figure 24* for an example.

9.11 Personal Protective Equipment

Where personal protective equipment is required to access battery systems, a sign should be installed to indicate:

- The requirement for personal protective equipment; and,
- The specific type of equipment

The sign shall be adjacent to the enclosure or on all doors to the room/ section of a larger room.

Refer to *Figure 25* for an example.

10 COMMISSIONING AND TESTING

After installation, a battery system and pre-assembled BESS shall be commissioned in accordance with manufacturer's instructions and the requirements of this section.

The following shall occur:

- Confirmation of the installation:
 - Labelling; and,
 - Signage
 - Submission of documentation as per *11 DOCUMENTATION*
 - Visual inspection including:
 - Basic protection (eg. cable insulation and conduit integrity, etc)
 - Fault protection (eg. installation of switchgear, appropriately insulated cable, etc)
 - Protection against hazardous parts (eg. shrouded terminals, battery accommodation restricting access to authorised persons, etc)
 - Protection against spread of fire, as per *8.3 Fire Hazard*
 - General condition and integrity of connected electrical equipment
 - Check tightness of battery system terminals, links, intercell connections as per manufacturer's specified torque settings
 - Ensure operational parameters are correctly set (eg. charge and discharge settings, communication, etc)
 - Testing, including:
 - Polarity
 - Resistance between active conductors and earth, where relevant
 - Battery system voltage
 - Individual battery voltages, where relevant
 - Other relevant battery parameters, such as specific gravity, state of charge, etc
 - Isolation in accordance with specified shut down procedure
 - Confirmation of functioning charge and discharge cycle
- Note, AS 4086 provides guidance regarding initial charge for traditional chemistries
- Testing and Confirmation of anti-islanding and emergency power supply mode
 - Confirmation of functioning monitoring system(s), where relevant

Commissioning may be conducted in accordance with:

- AS/ NZS 4509.1, clause 10
- AS 2676.1 & 2, clause 5.5
- AS 4086.2, Appendices C, D, E & F

An example commissioning checklist, as adapted from CSIRO's Energy Storage Safety report, can be found in *APPENDIX A – EXAMPLE COMMISSIONING SHEET*.

11 DOCUMENTATION

11.1 General

At the completion of the installation of a battery system or pre-assembled BESS, documentation shall be provided in accordance with the requirements of this section.

This documentation shall ensure that key system information is readily available to customers, inspectors, maintenance service providers and emergency service personnel.

Additional documentation may also be required in accordance with:

- AS/ NZS 5033 - Installation and safety requirements for photovoltaic (PV) arrays
- AS/ NZS 4777.1 - Grid connection of energy systems via inverters Installation requirements

11.2 System Manual

A manual, complete with the following items, shall be provided:

- Installer address and contact details
- Battery system information, including:
 - kWh capacity
 - Voltage
 - UN code and chemistry
- Operating instructions (eg. a short description of the function and operation of all installed battery system equipment)
- Safety Certificate, where applicable
- Safety Data Sheet (SDS)
- A complete list of installed equipment, including model and serial numbers
- A list of actions to be taken in the event of an earth fault alarm, where applicable
- The shutdown and isolation procedure for emergency, maintenance, repairs and inspection
- A basic connection diagram that includes electrical ratings of the battery system and the ratings of all switchgear
- System performance estimate
- Recommended maintenance of the system
- Maintenance procedure and timetable
- Warranty information
- Manufacturer's documentation, datasheets, handbooks, etc
- Recommendations on battery end-of-life recycling and disposal

12 MAINTENANCE

Battery system and pre-assembled BESS maintenance will promote and prolong:

- Safety
- Reliability
- Performance

Only authorised persons shall perform battery system and pre-assembled BESS maintenance.

Maintenance shall be conducted in accordance with:

- Manufacturer's:
 - Instructions
 - Safety Data Sheet
- System Manual, as per *11.2 SYSTEM MANUAL*
 - Recommended maintenance of the system
 - Maintenance procedure and timetable
- Work Health and Safety
 - Standard operating procedures
 - Safe work methods statement

Maintenance may be conducted in accordance with:

- AS/ NZS 4509.1, Appendix A
- AS 2676.1 & 2, clause 6.4
- AS 4086.2, clause 3.2

Examples of battery system/ BESS maintenance include:

- Cleaning battery system terminals of dirt and electrolyte
- Ensuring electrical terminals are set to correct torque settings
- Ensuring battery accommodation integrity is maintained (eg. not damaged, free from debris/ rubbish; and, access is not obstructed)
- Ensure proper functioning of overcurrent and isolation devices
- Check charge and discharge parameters are correctly set
- Ensure correct ventilation has been provided and is maintained
- Check cable mechanical support, protection and penetration is maintained

APPENDIX A – EXAMPLE COMMISSIONING SHEET

Battery enclosure, room or fenced off section of a larger room is: <ul style="list-style-type: none"> mechanically sound suitable for the local environmental conditions designed to prevent the formation of 'gas pockets' (where an explosive gas hazard is present) not in a habitable room (as defined by the National Construction Code 2015) not in direct contact with the floor of the enclosure or room. 	<input type="checkbox"/>
The system is installed in accordance with the environmental conditions it will be subjected to	<input type="checkbox"/>
All battery terminations and interconnect cable connections have been checked for tightness, where applicable	<input type="checkbox"/>
All electrical cables, isolators and fuses are correctly rated and sized for operating and fault conditions	<input type="checkbox"/>
There are no readily accessible 'live' parts on any installed equipment.	<input type="checkbox"/>
All battery cell interconnects and terminals are covered and protected against accidental short circuit, where applicable	<input type="checkbox"/>
All 'live' cables have been tested for electrical leakage to earth, where applicable	<input type="checkbox"/>
Electrical wiring is routed so as to be protected from any physical damage or mechanical stress and exposure that could cause corrosion	<input type="checkbox"/>
Installation activities have not caused any damage to any cable insulation	<input type="checkbox"/>
All electrical wiring has been installed in accordance with AS/NZ 3000, and equipment is certified for use in Australia	<input type="checkbox"/>
Unearthed conductors in battery banks (including multiple strings) are protected by overcurrent protection devices	<input type="checkbox"/>
Battery banks have a means of isolation. Such isolation has been checked and tested	<input type="checkbox"/>
All other appropriate signage is displayed; for example, shut down procedure, 'Warning – Spark hazard', 'electrolyte Burns', battery voltage and short circuit fault current warning	<input type="checkbox"/>
Voltage, current and power throughput have been verified and are within the design specification for intended use and load profile	<input type="checkbox"/>
Metering is installed to monitor the battery voltage	<input type="checkbox"/>
Visual and audio alarms and warning notifications have been tested correctly	<input type="checkbox"/>
A tailored fire response, including, if necessary, a fire extinguisher has been installed adjacent to the batteries along with a sign detailing the actions to be taken in the event of a fire	<input type="checkbox"/>
All commissioning tests and results have been documented	<input type="checkbox"/>

Lead-acid specific	
All crimp lugs have been fitted using an appropriate tool	<input type="checkbox"/>
Batteries are installed on a timber or other suitable platform (to reduce short circuit risk and hazardous gas production if a battery were to leak acid)	<input type="checkbox"/>
The clearance and ventilation of equipment and arc-producing devices is in accordance with manufacturer's installation guidelines or relevant standards, including AS4086.2 and AS4509.2.	<input type="checkbox"/>
The enclosure is constructed of corrosive-resistant materials	<input type="checkbox"/>
Personal protective equipment and electrolyte containment is provided, including spill kit, eye protection, gloves and eye wash water	<input type="checkbox"/>

Lithium specific	
Platform and enclosure is constructed of aluminum, steel or equivalent (to minimize risk of fire)	<input type="checkbox"/>
Batteries are in a sealed enclosure with pressure activated venting, ducted to the open atmosphere away from living spaces or areas occupied by people and animals	<input type="checkbox"/>
Enclosure base is sealed from the atmosphere	<input type="checkbox"/>
Battery management system has been verified as operating correctly, including logging data	<input type="checkbox"/>

APPENDIX B – SIGNS



Figure 12 Example sign for energy storage required adjacent to the meter box and main switchboard

Refer to 9.1 Energy Storage and Battery Type UN Number

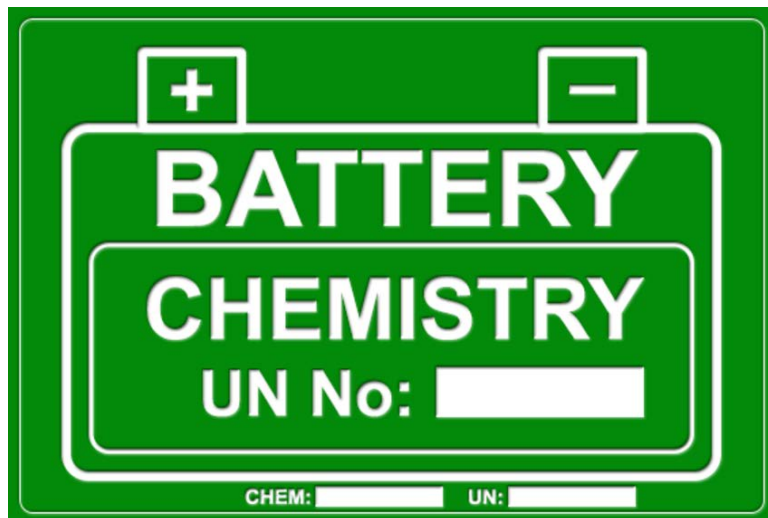


Figure 13 Example sign for energy storage required adjacent to the meter box and main switchboard

Refer to 9.1 Energy Storage and Battery Type UN Number

EMERGENCY EVACUATION DIAGRAM

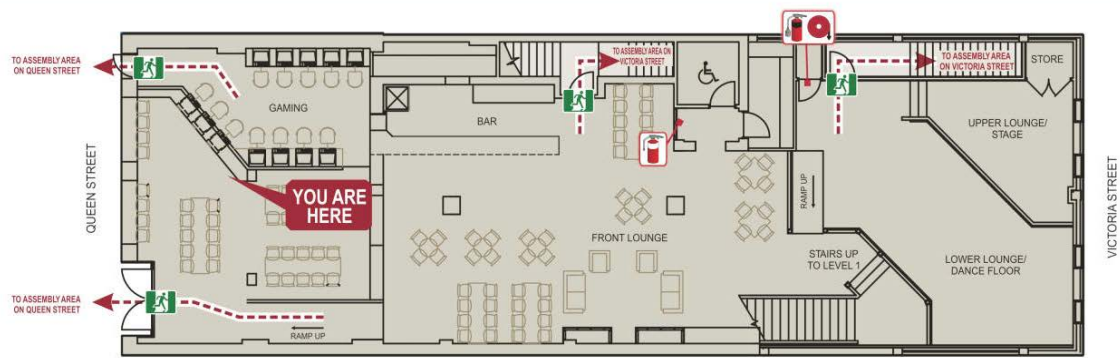


Figure 14 Example sign indicating location of battery system (where difficult to locate – such as large buildings) required at the main metering panel and fire panel

Refer to 9.2 Battery System Location



Figure 15 Example sign where battery systems are accessible. Required on the battery enclosure; or, all doors to the room/ fenced off section of a larger room where the battery system is accommodated

Refer to 9.2 Battery System Location

BATTERY SUPPLY	
LOCATION:	_____
SHORT CIRCUIT CURRENT:	_____ A
MAX DC VOLTS:	_____ V

Figure 16 Example sign for battery systems (not exceeding 600VDC). Required on enclosures, doors to battery rooms/ fenced off section of a larger room. The sign shall be adjacent to the battery system isolator – or an additional sign shall be installed.

Refer to 9.3 Voltage and Current

BATTERY SUPPLY	
LOCATION:	_____
SHORT CIRCUIT CURRENT:	_____ A
MAX DC VOLTS:	_____ V
WARNING: HAZARDOUS DC VOLTAGE	

Figure 17 Example sign for battery systems (exceeding 600VDC). Required on enclosures, doors to battery rooms/ fenced off section of a larger room. The sign must be adjacent to the battery system isolator – or an additional sign shall be installed.

Refer to 9.3 Voltage and Current



Figure 18 Example sign where explosive gas hazards apply. Required on enclosures, doors to battery rooms/ fenced off section of a larger room.

Refer to 9.4 Explosive Gas Hazard



Figure 19 Example sign where a toxic fumes hazard applies. Required on enclosures, doors to battery rooms/ fenced off section of a larger room

Refer to 9.5 Chemical Hazard

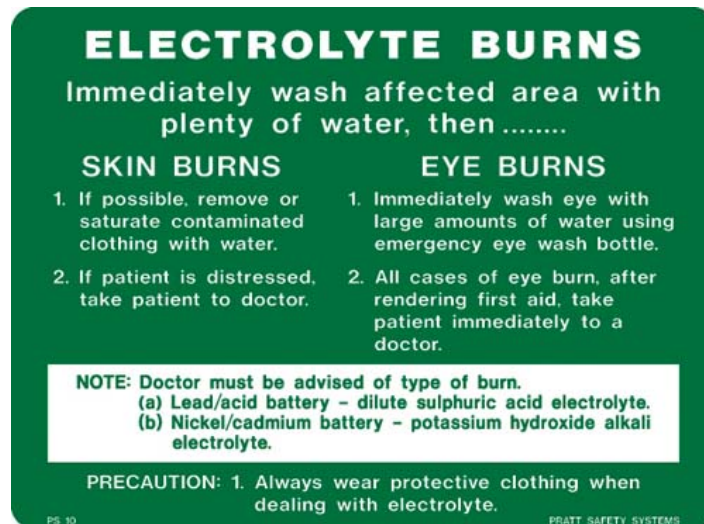


Figure 20 Example sign where an electrolyte burns hazard applies.
 Required on enclosures, doors to battery rooms/ fenced off section of a larger room

Refer to 9.5 Chemical Hazard



Figure 21 Example sign should be installed on battery systems. Required on enclosures, doors to battery rooms/ fenced off section of a larger room.

Refer to 9.6 Energy Hazard

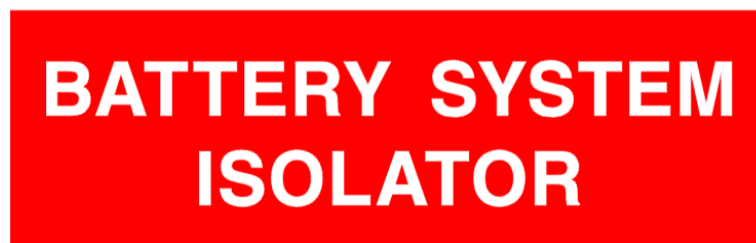


Figure 22 Example sign for battery system isolator. Required in a prominent location to identify the switchgear to which it applies.

Refer to 9.7 Isolation Devices

BATTERY SYSTEM CIRCUIT BREAKER

Figure 23 Example sign for battery system overcurrent protection (eg. Circuit Breaker). Required in a prominent location to identify the switchgear to which it applies.

Refer to 9.8 Overcurrent Devices

SHUTDOWN PROCEDURE

Where possible, turn off all appliances, lighting, refrigerator/freezer etc. prior to shutting down.

1. Isolate the AC supply side (house)
Turn the main AC Switch at the main switchboard to OFF
2. **ISOLATE THE PV ARRAY**
TURN OFF THE DC ISOLATORS
3. Power off the AC Inverter
TURN OFF THE SOLAR MAIN SWITCH
4. **POWER OFF THE ISLAND INVERTER**
PRESS AND HOLD THE CONTROLLER DIAL
PRESS AND HOLD THE ISLAND POWER BUTTON
5. **TURN OFF THE BATTERY ISOLATOR**
TURN OFF THE BATTERY CIRCUIT BREAKERS

TO STARTUP FOLLOW PROCEDURE IN REVERSE

Figure 24 Example Shutdown Procedure sign. Required at the main switchboard, at the distribution board (where a BESS terminates into such); and, adjacent to equipment to be operated (eg. battery overcurrent protection)

Refer to 9.10 Shutdown Procedure

<h1>PROTECTIVE EQUIPMENT</h1> <h2>THE FOLLOWING MUST BE WORN IN THIS AREA</h2>		
<input type="checkbox"/>		SAFETY GLASSES
<input type="checkbox"/>		HARD HAT
<input type="checkbox"/>		EAR PROTECTION
<input type="checkbox"/>		SPLASH GOGGLES
<input type="checkbox"/>		GLOVES
<input type="checkbox"/>		RESPIRATOR
<input type="checkbox"/>		FACE SHIELD
<input type="checkbox"/>		SAFETY SHOES
<input type="checkbox"/>		DUST MASK
<input type="checkbox"/>		PROTECTION SUIT
<input type="checkbox"/>		HIGH VIS VEST
<input type="checkbox"/>		APRON
<input type="checkbox"/>		
<input type="checkbox"/>		

(PLEASE CHECK OFF OR WRITE IN THE CORRECT PROTECTION TO WEAR)

Figure 25 Example sign for battery systems where access requires personal protective equipment. The sign should be adjacent to the enclosure or on all doors to the room/ section of a larger room.

Refer to 9.11 Personal Protective Equipment