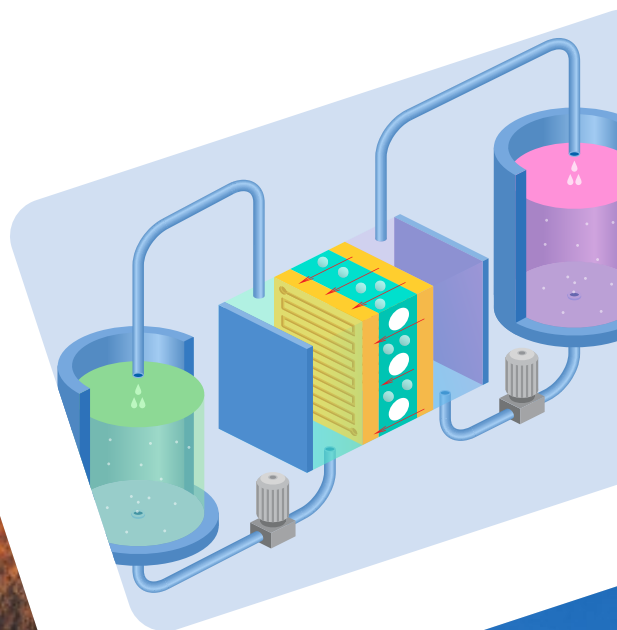


Flow Battery Energy Storage

GUIDELINES FOR SAFE AND EFFECTIVE USE

STANDARDS
Australia



Acknowledgements

Flow Battery Energy Storage – Guidelines for Safe and Effective Use (the Guide) has been developed through collaboration with a broad range of independent stakeholders from across the energy battery storage sector. It incorporates valuable input from energy network operators, industry experts, researchers, and electrical safety regulators. The following organisations contributed to the development of the draft:



This guide is open to use by all manufacturers and importers and others in the supply chain to assist them to address identified risks or battery storage equipment associated with flow batteries.

We gratefully acknowledge the Queensland Department of State Development, Infrastructure and Planning for their financial support, which has been vital to the development of these guidelines. We also thank Standards Australia for leading and managing the project process, ensuring broad industry engagement and a rigorous, collaborative approach to guide development.



Disclaimer

This guide has been developed by individuals with current knowledge and experience in flow battery storage technologies and associated risks. However, it does not claim to address all safety issues across every type of design, construction, or technology.

The information provided is for general guidance only and does not override any legislative obligations or duties of individuals or organisations involved in the flow battery supply chain. Users of this guide are responsible for obtaining their own legal, professional, and safety advice to ensure compliance with all applicable legal and commercial responsibilities.

To the extent permitted by law, the authors disclaim all liability (including liability in negligence) for any loss, damage, cost, or expense incurred due to a reliance on this guide or from any failure to meet legal, contractual, or regulatory obligations.

This document does not preclude the application of additional safety measures or other requirements, whether imposed by legislation, contractual agreements, or identified by an individual or organisation as necessary.

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Supporting the development of the flow battery sector

This Guide is an industry-led initiative designed to support the safe and effective development of Australia's emerging flow battery sector. As the first guide of its kind, it provides foundational guidance on best practices across key aspects of the flow battery lifecycle, including system design, installation, operation, and maintenance.

The guide is chemistry agnostic – relevant to all flow battery chemistries – and applicable regardless of the size or scale of the battery system. A strong focus is placed on hazard identification and mitigation to support safe deployment and operation across diverse use cases.

Developed in collaboration with an expert advisory group, the guide benefits from the input of professionals with deep knowledge of flow battery technologies and practical operational experience. This group played a key role in shaping the guide's content to ensure it reflects real-world considerations and current best practice.

This initial edition may be updated as the sector evolves or inform the development of new national technical specifications or standards. It could also be integrated into existing frameworks as flow battery deployment scales across Australia.

This vital work was proudly funded by the Queensland Government through the Department of State Development, Infrastructure and Planning, underscoring Queensland's strong commitment to advancing clean energy solutions and fostering the growth of emerging battery technologies.

Section 1: Scope and General

This guide has been developed to support safe, consistent, informed design, installation, operation, and maintenance of flow battery energy systems (FBES) within Australia. It provides guidance based on current industry knowledge, existing standards, and stakeholder consultation across regulatory, manufacturing, and operational domains.

NOTE: In this document, all references to “design” mean the design of the installation and site layout. Manufacturers are encouraged to consider these installation best practices when designing their flow battery systems.

This Guide is a living document, developed collaboratively with experts. It is intended to evolve with sector advancements. Feedback is welcome through the nominated review processes.

The Guide is intended for system designers, installers, manufacturers, asset owners, operators, and regulators. It offers practical direction while acknowledging that flow battery systems vary in design, chemistry, and application. The intent is to promote harmonised approaches and reduce ambiguity, particularly in areas not yet addressed by formalised standards.

Users are encouraged to apply the Guide with site-specific risk assessments, applicable laws, and relevant technical documentation. Where formal standards exist, this Guide supports alignment with those requirements. Where standards are still emerging or evolving, it offers best practice direction to assist decision-making and improve safety, reliability, and performance outcomes.

This Guide is not prescriptive. It should be interpreted in the context of each system’s unique characteristics and used to foster communication, consistency, and continuous improvement across the growing flow battery sector.

1.1 Scope

This guide specifies best practice principles for designing, installing, operating, maintaining, and decommissioning flow battery systems. It applies to flow battery energy systems of any size. System scale does not affect the applicability of the safety, installation or decommissioning principles outlined herein.

This Guide is intended to supplement existing Australian Standards (including AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, AS/NZS 3000:2018, *Electrical installations*, and relevant IEC standards) by addressing flow battery-specific hazards and considerations. It does not override existing legal or regulatory requirements.

Flow battery technologies within the scope are systems of all common chemistries, including, but not limited to, vanadium redox, zinc-bromine, iron flow, and emerging chemistries that store energy in external liquid electrolytes and address the entire lifecycle of these systems.

Key aspects include:

- **System Design and Installation** – Site planning, equipment selection, and installation practices for flow batteries, emphasising compliance with electrical wiring rules and safety standards.
- **Commissioning and Testing** – Procedures for initial system commissioning, performance verification, and safety testing before operation.
- **Operation and Maintenance** – Best practices for operating flow batteries and maintaining them over time to ensure reliability and longevity.
- **Safety and Risk Management** – Identification and mitigation of hazards such as electrical, chemical, thermal to align with AS/NZS 5139:2019, *Electrical installations - Safety of*

battery systems for use with power conversion equipment, requirements for battery system safety and the IEC 62932 series safety measures for flow batteries.

- **Environmental Considerations** – Guidance on ventilation, spill containment, and other environmental controls (e.g., managing hazardous gases or electrolytes) to protect personnel and sites.
- **Standards Compliance** – Cross-references to relevant standards and codes (e.g., electrical installation standards, inverter standards, confined space regulations) to ensure installations meet all mandatory requirements.
- **End-of-Life Management** – Recommendations for safe decommissioning, removal, recycling and disposal of flow battery systems and electrolytes.

1.1.1 Considerations for Risk Management

The following list of Australian and international standards is provided as a guide only. It is intended to support informed decision-making in the context of risk management for the transport, storage, installation, maintenance, and decommissioning of flow battery systems. It is not exhaustive, nor is the application of any specific standard mandatory unless expressly required by regulation, contract, or jurisdictional authority.

Risk assessment and management remain the user's sole responsibility, and it is incumbent upon each organisation to ensure that its practices are tailored to the specific operational context, environmental conditions, and technical specifications of the flow battery system in question.

While the standards noted throughout this section highlight the range of considerations involved in a comprehensive risk management process, they should not be construed as prescriptive. Instead, they provide a framework of best practices, reflecting industry-recognised methods for hazard identification, risk mitigation, safety assurance, and environmental protection.

Users are encouraged to seek specialist advice where appropriate, undertake thorough risk assessments in line with organisational policies and legal obligations, and ensure continuous improvement by reviewing and adapting their risk management strategies.

The following standards are provided as references to guide the development and implementation of general risk management frameworks:

- **AS ISO 31000:2018**, *Risk Management – Guidelines*

Provides the overarching methodology for identifying, assessing, treating, monitoring, and communicating risk across all phases. Should underpin all project and operational decisions.

- **AS/NZS ISO 45001:2018**, *Occupational Health and Safety Management Systems*

Addresses OHS risks in battery installation, operation, and maintenance. Critical for managing human safety risks, including chemical exposure and electrocution.

- **AS/NZS ISO 14001:2016**, *Environmental Management Systems*

Applies to environmental impacts throughout the battery lifecycle, particularly concerning electrolyte containment, disposal, and emissions.

1.2 Application

This Guide applies to stationary flow battery installations across residential, commercial, industrial, and grid-scale environments.

For the purposes of this Guide, factory-assembled and custom-built flow battery systems are considered installations for risk control and compliance purposes.

NOTE: This guide is intended as a best-practice reference and does not override legal requirements. Those must be followed where more stringent regulations apply (e.g., dangerous goods handling, workplace health and safety laws). The content is chemistry-agnostic and focuses on flow batteries; other battery technologies (e.g., lithium-ion, lead-acid) are outside the scope except for comparative context.

Where a flow battery system includes or integrates with power conversion equipment, such as an inverter or DC-DC converter, that equipment shall comply with the relevant standards (e.g., AS/NZS 4777.2:2020, *Grid connection of energy systems via inverters, Part 2: Inverter requirements*). This Guide only addresses aspects of power electronics directly affecting the flow battery subsystem.

1.3 General Requirements

All chemical handling must be conducted using the PPE specified in the relevant Safety Data Sheet (SDS), appropriate to the hazards and tasks involved.

1.3.1 Design Approach

Flow battery energy systems shall be designed so that foreseeable hazards are either eliminated or reduced to an acceptable level. The design shall incorporate safe installation, operation, maintenance, and decommissioning provisions following relevant standards and this Guide.

1.3.2 Performance Considerations

Flow battery systems should be capable of operating within the environmental conditions specified by the manufacturer. The manufacturer shall state the allowable temperature range, humidity range, and ventilation requirements. Any variation from these parameters shall be documented in the system documentation.

1.3.3 Quality Assurance

Manufacturers shall maintain a documented quality management system or equivalent processes to ensure consistent product safety and reliability.

Whilst not mandatory, compliance with recognised standards (e.g., ISO 9001, *Quality management systems - Requirements*) is recommended.

Section 2: Normative References

The following standards and documents are referenced in this guide. This is not an exhaustive list but provides the most relevant standards for guidance.

The latest edition of each document (including any amendments) should be used:

- **AS 2865:2009**, *Confined Spaces*
Requirements for safe working in confined spaces – applicable if a flow battery installation involves tanks, pits, or enclosed battery rooms where asphyxiant or toxic gases could accumulate.
- **AS 3780:2023**, *The storage and handling of corrosive substances*
Sets out requirements and recommendations for the safe storage and handling of corrosive substances, i.e. substances that meet the Class 8 classification criteria of the Australia Dangerous Good Code (ADG Code).
- **AS/NZS 3000:2018**, *Electrical Installations (Wiring Rules)*
General electrical installation requirements – applicable to wiring, earthing, and electrical work associated with flow battery systems.
- **AS/NZS 4777.1:2016**, *Grid connection of energy systems via inverters, Part 1: Installation requirements*
Specifies the electrical and general safety installation requirements for inverter energy systems (IES) up to or equal to 200kVA for the injection of electric power to an electrical installation connected to the grid at low voltage.
- **AS/NZS 4777.2:2020**, *Grid connection of energy systems via inverters, Part 2: Inverter requirements*
Requirements for inverters used in grid-connected systems are relevant if a flow battery system includes or connects to an inverter.
- **AS/NZS 5139:2019**, *Electrical installations – Safety of battery systems for use with power conversion equipment*
Specifies installation and safety requirements for battery energy storage systems in Australia/New Zealand that flow battery installations must meet.
- **IEC 62932-1:2020**, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*
Provides definitions and general principles for flow battery systems. The guide aligns its terminology with this standard.
- **IEC 62932-2-1:2022**, *Flow battery energy systems for stationary applications – Part 2-1: Safety requirements*
International safety requirements for flow battery systems are used as a reference for hazard management and safety design.
- **IEC 62932-2-2:2020**, *Flow battery energy systems for stationary applications – Part 2-2: Safety requirements*
Additional or specific safety and test methods for flow batteries are referenced in this guide for developing test and compliance criteria.

- **UN 2794**, *Batteries, wet, filled with acid*

Dangerous Goods Classifications for Batteries. Relevant for transport of batteries/ electrolytes where applicable, e.g., if electrolytes are classified as dangerous goods for shipping.

- **UN 2795**, *Batteries, wet, filled with alkali*

Dangerous Goods Classifications for Batteries. Relevant for transport of batteries/ electrolytes where applicable, e.g., if electrolytes are classified as dangerous goods for shipping.

- **UN 2800**, *Batteries, wet, non-spillable*

Dangerous Goods Classifications for Batteries. Relevant for transport of batteries/ electrolytes where applicable, e.g., if electrolytes are classified as dangerous goods for shipping.

Section 3: Terms and Definitions

For the purposes of this guide, the principal terms and definitions related to flow batteries are aligned with IEC 62932-1:2020, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*.

NOTE: This Guide does not specify shipping requirements for flow battery systems or electrolytes. All transport activities must comply with the Australian Code for the Transport of Dangerous Goods by Road & Rail (2024) ('ADG Code') and, where applicable, relevant international shipping regulations and standards. The consignor and transport operator are responsible for ensuring full compliance with these regulatory frameworks. Compliance with the rules and regulations of the destination jurisdiction must also be assured, including appropriate classification, packaging, labelling, documentation, and emergency response provisions.

3.1 Key Terms

The definitions provided in this Guide are intended to support clarity and consistency in the use of terminology across the flow battery industry. While not all terms may be explicitly referenced within the document's body, their inclusion assists users, manufacturers, regulators, and other stakeholders in developing a shared understanding of relevant concepts.

A glossary of terms is provided in Appendix A – Glossary.

3.2 Abbreviated Terms

BMM	Battery Management Module
BMS	Battery Management System
BSS	Battery Support System
CoC	Certificate of Compliance
EES	Electrical Energy Storage
FBES	Flow Battery Energy System
FBS	Flow Battery System
IP	Ingress Protection
OHS	Occupational Health and Safety
PCS	Power Conversion System
POC	Point Of Connection
PCS	Power Conversion System
POM	Point Of Measurement
PPE	Personal Protective Equipment
PCS	Power Conversion System
SDS	Safety Data Sheets
SPE	Stack Power Electronics
SOC	Standard State Of Charge
WHS	Work, Health and Safety

3.3 Key Components

While FBES can be based on various chemistries, they all share a common architecture comprising several key components essential for their operation. Figure 1 provides an overview of these core elements to support the reader's understanding. Central to the system is the cell stack, where electrochemical reactions occur during charge and discharge. Fluid systems manage the storage and circulation of electrolyte solutions through the stack, enabling energy conversion. The BMS monitors system health, manages state of charge, and ensures safe operation. A BSS (including sensors, pumps, and controllers) provides critical control and thermal regulation functions. The DC-DC converter regulates voltage levels between the battery and external systems, while the PCS enables the interface between the battery and the grid or load by converting DC to AC and vice versa. Although this configuration broadly represents most flow battery systems, specific layouts and technologies may vary depending on the chemistry, application, and manufacturer.

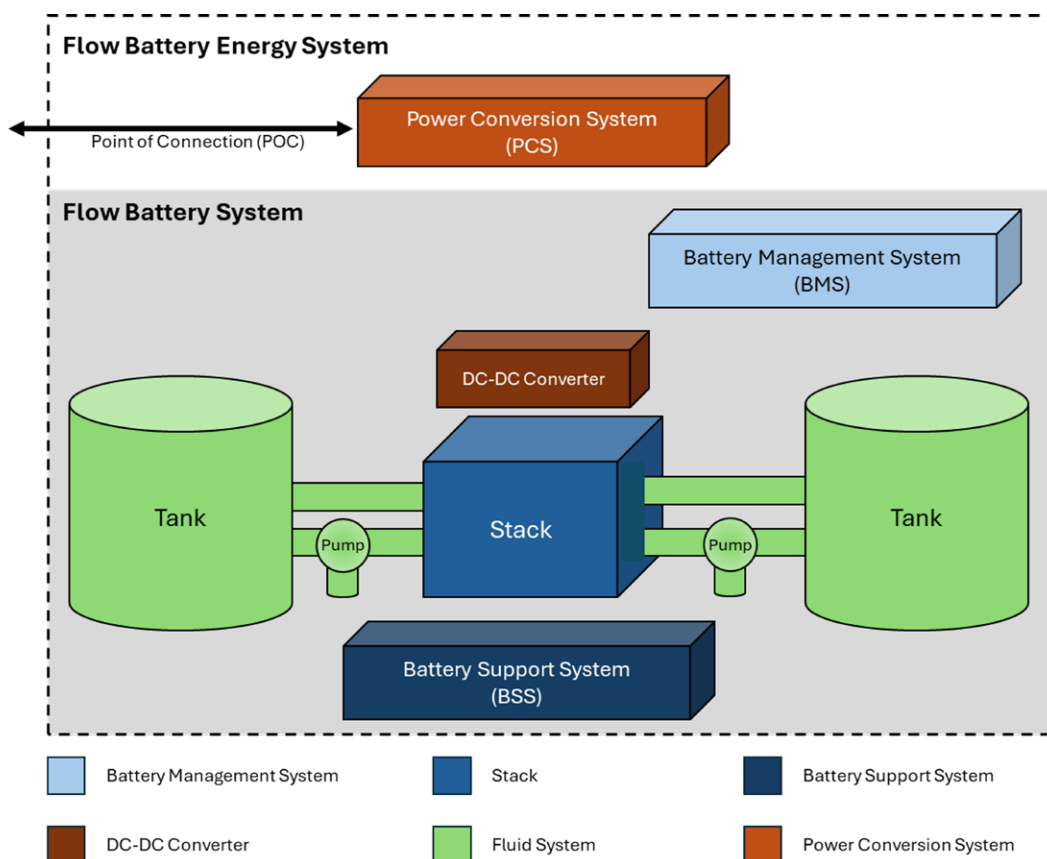


Figure 1: Flow Battery system (FBS) within the Flow Battery Energy System (FBES). Modified after IEC 62932-1:2020, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*.

For the purposes of this guide, battery storage equipment is defined as factory-built systems designed, manufactured, and tested as a complete, standalone package supplied by a single manufacturer or importer for installation. While the system may be delivered in multiple parts for transport and assembled on site, it does not require any on-site manufacturing, modification, or the supply of additional components beyond those provided to complete the installation. This definition is illustrated in Figure 2, which outlines the typical structure and components of a complete FBES.

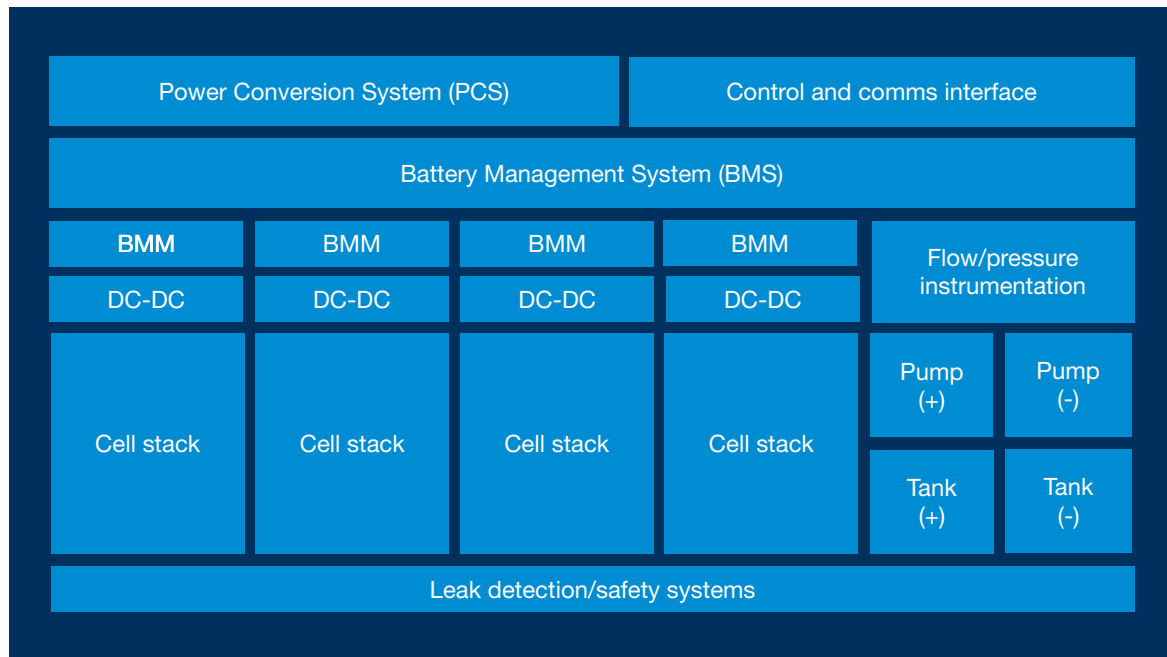


Figure 2: Example of components of integrated FBES equipment. Modified after Best Practice Guide: Battery Storage Equipment. Electrical Safety Requirements 2018. Note Abbreviations: BMS = Battery Management System; BMM = Battery Management Module; DC-DC = DC-DC Converter; PCS = Power Conversion System

3.4 Key Operational Status

FBES’s have distinct operational stages that require careful timing and control to ensure safe and efficient performance (Figure 3). During the stop stage, it is important to understand how long the system can remain idle at various states of charge—such as 0%, 50%, or 100%—without degrading system components or compromising electrolyte stability. Transitioning to the start or ramp stage, operators must consider the time required to bring the system from a fully stopped state to operational flow rates and pressure, which enables effective charge or discharge. In the run stage, the duration that pumps can operate continuously must be defined. While some systems may be able to cycle indefinitely, it is essential to assess the impact of continuous circulation on electrolyte mixing, potential losses, or imbalance over time.

A low power mode may be available in some systems, where pumps operate at minimal speeds to maintain circulation while waiting for charge or discharge commands. Identifying this state’s most energy-efficient pump speed helps reduce standby energy losses. The stop sequence itself is another critical consideration. Most systems require a controlled shutdown to depressurise and balance the stack safely. Restarting the battery during this shutdown window may lead to damage—such as rupturing the cell stack due to sudden thermal shock or pressure differentials—highlighting the need for strict observance of cooldown and pressure equalisation times before attempting a restart.

Understanding and clearly defining the timing across these stages—including idle duration at specific charge states, ramp-up durations, maximum continuous operation periods, and low-power standby capabilities—is vital to safe and reliable flow battery operation.

These operational stage timings must be factored into site- specific risk assessments to ensure safe and reliable flow battery operation.

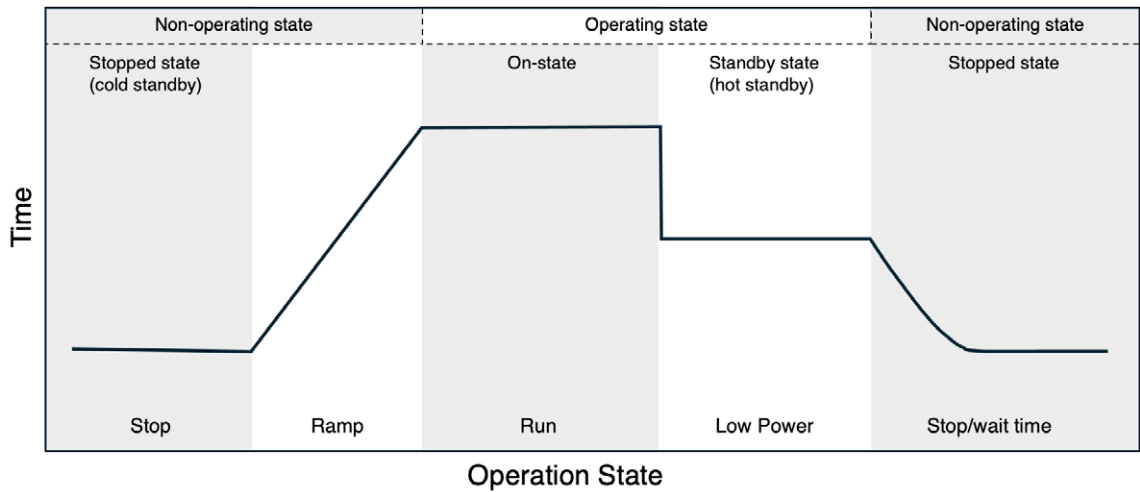


Figure 3: Operational stages of a flow battery system, illustrating key timing considerations across stop, start/ramp-up, run, low power, and shutdown phases. The diagram also incorporates the definitions defined in IEC 62932-1:2020 for operations stages. Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects

3.5 Electrical Diagram

The electrical diagram of a generalised flow battery illustrates the fundamental components and operational principles of this electrochemical energy storage system. Figure 4 shows how electrical energy is converted to chemical energy and chemical energy converted electrical energy. Pumps control the movement of electrolyte between the reservoirs and the cell stack, ensuring continuous operation. This schematic provides a simplified overview of the system's electrical configuration, suitable for both high-level understanding and technical analysis.

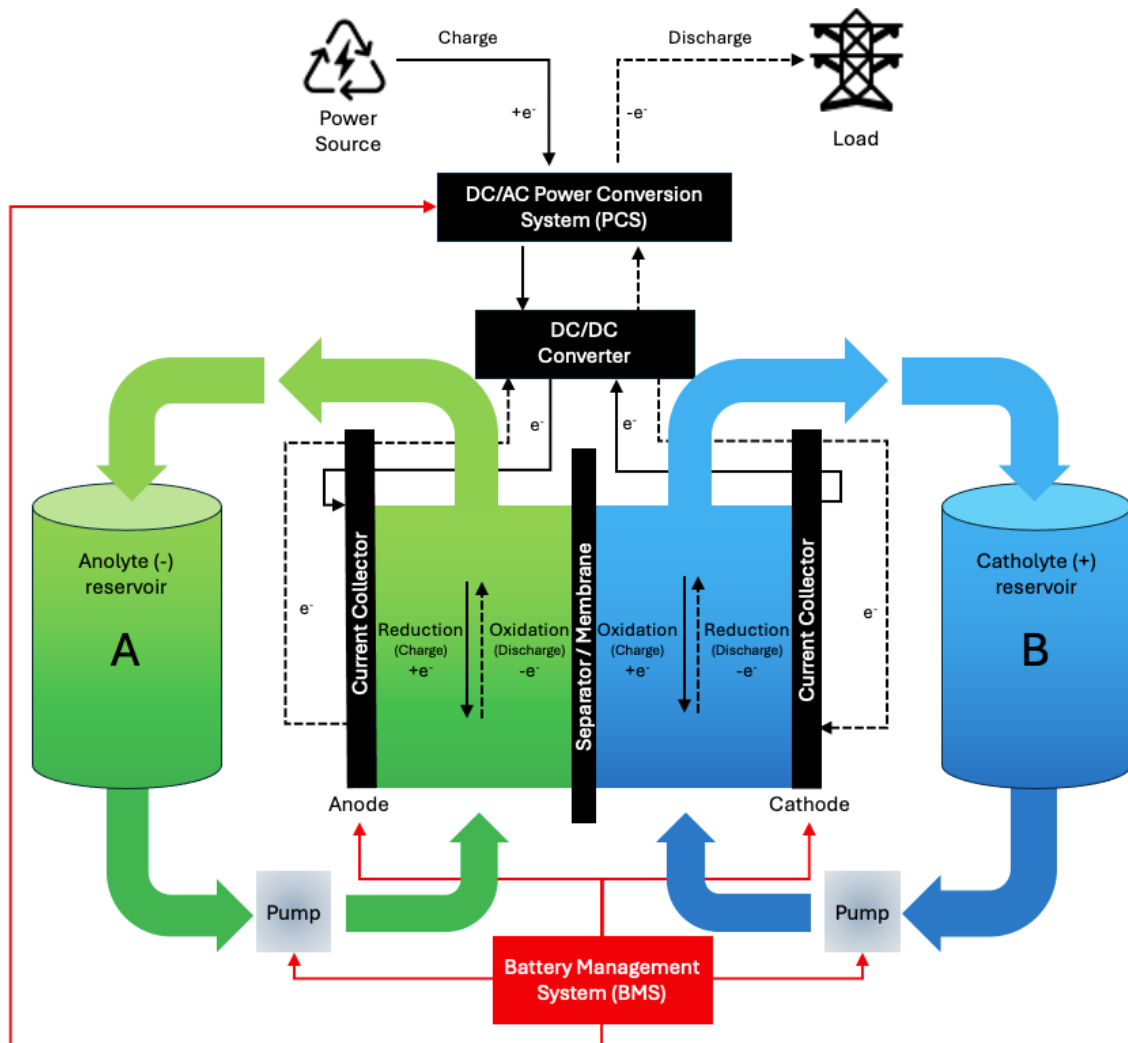


Figure 4: Electrical schematic of a generalised flow battery system, illustrating the key components including the cell stack, electrolyte reservoirs, pumps, and power conditioning system. This diagram highlights the bidirectional flow of energy during charge and discharge cycles.

Section 4: Protection Against Hazards

4.1 General

All flow battery installations shall meet the safety requirements of AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, and AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*. Additional measures specific to fluid-based energy systems are outlined in this section.

Risk assessment for flow battery energy systems must consider the specific characteristics of each installation, including system configuration, geographic location, environmental conditions, operational profile, and any site-specific constraints. While general guidance may be obtained from standards such as AS 3780:2023, *The storage and handling of corrosive substances*, such resources should only be used as reference material. Each system requires a tailored risk assessment to ensure that all relevant hazards and controls are appropriately identified and implemented.

Appendix L – Risk Management Guidelines provides additional guidance on risk management considerations.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

4.2 Fault and Abnormal Conditions

Flow batteries and their control systems should detect and safely respond to fault conditions or abnormal operations. This includes conditions such as pump failures, sensor malfunctions, valve stuck positions, loss of power, electrolyte leaks, or electrolyte imbalances. The system shall be equipped to fail-safe under such conditions (e.g., automatic shutdown of pumps and isolation of the battery stacks on critical faults). Protective controls should follow the principles of redundancy and independence to the extent practicable, ensuring that no single failure leads to an unsafe situation.

4.3 Short-Circuit and Overload Protection

Flow battery circuits shall include overcurrent protection sized for the maximum prospective fault current. DC isolation devices shall be provided for safe servicing. The design shall ensure that no single external short-circuit leads to uncontrolled release of stored energy.

4.4 Protection Against Electric Shock

All exposed conductive parts of the flow battery system such as racks, enclosures, and metal piping must be adequately earthed (grounded) following AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*, to prevent shock hazards. Insulation coordination and barrier protections should be such that operators cannot meet hazardous voltages during regular operation and routine maintenance.

The electrolyte is conductive; thus, access to electrolyte tanks or plumbing must be treated as a potential electric shock hazard unless the system is fully de-energised. Even when the main terminals are isolated, the fully charged electrolyte in the tanks remains at high potential. Any leak can expose conductive fluid between tanks or to earth, presenting a serious shock hazard.

Enclosures should have interlocks or warnings to prevent access while energising the system. Personal protective equipment (PPE) and safety procedures should be defined for technicians handling tasks that could expose live parts.

4.5 Protection Against Electrical Energy Hazards

Beyond shock and short-circuit, flow batteries present stored energy hazards such as high fault currents, arcs. Safe energy isolation procedures (lock-out/tag-out) must be established. Components such as capacitors in the power electronics or residual charged electrolytes in stacks should be discharged or isolated before maintenance.

The design should minimise trapped energy: for instance, quick-action dump loads or shunt resistors might be employed to bleed off charge when needed. Arc flash risk assessments shall be conducted and follow AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*, and WHS/OHS requirements for systems exceeding 120 V DC and 100 A continuous output to determine necessary flash protection boundaries and PPE.

Warning labels indicating the presence of high DC voltage and batteries should be posted. The system's Emergency Stop function (if provided) should rapidly de-energise the appropriate sections of the system to mitigate uncontrolled energy release in an emergency.

4.6 Protection Against Fire and Thermal Hazards

Flow battery systems use non-flammable electrolytes, reducing fire risk compared to lithium-ion batteries. However, thermal hazards remain, including overheating pumps, power electronics, and chemical reactions under fault conditions. Components must operate within temperature ratings, with over-temperature sensors and alarms recommended, particularly in enclosed systems. Fire detection and suppression should be suited to chemical fires, such as inert gas or water mist systems for large installations. Gas detection and ventilation are required if the electrolyte can release flammable or toxic gases. Firefighting procedures and responder guidance, including suitable suppression agents, must be documented.

4.7 Protection Against Gas Hazards

Where flow battery chemistries produce flammable or toxic gases (e.g., hydrogen, bromine), systems shall include fixed gas detection and forced ventilation designed to maintain concentrations below exposure thresholds defined in the SDS or WHS/OHS regulations.

4.8 Protection Against Mechanical Hazards

Storage tanks, piping, and pumps shall be installed per the manufacturer's instructions and secured against seismic or mechanical stress. Guards shall protect personnel from rotating or pressurised components. The floor or support structure shall be rated to accommodate the total system mass, including electrolytes.

All pressurised fluid circuits shall include pressure relief and isolation provisions. Pressurised pipework shall be rated and tested per manufacturer specifications.

4.9 Equipment with Multiple Sources of Supply

Flow battery systems often interface with multiple energy sources, including the battery, grid via an inverter, and potentially a generator or PV array. All power sources must be clearly identified and isolated before maintenance to prevent unintended energisation. Systems may have AC supplies for auxiliaries, DC outputs to inverters, and external charging sources—all requiring isolation. A single-point isolation procedure or documented plan should be used. Equipment labelling must indicate multiple power sources. In compliance with AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*, and AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, lockable isolators shall be installed on battery outputs and all incoming/outgoing circuits. Modular systems must allow individual module isolation for servicing.

4.10 Protection Against Environmental Stresses

Flow batteries must be protected from environmental conditions that compromise safety or performance. Maintain ambient temperature within the electrolyte's optimal range to prevent freezing or overheating. Ensure adequate ventilation and protection from water ingress and dust, using enclosures with appropriate Ingress Protection (IP) ratings for indoor or outdoor installations. Outdoor systems must account for solar heating, humidity, and wildlife intrusion.

Equipment shall be elevated or protected in flood-prone areas to prevent environmental contamination. Corrosion-resistant materials should be used in coastal or high-sulphur environments. Confined space installations, such as in containers or buildings, must comply with confined space regulations and include forced ventilation. Lightning and surge protection shall be implemented per AS 1768: 2021, *Lightning protection and relevant electrical standards*.

Where bunds are exposed to weather, procedures shall be implemented to manage rainwater accumulation, including lockable drains, inspection protocols, and water sampling where required.

Bunds or containment systems shall comply with AS 3780:2023, *The storage and handling of corrosive substances*, and be designed to hold 25% of the site's total electrolyte volume or 100% of the largest tank—whichever is greater.

4.11 Protection Against Sonic Pressure Hazards

Typically, flow battery systems are not significant sources of hazardous noise or sonic pressure; however, certain failure modes (like a rapid release of pressurised gas or electrolyte) might create loud sounds or pressure waves. Also, large pumps or cooling fans can contribute to high noise levels during operation. Any equipment producing noise above safe hearing thresholds should be enclosed or silenced to protect personnel, and appropriate hearing protection should be used during maintenance if necessary. If alarm sirens or warning horns are part of the safety system (to indicate leaks or fire), ensure they are placed appropriately so as not to cause hearing damage from prolonged exposure.

4.12 Wiring and Connections

All electrical wiring and connections in flow battery systems shall comply with AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*, and AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*. DC battery circuits must use appropriately rated cables with dual insulation, UV resistance for outdoor use, and flame-retardant properties. High-current DC connections shall be securely bolted or crimped and periodically checked for tightness. Cables must be routed to minimise heat exposure and avoid electrolyte contact, using separate trays or chemical-resistant conduits and cables where necessary. All terminals, disconnects, and junctions must be clearly labelled. A licensed electrician shall install Interfaces with external systems, with isolation points clearly marked. Control and communication cables must be segregated from power cables to prevent interference, following supplementary AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment* guidelines.

NOTE: Flow battery systems and installations should undertake hazardous area assessment - with electrical equipment and wiring in hazardous areas appropriately treated as per AS3000 | AS5139 | AS60079.

4.13 AS/NZS 4777.2:2020 Requirements

Flow battery systems integrated with grid-connected inverters must comply with AS/NZS 4777.2:2020, *Grid connection of energy systems via inverters, Part 2: Inverter requirements for inverter performance, safety, and grid interface*, and AS/NZS 4777.1:2016, *Grid connection of energy systems via inverters, Part 1: Installation requirements for installation*. This guide does not duplicate inverter requirements but mandates using 4777.2:2020, *Grid connection of energy systems via inverters, Part 2: Inverter requirements -certified inverters*. Control coordination must prevent the inverter from exceeding the battery's safe operating limits. Hybrid systems incorporating solar photovoltaics or other generation sources must comply with AS/NZS 5033:2021, *Installation and safety requirements for photovoltaic (PV) arrays*, and relevant grid connection standards. In addition, practitioners must consult the relevant electricity supply authority's service and installation rules, which take precedence over national standards where applicable.

NOTE: Inverter information is out of scope for this Guide; however, it represents required knowledge for those designing, installing, or operating flow battery energy systems.

Section 5: Verification and Test Requirements

The following section provides general guidance on verifying and testing flow battery systems. However, it is the reader's responsibility to ensure that all site-specific factors are appropriately considered.

This includes, but is not limited to, compliance with relevant WHS/OHS laws, electrical safety standards, manufacturer requirements, environmental conditions, and any obligations imposed by local authorities, testing bodies, or network operators.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

5.1 Commission Type Testing

Manufacturers shall conduct commission-type testing to verify compliance with safety and performance requirements. Tests may include:

- Electrical safety (insulation, dielectric withstand)
- Overload and short-circuit performance
- Over-temperature and thermal stability
- Leak containment for electrolyte and generated gases
- Control system fault response
- Testing shall be conducted at a representative state of charge (SOC), defined by the manufacturer, to reflect expected system duty cycles and the surrounding conditions.

For containerised or enclosed flow battery systems, large-scale fire behaviour testing (e.g., UL 9540A) may be undertaken to support site approvals or fire safety validation where applicable.

5.2 Test Specifications

Where no specific AS/NZS or IEC test standard applies to a given function, test protocols should be developed following the manufacturer's recommendations and guidance and industry best practice.

5.3 Periodic In-Service Checks

Operators should implement periodic checks to monitor system performance, fluid integrity, and hazard controls. These may include inspection of electrolyte clarity (to detect precipitation), gas evolution patterns, or flow rate stability. Where applicable, follow manufacturer recommendations for chemical analysis.

Section 6: Information and Marking Requirements

6.1 General

Manufacturers and suppliers shall provide documentation that outlines the safe selection, installation, commissioning, operation, and maintenance of flow battery systems.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

6.2 Information for Selection

System data sheets shall specify the following:

- Rated power and energy capacity
- Operating voltage range
- Acceptable ambient conditions
- Electrolyte data (type, volume, hazard classification)
- Weight and dimensions (including electrolyte)

Product datasheets shall present the above parameters in a format consistent with AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, Appendix B, where applicable.

6.3 Information for Installation and Commissioning

The installation manual may follow the structured guidance format recommended in AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, Appendix C to improve consistency with broader energy storage documentation.

An Installation Manual shall include:

- Site requirements (e.g., clearances, bunding, ventilation) shall reflect system scale and electrolyte hazards, as guided by AS 3780:2023, *The storage and handling of corrosive substances*, and WHS/OHS legislation.
- Electrical connection diagrams
- Commissioning steps (inspection, leak checks, initial charging)
- Warnings on chemical handling and required PPE

6.4 Information for Use (User Manual)

Manufacturers shall provide concise instructions for routine operations. These instructions shall include normal operating modes, alarm conditions, system monitoring, and emergency shutdown procedures.

6.5 Information for Maintenance

Maintenance instructions shall detail:

- Necessary electrolyte handling, spill response and PPE guidance as part of scheduled servicing (referencing the electrolyte SDS)
- Inspection intervals for hoses, seals, or pumps
- Filter or electrolyte condition checks
- Sensor calibration
- Personal protective equipment requirements

6.6 Compliance Documentation

A Certificate of Compliance (CoC) is recommended for each installed system. The CoC shall confirm adherence to relevant standards (e.g., AS/NZS 3000:2018, *Electrical installations (Wiring Rules)*, AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*). The manufacturer should supply a Declaration of Conformity aligned with IEC 62932-1:2020, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*, IEC 62932-2-1:2022, *Flow battery energy systems for stationary applications – Part 2-1: Safety requirements*, and IEC 62932-2-2:2020, *Flow battery energy systems for stationary applications – Part 2-2: Safety requirements*.

6.7 Labelling and Signage

All safety signage, electrical hazard labels, and electrolyte warnings shall comply with AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, AS/NZS 4777.1:2016, *Grid connection of energy systems via inverters, Part 1: Installation requirements*, and WHS/OHS labelling requirements. Where hybrid systems are deployed, signage must indicate all power sources present (e.g., PV, generator, grid, battery). Labels shall be weather-resistant and permanently affixed.

Section 7: Electrical Energy Storage Systems Safety Compliance

7.1 General

Flow battery systems shall comply with the fundamental electrical safety requirements of Section 3. Chemical and fluid-specific controls shall also apply to manage electrolyte, pressure, and gas hazards, as described in this section.

All chemical handling must be conducted using the PPE specified in the relevant SDS, appropriate to the hazards and tasks involved.

AS 3780:2023, *The storage and handling of corrosive substances*, refers to storing dangerous chemicals and must be referred to when handling electrolytes.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

7.2 Safety Requirements (All Technologies)

The flow battery system shall incorporate the following general safety features and design measures (many of these align with AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, and IEC 62932 series safety principles):

Metallic or reinforced polymer enclosures shall protect against accidental contact and environmental ingress.

7.2.1 Battery Modules

If the system comprises discrete modules or stack units, each module should be constructed to relevant safety standards (for example, no sharp edges, flame retardant materials, proper insulation). Within each module, cells/stacks should be secured against movement and provided with sensors (temperature, voltage, flow) as necessary for monitoring. Modules should have a means of electrical disconnect (such as removable links or isolators) for safe servicing.

7.2.2 Isolators

Manual isolation switches or circuit breakers must be considered to disconnect the flow battery from external circuits (both AC and DC) and to isolate sections of the battery if it's modular. These isolators should be clearly labelled and readily accessible in an emergency. For instance, a DC isolator at the battery output and an AC mains isolator for any integrated battery control cabinet. The isolators should be lockable in the off position for maintenance lockout/tagout.

7.2.3 Safety Data Sheets

The supplier shall provide SDS for all electrolytes or chemical additives. The SDS shall be current, accessible on-site, and conform to the WHS/OHS Code of Practice for hazardous chemicals. SDS must inform installation, maintenance, and emergency response procedures.

7.2.4 Installation Instructions

The manufacturer's installation manual (see section 5.3) is considered part of safety compliance. It should specify all required installation conditions for safety such as ventilation, clearances amongst others.

7.2.5 User Maintenance Instructions

Likewise, the user maintenance guidelines (see section 5.5) are integral to maintaining safety over the life of the system. The system design should accommodate safe maintenance.

7.2.6 Labels and Markings

All labels shall comply with AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, and WHS/OHS regulation requirements. Systems with multiple power sources (e.g., grid, PV, generator, battery) shall have signage identifying all sources. Labels must remain legible over the system's lifetime. Any electrolyte pipes should be marked (e.g., flow direction and contents).

7.2.7 Ingress Protection (IP) Ratings

Equipment enclosures, battery containers, and electrical boxes must have suitable IP ratings for their environment. Ingress protection also applies to electrolyte containment. If a battery is installed in an area prone to small animals/insects, mesh or seals should prevent ingress that could cause damage or shorts.

Ingress protection shall apply to electrolyte tanks and bunds. Bunds shall be sealed and, where exposed to weather, incorporate drainage controls following IEC 62932-2-2:2020, *Flow battery energy systems for stationary applications – Part 2-2: Safety requirements* and AS 3780:2023, *The storage and handling of corrosive substances*.

7.3 Safety Requirements for Specific Flow Battery Chemistries

Flow battery energy systems (FBES) utilise a range of electrolytes that may present chemical, thermal, or environmental hazards. The storage, handling, and transport of these substances must comply with relevant legislation, including the WHS/OHS regulations and AS 3780:2023, *The storage and handling of corrosive substances*.

These references provide essential guidance on bunding, ventilation, emergency controls, and worker protection. The system designer, installer, and operator are responsible for assessing all site-specific risks and implementing appropriate control measures.

7.3.1 General Safety Considerations (All Chemistries)

The following principles apply to all flow battery systems, regardless of chemistry:

- Compliance with SDS and WHS/OHS regulations, including occupational exposure limits (TWA, STEL) and appropriate PPE.
- Bunds or sealed sumps to manage spills in accordance with AS 3780:2023, *The storage and handling of corrosive substances*.
- Adequate ventilation and, where applicable, gas detection systems in enclosed spaces to address toxic or flammable gases.
- Temperature control systems where electrolytes may precipitate or degrade outside specified limits.
- Emergency planning, including fire response and spill containment, aligned with site-specific risk assessments.
- Safe commissioning and maintenance practices, including electrolyte balancing, isolation procedures, and pre-maintenance venting where required.

7.3.2 Additional Considerations by Chemistry

NOTE: Chemical compatibility must be considered wherever multiple substances are present. System design must prevent unintended chemical interactions through segregation, appropriate materials, and labelling. Where oxidising reactions or oxygen depletion are possible, ventilation and atmospheric monitoring must be implemented. A documented risk assessment shall confirm compatibility, identify hazards, and inform controls. All personnel must be trained in chemical awareness and appropriate PPE use.

- **Acidic Electrolytes**

These may be corrosive and require materials compatible with acidic environments. Where applicable, containment and thermal regulation should be considered.

- **Gas Evolution**

Some systems may emit gases such as hydrogen or halogens under certain conditions. Adequate ventilation, detection, and enclosure design may be necessary to manage potential exposure and accumulation.

- **Toxic or Volatile Substances**

Where the chemistry presents toxicity risks (e.g., bromine), provisions such as sealed systems, localised exhaust, and monitoring should be evaluated.

- **Emerging or Hybrid Chemistries**

New materials, including organic solvents or compound systems, may pose combined risks (e.g., flammability, toxicity, electrical isolation). Risk controls should reflect the nature of the hazards identified and align with recognised safety principles.

Section 8: Transport, Handling and Storage

The following section provides general guidance on transporting, handling, and storing flow battery systems and associated electrolytes. However, it remains the reader's responsibility to ensure that all site-specific factors are identified and appropriately managed.

This includes, but is not limited to, compliance with relevant WHS/OHS laws, The Australian Code for the Transport of Dangerous Goods by Road & Rail (2024) ('ADG Code'), environmental conditions, system design, chemical characteristics, and any local regulatory or operational requirements.

All chemical handling must be conducted using the PPE specified in the relevant SDS, appropriate to the hazards and tasks involved.

NOTE: This Guide does not specify shipping requirements for flow battery systems or electrolytes. All transport activities must comply with the ADG Code and, where applicable, relevant international shipping regulations and standards. The consignor and transport operator are responsible for ensuring full compliance with these regulatory frameworks.

The following standards are provided as references to guide the safe transport, handling, and storage associated with flow battery components:

- **Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG Code)**
Governs the classification, labelling, containment, and documentation of battery electrolytes and other hazardous materials in transit.
- **AS 3780:2023, *Storage and Handling of Corrosive Substances***
Essential if vanadium electrolyte or other Class 8 substances are stored before or during deployment.
- **AS/NZS 2809 series, *Road Tank Vehicles for Dangerous Good***
Provides detailed design and safety requirements if mobile tankers are used for bulk electrolyte transport.
- **AS 1216: 2006, *Class labels for dangerous goods***
Sets out details of the design of labels for the classes, divisions and subsidiary risks of dangerous goods as given in the 14th edition of the UN Recommendations on the Transport of Dangerous Goods and the seventh edition of the Australian Code for the Transport of Dangerous Goods (ADG Code). A large replica of each label is provided as a model for the production of correct labels. This information is essentially the same as that which will be published in the seventh edition of the ADG Code.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

8.1 Pre-Transport Checklist

Equipment shall be inspected for leaks or damage before shipping. Containers shall be labelled according to the ADG Code. Electrolyte volumes that exceed regulatory thresholds shall be declared as dangerous goods.

Ensure the SDS for each transported chemical is accessible and that workplace responsibilities under WHS/OHS legislation are acknowledged once the system arrives on-site.

8.2 Transport Methods

Large flow battery systems should be shipped without electrolyte ('dry shipping') where practicable. If wet shipping is used, packaging must comply with the ADG Code and include measures to prevent leakage or pressure build-up.

When dry shipping is employed, it shall be assumed that residual electrolyte may remain within the system, and appropriate handling precautions must be taken in accordance with the relevant Safety Data Sheets (SDS) and WHS/OHS obligations.

8.3 Post-Transport Checklist

Upon receipt, installations shall undergo inspection for any transport damage, fluid loss, or compromised connections. Any abnormality shall be rectified before commissioning begins.

A site-specific emergency contact list and spill response procedure shall be confirmed and posted following WHS/OHS requirements before handling or unpacking any equipment containing electrolyte.

8.4 Storage

If storage prior to installation is required, systems shall be maintained within the environmental conditions specified by the manufacturer, including temperature and humidity limits, to preserve electrolyte stability and system integrity. Electrolyte storage vessels shall remain sealed, clearly labelled, and handled in accordance with the manufacturer's Safety Data Sheets (SDS).

Where systems or components contain dangerous goods, storage must comply with applicable WHS/OHS and environmental protection regulations, including placarding, ventilation, and spill containment provisions, as required based on the classification and quantity of substances involved.

Section 9: Installation and Commissioning

The following section provides general guidance on installing and commissioning flow battery systems. However, it is the reader's responsibility to ensure that all site-specific factors are identified and addressed appropriately. This includes, but is not limited to, compliance with relevant WHS/OHS laws, electrical and planning regulations, system configuration, environmental conditions, and any local authority or network operator requirements.

The following standards are provided as reference to support the safe installation and commissioning of flow battery systems:

- **AS/NZS 3000:2018**, *Electrical installations (Wiring Rules)*
Applies to all fixed electrical installations. Specifications for switchgear, grounding, protection devices, and proximity to hazardous areas.
- **AS/NZS 5139:2019**, *Electrical Installations – Safety of Battery Systems for Use with Power Conversion Equipment*
Although primarily developed for lithium systems, several provisions apply to the design and safe installation of stationary energy storage systems, including flow batteries.
- **AS/NZS 1170.4:2007**, *Structural Design Actions – Earthquake Actions*
Relevant for anchoring and mounting large systems, particularly in seismically active zones.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

9.1 Design and Planning Considerations

Effective flow battery installation begins with thorough design planning. Adequate space shall be provided for the safe placement of system components and maintenance access. Structural integrity must support the full operational weight of the system, including electrolyte volumes, with engineering input where appropriate.

A site-specific risk assessment will determine containment, ventilation, and emergency response provisions. This assessment should consider chemical classification, quantity, environmental conditions, proximity to personnel, and potential impacts on surrounding infrastructure. AS 3780:2023, *The storage and handling of corrosive substances* may be used as a reference to inform risk assessment methodology but shall not be treated as a mandatory standard.

Containment solutions, including bunding, shall be risk-assessed to determine appropriate capacity and construction, considering the electrolyte's nature and volume. Emergency wash facilities, ventilation design, and gas detection requirements must align with the chemical SDS and relevant WHS/OHS obligations.

Where applicable, electrical integration shall be coordinated with site switchboards and comply with applicable isolation, bonding, and grid connection standards. Planning should also address future system expansion and end-of-life requirements, including space for additional tanks or electrolyte removal systems. A well-considered layout reduces risk and supports long-term safety, efficiency, and regulatory compliance.

9.2 Installation Procedure

Installation shall be performed by qualified personnel, including licensed electricians for electrical work and trained technicians for battery chemistry handling: position and secure mechanical components and anchoring tanks as needed.

Connect components to the control cabinet/BMS and main power, following manufacturer diagrams with proper cable protection and labelling. Verify DC polarities and insulation before energising.

If shipped dry, mix and fill electrolyte per specifications.

For wet shipments, verify and top up levels as required.

9.3 Commissioning

Whilst not exhaustive, the following is provided for guidance:

- post installation checks
- plumbing and mechanical checks
- electrical connection checks
- zero voltage electrical checks [DC and AC]
- electrical verification checks as per AS3000
- energise control circuit and BMS
- network communication tests
- verify inputs and outputs
- calibrate sensors
- perform functional tests and safety tests [including emergency STOPs]
- auxiliary power energisation – including electrical verification checks as per AS3000
- verify DC – DC converter configuration and motor control configuration
- bump pump motors to confirm correct rotation
- pressurise electrolyte tank and plumbing [with inert gas] – check for leaks
- hydrate the system
- ensure necessary provisions in place to capture and contain electrolyte leaks
- prove hydration plumbing [with demineralised water] – check for leaks
- hydrate system once plumbing proven – monitor for leaks during hydration
- post hydration electrolyte mixing and conditioning – check for leaks when starting pumps
- electrolyte sampling and testing – electrolyte adjustments
- post hydration functionality tests
- initial flow through cell stack checks
- gas and fluid leak checks
- charge the system gradually per commissioning instructions – using a temporary power source
- conduct a trial charge/discharge cycle at low and full power, monitoring key parameters
- perform site acceptance test

A commissioning checklist, completed and signed by the authorised technician, shall be used to verify and document the successful completion of all commissioning tests. This checklist shall record all relevant readings and settings for future reference and shall be retained as a formal record of commissioning status. The system shall only be deemed operational once this process is complete.

Section 10: Operations and Maintenance

The following section provides general guidance on the operation and maintenance of flow battery systems. However, it is the reader's responsibility to ensure that all site-specific factors are appropriately identified, assessed, and managed. This includes, but is not limited to, compliance with relevant WHS/OHS laws, electrical safety and environmental regulations, system operating parameters, manufacturer maintenance schedules, and any specific requirements set by regulators, asset owners, local authorities, or network operators.

Proper operation and maintenance are critical to ensuring flow battery systems' safety, reliability, and longevity. Operational considerations include control and monitoring protocols, system performance, and environmental conditions. Maintenance activities generally fall into three categories: routine inspections, preventive maintenance, and corrective repairs. The nature and frequency of these tasks will depend on the system design, operating environment, and technology-specific requirements.

The information provided in this section is intended as general guidance only. A risk-based approach should be applied to all operational and maintenance practices, and the onus remains on the user to ensure that appropriate measures are in place for their specific context.

The following standards are provided as reference to support the safe and effective operation and maintenance of flow battery systems:

- **AS IEC 60950 / AS IEC 61010**, *Electrical Equipment Safety Standards*
Apply protective measures for users and maintainers of battery equipment and control systems.
- **AS/NZS 4024.1:2014**, *Safety of Machinery*
Essential if flow battery systems involve mechanical pumps, valves, or moving components—mandates risk assessment and safeguarding measures.
- **AS 1940:2017**, *Storage and Handling of Flammable and Combustible Liquids*
Relevant where flammable coolants, cleaning agents or solvents are used in maintenance procedures.
- **AS 3745:2010**, *Planning for Emergencies in Facilities*
Mandates emergency response planning, including for chemical spills, fire, and electrical hazards.
- **Work Health and Safety Regulations (WHS) – Part 7.1 and 7.2**
Legally enforces controls around hazardous chemicals, workplace conditions, and emergency preparedness.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

10.1 General Operation

Operators should follow the user manual to ensure safe and efficient use of flow batteries, including recommended charge/discharge schedules. Monitoring systems are encouraged to detect abnormal conditions (e.g., high temperature, flow disruption).

10.2 Idle Periods

Particle cycling or periodic fluid circulation should be considered where extended idle periods occur to avoid electrolyte stratification or precipitation.

Fluid cycling should be implemented during extended idle periods to prevent stratification or precipitation.

10.3 Emergency Response

Emergency procedures should be clearly displayed. Operators should train staff to respond to chemical spills, toxic vapour alarms, and any high-voltage incidents.

Emergency plans must follow SDS guidance and comply with WHS/OHS regulations for hazardous chemical response.

10.4 Routine Inspections

Done monthly or quarterly: checking electrolyte levels, inspecting all hoses and connections for signs of weeping or corrosion, ensuring no unusual noises from pumps, and reviewing the error log of the BMS for any warnings that might not have triggered alarms. Safety devices like gas detectors or fire suppression units should also be checked.

Electrolyte circulation during extended idle periods should be implemented in accordance with manufacturer recommendations to prevent stratification or precipitation.

10.5 Preventive Maintenance

Preventive maintenance requirements may vary depending on environmental conditions, system configuration, and manufacturer specifications. The following minimum actions should be considered as part of a routine maintenance program:

- Replace or clean electrolyte filters (if fitted) to prevent pump strain
- Clean cooling fans and HVAC filters periodically
- Inspect and check electrical panels
- Perform electrolyte rebalancing or reconditioning if specified by the manufacturer
- Calibrate sensors (pressure, flow, voltage) as required—typically annually
- Test emergency stop functions and safety interlocks at regular intervals

10.6 Corrective Maintenance

Addresses issues or failures. In any corrective action, first make the system safe (drain electrolyte from the component, isolate electrical power). After significant maintenance, a brief re-commissioning step (testing that everything is back to normal) should be done.

10.7 Records

A maintenance log should be maintained. The log should document inspection findings, parts replaced, electrolyte balancing operations, and any corrective actions.

10.8 Disposal

Dispose of any waste safely: used oil from pumps, contaminated absorbents from cleaning minor spills, or replaced components that have electrolyte residue should be treated as hazardous waste per local regulations. Rinse water from cleaning acidic components should be neutralised and disposed of in accordance with SDS and local environmental regulations.

Section 11: Decommissioning and End-of-Life

At end-of-life or when a flow battery installation needs to be removed or replaced, careful decommissioning is required to ensure safety and environmental responsibility. Decommissioning starts with planning: consult the manufacturer's guidelines (they often have instructions for shutdown and removal) and local regulations for the disposal of battery electrolytes and components.

The following section provides general guidance on flow battery systems' decommissioning and end-of-life management. However, it is the reader's responsibility to ensure that all site-specific factors are fully addressed.

Decommissioning activities must only be carried out by authorised personnel. They must comply with all relevant WHS/OHS laws, environmental regulations, manufacturer instructions, chemical handling requirements, and any additional obligations set by regulators, network operators, or asset owners.

Key steps include:

Shut Down and Electrical Isolation

Fully discharge the flow battery if possible to minimise stored energy (some systems allow you to discharge into a load or back to the grid until empty). Turn off all power sources, isolate the battery from any connected generation or loads, and lock out the isolators. Verify zero voltage as per electrical safety practices.

Electrolyte Removal

Pump out the electrolyte from the tanks and system into appropriate containers. It may be possible to return the electrolyte to the manufacturer for recycling. If not reused, treat the electrolyte as chemical waste. Neutralisation and disposal procedures shall follow manufacturer instructions and the SDS.

Flushing and Cleaning

After draining, flush the system's plumbing with water or a neutralising solution to remove residual electrolytes. Rinse water shall be disposed of following the SDS and applicable environmental regulations.

Dismantling Equipment

Disassemble the battery stacks, tanks, piping, and electrical components. Heavy components should be lifted with lifting equipment when dismantling. Segregate materials for recycling: many parts of flow batteries are recyclable – plastic tanks (if HDPE or similar) can often be recycled, metals like vanadium can be recovered from electrolytes, and steel frames/shells go to metal recycling. Certain parts, like membranes or electrode materials, might be specialised waste if they contain contaminants. If functional, BMS and power electronics (inverters) should be handled as e-waste or reused.

Site Restoration

You may remove the entire container if the battery is in a container. If it was in a dedicated room, once empty, the room can be cleaned, and any contamination in secondary containment can be addressed (e.g., neutralise any traces of acid). Ventilation systems can be cleaned or removed. Leave the site safe – no chemical residues, live electrical connections, or physical hazards (like pits or protruding bolts).

Documentation and Reporting

Document the decommissioning process, including how much electrolyte was removed and where it was sent, and confirm that the system has been rendered safe. If required, notify environmental regulators of the disposal of hazardous materials (some jurisdictions require tracking of large volumes of battery electrolyte disposal). Also, inform the network operator or relevant authority that the energy storage system has been decommissioned (to update any registration or fire department records).

Documentation of decommissioning should meet the minimum record-keeping expectations described in AS/NZS 5139:2019, *Electrical installations - Safety of battery systems for use with power conversion equipment*, section 4.4, where applicable.

Recycling and Sustainability

This guide encourages maximising recycling in line with the National Battery Strategy's goal of a circular economy for batteries. Vanadium electrolyte, for instance, can be purified and used in new batteries. Lead from any components (if used in alloys) and plastics should be recycled. Only minimal, truly hazardous waste (like certain chemical additives or spent membranes) should go to disposal. If a new battery system replaces the old one, plan the changeover to minimise downtime and safety risks (possibly installing the new system in parallel or in the same footprint after removal).

The following standards are provided as reference to support the decommissioning and end-of-life of flow battery systems:

- **NEPM (National Environmental Protection Measure) Guidelines – Contaminated Sites and Hazardous Waste**
Inform decommissioning protocols where site remediation or hazardous waste disposal is required.
- **AS 2601:2001, *The Demolition of Structures***
Relevant if battery systems are fixed structures or integrated into facility infrastructure.

NOTE: Only qualified, licenced, and authorised personnel should perform decommissioning activities.

NOTE: All chemical handling must be conducted using PPE specified in the SDS.

Section 12: Bibliography

Electrical Energy Storage - Equipment Safety Requirements (in prep). Standards Australia.

National Battery Strategy (2024). Department of Industry, Science and Resources. Australian Government.

National Environmental Protection (Assessment of Site Contamination) Measure (2013). National Environment Protection Council.

The Australian Code for the Transport of Dangerous Goods by Road & Rail (2024). Edition 7.9. National Transport Commission.

Appendix A: Glossary of Terms

These definitions are provided as a common language reference to aid communication, interpretation, and application of best practices within the context of flow battery energy systems.

Key terms include:

Ambient temperature

environmental temperature around a flow battery energy system

[SOURCE: IEC 62932-1:2020]

Auxiliary energy

energy consumed by all the auxiliary equipment and components of a flow battery and of a flow battery energy system

Note 1 to entry: The equipment and components include, but are not limited to, battery management system, battery support system, fluid circulation system.

[SOURCE: IEC 62932-1:2020]

Battery Management Module (BMM)

distributed battery and battery module device that feeds into the BMS and are generally part of the electronics on an individual cell or module

[SOURCE: Best Practice Guide: Battery Storage Equipment. Electrical Safety Requirements, 2018]

Battery Management System (BMS)

electronic system associated with a flow battery energy system that monitors and/or manages its state calculates secondary data, reports that data and/or controls its environment to influence the flow battery energy system's performance and/or service life.

Note 1 to entry: The function of the battery management system can be fully or partially assigned to the battery pack and/or to equipment that uses flow battery energy store systems.

[SOURCE: IEC 61427-2:2015, 3.8, modified – admitted terms "battery management unit" and "BMU" omitted, "battery" replaced by "flow battery energy system", Notes 2 to 4 deleted.]

Battery Support System (BSS)

auxiliary units, such as heat exchanger, ventilation system, safety system, and inert gas system, used in an FBES, and which are not stacks, or part of the fluid circulation system, power conversion system, or battery management system

Note 1 to entry: The battery support system is controlled by the battery management system.

[SOURCE: IEC 62932-1:2020]

Charge / Charging

<of a battery> operation during which a secondary cell or battery is supplied with electric energy from an external circuit which results in chemical changes within the cell and thus the storage of energy as chemical energy

Note 1 to entry: A charge operation is defined by its maximum voltage, current, duration and other conditions as specified by the manufacturer.

[SOURCE: IEC 60050-482:2004, 482-05-27, modified – term “charging of a battery” separated into “charge” and “charging” with “of a battery” as the domain, and addition of the note.]

Cold Standby

standby state requiring warm up before a demand to operate can be met

Note 1 to entry: A cold standby state may apply to redundant or stand-alone items.

Note 2 to entry: In this context “warm up” includes meeting any conditions required to operate as required (e.g., achieving the required temperature, speed, pressure).

[SOURCE: IEC 60050-192:2015, 192-02-11, modified – “state” omitted from the term, and the domain, “of an item”, deleted.]

DC – DC Converter

bidirectional DC converter that manages power transfer between the battery stack and the power conversion system (PCS)

Note 1 to entry: The stack interface converter modulates the DC voltage output of the stack to enable efficient integration with the PCS for both charging and discharging operations.

Note 2 to entry: The converter supports bidirectional power flow, allowing controlled energy transfer to and from the stack.

Discharge / Discharging

<of a battery> operation during which a secondary battery supplies electric energy to an external circuit which results in chemical changes within the cell and the release of energy as electrical energy

Note 1 to entry: A discharge operation is defined by its maximum voltage, current, duration and other conditions as specified by the manufacturer.

[SOURCE: IEC 62932-1:2020]

Dry Shipping

method of transporting a flow battery system without electrolytes or with electrolytes stored separately in sealed containers.

Where a system has contained electrolytes (e.g., for testing), it must be flushed and sealed to prevent leakage of residual fluid and labelled accordingly.

Caution: Battery stacks and stack assemblies may retain residual electrolytes after flushing and must be handled appropriately, including using PPE and spill containment measures as per the system’s SDS.

[SOURCE: IEC 62932-1:2020]

Emergency Shutdown

rapid regulated shutdown of the flow battery energy system triggered by a protection system or by manual intervention

[SOURCE: IEC 60050-415:1999, 415-01-11, modified – the word “regulated” added, and “wind turbine” replaced by “flow battery energy system”.]

Emergency Stop

function which is intended to avert arising or reduce existing hazards to persons, damage to machinery or to work in progress and be initiated by a single action

[SOURCE: ISO 13850:2015, 3.1, modified – “(E-Stop)” omitted from the term, second preferred term “emergency stop function” omitted, layout modified.]

Energy Efficiency

useful energy output at primary POC divided by the required energy input by the FBES/FBS

including all parasitic and auxiliary energy needed to run the system and evaluated during FBES/FBS operation with the same final state of charge as the initial state of charge

Note 1 to entry: The energy efficiency for FBES includes necessary conversion loss of power conversion system (PCS), auxiliary energy required for fluid circulation system, BMS and BSS.

Note 2 to entry: Efficiency is generally expressed in percentage.

[SOURCE: IEC 62933-1:2018, 4.12, modified – “EES” replaced by “FBES/FBS”, Note 1 to entry replaced.]

Energy Storage Fluid

fluid that contains active materials and flows through the battery cell, consisting of liquid, suspension or gas

[SOURCE: IEC 62932-1:2020]

End of Charge

limit conditions specified by the manufacturer at which a charge is (to be) terminated

[SOURCE: IEC 62932-1:2020]

End of Discharge

limit conditions specified by the manufacturer at which a discharge is (to be) terminated

[SOURCE: IEC 62932-1:2020]

Flow Battery

a rechargeable electrochemical battery in which electrolyte solutions (typically containing dissolved metals or ions) are stored in tanks and pumped through a reactor stack to convert chemical energy to electricity and vice versa. (This encompasses all redox flow batteries, e.g., vanadium redox, zinc-bromine.)

Flow Battery Energy System (FBES)

system to store energy consisting of FBS(s) and power conversion system(s)

[SOURCE: IEC 62932-1:2020]

Flow Battery System (FBS)

two or more flow cells electrically connected including all components for use in an electrochemical energy storage system such as battery management system, battery support system and fluid circulation system

[SOURCE: IEC 62932-1:2020]

Flow Cell

secondary cell characterised by the spatial separation of the electrodes and the movement of the energy storage fluids

Note 1 to entry: Flow battery cell includes the hybrid flow cell.

[SOURCE: IEC 62932-1:2020]

Fluid System

components and equipment destined to store and circulate energy storage fluids, such as tanks, pipes, manual valves, electrical valves, pumps and sensors

[SOURCE: IEC 62932-1:2020]

Forced Ventilation

movement of air and its replacement with fresh air by mechanical means

[SOURCE: IEC 62932-1:2020]

Fully Charged

condition (status) where, after a charge process as specified by the manufacturer, the flow battery energy system reaches the end of charge point

[SOURCE: IEC 62932-1:2020]

Fully Discharged

condition (status) where, after a discharge process as specified by the manufacturer, the flow battery energy system reaches the end of discharge point

[SOURCE: IEC 62932-1:2020]

Gas Release

emission of gas from the flow battery energy system to the environment

[SOURCE: IEC 62932-1:2020]

Grid-Connected State

condition in which the flow battery energy system is connected to the point of connection

[SOURCE: IEC 62932-1:2020]

Ground Fault

occurrence of an accidental or unplanned conductive path between a live conductor on the fluid system of the battery and the earth

Note 1 to entry: A conductive path can pass through faulty insulation, liquid films, structures (e.g., poles, scaffoldings, cranes, ladders), or vegetation (e.g., trees, bushes).

[SOURCE: IEC 62932-1:2020]

Hot Standby

standby state providing for immediate operation upon demand

Note 1 to entry: A hot standby state may apply to redundant or stand-alone items.

Note 2 to entry: In some applications, an item in a hot standby state is considered to be operating.

[SOURCE: IEC 60050-192:2015, 192-02-12, modified – “state” omitted from the term, and the domain, “of an item”, deleted.]

Hybrid Flow Battery / Hybrid Flow Cell

flow battery or flow cell in which one of the active materials is, depending on the state of charge, a solid material deposited on one of the electrode surfaces

[SOURCE: IEC 62932-1:2020]

Input Power

electrical power supplied to the FBES during charge and standby

[SOURCE: IEC 62932-1:2020]

Insulation Resistance

resistance under specified conditions between two conductive elements separated by insulating materials

[SOURCE: IEC 60050-151:2001, 151-15-43]

Interlock

circuit linking mechanical, electrical or other devices, for example, through auxiliary contacts, intended to make the operation of a piece of apparatus dependent on the condition or position of one or more others

[SOURCE: IEC 60050-811:2017, 811-25-13, modified – “circuit” omitted from the term.]

Fluid Leakage

unplanned escape of fluids from a cell or from an FBS

Note 1 to entry: Concentrating on leakage of energy storage fluids is incomplete as there is also leakage of fluid which is considered in the “safety” standard text.

[SOURCE: IEC 62932-1:2020]

Maximum Ambient Temperature

highest ambient temperature at which the battery is operable and should perform according to specified requirements[SOURCE: IEC 62932-1:2020]

[SOURCE: IEC 62932-1:2020]

Maximum Discharge Energy

largest energy declared by the manufacturer that an FBS/FBES can provide under specified discharge operating conditions

Note 1 to entry: The maximum discharge energy is normally expressed in watt hour (Wh).

Note 2 to entry: The maximum discharge energy of an FBES is customarily measured at the point of connection (POC) to account for the auxiliary energy consumption.

[SOURCE: IEC 62932-1:2020]

Maximum Input Power

highest level of power in watt that can be supplied to the FBES and at which it is operable and performs according to specified conditions

Note 1 to entry: This level is specified by the manufacturer.

[SOURCE: IEC 62932-1:2020]

Maximum Output Power

highest level of power in watt that can be supplied by the FBES and at which it is operable and performs according to specified conditions

Note 1 to entry: This level is specified by the manufacturer.

[SOURCE: IEC 62932-1:2020]

Minimum Ambient Temperature

lowest ambient temperature at which the battery is operable and should perform according to specified requirements

[SOURCE: IEC 62932-1:2020]

Natural Ventilation

movement of air and its replacement with fresh air due to the effects of wind and/or temperature gradients

[SOURCE: IEC 60050-426:2008, 426-03-07]

Negative Terminal

accessible conductive part provided for the connection of an external electric circuit to the negative electrode of the cell

[SOURCE: IEC 60050-482:2004, 482-02-24]

Non-operating State

state of not performing any required function

Note 1 to entry: The adjective “non-operating” designates an item in a non-operating state.

[SOURCE: IEC 60050-192:2015, 192-02-06]

On-state

state of a flow battery energy system when it is actively delivering or absorbing energy

[SOURCE: IEC 62932-1:2020]

Operating State

state of performing as required or ready to perform

Note 1 to entry: The adjective “operating” designates an item in an operating state.

Note 2 to entry: In some applications, an item in an idle state is considered to be operating.

[SOURCE: IEC 60050-192:2015, 192-02-04, modified – The domain “<of an item>” omitted and the words “or ready to perform” added to the definition.]

Operational Coordination

activity or status where all the different elements of a complex activity such as PCS, BMS and BSS, are brought into a harmonious and efficient relationship

[SOURCE: IEC 62932-1:2020]

Output Power

electrical power supplied by the flow battery energy system during discharge

[SOURCE: IEC 62932-1:2020]

Overcharge

continued charging of a fully charged FBS

[SOURCE: IEC 60050-482:2004, 482-05-44, modified – “secondary cell or battery” replaced with “FBS” and note omitted.]

Point Of Connection (POC)

reference point in the electric power system where the FBES is connected to the grid or to the final application point

[SOURCE: IEC 60050-617:2009, 617-040-1, modified – abbreviated term “POC” added, “user’s electrical facility” replaced by “FBES”, and “to the grid or to the final application point” added to the definition.]

Power Conversion System (PCS)

manages energy flow between the battery stack and the grid. It converts DC from the stack to AC for external use and vice versa during charging, ensuring efficient and safe operation.

Point Of Measurement (POM)

physical location in the (FBES) circuit where the energy delivered to or from the battery and the energy consumed by the BMS/BSS is to be reproducibly measured/recorded

Note 1 to entry: This location is specified by the manufacturer and may be indicated in contractual documents.

[SOURCE: IEC 62932-1:2020]

Positive Terminal

accessible conductive part provided for the connection of an external electric circuit to the positive electrode of the cell

[SOURCE: IEC 60050-482:2004, 482-02-25]

Power Conversion System (PCS)

manages energy flow between the battery stack and the grid. It converts DC from the stack to AC for external use and vice versa during charging, ensuring efficient and safe operation.

Rated Energy

manufacturer declared value of the energy content of the FBES system when discharged under specified (rated) conditions and measured at the primary POC

Note 1 to entry: (J) is the base unit, other units may be chosen for convenience as well (kWh, MWh).

[SOURCE: IEC 62932-1:2020]

Rated Input Power

manufacturer declared value of input power for a specific set of operating conditions of the FBS/FBES

Note 1 to entry: The rated input power is expressed in watts (W).

[SOURCE: IEC 62932-1:2020]

Rated Maximum Power

manufacturer declared highest power level that the FBS/FBES can accept or deliver

[SOURCE: IEC 62932-1:2020]

Rated Output Power

manufacturer declared value of output power for a specific set of operating conditions of the FBS/FBES

[SOURCE: IEC 62932-1:2020]

Routine Test

conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

Sampling Test

test on a sample

[SOURCE: IEC 60050-151:2001, 151-16-20]

Sensor

<of a measurement element> device which detects or measures a physical property and records, indicates or responds to it

[SOURCE: IEC 62932-1:2020]

Service Life

duration from the time of the FBES system commissioning test to the end of service life

Note 1 to entry: The term “commissioning test” is defined in IEC 60050-411:1996, 411-53-06.

[SOURCE: IEC 62932-1:2020]

Short-Circuit Current

maximum current, which should be delivered by a flow battery system or flow battery energy system into an external circuit with zero electric resistance or an external circuit that depresses the cell or battery voltage to approximately zero volt

Note 1 to entry: Zero electric resistance is a hypothetical condition and in practice the short-circuit current is the peak current following in a circuit of very low resistance compared to the internal resistance of the battery.

[SOURCE: IEC 60050-482:2004, 482-03-26, modified – “(related to cells or batteries)” omitted from term, and “cell or battery” replaced by “flow battery system or flow battery energy system” in the definition.]

Site Requirement

prerequisite for the operation of the battery in conditions as specified by the manufacturer

[SOURCE: IEC 62932-1:2020]

Stack

<of an FBS> group of flow cells, assembled in a contiguous form and usually connected electrically in series

Note 1 to entry: In theory, stacks can also be formed by connecting cells in parallel. But due to minimum voltage requirements, the cells are usually connected in series.

[SOURCE: IEC 62932-1:2020]

Stack Power Electronics (SPE)

regulates power transfer between the battery stack and the broader Power Conversion System (PCS). It optimises DC voltage and current from the stack, ensuring efficient conversion and integration with the PCS for grid or load connection.

Standard State Of Charge (SOC)

proportion of charge remaining in a battery or battery system, expressed as a percentage of its rated capacity.

Standby State

state of a flow battery energy system when it is fully functional but not actively delivering or absorbing energy

[SOURCE: IEC 62932-1:2020]

Stopped State

operating state in which the FBES is in grid-disconnected state and the accumulation subsystem is not connected with the power conversion subsystem

Note 1 to entry: In this state the auxiliary subsystem is energised.

[SOURCE: IEC 62933-1:2018, 6.1.8, modified – “EES system” replaced with “FBES” and Note 1 to entry replaced.]

Tank

<of an FBS> large receptacle or storage chamber for energy storage fluid

[SOURCE: IEC 62932-1:2020]

Type Test

conformity test made on one or more items representative of the production

[SOURCE: IEC 62932-1:2020]

Wet Shipping

method of transporting a flow battery with electrolyte remaining in the system.

[SOURCE: IEC 62932-1:2020]

Appendix B: Hazards

The following list outlines common risks and hazards relevant to the design, installation, and operation of flow battery energy systems. While this list is not exhaustive, it serves as a useful reference tool to assist designers, installers, and assessors in verifying that key considerations have been addressed as part of the project's safety and compliance obligations.

Risk assessments for flow battery energy systems must be tailored to the specific characteristics of each installation. This includes, but is not limited to, system configuration, geographic location, environmental conditions, operational profile, and site-specific constraints.

Risks should be:

- **Identified** using the guidance below in consideration of the unique circumstances of the installation.
- **Assessed** based on:
 - **Consequence** (e.g., insignificant | minor | moderate | major | catastrophic), considering impacts on people, environment, plant and property, community, legal compliance, and quality.
 - **Likelihood** (e.g., almost certain | likely | occasional | unlikely | rare), with timeframes selected based on relevance to the risk in question.
- **Rated and treated** by evaluating the combined consequence and likelihood to determine risk levels and appropriate mitigation measures.

This list should be read in conjunction with relevant standards and legislative requirements, including those governing work health and safety, environmental protection, and electrical installations.

Type of Risk/Hazard	Description
Bund and Containment Integrity Hazard	Inadequate bunding or alternative containment measures may fail, especially under adverse weather (e.g., heavy rain), leading to overflow of leaked electrolytes and exposure to hazardous chemicals.
Chemical Hazards – Electrolyte Leaks/Residues	Spills or leaks of electrolytes during installation or transfer may cause chemical burns or environmental contamination. Charged electrolyte leaks may bridge high potentials between tanks or earth; treat fluid leakage as an electrical shock hazard and use only chemical - resistant cabling and containment trays.
Chemical Hazards – Storage/Handling Hazards	Classification ambiguities (chemical store vs. operational battery) can affect proper storage, handling, and manifest requirements, leading to potential risks.
Compliance Claim Ambiguity	There is a risk that parties may claim compliance with certain standards sections without sufficient substantiation, leading to safety gaps and potential regulatory non-conformance.
Cybersecurity & Data Risks	Vulnerabilities in networked monitoring or control systems may compromise operational safety if subjected to cyber-attacks.
DC Conversion & PCS Hazards – DC to DC Converter Issues	Poor earthing, inadequate isolation, or failed fusing/disconnects within the DC-to-DC converter may compromise system safety.

Table continued	
Type of Risk/Hazard	Description
DC Conversion & PCS Hazards – Interface Hazards	The interface between the battery stack and the power conversion system may experience contamination or improper electrical continuity, increasing hazard potential.
DC Conversion Block Integration Hazard	The absence or improper integration of a dedicated DC converter block between the battery stack and the power conversion system may result in inadequate voltage regulation or safety gaps.
Definition/Classification Ambiguity	Uncertainty in defining a flow battery as either equipment or installation may lead to misinterpretation of regulatory requirements and safety gaps.
Electrical – DC Voltage Risk	Low-voltage DC at battery stack terminals (~50 V) and higher DC voltages (up to approximately 1100 V) may deliver hazardous currents if exposed, posing significant shock risks.
Electrical Hazards – Electric Shock	Live or exposed electrical parts may cause electrical shock during installation, maintenance, or operation.
Electrical Hazards – Residual Voltage & Live Terminals	Residual electrical charges may remain on live terminals if the battery is not fully drained before maintenance.
Electrical Hazards – Wiring Non-Compliance	Incorrect grounding or wiring practices (e.g., pure green earth wiring instead of green-yellow) may lead to unsafe conditions.
Emergency Shutdown System Design Hazard	The emergency shutdown mechanism (or equivalent) may not effectively isolate all critical components due to design constraints or inadequate integration with the battery management system.
Environmental Hazards – Gas Emissions	Inadequate gas purging during commissioning may lead to hazardous gas buildup (e.g., hydrogen), increasing the fire risk or explosion.
Environmental Hazards – Regulatory Compliance	Non-compliance with EPA requirements or misclassification regarding material change of use may lead to environmental and legal risks.
Inadequate Shipping/Storage Guidelines	Unclear or insufficient guidelines on shipping, storage, and handling of battery components may lead to improper labelling, residual electrolyte presence, or unsafe storage conditions.
Installation Certification Integration Hazard	When assembled into a larger installation, individually certified modules may not collectively achieve proper installation certification due to insufficient integration verification.
Mechanical Hazards – Component Failure/Physical Damage	Mechanical failure or physical damage (e.g., breaches in tanks or fittings) may lead to leaks or system compromise.
Mechanical Hazards – Inadequate Isolation/Access	Insufficient isolation between high-voltage areas and accessible parts (including missing or improperly placed isolators) may lead to hazards during maintenance or emergency intervention.

Table continued	
Type of Risk/Hazard	Description
Process & Operational Hazards – Commissioning & Transport Checks	Hazards during pre- and post-transport inspections—including risks during electrolyte transfer and gas purging—if procedures are not properly followed.
Process & Operational Hazards – Incomplete Hazard Assessment Process	An incomplete or inconsistent hazard assessment process may overlook critical risks, leading to overall safety or compliance gaps.
Undefined Exclusion Zones Hazard	The lack of clearly defined exclusion zones or separation distances for installations may result in unsafe proximity between modules or between the installation and adjacent structures.

Appendix C: Relevant Standards – Electrical Regulations by State/Territory

Queensland

Electrical Safety Regulations 2013

Designation	Standard Title
AS/NZS 3000:2018	Electrical installations (Wiring Rules)
AS/NZS 3012	Electrical installations - Construction and demolition sites
AS/NZS 3105	Approval and test specification - Electrical portable outlet devices
AS/NZS 3560.1	Electric cables—Cross-linked polyethylene insulated—Aerial bundled—For working voltages up to and including 0.6/1(1.2)kV
AS/NZS 3760	In-service safety inspection and testing of electrical equipment and RCDs
AS/NZS 3820	Essential safety requirements for electrical equipment
AS/NZS 4417.1	Regulatory compliance mark for electrical and electronic equipment, Part 1: Use of the mark
AS/NZS 4961	Electric cables—Polymeric insulated—For distribution and service applications
AS/NZS 5000.1	Electric cables—Polymeric insulated—For working voltages up to and including 0.6/1 (1.2) kV

Victoria

Electricity Safety (General) Regulations 2019

Designation	Standard Title
AS 1074	Steel tubes and tubulars for ordinary service
AS 2067	Substations and high voltage installations exceeding 1 kV a.c.
AS/NZS 2053.2	Conduits and fittings for electrical installations, Part 2: Rigid plain conduits and fittings of insulating material
AS/NZS 2053.3	Conduits and fittings for electrical installations, Part 3: Rigid plain conduits and fittings of fibre-reinforced concrete material
AS/NZS 2053.5	Conduits and fittings for electrical installations, Part 5: Corrugated conduits and fittings of insulating material
AS/NZS 2053.6	Conduits and fittings for electrical installations, Part 6: Profile-wall, smooth-bore conduits and fittings of insulating material
AS/NZS 3000:2018	Electrical installations (Wiring Rules)
AS/NZS 3003	Electrical installations - Patient areas
AS/NZS 3007	Electrical equipment in mines and quarries — Surface installations and associated processing plant
AS/NZS 3013	Electrical installations — Classification of the fire and mechanical performance of wiring system elements
AS/NZS 3016	Electrical installations — Electric security fences
AS/NZS 3560.1	Electric cables — Cross-linked polyethylene insulated — Aerial bundled — For working voltages up to and including 0.6/1(1.2) kV, Part 1: Aluminium conductors
AS/NZS 3560.2	Electric cables — Cross-linked polyethylene insulated — Aerial bundled — For working voltages up to and including 0.6/1 (1.2) kV, Part 2: Copper conductors
AS/NZS 3599.1	Electric cables — Aerial bundled — Polymeric insulated — Voltages 6.35/11 (12) kV and 12.7/22 (24) kV, Part 1: Metallic screened
AS/NZS 3599.2	Electric cables — Aerial bundled — Polymeric insulated — Voltages 6.35/11(12) kV and 12.7/22(24) kV, Part 2: Non-metallic screened
AS/NZS 3600	Concrete structures

Table continued	
Designation	Standard Title
AS/NZS 3891.1	Air navigation — Cables and their supporting structures — Marking and safety requirements, Part 1: Marking of overhead cables and supporting structures
AS/NZS 3891.2	Air navigation — Cables and their supporting structures — Marking and safety requirements, Part 2: Low level aviation operations
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 4702	Polymeric cable protection covers
AS/NZS 4792	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 5139:2019	Electrical installations - Safety of battery systems for use with power conversion equipment
AS/NZS 7000	Overhead line design

New South Wales

Electricity (Consumer Safety) Regulation 2015

Designation	Standard Title
AS 4509.1	Stand-alone power systems
AS/NZS 3000:2018	Electrical installations (Wiring Rules)
AS/NZS 3820	Essential safety requirements for electrical equipment

Western Australia

Electricity (Licensing) Regulations 1991

Designation	Standard Title
AS 2067	Substations and high voltage installations exceeding 1kV a.c.
AS 2381.6	Electrical equipment for explosive atmospheres — Selection, installation and maintenance — Increased safety e
AS 2381.7	Electrical equipment for explosive atmospheres — Selection, installation and maintenance — Intrinsic safety i
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 4086.1	Secondary batteries for use with stand-alone power systems — General requirements
AS 4777.1:2016	Grid connection of energy systems via inverters — Installation requirements
AS 4777.2:2020	Grid connection of energy systems via inverters — Inverter requirements
AS 4777.3:2005	Grid connection of energy systems via inverters — Grid protection requirements
AS/NZS 2381.1	Electrical equipment for explosive gas atmospheres — Selection, installation and maintenance — General requirements
AS/NZS 2381.2	Electrical equipment for explosive atmospheres — Selection, installation and maintenance — Flameproof enclosure 'd'
AS/NZS 3001	Electrical installations — Transportable structures and vehicles including their site supplies
AS/NZS 3002	Electrical installations — Shows and carnivals
AS/NZS 3003	Electrical installations — Patient areas

Table continued	
Designation	Standard Title
AS/NZS 3004.1	Electrical installations — Marinas and recreational boats — Marinas
AS/NZS 3004.2	Electrical installations — Marinas and recreational boats — Recreational boats installations
AS/NZS 3008.1.1	Electrical installations — Selection of cables — Cables for alternating voltages up to and including 0.6/1kV — Typical Australian installation conditions
AS/NZS 3010	Electrical installations — Generating sets
AS/NZS 4509.1	Stand-alone power systems — Safety and installation
AS/NZS 5033	Installation of photovoltaic (PV) arrays
AS/NZS 7000	Overhead line design — Detailed procedures
AS/NZS 60079.0	Explosive atmospheres — Equipment — General requirements
AS/NZS 60079.10.1	Explosive atmospheres — Classification of areas — Explosive gas atmospheres (IEC 60079-10-1, Ed. 1.0(2008) MOD)
AS/NZS 60079.14	Explosive atmospheres — Electrical installations design, selection and erection (IEC 60079-14, Ed. 4.0(2007) MOD)
AS/NZS 60079.17	Explosive atmospheres — Electrical installations inspection and maintenance (IEC 60079-17, Ed. 4.0(2007) MOD)
AS/NZS 61241.0	Electrical apparatus for use in the presence of combustible dust — General requirements
AS/NZS 61241.14	Electrical apparatus for use in the presence of combustible dust — Selection and installation (IEC 61241-14, Ed. 1.0(2004) MOD)

South Australia

Electricity (General) Regulations 2012

Designation	Standard Title
NA	NA

Appendix D: Relevant Standards – WHS/OHS Regulations by State/Territory

Victoria

WHS Regulations 2011

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management

Queensland

OHS Regulations 2017

Designation	Standard Title
AS 2030	Gas cylinders
AS 2971	Serially produced pressure vessels
AS 4343	Pressure equipment – Hazard levels
AS/NZS 1200	Pressure equipment
AS/NZS 3509	LP Gas fuel vessels for automotive use

New South Wales

WHS Regulations 2017

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management
AS/NZS 3012	Electrical installations - Construction and demolition sites
AS/NZS 3788	Pressure equipment – In-service inspection
AS/NZS 4801	Occupational health and safety management systems

Western Australia

WHS (General) Regulations 2022

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management
AS/NZS 3012	Electrical installations - Construction and demolition sites
AS/NZS ISO 45001	Occupational health and safety management systems - Requirements with guidance for use
AS/NZS 4801	Occupational health and safety management systems

South Australia

WHS Regulations 2012

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management
AS/NZS 3012	Electrical installations - Construction and demolition sites
AS/NZS 3760	In-service safety inspection and testing of electrical equipment and RCDs

Tasmania

WHS Regulations 2012

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management
AS/NZS 3012	Electrical installations - Construction and demolition sites

ACT

WHS Regulations 2011

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management
AS/NZS 3012	Electrical installations - Construction and demolition sites

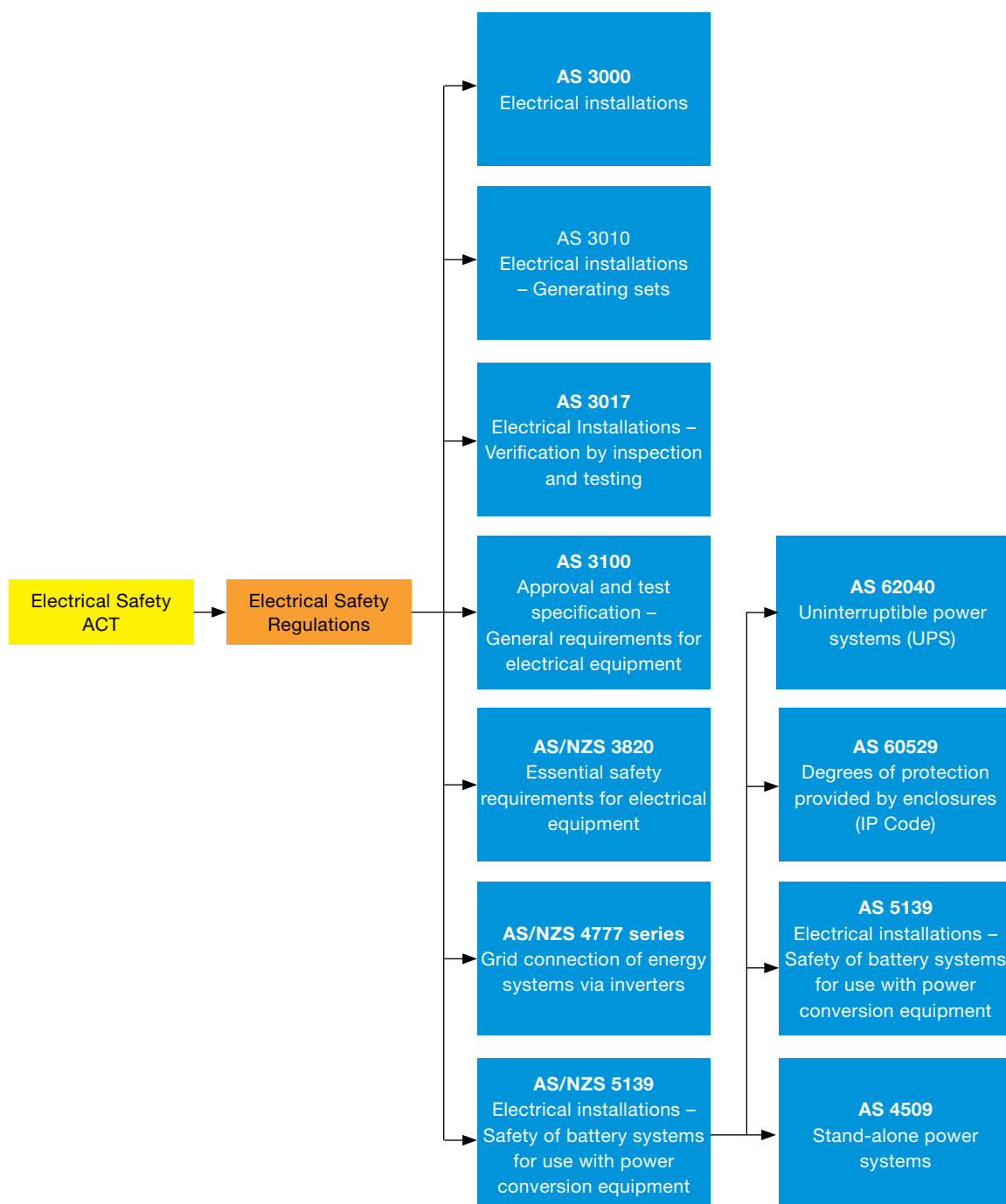
Northern Territory

WHS Regulations 2011

Designation	Standard Title
AS/NZS 1200	Pressure equipment
AS/NZS 1269	Occupational noise management

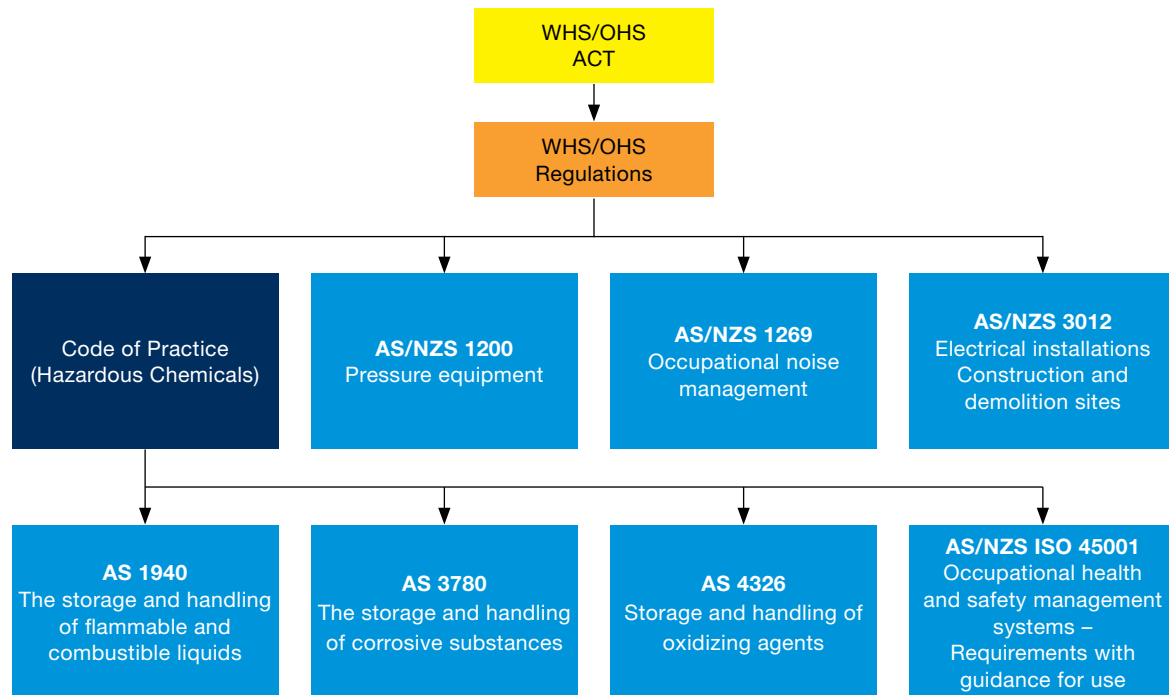
Appendix E: Flow chart for Electrical Regulations

This flow chart highlights commonly referenced standards under state-based WHS/OHS regulations across Australia and is intended for general guidance only.



Appendix F: Flow chart for WHS/OHS Regulations

This flow chart highlights commonly referenced standards under state-based electrical regulations across Australia and is intended for general guidance only.



Appendix G – Optional Compliance Tests - (Informative)

This appendix outlines a set of optional compliance tests and assurance measures that may be considered for FBES. While not mandatory, these tests support enhanced safety, durability, and quality, particularly in complex or high-risk installations. They may also assist manufacturers and asset owners in demonstrating robust engineering practices and mitigating site-specific hazards.

These optional tests are grouped thematically below for ease of reference.

G.1 Electromagnetic Compatibility (EMC)

While power conversion systems must meet applicable EMC standards, the flow battery system—including pumps, sensors, and control electronics—should not generate or be unduly susceptible to electromagnetic interference. EMC testing is recommended, particularly when deploying systems near sensitive equipment or in dense installations.

Tests may include:

- Radiated and conducted emissions
- Radiated and conducted immunity

Applicable standards include:

- CISPR 11, *Industrial, Scientific and Medical Equipment – Radio-Frequency Disturbance Characteristics – Limits and Methods of Measurement*
- CISPR 32, *Electromagnetic Compatibility of Multimedia Equipment – Emission Requirements*, and
- IEC 61000, *Electromagnetic Compatibility (EMC) series*
 - IEC 61000-4-2, *Electrostatic discharge immunity test*
 - IEC 61000-4-3, *Radiated, radio-frequency, electromagnetic field immunity test*
 - IEC 61000-6-x, *Generic standards for residential, commercial, and industrial environments*

G.2 Environmental Resilience

Additional environmental testing may be conducted to validate the system's robustness under adverse or site-specific conditions. Recommended tests include:

- Temperature cycling (e.g., for desert or alpine conditions)
- Humidity and condensation exposure
- Salt mist testing (for coastal or maritime installations)
- Seismic resilience testing (e.g., shake-table simulation)

These tests provide assurance that the system remains safe and functional beyond standard conditions.

G.3 Software Functional Safety

If the BMS is responsible for critical safety functions, software validation aligned with functional safety standards is advised.

Relevant standards may include:

- IEC 61508, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems*
- ISO 26262, *Road Vehicles – Functional Safety*
- EN ISO 13849, *Safety of Machinery – Safety-related Parts of Control Systems*
- UL 1998, *Standard for Software in Programmable Components*

- IEC 62133, *Secondary Cells and Batteries Containing Alkaline or Other Non-acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications*

Tests may simulate sensor failures, communication loss, or boundary condition violations to validate system response and fallback behaviours.

G.4 Warning and Protection Systems

BMS-integrated safety and alarm systems should be verified to confirm correct response under fault or abnormal conditions. These systems may include:

- Low flow or pressure shutdown
- Overtemperature protection
- Leak detection
- Ventilation failure alarms
- Emergency stop validation

Verification should occur during type testing and/or commissioning, supported by documentation of protection setpoints and outcomes.

G.5 Quality Assurance and Factory Acceptance

Manufacturers are encouraged to implement and document a formal quality management system, such as ISO 900, *Quality Management Systems – Requirements*, to ensure consistent manufacturing quality.

Recommended practices:

- Conduct a Factory Acceptance Test (FAT), including verification of workmanship, component conformity, and system configuration.
- Maintain accessible records of service diagnostics, operational anomalies, and customer feedback to inform continuous improvement.
- Implement fleet monitoring programs for early detection of common faults.

G.6 Additional Hazards and Special Risk Testing

Depending on the system design or chemistry, the following additional tests may be applicable:

- Pressure vessel compliance (if using pressurised fluid systems)
- Explosive gas detection systems (e.g., hydrogen or halogen monitoring)
- Flame propagation or enclosure deflagration resistance
- Large-scale fire testing (e.g., adapted UL 9540A, *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* methodology)

Battery manufacturers are encouraged to adopt a proactive approach to managing risks – testing for risks even if not explicitly mandated.

These tests are especially relevant for emerging chemistries or hybrid configurations where specific risks are not yet fully addressed by standardisation.

