Snowy Hydro Limited — renewable energy		
Snowy Technical Standards		
SHL-ELE-156 (J)	***Annexure J - DC Battery Supplies*** ***General Low Voltage Electrical Requirements***	
Subject Matter Expert *Kapila Nanayakkara* *Principal Electrical Engineer*	Version Date: 1 January 2017 Revision: *Original*	

This annexure forms part of the General Low Voltage Electrical Requirements Standard (SHL-ELE-156).

1. Scope

This Annexure sets out minimum requirements for DC supplies. This Annexure is aimed primarily at low voltage DC battery supply installations, however it also addresses general requirements for 48V DC battery supply installations. DC supplies must be designed and constructed conforming to the General Electrical Requirements and this Annexure.

1.1. Applicable Standards

The design, manufacture and testing of equipment and components detailed in this annexure must comply with the requirements of all relevant Australian Standards or in the absence of appropriate Australian Standards, with relevant IEC, ISO or International Standard, together with the requirements of competent authorities having jurisdiction over all or part of the manufacture, installation or operation of the equipment, except where modified by this specification.

All works must comply with the requirements of the most recent releases of the regulations and standards noted in Snowy Standard SHL-ELE-156. In the event of a conflict between different Codes, Standards or Regulations, the highest requirement must apply.

2. Safety Requirements

DC supplies must be designed, manufactured and tested with the safety requirements detailed in the General Electrical Requirements (SHL-ELE-156) Specifications.

3. Technical Requirements

3.1. Batteries

3.1.1. Type

For stationary service in a power plant, each cell of each battery must be of the stationary, lead acid type, suitable for undertaking continuous constant voltage charge and comply with AS 4029. Battery systems must also be of vented type for use in hydro power stations and sealed type for use in gas and diesel power stations.

Batteries that are fully enclosed, maintenance-free, high performance type, assembled in heat resistant high impact polypropylene containers, with a permanent leak-proof seal can be utilised for other installation types, such as communication systems and fire systems.

3.1.2. Operational life

The design of the cells must ensure that the life of the battery when designed for the type of duty required and when maintained in accordance with the manufacturer's recommendations will achieve a minimum of:

- 20 years for flooded batteries used for primarily battery systems in hydro power stations
- 10-15 years for sealed gel batteries in outlying areas
- 10-15 years for sealed batteries in gas and diesel power stations, secondary battery systems in hydro power stations and data centres
- 8-10 years for sealed AGM batteries used communications systems

3.1.3. Design

Arrangement

Low voltage battery systems must be arranged as ungrounded with a high impedance mid-point earth and an appropriate earth fault detection method and meet the requirements of AS 2676.

Extra-low voltage battery systems, will have an earthing arrangement to suit the intended application. Typically within SHL, 48V DC negative-earthed systems are used for communication systems and 48V DC positive-earthed systems are used for some control systems. Where an extra-low voltage battery system is unearthed, it must be provided with appropriate earth fault detection. Extra-low voltage battery systems must meet the requirements of AS 2676.

Due to the use of extra-low voltage battery systems for critical applications, consideration should be given to the provision of paralleling redundant extra-low voltage battery systems through an appropriate bus-tie arrangement. This is primarily used for maintenance purposes.

Each battery bank must be provided with a combined fuse switch. The combined fuse switch must be located as close as practicable to the battery bank to minimise cabling. The combined fuse switch must be provided with an auxiliary contact for position monitoring. Cabling between the combined fuse switch and the battery bank must be single core, double insulated, flexible, clearly identified, rated for the voltage and current of the battery and must comply with the requirements of Annexure D – Low Voltage Cables. Battery cabling must be resilient to sulphuric acid and be protected against mechanical damage. The battery cable conductor must be sized for a maximum disconnection time of one second.

Battery systems must be provided with under- and over-voltage detection. This will be alarmed to SCADA.

Each battery bank must be provided with a means of connecting to a load bank for full discharge testing. The connection point must be located on the load side of the combined fuse switch.

Where an installation can be classified as stand-alone, the requirements of AS 4086 and AS 4509 must be considered.

Typical battery system voltages

The following battery system voltages are commonly found across SHL sites:

- 48V DC Negative-earthed
    - System minimum voltage: 44.4 V DC
    - Float voltage: 54.0V DC
    - Boost voltage: 56.4 V DC
    - Applications: Communication
- 48V DC Positive-earthed
    - System minimum voltage: 44.4 V DC
    - Float voltage: 54.0 V DC

    - Boost voltage: 56.4 V DC
    - Applications: Dam controls, monitoring and protection, outlying areas control systems, measurements and protection
- 125V DC floating
    - System minimum voltage: 111 V DC
    - Float voltage: 135 V DC
    - Boost voltage: 141 V DC
    - Applications: Gas power stations - emergency loads, protection, control systems, circuit breaker trip/close coils
- 220V DC floating
    - System minimum voltage: 199.8 V DC
    - Float voltage: 243 V DC
    - Boost voltage: 253.8 V DC
    - Applications: Gas power stations - emergency loads, protection, control systems, circuit breaker trip/close coils
- 250V DC floating
    - System minimum voltage: 210.9 V DC
    - Float voltage: 256.4V DC
    - Boost voltage: 267.9 V DC
    - Applications: Hydro power stations - emergency loads, protection, control systems, circuit breaker trip/close coils
- 400V or above DC
    - Applications: Emergency lighting UPS, control centre UPS

Any new installation should install low voltage battery systems and use DC power supplies to provide the required extra-low voltages rather than install extra-low voltage battery systems.

Arc flash

The risk of arc flash must be considered with low voltage battery bank installations. The installation must meet the requirements of either Annexure B – Low Voltage Switchboards or Annexure M – Lighting and Power depending on the purpose of the DC supply.

3.1.4. Batteries

The batteries must normally operate on float charge and supply the normal dc load on the loss of mains supply without any interruption.

The batteries must be sized to provide the minimum design capacity based on a nominated discharge rate for a preferred end voltage of 1.85V per cell and an electrolyte temperature of 25°C at end of life and should be sized in accordance with the relevant IEEE standard noted in Table J1.1. The following factors must be considered in the calculation:

- An ageing factor of 25%
- A design margin of 15%
- Temperature correction as per Table 1 from IEEE 485-2010
- Maximum depth of discharge to be greater than the minimum system voltage

Typically the batteries will be sized to provide a design capacity for full load current based on a 10 hours discharge rate for hydro power stations and a minimum 4 hours discharge rate for gas and diesel power station. A four hours discharge rate will be used to size all other applications, unless otherwise specified (i.e.it may increase due to the remoteness of an installation).

The float charge voltage must automatically compensate for battery (cell) temperature.

The maximum and minimum cell voltages must be chosen to meet charge equalisation and end of load cycle discharge voltage, respectively, without damage.

Battery terminal posts must be equipped with connector bolts having corrosive resistant nuts. All exposed battery terminals must be provided with insulated coverings or shrouds.

3.1.5. Battery Stands

A battery stand for each cell must be constructed of steel and coated with an electrolyte resistant paint and comply with AS 2676, and where local seismic activity requires it, AS 1170.4.

Battery stands must be constructed so that a failed cell can be replaced without having to dismantle a complete battery.

Support legs for the stands must be located at points where cells are connected and cell retaining bars are removable.

Battery cell bases must be isolated from the steelwork using a layer of insulating material.

Each battery stand must incorporate a removable drip tray constructed of a non-conductive material of sufficient size to collect the volume of the electrolyte of one cell plus 25%.

The battery stands of a single row of cells must be bolted to the wall where convenient.

All battery stands must be fitted with side rails to contain the cells if there is vibration or an earth tremor.

The battery stands must be fitted with adjustable insulated feet to ensure that the stands are level. Consideration should be given to providing damping pads under the insulated feet to minimise vibrations where battery rooms are located near active plant.

All battery stands must be bolted to the floor and braced as required to meet AS 1170.4.

3.1.6. Labelling

Each cell must be durably constructed and clearly marked with:

- the make
- type
- date of manufacture
- maximum and minimum electrolyte levels
- Nominal rating of battery to 1.85V per cell
- Each cell must be identified with a cell number starting with number 1 at the positive end

3.1.7. Battery Room Safety signs at the designated entrance to the battery room.

- A notice identifying the room as being a battery room
- unauthorized entry to the battery room is prohibited
- no-smoking prohibitive sign (Ref AS 2676)
- Electrolyte burning sign (Ref AS 2676)
- open flames are prohibited inside the battery room

- corrosive substance warning sign

A notice indicating the location the emergency shower/Eye wash facility next to the emergency shower

3.1.8. Condition monitoring

Low voltage battery systems must be fitted with continuous individual cell monitoring equipment to cause an alarm in the event of individual cell failure or deterioration and be able to provide a day by day record of the condition of each cell.

Battery cell monitoring must provide:

- cell and battery status;
- cell voltage on and off load;
- float voltage;
- battery current;
- cell ohmic values and history;
- inter-cell resistances;
- battery temperatures;
- individual cell history trends

The cell monitoring system must be capable of interfacing to a local PLC via communications.   The cell monitoring system must also be capable interfacing of selected data and alarms to the Snowy Hydro corporate LAN.

Spare cell/s must be connected to the cell monitoring system.

3.1.9. Remote monitoring and alarming

An example of the alarms to be provided is outlined below:

Table J2.2 SCADA signals

	Signal	Source	Type
1	Battery room temperature high	sensor	Alarm
2	Battery room fan failure	sensor	Alarm
3	Battery room fan running	contactor	Status indication
4	Battery Room Air Flow Low	Flap Switch	Alarm
5	Battery Room supply air fan failure	overload	Alarm
6	Battery Room supply air fan running	contactor	Status indication
7	Cell monitoring signals and alarms	Cell monitoring system	Alarms and trends
8	Cell monitoring system Fault	Cell monitoring system	Alarms and trends
9	Battery Bank A any cell Fault (i.e. low voltage, overvoltage)	Cell monitoring system	Alarms and trends
10	Battery Bank B any cell Fault (i.e. low voltage, overvoltage)	Cell monitoring system	Alarms and trends
11	Spare battery any cell Fault (i.e. low voltage,	Cell monitoring system	Alarms and trends

	overvoltage)		
12	Spare battery charger Fault	Spare charger	Alarm

3.2. Battery charger

Battery chargers must be:

- capable of providing the charge rate required;
- where possible, installed in a location that is external to the battery room.
- alarmed into Snowy Hydro's SCADA system

3.2.1. Type

Rectifiers must be of the constant voltage, current limited type, suitable for automatic boost charging and float charging of the battery.

Rectifiers must comply with the requirements of AS 60146 and IEC 61204.

3.2.2. Performance Requirements

Disturbances to the AC power supply system due to harmonics caused by the rectifier must be limited in accordance with AS 61000. Under float conditions the battery ripple current must be less than 1% of the C10 battery current rating.

Load step stabilisation must be provided to comply with IEC 61204.

The rectifier unit must be equipped with both ac and dc surge suppression networks in accordance with the following:

- The peak output of the combined ripple noise and hum must not exceed 2 percent of the float voltage, for an output current range of 0-100 percent, into a resistive load in accordance with IEC 61204.
- The peak value of the combined ripple noise and hum content in the dc output must not exceed 1 percent of the rated output voltage for a rectifier output current range of 0 to 100 percent. This value must be measured with a battery connected.
- At full load output power the supply input current must not exceed 10% THDi.
- The peak voltage of any output transient must not exceed 10 percent of the rated float voltage, with the battery bank connected.

The float charge voltage of the rectifier must maintain the battery bank at 100 percent capacity without requiring periodic refresher charging and must be automatically maintained with ±1 percent of the rated float voltage over the dc load current range of 0-100 percent and with the power supply parameters specified.

The battery charger must equalise the batteries when required. They must also be capable of recharging their respective batteries in 12 hours at the end of the battery discharge load cycle while supplying the normal load of their respective batteries.

3.2.3. Charger testing functionality

It is preferable that the charger incorporates a microprocessor to enable the battery to be tested for one minute at periodic intervals.

Where provided, the test functionality must monitor that the battery and the connecting cables are in good condition. Before starting the test the power supply must be checked that no discharge has occurred in the previous 24 hours. The battery test must be performed without any risk to the load, even with the battery disconnected or defective. This method of testing must not cause any degradation in terms of expected life of the battery system. A detected battery fault must be alarmed. The charger must use sophisticated algorithms to determine the battery life remaining based on real operating conditions such as temperature, discharge and charging cycles, and discharge depth.

3.3. Installation requirements

Low voltage battery systems are to be installed purpose-built rooms that meet the requirements of AS 2676 and AS 3011. Extra-low voltage battery systems may be installed in cubicles.

Where fans are installed to provide forced ventilation to the battery rooms, the fans must be provided with low flow detection. Red LED strobe lights must be installed outside the battery room that illuminate in failure scenarios. This indication must determine that current flow to the fan motor has ceased or that air extraction has ceased to flow.

Fan motors must be designed for continuous running and operation in a battery room environment. Fan controls must be mounted outside the battery room and must have an indication to show whether the fan is running or not.

Doors into rooms or buildings containing lead-acid battery systems must be provided with approved signs. The signs must state that the room contains lead-acid battery systems that the battery room contains energised electrical circuits and the battery electrolyte solutions are corrosive liquids. Safety signs must take the form depicted in Australian Standard AS 2676 Figure J1.

DC low voltage switchboards must be located externally or appropriately segregated from the battery room.

3.4. Type testing

Battery systems must be supplied with type test certification. The type test certification must detail the successful completion of the type tests recommended in AS 4029.

3.5. Acceptance testings

Where specified, battery systems will undergo factory acceptance testing prior to shipment to site. At a minimum, the acceptance testing must comprise of battery capacity testing as outlined in AS 4029.

3.6. Commissioning requirements

The following performance tests and measurements are required on battery systems:

- Ductor testing of battery terminal connections. All battery terminal connections must be ductor tested and the resistance must be less than 20μΩ at 10A at ambient temperature.
- Measurement of initial cell impedance values at float charge condition.
- Measurement initial inter-cell connection resistance values. This must be measured as voltage drop across the cell terminals between adjacent cells referred to a specific current.
- Measurement of individual cell electrolyte density (corrected to the temperature)
- Measurement of the float voltage of each cell with the charger connected.
- Battery capacity testing. The battery must be fully discharged into a dummy load at a constant current to confirm its capacity. The results of the battery capacity testing must include individual cell voltages, the time taken to reach 1.85 V per cell and ambient temperature. Individual cell discharge curves must match the manufacturers expected results. Cell voltage should be within 0.3 V per 12V block during

discharge.

- Measurement of battery charger ripple current and ripple voltage at float charge condition.
- Measurement of battery floating current.
- Stability checks. The output voltage and ripple voltages must remain within the specified limits with any combination of the input voltage, frequency and load variations. Several scenarios must be demonstrated during commissioning of the battery systems.
- Functional alarm and indication functions of the charger, both to local systems and to the Snowy Hydro control room.

3.7. Disposal of battery systems

Batteries are classified as hazardous waste and must be disposed of in accordance with the relevant state environmental protection act and regulations. Care should be taken to ensure that the appropriate permit or licenses are obtained for the disposal of redundant batteries, and that redundant batteries are appropriately package prior to removal from site. Disposal certificates must be provided to document the correct disposal of the batteries.