snowy hydro Limited renewable energy	
Snowy Technical Standards	
SHL-ELE-156 (K)	***Annexure K - Low Voltage Earthing General Low Voltage Electrical Requirements***
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This annexure forms part of the General Low Voltage Electrical Requirements Standard (SHL-ELE-156).

1. Scope

This Annexure sets out the requirements for Low Voltage and Extra-Low Voltage earthing in Low Voltage, High Voltage and Extra High Voltage installations. The requirements for earthing of High Voltage and Extra High Voltage are not detailed in this Annexure.

Earthing 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

An effective earthing system must be provided for all electrical equipment, in accordance with the Statutory Regulations, ENA EG1 and AS 3000. The earthing system is required to:

- Provide protection of personnel from electrical shock
- Protect equipment by providing a low impedance path for lightning, switching surges and fault currents
- Provide a low-impedance leakage path for any static charge that might accumulate on equipment
- Ensure proper operation of protection relays and surge arresters
- Minimise noise interference in instrumentation and control circuits

3. Technical Requirements

3.1. High Voltage and Extra-High Voltage Installations

High Voltage and Extra High Voltage installations are provided with a facility earthing grid typically comprising of buried copper earth grid around the facility foundations supplemented, as necessary, by driven earth stakes.

All metallic structural work must be bonded to the earthing grid. As a minimum, skids must be bonded to the

main rid at two diagonally opposite ends.

All gas / hazardous pipes must be bonded to earth. All “Ex” classification equipment frames must be bonded to earth (this is in addition to internal earths for the supply or signal cables).

All metallic pipes, communication circuits or conductor which leave the facility must be effectively, isolated from the facility earthing system at the facility boundary to prevent the transfer of the earthing system voltage under fault conditions to a remote point. The use of optic fibre cabling for communication circuits is the preferred method to manage transfer voltage hazards. The requirements of AS 4853 must be considered for metallic pipelines.

To manage galvanic corrosion, where stranded copper earth conductors are connected to steel or aluminium structures using tinned copper lugs and bolted joints.

3.2. Local earthing systems

In areas remote from the facility earthing grid where the structures are completely separated by an area of land, a local earthing system must be provided. For low voltage systems a local MEN link must be provided within the local main switchboard. All sub-switchboards and adjacent metallic structural work must be bonded to the local earthing system. The total earth resistance of the local earthing system must meet the requirement of earth fault-loop impedance specified in AS 3000.

The effectiveness of the local earthing grid must be verified grid by means of primary current injection.

3.3. Earthing system components

3.3.1. Conductor

All earthing and bonding conductors must be copper conductor. Aluminium or steel, including galvanised steel, may only be used as an earthing conductor where galvanic erosion is a concern and only by approval by SHL..

Surface earthing conductors must be stranded copper conductor, PVC insulated to prevent contact with excessive touch potential during an earth fault.

Buried earthing conductors must be bare copper and must be located at a minimum depth of 500mm below ground.

3.3.2. Minimum sizes

Earthing conductors must be sized in accordance with ENA EG1 and AS 3000 and must utilise the fault current rating of the largest supply. If the equipment is located in the vicinity of exposed High Voltage conductors, the maximum fault current will be the High Voltage primary system fault level.

The minimum size of the earthing conductor must be:

- High Voltage enclosures: 25 x 3 mm copper bar or a 70 mm2 conductor
- All other locations: 25 mm2 conductor

3.3.3. Colour coding

Earthing conductor insulation must be coloured green/yellow.

3.3.4. Mechanical protection

All earthing conductors must be installed in accordance with ENA EG1 and AS 3000. All earthing conductors must be installed in a manner that provide adequate protection against likely mechanical damage, inadvertent inferences and chemical deterioration. Earthing conductors must be protected from corrosion, including the effects of moisture or contact with dissimilar metals.

Earthing conductors must be mechanically protected and supported for their entire run length. Mechanical protection may be but is not limited to cable ladders and conduits. The minimum cable bending radii must be as recommended by the cable manufacturer.

3.3.5. Earth electrode

Earth electrodes must be 15mm diameter, 3m long, copper sheathed steel rods driven to the ground.

Earth electrodes must be installed complete with pit and cover. A pit must be provided around the top 250mm of the earth electrode. A lid must be provided for the pit.

In the event the ground is rocky, 40 mm diameter holes must be drilled to a depth of 6 m. After drilling of the holes, they must be filled with a mixture of 50% gypsum and 50% Bentonite by volume, to which must be added 1% by volume washing soda. The mixture must be thoroughly mixed, formed into a slurry and poured into the earth electrode holes. The earth electrode must then be lowered into a hole. It must be ensured that the connection between the earth cable and the earth electrode is accessible above the level of the Bentonite mixture. The earth electrode resistance must be measured to verify that it provides a sufficiently low impedance path.

The connection between the main earthing conductor and the earth electrode must be via an approved copper compression earth clamp, i.e. a ‘Figure 6’ ground tap connector.

3.3.6. Earthing connections

All exposed earth joints and connections must be made using approved bolted earth connectors and lugs or bolted earth clamps. Exposed bolted connection must be protected from corrosion by covering with approved sleeving or tape. Serrated lock washers are not to be used due to increased risk of corrosion. Spring lock washers with plain washers may be used when connecting cable lugs to structures

All underground earth connections must be made by copper compression “C” clamp. Clamp to be a Burndy copper C-tap style clamp or an approved equivalent. The connection must be tested to the appropriate fault levels.

3.4. Electrical equipment earthing

All electrical components, devices and apparatus having a metallic enclosure or framework which may become directly connected to electricity supply following breakdown of insulation, must be provided with means of attaching earthing conductors. Note that hold-down bolts are not suitable for ground connections.

3.4.1. Motors and other auxiliary low voltage equipment earthing

Typically motors and other auxiliary low voltage equipment (i.e. low voltage instrumentation) will be grounded via the earthing conductor in the supply cable to the switchboard earth bar, with the frame of the device grounded locally to the facility earthing grid.

In some installations, particularly the underground hydro stations, large circulating currents can flow in the

earthing conductor in the supply cable. In these instances the motors and other auxiliary low voltage equipment must only be grounded locally to the facility earthing grid. The earth conductor in the supply cable must be cut back the cable outer sheath and insulated with heat shrink. The earth conductor in the supply cable must still be grounded to the switchboard earth bar.

Where copper-tapped screen cabling is used supply motors or other auxiliary low voltage equipment due to harmonic currents, the cable screen must insulated from earth throughout its entire length except for a single earth point. Unless specified otherwise, the earth point must be at the supply end.

The field end of the wiring must be isolated from earth. To achieve this any exposed screen and drain wire must be removed and finished with heat shrink.

On the supply end, the sheaths of cables must be bared back to within 25 mm of a cable gland or 50 mm of a unistrut cable cleat. Overall cable screens must either have a 2.5 mm2 earth wire (green/yellow insulation) wrapped a minimum of three times over 25 mm of exposed screen and soft soldered or utilise an approved cable clamp. This part of the cable must be finished off with a small piece of heat shrink. Where the overall cable screen is grounded via an earth wire, the earth wire must be labelled with the name of the cable

3.4.2. Cubicle and junction box earthing

Earthing of electrical switchboard, cabinets and junction boxes must be bonded to earth irrespective of the voltage levels. Earth connections must be by electrical bonding conductors only and not via bolting.

For assemblies containing several such components or devices, a copper earth bar must be provided within the assembly to which all devices and enclosures must be individually earthed. This earth bar must also be drilled to accommodate connection back to the facility earthing grid.

Where electrical equipment is mounted on hinged doors or panels, additional means of earthing must be connected across the hinge points.

All steelwork, including all hinged panels and doors, must be earth with separate earth conductor using bolted connections. Paint must be removed from around the connections to ensure a low resistance connection. The surface must be re-painted to ensure adequate surface protection.

Welded studs must be installed within enclosures for earthing connections. Studs must be provided on doors, panels, gland plates and other fixed metal work.

3.4.3. Cable support systems and conduit earthing

Cable ladder sections must be bolted together to provide electrical continuity. Unless a larger cable is specified a 35mm^2 earth cable must be provided in each cable ladder or group of cable ladders. This earthing cable must be bonded to each bolted cable ladder section including, but not limited to, bends, tees and crosses, using approved cable ladder earth clamps.

Care must be taken in some installations, particularly the underground hydro stations, to ensure that cable support systems are only earthed at one point to prevent large circulating currents from forming. Where required, segments of cable support systems may need to be insulated from each other.

Cable metallic trefoil clamps must be solidly connected to earth.

Continuous metallic conduit systems must be earthed at one end only.

3.4.4. Instrument transformers

Conductive instrument transformer cases must be grounded with conductors meeting the maximum local fault levels. There should be only one grounding point on any instrument transformer secondary circuit at a termination point near the relay room cable entrance. Here the size of ground conductor should be the same as the circuit conductors but under no circumstances less than 10 mm²

Where copper-tapped screen cabling is used for instrument transformers, the cable screen must insulated from earth throughout its entire length except for a single earth point. Unless specified otherwise, the earth point must be at the control system/protection/AVR end.

The instrument transformer end of the wiring must be isolated from earth. To achieve this any exposed screen and drain wire must be removed and finished with heat shrink.

On the control system/protection/AVR end, the sheaths of cables must be bared back to within 25 mm of a cable gland or 50 mm of a unistrut cable cleat. Overall cable screens must either have a 2.5 mm2 earth wire (green/yellow insulation) wrapped a minimum of three times over 25 mm of exposed screen and soft soldered or utilise an approved cable clamp. This part of the cable must be finished off with a small piece of heat shrink. Where the overall cable screen is grounded via an earth wire, the earth wire must be labelled with the name of the cable

3.4.5. Permanent standby generators

The frame of permanent standby generators must be connected to the facility earthing grid by two grounding conductors for redundancy.

The generator neutral connection must be as Annexure B – Low Voltage Switchboards.

3.4.6. Portable standby generators

A “Portable Generator” is an electrical generating set which can be moved from place to place by one or more persons, by mechanical means, or by means of its own wheels, tracks or skids. Circuit voltage of portable generators does not exceed 500V.

When a single phase generator supplies portable equipment directly via a socket outlet:

- A generator of isolated winding type can be used to supply double-insulated equipment only.
- A generator fitted with an integral residual current device (RCD Protected) can be used to supply single insulated or double insulated equipment.

A two or three phase generator must have RCD protected socket outlets.

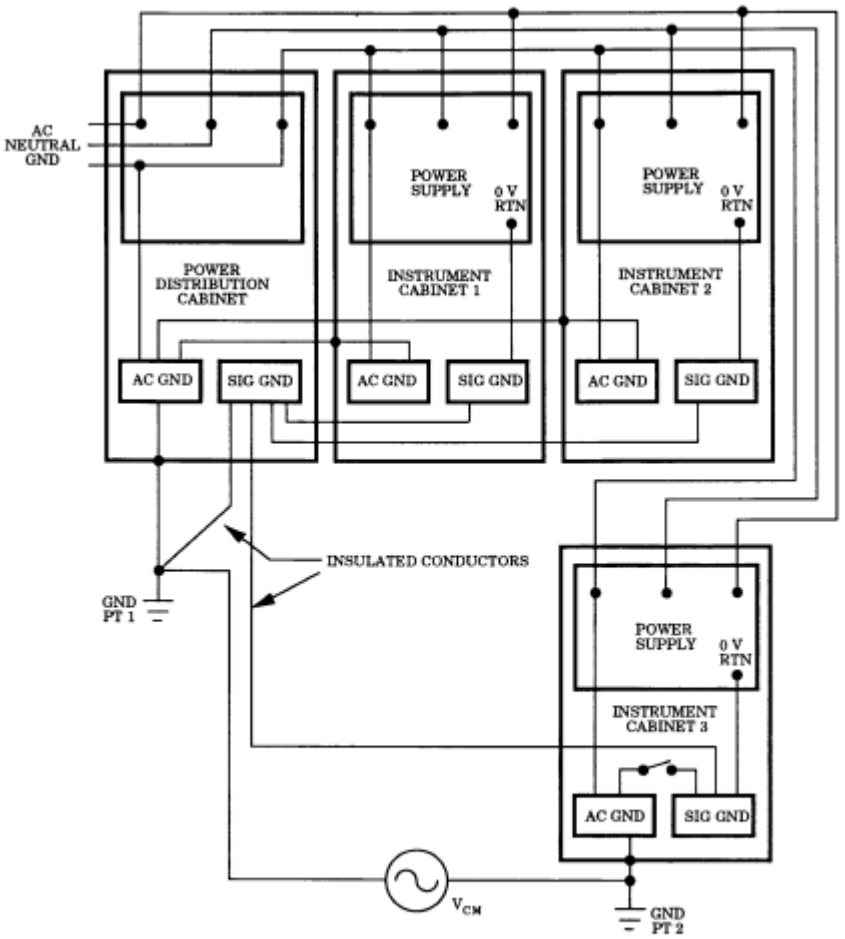
When a portable generator is connected to a switchboard, the frame of the generator is earthed by connecting an earthing conductor to the earth bar of the installation. Note: only isolated winding type generators or generators with a removable link between neutral and frame (floating neutral) can be used for this application.

Where the portable generator is not earthed, either via an earth stake or to the earth bar of an installation it is recommended that the RCD protection is augmented with an additional voltage sensing device that detects a rise of voltage level to earth.

3.5. Instrument and control system earthing

An instrument and control system earth bar must be provided separate to the Low Voltage supply earth bar (typically the main switchboard earth bar). The instrument and control system earth bar must be connected to

the main switchboard earth bar at one point. All instruments and components of the control system excluding low voltage power supplies must be grounded to the instrument and control system earth bar. Refer to below for further details.



NOTE: For safety reasons a door switch may be used on the remote cabinet to tie the signal and local equipment grounds together when the door is opened. This protects maintenance personnel while troubleshooting the equipment at the remote site. Thus, the risk to personnel is eliminated when the door is opened at the price of damaging the transmitter/receiver circuits if a ground imbalance due to large currents in the ground grid happens at the same time as maintenance is scheduled for the remote site.

Figure K.1 Distributed I&C grounding arrangement (reference Figure 27, IEEE 1050)

Instrument circuits must insulated from earth throughout their entire length except for a single earth point. Unless specified otherwise, the earth point must be at the control system/switchboard end. Screen drain wires and spare cores must also be earthed at the same point.

The field end wiring must be isolated from earth. To achieve this any exposed shield and drain wire must be removed and finished with heat shrink.

On the control system/switchboard end, the sheaths of cables must be bared back to within 25 mm of a cable gland or 50 mm of a unistrut cable cleat. Overall cable screens must either have a 2.5 mm2 earth wire (green/yellow insulation) wrapped a minimum of three times over 25 mm of exposed screen and soft soldered or utilise an approved cable clamp. This part of the cable must be finished off with a small piece of heat shrink. Where the overall cable screen is grounded via an earth wire, the earth wire must be labelled with the name of the cable. Individual twisted pair screens are to be terminated to a grounding terminal block. The din rail

the grounding terminal blocks are installed on must be grounded to the instrument and control earth bar.

There are some scenarios where the instrument sensing element is earthed. This arrangement is not preferred, however in this scenario, the screen must be terminated at the field end. Instruments with an earthed sensing element must be run in separate cables to instruments with floating sensing elements. Instrument cables earthed at the field end must be provided with a label at the control system/switchboard end stating where the cable screen is earthed. Cable schedules or drawings must also detail where field termination of cable screens have occurred.

3.6. Earth bonding

All metallic parts of the plant not intended to be alive, including fencing and gates, must be bonded to create a substantially uniform earth potential.

The following items of equipment must be connected solidly to the earth system:

- cable bridges;
- pipe rack frames;
- steelwork of bridges;
- hazardous area equipotential bonding;
- Metallic grating and stairs;
- Hand rails;
- other items as indicated by AS 3000.

A minimum copper earth conductor size of 3 x 25mm2 strap or 120mm2 cable must be utilised for bonding the above items to the earth system to ensure sufficient mechanical strength and corrosion resistance.

3.7. Lightning protection

Lightning protection must be supplied and installed in accordance with requirements of AS 1768.

As a minimum this must include:

- Air terminal network at the highest point on the structure
- Down conductor for the lightning arrester
- Earth electrodes and dissipation pits
- Earth wire for equipotential bonding to the earth grid

The base of steel columns around the perimeter of a building must be connected to a perimeter ground grid by 95 mm² bonds for mechanical strength and corrosion resistance. Metallic objects such as door frames should be bonded when within 2 m of other grounded objects in order to maintain small hand to hand touch potentials. Here the minimum conductor size is 16 mm².

All piping tanks, heat exchangers or any vessel in a system in which liquids or gases are stored or transported should also be bonded.