snowy hydro Limited renewable energy	
Snowy Technical Standards	
SHL-ELE-156 (F)	***Annexure F - Low Voltage Motors 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 motors.

Low voltage motors must be designed and constructed conforming to the General Electrical Requirements and this Annexure.

AC motors must be of the three phase, squirrel cage, induction type suitable for direct-on-line starting at full voltage or suitable for VVVF drives where applicable.

DC motors must be compound-wound type, preferably cumulative, suitable for direct-on-line starting at full voltage / full current or via an appropriately designed full voltage / controlled current starting method i.e. switched starting resistors.

The rated motor output must not be less than the maximum load which will be demanded by the driven equipment.

Motors to be connected to 415V (3-phase) supplies must be limited to the range of ratings from 0.37 kW to 250kW. Motors less than 0.37 kW may be single phase.

Unless otherwise specified, motors must be 4 pole. Rated speed must not exceed 1500 rpm.

Motor protection philosophy varies throughout the SHL scheme. Refer to the respective SHL functional specification for motor protection requirements for the installation location/environment. These functional specifications will specify the following:

- Motor protection
- Signal interfacing
- Setting definition scheme
- Hardware selection

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

Low voltage motors must be designed, manufactured and tested in accordance with the safety requirements detailed in the General Electrical Requirements Specification (SHL-ELE-156).

3. Technical Requirements

3.1. Motor Characteristics

Motor sizes and ratings must take into account transient conditions, including starting, braking, reversing, load and speed variations, load torque requirements, and motor speed - torque characteristics.

Motors must be rated at not less than 110% of their specified driven load, or as otherwise specified. They must be suitable for the starting method specified.

Locked rotor current must not exceed 700% full load current.

3.1.1. Frame

Motor frame sizes must be in accordance with AS 60034.

3.1.2. Enclosure

General

All motors must be totally enclosed, fan cooled (TEFC), protected to not less than IP56 in accordance with AS 60034. Consideration shall be given to increasing this rating for extreme dust/wet environments. Motor frame and end shield must be cast iron construction. End shields must be fixed individually with non-corrodible machine screws or bolts. All joints must be fitted with approved O-rings. Sufficient and adequate porous type drain plugs must be fitted at either end of the motor, to suit the shaft orientation.

Where motors are required to operate in direct sunlight suitable sunshields must be provided. These shields may be deleted on submission of supporting evidence that the required output power can be delivered at all times without overheating.

Painting

The enclosure colour must match the process in accordance with Annexure N – Paint and Corrosion or as otherwise specified.

Hazardous area requirements

Where possible, motors must be located outside of hazardous areas. It is preferable to use a driveshaft arrangement than to locate motors in hazardous areas.

Where motors are required to be installed in hazardous areas, the enclosure must meet the requirements of AS 60079.1 for flameproof enclosures for the zone category.

3.1.3. Lifting points

All motors must be fitted with suitable lifting eye bolts, or other approved means, for lifting the motor. The lifting facility must be capable of lifting not less than twice the motor weight (i.e. factor of safety not less than two).

3.1.4. Service factor

Motors must have a minimum service factor (s.f.) of 1.1 or higher as required for special applications.

3.1.5. Efficiency

All motors, other than those requiring high starting torque, must be of the high efficiency type. Motor efficiency calculations must be performed in accordance with AS 1359.102 or an equivalent standard. Efficiencies and performance data must be for bi-directional rotation. Type test certificates for motor efficiencies must be provided.

3.1.6. Temperature rise

The drives must provide high levels of operating reliability and life under high ambient temperature conditions. The motor winding temperature rise measured in accordance with AS 60034, for continuous running at full load must not exceed 80°C rise over 40°C ambient temperature at 1.1 service factor. The temperature rise must not exceed Class F insulation at 1.15 service factor. The supply voltage variation and voltage drop along cables must be taken into account.

3.1.7. Torque

Torque characteristics of motors must be dependent on the specific application for the motor. The starting and breakdown torque must be as per AS 60034.

The motor torque classification must be stamped on the motor nameplate.

3.1.8. Mounting

Motors must be mounted to suit the mechanical drive (i.e. pump, fan), it is preferred that motors be horizontal foot mounted where possible. The terminal box must be located to be readily accessible.

3.1.9. Motor rotation

Motors must have bi-directional rotation, without adjustment of fans.

3.1.10. Rating plate

A rating plate in accordance with AS 1359 must be provided on each motor. All motors above 100kW must have the weight of the motor and bearing details included on the rating plate.

3.2. Service Requirements

Motors must operate at all loads with the least practicable amount of noise and without undue vibration as specified under the relevant headings below.

Motors must be able to operate continuously at rated power output without overheating at ±10% of the nominal switchboard voltage and not less than five minutes at a voltage of 25% below rated voltage and rated frequency, after having been operated at full load for not less than two hours prior to the reduction to this voltage.

The motors must be designed so that start-up can be performed at 20% of the rated voltage of the motor. Motors must also be capable of maintaining rated output at any frequency between 48 Hz and 52 Hz.

Motor starting current must be no more than 7 times rated full load current.

Each motor must be capable of performing the following minimum starting duty without exceeding the rated temperature of the materials used whilst being connected to its associated equipment in the maximum load condition and with an initial motor temperature of 40°C.

- Two consecutive starts, supply being disconnected from the motor as soon as normal operating speed is reached on the first start and the second start being made as soon as the motor and load have come to rest.
- Three starts at 20 minute intervals, supply being disconnected from the motor as soon as normal operating speed is reached.

3.2.1. Specific requirements for Hydro Stations

Motors must be able to operate continuously at rated power output without overheating at +10%, -15% of the nominal switchboard voltage and between 47 Hz and 53 Hz.

3.3. Variable frequency drive

3.3.1. General

Variable Speed Drives (VSD's) must be three phase, full wave, minimum six pulse, Pulse Width Modulated (PWM) Variable Voltage Variable Frequency (VVVF) converters and must be matched to 3 phase squirrel cage induction motors preferably from the same manufacturer and suitable for use at variable speeds.

Each motor and its VSD must be suitably matched to the load's torque, speed and inertia characteristics as well as the environmental conditions in which they are located.

Earthing must be in accordance with AS 3000 and Annexure K – Low Voltage Earthing.

3.3.2. Performance

The drive must be stable throughout the entire speed range and, unless otherwise required by the process, have a worst case speed control accuracy of +/-2.0% of rated speed under any combination of the following conditions:

- Load change +/- 10% for loads between 25% and 100% of rated load
- Temperature change +/- 10°C at 45°C ambient
- Frequency change +/- 2% of 50 Hz
- AC line voltage change +/- 15% of nominal

Power disturbances causing a voltage dip of 25% for 2 seconds must not cause the drive to shut down, nor damage components.

3.3.3. Power supplies

Surge suppression must be provided on the incoming power supplies to the variable frequency drive equipment. The converter must be able to withstand a 2.5 kV 1.5/50 microsecond surge applied 3 consecutive times to the nominal switchboard votlage.

The control circuit supply must be obtained from the main power supply. Any step down or isolation transformer and rectifiers / regulators etc, if required, must be included in the drive.

3.3.4. Harmonic distortion

The harmonic distortion and electromagnetic interference must not exceed the limits specified in AS 61000.3

series and AS/NZS CISPR 14.1 respectively.

3.3.5. Radio Frequency Interference

The static frequency converter must be expected to function in close proximity to hand held 27 to 460 MHz VHF transceivers which must not affect its operation. The converter must meet the requirements of the AS/NZS CISPR 11 and must include integrated radio frequency suppression according to the requirements of AS/NZS CISPR 11, Group 1 Class A and must carry the C tick logo as proof and traceability of this claim.

3.3.6. Main speed reference

Control of the output frequency must be either by manual speed controls mounted on the front of the cubicles, or by remote signals. Selection of the mode of control must be by a selector switch on the front panel of the cubicle.

The maximum and minimum frequencies obtained from the converter must be capable of being set within the specified limits by internal adjustments.

The remote speed reference signal can be either an analogue control signal of via a communication interface.

3.3.7. External interface

All external interlocking and/or digital control signals must be either through volt-free dry contacts or at 24 V DC. Interposing relays, if required, to adapt to an external interface, must be included.

The following signals must be provided as a minimum for:

- “Run” input to the drive
- “Run confirm” output from the drive
- “Fault” output from the drive
- “Ready to run” output from the drive - this indicates that all internal and external interlocks are closed
- “Main AC power supply” available from the drive

3.3.8. AC drive interface with motor

For consideration of long term reliability on larger drives over-voltage stress should be minimised by limiting the rate of change of voltage to 500 volts/micro second. Also steps must be taken to prevent motor bearing damage due to Electro Discharge Machining.

3.3.9. Communications connection

The drive must be provided with a suitable communication interface to enable remote control and monitoring of the VSD from HMIs and engineering workstations.

3.3.10. Protection and alarms

Each VSD must contain all protection requirements for the motor and for the VSD itself and a fused contactor or circuit breaker for the supply and isolation of the motor.

VSDs must be provided with, as a minimum, adjustable current limit and alarms for

- overcurrent,
- overvoltage,
- undervoltage,

- overtemperature,
- earth fault,
- overload,
- motor trip,
- inverter fault.
- Ventilation failure

3.3.11. Interlocks

Starting interlocks must be provided such that a motor can be started from stationary condition only when its VSD is set to the minimum motor speed. Each VSD must automatically return to the minimum speed setting when the motor is stopped.

3.3.12. Instruments and indication

All indicating instruments must comply with IEC 60051, Class 2.5, and must be flush mounting or alternatively, digital indicators may be supplied. Remote indication must also be supplied on the appropriate HMI.

The following meters are required for the converter:

- Converter output current
- Converter output voltage
- Converter output frequency, or speed indicator

3.3.13. In-built monitoring and fault finding

A system is required to permit rapid identification of interlocks or trips, which may stop the drive or prevent it from starting. It should enable, without detailed knowledge of the drive, identification of a fault condition without reference to diagrams and use of multimeters, etc. The system must be an in-built or supplementary test module. It must be permissible to connect the test equipment at any time during running without disturbance to the drive output.

3.3.14. Switchgear and controlgear assembly

Enclosures must meet the applicable requirements of General Electrical Engineering Specification, Annexure C - Electrical Cubicles and Junction Boxes, and Annexure B - Low Voltage Switchboards. Each VSD and associated equipment must be mounted in its own Switchgear and Controlgear Assembly. If a VSD is included as part of a motor control centre, it must be housed in a dedicated cabinet without other control components. Cooling air must be ducted outside the panel and not via cabinets containing electrical equipment.

3.4. DC starting resistors

Where starting resistors are required for the starting of DC motors, starting resistors should either be grid or ribbon type with an appropriate number of steps to suit the starting application. The resistor must be rated to an appropriate NEMA resistor class and must be able to accommodate 150% of the full load current when starting from rest as well as 100% of continuous duty current to allow for failures of the starting resistor switching mechanisms.

The DC starting resistor must be located in a separate enclosure to the motor control circuitry. The enclosure must be suitability ventilated, and must ensure that the enclosure temperature does not exceed 60°C with the resistor continuously in service. Cables entering the DC starting resistor enclosure must have a suitable temperature rating or be provided with heat resistant cable sleeving.

3.5. Safe-guarding

All motors must be safe guarded in accordance with AS 4024.

3.6. Control and isolation

3.6.1. Local isolation requirements

Where specified, motors must be fitted with either a lockable local isolator or a de-contactor. The isolator must be of the full-load current break type, fitted with early break and late make auxiliary contacts. Auxiliary contacts must be provided for remote monitoring of the isolator position. Thermistors on motors with de-contactors must be connected via plug and socket.

All local isolator enclosures should be fully welded folded 316 stainless steel sheet metal not less than 1.6mm and comply with Annexure C - Electrical Enclosures and Junction Boxes unless otherwise specified.

Local Isolators must be provided with the following:

- Motor full load break rated isolator, mechanically interlocked with the door. The isolator must be able to locked in the open position.
- Terminals of the isolator must be shrouded and labelled with an appropriate warning message approved by SHL.
- A sloped rain hood (35 degrees or greater) that extends past the top door seal by at least 60mm when located in outside areas.
- All equipment must be mounted rigidly and braced sufficiently to prevent vibration.
- Locks must be ¼ turn requiring a tool to operate.
- All rotary type isolator handles must be mounted such that the hand is vertical – with the “head end” pointing up – when the isolator is open. Isolators must be closed by rotating the handle 90° in the clockwise direction.
- All metal doors must be provided with an earth stud, and must be bonded to the enclosure with an earth strap.
- All gland plates must be made of aluminium minimum 4mm thick. They must be sealed with neoprene rubber gaskets, and must have earthing studs.
- Minimum requirements for drives of 15kW and above must be for gland plates of 6mm, and gaskets of 3mm.
- Outside panel labelling must be stainless steel tag minimum 1mm thick – laser etched or deep engraved and painted with minimum text height of12mm. Inside panel labelling must be white traffoylette, black lettering with minimum text height of 5mm. All labelling must be submitted to SHL for approval.
- The enclosure must be labelled warning the voltage enclosed.
- Enclosure must be rated to IP65.
- Large doors (greater than 600mm) must be adequately stiffened, using minimum of 100m wide and 20mm deep folded sheet metal, spot welded to the door or panel.

Where possible, viewing window to observe status of isolator main contacts should be provided.

3.6.2. Local control panel requirements

Where specified, motors must be fitted with a local control station. Local control stations must comply with Annexure C - Electrical Enclosures and Junction Boxes.

The local control station must be fitted with the following items:

- A sloped rain hood (35 degrees or greater) that extends past the top door seal by at least 60mm where

located in outside areas.
- Locks must be ¼ turn requiring a tool to operate.
- Gland plate made from minimum 4mm thick aluminium.
- All metal doors must be provided with an earth stud and must be bonded to the enclosure with an earth strap.
- The local push buttons and switches must be mounted on the door of the local control station and be IP65 rated.
- The local control station may be combined with the local isolator.
- Outside panel labelling must be stainless steel tag minimum 1mm thick – laser etched or deep engraved and painted with minimum text height of12mm. Inside panel labelling must be white traffoylette, black lettering with minimum text height of 5mm. All labelling must be submitted to SHL for approval.

Four types of stations are applicable - the one to be used must be as detailed in the project specification.

The types are:

- Standard Local control station (LCS) - with one START pushbutton, and one combined STOP / EMERGENCY STOP pushbutton.
- Reversing local control station (LCS) – with one FORWARD and one REVERSE pushbutton, and one combined STOP/EMERGENCY STOP pushbutton.
- VSD local control station (LCS) – with one START pushbutton, one EMERGENCY STOP pushbutton, and one standard STOP pushbutton.
- Emergency stop station (ES) - with one EMERGENCY STOP pushbutton.

Pushbuttons and terminals must be in accordance with Annexure E - General hardware requirements.

3.7. Insulation

A vacuum pressure impregnation system must be used for insulation.

Motor windings must be enamelled with class H anti-fungus non-hydroscopic varnish, and have a minimum of Class F insulation, with a maximum temperature rise of 80°C (Class B rise), as per AS 60034.

For each type of motor, the recommended minimum insulation resistance above which he will guarantee the performance of the motor under operating conditions without the need for a drying out procedure. For motors below this stated value the Contractor must dry out the windings of the motors before commissioning.

3.8. Stator windings

Motors must be form wound coils using Class F materials securely braced. All windings must be copper.

The windings must be rigidly braced to withstand an average of three D.O.L. starts per day for the design life of the motor.

The windings must also be inductively balanced such that the variation in coil inductance measured in the assembled machine is within ± 1%.

3.9. Rotor construction

The design of the rotor must take into account the expected run-up time for the drive allowing for both the thermal and the mechanical stresses involved.

3.10. Shaft

Motor shaft machining must have a radius at all diameter changes. The radius must be as specified by the Manufacturer. Shafts must be fitted with keys suitable for the driven equipment.

3.11. Fans

Fans must be of cast iron or cast aluminium construction and bi-directional. Pressed mild steel fan cowls or plastic fans must not be used.

3.12. Bearings and seals

The bearing manufacturer's number must be stamped on the nameplate.

Bearings must be Spec B-10 minimum life, or better. For vertically mounted motors, bearings must be thrust type.

Frame sizes D80 to D315 must be supplied with bearings rated for the maximum load and life rating within the standard frame design.

Unless motors are mounted vertically, bearings for motors of 160 frame and above must be grease lubricated roller bearings (steel caged) on the drive end, and ball type on the non-drive end. Motors 132 frame and below must be fitted with 'sealed for life' ball bearings.

Plastic or nylon caged bearings are not acceptable.

Each bearing housing must be provided with means of achieving automatic pressure relief and grease purging, permitting on the run greasing. This facility must be fitted to all motors of frame size 132 or larger, and is preferred for all motors of smaller frame size. Where this facility is unavailable below frame size 132, the minimum acceptable standard is fitting of grease nipples, plus removable grease evacuation plugs to permit re-greasing of the bearings.

Provision must be made for easy greasing whilst in operation, with grease nipples clear of any restriction. Grease nipples located on bearing grease plates are not acceptable.

For large motors, plain bearings must be used. Oil lubrication must be automatic.

The bearing re-lubrication interval must be 8,000 hours minimum.

Seals must be fitted to the bearing housings at both ends of the motor. For flange mounting motors, intended for fitting to gearboxes, sealing against the gearbox oil entering the drive-end bearing must be incorporated.

Ball and roller bearings must be standard types and sizes which are readily available.

It is preferred that plant which may be subject to vibration, while stationery, be provided with sleeve type bearings. Alternative types of roller bearings, designed to withstand vibration, may be used subject to the approval by SHL.

To prevent brinelling of ball and roller bearings, all motors larger than 15 kW and other equipment of comparable size incorporating such bearings must be shipped, unless otherwise approved, with the shafts clamped or without the bearings fitted and the shafts suitably supported on dummy bearings manufactured from approved materials. Where applicable the bearings must be fitted at site, such work being done in a dust free enclosure.

3.13. Drain plugs

All motors above 20kW must have porous drain plugs provided in the bottom of the motor case and positioned so that any water condensed inside the motor may drain away.

3.14. Anti-condensation heaters

Motors of ratings of 100kW and above, or as required due to the installation environment, must be fitted with anti-condensation heaters rated for 240 VAC supply voltage. Provision of these heaters may be deleted on submission of satisfactory evidence from the motor manufacturer that the motors are suitable for long periods of storage and for use under the specified duty and location without anti-condensation heaters.

Heaters must be switched off when the motor is running and all switching must be performed at the motor by a thermostat or other means. This switching device must be supplied and wired by the manufacturer and be accessible for maintenance or replacement while the motor is in service. Heaters designed to be switched by auxiliary contacts of the motor starter are not permitted.

Heater and thermostat leads must be brought out to a terminal box mounted on the same side of the motor as the power cable terminal box. A warning label, stating that isolation of the motor starting device does not isolate the heater supply, must be provided on the heater terminal box.

3.15. Temperature monitoring

Thermal detector, with characteristics to AS 60947.8, must, where required, be inserted in the stator windings of the motors. Unless otherwise specified, motors required for low or variable speed operation must be fitted with thermal detectors.

All motors 37 kW and above must be fitted with positive temperature coefficient thermistors embedded in each phase of the stator winding to sense overheating on load and when stalled. These must be connected in series for the purpose of tripping the motor on high temperature. Thermistor control devices must be fail safe and be of the 1000-ohm type. Thermistors must be individually wired out to a terminal box on the same side of the motor as the power cable terminal box.

Motors above 150kW must be fitted with three Resistance Temperature Detectors (RTDs), one in each phase of the stator winding, located to measure the coil temperature at the hottest location in the slot. Temperature sensor leads must be brought out to a terminal box which must be mounted on the same side of the motor as the power cable terminal box.

Temperature sensors for all temperature measurement up to 150°C must be Pt 100 RTDs or an approved equivalent.

3.16. Motor terminals and terminal boxes

Motor terminations must be rigidly mounted and firmly supported within a totally enclosed terminal box. Rubber insulated cable must not be used for connections from the windings to the terminals.

Separate terminal boxes must be provided for power supply, for current transformers, anti-condensation heaters and temperature monitors. Each box must be fitted with a conduit entry or an undrilled gland plate.

Terminal boxes must be designed to provide adequate space to terminate the cable. Terminal boxes must be suitable for top or bottom cable entry.

3.17. Motor earthing

All motors must be provided with an earthing stud on the foot of the motor on the same side of the motor as the terminal box. Motors must also be provided with an earth terminal in the motor terminal box.

3.18. Refer to the Annexure K – Low Voltage Earthing for specific earthing connection details for motors. Motor data for protection setting

The following information must be supplied by the motor manufacturer after design of the motors has been completed.

- rated full-load current
- locked-rotor current
- run-up time under design load
- speed-torque curves for 80, 90 and 100% terminal volts
- undervoltage-time withstand curve (at full load)
- thermal limit curves, hot and cold
- locked rotor thermal-limit curves for 80, 90 and 100% volts, hot and cold
- number of permissible starts per hour, hot and cold
- negative sequence (out of balance) withstand curve
- rotor temperature limits
- rotor and stator accelerating thermal limits for 80, 90 and 100% volts, hot and cold
- residual voltage/time curves
- current/phase-angle curves from start to full load to no load at 80, 90, 100 and 120% volts

3.19. Noise level

Motors must be designed to comply with the noise level limits of AS 1359.109 or better. Any options which are available to reduce noise, and the guaranteed results achievable, must be provided.

The mean sound pressure level at 1.0m must be not more than 80 dB(A) at 75% load.

3.20. Vibration

The vibration produced in each motor, when running at normal operating speed and freely suspended or resting on resilient blocks, must comply with the requirements of AS 1359.114. The shaft extension keyway must be provided with a half height key for the purpose of this test.

3.21. Specific requirements for submersible motors

Submersible motors must be protected to IP68. The use of corrosion resistant materials for motor manufacture is preferred.

Supply cables to the submersible motor are to be supplied pre-installed with the motor as trailing supply cables. These trailing cables are to be terminated to a junction box. The junction box must be located at a sufficiently high level above fluid to prevent any ingress of fluid during normal and adverse situations. The junction box must have a minimum protection rating of IP68. The trailing cable insulation must be Hypalon or an approved equivalent.

Consideration should be given to providing detection and monitoring for submersible pumps to trip on seal failure.

3.22. Testing

Performance tests in accordance with AS 1359.101 must be carried out at the manufacturer's works to show that the motors fully comply with the requirements of this Annexure. Type test certificates must be provided with each motor design and rating. Where no type tests have been carried out on the specific motor design and rating, the following Type tests must be carried out:

- Resistance of windings
- No load losses and current
- Locked rotor tests (see below, this Clause)
- Temperature rise, by resistance (
- Power factor
- Efficiency
- Momentary overload
- High voltage insulation
- Vibration
- Noise

Duplicate tests must be carried out on all motors by the manufacturer. Duplicate tests must consist of the following tests:

- Resistance of windings
- No load losses and current
- High voltage insulation
- Vibration