Snowy Technical Standards	
SHL-ELE-156 (E)	***Annexure E - General Hardware Requirements 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 General hardware.

General hardware 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

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

3. Technical Requirements

3.1. General

All equipment must be designed and installed strictly in accordance with the manufacturer's instruction in all regards. The equipment must be installed so that it maintains its operational rating when for installation within an electrical enclosure and ambient temperature is at maximum.

All equipment must be installed strictly in accordance with the manufacturer's instruction in all regards particularly concerning temperature rise, clearances and maximum current rating.

3.2. Design Life

Electrical hardware and equipment must be designed for a minimum life duration of 20 years in the environment and for its nominal duty. The equipment must also be suitable for a minimum 1-year normal continuous operation without maintenance at its nominal duty.

3.3. Site Climatic Conditions

All electrical components must be selected and installed such that all circuits can operate simultaneously at the full load rating at the worst climatic extreme detailed in the table below.

Condition	**Detail**	**Value**
Location	Southern NSW South Eastern SA Southern Victoria	- - -
Altitude	Above mean sea level	0-1000m[1]
Ambient Temperature (Dry bulb)	Minimum – Indoor Minimum – Outdoor	-5°C -15°C
	Typical Maximum	35°C
	Extreme Maximum	40°C
Relative Humidity	Minimum	10%
	Maximum – Indoor Maximum – Outdoor	50% 100%

3.4. Relays

3.4.1. General

Ratings

Relay contacts must have a utilisation category appropriate with the required duty in accordance with AS 60947. The voltage and current rating of relay contacts must be selected to suit the maximum switching voltage and current.

Spare contacts

At least one spare change-over contact, or one spare normally open contact and one spare normally closed contact must be provided on each relay in addition to the contacts required by the control scheme.

[1] The altitude of any Snowy Scheme installations above 1000m are detailed in the project specific documentation.

Continuously rated coils

Relay coils must be continuously rated. Alternating current operated coils must be suitable for operation at +10% to -15% of the nominal voltage of the circuit. DC operated coils must be suitable for operation at 80% to 120% of nominal circuit voltage for control relays and 50% to 110% of nominal circuit voltage for trip relays

3.4.2. Overload relays

A blank overload setting label must be attached to the rear of each starter cell door for recording overload set-points. The material must be suitable for marking with a pencil or whiteboard marker.

All overload relays must be provided with not less than one normally open and one normally closed contact to activate trip and indication conditions. A single changeover contact is not acceptable.

3.4.3. Thermal overload relays

Thermal overload relays are to be used where the motor is less than or equal to 30 kW and suitable for direct attachment to the contactor. Thermal overload relays must be in accordance with AS 60947. Electronic overload relays may be required as per project specific applications and must comply with Section 3.1.4.

Thermal overload relays must be of the ambient compensated, three-element bi-metal adjustable type, with phase loss protection.

Such devices must be capable of withstanding the let-through fault of the upstream circuit protection.

Thermal overload relays must be selectable for manual or automatic reset.

3.4.4. Electronic overload relays

Electronic overload relays with thermal overload and single phasing must be used where the motor is over 30 kW and below 110 kW.

For motors above 110 kW motor temperature detection and earth protection must be provided in addition to the requirements above.

Electronic overload relays must comply with requirements of IEC 60255 and AS 60947.

Where the single phasing protection is provided as a negative phase sequence characteristic this must be capable of adjustment to 50%.

The relays must have the additional characteristics of “stall” protection, which operates quickly on a prolonged locked rotor at start, without the need for input from a speed switch or similar device.

Electronic overload relays must be capable of being flush door mounted as well as being capable of being reset remotely from a programmable controller or communication link.

Electronic overloads must be equipped with manually operated trip-test facilities.

Electronic overload relays must be fitted with indication of the type of trip, which has occurred. Relay output contacts must be manual-reset type.

Electronic overload relays must be rated for continuous operation at the full-load operating temperature of the cubicle in which they are located.

Electronic overload relays must be located within contactor compartments, adjacent to other auxiliary equipment in the starter control circuit.

All electronic relays must be fitted with provision to plug-in portable testing and calibration equipment, to enable testing the relay operation using the secondary injection method. One portable testing unit, designed for operation with 240VAC power supply, must be provided.

Where relays have the facility to provide direct indication of circuit current, this may be provided in lieu of separate Current Transformer and transducer (i.e. Hall effect current transformer).

Electronic overload relays must be supplied and set up for manual reset. Provision must be made for resetting from the front of the board without module withdrawal.

During normal operation, electronic overload relays must indicate motor load as a percentage of full motor rated load.

Under fault conditions, the following indications must be provided:

- motor overload
- phase loss
- locked rotor
- motor earth leakage
- Motor current imbalance

3.4.5. Thermistor relays

Thermistor relays must comply with the requirements of AS60947.

Thermistor relays must be fitted with indications of both trip readiness and trip output. On restoration of a thermistor relay's auxiliary power supply, the relay must automatically reset unless it was in the tripped condition prior to interruption of the power supply. It is preferred that thermistor relays are of the type, which are integral with the associated thermal overload relays.

Thermistor relays must be selected to suit the thermistor characteristics which must be of the positive temperature coefficient type. A thermistor must be provided in each phase winding of the applicable motor.

Thermistor relays must be suitable for operation with a power supply voltage ranging from 70% to 130% of the control circuit voltage.

Thermistor relays must be provided with not less than one normally open and one normally closed contact to activate trip and indication conditions. A single changeover contact is not acceptable.

Thermistor relays must be selectable for automatic or manual reset.

3.4.6. Auxiliary relays

Auxiliary relays must comply with the requirements of IEC 60255, particularly the requirements for high-frequency disturbance testing and must be suitable for continuous duty at rated voltage and frequency

surrounding the relay of up to 60°C. The rated voltage of a relay must be suitable for the particular circuit.

Relays must have plug-in features and must be designed to prevent the relays working loose under vibration. Relays with different coil voltages must have different pin and socket arrangements.

Transparent dust covers made from non-flammable material must be provided for all relays.

Where associated with circuit breakers or large contactors, auxiliary relays must be positioned to eliminate as far as possible the effect of the mechanical shock of closing and tripping of the circuit breaker or contactor.

All auxiliary relays must have a minimum of two normally open and two normally closed contacts.

It is preferred that auxiliary relays are fitted with integral LEDs to indicate that the relay is in the energised state.

Back EMF suppression diodes must be connected across the coil of auxiliary relays operating on DC supplies. DC relays must have the polarity of the coil connections clearly marked and a maximum coil consumption of 5VA. Series dropping resistors must not be used in DC relay circuits.

Relay contacts must be adequately rated for the service conditions. The minimum acceptable contact ratings must be 5A inductive (0.4 p.f.) at 240V AC rated voltage with maximum switching voltage 265V.

or 1A inductive (L/R = 10 ms) at 220V DC rated voltage with maximum switching voltage 265V.

3.4.7. Timing and specialty relays

Time delay relays must be of the solid-state type. It must be possible to adjust the timing delays easily and the relays must hold that adjustment. The timing range of the relays must overlap the expected setting by at least +50 per cent. The setting adjustment must be clearly visible and protected from being accidentally changed by bumping.

3.4.8. Transformer protection relays

The switchboard incomers fed by power transformers must be supplied with a current transformer in the 415V secondary neutral circuit to provide for neutral earth fault protection.

Each incomer 415V circuit breaker must be provided with a transformer protection relay mounted in the circuit-breaker control cubicle of the switchboard and wired to the 415V secondary neutral circuit CT.

The relays must be flush panel-mounted, in drawout cases. During withdrawal of the relays, the current transformer circuit must be shorted by contacts within the relay casing.

3.5. Control switches

Control switches complying with the requirements of AS 60947.5.1 must be provided where directly specified or where otherwise necessary for the operation of the plant.

3.5.1. Control Switches

Control switches (CS), unless otherwise specified, must be of three-position heavy-duty spring return-to-neutral type. Control switches for circuit breaker OPEN and CLOSE control must have pistol-grip Kraus & Naimer ‘P’ type (or similar) handles. All other control switches must have Kraus & Naimer ‘R’ type (or similar) handles.

An escutcheon must be fitted engraved with the following information in the positions stated:

- switch function (at top)
- control function selected (opposite each switch position); and
- device number (bottom right).
- Switch escutcheons must be of white plastic or aluminium, clearly engraved in black lettering with the approved functional description identical to that shown on the schematics of wiring diagrams (abbreviated if necessary), corresponding to each switch position.

3.5.2. Control Selector Switches - Mode selection

Control selector switches (CSS) provided to select a particular mode of operation of the plant must be of Kraus & Naimer 'L' type (or similar) handles and fixed operating positions spaced 90° apart.

Selector switch contacts must be of the double-break silver or silver-alloy type, adequately rated for the required switching duty and continuous current carrying capacity.

An escutcheon must be fitted with the following information in the positions stated:

- switch function (at top)
- mode selected (opposite each switch position); and
- device number as shown on circuit diagram (bottom right)

3.5.3. Normal operating position

Control switches (CS) and Control selector switches (CSS) must have 12 o'clock as their normal operating position.

3.5.4. Arrangement of switches

Control devices must be arranged to turn:

- Clockwise – for RAISE, CLOSE (switches), START, ON and OPEN (valves) positions
- Anti-clockwise – for LOWER, OPEN (switches), STOP, OFF and CLOSE (valves) positions.

3.6. Pushbuttons

3.6.1. Type

Push button switches must be of heavy-duty type and constructed for definite over travel in both directions. Push-buttons, except those installed in control rooms and the like, must be guarded to prevent accidental operation.

Where panel-mounted push buttons are required, these must be of the spring-loaded type such that the contacts change state only when the pushbutton is firmly depressed or subsequently released.

All push buttons must be sized not larger than 40 mm diameter, and not smaller than 22 mm diameter.

3.6.2. Labelling and colours

Pushbuttons intended for stopping and starting a particular device must be coloured red and green respectively. In such cases, the push buttons must be mounted adjacent to each other in a horizontal line, with the red button on the left-hand side.

Pushbuttons for other functions must be coloured black and mounted in the same line as stop and start push buttons where applicable. A separate label must be provided to clearly describe the function of these pushbuttons.

3.6.3. Emergency stop / shutdown pushbuttons

Emergency stop or emergency shutdown push buttons mounted on control panels/cubicles for main plant must have, in addition, a protective flap held in front of the button by a spring or gravity and the exposed face of the flap marked ‘EMERGENCY STOP’ or ‘EMERGENCY SHUTDOWN’ respectively in red.

Emergency stop push buttons for auxiliary plants must comply with AS 3000 Wiring Rules – Devices for Emergency Switching including Emergency Stopping.

3.7. Auxiliary contacts

All high-voltage and low-voltage switchgear and control gear must be provided with the necessary auxiliary switches for the closing and opening mechanism and for control, indications, interlocking and other functions and must include as a minimum one makes and one break contact as spare.

Auxiliary switches must be mounted on the equipment and directly coupled to the operating mechanism. The switches must be arranged so that they will not be damaged by over-travel of the drive. Contacts must be inherently self-cleaning to ensure low contact resistance at all times.

Auxiliary switch and control relay contacts must be robust, reliable and rated for the circuits being switched. The minimum acceptable contact ratings must be 5A inductive (0.4 p.f.) at 240V A.C. or 1A inductive (L/R = 10 ms) at 250VD.C.

3.8. Indicating lights

3.8.1. General

Indicating lights must be of the miniature type using incandescent or Multichip LED lamps to a manufacturing standard in common usage to ensure continuity of replacement supplies. Rating of indicating lamps must be 24V AC/DC unless otherwise specified.

Indicating lights must give satisfactory indication when viewed from the side at an angle of up to 60° from the axis of the lamp, against background lighting employing white fluorescent tubes or outdoor ambient light.

The fittings must withstand 500V dc for one minute and must be so constructed that the lamp can be readily fitted and removed, and the lens changed from the front of the panel.

The fittings must be capable of continuous operation at the nominal lamp voltage regardless of the position in which they are mounted.

Lenses must be of translucent glass or other approved material. Plastic lenses will be accepted if fitted with a robust anti-shrink ring or other approved device to prevent the lenses becoming loose due to deformation or shrinking. Where colour indication is required, coloured lamp covers are not acceptable. Coloured lenses are required.

All types of indicating light fittings must be suitable for the replacement of the lamps from the front without the use of tools. Lamp-holders must be made for metal or an approved high grade plastic material. Plastic used in the lamp-holder body or for clamping rings must be dimensionally stable to a degree such that jamming of threads must not occur during normal service. Where metallic lamp holders are used, the holder must be earthed, and not used as a part of the lamp circuit.

Indicating lights must be mounted in either a horizontal or vertical line, with the green light on the left or top respectively. Where applicable, indicating lights must be mounted directly above any pushbuttons with which they are associated.

Indicating lights, other than red or green, must be clearly labelled to indicate their function.

Indicating lights must be provided with a test functionality. This must allow for the light to be energised to confirm that the light operates correctly.

3.8.2. Discrepancy Lamp Semaphore (DLS)

Discrepancy lamp semaphores (DLS) must conform with the appearance of the control panel mimic diagram in which they are mounted and must be fitted with one or more central lamps and contacts so that the lamp is alight when the position of the DLS is not in accordance with the position (OPEN or CLOSED) of the isolator, circuit breaker or earthing switch which the DLS represents.

3.9. Isolators and combined fuse switches

3.9.1. General

Fuse switch units and rotary switch isolators must be supplied in accordance with the requirements of AS 60947, with a rated duty of 'uninterrupted' and an utilisation category of AC-23. The switching mechanisms must provide a quick-make, quick-break action such that the speed and force of the operation are independent of the action of the operator. The design of the switches must be such that in the isolated position there is no danger of inadvertent contact with live metal.

Covers or barriers may be utilised to prevent contact, provided that such covers or barriers are firmly secured in place, cannot be removed without the use of tools, ensure a degree of protection of at least IP 30 with the enclosure doors open, and do not cause excessive temperature to rise with the enclosure doors closed.

The compartments enclosing the fuse switch units and rotary switch isolators must retain their IP rating with the switches isolated. Where operating handles are mounted as part of a hinged door, the handle must be situated on the opening side of the door rather than the hinge side. The hinged access door to the compartment must be interlocked with the switch such that:

- the door cannot be opened until the switch is 'OFF'
- the switch cannot be closed with the door opened.

For test purposes, provision must be made for interlock to be intentionally defeated in which case the door must not be capable of being closed until the switch is reopened.

Mechanically operated 'ON-OFF' indication must be provided on all fuse switch units and rotary switch isolators. This requirement may be achieved by labelling the switch operating handle position.

Auxiliary switches must be provided on fuse switch units or isolators where specified. The minimum acceptable contact rating must be 5A inductive (0.4 p.f.) at 240V A.C. or 1A inductive (L/R = 10 ms) at 250V D.C for 250V applications.

Provision must be made at each device that must or may form part of an isolation point, a facility for the attachment of a locking device and isolation tag.

3.9.2. Specific requirements for DC applications

DC isolators and combined fuse switches must be supplied in accordance with the requirements of AS 60947, with a rated duty of 'uninterrupted' and a utilisation category of DC-23.

As SHL utilises a low voltage unearthed DC system, both the positive and negative buses must be protected by a fuse, where combined fuse switches are used. Due to the potential of earth faults on the DC system, each pole must be rated for the full fault current. It is permissible to use a combination of poles to achieve the breaking capacity, however an even number of poles must be provided for both the positive and negative bus (i.e. 4 pole).

Main battery positive and negative fuses should be in separately insulated compartments.

3.10. Circuit Breakers

3.10.1. Air circuit breakers

General

Air circuit breakers must be 3 poles, or 4 poles as required, trip-free, with-drawable, in accordance with AS 60947 and suitable for use on a 415 Volt 50 Hz system.

Air circuit breakers must have been tested by a recognised testing authority for compliance with AS 1930.

The circuit-breakers must have a minimum rated insulation voltage of 660 volts and a rated operational voltage of 415 volts.

Each circuit-breaker must be suitable for uninterrupted duty with rated uninterrupted current adequate for the circuit to which it will be connected.

Enclosed circuit-breakers must comply with the provision of AS 60947 for temperature rise limits.

Circuit-breakers requiring forced ventilation to comply with these temperature limits will not be considered.

Each circuit-breaker must have the following minimum requirements:

- A rated short circuit breaking capacity of 50kA.
- A rated short time withstand current of 50 kA for 1 second.
- A short circuit performance category of P-2.

The circuit-breakers must be fitted with renewable main and arcing contacts, and provision must be made to adjust their alignment to ensure that arcing contacts are made simultaneously on all three poles and similarly for the main contacts.

Arc chutes must be asbestos free and designed to permit easy removal for inspection and maintenance of the main and arcing contacts. Arc chutes must be firmly located when in the working position.

The main isolating plugs and sockets for the circuit-breaker must be of the self-aligning type capable of carrying the rated making and breaking current of the circuit-breaker as well as the specified continuous rating without damage. The circuit-breakers must be jig assembled to ensure accurate lining up of main and auxiliary isolating plugs and sockets.

Each circuit-breaker must be equipped with a 5-digit operations counter to record the total number of circuit breaker closures.

Circuit-breaker auxiliary switches must be mounted on the circuit- breaker truck and operated directly by the circuit-breaker.

Operation

The opening and closing circuit of each circuit breaker must include an arrangement to prevent pumping of the circuit-breaker should the opening or closing signals be maintained.

Circuit-breakers must be closed by motor wound springs and must be fitted with a shunt trip coil. Electrical closing and tripping circuits and spring winding motors must operate at station DC voltage range unless otherwise specified.

Provision must be made for manual charging of the spring closing mechanism. The manual spring charging operation must not rely on the operator to counterbalance the full stored energy of the spring.

Mechanical indication of the condition of the closing springs, charged or discharged, must be provided and must be visible when the cubicle door is closed.

Local electrical close and trip push buttons must be provided at the switchboard to enable testing of each circuit-breaker when it is in the ‘test' position.

Facilities for mechanically closing and tripping the circuit-breakers must be provided together with a mechanical device to indicate whether the circuit-breaker is open or closed. These facilities must be visible when the cubicle door is closed.

Manual slow closing facilities must be provided for maintenance purposes where mechanism or contact checking/adjustments are necessary in the closed position.

Air circuit breakers must be provided with provision for the connection of remote open/close facilities.

Consideration must be given to providing circuit breakers with remote racking facilities and equipment, where required.

Isolation

Provision must be made at each device that must or may form part of an isolation point, a facility for the attachment of a locking device and isolation tag.

Protection

Each air circuit-breaker must incorporate an electronic protection relay with field adjustable tripping characteristics to provide protection for the 415V switchboard.

The relays must incorporate the following characteristics at a minimum:

- Overload (long-time pickup);
- Overload (long-time delay);
- Short-circuit pickup;
- Short-circuit (short-time delay and high-set instantaneous);
- Ground fault pickup;
- Ground fault delay;

Relay characteristic curves must be extremely inverse and adjustable to provide discrimination with downstream HRC fuses or MCCBs.

All current and time settings must be fully adjustable by means of setting switches or dials on the front-plate of the relay, without the need for internal modification or adjustment. Provision must also be made to disable the operation of the relay by a suitable setting switch.

The relays must be provided with hand-reset LEDs or flags to indicate which of the protective functions has operated. The tripping output of the relays must also be hand-reset.

Each relay must be equipped with clean output contacts for remote indication of trip operations.

The relays must conform to IEC 60255, particularly the requirements for high-frequency disturbance testing. The relays must be provided with means to carry out on-site testing of relay operation using portable equipment by the secondary injection method, in addition to any other facilities which are integral to the relays for diagnostic purposes.

Where relays have the facility for remote indication of circuit current, this may be provided in lieu of the separate Current Transformer and transducer providing that equivalent accuracy and other performance factors can be demonstrated.

Auxiliary switches

Auxiliary switch contacts must preferably be convertible from normally open to normally closed and must be readily accessible when the circuit-breaker is withdrawn from its cubicle.

If the number of available auxiliary switches is not sufficient for the total number of functions required, auxiliary relays must be provided and mounted on the fixed portions of the switchgear. Important functions required for

the safety of the plant (interlocks, control signals, etc.) must be connected directly to the auxiliary switches and not to the contacts of the auxiliary relays which must only be used for alarms, indications etc.

Earthing

An earthing connection must be provided to earth the circuit-breaker frame. This connection must 'make' before and 'break' after any other connection, during the racking procedure.

3.10.2. Moulded case circuit breakers (MCCBs)

Moulded Case Circuit-Breakers (MCCBs) must comply with AS 60947. MCCBs must have been tested by a recognised testing authority for compliance with AS 2184.

Motorised MCCBs must be considered for the isolation of high arc energy circuits.

MCCBs must be capable of carrying rated load current continuously and must be capable of making and breaking the maximum prospective fault current of the installation.

Where MCCBs are proposed as protection for feeders from switchgear and control assemblies, only current limiting MCCBs successfully tested to AS 60947 for through fault and making capacity will be considered. The use of additional lengths of conductor to limit the fault current is not acceptable.

MCCBs with fault interrupting capacity of 22kA or less will be allowed only on circuits where fault current is limited by means of HRC fuses. Integrally fused circuit-breakers are not acceptable.

The MCCBs must be operated by a toggle or handle which must clearly indicate the three fundamental positions ON, OFF and TRIPPED. Where required rotary handles must be fitted to the breaker.

The MCCBs must be mounted so that the “ON-OFF” and current rating indications are clearly visible with the cover or escutcheon in position (unless noted otherwise), and so that arc discharges from the circuit breakers are directed away from live metal and insulation. The operating toggles are to be aligned in the same plane.

All electrical auxiliaries must be equipped with built-in control terminals. All internal electrical auxiliaries must be of snap-in type.

All MCCB’s must be provided with a volt free contact for monitoring the OFF position.

Live metal on MCCBs and MCBs must be fully shrouded to prevent accidental human contact.

All MCCBs must be provided with a facility to be padlocked in the open position and capable of being fitted with electronic trip units. However, it is preferred that automatic trip, inverse - time - instantaneous circuit-breakers must be used.

MCCB frame size 400A or above must have electronic trip unit with field adjustable tripping characteristics as follows:

Long time pickup
Long time delay
Short time pickup
Short time delay
Instantaneous trip point
Ground fault trip point

Ground fault trip delay

MCCBs from 100A to 400A frame size must have trip units either electronics or thermal magnetic with adjustable, inverse time, and instantaneous magnetic trips.

MCCBs with 100A frame size or less must have either fixed or adjustable, inverse time, and instantaneous magnetic trips.

The trip units of MCCBs must be easily interchanged with standard tools.

Provision must be made at each device that must or may form part of an isolation point, a facility for the attachment of a locking device and isolation tag.

Specific requirements for DC applications

As SHL utilises a low voltage unearthed DC system, both the positive and negative connection must be switched. Due to the potential of earth faults on the DC system, each pole must be rated for the full fault current. It is permissible to use a combination of poles to achieve the breaking capacity, however an even number of poles must be provided for both the positive and negative connections (i.e. 4 pole).

It is preferred that magnetic trips only MCCBs are used for DC motor applications. A separate thermal overload should be provided however, where the application is critical, the thermal overload for the critical motors should be used for alarming purposes only.

AC MCCBs may be used for DC applications, however the AC MCCB must specifically state that the MCCB operation, voltage level and the interrupting current is suitable for DC applications.

3.10.3. Miniature circuit breakers (MCBs)

Miniature circuit breakers (MCB's) must comply with the requirements of AS 3111 and AS 60947.

Miniature circuit breakers (MCB's) must be used for the protection of the control circuits for circuit breakers and contactors.

MCBs must have a minimum interrupting capacity of 10 kA at the voltage of the circuit in which they are wired, and a continuous current rating according to the actual circuit requirements. MCBs must be rated to provide adequate protection for the devices and/or circuits with which they are associated, and to discriminate with other protective devices in the same circuit.

MCBs in AC circuits must switch the active connection only. MCBs in unearthed battery-fed DC circuits must switch both the positive and negative connection and must not be polarity sensitive.

MCBs must be resistant to faulty operation caused by the shock forces during operation of circuit breakers or contactors mounted in the same assembly.

MCBs must be fitted with an auxiliary contact which makes when the main contacts are closed and an alarm contact which makes only when the circuit breaker is tripped by its in-built protective devices.

Provision must be made at each device that must or may form part of an isolation point, a facility for the attachment of a locking device and isolation tag.

3.11. Automatic Transfer Switch

Where an Automatic Transfer Switch (ATS) is installed, the availability of the incoming power supply must be monitored via a phase failure relay. Automatic transfer must occur when normal supply is unavailable and there is a standby supply available. The ATS will return to normal supply once the normal supply has been restored for a suitable period.

3.12. Earth leakage protection

Feeder circuits rated 32A and less must have 30mA RCD provided in the switchboard. Integrated RCD test facilities must be provided for each RCD device.

Earth leakage protection must be provided for other circuits based on a risk analysis.

The ELR must be core balance type having minimum 100mA sensitivity with adjustable trip settings and incorporated with toroidal type CT. The selection of ELP devices at main switchboards must take into account the requirement for discrimination with downstream Protective Devices.

For small supplies (200A or less), a 300 mA ELR device may be used, with a time delay of 200 ms. For larger supplies (above 200A), Earth Leakage Protection relays may be used in conjunction with MCCBs or ACBs incorporating a trip unit (e.g. 1A, 3A, 5A with a suitable time delay to ensure proper discrimination with downstream Protective Devices). Irrespective of the Earth Leakage Protection provided at the main switchboard, the incomer MCCB or ACB must have short-circuit protection to ensure tripping within 400 ms taking into account the Earth Fault Loop Impedance.

Independent test, reset and status indication facilities must be provided for each ELR device.

All earth leakage devices must be capable of being tested and reset without isolating the switchboard to gain access to the switchboard interior. The status of ELR to be alarmed in the SCADA.

Earth Leakage devices intended to be used with miniature circuit breakers or MCCB, integrated or otherwise, must comply with the requirements of AS3190.

Residual Current Device Test Circuit

The following system must be provided in a compartment that contains any RCDs:
A dedicated special-purpose outlet (SPO) for connection to a portable appliance tester;
Rotary selection switches for connecting the active of each circuit to the SPOs active pin;
All associated devices must be fixed in the compartment, not on the escutcheon which can be freely opened away.

3.13. Contactors

The contactors in all electrical control devices must be adequately rated for the service conditions. Contactors must be silver, or silver plated except where the conditions of operation require the use of harder materials such as tungsten or where special contact assemblies are of gold.

Contactors must comply with AS 60947 and AS 1029 and must be protected by a short circuit protective device selected to have Type 2 Coordination. Unless otherwise specified, all contactor coils must be continuously rated at 24 V DC. Each contactor must be fitted with a minimum of one auxiliary contact,

The minimum size contactor used must be suitable for a 5.5kW load. All contractors must be derated, if necessary, for operation at the temperatures likely to be attained inside the enclosure it will be housed based on the site climatic conditions.

All contactors must operate without damage or welding when supplied through the maximum setting of the upstream circuit breaker.

All contactors and their respective wiring connections must be selected such that the temperature rise on the conductor terminals is limited to a maximum of 60°C. Contactors must have a continuous and class 3 rated duty of 300 operations per hour, with a utilisation category of AC3 for 10 million operations.

Reversing starters and changeover contactors must be electrically and mechanically interlocked.

3.13.1. Specific requirements for DC applications

DC contactors and their respective wiring connections must be selected such that the temperature rise on the conductor terminals is limited to a maximum of 60°C. Contactors must have a continuous and class 3 rated duty of 300 operations per hour, with a utilisation category of DC3 for 10 million operations.

3.14. LV fuses and fittings

Fuses are to be cartridge-type HRC fuse links, carriers and bases must be designed, manufactured, and tested in accordance with the requirements of IEC 60269. GEC type SC32P fuse holders are preferred.

Fuse carriers must be readily removable from the base without the use of tools. Bolted or screw-in type fuse fittings are not acceptable.

All fuse fittings must be of the type in which live metal is fully shrouded at all times, including withdrawal and insertion of the fuse carrier.

Where specified, fuses must be provided in the active (phase) connections of all AC circuits, solid links provided for AC neutrals. Where the DC supply is unearthed then fuses must be supplied in both the positive and negative connection of all DC circuits. In earthed DC supplies only, the unearthed phase must be supplied with a fuse, with a solid link provided for the earthed phase.

Links are to be provided for outgoing trip circuits.

The wiring to fuses and links associated with incoming VT secondaries and panel supplies must be so arranged that incoming or live connections are at the top terminal.

Fuse carriers and bases must be coloured black. Link carriers and bases must be coloured white. Painting of carriers and bases is not acceptable.

All fuses must be of the 'general purpose' type. Exceptions to this requirement will only be accepted in special applications such as the protection of semiconductor circuits.

Fuse ratings must be chosen to provide adequate protection for the devices and the particular circuits to which they are connected and also to ensure the correct co-ordination or discrimination with other protective devices in the same circuit.

Labels must be provided adjacent to all fuse bases. These labels must contain the following information as a minimum:

- fuse number;
- circuit description;
- phase identification (for 2 or 3 phase circuits), active/neutral identification (for single phase circuits) or positive/negative identification (for dc circuits);
- fuse rating (in accordance with the approved drawings);
- any other information which may assist in the unambiguous identification, isolation or replacement of the fuses.

Where fuse distribution boards are provided, the following requirements must apply in addition to those above:

- each phase must be clearly marked;
- each fuse fitting must be uniquely numbered;
- a circuit identification schedule must be provided in a protective pocket located on the inside of the fuse-board enclosure door, with circuit descriptions typed or neatly written by the Contractor.

Provision must be made at each fuse that must or may form part of an isolation point, a facility for the attachment of a locking device and isolation tag.

3.15. Indicating panel instruments

Indicating instruments for panel mounting must be of the flush mounting type. They must comply with IEC 60051 accuracy Class 1.0 with 96 mm minimum square face and external zero adjustment. All indicating panel instruments must have a maximum scale deflection of at least 240 degrees.

Ammeters must be provided with red lines on the scales to indicate the full load current of the circuit. The full load current of the circuit must be between twenty-five percent (25%) and eighty-five percent (85%) of the effective range of the ammeter. Ammeters for motors must be rated for indicating momentary overloads of up to six times their rated current.

All panel instruments must be capable of carrying their full load currents without undue heating. They must not be damaged due to the passage of fault currents up to the maximum fault current of the switchgear. All panel instruments must be back connected.

Panel instruments connected to dual ratio current transformers must be provided with reversible scales. Panel instrument movements of the taut band type are preferred. Panel instrument glasses must be coated with anti-reflective material.

3.16. Electrical transducers

3.16.1. General

Transducers must be used wherever remote monitoring of electrical quantities is required. The remote equipment may consist of either indicating instruments or data processing equipment. Electrical quantities in the above category may include current, voltage, frequency, real power and reactive power.

All transducers must be designed, manufactured and tested in accordance with the requirements of IEC 60688-1, except as otherwise provided below. Transducers must be of the static, isolating, filtered output type and will be used to convert electrical power system quantities to proportional DC analogue outputs.

All transducers must be suitable for use with a redundant 24V DC supply.

Where possible transducers must have multiple functions. For example if a transducer has three phase volts and current, it must have watt, Var, amp and voltage outputs.

3.16.2. Input quantities

Transducer inputs must be suitable for direction connection to secondary circuits of current transformers or voltage transformers having the following characteristics:

- Rated current: 1A or 5A
- Rated voltage: 110V
- Rated frequency: 50Hz

The neutral points of all such secondary circuits will be solidly earthed.

Transducers must be designed to withstand the following variations in input quantities without sustaining any damage or deterioration in performance:

- Current: 0 to 200% I n (continuously)
- 20 X I n (for 2 seconds)
- Voltage: 0 to 115% V n (continuously)
- Frequency: 45 to 55 Hz (continuously)

The burden of all transducers on the respective input measuring circuits must not exceed 2VA (at rated current) per current circuit, and 4VA per voltage circuit.

3.16.3. Output quantities

Transducer outputs must bear a linear relationship to the input quantities, and have a range of 4 to 20 mA DC corresponding to 0-100% of the rated input range. Where specified, the transducer must also have a communications output (i.e. MODBUS RTU, DNP3) to interface the data directly into the control system without two 4-20 mA conversions.

Transducers must be capable of withstanding indefinitely open-circuits or short-circuits across their output terminals, without sustaining any damage or deterioration in performance.

Transducer outputs will normally be floating, but it must be possible to use the transducer with either output terminal solidly earthed if required by the Peripheral.

For Power transducers the output must be equivalent to “zero” MW/MVARs for zero current and rated volts or zero volts.

3.16.4. Accuracy, Calibration and Adjustment

Transducers must be of accuracy class 1.0. This accuracy must be maintained for any output circuit impedance in the range 100 to 1000 ohms.

Calibration certificates must be provided by the Contractor with each transducer, showing details of the accuracy class of the calibration equipment.

The range of adjustment provided for the output span must be not less than ±10% and not greater than ±15%.

The range of output off-set adjustment on voltage and frequency transducers must be not less than ±5% and not greater than ±10%.

The range of zero adjustment must be not less than ±2% and not greater than ±5%.

Full details of the procedures required to adjust span, offset and zero must be provided with each transducer.

3.16.5. Environment

Transducers must be mounted, wherever possible, with other associated control and measurement equipment.

All transducers must be suitable for use in a climate under the service conditions detailed below, where no special precautions are taken to control temperature or humidity or to maintain a dust-free environment:

- Temperature: Maximum average (1 hour) 55 ^{0} C
- Maximum average (24 hours) 40 ^{0} C
- Minimum -5 ^{0} C
- Humidity Maximum 93% at 40 ^{0} C

Transducers must be suitable for use in the vicinity of large electrical power generation, transmission and distribution equipment.

Transducers must be resistant to the effects of shock and vibration.

3.17. Changeover switches

Changeover switches must be a combination unit which transfers between power supplies through a manually operated rotary handle. The changeover switch must be load break type rated, as a minimum, to the system voltage and full load current being switched. The switching contacts must be “break” before “make” unless specifically required to be “make” before “break” (i.e. transferring between synchronised DC supplies).

3.18. Surge protective devices

Surge protective devices must be metal oxide varistor (MOV) type in accordance with AS 1307.2. Surge protective devices must have visual indication to indicate MOV operation, loss of power, and thermal overload. In the event of a thermal overload, the protection must remain in circuit.

Surge protective devices must also be provided with a voltage free changeover contact (Alarm output). This must activate upon any MOV failure, power failure or thermal overload condition and must be fail safe in operation.

Surge protective devices must be protected by an appropriate fuse of circuit breaker separated from the device. The short circuit withstand rating of surge protective device and the fuse or circuit breaker must be greater than the fault levels at the point of installation.

Consideration should be given to the maximum allowable length of the earthing conductors connected to the surge protection devices. Size of the earth conductor connecting the surge protective device must be minimum 25mm^2.

Consideration should be given to the use of surge filters for protection of critical and essential equipment. Surge filters must be MOV type with LC filters.

3.19. Socket Outlets

Socket outlets must be in accordance with AS 3112 and the following:

- Socket outlets must be switched;
- Outlets in office areas must be white and flush mounted with concealed wiring;
- In other areas, outlets may be either flush mounted or surface mounted with appropriate mounting blocks;
- Socket outlets supplied by UPS must be colour coded and/or appropriately labelled;
- Socket outlets in the following locations must have a degree of protection of not less than IP 56:
    - Indoor locations which are subject to dampness or ingress of water;
    - Indoor locations where additional mechanical protection is required;
    - Corrosive environments;
    - All outdoor locations;

- Fitted with a phase coloured and numbered stud matching that of the associated circuit breaker feeding the outlet;
- Wiring to three phase outlets must be such that, when viewing the socket from the front and reading the phases clockwise from the earth pin, the phases must be red, white, and blue. The neutral pin, where fitted must be the central pin;