snowy hydro Limited renewable energy	
Snowy Technical Standards	
SHL-ELE-156 (D)	***Annexure D - Low Voltage Cables and Cable Management Systems*** ***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 cables and cable support systems.

Cables and cable support systems for extra-low voltage and low voltage must be designed and constructed conforming to the General Electrical Requirements and this Annexure.

Specific earthing requirements for cable and cable management systems can be found in Annexure K – Earthing.

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

Cables and cable support systems must be designed, manufactured and tested with the safety requirements detailed in the General Low Voltage Electrical Requirements (SHL-ELE-156).

3. Technical Requirements

3.1. Cable Insulation Colour

Wire colouring and marking must be as nominated below.

Low Voltage power cabling:

Type	Colours
400V AC power – 3 phase	

Active	Red/white/blue
Neutral (where required)	Black
Earth	Green/yellow
230V AC power	
Active	Light brown
Neutral	Light blue
Earth	Green/yellow
120V AC power	
Active	Red
Neutral	Black
Earth	Green/yellow
Low voltage DC power (125V DC +)	
Positive	Red
Negative	Black
230V AC signal – solenoid, limit switch, relay	
Active	White
Neutral	White
Earth	Green/yellow

Control and Extra-low voltage cabling:

TYPE	**COLOURS**
24V DC power	
Positive	Red
Negative	Black
125V DC signal – solenoid, limit switch, relay	
Positive	White
Negative	Black
24V DC signal – solenoid, limit switch, relay	
Positive	White

Negative	Black
24V DC signal – screened analogue	
Positive	White
Negative	Black

3.2. Cable supply

All cables must be supplied on drums, clearly marked with the SHL's Order or Contract number and a detailed description of the cable contained on the drum, including gross weight.

3.3. Low Voltage Power Cables

Low Voltage power cables refers to cables for use on circuits having a nominal voltage rating of above 50V and below 1000V for AC and above 120V and below 1500V for DC.

3.3.1. Conductor

Low voltage power cables must be class 2 stranded annealed copper conductor with minimum number of strands and maximum DC resistance of the conductor at 20ºC in accordance with AS 1125. All cable conductors must be of circular cross-section and comprise not fewer than seven strands, unless otherwise specified. The finished cables must be circular in cross section.

Low voltage cables must be sized for compliance with AS 3008 regarding current carrying capacity, voltage drop, short circuit temperature limit, and earth fault loop impedance. Cables must be fault rated for one second. The sizing of neutral and earthing conductors in each different cable type must conform to the requirements of AS 3000.

Minimum conductor size must be 7/0.67mm (2.5mm^2).

3.3.2. Insulation and Sheath

Cable insulation will be cross-linked polyethylene (XLPE) or V-90 grade PVC and must be rated at 0.6/1 kV. Speciality insulation materials may be required to suit certain scenarios (i.e. submersible motors) and must approved by SHL.

Cables must be V-90 grade PVC bedded and sheathed. In certain scenarios, such as where fire resistant cabling is required, clause D9.2 applies. Cables must be V-90 grade PVC bedded and sheathed. Cable mechanical protection must be provided in accordance to AS 3000. Where available, cable length markings of a contrasting colour must be indelibly printed on the sheath at one-metre intervals throughout the full length of the cable. Embossed length markings may be used, subject to approval by SHL.

3.3.3. Screening

Screening is required on cables carrying harmonic currents (i.e supplying variable speed drives).

Metallic screen must be continues over all the cores for the length of the cable. The screen material must be of copper tape having a thickness of not less than 0.075 mm.

3.4. Specific requirements for protection and measurement cables

All signal cables used between instrument transformers (i.e. current and voltage transformers) and protection relays, Automatic Voltage Regulators and Power Quality Meters must have a continuous copper tape screen for the length of the cable.

All signal cables between sensors (i.e. limit switches) and protection final elements (i.e. circuit breaker trip coils, trip solenoids) must a continuous copper tape screen for the length of the cable.

The copper tape screen thickness must not be less than 0.075 mm.

3.5. Specific requirements for Variable Speed Drive (VSD) cables

Power cabling between the Switchboard and the VSD and the VSD and its motor must be specifically made for variable speed drive applications. The cable must have three balanced earth cores and must be shielded in accordance with Section D4.3 to minimise the level of radiated electro-magnetic fields. VSD power cables must be run in a dedicated support system. Power cabling to and from the VSD must be equivalent in size and must be sized in accordance with AS 3008. Control cables must be shielded and installed in metal conduit or metal ducts at least 300mm from the motor power cables.

3.6. Control and Signal Cables

Control and signal cables refers to cables for use on circuits having a nominal voltage rating not exceeding 50V AC and 120V DC. Control cable refers to multicore control cables and signal cable refers to multi-pair screened cables. It is preferred that signal cables are used for both extra-low voltage digital and analogue signals and not just analogue signals.

Multi-core control cables must not be used as a combined power and control cable.

3.6.1. Conductor

Control and signals cables must be class 2 stranded annealed copper conductor. All conductors must be tinned.

All cable conductors must be of circular cross-section and comprise not fewer than seven strands, unless otherwise specified. The finished cables must be circular in cross section.

Minimum conductor size must be 7/0.30 mm ($0.5mm^2$).

3.6.2. Insulation and Sheath

Control cable insulation must be V-90 grade and must be rated at 0.6/1 kV. Signal cable insulation must be V-90 grade and must be rated at 110VAC/150VDC.

Control cables must have each core uniquely identified by a number stamped indelibly on the insulation at regular intervals not exceeding 80mm. Signal cables must have each pair uniquely identified and the pair number indelibly on the insulation at intervals not exceed 80mm.

Control and signal cables must be V-90 grade PVC sheathed. The sheath must be fire retardant. Cable mechanical protection must be provided in accordance to AS 3000.

3.6.3. Cable screen

Signal cables must be overall screened with aluminium polyester tape having a thickness of not less than 0.025mm with a tinned annealed copper drain wire of at least 7/0.25mm and rip cord. The metallic screen must

be continuous over all the twisted pairs for the length of the cable.

The drain wire must be in continuous contact with the aluminium screen.

For multi-pair signal cables each twisted pair must be individually screened.

Consideration must be given to overall screening of control cables, particularly for voltages below 48 VDC, given the environment in which they are installed. Cables used for signals, communication or data transmission purposes shall also have each twisted pair individually screened.

3.6.4. Thermocouple extension leads

Thermocouple extension leads must be screened twin or multicore tough PVC sheathed cable with solid conductors of the same metal composition as the thermocouple. Individual conductors must have a minimum cross sectional area of 0.5mm^2.

Where multicore extension leads are used each thermocouple pair must be twisted and all the pairs must be PVC sheathed individually screened pairs with an overall screen.

3.6.5. Resistance Temperature device cable

RTDs must be cabled using overall screened single or multi-triad cables with the cores twisted together in threes and with all triads number coded. The individual cores of each triad must be colour coded red, white and black and the triad number must be stamped indelibly onto the insulation of the white core at intervals not exceeding 80 mm.

Core insulation, screening and conductor stranding must be as specified for instrument cables.

3.6.6. Spare cores

All spare cores in multicore control and signal cables at the switchboard/control cubicle end must be neatly loomed together and must be of sufficient length to allow for future termination to any position on the terminal rows within the cubicle (i.e. twice the cubicle height) to which the cable is glanded. These spare cores must be identified by the cable number and detailed on the drawings. Spare cores at the field end (i.e. to a junction box) must be terminated.

The minimum number of spare cores in each multicore and signal cable that must be provided is detailed below:

Table D.2 Spare Cores

NUMBER OF CORES IN CABLE	MINIMUM NUMBER OF SPARE CORES
Up to 4	Nil
Up to 12	2
Up to 20	4
Over 20	6

3.7. Communication cabling

3.7.1. General

Cable for proprietary communication systems (i.e. Devicenet, ControlNet) must comply with the relevant standard.

3.7.2. Serial cabling

Cables used for serial data transmission purposes must have an overall screen as well as have each twisted pair individually screened. Appropriately sized terminating resistors are to be supplied.

3.7.3. Ethernet cabling

Ethernet cables must be Category 6 as a minimum. Where Ethernet cables run external to a cubicle (i.e. between cubicles), the Ethernet cable must be supplied with an overall screen.

3.7.4. Fibre optic cable

General

The use of loose tube single-mode fibre is preferred. Single-mode fibre must meet OS2 as defined in AS/NZS ISO/IEC 24702.

Fibre optic patch cables must be supplied as factory-terminated pigtails with protective caps on each connector.

The colour of the tubes must be in accordance with TIA-598-C.

Jackets

Fibre optic jackets will typically be PVC. PE jackets must be supplied where the fibre optic cable is to be installed in existing conduits to prevent damage to the cable. Where there is a risk of vermin damage to the fibre optic cable, Glass Reinforced Plastic (GRP) armoured cables must be provided.

Spare cores

New fibre optic cable installations must allow for an additional 50% spare fibres per cable. These fibres must be terminated and tested.

3.8. Special considerations

3.8.1. Hazardous areas

Where low voltage power cables and control/signal cables are required in hazardous areas, the cables must be designed and installed for the intended application and must comply with AS 60079 and AS 2381. Cables installed for intrinsically safe components must have a light blue outer sheath.

Cable glands must be suitable to the hazardous area protection utilised.

3.8.2. Fire rating

Where cables are required to be fire rated (i.e. fire systems or critical trip signals), cables must have a minimum two hour fire rating, and preferably rated as WS52W in accordance with AS 3013. The insulation must be Halogen free.

3.8.3. UV protection

Where degradation on the cable due to ultraviolet radiation is considered a risk, the sheath material must be stabilised using 2.5 ± 0.5% carbon black.

3.9. Cable and core identification

3.9.1. Sleeve numbering system

All individual cores must be provided with identification (individual core is to be labelled even if it is colour coded or has factory marking for core identification) as detailed on the connection diagrams and cable schedules. Both ends of every core must be identified with marking ferrules.

Wire markers must be slip-on transparent sleeves of self-extinguishing PVC, which are resistant to weather, acid and alkaline solvents, and into which black characters on a white background are inserted. The sleeves must be correctly sized to fit firmly over the core insulation so that on disconnection of the wire, the sleeve is retained on the core. Marking ferrules of the clip-on type or printed-sleeve type are not acceptable.

3.9.2. Markers

Markers must be provided for the identification of all cables (including earthing cables) with the identification of cables with numbers in accordance with the cable schedules. Cable located outdoors must be identified with corrosion-resistant metal tags attached securely to the cable by corrosion-resistant wire. The cable number must be clearly stamped on the metal tag. Metal cable markers must be installed such that there are no sharp edges which may cause damage to cable sheaths or injury to personnel. Plastic cable markers may be used only in indoor locations. Plastic cable markers are to be Critchley Unilabel or K-type markers with black text on a yellow background.

Cable markers must be installed adjacent to the glands at each end of every cable, and be clearly visible. Where necessary, cable markers must be installed on both sides of the gland to achieve this requirement. Cables must be fitted with markers above and below gland plates. Cables run underground must be fitted with labels where they merge from conduit or trench and at each intermediate cable pit.

3.10. Cable installation

3.10.1. Cable restraints and supports

At all changes in direction and at other positions where restraint is required to maintain the position of cables on the ladder, nylon cable straps must be used which are suitable rated for their application (mechanical strength over the life of the installation, UV rated for outdoor application, etc). Spring clip cable supports are not permitted.

Cables run in the vertical plane must be supported either by cable clamps fastened to channel fixed directly to walls or steelwork specifically for the purpose or secured to the rungs of the cable ladders in a similar manner to that used for change of direction above. Cables must be supported at intervals not exceeding 900 mm or closer as directed by SHL. Small cables may be neatly bunched on vertical runs and supported by cable or pipe clamps.

All three phase a.c. power circuits comprising single-core cables must be installed in trefoil formation throughout their entire length, whether enclosed in conduit or run in ladders. Where multiple circuits are required, like phases are not to be grouped together in trefoil formation. Trefoil arrangements comprising of Red-White-Blue phases will only be accepted.

Where trefoil groups are installed on ladders, a system of mechanical support must be provided to restrain the cables from movement under short-circuit conditions. Restraints must be designed, tested and installed in such a manner to prevent movement or breakage of the restraining clamps, prevent permanent harmful deformation of the cables, and prevent the cables from damaging adjacent cables, equipment or personnel.

Single core cables must be installed so as to avoid hysteresis and eddy currents in surrounding metal work or cleating.

3.10.2. Cable lugs

Lugs must be fitted to all cables.

Power cable lugs must be electro-tinned manufactured from seamless solid drawn copper tube and designed for connection to the conductors. Lugs sized for 16 mm^2 and above must have circumferential hexagonal crimps whilst indent crimping must be utilised for the smaller sizes. Only plain non-insulated lugs must be used on power cables. Crimping tools and dies designed, tested and recommended by the cable lug manufacturer for the crimping of their cable lugs must be used. Evidence of this must be permanently imprinted on the finished crimp.

3.10.3. Cable glands

All cables must be installed with suitable glands, Glands must provide a degree of protection of IP68.

In outdoor situations, for power and control cables, glands must be metal compression glands or a UV resistant PVC. In indoor situations, metal glands must be used on power cables having an outer sheath diameter 25 mm and greater.

In indoor situations, plastic compression glands may be used on power cables less than 25 mm in diameter, and all control cables.

Glands must be fully waterproofed including the fixing to the gland plate. All unused gland entries must be sealed using proprietary blanking plugs.

When drilling is carried out in cubicles measures must be taken to ensure that electrical equipment or terminals installed in the cubicle do not become contaminated by swarf. Swarf must as much as practical be contained at the source.

Cable supports must be supplied and installed so that no more than one metre of cable is supported by the compression gland.

3.10.4. Termination of power circuits

Power cables must be glanded at each termination. The cores must be saddled or tied and each must be provided with one loop then terminated with a compression lug. Lugs must be crimped using the tools and methods specified by the lug manufacturer. Pre-insulated lugs must be used where possible.

Each cable must be cut square and the minimum length of insulation and sheath must be removed. Care must be taken at all times to ensure that the strands of the cable are not damaged when removing insulation. Correct cable stripping tools must be employed.

Cable lugs must be selected to suit the cable core size and the mounting bolt.

Crimping tools and dies designed, tested and recommended by the cable lug manufacturer for the crimping of

their cable lugs must be used. Evidence of this must be permanently imprinted on the finished crimp.

Stainless steel Grade 304 bolts, nuts, washers and spring washers must be used to complete the connection. A flat washer must be placed under the head of each bolt, and a flat and a spring washer under each nut.

Phase-coloured heat-shrinkable plastic sleeves must be applied over the lug body and at least 25mm of the core insulation. This need not be applied to pre-insulated lugs. The sleeves must be coloured red, white or blue as appropriate.

In other applications where lugs are not appropriate, the cores must be stripped of insulation and tightly clamped at the terminating point. Bare conductors must not be exposed beyond the terminating point.

3.10.5. Termination of control and signal cabling

All control and signal cables must be terminated using lugs or pins of pre-insulated type as required. Control and signal cable conductors must be terminated so that there is no exposed live metal at the termination.

Where multi-stranded control and signal cables terminate into screw-clamp tunnel type terminals, 'boot-lace' type cable ends with insulated sleeves must be used. The cable ends must be properly crimped using the correct tool prior to fitting in the terminal. The cable ends must be fitted strictly in accordance with the manufacturer's recommendations and only one conductor must be terminated in each cable end.

3.10.6. Termination of screen wires

Screen wires must be terminated in accordance with Annexure K – Low Voltage Earthing.

3.10.7. Termination of Thermocouples

For thermocouple extension leads, connections must be screwed and the number of such connections must be kept to a minimum.

In cases where the relative movement between thermocouple and adjacent cable supports is small, the extension cable may be connected directly to the thermocouple. Where this relative movement is large, the extension lead must be enclosed in flexible conduit. This conduit must be terminated at a local junction box and must be of sufficient length to allow for the maximum relative movement, which can occur.

3.10.8. Specific requirements for the installation of fibre optic cables

General Requirements

The installation of fibre optic must be to the manufacturer’s specification and ensure compliance with the relevant Australian Standards for all fibre optic cable runs.

The cable must be separated from other services (ie. water, air/gas lines, etc.). The cable must be installed in separate trays/pipes/conduits and separately supported away from such services. Under no circumstances must the cable be tied to or installed with such services. Fibre Optic cables must be run in communications/data cable tray only or where required to be run on Low Voltage cable tray must be segregated from the low voltage cables by a suitable mechanical barrier.

Terminations

The installed attenuation for connections must be:

Table D.3 Installed connection attenuation

Average	Maximum	Comments
0.5 dB	1.0 dB	Connector to connector interface. (Note 1)
0.2 dB	0.4 dB	Mechanical through splice.
0.1 dB	0.2 dB	Fusion through splice.

Notes:

1. The average initial installed connector loss (for the batch of new connectors) must approach 0.5 dB per mated pair. All connectors must be individually guaranteed (including over time aging effects) to not exceed the maximum of 1.0 dB loss per mated pair.

2. The average losses of all the new connections must approach the average figures listed above. Individual connections that greatly exceed the average measured losses (within the group of new connections); will require explanation and possible correction.

Cable glands must be installed when terminating fibre optic cables into termination panels. Where SWA cables are used, suitable cable glands must be used.

All cable glands must be shrouded.

When cable glands are installed on SWA cables, no armour must be exposed. Earth tags must be individually bonded to the equipment earth bar.

Cable glands installed on gland plates other than brass, must be fitted with brass earth tags and brass locknuts.

Cable entries in switchboards and panels, must be installed in such a manner as to permit the orderly accommodation of the total potential requirement for cable glands at each location.

As a general rule, non-specified splice joints or cable joints using junction boxes in fibre optic cable are not acceptable. All joints in fibre optic cable are to be approved by the SHL prior to installation.

3.11. Penetrations and sealing

All floor and wall cable penetrations which have been specifically allocated for cable installation, on completion of the cable installation or at the direction of SHL, whether such penetrations have been utilised or not, must be sealed.

For the method of sealing cable penetrations to be considered the method must satisfy the following criteria:

- A certified and tested method.
- Additional cables must be easily installed once the penetration has been sealed.
- The sealant can provide the required rating.
- The sealant is asbestos free.
- The sealant does not crumble and generate dust.

3.11.1. Penetration requirements

Fire proof sealing

Where cables, including cables is ducts, trays or trenches, pass through a concrete wall, floor or ceiling or enter or leave pipes the space between concrete or pipe and the cables must be sealed with a fireproof sealing with a

minimum of 2 hour fire rating. Cabling through concrete floors into bottom entry cubicles is included in this requirement. The method of fire sealing must be approved to the above rating by either Factory Mutual (FM) or Underwriters Laboratory (UL).

Weather proof sealing

Cable pipes and ducts entering buildings and pits must be first fireproofed with the seal described above then sealed with plastic weatherproof compound similar to BICC compound No. D391. Plastic Pipes/Conduits passing through walls and floors must use KBS or Hilti pipe seals in addition to the fire rated seal.

Cable trenches entering buildings and openings between building interiors and external cable pits must, at the point of entry, have the fireproof seal overlaid with a weatherproof compound on the external side.

Cable trenches entering buildings and openings between building interiors and external cable pits must, at the point of entry, have the fireproof seal overlaid with a weatherproof compound on the external side.

Vermin and insect proof sealing

All cable penetrations into conduits (including in cable pits) must be sealed using grout to prevent vermin from entering.

The sealing must be carried as per the manufacturers instructions.

3.11.2. Appearance

The seals around the cables must be trimmed as required to give a neat appearance and be match-painted when forming part of painted concrete surfaces.

3.12. Cable support systems

3.12.1. General

Cables must be run using one of the following methods:

- Steel ladder
- Perforated steel tray
- Exposed steel or PVC conduit
- Underground PVC conduit
- Direct buried

Cable routes must avoid areas of high ambient temperature and areas subject to fire hazards whenever possible. All cables must be clear of pipework, walkways and areas used for operating and maintenance. No cables must be run beneath valves, pipe joints or other areas subject to leaking fluids unless a protective covers is installed to prevent damage to cables by leaking fluids. All penetrations of cable support systems through floors and walls must be sealed to prevent the spread of fire.

Care must be taken to run cable support systems either perpendicular or minimise parallel runs as much possible when adjacent to High Voltage bus and cabling. This will assist in minimising the inductive coupling between the cable support systems and High Voltage cabling.

Customised fittings must only be used where accessories are not available as proprietary items.

3.12.2. Cable ladder

Type

Unless otherwise approved, cable ladders must be of the open type. Cable ladders to be supplied must be rated for either light, standard or heavy duty according to the application and must meet the requirements of NEMA Standards Publication VE1-2009 "Cable Tray Systems", and must be installed in accordance with the manufacturer's recommendations.

Cable ladders, and accessories must be preferably manufactured form aluminium. If manufactured from steel they must be hot-dipped galvanised after forming and must have rungs at a spacing not greater than 300 mm. Cable ladder rungs must have slotted holes suitable for fixing cables with cable ties. The side rails of the cable ladders, and all bends, risers, tees and similar fittings have a rolled or double return top edge of at least 10 mm diameter (or width).

Installation

Cable ladder systems must be of an established design equal to Burndy or GKN type complete with horizontal bends, tees, inside and outside risers and all the necessary accessories including splices, support brackets, hangers, clamps etc. Double hanger rods or single centre rail supports are acceptable. Other designs may be suitable if the adequacy of the strength design can be demonstrated.

All changes of direction of cable ladder must be achieved via standard smooth sided fittings, which are free from sharp edges. The practice of changing direction by butting together straight sections is not acceptable. "Crosses", "Tees", "Bends" or "Hinged Splices" must be used as applicable to achieve the change in direction.

Expansion joints must be provided in accordance with manufacture’s specification.

The loading of cable ladders must in no case exceed the manufacturer’s recommended design load.

The span deflection of cable ladders must not exceed the ratio of 1 in 200.

Covers

Where the cable ladders are installed outdoors, covers of accepted design and manufacture must be provided and clamped to the top of the ladder array to protect the cables. Painting of galvanised cable ladders will not be required unless otherwise specified.

3.12.3. Cable tray

Type

Unless otherwise approved, cable trays must be of the open type.

Cables trays must be perforated and must be hot-dipped galvanised trays with returned edges not less than 12 mm high, made from not less than 1.5 mm think sheet steel. Trays must be installed with the returned edges against the wall or ceiling surface. Cable tray in corrosive areas must be constructed of fiberglass and must be subject to the approval of SHL.

Cable saddles must be fixed to the perforated cable trays with screws and nylon-type nuts inserted from the cable side into the slotted holes.

Installation

Cable tray installation must ensure a minimum head height of 2,000mm for all areas generally accessible by personnel. Installed cable tray must maintain a minimum clearance of 300mm between all hot pipe work and other cable support systems. Separate cable trays must be installed for Power, Control and communications/data cabling, trays must be installed with the power tray on top, followed by control and then communications/data. All vertical runs must be protected from mechanical damage for a distance of 2,500 mm from any floor.

Covers

Where the cable trays are installed outdoors, covers of accepted design and manufacture must be provided and clamped to the top of the tray array to protect the cables. Painting of galvanised cable trays will not be required unless otherwise specified.

Cable Ties

Unless otherwise approved, the following type of cable ties must be used:

- For multicore cables, nylon cable ties with a minimum tensile strength of 530N, similar to Burndy type TF-7D.
- For single-core power cables protected by HRC fuses:
    - For holding in trefoil formation, stainless steel ties complete with stainless steel buckles, 12.5 mm wide with a minimum tensile strength of 2kN.
- For fixing to cable ladders, nylon ties in accordance with a minimum tensile strength of 530N, similar to Burndy type TF-7D.For single-core power cables not protected by fuses, for holding in trefoil formation, stainless steel ties complete with stainless steel buckles, not less than 12.5 mm wide with a minimum tensile strength of 4kN.

3.12.4. Cable Cleats

Trefoil cable cleats must be of non-magnetic material, fitting the contours of the cable and securely anchoring the cable into position. The cleats must be capable of withstanding bursting forces of 4kN due to fault current in the cable.

3.12.5. Brackets and supports for ladder and tray

All supporting steelwork must be of adequate strength and hot dipped galvanised after manufacture.

SHL prefers that standard proprietary cable ladder brackets or supports are used as extensively as possible in the execution of these works. Brackets or supports based upon the Unistrut P1000 Series or approved equivalent range of products is acceptable. Braced cantilever support brackets must be used to facilitate the cable installation.

Where standard proprietary cable ladder brackets or supports cannot be used, the design of brackets and supports must be based on a minimum of 51 x 51 x 6.5 mm steel angle. Fabricated brackets or supports must be galvanised.

To prevent ladder distortion and/or deflection particularly where fittings are installed, SHL will require each separable ladder section or fitting to be supported. In the absence of Manufacturer’s recommendation in this respect, the ladder sections and fittings must be supported in accordance with the requirements of the NEMA Standard Publication VEI-2009.

On-site welding of brackets and supports to the station structural steelwork must be carried out only in those areas not adversely affected by the weather. Following welding, the surfaces must be de-slagged, thoroughly

power wire brushed and the surfaces affected reinstated to their previous condition. It should be noted that the "previous condition" may be the final finish. In areas susceptible to weather or impure water influence, galvanised cable tray brackets or supports must be fixed using mechanical means such as galvanised nuts and bolts or U-shaped brackets. In these areas, galvanised surfaces must not be disturbed by welding.

The proprietary brackets and fabricated supports must be capable of bearing the full potential loads of cables and ladders without distortion and with a factor of safety of not less than 1.5.

3.12.6. Intermediate Cable Supports

Intermediate cable supports must be provided where cables leave cable trays headed for conduits or equipment cable glands or otherwise. The cables must be supported at not less than 900 mm centres in the vertical plane not less than 300 mm in the horizontal plane.

Cables may be saddled to steelwork using double sided saddles secured with metal threads screwed into tapped holes or to brick or concrete walls with expanding metal insert fasteners. Impact fasteners must not be used. Saddles must be provided at regular intervals to ensure that cables remain straight and free from sags. Cables run in this manner must be protected at all points subject to possible mechanical damage. Conduits may be used to carry cables where other support systems are not available and where mechanical protection is required. Power cables must be supported by an accepted structure, which may be galvanised fabricated steel. Cables rising out of cable ladders may be supported at the sides of cable ladders at a higher level. Large numbers of cable rising together beneath equipment such as switchboards must be supported in a manner of the approval of SHL.

Where applicable, due allowance must be made for relative movement between the equipment and the fixed cable support by terminating the cable at the last fixed support in a local junction box and cabling the remainder of the circuit in flexible conduit. The junction box and the equipment must be properly glanded to maintain the integrity of the circuit.

Conduits

Conduit and fittings must comply with AS 61386 and must be installed in accordance with AS 3000. Metallic conduit and fittings must be hot dipped galvanised. Metallic fittings must be malleable cast iron. UPVC conduit must be of the heavy duty type.

Conduits for the support or protection of individual cables, in accordance with AS/NZS 3000, must be provided where other support systems are not available or where mechanical protection is required.

Conduits and their fittings must be manufactured of either hot dipped galvanised steel (high protection), flexible metal or PVC in accordance with AS 61386, depending upon the application. Where a continuous conduit installation is used it must be installed with a degree of protection of IP 65 to AS 60529.

Metallic conduit only must be used in areas having ambient temperatures in excess of 50°C.

Metallic conduit must not be used in areas subject to corrosive fluids and where installed in wet areas must be self-draining.

The ends of all metallic conduit must be bushed with nylon bushes or an accepted equivalent. Screwed fittings must be used at all joints.

Damage to the galvanised surface of metallic conduit must be repaired in accordance with the General Engineering Requirements.

PVC conduits must not be installed in areas exposed to direct sunlight. Rigid PVC conduit must be orange, heavy duty and must be installed in areas of high corrosive influence. The manufacturers recommended adhesive is to used and care must be taken to ensure that the joints are permanent.

Flexible conduit must be black PVC sheathed metal spiral wound, and must be supplied complete with accepted terminators providing an oil and water tight installation.

Conduit must be screw fixed to surfaces using double sided saddles at spacings as follows:

Conduit type	**Required spacing**
Metal conduit	Not greater than 1500 mm
Rigid PVC Conduit	Not greater than 900 mm
Flexible Conduit	Not greater than 900 mm

Saddles must be fixed to steelwork with metal threads screwed into tapped holes and to brick and concrete walls with expanding metal insert fasteners. Impact fasteners must not be used.

3.12.7. Earthing

Earthing of cable support systems must be in accordance with Annexure K – Low Voltage Earthing.

3.13. Underground wiring systems

3.13.1. General

Before commencement of excavation of any cable trench, all precise alignments and finished site levels must be confirmed. Any existing underground utilities must be positively identified and marked prior to starting excavation. Excavation must occur under the appropriate permit.

Trenches must be kept to the minimum width and must have vertical sides. The excavation must be sheeted and strutted as necessary to prevent falls and all sheeting and struts must be removed in the course of backfilling.

Care must be taken to keep cable trenches free from water.

The trenches must be left open for a minimal period and backfilling must take place as soon as possible after the last cable has been laid in the trench, and inspected.

All excavations must be backfilled with accepted material, which must be free from large rocks and compacted to minimise trench slumping.

Immediately following reinstatement of cable trenches, cable route markers must be installed. These markers must be installed no greater than 25 metres apart and at each extremity of a change in direction and meet the requirements of AS 1319.

Drawings containing the ‘As Built’ location of all new installed services must be provided.

Excess spoil must be removed.

3.13.2. Buried Conduits

All conduits must be Heavy Duty light orange conduit.

Cables laid in conduits buried in the ground must be buried to such a depth as to give 600 mm from the top of the conduit to the finished site level.

The conduit must be laid on at least 100mm layer of stone-free bedding material (clean soil or bedding sand) and at least 100mm cover of stone-free bedding material compacted to minimise trench slumping.

Wiring systems installed underground must be identified by an orange marker tape complying with AS 2648.1 and installed in accordance with AS 3000 Section 3.11. For trenches wider than 450 mm two tapes must be installed.

3.13.3. Direct buried cabling

Direct buried cable is not SHL's preferred cable installation method for underground wiring systems and is only to be utilised on the approval of the relevant asset owner.

Changes in direction of cable routes must be made in even sweeps of a radius of not less than twenty times the diameter of the largest cable to be installed.

Cables laid direct in the ground must be buried to such a depth as to give 750 mm from the top of the cable to the finished site level.

Where cables leave cable ducts laid directly in the ground, the cables must be supported adequately to prevent damage to the cables at the ends of the conduits.

The cable must be laid on an 50 mm bedding of sand with a further 50 mm layer of bedding sand placed on top of the cables. The bedding material must have a dry thermal resistivity not exceeding 1.2 Km/W. The bedding sand must contain no extraneous matter, particularly in the form of rocks or clay powder, and must be well graded from coarse to medium.

Where two or more power cables are laid in a common trench, they must be placed no closer than a centre to centre spacing of 150 mm.

The bedding sand must not be rammed following laying.

Acceptable cable covers must be installed in accordance with AS 4702.

Wiring systems installed underground must be identified by an orange marker tape complying with AS/NZS 2648.1 and installed in accordance with AS/NZS 3000 Section 3.11. For trenches wider than 450 mm two tapes must be installed.

3.13.4. Cable pits

Cable pits must meet the following minimum requirements.

- Precast concrete pit with a minimum strength of 35Mpa at 28 days.
- A minimum inside dimensions of 1000mm x 1000mm (depth to suit conduit buried depth with side entry)
- 100mm dia. drain hole in the base of the pit.
- At least 2 pit covers (galvanised steel frame precast concrete cover and galvanised 'T' support between covers) clearly marked "ELECTRICAL CABLE".
- Cast iron lifting sockets that require the aid of a special tool to remove the pit covers.

- Conduit penetrations at least 100mm from the base of the pit.

A maximum distance between cable pits must not exceed 250 metres.

Cable pits must not be installed in locations subject to vehicular traffic.

Cable pits must be used:

- Where change in direction of conduit alignment is more than 10 degrees.
- Where interface is required between different cables routes.
- Each end of an under road crossing.

Cable pits must be installed either:

- 100mm above the finished ground with the surrounding soil graded up to the top of the pit (non paved/concreted or non pedestrian areas) and must have 50mm dia. Galvanised pipe bollards at each corner of the pit; or
- Flush with the paved/concrete in area.

Note: Protective Bollards must be installed at each corner of the cable pit where there is a potential for vehicles to drive over the top of them.

Drainage of pits must be done either:

- By providing a drainage pit filled with 20mm-40mm graded rock, covered with geo-textile fabric, sloping away from the cable pit. The minimum size of the drainage pit must be 300mm wide by 300mm deep by 2000mm long; or
- Connect the drain to the storm water drainage system. With this option the pit drain outlet must be installed with a grid to prevent vermin from entering the cable pit.

Cable pit conduit entries points must be sealed to prevent water ingress.

Cables must be supported by a ‘unistrut’ frame at intervals not exceeding 500mm and at heights equal to the bottom of the conduit entry. This is to ensure the stress at the cable entry is kept to a minimum and the cables are kept clear of the cable pit floor.

3.14. Segregation

Internal wiring layout design must ensure maximum separation between power and signal wiring.

3.14.1. Voltage

The following voltage of circuits must be segregated into separate conduits/ladder/trays or separate compartment of a conduits/ladder/trays in accordance with AS 3000:

- Low voltage power cables (above 50 VAC / 120 VDC and up to 1000 VAC / 1500 VDC)
- Low voltage control cables (above 50 VAC / 120 VDC and up to 1000 VAC / 1500 VDC)
- Extra low voltage power and control cables (below 50 VAC and 120 VDC)
- Signal cables – screened twisted pair

3.14.2. Category

Cabling for the following categories of circuits must be segregated into separate cables and where practicable run over separate routes or ladders and must use separate marshalling enclosures. Proposed departures from

this requirement must be submitted to SHL for approval in each case:

- Protection, alarm, control and indication circuits and unit auxiliary circuits of one generator unit from those of another unit;
- 'X' and 'Y' duplicated AC and DC protection circuits of each unit from each other; and
- Circuits from non-unit equipment.
- ACA standards for segregation of communication cables.

Control cables must be dedicated to one unit of plant and contain one voltage group. Power and instrument cables must be segregated in accordance with BS 6739.

3.15. Testing of Cables

3.15.1. Low Voltage Cables

All cable installations must be tested and verified in accordance with AS 3000 section 8. The tests must include the following:

- Visual inspection
- Earth continuity
- Insulation resistance
- Polarity
- Correct circuit connection
- Earth fault-loop impedance

Completed test record sheets with measured values must be submitted to SHL for approved.

3.15.2. Fibre Optic Cables

The minimum testing requirements for testing of fibre optic cables is detailed below.

Testing must use an optical light meter and light source. All tests must be performed in both directions. The accuracy and calibration of the test equipment must be specified in the final test report.

All terminated fibres, must be tested:

- Individually (ie. Basic Cable Loss Tests; from connector to connector without intermediate patchable connections) and,
- From device to device (ie. System Link Loss Tests; with all intermediate patch-cords in place, including end patch-cords).

All new cable's distance measurements, installed must be accurately recorded, by either using OTDR measurements or if available from the cable's own meter markings. These results must be detailed in the final test report.

For all tests, the following must be recorded as a minimum:

- The equipment used and their serial numbers
- the test method used
- date of testing
- the measured length of the fibres
- the loss in dB
- the wavelength used in the test

- identifying numbers of the cable and fibres

All point to point terminated fibres theoretical losses must be calculated, assuming the maximum cable manufacturers specified loss (in dB/km), times the length of the fibre being tested, plus the sum of all the additional losses (for splices and connectors).

If the measured loss exceeds the theoretical value the connection must be deemed to have failed and must appropriately rectified.

If the measured loss is less than theoretical value the connection must be deemed to be acceptable.