Standard

HV and LV Cable Systems Standard

R0000590630

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Authorisations

Action	Name and title	Date
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Reviewed by	Santosh Dhakal, Asset Engineer	June 2018
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Review cycle	30 months	

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Minimum Requirements

The requirements set out in TasNetworks' documents are minimum requirements that must be complied with by all TasNetworks team members, contractors, and other consultants.

The end user is expected to implement any practices which may not be stated but which can be reasonably regarded as good practices relevant to the objective of this document.

Record of revisions

Section number	Details
Entire doc	Updated Transend to TasNetworks document reference numbers where known including Australian Standards.
Authorisations	Review cycle changed from 60 months to 30 months.
6.4	Removed section
4.3.2 (a)	Added detail for flush finished mortar in switchyard.
4.12	Modified to have external and internal sections
6.3.1 (g) (h) (i)	Added
6.3.4 (d)	Added "10mm^2 and under or fine multi-stranded wire"
6.6	Added
7.2 (b)	Added
10.3	Changed from "Routine Test" to "FAT"

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1 General

1.1 Purpose

To define the requirements of high voltage (HV) and low voltage (LV) cable systems under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as "TasNetworks").

1.2 Scope

This standard applies to all HV and LV cables under the responsibility of TasNetworks.

Specific requirements for extra high voltage (EHV) cable systems must be in compliance with document EHV Cable System Standard R565986.

This standard contains requirements for design, engineering, manufacture, construction, testing at manufacturer's works, secured packaging, supply, transportation, delivery to site, testing and commissioning with complete documentation of cable systems and is to be applied to new installations as well as redevelopment of part or all of existing installations.

1.3 Objective

TasNetworks requires design, construction, installation and commissioning of equipment and services as covered in this standard to ensure:

(a) personnel and public safety;

(b) safety of TasNetworks' assets;

(c) the requirements of the PSSR are met;

(d) that the requirements of the Tasmanian Electricity Code (TEC) and National Electricity Rules (NER) are met;

(e) TasNetworks meets its performance objectives; and

(f) the exposure of TasNetworks' business to risk is minimised.

1.1 Precedence

Any apparent conflict between the requirements of this standard and the law, mandatory requirements, industry standards, project specifications, non-statutory standards or guidelines, and any other associated documents should be brought to the immediate attention of TasNetworks for resolution and no action must be taken that might result in a breach of law or mandatory requirement.

Where there may be a conflict between the requirements of this standard and any:

(a) law, mandatory requirement or industry standard, then that law or statutory requirements will prevail over this standard;

(b) non-mandatory standard, or guideline, then this standard will prevail over that standard or guideline; and

(c) project specification, then the contract documentation will prevail over this standard.

Except that, the selection of equipment, design and all works associated with substation lightning protection and earthing systems must conform to the requirements as specified in document R522687, General substation requirements standard.

1.1 References

As a component of the complete specification for a cable system, this standard is to read in conjunction with other relevant standards as applicable. Unless otherwise specified in the project specification, the equipment shall be in accordance with the latest edition and amendments of the standards listed below. The following documents, without reservation, contain provisions that, through reference in the text, constitute the requirements of this standard:

1.1.1 TasNetworks standards

Substation Civil Design and Construction Standard	R590634
Substation Lightning Protection and Earthing Standard	R522692
General Substation Requirements Standard	R522687
Extra High Voltage System Standard	R586386
High Voltage System Standard	R565983
Supply Transformer Standard	R527890
Testing, Commissioning and Training Standard	R246497
EHV Cable Systems Standard	R565986
HV and LV Cable Systems Schedule	R590633
HV and LV Cable Systems deliverables	R590632
Excavation Work Standard (Ex. D11/12740)	R192947
Excavation Procedure	R793081

1.1.2 Other standards

Electric cables – polymeric insulated – For working voltages 1.9/3.3(3.6) kV up to and including 19/33(36) kV	AS 1429.1
Substations and high voltage installations exceeding 1 kV a.c.	AS 2067
Electric cables – polymeric insulated – For working voltages 19/33(36) kV up to and including 87/150(170) kV	AS 1429.2
Electric cables - Twisted pair for control and protection circuits	AS 2373
High Voltage switchgear and controlgear - Dimensional standardization	AS 62271.301
Underground marking tape – Non-detectable	AS 2648
SAA Wiring rules	AS/NZS 3000
Electrical installations-Selection of cables	AS/NZS 3008
Installation requirements for customer cabling (Wiring Rules) AS/ACIF 009	
Approval and test specifications - Electric cables - Thermoplastic insulated for working voltages up to and including 0.6/1 kV	AS/NZS 5000
Cable protection covers	AS 4702
Conduits and fittings for electrical installations	AS 2053.1

Installation requirements for customer cabling (wiring rules)	AS/ACIF S009
Guide on EMC in Power Plants and Substations	CIGRE SC36 WG04 1997
Insulation coordination - (phase-to-earth and phase-to-phase above 1 kV) - Application Guide	IEC 60071-3
Power cables with extruded insulation and their accessories for rated voltage above 30 kV up to 150 kV – test methods and requirements	IEC 60840
Power cables with extruded insulation and their accessories from 1 kV to 30 kV	IEC 60502-2
Test requirements on accessories for cables with rated voltages from 6 kV up to 30 kV	IEC 60502-4
IEEE Guide for field testing of shielded power cable systems using very low frequency (VLF)	IEEE 400.2
NEMA Standard	VE-1

2 General Requirements

Project specific requirements for the cable systems will be listed in the project specifications.

2.1 Data for asset management information system

TasNetworks maintains comprehensive Asset Management Information System (AMIS) that contains all design, test results and condition of all TasNetworks assets. The AMIS also contains maintenance regimes for all assets.

The Contractor must provide information required to maintain the currency of AMIS for each asset in standard proformas. TasNetworks will provide the proformas to the selected Contractor. The proformas are required to be populated for both new and decommissioned assets.

The completed proformas must be filled in and submitted to TasNetworks as below:

(a) design information and maintenance regime information for all assets must be submitted to TasNetworks before commencing installation on site; and

(b) information on test results for all assets must be submitted prior to commissioning.

2.1 Civil works

All civil works associated with cable systems must be in accordance with document Substation Civil Design and Construction Standard R590634, and the Excavation Standard R192947.

2.2 Earthing

Earthing of all equipment and works associated with cable systems must be in accordance with document Substation Lightning Protection and Earthing Standard R522692.

2.3 Service conditions

Environmental conditions and any specific design criteria for particular works will be stated in the project specifications. Minimum service conditions for cable systems are stated in the General Substation Requirements Standard R522687.

All equipment must be capable of operation at its specified rating without assisted means, for example, forced cooling will not be permitted to achieve the rated capacity.

2.4 Performance

Cable systems must, as a minimum meet or exceed the following performance criteria:

(a) cables and accessories must provide reliable performance and be designed for an intended service life of 50 years; ensure reliability, security and redundancy;

(b) the performance of the cables and its accessories must meet all specified electrical, mechanical and environmental criteria under both normal and abnormal system conditions, such as rated fault current and duration;

(c) HV cable and its accessories must be capable of meeting its rated current-carrying capability continuously, without degradation to the service life. The continuous rating is not to take into account any cyclic or intermittent loading that may occur;

(d) HV cable and its accessories must be segregated from existing services by at least 1.0 m horizontally and 0.5 m vertically, such as telecommunications, water, sewerage and electricity distribution network service provider's infrastructure, so as to not interfere with their existing function, impose a safety hazard or interfere with the HV cables function;

(e) the selection of equipment, design and all works associated with HV cable must conform to the requirements as specified in document General Substation Requirements Standard R522687;

(f) details of maintenance items, their accessibility and the frequency of maintenance must be provided with the tender; and

(g) the selection of the equipment must be based on most severe of:

  (i) requirements mentioned in this standard;

  (ii) project specifications; or

  (iii) results from system analysis and requirements as stated in document General Substation Requirements Standard R522687.

3 Cable Systems

3.1 General design requirements for cables

Design and selection of cable sizes and cable types must take into consideration the requirements mentioned below, and in accordance with AS/NZS 3008:

(a) cables must be suitable for most onerous of:

  (i) outdoor installation;

  (ii) indoor installation in ducts; or

  (iii) exposed to direct sunlight.

(b) to meet the design requirements, electrical and mechanical design of the cable circuits must be undertaken.

(c) The design of LV cable systems must not contain parallel conductors regardless of voltage drop or current carrying capacities for the purpose of cable selection.

(d) cables must be rated and installed to support the circuit maximum input and output powers, taking into account the maximum overloads that may occur, without any overheating and without any degradation to the service life.

(e) appropriate de-rating factors must be applied in the cable sizing calculations for factors that are different to the conditions nominated by the cable manufacturer in determining the standard cable current ratings. The de-rating factors must compensate for without limitation:

(i) the variations in the ambient temperature;

(ii) the variations in soil temperatures;

(iii) group heating effect;

(iv) depth of underground installation;

(v) cable laying formation;

(vi) thermal resistivity of the soil; and

(vii) spacing.

(f) the cable oversheath must be designed to withstand the extremely high UV index pertaining to Tasmania.

(g) the design of the cable systems must ensure that:

(i) the reliability requirements as stipulated in standard General Substation Requirements Standard R522687are met; and

(ii) adequate provision is made for future expansion as defined in the project specifications.

(h) the design and design calculations must include, but not be limited to:

(i) cable size and sheath size calculation;

(ii) cable sheath, single or double point-bonding system;

(iii) voltage rise under fault conditions for single point bonding;

(iv) type of installation, (eg in ground direct buried/conduit /cable trenches/cable ducts; above ground; cable tunnel);

(v) selection of cable route; and

(vi) for HV cables, thermal performance of the cable installation.

(i) where cables enter or pass through the switchyard or at locations possibly subject to electromagnetic or electrostatic interference, they must be screened.

4 Installation requirements for cable systems

The cable systems must be installed such that:

(a) their installation is in accordance with manufacturer's recommendations;

(b) cables are be installed in cable ducts for interior routes or conduits elsewhere;

(c) outdoor cables are laid in conduits unless otherwise specified in project specifications;

(d) cables are not direct buried unless specifically allowed in the project specifications;

(e) the final installation must be able to withstand any vehicular loading that may occur;

(f) all cables are installed for easy access throughout the entire length for future replacement and repair; and

(g) all new cable supports, ducts and conduits are filled to no more than 50 percent of their working capacity to permit future expansion or modification; and

(h) cables damaged during installation are replaced in their entirety. If TasNetworks has reason to doubt the integrity of the cable system, TasNetworks reserves the right to reject the cable system even if there is no sign of it being damaged.

Details of the cable installation must be included in the design documentation submitted to TasNetworks for review and approval before commencement of works.

4.1 Cable segregation

The installation of cables must ensure that:

(a) all cables are grouped and segregated by type and function;

(b) all cables are grouped and segregated, based on voltage level, to eliminate the possibility of induced voltages or static over voltages. Grouping must be made as follows without limitation:

(i) separate groups of EHV cables for each voltage present;

(ii) separate groups of HV power cables for each voltage present;

(iii) 400V/230V cables;

(iv) control cables including current and voltage transformers cables;

(v) DC cables; and

(vi) communication and instrumentation cables.

(c) where the number of low voltage power cables and control cables installed on a site do not warrant the installation of a separate duct or support system, special approval must be sought from TasNetworks to allow for cable installation without segregation in ducts. If TasNetworks does not approve the suggested installation, cables must be segregated and installed in separate ducts. Where cables are approved to be installed without segregation in ducts suitable, means must be provided to eliminate possible induced voltage.

4.1 Underground installations

4.1.1 Excavation

All excavation works must be in compliance with R192947 Excavation Standard.

Care must be exercised at all times to ensure that no underground infrastructure is damaged during the excavation process. Excavation must be performed by hand, unless it can be demonstrated with certainty that no underground services exist.

The Contractor is responsible for the repair of any damaged underground infrastructure at the Contractor's cost, including provision of any temporary bypass services.

4.1.2 Cable protection

Cable conduits or ducts must not be reinstated until TasNetworks has inspected the cables. Cable protection must comply with the following requirements:

(a) cable protection must be provided in all locations where cables may be exposed to mechanical damage, suitable means must be provided to protect the cables;

(b) protection of all cables, where they rise from ground, must be mechanical protected by minimum 1mm thick metallic cover to a minimum of 1200 mm above finished level;

(c) cables may use the inside of structures as a method of protection;

(d) All underground wiring systems must be installed in Heavy Duty conduit as per AS2053.

(e) All underground wiring systems are to be classified as Category 'B'. Additional mechanical protection shall be provided as specified by AS/NZS 3000.;

(f) backfilled soil must be free from wastes, metals and large debris.

4.1.1 LV and communications Cable pit installation

(a) All cable pits to be drained into the stormwater system;

(b) Each layer of backfill must be consolidated by hand until dense and firm consolidation is obtained;

(c) All pits must have a 100mm wide and 50mm thick concrete edge around all sides to prevent foreign material entry;

(d) Nominal minimum size to be 600mm long by 400mm wide;

(e) Where applicable, pits must trafficable;

(f) Unused conduits must have draw wires installed;

(g) All conduit entries must be sealed to prevent water ingress; and

(h) All pits to be installed without side wall deformation.

4.1 Above ground cable installation

4.1.1 Cable installation and support

All cables installed above-ground must:

(a) be well supported without visible sag;

(b) be adequately protected against damage;

(c) not be loosely bundled in air;

(d) all surface mounted wiring systems is to follow building lines;

(e) be easily identified throughout its entire route. They are not to be bunched or crossed; be free from kink and unnecessary bends; and

(f) be supported by suitable cable clamps at minimum of 0.6 m between each clamp. The material used in cable clamps must not induce circulating currents and must be light weight and UV resistant.

The number of layers on each level of support system must be kept to a minimum to facilitate future work. Separation between each level of support must be provided for easy access to the furthest cable at each level.

4.1.1 Cable installation sealing

The sealing of cable installations must comply with the following requirements:

(a) used and unused cable conduits and openings in the switchyard or in control building must be sealed with waterproof and fire resistant sealant material and in switchyard to have mortar on top to achieve flush finish. The sealing materials must be easily removable and resealable to facilitate future modifications to the cabling system;

(b) all cable entries must be vermin proofed;

(c) cable entries at transformer pits, including all duct lids where used, must be sealed with an approved fire resistant and oil compatible sealant to eliminate entry of water and other foreign material;

(d) all cable entries must be installed using glands as per Clause 4.12 of this standard; and

(e) all cable pits to be drained into the stormwater system.

4.1 Labelling and identification

Labelling and identification of cables must comply with the following requirements:

(a) cables must be identified throughout its entire length; and

(b) all equipment is adequately labelled to provide for safe and convenient operation and maintenance.

(c) approved surface markers must be provided to indicate the position of the cables laid directly in the ground and conduits. The markers must:

(i) be erected immediately on completion of the laying of the cable;

(ii) cables within substation boundaries require approved surface markers be placed at a maximum interval of 10 metres to indicate the position of the buried cables;

(iii) be placed at every position where the cable changes direction; and

(iv) be placed as required by TasNetworks.

(d) approved surface markers are to be provided to indicate the position of Transmission Cables located outside Substation boundaries (TasNetworks to approve surface markers prior to installation);

(i) surface markers are to be installed at distances between consecutive markers at the lesser of 50–100 m or line of sight;

(ii) at each deviation/direction change of the cable;

(iii) at both ends of road crossings;

(iv) at each end of joint bays;

(v) Where a cable is installed under a road, the surface markers are to be installed on a vertical edge of concrete gutters for ease of visibility and must be affixed to the concrete by bolts, rivets or other similar means. Glue as the sole means of affixing the label will not be permitted;

(vi) Where cables are installed in rural and peri-urban environments, the label should be affixed to a galvanised steel fencing post (typically 40 mm), extending a minimum of 800 mm above the ground, to the bottom of the marker plate;

(vii) as a minimum the markers are to be 75mm high by 200mm wide and have black lettering on yellow background;

(viii) The marker must be of non-combustible material. The wording on the marker must be legible, permanent, and fade resistant; and

(ix) Example of acceptable wording below:

"TASMANIAN NETWORKS

22 000 volt power cable

laid in this area"

4.1 Conduits

Conduits must comply with AS 2053.1 and with the following requirements:

(a) cable conduits must be heavy duty orange PVC;

(b) new cable conduits must be sufficiently sized to cater for no more than 50 per cent capacity thereby making allowance for future installations;

(c) all cable conduit openings and cable entries in transformer pits, whether used or unused must be sealed with approved type of fire and oil resistant breakable sealant material to avoid entry of water or any other foreign material;

(d) the conduit entrances at both ends must be completely sealed as necessary to prevent the ingress of moisture after the installation;

(e) all conduits entering cable pits must be fitted with bell mouthed fittings;

(f) there must be no sharp edges in any conduits; and

(g) draw out rope shall be a general purpose synthetic polypropylene filament rope of minimum dia. of 4 mm. Metallic wire or cable shall not be used as draw rope. A draw out rope shall be installed in each conduit and shall have a minimum of 1.5 m excessive length in each pit. Rope ends shall be firmly secured to prevent the ends being lost in a conduit and if used a replacement rope must be installed.

4.1 HV Cable pits

HV cable pits must comply with the following requirements:

(a) pits must be manufactured of concrete and have smooth internal walls.

(b) pits must have hooks for lifting.

(c) must have galvanised mild steel or stainless steel earthing tabs at diagonal opposite for earthing.

(d) removable cover must be placed on top of pit.

(e) the cover must be manufactured from highly durable material and must have protection against solar radiation and be abrasion resistant.

(f) it must have protective treatment to prevent corrosion. Lifting holes must be designed to prevent entry of foreign objects so lifting is not impeded.

(g) the cover must be watertight with suitable concrete sealant to achieve a good seal.

(h) all pits must be provided with drainage holes in the bottom of the pit.

(i) the pits must be connected by drain pipe to drain the water into the storm water system.

4.1 Cable route

Cable routes must comply with the following requirements:

(a) the cable routes must be selected after a careful consideration of conditions on site and must factor the implementation process of the work to avoid minimal disruptions and avoid risks;

(b) all cable installations must be neat and follow a most direct, straight route with minimum number of crossings and minimum number of bends;

(c) there must be no sharp bends along the cable installation route; and

(d) a layout drawing showing the proposed cable route with an illustrative description of the method of cable installation must be submitted to TasNetworks for review This must include, as a minimum, the formation, depth in ground and support above ground.

4.1 Cable length

The cable length must comply with the following requirements:

(a) cable must be of sufficient length for their purpose and selected route;

(b) while calculating the cable lengths allowance must be given to the following:

(i) terminations,

(ii) possible route deviations that may be found necessary during laying of the cable; and

(c) all cables must be run in continuous lengths between connected devices. 'In-line joints' to make up for shortfalls in lengths are not acceptable.

4.1 Cable bending radii

The requirement for maintaining the bending radii applies to both the following conditions:

(a) during the installation process while the cable is being laid; and

(b) the installed cable.

The minimum cable bending radii must not be less than the recommended bending radii by the cable manufacturer.

If the cables are compromised due to exceeding the recommended radius in the installation process or in final configuration, the cables must be replaced in their entirety.

4.1 Cable laying

The Contractor must provide a detailed cable haulage plan showing how the cable will be laid. The plan must consider:

(a) while laying the cables, the cables must be pulled by both the conductor and sheath;

(b) pulling of the cables must use methods and procedures as recommended by the cable manufacturer;

(c) the maximum pulling tension and maximum sidewall force as recommended by the cable manufacturer must not be exceeded during any process of cable laying;

(d) the cable ends must be sealed before it is laid;

(e) suitable means, such as pulleys, rollers at bends and proprietary brands of pulling lubricant must be used to reduce friction and tension exerted on the cable. The lubricants must:

(i) be compatible with the cable outer sheath;

(ii) not set or harden during cable installation;

(iii) not set in future; and

(iv) not consist of oil or grease.

(f) free running rollers must be positioned on the trench bottom to minimise frictional forces. The curvature of the roller must match that of the cable to ensure that the cable is not deformed;

(g) skid plates must be installed at bends and maintain a smooth effective curvature not less than the cable minimum bending radius; and

(h) the cable must not be used as a means of turning the reel in the laying process, and must be prevented from being subjected to a reverse bend as it is pulled from the reel.

4.1 Cable supports

(a) Cables in buildings and switchyard must be supported by a suitable proprietary cable support system. The system must:

(i) consist of tray type supports;

(ii) comply with NEMA Standard No VE-1;

(iii) use hot-dipped galvanised steel for indoor and outdoor installation;

(iv) be designed to carry a safe working load, including allowance for future expansion, with a minimum design safety factor of not less than 1.5; and

(v) be provided with expansion fittings at appropriate spacing for each continuous straight run where required.

(b) Overhead cable support systems must not impede the movement of personnel, vehicle and equipment.

(c) Suitable cable supports must be provided for the transformer power cables between the transformers cable box and the civil structure below the cable box.

4.1 Cable fittings

4.1.1 External application

Cable glands must be of Nickel plated brass construction type designed for armoured or non-armoured cables.

4.1.2 Internal application

Cable glands can be of Nickel plated brass construction or nylon/rubber type designed for armoured or non-armoured cables.

4.2 Earthing of cable sheaths and screens

(a) Earthing of cable systems must as a minimum comply with document R522692.

(b) Screens must be bonded to earth according to the document (CIGRE SC36 WG04 1997).

(c) Where single point bonding of sheaths is used, the maximum standing voltage developed at the cable sheaths at the open-end must be limited to a maximum of 65V.

(d) A dedicated earth bar must be fitted within HV cable boxes (except power transformers) for earthing of cable sheaths and screens terminated within the boxes.

(e) For protection, control and metering cables, single copper braid/tape must be used for the screens.

(f) Earthing points must be shown on the cable layout drawings, schematics and the wiring diagrams.

4.1 Dimensioning of cable installation

The position of all cables must be identified on a drawing. This drawing must detail the position of the cables including dimensions. All dimensions must be taken from survey or from structures/boundaries etc. Dimensions must be taken from points that are reasonably expected to remain in service for the life of the cables.

4.2 Removal of redundant cables

Before removing redundant cables and wiring, both cable ends must be appropriately identified, disconnected and decommissioned.

Wherever possible, redundant cables should be completely removed from the duct, tray, tunnel, conduit or other storage medium within which the cable resides. Redundant inter-panel cabling and wiring must be removed completely.

Under some circumstances it may be difficult for the Contractor to identify the decommissioned cable requiring removal (eg. where numerous cables are in close proximity within an enclosed space). If, after making all reasonable attempts the Contractor believes they are unable to identify the correct cable then, after formal approval by TasNetworks the cables may be cut and capped at an alternative location as agreed with TasNetworks.

In some cases full removal may not be feasible to:

- interwoven cables preventing removal of a single redundant cable; and
- large number of cables installed in a single location causing cables to wedge tightly.

In these situations where it is deemed that damage may occur to adjacent cables, and upon the formal approval of TasNetworks, the redundant cable must be cut as close as practicable to the transition point between cable storage mediums. For example, where a redundant cable passes from a tray into a conduit and the cable cannot be pulled clear of the conduit without damaging adjacent cables, the redundant cable must be cut as close as practicable to the conduit end.

Unless requested otherwise by TasNetworks, where the redundant cable is direct buried and it is impracticable to remove completely, the cable will be cut below the substation ground level.

Where cables are stored in ducts, all duct covers must be removed before commencing cable removal. This will ensure that the assessment of the likelihood of damage to adjacent cables is performed with greater accuracy prior to any removals occurring.

All cables that have been cut off are to be treated as follows:

- all cuts to be square through the cable;
- cable ends are to have a heat shrink cap fitted; and
- original cable numbers are to be retained on sealed cable ends.

If the original cable numbers are illegible or in poor condition then the Contractor must reapply the cable number. Additional marking to indicate 'redundant' (eg large red '**R**' on number tag) must be fitted to the cable.

Ducts, cable trays, conduits or other cable storage mediums must be left in a tidy, orderly and secure condition.

All redundant cables will be disposed of by the Contractor unless specified by TasNetworks.

5 High voltage Cable Systems

5.1 Design of HV cable systems

The design of HV cables must comply with the following requirements:

(a) cables from the power transformers to the HV switchboard must comprise 630 mm2 as a minimum single-phase copper conductors that are rated for the maximum thermal capacity of the transformer. The cable rating will be specified in the project specifications and should generally be 1.3 times for

type 2 &3 transformers and 1.5 times for type 1 transformers, as per the Supply Transformer Standard R527890, with all cooling mechanisms for transformer in-service and taking into consideration the most unfavourable system voltage;

(b) The cable sheath is to be earthed at the switchboard end only;

(c) cables to station services transformer must comprise 120 mm2, three-phase copper conductors;

(d) phase identification must be provided on each cable termination;

(e) outgoing feeder cables are normally a three-phase arrangement, rather than arranged as three single-phase cables. Cable sheaths are to be looped back through any core-balance CTs and cable sheaths are to be earthed at the switchboard end;

(f) HV cables must be provided with the following:

(i) copper conductor with XLPE insulation;

(ii) copper wire or tape screen incorporated with semi conducting tape;

(iii) a PVC inner oversheath to prevent the metallic sheath from corrosion. The PVC inner oversheath must be orange coloured; and

(iv) a HDPE outer oversheath for additional mechanical protection must be provided. The outer oversheath must be black, embossed and coated with graphite.

(g) The design of the HV cable systems must ensure:

(i) that the inner and outer oversheath are fire proof;

(ii) that where single point bonding is used, the maximum standing voltage developed at the cable sheaths at the open-end must be limited to a maximum of 65V. A removable connection or link must be provided at the earth end to facilitate testing of the cable oversheath;

(iii) voltage parameters must be in accordance with the point of installation and project specifications; and

(iv) cable technical parameters must be in accordance with Table 1 HV cable system requirements.

Table 1 HV cable system requirements

Sr. No.	Description	Unit	Requirement
1.	Design conductor temperature	°C	90
2.	Maximum conductor temperature	°C	105
3.	Short time current withstand ratings Conductor Copper screen including metallic over-sheath	- -	Refer to Project Specifications
4.	Short circuit duration	sec	Refer to Project Specifications
5.	Maximum conductor temperature designed for the short circuit rating	°C	250

5.1 Installation requirements for HV cable systems

5.1.1 HV cable installation

The cable systems must be installed such that:

(a) the length of cables installed in air must be kept to a minimum. Where portions of cables are installed in air, ventilation and / or shading must be provided;

(b) all cable tails must have highly visible coloured phase identification marking on them;

(c) all transformer to switchboard cables are installed in conduits;

(d) where conduits are used, they must have an internal diameter not less than twice the cable overall outer diameter; and

(e) appropriate trench base and back filling materials are used, taking into account thermal conductivity requirements.

5.1.1 HV cable accessories

All accessories necessary for the effective and efficient implementation of the cable systems must be supplied. As a minimum the following accessories must be provided:

(a) Outdoor cable sealing ends. HV cable sealings must:

(i) be suitable for outdoor installation;

(ii) have a creepage distance greater than 50mm per kV in accordance with AS 1824.2;

(iii) have a rated 1 minute power frequency withstand (dry) and lightning impulse withstand voltage of magnitude as stated in the Extra High Voltage System Standard R586386 or the High Voltage System Standard R565983, depending on the nominal voltage of the power system where the cable is installed;

(iv) have primary line terminal compliant with AS 62271.301; and

(v) have a support that maintains the minimum ground safety clearance as specified in AS 2067.

(b) Cable terminations;

(c) Earthing cables. Earthing cables must be:

(i) constructed of stranded copper;

(ii) appropriately rated for greater of:

- the future maximum earth fault rating at site; and
- fault rating and duration as specified in Table 1.

(d) Sheath voltage limiters (SVL);

(e) All bonding leads and cabling;

(f) Link boxes; and

(g) Support structures.

6 Low voltage cable systems

Low voltage cable systems include all cable installations within the boundary of the works, including those for protection, control, metering and power circuits.

Multicore cables must have a minimum of 10 per cent spare cores. Spare cores must have sufficient length to allow termination on any terminal in the cubicle terminal strip.

6.1 Cable types

Low voltage cables must be circular, stranded, plain annealed copper conductor, 0.6/1kV PVC insulated, PVC sheathed and where applicable, screened. Multicore (except instrumentation) cables must have white insulation on each core and have core numbers inscribed on the sheath.

6.2 Segregation of cables

(a) Cable runs must not give rise to induced voltages or build up of static overvoltages. Where parallel runs are unavoidable, the control and auxiliary cables should be separated from the busbars by the maximum practicable distance.

(b) Switchyard cables entering the control building must be physically separated from the internal cables and from cables containing low-level signal circuits.

(c) Separate individual cables must be used for each of the following purposes:

(i) AC Voltage Transformer secondary circuits.

(ii) AC Current Transformer secondary circuits.

(iii) DC controls.

(iv) DC supplies.

(v) analog control signals.

(vi) revenue metering.

(d) AC and DC circuits must not be combined in the same cable.

6.1 Wiring standards

6.1.1 General

(a) Protection and control wiring must be terminated in clamp type screw tightened terminals where the screw does not bear a direct pressure on the wire.

(b) DC power supply cables to be marked Red for positive and Black for negative.

(c) Looping connections between three or more devices on a panel must be arranged to achieve the shortest route length.

(d) Where DC bus positive supplies are required in panels, the corresponding negative must be included on an adjacent terminal irrespective of whether it is required in the internal wiring.

(e) If a panel contains terminals or other items connected to 230 volts AC or greater then these parts must be shrouded, a danger label provided and a note to this effect must be placed on the wiring diagram.

(f) Wiring is to be designed to be protected from heat damage or be heat resistant where required. This applies for example for wiring to anti-condensation heaters.

(g) All control cables shall have copper armoured screen.

(h) Cable ties (fixing) shall be UV resistant Nylon used in an outdoor and indoor application, except on transformers which shall be stainless steel.

(i) Cable tags (labels) used in an outdoor application shall be of stainless steel

6.1.1 Standard wire sizes

(j) Both panel internal wiring and external control/auxiliary cabling must be sized and rated to fit for the application purpose in regard to normal voltage and current ratings, voltage drop, and short-circuit rating.

(k) Minimum of V-90 grade insulation.

(l) The minimum standard for wiring sizes is:

(i) As per AS/NZS 3000 and AS/NZS 3008;

(ii) All instrument transformer LV wiring shall be not less than 4mm2; and

(iii) Wiring for circuits carrying data must be 7/0.030 shielded pairs.

6.1.1 Standard wire colours

The standard for wiring colours is:

(i) DC panel wiring must be grey;

(ii) AC current carrying conductors must be red, white, blue or black as required, except for flexible leads which are to be brown and light blue;

(iii) Earth wiring must be green/yellow; and

(iv) Only wire colours other than grey must be shown on the wiring diagram.

6.1.1 Wire termination

(a) Both ends of each wire must carry wire numbers as shown on the wiring diagram or in the wiring /connection table.

(b) Wire numbers must be attached to wiring with slide on carriers, all other systems will not be accepted.

(c) Wires connected to the equipment side of a trip link must be fitted with red PVC sleeving or white ferrule with red letter "T" (approximately 10mm in length) located between the link and the wire number.

(d) All terminations 10mm^2 and under or fine multi-stranded wire which terminate at tunnel type terminals must be fitted with 'Boot Lace' ferrules with the use of correct crimping tool.

6.1 Wire numbering

Refer TasNetworks Nomenclature Standard R0000684808.

6.2 Wiring and connection diagrams/tables

(a) The connection of all equipment must be shown on wiring connection diagrams/tables.

(b) Termination diagrams must be combined with equipment wiring diagrams.

(c) Wiring diagrams must show the following details for each cubicle, cabinet, device or other equipment to which the Contract cabling is to be connected:

(i) The cubicle designation.

(ii) All terminal strips or terminals in there correct relative location.

(iii) A wire number (or blank space in the case of a spare terminal) against each side of a terminal.

(iv) For each cable, the cable identification numbers, the total number of cores and the number of spare cores and the designation of the cable.

(v) The wire number of each core in each cable.

(d) Equipment removed from service must be deleted from any existing drawing/table.

(e) When removing equipment from service it must be ensured that looping of signals to other equipment that is to remain in service is maintained. 'Tee-offs' or in-line joins on looping wires are not acceptable. Rewiring is required.

6.1 AC and DC power supply cables

AC and DC power supply cables shall have orange coloured outer-oversheath and individual core sheath to be colour coded as follows:

(a) AC supply

i *Phase (active) conductors- Red, White and Blue*

ii *Neutral conductor-Black*

iii *Earth-Green and Yellow*

(b) *DC supply*

i *Positive (active) conductor- Red*

ii *Negative conductor-Black*

7 Fibre optic cables

7.1 Installation of fibre optic cables

Fibre optic cable installations must adhere to the following requirements:

(a) all fibre optic cables must be installed in telecommunications conduits (white) with a minimum diameter of 32 mm, so that cables will be protected from the weight of other cables, crushing, ground disruption or any other environmental abuse. The conduit should be identified suitably at regular intervals. Such identification will be provided at a minimum of 3 metre intervals;

(b) all buried communications conduits must have a metallic trace wire provided above conduit route to allow future conduit locating;

(c) a draw wire must be provided in each conduit for future use;

(d) cable pits must be provided at every bend and other suitable locations;

(e) any fibre optic cable run indoors must be installed in flexible telecommunication conduit to prevent mechanical damage. The conduit must not be laid under other cables;

(f) all fibre optic cables must be installed using proper installation techniques with particular care exercised during the installation;

(g) cables must not be subject to excessive pulling tension, sharp jerks, kinks or twists that may damage the cables. There must be no sharp bends along the installation route or sharp edges in conduits;

(h) there must be no more than three 90 degree changes in direction for any single cable pull. If so then the cable must be pulled through to an intermediate point after the third 90 degree change of direction and the cable must then be backed;

(i) the minimum bending radii of the fibre optic cable must be in accordance with those recommended by the cable manufacturer during installation and at the as-installed position;

(j) the cable must be under minimal tensional stress at the completion of the installation;

(k) no joints must be allowed along the length of the fibre optic cables;

(l) the cable must be sufficiently covered in pulling lubricant and the cable end must be completely sealed and made waterproof before it is pulled into the conduit;

(m) the conduit entrances at both ends must be completely sealed to prevent the ingress of moisture after installation; and

(n) sufficient length of spare fibre optic tail must be left for termination.

Fibre optic cabling may be run without the need for conduit if the following conditions are adhered to:

(o) the run must be within a single building;

(p) must be run in cable duct or on cable tray; and

(q) must not be exposed to mechanical forces beyond specification.

The use of Fibre Optic Patch type cables must be limited to patch panels only, however, if they are to be run within a SCADA or a protection panel, appropriate mechanical protection is required and must be secured by suitable means. Neither cable ties nor spiral wrap are to be used.

Care must be taken when installing fibre optic cables within a panel to ensure they will not be damaged by future work within the panel.

7.1 Fibre optic termination

(a) Termination of fibre-optic cables must be via ST connectors unless this type of connector is unavailable for the specified equipment.

(b) Connections to relays must not be connected via multiple connectors or converters such that the length of the connection protrudes and is likely to be damaged

8 Installation of communications and data cables

All communications and data cables to be installed in accordance with AS/ACIF S009, installation requirements for customer cabling (wiring rules).

9 Cable schedules

(a) New or updated existing cable schedules must be prepared to show all cables added or modified for the works.

(b) Cable schedules must show for each cable:

(i) cable identification number;

(ii) from/to information, showing the location of the two cable ends in separate columns by cubicle designation or device description with, where applicable, the device number as shown on the circuit diagrams;

(iii) brief description of route, listing cable trays, trenches, etc. by identification number or letter;

(iv) details of cable (type, conductor size, number of cores, route length in metres); and

(v) type and size of cable glands.

10 Testing

(a) Testing, installation and commissioning must comply with the requirements of the document R246497.

(b) All components of the Cable systems must be duly tested in accordance with relevant applicable Australian and International standards. Where tests are optional in the standards, it will be considered that these tests are required by TasNetworks, unless otherwise requested by Contractor and agreed in writing by TasNetworks before the award of Contract.

(c) All test reports must be forwarded to TasNetworks for approval and acceptance. The tests will be considered as completed, only after, an approval and acceptance of test results by TasNetworks in writing. A list of the tests to be conducted on the Cable systems is given below.

10.1 Type tests

(a) Type tests are intended to prove the soundness of design of the systems and their suitability for operation under the conditions detailed in the specifications. Type tests must be carried out before the delivery of the system. A certified test report, detailing the results of such tests along with the procedures followed, must be provided to TasNetworks. These tests must have been made applied to a system of identical design with that offered, or on a system of a design which does not differ from that offered in any way which might influence the properties to be checked by the type test.

(b) Where such tests have already been performed, a copy of type test reports that qualifies for the exemption from conducting these tests must be provided with the tender.

(c) For HV cables, relevant type tests as specified in AS 1429.1 will apply.

10.1 FAT tests

As a minimum the following Factory Acceptance Testing (FAT) is required.

(a) The FAT tests must be conducted on the complete system to prove quality of manufacture and conformance with the relevant performance requirements of the applicable standards. Splitting of FAT tests into separate phases for individual components of the system is not acceptable. FAT testing must be performed at the manufacturer's works before delivery.

(b) Procedures for FAT tests with supporting documentation must be submitted to TasNetworks for approval and acceptance. FAT tests will not be conducted unless the FAT test procedures have been accepted and approved by TasNetworks.

(c) FAT test results and certificates must be submitted to TasNetworks for acceptance. FAT tests will not be considered as completed only after TasNetworks approves and accepts the test results.

(d) FAT test results must be approved and accepted by TasNetworks before dispatch of equipment to site.

10.1 Site tests

Site installation and commissioning tests must be conducted on the installed system after erection on site and before it is put into service to prove that it has not been damaged during transportation or erection. The site test procedures must be submitted to TasNetworks for review.

Site test reports must be approved and accepted by TasNetworks before placing equipment in service.

As a minimum the tests stated below must be conducted:

(a) phasing / continuity check;

(b) oversheath bonding contact resistance measurement where applicable;

(c) 5 kV DC insulation resistance oversheath test;

(d) 5 kV insulation resistance test of the main insulation before and after Very Low Frequency (VLF) tests;

(e) VLF test on new cables between 2.5 and 3.0 times the cable operating voltage (U0) for 30 minutes;

(f) VLF test on existing or aged cables for recommissioning at a maximum of 1.5-2.0 times the cable operating voltage (U0) for 15 minutes;

(g) Sheath Voltage Limiter (SVL) test where applicable; and

(h) At the conclusion of all the tests and approval from TasNetworks the cable must be allowed to soak for a minimum of 24 hours at nominal operating voltage (U0) and frequency before being put onto load.

11 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in the document Cable Systems Schedule R590633.

12 Deliverables

Requirements for project deliverables are outlined in the document Cable Systems Deliverables R590632.

13 Documentation

Requirements for documentation are listed in the document Cable System Deliverables R590632.

14 Hold points

The hold points for Cable systems will be included in the project specifications.