Standard

Extra High Voltage (EHV) Cable System Standard

R565986

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Authorisations

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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
Various	General update to entire standard.
Various	Drawing reference numbers prefix changed from TSD to Z.
Various	Optical fibre cable details referenced towards separate TasNetworks communications standard.

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1 General

1.1 Purpose

To define the requirements for 'Extra High Voltage (EHV) Cable Systems' under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

1.2 Scope

This standard contains the 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 EHV crosslink polyethylene (XLPE) cables for fixed installations for electricity supply systems at working voltages of 110 kV and 220 kV and is to be applied to new installations as well as redevelopment of part or all of existing installations.

1.3 Objective

TasNetworks requires the design, manufacture, installation and commissioning of equipment and services covered in this standard to:

(a) ensure the relevant Australian legal requirements are met;

(b) ensure the requirements of the National Electricity Rules (NER) are met;

(c) ensure personnel and public safety;

(d) ensure ease in operation and maintenance;

(e) ensure reliability and continuity of power supply to the power transmission network;

(f) support the implementation of TasNetworks' performance objectives; and

(g) enable customer requirements to be met.

1.4 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 standard.

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 the EHV cables must conform to the requirements as specified in document R522687, General substation requirements standard.

Approval for a deviation to this standard may only be accorded if it does not reduce the quality of workmanship, pose a safety risk to personnel or equipment and does not deviate from the intent of this standard. Deviations if any must be specifically requested and approved in writing by TasNetworks' Network Performance and Strategies Manager.

Designers shall comply with the Occupational Licensing (Standards of Electrical Work) Code of Practice 2017 (as amended or replaced), including compliance with:

- AS 2067 (Substations and high voltage substations)
- AS/NZS 3000 (Wiring Rules)
- AS/NZS 7000

Any additional obligations imposed by AS 2067, AS/NZS 3000 and AS/NZS 7000 referring to further Australian Standards or documents, including any amendments or revisions of those Australian Standards or documents from time to time

1.5 References

As a component of the complete specification for EHV cables, this standard is to be read in conjunction with other relevant standards as applicable. Unless otherwise specified in the project specifications, 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:

1.5.1 Australian and International standards

Telecommunication cables – Insulation, sheath and jacket	AS 1049
Conductors	AS 1125
Conduit	AS 2053
Substation and high voltage installations exceeding 1 kV a.c.	AS 2067
Underground marking tape – Non-detectable tape	AS 2648
Polymeric cable protection covers	AS 4702
Installation of underground utility services and pipelines within railway boundaries	AS 4799
High voltage switchgear and control gear – Dimensional standardization of terminals	AS 62271.301
Crossing of waterways by electricity infrastructure	AS 6947
Requirements for customer cabling products	AS/ACIF S008
Telecommunication installations – Generic cabling for commercial premises	AS/NZS 3080
Electric Cables – Polymeric insulated - For working voltages above 19/33 (36) kV up to and including 87/150 (170) kV	AS/NZS 1429.2
Electric cables – Electric cables - Calculation of the current rating	IEC 60287
Electric cables – Calculation of the cyclic and emergency current rating of cables	IEC 60853
Optical fibres	IEC 60793
Optical fibre cables	IEC 60794
Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) Test methods and requirements	AS/NZS IEC 60840
Power cables with extruded insulation and their accessories for rated voltages above 150 kV (Um = 170 kV) up to 500 kV (Um = 550 kV) Test methods and requirements	IEC 62067
IEEE Guide for Thermal Resistivity Measurements of Soils and Backfill Materials	IEEE Std 442

1.5.2 TasNetworks standards

R586386	Extra High Voltage System Standard	
R590634	Substation Civil Design and Construction Standard	
R522687	General Substation Requirements Standard	
R579297	Security Fences and Gates Standard	
R246497	Testing, Commissioning and Training Standard	
R590630	HV and LV Cable System Standard	
R522692	Substation Lightning Protection and Earthing Standard	
R522696	Surge Arrestor Standard	
R579290	Extra High Voltage Cable Systems - Schedules	
R579289	Extra High Voltage Cable Systems - Deliverables	
R192947	Excavation Work Standard	Ex. D11/12740
R793081	Excavation Procedure	
R1058569	Communications Fibre Optic Cable Standard	

1.5.3 TasNetworks drawings

Typical Overhead Transmission Line Structures Cable Conduit Layout	Z-808-0087-SD-001
Typical Cable Trench Details (Type A without Conduits)	Z-808-0088-SD-001
Typical Cable Joint Bay Arrangement details	Z-808-0089-SD-001
Typical Cable Cross Bonding Diagram	Z-808-0090-SD-001
Typical Joint Bay Retaining Wall and Channel Arrangement	Z-808-0091-SD-001
Typical Highway/River/Railway Crossing Bored Conduit Details	Z-808-0092-SD-001
Typical Cable Trench Details (Type B with Conduits)	Z-808-0093-SD-001

1.6 Glossary

AMIS	Asset Management Information System
CBRM	Condition based risk management
DTS	Distributed temperature sensing
EHV	Extra high voltage
FAT	Factory acceptance testing
FC	Fixed connection
FTB	Fluidized thermal backfill
GVM	Gross vehicle mass
HDPE	High-density polyethylene
MDPE	Medium-density polyethylene
VCV	vertical tower continuous vulcanising
CCV	catenary continuous vulcanising

NER	National Electricity Rules
OPGW	Optical fibre ground wire
EMF	Electro magnetic force
OPUC	Optical fibre underground cable
OTDR	Optical time domain reflectometry
PVC	Polyvinyl chloride
SCADA	Supervisory control and data acquisition
RTU	Remote terminal unit
SCM	Sand cement mixture
SVL	Sheath voltage limiters
TEC	Tasmanian Electricity Code
UV	Ultraviolet
VLF	Very low frequency
XLPE	Cross-linked polyethylene
MTBF	Mean time before failure

2 General requirements

Project specific requirements for TasNetworks 110 kV and 220 kV EHV crosslink polyethylene (XLPE) cable and accessories will be listed in the project requirements.

2.1 Data for asset management information system

TasNetworks maintains a 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 the EHV cable/s in standard proformas. TasNetworks will provide the proformas to the 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, including details of maintenance items, their accessibility and the frequency of maintenance for the EHV cable/s must be submitted to TasNetworks before commencing installation; and

(b) information on test results for the EHV cable/s must be submitted prior to commissioning.

2.2 Cable systems

All link boxes, joint terminations, cables, cable accessories and cable systems associated with EHV cable must be in accordance with this document.

2.3 Civil works

All civil works associated with EHV cable systems must be in accordance with relevant standards.

2.4 Earthing

Earthing of all equipment and works associated with EHV cable systems (including earthing at joint bays) must comply with the requirements of this standard and must employ sheath voltage limiters (SVL) to limit sheath voltages. Cable sheath bonding system can comprise cross-bonded and/or single bonded arrangements as necessary for suit design requirements.

2.5 Service conditions

Service condition parameters comprising the particulars of the system are stated in Table 1 of this standard, together with site conditions that may affect the performance of the cable, such as soil thermal resistivity. The assessment of substation and cable route site conditions is the responsibility of the Contractor.

Specific environmental conditions and any specific design, installation, operation or maintenance criteria for particular works will be stated in the project requirements, such as availability of space and proposed switchyard layout.

2.6 Performance

EHV cables, must as a minimum meet or exceed the following performance criteria:

(a) The EHV cables and accessories must provide reliable performance and be designed for an intended service life of 45 years.

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

(d) The EHV cable and its accessories must be physically separated from existing services, such as telecommunications, water, sewerage and electricity distribution network service provider’s infrastructure, by at least 1.0 m horizontally and 0.5 m vertically , so as to not interfere with their existing function, impose a safety hazard or interfere with the EHV cables function. Crossing of other services is to be perpendicular to the EHV cable.

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

  (i) requirements mentioned in this standard;

  (ii) project requirements;

  (iii) results from system analysis; or

  (iv) the requirements as stated in document R522687, General Substation Requirements Standard.

2.7 Installation Design Requirements

2.7.1 Cable route

The designer shall ensure site visits are completed to understand the onsite elements present for the underground design for the purpose of cable route selection. The minimum elements the designer shall consider as part of the cable route selection are:

- Any easements that may be required. For further details refer to TasNetworks’ Planning Standards and the Connection Contract published on TasNetworks’ website
- Accessibility – for future operations and installation
- The cable route selection should reduce sharp bends and ensure that cable minimum bending radii are not exceeded.
- Cable joints pits – reduce the number of cable joints in alignment with minimum cable lengths for EHV cable.
- Surface layer – soil, road crossing, river crossing, rail crossing, etc.
- Avoidance of unstable ground and waterways where possible.
- Minimise total route length to critical electrical infrastructure
- Potholing every 100-200m in areas where suspected poor soil conditions for the purposes of ambient ground temp, soil thermal resistivity and moisture content where applicable

The designer shall ensure the appropriate level of locating/marking of existing underground services is completed prior to confirming cable routes. Existing underground services may include the following:

- Large sewer and high pressure water mains
- Large telecommunication cables and all fibre optical installations
- TasNetworks underground cables
- Gas mains
- Traffic signalling cables

Excavation around sensitive services must be performed by hand for precise location before machinery is allowed in the vicinity. Appropriate levels of environmental planning shall be allowed if these sites have been clearly identified in the design phase.

Ground surface marks shall be made in accordance with AS 1345.

2.7.2 Environmental conditions

Environmental conditions to minimise environmental harm as listed below to be considered and, in general, with reference to TasNetworks' Environmental and Heritage Design and Construction Standard (R392685):

- Aboriginal heritage and historic cultural heritage
- Threatened species and threatened communities
- Land tenure e.g. reserves and Crown land
- Land usage – assessment of the chosen cable route impact on current and future use
- Declared weeds and environmental weeds
- Contained sites
- Acid sulphate soils
- Waterways
- Parks, gardens with trees, landscaped areas etc.
- Areas with major pedestrian or vehicular traffic flow
- Native vegetation including grasslands
- Ground conditions – slope, flooding level, soil structure, soil resistivity, dispersive soils, temperature, wind extremes and run-off that impact waterways and wetlands
- Safety from inadvertent damage by vehicles or other commercial or industrial work processes in the vicinity.
- DBYD – detailed review and identification of other utility infrastructure to ensure the minimum clearances from other amenities (e.g. gas, water and communication reticulation)

A thorough investigation must take place at the project design stage for these potential problems which includes an Environment and Heritage Assessment as per TasNetworks' Environmental and Heritage Design and Construction Standard.

2.7.3 Site location comparison

- Cables shall cross under roads and railways at right angles to minimise reinstatement works and asset risks. This applies when under boring.
- The designer shall consider environmental constraints in terms of threatened species and associated permit requirements and environmental offsets as a potential cost factor.
- An easement is required over all TasNetworks owned equipment installed on, over or under private property, council land, schools, reserve roads, Crown land, or TasRail assets.
- 24 hour access must be available to all TasNetworks owned equipment.

2.7.4 Safety in Design

Designers must consider and comply with all safety requirements to exercise due diligence in assessing design work, including under the Work Health and Safety Act 2012. The elements to consider include:

- Early identification of hazards and assess risk associated in the design process, construction phase, operating and maintenance phase and the decommissioning and demolition phase
- Elimination of identified risks as so far as reasonably practicable or the minimisation of these risks throughout the entire lifecycle of the plant, substance or structure
- Consultation and communication of the assessment outcomes through formal documentation

The safety in design process integrates the above elements into an industry recognised framework, with the focus on early identification of risk. This approach often yields an easier and cheaper outcome to the design as it reduces the likelihood of a need to undertake future design changes as hazards become real risks. The designer shall complete a safety in design report for each new design, where the safety in design content detail shall be proportional to the complexity of the design.

2.7.5 Electrical design

The electrical design component shall comprise the following as a minimum:

- Develop detailed electrical design drawings and documentation (single line diagram, equipment general arrangement, etc.

2.7.6 Civil design

The civil design component shall comprise the following as a minimum:

- Confirm cable route, including offsets to other services, property boundaries and other points of interest
- Confirm trenching details – to include cable configuration, trench material, bending protection, mechanical and labelling location compliant with AS 3000, AS 2067 and TasNetworks standard design
- Confirm pulling cable calculations
- Complete potholing and soil thermal resistivity
- Reinstating of the surface shall be completed to the original form

2.7.7 Easement requirement

110 kV circuits - A minimum 10m easement is required for single circuit installations, 5m from centre.

220 kV circuits - A minimum 15m easement is required for single circuit installations, 7.5m from centre.

Where multiple circuits are installed a minimum 5m separation between circuits is required, e.g. for two circuits @ 110kV will result in a total minimum 15m easement requirement.

Note these a typical minimum overall widths, with electricity asset in centre of easement and depend on a number of parameters including.

- Cable configuration, (3 phase, single core in trefoil or side by side)
- The location and size of joint pits
- EMF levels at edge of easement (Voltage & current magnitudes, cable spacing and depth)

Final easement width required can be reduced depending on design or may need to be increased if necessary, subject to project approval.

3 Extra high voltage cable

3.1 Manufacturing plant requirements

Manufacturing plant processes must take into consideration TasNetworks' stipulation that:

(a) plant audits by TasNetworks or its representative may be deemed necessary steps to ensure that the best manufacturer is chosen for specific project;

(b) the manufacturer must be able to demonstrate at least 5 years experience with similar cable design;

(c) the manufacturer's plant must be ISO 9001 certified;

(d) the cable insulation must ensure that:

  (i) the cable shall be insulated as specified in AS 1429.2;

  (ii) only cross-linked polyethylene (XLPE) is used.

  (iii) The semi-conductor polyethylene is not to be stored next to the insulating cross-linked polyethylene due to cross contamination; and

  (iv) dry curing method is to be used in order to reduce the number and size of voids, reduced moisture content, reduced moisture absorption and increased insulation strength.

(e) The extrusion method is to be detailed noting that comments to be provided if differs from previous TasNetworks standards specification of *triple extruders method is used in the manufacturer of the cable with cross section of 500 sq mm or greater. This shall be carried out on a vertical tower continuous vulcanising (VCV) or Mitsubishi Dainichi continuous vulcanising (MDCV) extrusion line. For a conductor with cross sectional area of 630 sq mm, catenary continuous vulcanising (CCV) extrusion method shall be used;*

(f) the distance between insulator hoppers and extruders must be as close as possible (1 to 2 metres), with manufacturer comments expected to be provided if differs from this;

(g) the method of joining the phase conductors must be specified when doing a manufacturing run;

(h) incoming materials used in the construction of the cable must:

  (i) specify where the copper comes from;

  (ii) specify purity of the copper;

  (iii) provide relevant data sheets on the copper used to TasNetworks;

  (iv) provide samples and records of materials used to TasNetworks;

  (v) provide wafers of the cable at the start and finish of each cable run for inspections of voids and other microscopic analysis to TasNetworks;

  (vi) ensure that the bond between the semi-conductor and the XLPE compounds are checked and supplied as reference records of the cable; and

  (vii) provide evidence of online diagnostic X-ray being carried out during manufacturing to ensure the conductor is located in the middle of the insulation.

(i) stipulate the time between the cable being removed from the oven to when the metallic screen is applied; and

(j) provide certified test type reports on prototype.

3.2 Spare parts

The following spare parts requirements will be applicable:

(a) A comprehensive list of recommended spares is required for the cable systems, including a price for each item and the expected shelf-life if applicable. The spare parts, if ordered, must be identical in all respects with similar parts incorporated in the cable and will be submitted to the tests and inspections specified herein wherever applicable. Note that TasNetworks will seek advice from the manufacturer as to what spare parts should be held.

(b) The spares parts are part of the contract and need to be supplied. These included, but are not limited to:

- (i) cable joint terminations;
- (ii) cable accessories; and
- (iii) cable systems associated with EHV cable.

(c) Manufacturers are required to outline their policy for holding essential spare parts for the life of the cable, i.e. 45 years. Information to be supplied includes:

- (i) the policy of holding spares;
- (ii) details of what spares are held by the manufacturer;
- (iii) the duration spares will be held;
- (iv) the facilities to manufacture spares over this time period; and
- (v) an assurance that the capability, facilities and any information required to supply and manufacture spares will be retained by the manufacturer over the life of the cable.

(d) The information provided in response to the above queries will determine whether or not some essential spare parts will be purchased and stored by TasNetworks.

(e) Manufacturers are required to outline their policy for maintaining technical support and servicing capabilities for the life of the cable, i.e. 45 years.

(f) Spare parts must be packed in long term sealed plastic bags and delivered to the TasNetworks’ store in wooden cases of adequate strength to protect the equipment from damage and the ingress of moisture during transport and handling.

(g) Each case must be suitably marked so the contents can be ascertained without it being necessary to open the case. Case marking must include the purchaser’s contract No. and the mass of the crate.

3.3 Packaging

Packaging, including cable drums must:

(a) provide adequate protection to minimise the risk of damage to the cable and cable systems during delivery;

(b) be suited to the particular methods of delivery and provide protection against damage from all foreseen hazards; and

(c) be suitably marked so the contents can be ascertained without it being necessary to open the package. Marking must include TasNetworks’ Contract No. and the mass of the crate.

Details of packaging methods must be submitted to TasNetworks for prior approval.

3.4 General design requirements

Design and selection of cable sizes and cable types must take into consideration the requirements as mentioned below:

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

(i) outdoor installation;

(ii) indoor installation in ducts; or

(iii) exposed to direct sunlight,

(b) Cables must be rated and installed to supply the maximum circuit power as specified in the project requirements, taking into account the maximum overload that may occur, without any overheating and reduction to the service life.

(c) 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 soil ambient temperature of 25°C must be utilised for the cable sizing calculations;

(iii) Soil thermal resistivity;

(iv) group heating effect;

(v) depth of underground installation;

(vi) cable laying formation;

(vii) Earthing arrangement; and

(viii) spacing.

(d) The cable over-sheath must be designed to withstand the extremely high UV index pertaining to Tasmania.

(e) The design of the cable systems must ensure that provision is made for future expansion if required. Such requirements will be defined in the project requirements.

(f) The cable design and design calculations must include, but not be limited to:

(i) conductor size and sheath size calculation;

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

(iii) voltage rise under normal and fault conditions for single, double and cross bonding;

(iv) type of installation, (e.g. in ground: direct buried/conduit/cable trenches/cable ducts; above ground; cable tunnel);

(v) selection of cable route;

(vi) the thermal performance of the cable installation; and

(vii) thermal expansion and contraction.

(g) The Contractor may be made responsible for supplying, delivery, installing and testing sufficient length of cable for the circuit requirements as stipulated in the project requirements. A schematic is to be provided in the project requirements detailing the typical design of a joint bay, including an allowance for a sufficient length of cable for termination and joints (includes provision for sufficient length of cable for possible future fault repairs). A schematic is also to be provided in the project requirements detailing the typical design for a spare loop of cable to facilitate any minor route deviations required due to site conditions.

3.5 Design parameters for EHV cables

A transmission circuit is to comprise of three single-core, copper conductor cable, of a rating and voltage to be specified in the project requirements, with semi-conductive tape, conductive screen, cross-linked polyethylene insulation (XLPE), insulation screen, water swellable tape, and supplied with three optical fibre cores for distributed temperature sensing (DTS).

Conductors shall be stranded plain annealed copper or aluminium, as specified and of circular compacted construction. For conductors of 800 mm^2 cross sectional area or larger, compacted Milliken type construction shall be used.

A corrosion resistant metallic sheath must either be, corrugated stainless steel or corrugated aluminium and provide an effective impermeable moisture barrier for the expected life of the cable and be effectively coated to prevent corrosion through moisture, oxidisation and electrolysis. Where stainless steel is specified in the project specifications as the sheathing material, it shall be of the Type 304 with a surface finish of Class 2B and must incorporate a copper wire screen to improve the electrical characteristics of the stainless steel sheathing material. Where aluminium is specified in the project specifications as the sheathing material, the thickness shall be stated in the project specifications and be adequately coated to prevent corrosion.

The cable must be supplied with a polyvinyl chloride (PVC) inner over-sheath and a high-density polyethylene (HDPE) outer over-sheath. Where bonded Aluminium laminate is specified in the project requirements as the sheathing material, the PVC will be replaced with medium density polyethylene (MDPE). The inner over-sheath must be orange coloured. The outer over-sheath must be black HDPE, ultraviolet (UV) resistant, fire retardant, embossed and coated with graphite.

The cable must be metre marked in accordance with AS 1429.2.

Specific design requirements and parameters for EHV cables are detailed in Table 1.

Table 1 Parameters for EHV cable

Sr.No.	Parameter	Unit	Requirement
1.0	Particulars of the system		
1.1	Number of phases	-	3
1.2	Frequency	Hz	50
1.3	Normal operating frequency excursion band	Hz	48.8 to 52
1.4	Power system frequency range	Hz	44.8 to 52
1.5	Rated voltage (phase to phase)	kV	As per project requirements
1.6	Highest voltage (U_{max})	kV	As per project requirements
1.7	Lighting Impulse Withstand Voltage	kV_p	As per project requirements
1.8	AC Withstanding Voltage	kV_{rms}	As per project requirements
2.0	Particulars of EHV Cable		
2.1	Number of phase per cable	-	1
2.2	Rated MVA (continuous)	MVA	As per project requirements
2.3	Rated A (continuous)	A	As per project requirements
2.4	Maximum rated conductor temperature	ºC	90
2.5	Maximum emergency conductor temperature	ºC	105
2.6	Maximum conductor temperature during fault current	ºC	250

2.7	Maximum fault current	kA	40
2.8	Fault current duration	s	1
2.9	Short term overload rating (4hrs)	MVA	As per project requirements
2.10	Nominal Depth to top of cable	m	1
2.11	Nominal cable separation	mm	300
2.12	Maximum sheath standing voltage	V	250
2.13	Conductor cross section	mm^2	As per project requirements
2.14	Maximum thermal resistivity of thermal stabilised backfill, when dry	ºC m/W	1.0
2.15	Soil ambient temperature	ºC	25

3.6 Design parameters for optical fibre cable

The optical fibre cable requirements and parameters must be read in conjunction with TasNetworks Communication Fibre Optic Cable Standard along with Australian Standard AS/ACIF S008, AS 1049, AS 3080, IEC 60794 and IEC 60793.

The optical fibre cable must be of a water-blocked, single loose tube, non-metallic cable design suitable for power or umbilical cables in short or long haul applications.

Design requirements and parameters for optical fibre cables are detailed as typical in Table 2 with more specific details in TasNetworks Communication Fibre Optic Cable Standard.

Table 2 Parameters for optical fibre cable

Sr. No.	Parameter	Unit	Requirement
1.0	Maximum optical loss	dB/km	≤ 0.3 at 850nm
1.1	Maximum splice loss	dB/km	0.2
1.2	Minimum bending radius (under load)	mm	60
1.3	Minimum bending radius (no load)	mm	30
1.4	Temperature range	ºC	-40 to 70
1.5	Maximum crush resistance	kN/mm	1.0 kN/100 mm
1.6	Impact	Kg/m	0.25 kg/1.0 m

3.7 Cable accessories

Each EHV cable's accessories shall comprise as a minimum:

(a) cable sealing ends;

(b) cable termination kits and palm terminals;

(c) surge arrestors;

(d) surge counters;

(e) earthing cables;

(f) earth mat conductor;

(g) prefabricated cable joints suitable for joining of power cable and splicing DTS optical fibre cores;

(h) sheath voltage limiters (SVL);

(i) all bonding leads and cabling;

(j) earth disconnecting link boxes, for use at substations and terminations;

(k) cross-bonding link boxes with SVL, for use at cable joints;

(l) support structures and cross-arms;

(m) 24 core, single mode, optical fibre underground cable (OPUC), with blue sheath;

(n) 50 mm diameter, white conduit for OPUC (only to be corrugated on short runs of 10 m or less and corners);

(o) optical fibre joint boxes and splicing kits for OPUC;

(p) conduit, for use at road crossings;

(q) concrete and steel mesh reinforcing material, as required; and

(r) stabilised thermal backfill, as required.

3.8 Design requirements for cable terminations

Cable termination must comply with the following requirements:

(a) the cable terminations comprise outdoor composite cable sealing ends with a primary line terminal compliant with AS 62271.301;

(b) surge arrestors (diverters) are required at cable terminations as per Surge Arrestor Standard, R522696. One surge counter per cable, visible and readable from ground level, must be supplied and installed for each surge arrestor;

(c) a spare loop shall be provided at each termination and joint bay to allow re-termination in the event of damage to sealing ends and joints;

(d) within substations, the three terminations are to be supported by separate independent structural steel supports that maintain the minimum ground safety clearance as specified by AS 2067. Surge arrestors are to be supported by the same structural steel supports as for the cable's sealing end. Galvanised steel cable guards are to be utilised to protect the cable from solar radiation, together with cable cleats to support the cable;

(e) at termination structures, the three single-core cable terminations and associated surge arrestors are to be mounted on a transition pole. A steel construction supporting the cable's sealing ends and surge arrestors is to be at a minimum height of 10 m above ground if outside the perimeter fencing of the substation or of sufficient height within the boundary of the substation perimeter fence so as to maintain safe electrical clearances at all times. Galvanised steel cable guards are to be utilised to protect each cable, surge arrestors earthing leads, sheath bonding leads and optical fibre ground wire (OPGW) cables to a minimum height of 6.0 m above ground and to the base of the concrete foundations;

(f) the cable guards are to be sized and arranged to allow for natural ventilation and not impair the thermal performance of the EHV cable; and

(g) cable cleats installed at a maximum interval of 1.0 m are to be used to support the EHV cable, leads and OPGW.

3.9 Design requirements for optical fibre underground cable

Optical fibre underground cable (OPUC) is required for provision of dedicated bearers for Supervisory control and data acquisition (SCADA), tele-protection and telecommunications associated with the transmission system. Metallic pilot cables are not to be installed within EHV cable trenches for this purpose.

OPUC must comply with the requirements of the TasNetworks Communications Fibre Optic Cable Standard. OPUC must also meet the following requirements:

(a) Installed within the same cable trench as the EHV cable at a depth of 750 mm. The OPUC must be installed directly underneath the cable protection;

(b) at substation sites, all cores are to be terminated to the telecommunications fibre termination cabinet within the building by qualified technicians. Terminations must be inspected and approve by the TasNetworks Telecommunications Group; and

(c) The telecommunications conduit network must not interconnect with any other site conduit networks systems. Conduit may share common trenches but must utilise separate pits. Where multiple OPUC are installed to provide diversity, spatially diverse conduit systems must be installed.

3.10 Joint bay construction

Joint bay construction must comply with the following requirements:

(a) joint bay construction must have a similar design as illustrated in the typical joint bay construction diagram Z-SD-808-0089-001; and

(b) detailed joint bay construction designs must be submitted to TasNetworks for approval at tender stage.

3.11 Design requirements for optical fibre for distributed temperature sensing

Optical fibre for distributed temperature sensing (DTS) must comply with the following requirements:

(a) where stainless steel is used as the metallic sheath, three multi-mode optical fibre cores for DTS are to be supplied and arranged in a single bundle embedded within each EHV cable's copper wire screen. In case of corrugated aluminium metallic sheath, the three multi-mode optical fibre cores for DTS are to be supplied and arranged in a single bundle enclosed within a stainless steel tube embedded inside the power cable and suitable jelly shall be filled between the tube and optical fibres.

(b) cores are required to be spliced at each cable joint to form continuous lengths of multi-mode optical fibre; and

(c) at least one optical fibre per EHV cable is to be terminated with fittings at each end suitable for DTS.

3.12 Design requirements for cable joints

Cable joints must comply with the following design requirements:

(a) EHV cable jointing is permitted if the total length of the cable is greater than 600 m. Where cable joints are required in the EHV cable, the section lengths are to be no greater than 1000 m, with the total length of cable divided into roughly even lengths. TasNetworks must be advised of the planned number of joints and arrangement prior to installation;

(b) prefabricated EHV cable joints shall be used. Joints and associated sheath link boxes are to be matched for all three phases in the same transmission circuit so that all cable joints are installed in the same joint bay in an arrow formation. Link boxes are to be of stainless steel construction;

(c) cross-bonding and transposition at each cable joint are to be used to limit sheath voltages. In addition, the optical fibres for DTS are to be spliced within each joint. EHV cable in flat formation are to be transposed as close as possible to each cable joint with the cable segregation of 300 mm between centres being maintained during the transposition. The top of the cables during transposition and the top of the joints is to be a minimum of 1.0 m below the ground surface;

(d) the joint bay is to be designed and installed to facilitate cable jointing in a clean, dry environment, with an earthed reinforced concrete base and side walls. EHV cables are to be supported, level and straight within the joint bay and clamped as appropriate to ensure the cable is secure. A typical joint bay drawing, including sufficient length of cable to allow for termination, a spare loop at terminations, jointing and any minor route deviations that may be made due to site conditions to be provided in the project submission. To optimise project efficiency cable joint bays are to be constructed prior to cable installation. Joint bays are not to be installed in 1 in100 year flood plains;

(e) If the cable route selection cannot avoid being installed in flood plains then the joint bay must be constructed such that it is able to maintain water tightness when subjected to a minimum head of 2 m of water above joint bay. Test reports must be provided to verify that joint bays installed in these positions are able to satisfy this requirement;

(f) after jointing, cross-bonding and testing, the joint bay is to be filled with the thermal stabilised backfill to a depth of 250 mm above the top of each joint after compaction. At a depth of 750 mm, cable protection comprising heavy-duty PVC strips (5 mm thick) above each single-core cable joint is required. The strips are to overlap each cable by at least 40 mm. The remainder of the fill is to be sieved, clean original trench soil, well compacted and consolidated; and

(g) accessible link boxes are to be provided to facilitate cross-bonding of the cable sheaths, together with internal and ongoing testing of each cable sheath at each joint bay. The link boxes, associated lids and cable entries shall prevent ground and surface water ingress in both rain and flood conditions. Whether underground of above ground, link boxes are to be physically protected and secure from in-advertant or un-authorised access. The cable sheaths are to be connected via insulated, continuous cross-bonding leads, together with copper bar within the cross-bonding link box. SVL are to be installed within the link box.

3.13 Cable link boxes

Cable link boxes must comply with the following requirements:

(a) Typically be of an underground design, with above ground use dependant on local conditions and to be confirmed during design phase,

(b) the cable link boxes must be lockable type, constructed from stainless steel (minimum grade 304) sheet metal panels;

(c) the minimum degree of protection of enclosure for single point bonding cable link boxes must be IP56 and for cross bonding link boxes IP 67;

(d) the cable link boxes must be large enough to accommodate clamp-on CTs for partial discharge monitoring; and

(e) for in ground link boxes the cross bonded cable link boxes must be covered by a removable lid (Gatic) capable of carrying a trafficable load of 20 tonnes (GVM) and it shall be lockable and sealed in a manner to prevent moisture ingress.

(f) for above ground link boxes they shall be physically protected from inadvertent damage with the installation of bollards with vertical bars that are arranged to provide unrestrictive maintenance access.

3.14 Design requirements for road crossings and intersections

EHV cables road crossings and intersections must comply with the following installation and design requirements:

(a) horizontal directional drilling (boring) is preferred for road crossings and intersections (rivers, creeks railway tracks, etc.) with separated and appropriately sized orange High Density Polyethylene (HDPE) conduits, orange in colour, for each EHV cable phase and a separate HDPE conduit for the optical fibre cable. TasNetworks will consider trenching for minor crossings subject to a written request prior to award of the contract;

(b) where horizontal directional drilling is used, there is no marker tape or any other type form of mechanical protection other than the conduits. For safety, the conduit used in horizontal directional drilling must have the following clearly legible warning printed in indelible ink at regular intervals so that the conduit and cable are easily identifiable:

“TASMANIAN NETWORKS

Danger power cable”

(c) heavy duty HDPE conduits are to be installed under the road for each cable at least 1.0 m below the road surface, or alternatively, 1.0 m below the surrounding ground surface, where the road has been built on fill;

(d) crossing of waterways must comply with the requirements of AS 6947. The depth of the directional drilling under river beds must take into consideration, but not limited to, the following criteria:

  (i) the thermal resistivity of the soil;

  (ii) the expected maximum scouring that may occur in that particular area;

  (iii) the depth of sediment that may occur in that particular area; and

  (iv) the uplift of the conduit.

  The Contractor must source the information pertaining to river scouring from the relevant government department;

(e) crossings of railway tracks must comply with the requirement of AS 4799. Where directional drilling is required for railway tracks the depth of the directional drilling must be such that the cable is not affected by vibrations imparted by train movements. The Contractor must acquire the relevant information required for directional drilling beneath railway tracks from the relevant Government department;

(f) the installation must be designed to take into account the expected vehicular traffic and loading that may occur over the design life of the cable installation. Typically the design should cater for a minimum gross vehicle loading capacity of 40 tonnes and an axle loading of 10 tonnes;

(g) the maximum amount of space (fill factor) that the installed cable/s should occupy in a given size conduit, expressed as a percentage of the interior volume must not exceed 53 per cent. In addition the inner diameter of the conduit should be at least 1.5 times the cable diameter. A minimum spacing of 300 mm must be provided between conduit centres;

(h) HDPE conduit sections are to be joined together with HDPE welds and PVC conduit sections are to be joined together with PVC cement. Conduit ends are to be capped to prevent entry of water prior to cable installation. The conduit ends are to be continued at least 3.0 m either side of the carriageway;

(i) conduit bends are to be sweeping bends;

(j) the conduit interior, entry and exit points are to be cleaned and free of debris and burrs. No debris is to enter the conduits during cable installation;

(k) all conduit ends to be 'bell' ends; and

(l) conduit ends are to be sealed with an approved material.

3.15 Design requirements for cable installation along road easements

EHV cables installation along road easements must comply with the following installation requirements:

(a) where EHV cables are installed in parallel with roads, EHV cables are to be direct buried. Alternative methods of installation may be considered by TasNetworks prior to the award of the contract should traffic volumes or other installation issues be identified by the Contractor;

(b) after cable installation, the road base, road surface and surroundings are to be restored to their original condition.

4 Labelling

The labelling of EHV cables must comply with the following requirements:

(a) cables are to be identified and metre marked in accordance with AS 1429.2;

(b) every drum of cable shall be durably branded , stencilled or labelled on the outside of the flange in accordance with AS 1429.2;

(c) following installation, respective permanent labelling (red, white, blue) of each EHV cable and cross-bonding leads is to be provided at cable terminations, joints and link boxes to assist in phase identification, testing, commissioning and maintenance;

(d) the cables must be additionally protected from future excavations by placing and identification electrical cable marker tape over the full width of the cables, comply with AS 2648. The marker tape must:

  (i) be installed at a 300 mm depth, above each single core cable or joint;

  (ii) be a continuous length and orange in colour;

  (iii) be positioned at 50 per cent of the distance between the mechanical protection and the surface but, however must not be more than 450 mm above the mechanical protection;

  (iv) be lettered with “WARNING”, or “DANGER ELECTRICAL CABLE” or similar wording; and

  (v) faithfully follow the route of the cable.

(e) approved surface markers are to be provided to indicate the position of the cables (TasNetworks to approve surface markers prior to award of contract);

(f) surface markers are to be installed at distances between consecutive markers at the lesser of 50–100 m or line of sight, at each deviation/direction change of the cable, at both ends of road crossings, at each end of joint bays. 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. 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;

(g) as a minimum the markers are to be yellow background in colour and engraved with the following in black lettering, with dimensions of 750 mm by 100 mm, The marker must be of non-combustible material. The wording on the marker must be legible, permanent, and formed in a non-combustible medium:

“TASMANIAN NETWORKS

110 000 volt power cable

laid in this area”

or

“TASMANIAN NETWORKS

220 000 volt power cable

laid in this area”

(h) where cables cross railway lines, cable markers must comply with the requirements of AS 4799.

5 Installation requirements

5.1 General

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

No excavation work will be permitted that compromises the minimum coverage of the cable. Should additional soil be added, care must be taken that it does not increase the thermal characteristics of the cable system installation and therefore decrease the rating of the circuit.

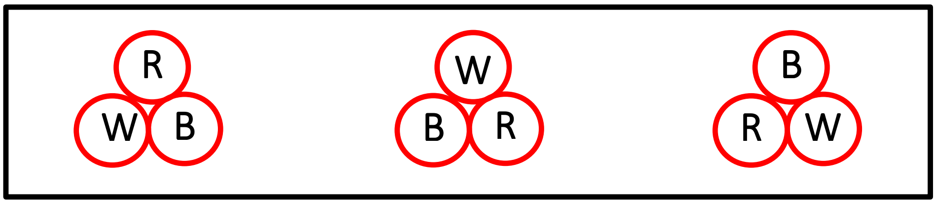
The Contractor is responsible for the repair of any damaged underground infrastructure at the Contractor's cost, including provision of any temporary bypass services.

5.2 Installation of EHV cable

The installation of EHV cables must comply with the following requirements:

(a) the cables are to be direct buried 1.0 m below the ground surface, preferably in flat formation with minimum of 300 mm separation between phase centres. Where a limited trench width is required, a trefoil formation with 300 mm separation may be utilised subject to approval from TasNetworks prior to award of contract;

When two or more cables per phase are employed the separation will be confirmed by system modelling to insure no magnetic field or thermal interference. If flat formation is used then similar phases are grouped together maintaining 300mm separation. If trefoil arrangement, phase separations is as shown typically below.



(b) For multiple cable circuits typically a separation of minimum 5m is required between circuits to provide access clearance.

(c) the bottom of the cable trench must be levelled and any gradients or changes in depth must be gradual. The trench must be free of loose earth and any stones before the cables are installed. The top of each cable is to be a minimum of 1.0 m below the ground surface and the bottom of each cable is to be a minimum 100 mm above the trench base. Thermal stabilised backfill is to be utilised to fill underneath and cover the top of each EHV cable by at least 250 mm after compaction and consolidation. The thermal stabilised backfill is to be extended to cover both the trench walls with the trench walls to be filled with at least 100 mm of thermal stabilised backfill to protect the outer cables. To prevent damage to the cable, backfilling must be carried out as soon as possible after the cables have been installed;

(d) thermal stabilised backfill sand cement mixture (SCM). The SCM must comprise of a sand cement mixture (14:1) and be thoroughly mixed. The thermal resistivity of SCM must be less than 1°Cm/W at 1.0 per cent moisture content. Compaction is to be achieved by a hand held mechanical compactor;

(e) the remainder of the trench is to be filled with native sieved clean soil that is friable, free of any waste material and sharp rocks, then well compacted and consolidated. This friable clean soil may be obtained from sieved original trench soil if tested results indicate that the thermal resistivity is less than 1.2 °C m/W at 1 per cent moisture content. Excess original trench soil, rocks and waste are to be removed and disposed by approved methods;

(f) cable protection, comprising heavy-duty PVC strips (5 mm thick), must be installed at ≤250 mm above the top of each single-core EHV cable. The typical width of the heavy-duty strips is 300 mm and must overlap by at least 100 mm on each side, however dependent on the installation the heavy-duty PVC strips may overlap each cable conduit by at least 40 mm subject to approval from TasNetworks;

(g) Cable marker warning tape must be installed 300 mm below the ground surface, in a continuous manner and extend across the trench width;

(h) the exception to direct buried installation method is for road crossings, where conduits are utilised. Where future requirements necessitate provision to be made for the installation of additional cables, conduits may be considered subject to approval from TasNetworks;

(i) protection from direct solar radiation is to be provided where the cable is above ground;

(j) cables must be provided with explosion proof link boxes if required by the design;

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

(l) the EHV cable ends must be sealed at the factory. Each EHV cable section must be equipped with factory installed ‘pulling eyes’ at both ends;

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

(n) 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 water based;

    (ii) be compatible with the cable outer sheath;

    (iii) not set or harden during cable installation;

    (iv) not set in future; and

    (v) not consist of oil or grease.

(o) free running rollers must be positioned on the trench bottom to minimise frictional forces;

(p) rollers used must match the curvature of the EHV cable to ensure that the EHV cable is not damaged or deformed;

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

(r) the EHV cable minimum bending radius must not be exceeded at any time;

(s) the cable drum must be assisted in turning while pulling the cable during installation and where necessary be prevented from being subjected to a reverse bend as the cable comes off the reel;

(t) an acceptable means of mechanical braking must be employed when laying cables in steep terrains;

(u) EMF mitigation techniques; and

(v) TasNetworks has the right to inspect both the EHV cable and joints during installation and prior to backfilling. Hold points will be stipulated in project requirements.

5.3 Road easements

Where cable installations impact road easements the following requirements must be satisfied:

(a) road crossings are to be made with a minimum of disruption to traffic;

(b) road easements are required to provide minimum of disruption to traffic access to properties during trenching; and

(c) where vehicle access is permitted during trenching, a heavy-duty traffic barrier must be erected.

5.4 Cable joints and joint bays

The following provisos will be applicable for cable joints and joint bays:

(a) all joint bay construction must have a similar design as illustrated in the typical joint bay construction diagram Z-SD-808-0089-001;

(b) the installation will not be accepted if additional in-line joints have been installed due to cable damage or shortfall during supply, installation and testing;

(c) the cable must be snaked to allow for thermal expansion applied to tunnel installation where supported on cable rack as illustrated in diagram Z-SD-808-0089-001; and

(d) if cable damage or shortfall occurs that requires additional in-line joints then the Contractor will be required to replace the entire cable section.

5.5 Optical fibre

The installation of optical fibre must comply with the following requirements:

(a) splicing is to occur at ground level;

(b) a qualified experienced communications officer must perform all splicing of optical fibre utilised for telecommunications purposes;

(c) a DTS test is required to be performed on the EHV cable immediately after energisation, with sufficient load present, to provide an initial assessment of the cable's thermal performance; and

(d) the Contractor must supply the DTS software and hardware required for each cable route. The software must, as a minimum, be able to capture and store the cable temperature over time and enable easy visualization of the circuit's historical and real time thermal profile. TSP-IP DNP 3.0 communications media shall be used to establish connectivity between the DTS hardware device/s and the existing RTU of the substation to enable critical alarms to be integrated into TasNetworks' SCADA system.

5.6 Cable route survey

The Contractor is responsible for accurately surveying and recording any modifications from the original material schedules, route and section drawings, including any dimension changes, transpositions, exact location of other underground infrastructure and any clearances from existing infrastructure and property boundaries. All dimensions must be taken from points that are reasonably expected to remain constant for the life of the cable.

5.6.1 Survey information

The survey must provide survey location information of:

(a) the cable at all bends sufficient to accurately determine the curvature of the cable. This is to include the relative level on the top of the protection slab where installed or the top of the conduit or duct, etc. or where direct laid the top of the cable and the natural surface level at these points;

(b) the beginning and end of cable route along a straight section with sufficient points along the route to accurately determine the cable location;

(c) where the cable is laid in elevated ground line or in-ground troughing, the location of all bends and the troughing at sufficient intervals to accurately determine the cable location;

(d) any cable pits, manholes etc. and where a change to the configuration of the cable occurs in the trench. This is to include the relative level at the top of these structures and or the relative level on top of the protection slab where installed or the top of the conduit or duct etc. and the natural surface at these points;

(e) other services which cross the trench, their location, depth and details of the service, e.g. is to be recorded. The depth is to be provided as a relative level on the top of the service, on the cable protection slab and the natural surface at the location;

(f) where cable routes cross over one another, the location of these intersections and the relative level of both cable routes and the natural surface level are to be provided;

(g) locations of any joints in the cable together with the relative level of the protection covering the joint and the natural surface levels at these locations;

(h) where cables pass under tracks, the location of the tracks and a level on the tracks is to be recorded; and

(i) the location of other structures and features within 5 metres of the centre line of the cable trench is to be recorded. Examples of other structures and features are transmission line poles, manholes, buildings, and fences etc.

5.6.2 Survey drawings

The following drawing information must be provided:

(a) cross section of diagrams are to be provided to indicate the configuration of cables in the trench, ducts, troughing, cable pits, tunnels and at points where cables cross;

(b) where cables are in ducts, cross section diagrams are to be provided at both start and finish of the ducts. The cross sections are to be drawn by looking along the cable route in the direction away from the point of supply;

(c) where the cable routes are cross-country the cross sections are to be drawn looking along the cable route in the direction away from the point of supply;

(d) survey field notes are to be provided with sketches of the area through which the cable route passes;

(e) survey field notes are to be provided with sketches of the area through which the cable passes; and

(f) where the cable is in public roads/footways a schematic showing the location of the kerb lines, street corners and building lines must be provided on the side of the roadway nearest to the cable trench.

Other details such as the date of the survey, the date of the cable installation, general description of the work and details of the cable laid, i.e. voltage, type, size, etc. must be provided.

6 Testing

Testing, installation and commissioning must comply with the requirements of the document R246497 Testing, Commissioning and Training standard.

All components of EHV 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.

All test reports must be forwarded to TasNetworks for approval and acceptance. The tests will be considered as complete, only after an approval and acceptance of test results is received in writing by TasNetworks. A list of the tests to be conducted on EHV cable systems is provided below.

6.1 Type tests

Type tests are intended to prove the soundness of design of the systems and their suitability for operation under the conditions detailed in Table 1 and therefore must comply with the following requirements:

(a) type tests must be carried out before the delivery of the cable. 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 applied to a system of identical design to that of the tender offer, 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 must be provided with the tender;

(c) type tests for cables as specified in AS 1429.2 will apply for all EHV cables; and

(d) TasNetworks may specify any additional type test requirements in the relevant project specification.

6.2 Routine tests

Routine tests must comply with the following requirements:

(a) routine tests for cables as specified in AS 1429.2 will apply for all EHV cables;

(b) routine tests must be conducted on the cable to prove quality of manufacture and conformance with the relevant performance requirements of the applicable standard. The tests must be performed at the manufacturer’s works prior to delivery;

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

(d) an optical time domain reflectometry (OTDR), attenuation and continuity test from both ends of each drum will apply to all optical fibre cores within both EHV cable and OPUC;

(e) TasNetworks may specify additional routine test requirements in the relevant project specification;

(f) certified test reports are required as part of the contract; and

(g) routine factory test results must be approved and accepted by TasNetworks prior to dispatch of equipment to site.

6.3 Special tests

Special tests must comply with the following requirements:

(a) the special tests must be conducted on the samples of the EHV cable to prove quality of manufacture and conformance with the relevant performance requirements of the applicable standards;

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

(c) sample tests for cables as specified in AS 1429.2 will apply for EHV cable production batch to prove quality of manufacture; and

(d) special factory test will only be considered as completed after TasNetworks accepts the test results.

6.4 Site and pre-commissioning tests

Site installation and pre-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, installation or jointing.

The site test procedures must be submitted to TasNetworks for approval.

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 and based on acceptable industry standards:

(a) soil thermal resistivity and stability test on at least one wet and one dry nominated sample of each different trench fill material utilised (e.g. thermal stabilised back-fill and friable original soil, free of any waste material) prior to use;

(b) attenuation, OTDR and continuity test on all optical fibre cores within both EHV cables and OPUC, from all cable termination points;

(c) FAT tests on cable link boxes must be submitted to TasNetworks for approval and acceptance;

(d) phasing / continuity check;

(e) over sheath bonding contact resistance measurement where applicable;

(f) 4kV/mm with max 10kV for 1 min d.c. over sheath test;

(g) 5 kV insulation resistance test;

(h) high voltage a.c. test at power frequency for 1 hour, (note: d.c. testing is not permitted);

(i) very low frequency (VLF) test on new cables between 2.7 and 3.0 times the cable operating voltage (Uo) for 30 minutes;

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

(k) sheath voltage limiter test;

(l) cable impedance measurement (positive, negative and zero sequence) test; and

(m) cross bonding verification test.

7 Information to be provided with tender

7.1 Maintenance procedures and plans

TasNetworks will carry out various maintenance tests during the life of the cable. These tests may be part of a routine preventive and condition based maintenance program and hence be carried out repeatedly at nominal intervals or they may be part of a refurbishment project after an overhaul or repair. TasNetworks' maintenance tests may consist of repeated operational tests and functional checks on the various protection, operation and control and indication systems as part of a routine maintenance program. The equipment offered must therefore be suitable for the repeated application of the various maintenance tests TasNetworks may wish to perform during the life of the cable installation.

The contractor must provide:

(a) a detailed maintenance plan, procedures and task guides covering the design life of the equipment;

(b) recommend the frequency for maintenance based on time, operational count, operational events; etc;

(c) a recommended routine test plan; and

(d) blank schedules and forms for maintenance and routine testing, for use by TasNetworks maintenance personnel.

7.2 Instruction manual

The Contractor must supply to TasNetworks, before the first delivery of the equipment, three hard copies of an instruction manual, plus an electronic version, giving all the information necessary for the installation, commissioning, operation and maintenance of each portion of the equipment.

Each manual shall relate solely to the equipment supplied, and shall not contain any material which is not applicable to this equipment.

The hard copy manuals shall be suitable for accepting A4 size sheets and all drawings shall be suitably folded or photographically reduced for convenient filing in the manual.

Within three months after the date of an order a draft instruction manual shall be submitted to TasNetworks for approval. The equipment shall be considered substantially incomplete for the purpose of payment until the approved copies of this manual have been received.

Each instruction manual shall comprise the following:

(a) For hard copy manual a cover suitable to withstand normal field handling;

(b) a comprehensive index of all material in the manual;

(c) a description of the cable system;

(d) a summary of all electrical parameters and the performance data of the cable system;

(e) calculations of the electrical design, cable ratings and sheath induced voltages;

(f) a general description followed by a detailed technical account of the operation of each portion of the equipment. This shall include the drawings, diagrams, graphs, and photographs needed to ensure clarity;

(g) a copy of each type and routine test certificate and report;

(h) a copy of the results of all tests made after delivery and installation;

(i) details of optical fibres installed including for distributed temperature sensing ;

(j) information on the inspection, testing, installation and maintenance of all equipment. This shall include:

  (i) instructions for installing each item of equipment and material. These shall include detailed cable jointing and terminating instructions;

  (ii) the instructions required to dismantle and assemble each item of equipment, where appropriate;

  (iii) details and schedule of the recommended tests, adjustments, replacements and other work required to maintain correct performance;

  (iv) values, with permissible tolerances, to be achieved in the scheduled tests and adjustments; and

  (v) any other information that the Contractor considers to be useful or relevant to the particular installation.

8 Health based risk management

The contractor must document all relevant information to support TasNetworks' Health Based Risk Management (HBRM) process[1]. If the Contractors do not have a CBRM or Failure Mode, Effects and Criticality Analysis (FMECA) process, Table 3 should be completed.

The purpose of the HBRM information is to review and analyses the EHV design to establish:

(a) potential failure modes;

(b) the likelihood of failure;

(c) the significance of failure in terms of safety, operational performance, environmental impact and economic consequence;

(d) the criticality of failure in terms of system operations;

(e) the potential risk the EHV cable installation subjects TasNetworks to over the life of the asset; and

(f) assist with identifying, development and optimising of maintenance regime and reliability improvement programs over the life of the cable.

Table 3 HBRM requirements

Heading	Requirement
Item/Assembly and Part No/Drg No.	Identify the asset, manufacturer's part identification, and drawing details.
Functional description.	Provide an overview description of the cable function including the functions of major component functions.
MTBF (hrs)	Enter the asset/item's Mean Time Between Failure in hours of the major components (i.e. cable, cable terminations, cable joints, etc)
Function	Principal functions - which represent the business reason for an assets existence. Enter the item name and, as concisely as possible, the function(s) of the item to meet the design intent. Functions may also be identified in the form of a desired standard of performance with functional failure deemed to have occurred when this level of performance is not available. Include information regarding the environment in which the system operates. (e.g., define temperature, voltage etc).
Failure mode	Failure modes are the effects by which failures are observed. It includes the manner by which the failure is observed & is generally described by the way in which the failure occurs and its impact, if any, on the equipment operation
Failure Rate, %	Identify the rate at which this type of failure occurs in failure per million hours (FPMH). If data is not available to establish exact rates, enter the indicative percentage in the next column (with % symbol) that this failure mode / cause combination contributes to the total equipment MTBF
Cause of Failure	State the engineering mechanism of failure that leads to the particular functional or conditional failure. Failure causes are derived from the design. They are associated with the detailed design approach taken, the materials used, the operating environment including such information as physical loads and corrosive materials. Human factor information is also required, to support the allocation of warning notices in manuals or service schedules.

[1] Similar in concept to contemporary Condition Based Risk Management (CBRM) process.

Heading	Requirement
Local effects	Identify that impact a particular failure mode has on the operation, function or status of an item. The description of the failure effect must be adequately detailed to allow classification into one of the criticality categories:- • Hidden/safety/environment. • Evident/safety/environment. • Evident/economic. • Hidden/economic.
Criticality	Identify the criticality a particular failure mode has on the operation, function or status of the equipment item. Multiple criticalities may be entered for a failure mode:- H – Hidden – Loss of function is not evident to the operator. S – Safety – Loss of function is likely to lead to death or injury. E – Environmental – Loss of function results in adverse impact on the environment. O – Operational /economic impact only.

9 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R579290.

9.1 Cable schedules

Updated cable schedules must be prepared to show all cables added or modified for the works.

Updated cable schedules must show for each cable:

(a) cable identification number;

(b) from/to information, detailing the location of the two cable ends in separate columns;

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

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

(e) type and size of cable glands.

10 Deliverables

Requirements for project deliverable are outlined in document R579289.