Standard

Fibre Optic Overhead Ground Wire (OPGW) Standard

R248806

Version 1.0, June 2018
Authorisations

<table>
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<th>Action</th>
<th>Name and title</th>
<th>Date</th>
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<tbody>
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Responsible

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

Please contact the Primary Systems 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.

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## Record of revisions

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1 General

1.1 Purpose

To define the technical specifications for the supply of Fibre Optic Overhead Ground Wire (OPGW) for installation on extra high voltage power lines, under the responsibility of TasNetworks Pty Ltd (hereafter referred to as ‘TasNetworks’).

1.2 Scope

This standard applies to all OPGW purchased for installation on extra high voltage transmission lines under the responsibility of TasNetworks.

This standard contains minimum requirements for:

(a) OPGW design;
(b) properties of both optical fibres and ground (earth) wire;
(c) engineering, manufacture, testing at manufacturer’s works;
(d) secure packaging, supply, transportation, and delivery to site; and
(e) associated documentation.

This standard is to be applied to new OPGW as well as replacement of part or all of existing OPGW.

This standard does not describe OPGW construction or commissioning requirements.

1.1 Objectives

OPGW purchased by TasNetworks, and its Contractors on behalf of TasNetworks, must meet the requirements of this standard to ensure:

(a) compliance with relevant Australian legal requirements;
(b) compliance with the Tasmanian Electricity Code and National Electricity Rules;
(c) personnel and public safety;
(d) safety of TasNetworks’ assets;
(e) ease in operation and maintenance;
(f) reliability and continuity of TasNetworks’ electrical transmission network;
(g) reliability and continuity of TasNetworks’ telecommunications network; and
(h) exposure of TasNetworks’ business to risk is minimised.

1.1 Certificate of conformance

Before any OPGW is supplied to TasNetworks, a certificate of conformance with this standard must be submitted to TasNetworks. The certificate of conformance (R118400) must be duly supported with documents, drawings, test results, test reports, test certificates, completed check lists and other documents as applicable. Where TasNetworks has approved deviation to any specific requirements of this standard, proof of all such approvals must be included with the certificate of conformance.

TasNetworks will supply a blank certificate of conformance (R1108400), to be completed by the Contractor and submitted with the tender.
The OPGW will be dispatched from the manufacturer’s factory only after receipt and acceptance by TasNetworks of the certificate of conformance. Title for the OPGW will transfer to TasNetworks upon both TasNetworks’ acceptance of the certificate of conformance and receipt of the goods. This requirement shall be reflected in the contracting arrangements made between TasNetworks and the supplier, or between TasNetworks and its construction Contractor if that Contractor is purchasing the OPGW on TasNetworks’ behalf.

1.2 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.

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.

1.1 References

As a component of the Principal’s Project Requirements (PPR) - Technical Specification (hereafter known as the ‘PPR-Technical Specification’), this standard is to be read in conjunction with other standards and documents as applicable. The Contractor must identify all applicable standards, codes, acts and regulations for the equipment, works or services required under the PPR-Technical Specification. The Contractor must ensure conformance with all such Australian and local standards. Where there is no Australian standard on a particular subject, the Contractor must conform to relevant applicable International standards. These include the following:

ANSI/EIA 359-A  Standard colours for identification and coding
IEC 60793-1  Optical fibres – Part 1: Generic specification
IEC 60793-2  Optical fibres – Part 2: Product specifications
IEEE 1138-1994 (R2002)  IEEE standard construction of composite fibre optic overhead ground wire
ITU-T G652  Characteristics of a single-mode optical fibre and cable
ITU-T G655  Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
R1108397  OPGW information to be provided with tender
R248811  OPGW deliverables
R1037048  Transmission line design standard
R1108400  Certificate of conformance
2 General requirements

The OPGW comprises an inner core containing optical fibres for data transmission, and an outer layer(s) of conductor strands to provide strength and to act as an overhead ground (earth) wire.

Project specific requirements for the OPGW will be listed in the PPR-Technical Specification.

2.1 Service conditions

Environmental conditions and any specific design criteria for particular works will be stated in the PPR-Technical Specification.

The OPGW must be capable of operation at its specified rating without assisted means.

2.2 Performance

The OPGW and fittings must be appropriate to satisfy the design criteria and to meet or exceed the specified performance.

2.3 Compatibility

The OPGW must be compatible with readily available fittings for all required applications, including, but not limited to:

(a) dead-ends;
(b) suspension clamps;
(c) vibration dampers;
(d) down-lead clamps; and
(d) joint (splice) boxes.

3 Fibre optic overhead ground wire

Mandatory OPGW requirements to be detailed within the PPR-Technical Specification will include the following parameters:

(a) Number of OPGW sections (drums), excluding spare drum;
(b) Drum lengths (m)

Other project specific OPGW requirements to be detailed within the PPR-Technical Specification include the following:

(c) Power system nominal voltage (kV);
(d) Power system highest voltage (kV);
(e) Transmission line total nominal length (m);
(f) Specific OPGW information, for each section, including:
   (i) Transmission line tower numbers, including ‘From’ & ‘To’ towers;
   (ii) Number of spans; and
   (iii) Nominal length (m).
(g) Details of proposed splice locations, such as terrain, land use and access conditions;
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(h) Length of spare drum (m), to be at least the longest drum; and

(i) Any project specific requirements, such as multiple earth-wires/OPGW at terminal spans into substations and power stations and any long spans in excess of 1000 m.

The OPGW design must be mechanically and electrically compatible with the design of the transmission line and comply with the requirements of the Transmission Line Design standard (R1037048).

A check for increased transverse cascade failure risk from augmentation with larger OPGW in an OHEW position should be assessed using ASCE No 74E.

General requirements for the OPGW are specified in Table 1. In addition, OPGW construction in the factory must also conform to the following requirements:

(j) Any material filled in the buffer tube, or alike, must be non-hygroscopic, non-nutritive to fungus, electrically non-conductive and homogenous. The filling must be free from dirt and foreign matter. The filling of the buffer tube in the factory must be performed in such a way that the filling material can be removed at a later date using conventional non-toxic solvents.

(k) The optical fibres must not adhere to the inside of the buffer tube, or alike, that is used to contain the optical fibres.

Table 1 – General requirements for OPGW

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Standard to be complied with as a minimum</td>
<td>-</td>
<td>IEEE 1138-1994 (R2002)</td>
</tr>
<tr>
<td>2.</td>
<td>Minimum design technical life of the OPGW</td>
<td>yrs</td>
<td>60</td>
</tr>
<tr>
<td>3.</td>
<td>Maximum nominal overall diameter</td>
<td>mm</td>
<td>14.5</td>
</tr>
<tr>
<td>4.</td>
<td>Mass</td>
<td>kg/m</td>
<td>&lt; 0.420</td>
</tr>
<tr>
<td>5.</td>
<td>Minimum number of fibre cores</td>
<td>No.</td>
<td>24</td>
</tr>
<tr>
<td>6.</td>
<td>Modulus of Elasticity</td>
<td>Gpa</td>
<td>≤ 120</td>
</tr>
<tr>
<td>7.</td>
<td>Coefficient of Linear Expansion</td>
<td>/°C</td>
<td>&gt; 15 x 10⁻⁶</td>
</tr>
<tr>
<td>8.</td>
<td>Minimum bending radius</td>
<td>mm</td>
<td>450</td>
</tr>
<tr>
<td>9.</td>
<td>Buffering</td>
<td>-</td>
<td>Loose</td>
</tr>
</tbody>
</table>
4 Optical Fibres

4.1 Characteristics

(a) All optical fibres must be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of the PPR-Technical Specification and applicable international standards.

(b) Optical fibre splices are not permitted for the delivered lengths of the cable.

(c) Optical fibre must be protected against micro-bending losses and abrasion.

(d) Protective coating of the optical fibre must be easily strippable by means of a mechanical stripping tool without damaging the optical fibre. The use of chemicals must not be required for this purpose.

(e) Depending on project requirements, the OPGW supplied to TasNetworks will be one of the following two types:

   (i) Single-mode optical fibre and cable (allowing higher bandwidth applications in the wavelength range 1360-1530 nm as well as at the standard wavelengths of 1310 nm and 1550 nm); or

   (ii) Non-zero dispersion-shifted single-mode optical fibre and cable (allowing the use of Dense Wavelength Division Multiplexing (DWDM) systems and providing better definition for chromatic dispersion).

(f) The optical characteristics of single-mode optical fibre and cable are detailed within Recommendation ITU-T G.652. Specifically, TasNetworks requires that optical fibre characteristics be compliant with the attributes defined within category G.652.D. The only exception to these requirements is with respect to the optical fibre attenuation coefficient, where TasNetworks requires a more onerous maximum attenuation coefficient than that described within ITU-T G.652.D. In particular, the optical fibre must have an attenuation coefficient of:

   (i) no more than 0.35 dB/km at 1310 nm;
   (ii) no more than 0.22 dB/km at 1550 nm; and
   (iii) no more than 0.25 dB/km at 1625 nm.

(g) The optical characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable are detailed within Recommendation ITU-T G.655. Specifically, TasNetworks requires that optical fibre characteristics be compliant with the attributes defined within category G.655.E. The only exception to these requirements is with respect to the optical fibre attenuation coefficient, where TasNetworks requires a more onerous maximum attenuation coefficient than that described within ITU-T G.652.E. In particular, the optical fibre must have an attenuation coefficient of:

   (i) no more than 0.35 dB/km at 1310 nm;
   (ii) no more than 0.22 dB/km at 1550 nm; and
   (iii) no more than 0.25 dB/km at 1625 nm.

4.1 Optical fibre core grouping and colour code

(a) Optical fibre cores must be bundled in groups of no more than 12 fibres in each group. The number of optical fibres in each group must be equal.

(b) The optical fibres must be marked by a coloured coating with different colours according to ANSI/EIA 359-A.
(c) Where the optical fibres are bundled in groups, each bundle must be distinguishable by a coloured yarn, coloured tube or ring mark/s. The colour code for the yarn or tube must be the same as that for the optical fibres as stated above. For example:

- Group 1: Blue
- Group 2: Orange
- Group 3: Green
- Group 4: Brown, etc.

(d) If ring marks are used to mark bundled groups, then the following methodology shall be followed:

- Group 1: without ring
- Group 2: with 1 ring
- Group 3: with 2 rings
- Group 4: with 3 rings, etc.

(e) The optical fibre, yarn and tube colours and ring marks must be stable during temperature cycling and must not be subject to fading or smearing either onto each other or into the gel filling material.

(f) The original colour coding system must be discernible throughout the design life of the OPGW.

(g) The colour coding system must not cause optical fibres to stick together.
5 Ground wire

In addition to the general requirements specified elsewhere in this standard, the ground wire must conform to the requirements listed in Table 2.

Table 2 – Requirements for ground wire

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DC resistance at 20°C</td>
<td>Ω/km</td>
<td>&lt; 0.35</td>
</tr>
<tr>
<td>2.</td>
<td>Operating temperature range</td>
<td>°C</td>
<td>40 to +70</td>
</tr>
<tr>
<td>3.</td>
<td>Installation temperature range</td>
<td>°C</td>
<td>25 to +60</td>
</tr>
<tr>
<td>4.</td>
<td>Minimum breaking load</td>
<td>kN</td>
<td>49</td>
</tr>
<tr>
<td>5.</td>
<td>Minimum strand diameter</td>
<td>mm</td>
<td>3.0</td>
</tr>
<tr>
<td>6.</td>
<td>Lay direction of outer most layer</td>
<td>-</td>
<td>Right hand lay</td>
</tr>
<tr>
<td>7.</td>
<td>Minimum short circuit capacity (I²t)</td>
<td>kA²s</td>
<td>100</td>
</tr>
</tbody>
</table>

6 Maintenance and routine test plans

All test plans and documentation as requested in this documentation must be in Microsoft Word format. As a minimum, documentation listed below is required for maintenance and routine testing:

(a) A routine test plan must be recommended and submitted to TasNetworks as a part of final documentation with delivery.

(b) Blank schedules and forms for maintenance and routine testing, for use by TasNetworks maintenance personnel, must be provided.

(c) Relevant task guides and procedures for testing must support the maintenance and routine testing forms and schedules.

(d) All procedures and task guides for the product supplied must be provided.

7 Testing

(a) All components of the OPGW 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.

(b) Tests must be conducted to determine mechanical, thermal and electrical characteristics of the OPGW. All tests as prescribed by the relevant IEEE and IEC standards must be conducted unless otherwise specifically approved by TasNetworks in writing.

(c) All test reports must be forwarded to TasNetworks within 14 days of the test for approval and acceptance. The tests will only be considered as complete after approval and acceptance of the test results is provided by TasNetworks in writing.

A description of the tests to be conducted on the OPGW is provided below.
7.1 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 PPR-Technical Specification. Type tests must be carried out before the delivery of the OPGW. 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 offered, or to a system with a similar design which does not materially alter the properties to be checked by the type test.

(b) Where such tests have already been performed, a copy of the type test reports must provided with the tender.

(c) As a minimum, the type tests listed in Table 3 must be conducted on the batch of OPGW manufactured for TasNetworks. TasNetworks will not accept any OPGW that fails any of these tests. The type tests listed must be conducted in accordance with IEEE 1138-1994 (R2002).

Table 3 - Type tests to be conducted on OPGW

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Parameter</th>
<th>Reference Clause IEEE 1138</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Water ingress test</td>
<td>4.1.1.1</td>
</tr>
<tr>
<td>2.</td>
<td>Seepage of flooding compound test</td>
<td>4.1.1.2</td>
</tr>
<tr>
<td>3.</td>
<td>Short circuit test</td>
<td>4.1.1.3</td>
</tr>
<tr>
<td>4.</td>
<td>Aeolian vibration simulation test</td>
<td>4.1.1.4</td>
</tr>
<tr>
<td>5.</td>
<td>Strain margin test</td>
<td>4.1.1.10</td>
</tr>
<tr>
<td>6.</td>
<td>Stress-strain test</td>
<td>4.1.1.11</td>
</tr>
</tbody>
</table>

7.1 Factory acceptance tests

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

(b) Factory acceptance tests must be carried out on an OPGW sample in the presence of a TasNetworks representative. Factory acceptance testing must be performed at the manufacturer’s premises prior to delivery.

7.1 Handover tests

Handover tests on OPGW must be performed on site, at the point of delivery. These tests are to be conducted in the presence of TasNetworks representatives. TasNetworks’ contractor will recommend relevant handover tests to be performed at site, at the point of delivery to prove that the OPGW has not been damaged during delivery, transportation and unloading. As a minimum, this will include optical time-domain reflectometer (OTDR) tests on all fibre cores at 1310 nm, 1550 nm and 1625 nm (one direction only), unless otherwise directed by TasNetworks.
8 Packaging

(a) OPGW cables must be supplied on drums.
(b) Each length of OPGW cable must be wound on a separate drum.
(c) The diameter of the drum barrel must be large enough to prevent damage to the cable during reeling or un-reeling. In no event must the diameter of the barrel be smaller than 40 times the outer diameter of the cable.
(d) The cable drum must be durable and constructed so as to prevent damage to the cables during shipment and handling.
(e) Wooden lagging or other suitable means of protection must be applied to the drum to prevent damage to the OPGW cables during shipment and storage.
(f) Nails and staples used in the construction of the drum must not be placed in a position where they could damage the OPGW cables during shipment, handling, reeling or unreeling.
(g) The drums will be non-returnable.
(h) Cable drum material must be certified free of insect infestation.
(i) The centre-hole diameter of the drum must be 128 mm as a minimum.
(j) For test purposes a length of at least 4 m of the inner cable end must be accessible without removing wooden lagging. This length must be securely fastened and protected during shipment and handling.
(k) The cable ends must be sealed using shrinking caps and fastened tightly. A protective wrap must be applied over the outer layer of the cable on each reel. The wrap must be weather resistant and must not be removed until the cable is installed.

8.1 Marking plate

(a) Marking plates must be provided with information marked indelibly and legibly.
(b) The plates must be of a non-corrosive material and information must be inscribed with black letters on white background.
(c) Marking plates containing the following information must be securely attached to the outer side on each drum flange (not to the inner side):
   (i) Type and size of cable.
   (ii) Cable length in metres.
   (iii) Gross weight in kilograms.
   (iv) Reel number.
   (v) Measured attenuation coefficients and other technical parameters of the cable.
   (vi) Manufactures name.
   (vii) Year of manufacture.
   (viii) Name of Customer “Tasmanian Networks Pty Ltd”.
   (ix) Project name and number with reference Contract Number.
   (x) Arrow showing roll/unwinding direction.
9 Shipping and storage

(a) During transport and storage the OPGW must not be exposed to ambient temperatures outside the range of -40°C to +70°C.

(b) It is also a requirement that OPGW cable drums be stored in an upright position (ie. not laid on their side) to prevent damage to OPGW fibres.

(c) During transport, each OPGW cable drum shall be placed on its flanges and tied down to at least two anchor points.

10 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document “OPGW information to be provided with tender” (R1108397).

11 Deliverables

Requirements for project deliverables are outlined in document “OPGW deliverables” (R248811).