

ICS 29.060

NRS 061-2:2004

ISBN 0-626-16108-8

Edition 1

Rationalized User Specification

SPECIFICATION FOR OVERHEAD GROUND WIRE WITH OPTICAL FIBRE

Part 2: Installation guidelines



This rationalized user specification is issued by
the Technology Standardization Department (TSD), Eskom,
on behalf of the
User Group given in the foreword
and is not a standard as contemplated in the Standards Act, 1993 (Act No. 29 of 1993).

Table of changes

Change No.	Date	Text affected

Correspondence to be directed to

The NRS Projects Manager
The Technology Standardization Department (TSD)
Eskom
PO Box 1091
Johannesburg 2000

Website: <http://www.nrs.eskom.co.za>

Printed copies obtainable from

Standards South Africa
Private Bag X191
Pretoria 0001

Telephone : (012) 428-7911
Fax : (012) 344-1568
E-mail : sales@sabs.co.za
Website : <http://www.stansa.co.za>

COPYRIGHT RESERVED

Printed in the Republic of South Africa
by Standards South Africa
1 Dr Lategan Road, Groenkloof, Pretoria

Contents

	Page
Foreword	2
Introduction	3
Keywords	3
1 Scope	5
2 Normative references	5
3 Terms, definitions and abbreviations	5
4 Requirements	6
4.1 General	6
4.2 Preparatory work	6
4.3 OPGW stringing	7
4.4 Fittings	11
4.5 Safety and environmental	14
4.6 Quality control	15
5 Tests	15
Annexes	
A (informative) Summary tables	17
B (normative) Acceptance procedure for optical fibre systems	19
C (normative) Installation drawings and fittings	22
Bibliography	30

Foreword

This part of NRS 061 was prepared on behalf of the Electricity Suppliers Liaison Committee (ESLC) and approved by it for use by supply authorities.

This part of NRS 061 is based on TRMASACB2:2000 and was compiled by M Korber and B Jacobs. Annex B is based on TPR 0150 compiled by D C Smith.

This part of NRS 061 was prepared by a working group comprising the following members:

D C Smith (Chairman)	Eskom, Transmission Technology
G S Anderson	Nelson Mandela Metropolitan Municipality
M Gittings	eThekweni Metropolitan Council
A Gouveia	Cape Town Electricity Distributor
B Jacobs	TransAfrica Projects (TAP)
K Koekemoer	Pretoria Electricity
J Masango	Project assistant, NRS PMA
T Naidoo	City Power Johannesburg (Pty) Ltd
V Sewchand (Project leader)	Technology Standardization Eskom
J Shillington	City Power Johannesburg (Pty) Ltd
I van der Merwe	Eskom (Western Cape Region)

A Manufacturers Interest Group (MIG) was also consulted on the contents of this part of NRS 061 and its comments were incorporated where the working group was in agreement. The MIG comprised the following members:

A Deitchman	ATC Cables
P Muller	Cable Manufacturers Association
R Phillips	Aberdare Cables

The Working Group was appointed by the ESLC, which, at the time of approval, comprised the following members:

R Wienand (Chairman)	eThekweni Electricity
M N Bailey	Eskom Distribution Technology, Simmerpan
A J Claasen	Standards South Africa (StanSA)
B de Jager	Mangaung Municipality
W G H Dykman	City of Tshwane, AMEU
A H L Fortmann	eKurhuleni, AMEU
V S Kobuwe	City Power Johannesburg (Pty) Ltd
M Mabila	Eskom Menlyn
R McCurrach	Eskom Transmission Line Technology
D M Michie	Nelson Mandela Metropolitan Municipality, AMEU
J J Roos	eKurhuleni Metropolitan Municipality
V Singh	Technology Standardization, Eskom
	Division of Resources and Strategy
N Singh	National Electricity Regulator
R van der Riet	City of Cape Town (Tygerberg administration)
J S van Heerden	SABS, NETFA
D van Wyk	Umhlathuze Electricity (Richards Bay)

Annexes B and C form an integral part of this part of NRS 061. Annex A is for information only.

Recommendations for corrections, additions or deletions should be addressed to the NRS Projects Manager.

Introduction

This part of NRS 061 was prepared to establish and promote uniform requirements for the installation of overhead ground wire with optical fibre.

The ESLC expresses the wish that, in the national interest and in support of government policy to foster local manufacture and stimulate export, all purchasers adopt the requirements of this part of NRS 061 insofar as their particular conditions will allow.

Keywords

Optical ground wire.

This page intentionally left blank

OVERHEAD GROUND WIRE WITH OPTICAL FIBRE

Part 2: Installation guidelines

1 Scope

This part of NRS 061 specifies the installation of overhead fibre links between patch panel enclosures at the two terminating substations. It also specifies the essential methods for stringing, tensioning, earthing, jointing and terminating of the overhead ground wire with optical fibre (OPGW).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of NRS 061. All normative documents are subject to revision and, since any reference to a normative document is deemed to be a reference to the latest edition of that document, parties to agreements based on this part of NRS 061 are encouraged to take steps to ensure the use of the most recent editions of the normative documents indicated below. Information on currently valid national and international standards can be obtained from Standards South Africa.

CIGRE TF 22.11.03, *Guide to fittings for optical cables on transmission lines – Part 1: Selection and use.*

IEC/TR 61328:2003, *Live working – Guidelines for the installation of transmission line conductors and earth wires – Stringing equipment and accessory items.*

SANS 60793-1-40/IEC 60793-1-40:2001 (SABS IEC 60793-1-40), *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation.*

SANS 61230/IEC 61230:1993, *Live working – Portable equipment for earthing or earthing and short-circuiting.*

3 Terms, definitions and abbreviations

For the purposes of this part of NRS 061, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1 acceptable

acceptable to the customer

3.1.2 birdcaging

loosening and separation of the outer layer wires from the inner wires

3.1.3 ghosting

false reflection which appears at an integral multiple of the distance from the initial (true) reflective event, for example if a large reflection occurs at say 1 000 m, there could be a ghost at 2 000 m due to the reflected light bouncing back and forth within the fibre

3.1.4 residual strength

remaining tensile strength of the conductor after it has been in service

3.1.5 splicing

fusion of the ends of two fibres to create a joint with minimal optical loss

3.2 Abbreviations

3.2.1 ADSS: all dielectric self-supporting

3.2.2 AGS: armour grip suspension

3.2.3 CST: corrugated steel tape

3.2.4 HDPE: high-density polyethylene

3.2.5 IP: ingress protection

3.2.6 MFD: mode field diameter

3.2.7 NCS: national calibration standard

3.2.8 OPGW: overhead ground wire with optical fibre

3.2.9 OTDR: optical time domain reflectometer

4 Requirements

4.1 General

The stringing of OPGW is analogous to the stringing of the standard ground wire but the presence of the optical fibre core implies the adherence to special protection measures to prevent damage to the fibres due to mechanical elongation, bending, twisting and crushing forces. This part of NRS 061 describes the measures required to correctly install OPGW on overhead transmission lines in such a way that a long service life is guaranteed and that there will be no danger to either the public or personnel involved in this process.

4.2 Preparatory work

It is essential that the installer is completely familiar with the requirements of the cable manufacturer. To ensure the integrity of the fibre optic core during stringing, the following preparatory work is essential:

- a) OPGW drum lengths shall be carefully selected for the specific line sections to be strung to avoid the necessity of installing splice enclosures on towers where the OPGW must be insulated from the steelwork as much as possible. Allowance shall be made for sag and winch tensioner take-up.
- b) The drums shall be transported to the designated material holding area in a vertical position with the cable ends fixed and sealed so that no moisture can affect the cable. Drums shall remain in the vertical position during unloading so that the drum is not damaged. Under no circumstances shall the drums be placed on their sides.

The drums shall be stored far from any activity that could damage the cable in order to facilitate the handling and loading. To minimize the risk of fire, the storage area shall be cleared of all vegetation.

- c) After selection of suitable locations for the tensioner and puller, OPGW drums, fittings and accessories, they shall be transported to the site and kept in a suitable place until their final use.

4.3 OPGW stringing

4.3.1 Special tooling and precautions needed for OPGW stringing

4.3.1.1 All the provisions for controlled stringing shall be in accordance with IEC/TR 61328. The equipment earths shall be in accordance with SANS 61230. Figure C.1 shows the recommended equipment necessary for OPGW stringing.

4.3.1.2 Hydraulic pullers equipped with dynamometers shall have a pulling capacity equivalent to twice the stringing tension. The pullers shall be properly anchored to resist any lifting forces during stringing.

4.3.1.3 A tensioner equipped with dynamometers that have a bull wheel 1,2 m or more in diameter shall be anchored to prevent any uplift force.

4.3.1.4 Drum jacks of suitable capacity shall be used on both sides of the drum so that the drum can rotate freely without touching the ground. Drum jacks shall have braking arrangements to ensure that rotation stops smoothly.

4.3.1.5 Anti-twisting counterweights that consist of a series of weights linked by hinges shall be used as follows:

- a) 12 kg for span lengths up to 300 m;
- b) 15 kg for span lengths from 300 m to 700 m; and
- c) 20 kg for span lengths of more than 700 m.

4.3.1.6 Neoprene or similar material lined pulley guides (sheaves) shall be 600 mm or more in diameter. A single wheeled pulley block shall be used if the line angle and the OPGW angle are less than 60°. If the angle is greater than 60°, a twin wheeled pulley (wheels placed in tandem) block will be necessary (see figure C.2).

4.3.1.7 Pre-formed pulling grips shall be used. Sock-meshed grips shall not be used on aluminium alloy clad steel armouring.

4.3.1.8 Pre-stretched polyester and steel ropes shall be used.

4.3.1.9 Guy grips for hauling cable at strain points shall be used. Come-along clamps shall not be used.

4.3.2 Stringing operation

4.3.2.1 To protect the integrity of the optical fibres and the armouring during stringing, the requirements in 4.3.2.2 to 4.3.2.8 (inclusive) shall apply.

4.3.2.2 The minimum diameters of the tensioner reels (on which the OPGW will be coiled during installation) shall be at least 80 times the diameter of the OPGW being installed, or as specified by the manufacturer. The bull wheel sheave diameter shall be more than 70 times the cable diameter or 1 200 mm, whichever is smaller. The wheels shall be in such condition that they do not have any burrs or cavities which may damage the cable. The running grooves shall be adapted in size to the cable diameter. At best, they shall be coated with neoprene or similar material. The tensioner shall be able to assure constant tension and allow a steady slow down at different stringing speed without the effect of cable run after. Tensioning shall be readily controllable and capable of maintaining constant and even operation. There shall be a minimum of six turns to anchor the cable. To prevent birdcaging, the correct orientation for entry and exit of the cable shall be considered. For right-hand lay, the cable shall enter the brake on the left and exit on the right. For left-hand lay, the cable shall enter on the right and exit on the left.

4.3.2.3 The distance from the winch to the first pulley on the tower shall be at least twice the height of the pulley attachment point.

4.3.2.4 The diameter of the pulleys shall not be less than 600 mm. However, at the first and last tower in the section and at towers with an angle of deviation between 15° and 60°, the pulley diameter shall be at least 800 mm. If the angle is greater than 60°, a twin pulley block (wheels placed in tandem) shall be used (see figure C.2).

4.3.2.5 The stringing shall be carried out using winches with settable pulling force limitations and automatic shutdown facility. The pulling force shall be monitored and the maximum pulling tension shall not exceed 50 % of the installed OPGW tension in the section. The winch shall be checked for correctness of pulling force before the start of stringing.

4.3.2.6 The stringing speed shall not exceed 30 m/min but depending on the stringing conditions this could change. The winch shall be started slowly at the minimum speed and the speed increased gradually to the maximum speed. When the anti-twisting device is approaching the pulley, the stringing speed shall be decreased to 5 m/min.

4.3.2.7 For new lines, the OPGW stringing operation will be governed by other construction activities such as erection of the towers and stringing of phase conductors. For existing lines, where the earth conductor is substituted by the OPGW, the earth conductor may be used as a pilot cable wire if it is in good condition and if the specific pulling force does not exceed the residual strength of the conductor. In both cases the stringing shall be carried out in accordance with 4.3.1. For lines without earth wire, the pulling rope shall be installed first and then the OPGW installed using the standard method shown in figure C.1.

4.3.2.8 The bull wheels of the tensioner shall be provided with a neoprene layer when the outer layer of the OPGW is made up of aluminium clad steel, aluminium or aluminium alloy.

4.3.3 Special conditions during stringing

4.3.3.1 Where specified by the manufacturer of the OPGW, anti-twisting counterweights shall be used to protect the optical fibres against excessive twisting action during the stringing operations. An anti-twisting counterweight shall be installed at the front end of the OPGW. If, subject to the requirements described in 4.3.1.5, more than one anti-twisting counterweight shall be used, then the anti-twisting counterweights shall be located as shown in figure C.1. Anti-twisting counterweights and pulleys shall be compatible. The anti-twisting counterweights shall pass through the pulley at reduced speed.

4.3.3.2 Care shall be taken to ensure that the cable is not damaged by dragging it along the ground or over any objects.

4.3.3.3 In order to prevent the OPGW from being damaged, sagging, clamping and installation of fittings shall only be performed after a short settling period. The installer shall be responsible for any damage caused to the cable if this subclause is ignored.

4.3.3.4 OPGW shall be strung and tensioned with minimum mechanical impact. The minimum bend radius shall not be less than that specified by the OPGW supplier.

4.3.3.5 A protective sleeve shall be inserted around the conductor for a length of 5 m, where the anti-twisting devices are positioned on the conductor. Subsequently, the conductor portion where the anti-twisting device was attached, shall be removed.

4.3.3.6 Owing to induction effects from power lines, running earths shall be provided to ensure personnel safety (see IEC/TR 61328).

4.3.4 Jointing and splicing between two sections of OPGW

4.3.4.1 The correct number of correctly dimensioned down-lead clamps shall be used at each down-lead cable to ensure that the OPGW is securely anchored to the tower in such a way as to eliminate vibrations and cable clashing against the tower. A down-lead clamp shall be installed at each tower member intersection. The distance between clamps shall be as specified in 4.4.6.5. Clamp bolts shall be tightened using torque wrenches. The torque that will prevent damaging stress concentrations due to clamping shall be obtained from the OPGW and clamp manufacturers. Only clamps approved by the OPGW manufacturer shall be used.

On insulated strain (see figure C.3) or suspension towers, the down-lead shall be insulated from the tower using insulated clamps. The minimum distance between the OPGW and any tower member shall be greater than or equal to 50 mm.

On non-insulated strain (see figure C.4) or suspension towers, the down-lead shall be electrically connected to the tower by means of non-insulated clamps.

4.3.4.2 Upon completion of section stringing, when optical fibre cables are hand fed through the tower structure, the minimum bending radius specified by the manufacturer, shall not be compromised and care shall be taken to avoid birdcaging.

4.3.4.3 Upon completion of stringing, sufficient spare cable shall be available to permit jointing to take place. The length of the OPGW for connection purposes shall allow sufficient slack from the strain clamp to permit splicing at ground level and at the same time to preserve the manufacturer's recommended bending radius (see figure C.6). A further minimum allowance of 5 m shall be provided in each enclosure to make fibre optic connections. In areas where there is a high risk of vandalism, jointing shall be done higher up on the tower. The basic requirements for hardware at splicing towers and standard towers as well as for insulated and non-insulated assemblies are depicted in figures C.3, C.4, C.5, C.6 and C.7. If splicing is required at either strain towers or suspension towers, the tension assemblies as shown in figures C.3 or C.4 shall be used, depending on whether insulated assemblies are required or not.

4.3.4.4 If OPGW sagging and jointing cannot be done in a continuous operation, the ends of the OPGW shall be sealed using a compressed pulling eye that shall remain in place until jointing work starts. Spare lengths of OPGW at jointing tower shall be coiled in coils greater than 1,5 m in diameter. The coils shall be securely attached, above the anti-climbing devices, to the tower in order to prevent OPGW damage under windy conditions as well as to prevent theft.

4.3.4.5 Well-trained technicians shall carry out splicing of optical fibres. Splicing machines shall be capable of creating splices consistently better than 0,05 dB. Tools and measuring equipment shall be provided and used for each splice. Splicing shall be done at ground level unless otherwise specified by the customer, after which the splice enclosure shall be fixed on the tower above the anti-climbing device. Splice losses shall be as stated in annex B, unless otherwise specified by the customer.

The operation of splicing shall follow the following sequence:

- a) fix an adapter for the mounting of the splice enclosure onto the tower; for an insulated OPGW strain assembly the splicing enclosure shall be insulated from the tower structure; for a non-insulated OPGW strain assembly the splicing enclosure shall be electrically bonded to the tower structure;
- b) remove the outer strands and expose the optical fibre unit in accordance with the splice enclosure manufacturer's instructions;
- c) clamp the OPGW as specified by the splice enclosure manufacturer;
- d) splice the optical fibres by fusion;

- e) reinforce the splicing point with heat shrinkable tube or by other means in accordance with the splice enclosure manufacturer's instructions;
- f) secure and lay the optical fibres in the splice organizer inside the enclosure on completion of a permanent splice;
- g) close and seal the splicing enclosure; and
- h) loop the excess cable and secure the splice box to the adaptor mounted onto the tower, to ensure that the minimum bending radius specified by the manufacturer is adhered to and that there is no birdcaging.

4.3.4.6 Fibre migration can be experienced in the central tube design. To avoid this, a minimum of two loops shall be installed immediately under the joint enclosure.

4.3.5 Jointing and splicing between OPGW and underground fibre cables

The termination of OPGW into substations shall be by means of a standard, non-insulated strain assembly.

The OPGW shall be attached to the gantry or alternatively a terminal tower, using an earth bond which is connected to the OPGW by means of a current transfer tab or flag, embedded in the armour rods that is protecting the OPGW. On the other end of the earth bond, a crimped lug shall be fitted to enable the earth bond to be bolted to the steelwork and which guarantees a proper current path. Dedicated earthing shall be required on all non-insulated assemblies.

Metallic, non-insulated clamps shall be used to attach the down-leads to steelwork.

The OPGW shall be clamped at every intersection with steelwork using approved hardware.

The termination enclosure linking the underground cable to the OPGW may be required at the terminal tower or gantry. In these situations the end of the HDPE tubing housing the underground fibre cable shall be sealed to prevent the ingress of water and rodents. The termination enclosure shall be secured and mounted in accordance with the requirements of the customer.

A general layout is shown in figure C.9.

4.3.6 Completing the OPGW connection to the termination room

The fibres from the OPGW shall in all cases be spliced directly to the underground duct cable leading to the patch panel, in the splice box at the tower or gantry. The fibres shall be terminated as required at the patch panel enclosure provided at the termination end. Minimum cable bending radius requirements shall be observed at all times.

This duct cable shall be run, where possible, physically separated from the other control cables in the cable trenches provided.

This can be achieved in one of two ways. The duct cable may be constructed with or without armouring:

- a) Using armoured duct cable

In a conventional substation arrangement where there is a common earth mat for the entire area and where armoured cable is specified, CST armoured optical fibre duct cable shall be used for the link between the OPGW splice enclosure installed at the gantry or terminal tower at the line entry and the patch panel enclosure in the termination room. The armouring shall be used for mechanical protection and shall never, even unintentionally, be used as a current-carrying conductor. The armouring shall always be cut well back (± 100 mm) and the end insulated with

heat-shrink sleeving at the two ends where the cable enters the cable compression glands at the splice enclosure at one end and the patch panel enclosure cabinet gland plate at the other, to prevent accidental connection to either earth or to personnel.

If the cable run is very long, the armouring shall be removed for a length of 150 mm for every 250 m of cable length. This isolation section shall be covered by an appropriate cast resin joint arrangement.

b) Using unarmoured duct cable

Armoured duct cable shall never be used where the two ends are on separate earth mats. In this latter case and where specified by the buyer, unarmoured duct cable laid inside class 6 high-density polyethylene tubing or similar of approximately 50 mm diameter, shall be used.

Where a tube is required to house the underground cable, it shall be an HDPE duct. A high pressure connector shall be used to protect against damage by rodents and ingress of moisture.

4.3.7 Underground interconnection of two OPGW sections

The OPGW shall be treated in accordance with 4.3.5 at the two line terminal towers.

4.4 Fittings

4.4.1 General

Any hardware provided, shall be such that no holes will be drilled into the tower steelwork.

All hardware shall be approved by the OPGW supplier and customer (see CIGRE TF 22.11.03). Hardware assemblies, including down-lead clamps, for the OPGW shall be compatible with the cable to ensure that the system so formed will survive the operating environment for the design life. All items of hardware shall conform to specified requirements. The hardware component supplier shall be fully responsible for his designs and their satisfactory performance in service. Approval by the customer does not relieve the supplier of responsibility for the adequacy of the design, dimensions and details.

Suspension and strain assemblies shall be designed so that line contact between coupled components occur. Point contact between components shall be avoided.

4.4.2 Drawings

Drawings of assemblies offered shall be supplied and shall indicate for each component

- a) the material type,
- b) the material grade (and heat treatment where applicable),
- c) the strength rating,
- d) tolerances (where applicable), and
- e) dimensions.

4.4.3 Tolerances

Dimensions of all items of hardware shall be subject to the tolerances specified in the referenced standards. Where no standard or tolerance is referenced, the fit tolerance shall be $\pm 2\%$ of the dimension. All tolerances shall be subject to the customer's approval. Items of hardware found to be out of tolerance shall be rejected.

4.4.4 Materials

4.4.4.1 Materials for OPGW

The material and construction of the OPGW shall be specified as given in the relevant contract.

4.4.4.2 Materials for fittings (tension and suspension assemblies) and current transfer tab

The choice of material for tension and suspension assemblies, as well as current transfer tab, shall be specified by the OPGW manufacturer to match the material of the OPGW and will take precedence over this part of NRS 061.

In general, if the OPGW outer layer is of steel, the fitting material shall be of steel material. When the OPGW outer layer is of aluminium material, the fitting material shall be of an aluminium alloy material. In cases where the OPGW outer layer is of aluminium clad steel, the fitting material shall be of steel material.

In all cases the correct lay direction of the fittings in relation to the OPGW shall be observed. Normally the lay direction of the fitting wire is opposite to the outer OPGW layer direction.

4.4.4.3 Materials for grounding cable or earth bonds

The type of material and size shall be adequate to safely handle the required short-circuit rating and requirements of the OPGW as specified. The choice of material shall also depend on compatibility with the OPGW and current transfer tab in order to prevent galvanic corrosion.

4.4.5 Installation procedures

Details of installation procedures of hardware assemblies and down-lead clamps shall be supplied both with a tender offer and with each batch delivered where requested.

4.4.6 Hardware

4.4.6.1 Tension assemblies

Tension assemblies shall comply with the following requirements:

- a) Tension assemblies shall be of the current transfer tab type (see figures C.3, C.4 and C.7).
- b) When selecting hardware for OPGW, great care shall be taken not to apply excessive stresses on the conductor that will affect the OPGW core.
- c) Tension assemblies shall withstand the fault current design parameters.
- d) Where the OPGW must be joined at a splicing tower, a ground cable shall be installed between the two spans to ensure electrical continuity between the two. Connection to the OPGW shall be by means of a current transfer tab or flag, embedded in the armour rods that is protecting the OPGW.
- e) In the case of an insulated strain assembly (see figure C.3) the ground cable shall be insulated from the tower. Depending on the geometry of the tower, using a support or stand-off insulator will prevent contact between OPGW and tower steelwork under all environmental operating conditions.
- f) The creepage of the insulation material shall be equal to or more than 50 mm.
- g) At the terminal tower, the OPGW may or may not be earthed, in accordance with local practice.

4.4.6.2 Suspension assemblies

Suspension assemblies shall comply with the following requirements:

- a) Only AGS type assemblies with a neoprene insert, or similar approved, shall be accepted (see figure C.7).
- b) Suspension assemblies shall withstand the fault current design parameters.
- c) Non-insulated suspension assemblies shall be fitted with a ground cable to ensure proper grounding between the OPGW and the tower steelwork. Connection of the ground cable to the OPGW shall be by means of a current transfer tab or flag, embedded in the armour rods that are protecting the OPGW.

4.4.6.3 Grounding connectors (jumpers, ties or earth bonds)

The ground cable installed between the OPGW and the tower steelwork, or between two spans across a tower, shall be connected to the OPGW by means of a current transfer tab or flag, embedded in the armour rods that are protecting the OPGW and which will ensure proper mechanical and electrical connection. The other end of the ground cable shall be fitted with a crimped lug or fitting which can be connected to the tower, using one of the tower bolts. Before connecting the crimped lug or fitting to the tower members, the tower steelwork shall be cleaned to remove paint or grease (or both) to ensure proper electrical connection. After connection the exposed area(s) shall be repainted or cold galvanized to prevent corrosion of the tower steel members. The arrangement for terminating and earthing of the OPGW at the substation gantry is depicted in figure C.8.

4.4.6.4 Aeolian vibration dampers

Vibration dampers that are capable of damping any aeolian vibration that the OPGW will experience, shall be used. The type, size, mass, quantity and spacing of vibration dampers shall be selected to limit the aeolian vibration bending amplitude so that the safe bending amplitude as prescribed by the OPGW manufacturer is not exceeded. Multi-frequency type Stockbridge dampers or spiral vibration dampers may be used.

4.4.6.5 Down-lead clamps

The design of down-lead clamps shall be such that no excessive stresses, which will affect the performance of the OPGW under any circumstances, will be induced.

Two options exist, namely insulated down-lead clamps and non-insulated down-lead clamps. The type to use will depend on whether the hardware assemblies, connecting the OPGW to the tower, are insulated or non-insulated.

Down-lead clamps shall be installed at every tower steelwork intersection and shall be not more than 2 m apart.

4.4.6.6 Non-insulated down-lead clamps

Non-insulated down-lead clamps shall ensure proper electrical connection between the OPGW conductor and the tower steelwork. When attaching the clamp to the tower steelwork care shall be taken to ensure electrical connection and that mechanical damage, which in turn could lead to corrosion damage, will not be imposed on the tower steelwork. Materials used for the down-lead clamp shall be such that galvanic corrosion will not start between the down-lead clamp and the tower steelwork.

A sufficient number of down-lead clamps shall be used to ensure sufficient support of the OPGW along the tower. This support shall be in such a manner that the OPGW will not clash with any part of the tower steelwork as a result of wind or due to its own mass if strung or laid in a horizontal configuration.

4.4.6.7 Insulated down-lead clamps

The requirements for the insulated down-lead clamps are exactly the same as those for the non-insulated down-lead clamps in 4.4.6.6, except that no electrical contact between the OPGW and tower steelwork shall occur. In all cases a minimum distance of 50 mm shall exist between the OPGW and tower steelwork. The creepage of the insulation material shall be equal to or more than 50 mm.

4.4.6.8 Splicing enclosure (joint enclosure)

All construction details and IP ratings of the proposed units shall be provided. The splicing enclosures shall be supplied with tower earth bonding fixtures. They shall facilitate fibre organization and splicing requirements and shall be vandal resistant if specified.

As far as possible, the use of insulated splice enclosure installations shall be avoided. The creepage of the insulation material shall be equal to or more than 50 mm.

4.5 Safety and environmental

4.5.1 General

Contractors shall be authorized by the local utility or by some other official capacity, for example, in terms of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) (OHS Act), for preparation of the earth wire for stringing purposes under energized conditions and stringing under de-energized conditions.

The stringing tension used shall be such that adequate clearance is maintained at all times.

4.5.2 Safety requirements

Requirements of the local operating regulations and the said OHS Act shall apply.

The following requirements shall also apply:

- a) Staff shall meet prerequisites, and shall be sufficiently trained, evaluated and authorized accordingly.
- b) Lifting machines and equipment shall comply with said OHS Act requirements.
- c) Access and keys shall be controlled in accordance with local operating instructions.
- d) Permit system or workers register system of controlling staff shall be enforced in accordance with local operating instructions.
- e) Risks shall be identified, evaluated and eliminated or managed to an acceptable level.
- f) Safe working electrical clearances shall be maintained at all times.
- g) Precautions against induction and system fault current in the form of equipotential earthing and bonding shall be enforced. This includes running earths, fenced winch or tensioner operator equipotential zones and bonding at tower earth peaks. All portable earths shall comply with the requirements of SANS 61230.
- h) Suitable personal protective equipment shall be used.
- i) Tools and equipment shall be correctly selected and applied.

4.5.3 Environmental requirements

All work shall be performed in compliance with environmental legislation.

The following requirements shall also apply:

- a) Minimal impact and disturbance of environment.
- b) Agreements and relationships with landowners shall be adhered to. This includes notification before arrival and ensuring access gates are left the way they were found.

4.6 Quality control

The quality control requirements shall be specified by the customer.

5 Tests

5.1 Optic fibre site tests before installation

5.1.1 The integrity and attenuation of individual fibres shall be tested with the OPGW still on the drums, before stringing.

The test shall be performed for each fibre in the OPGW at two wavelengths, 1 310 nm and 1 550 nm from one direction only. When requested, testing shall be witnessed by the customer representative.

5.1.2 The identity of individual fibres shall be clearly marked.

5.1.3 The results of the tests shall be produced in table 1. The table heading shall contain the drum number and the length of the OPGW.

5.1.4 The table shall record the attenuation for each fibre. Results shall be produced in paper and digital format (disc).

5.1.5 If the drum test was successful, the drum shall be handed over to the main contractor. In the case of failure the drum shall be returned to the supplier, and all costs associated with the replacement of the defective material shall be for the supplier's account.

5.1.6 Unless otherwise specified in the project requirements, the main contractor shall be held responsible for the proper protection and safekeeping of the OPGW drums until the completed transmission line is taken over by the customer and any surplus material has been returned to the customer. The contractor shall be held responsible for any loss or damage to material required for or surplus to, the contract works.

All material received shall be neatly stored in properly defined storage areas to facilitate checking of quantities and quality. Receipt slips shall be forwarded to the customer within two days of delivery, and a record of the total quantities of material received and used, shall be kept on site.

Table 1 — Optic fibre site test results before installation

1	2	3	4	5	6
Project			Drum number		
			Loss dB/km		
Tube	Fibre	Colour	1 310 nm	1 550 nm	Length
1	1				
	2				
	3				
	4				
	5				
	6				
2	1				
	2				
	3				
	4				
	5				
	6				

5.2 Testing after completion of installation

After completion, the OPGW shall be tested for integrity and attenuation of the optical fibres. All joints shall be of the fusion type and the average loss per splice for the entire route shall be less than that specified in annex B, unless otherwise specified by the customer. Test results shall be recorded and presented as shown in clause A.1.

An end-to-end light source or power meter test shall be performed and the results shall be recorded and presented as shown in clause A.2. The final test shall be performed in accordance with annex B. Only a calibrated OTDR shall be acceptable.

Annex A (informative)

Summary tables

A.1 Sample of splice loss summary table

Line : Bloukrans-Venus No. 1 **Fibre type:** G652
Cable type: OPGW **Refractive index:** 1,468
End 1: Bloukrans substation **Helix factor:** 9 %
End 2: Venus substation
Wavelength: 1 550 nm

		Tested from	Total length	Joint 1 distance	Joint 3 distance	Joint 9 distance	Joint 11 distance		
		End 1	0	1 926	5 730	16 686	20 632		
		End 2	21 144	19 218	15 414	4 458	506		
Fibre No.	Tested from	Total loss	Joint 1 loss	Joint 3 loss	Joint 9 loss	Joint 11 loss	Mean loss	Worst splice loss	
1	End 1	5,11	0,11	0,00	0,00	0,00	0,04	0,09	
1	End 2	5,324	0,06	0,12	0,00	0,00			
1	Average	5,21	0,09	0,06	0,00	0,00			
2	End 1	5,43	0,00	0,23*	0,00	0,00	0,02	0,07	
2	End 2	5,21	0,00	-0,10*	0,00	0,00			
2	Average	5,32	0,00	0,07	0,00	0,00			
:	:	:	:	:	:	:	:	:	
11	End 1	5,41	0,00	-0,07*	0,06	0,11	0,05	0,11	
11	End 2	4,90	0,00	0,09*	0,00	0,11			
11	Average	5,15	0,00	0,08	0,03	0,11			
12	End 1	5,02	0,09	0,00	0,05	0,06	0,06	0,10	
12	End 2	5,58	0,10	0,17*	0,00	0,00			
12	Splice loss	5,30	0,10	0,09	0,03	0,03			

*This value indicates a gain at the joint due to a variation in the MFD of the two fibres.

NB Total loss is the total line loss as read off during end to end testing and not only a sum of joint losses.

The above table is shortened for the sake of brevity.

NOTE The above table is not intended to represent real values. It is for illustrative purposes **only**.

Annex A
(concluded)**A.2 Sample of power source and light meter summary table****Line :** Bloukrans-Venus No. 1**Cable type:** OPGW**End 1:** Bloukrans substation**End 2:** Venus substation**Line length:** 21 km**Wavelength:** 1 550 nm**Reference:** -7,3 dB

Fibre no.	Tested from	dB/km	Receive level dB/km	Loss dB
1	End 1	0,24	-12,4	5,1
1	End 2	0,25	-12,7	5,3
2	End 1	0,26	-12,5	5,4
2	End 2	0,25	-12,3	5,2
3	End 1	0,25	-12,8	5,3
etc.				

The above table is shortened for the sake of brevity.

Annex B (normative)

Acceptance procedure for optical fibre systems

B.1 Scope

This procedure covers the testing of fibre optic cable systems. These systems may consist of OPGW, ADSS, externally attached cable, duct cabling or a combination of the aforementioned.

B.2 Splice acceptance procedure

All joints shall be of the fusion type and shall be to the following standard in table B.1 or otherwise agreed between the customer and contractor.

Table B.1 — Splice loss

1	2	3
Splice loss ^a	Single mode fibre	Multimode fibre
Maximum	≤ 0,1 dB	≤ 0,15 dB
Mean ^b	≤ 0,075 dB	≤ 0,1 dB

^a The splice loss is the numerical average of an individual splice as measured in both directions with an OTDR.

^b The mean splice loss is the sum of all individual splice losses on a particular fibre divided by the total number of splices on that fibre.

Any joint which has a measured loss higher than the specified value shall be broken and redone.

B.3 Fibre optic testing procedure

B.3.1 The aim of these tests is to establish whether the fibre optic installation is acceptable or not.

After installation the complete system shall be tested from end to end. The customer shall be given the opportunity to carry out final acceptance testing in conjunction with the supplier's staff. The customer's presence shall not relieve the supplier of his responsibility for the satisfactory performance of the equipment during site testing and thereafter through to the end of the warranty period.

B.3.2 Carry out the following tests for cable systems with one or more joints in the total length (excluding joints in fibre distribution units) using an OTDR. Take the basic measurements (i.e. attenuation coefficient, length and position and loss of splice joints) in accordance with SANS 60793-1-40.

Set the OTDR length range at least as long as the fibre under test to avoid ghosting and echoing. These phenomena are particularly evident at short lengths (< 1 km).

Use the correct effective group refractive index as provided by the optical fibre manufacturer. Indicate this on the splice summary table given in clause A.1.

Set the helix factor stipulated by the supplier and indicate it on the splice summary table (see clause A.1).

Indicate on the splice summary table (see clause A.1) the back scatter coefficient for each wavelength as supplied by the cable manufacturer.

Indicate acquisition time settings on the splice summary table (see clause A.1).

Annex B

(continued)

B.3.3 For normal attenuation measurement, the wavelength tolerance shall be within ± 20 nm of the normal central wavelength, for example 1 310 nm or 1 550 nm. For line lengths up to 50 km attenuation measurements shall include both wavelengths. For lines in excess of 50 km wavelength tests at 1 550 nm need only be done.

A launch fibre or dead-zone fibre of at least 200 m shall be used and shall be indicated as such on the test results.

All measurements shall be bidirectional.

B.3.4 OTDR traces shall provide for the complete length of fibre (patch panel enclosure to patch panel enclosure), indicating the distance to joints and the total length of the fibre as well as the loss at each joint. The tests shall be done in both directions at both 1 310 nm and 1 550 nm windows. Test results shall also be provided on a data disc.

NOTE The best method to determine the loss of a splice is the vertical separation of two best-fit straight lines, usually requiring placement of a pair of cursors on each side of the splice. Most modern instruments support this method as a standard function.

Bidirectional measurements with the same test conditions are required to eliminate the effects of backscatter coefficient differences. The loss calculation is made by averaging the bidirectional readings.

Ensure that the event analysis, event thresholds and event notifier are set.

Adhere to the OTDR maximum pulse widths as given in table B.2.

Table B.2 — OTDR maximum pulse widths

1	2
Range km	Maximum pulse width ns
< 2	100
> 2 and < 20	500
>20 and < 50	1 000
> 50	2 500

Insert the following information on each OTDR trace:

- a) date;
- b) fibre optic cable description;
- c) fibre number;
- d) the end from which the test is being performed;
- e) index of refraction;
- f) helix factor; and
- g) Rayleigh backscatter coefficient.

Annex B

(concluded)

B.3.5 Ensure that the following data are available on request:

- a) OTDR instrument (including make, model and manuals and also a copy of the trace analysis software);
- b) calibration data (central wavelength(s) as verified by an NCS-approved facility);
- c) launch conditions; and
- d) splice machine (including make, model and manuals).

Summarize all the information in table form as shown in the example in clause A.1.

Measure the total end-to-end loss (patch panel enclosure to patch panel enclosure) from both ends using a light source and an optical power meter. Results for both 1 310 nm and 1 550 nm windows are required. Provide details of the instrumentation and launch conditions used in the documentation in clause B.4.

Commissioning shall be done in close co-operation with, and to the full satisfaction of the customer.

The customer reserves the right to have several technicians actively participate in the fibre section link tests with the objective of them gaining intimate knowledge of the testing procedures.

B.4 Documentation

B.4.1 The supplier shall supply documentation as specified in the contract.

B.4.2 All documentation called for shall be provided in hard-cover ring files which comply with the requirements in B.4.3 to B.4.7 inclusive.

B.4.3 Documentation shall be supplied in English.

B.4.4 Documentation shall be supplied on A4 paper.

B.4.5 The hard-cover ring files shall be of a construction that can open flat on any page.

B.4.6 Any drawings and descriptions included shall conform to the A4 series (295 mm x 220 mm). Larger drawings shall be folded in a single panel along the 200 mm axis of the standard A4 size.

B.4.7 Different sections of the documentation shall be separated by means of thumb-tag separators.

B.4.8 The documentation shall include the following:

- a) an index;
- b) test certificates for site tests of fibre before installation;
- c) details of fibre numbering and colour coding;
- d) a system diagram that shows joint locations and distances between joints;
- e) a table of joint losses and distances similar to the example in annex A;
- f) OTDR traces for each fibre in both directions and at both 1 310 nm and 1 550 nm windows (paper copy and electronic copy on disc); and
- g) a table of end-to-end attenuation using the light source or power meter technique similar to the example given in clause A.2.

Annex C
(normative)

Installation drawings and fittings

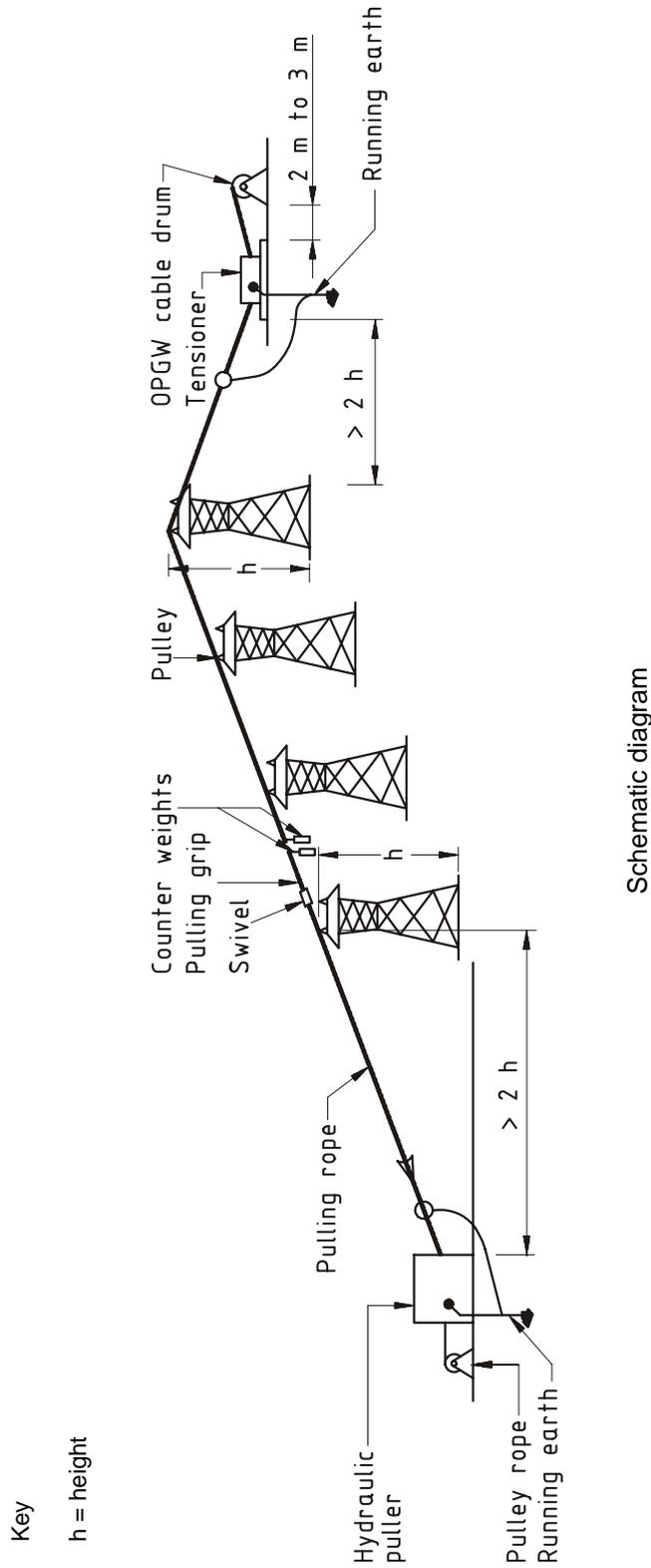


Figure C.1 — Standard method of stringing

Annex C
(continued)

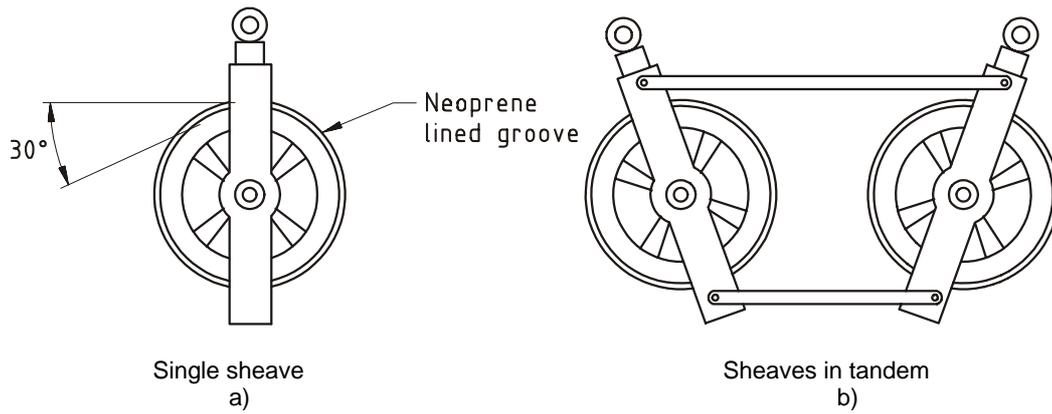


Figure C.2 — Sheave arrangement

Annex C
(continued)

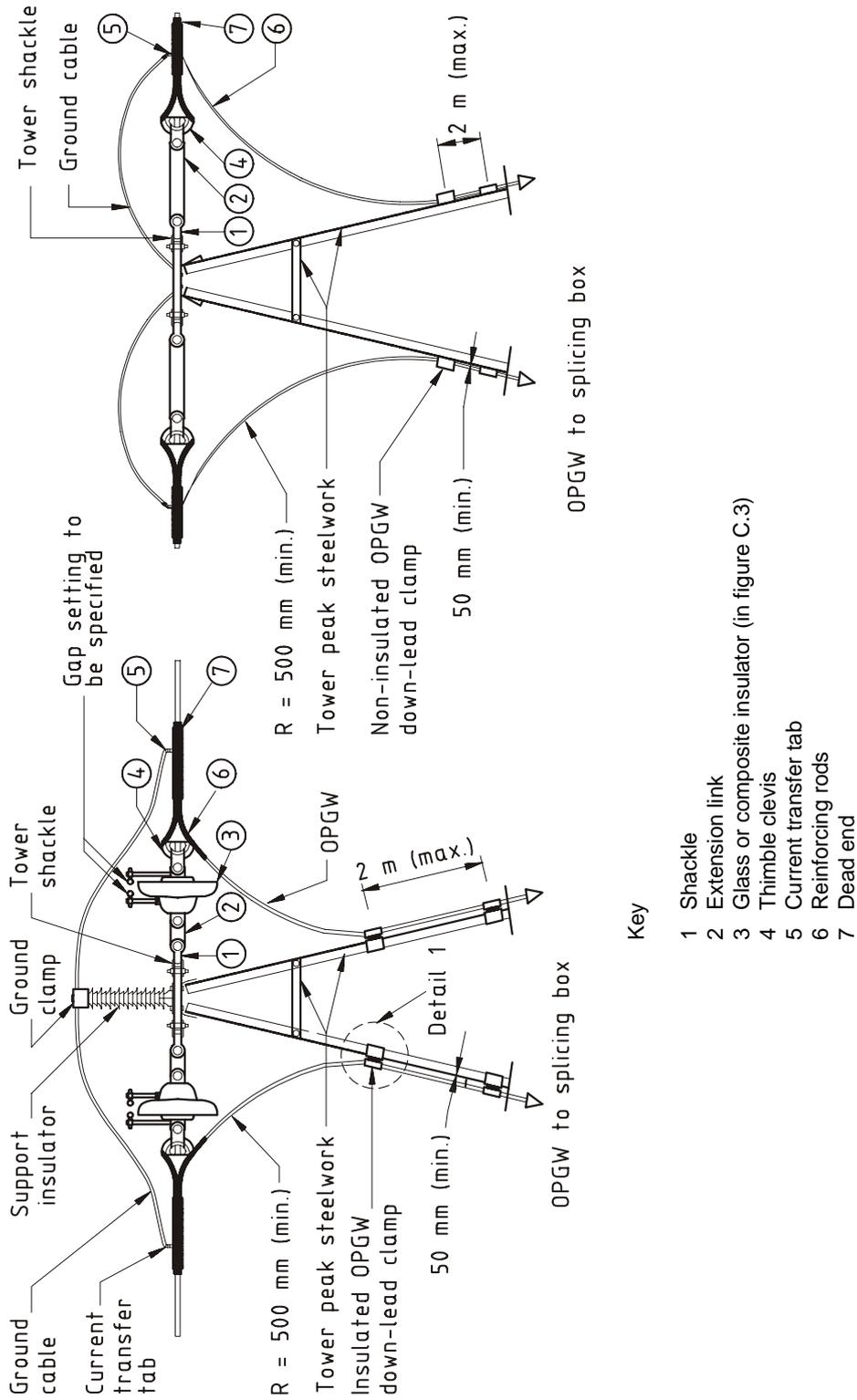


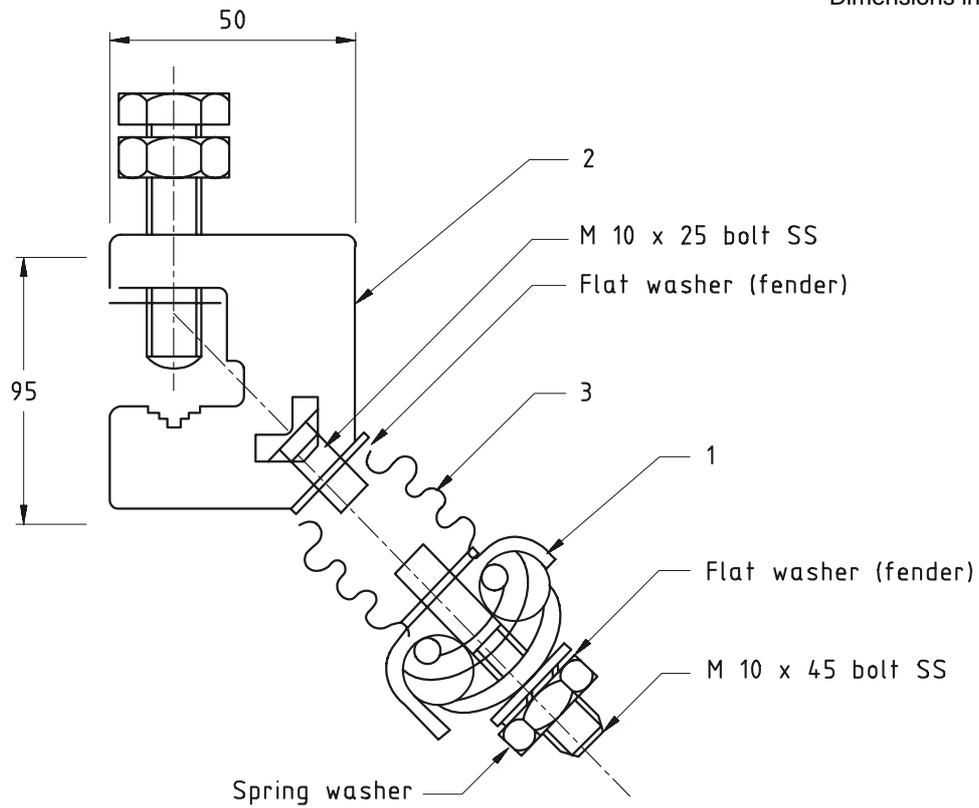
Figure C.4 — OPGW non-insulated strain assembly at splicing tower

Figure C.3 — OPGW insulated strain assembly at splicing tower

Annex C

(continued)

Dimensions in millimetres



Key

- 1 Cable clamping arrangement
- 2 Tower clamping arrangement
- 3 Insulator

Figure C.5 — Typical OPGW insulated down-lead clamp (detail 1 of figure C.3)

Annex C
(continued)

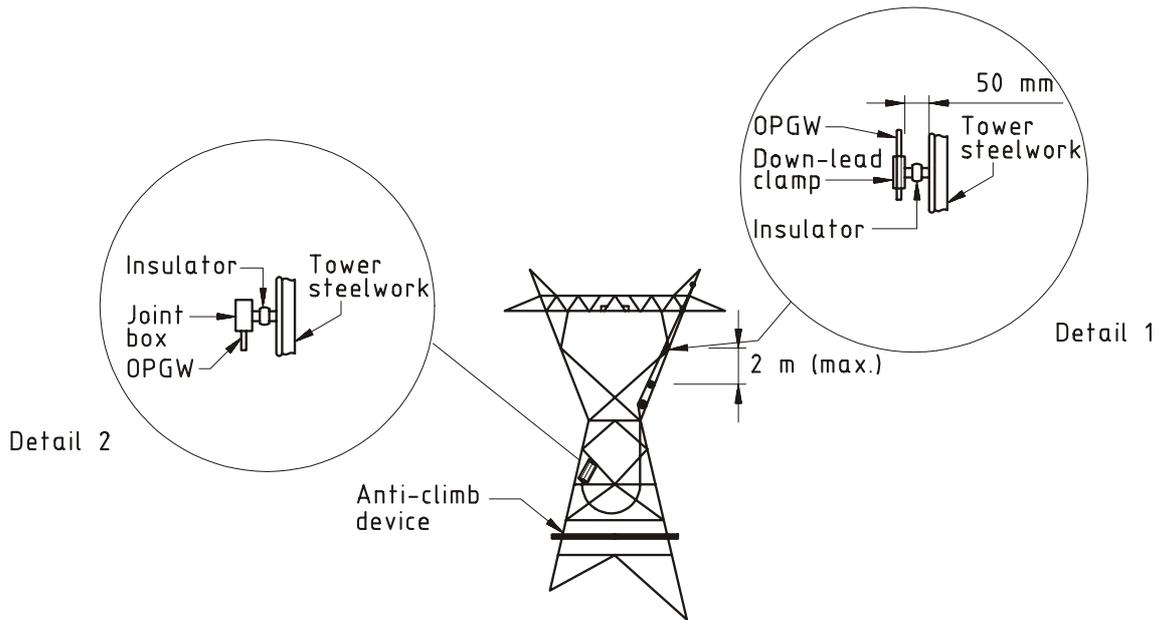
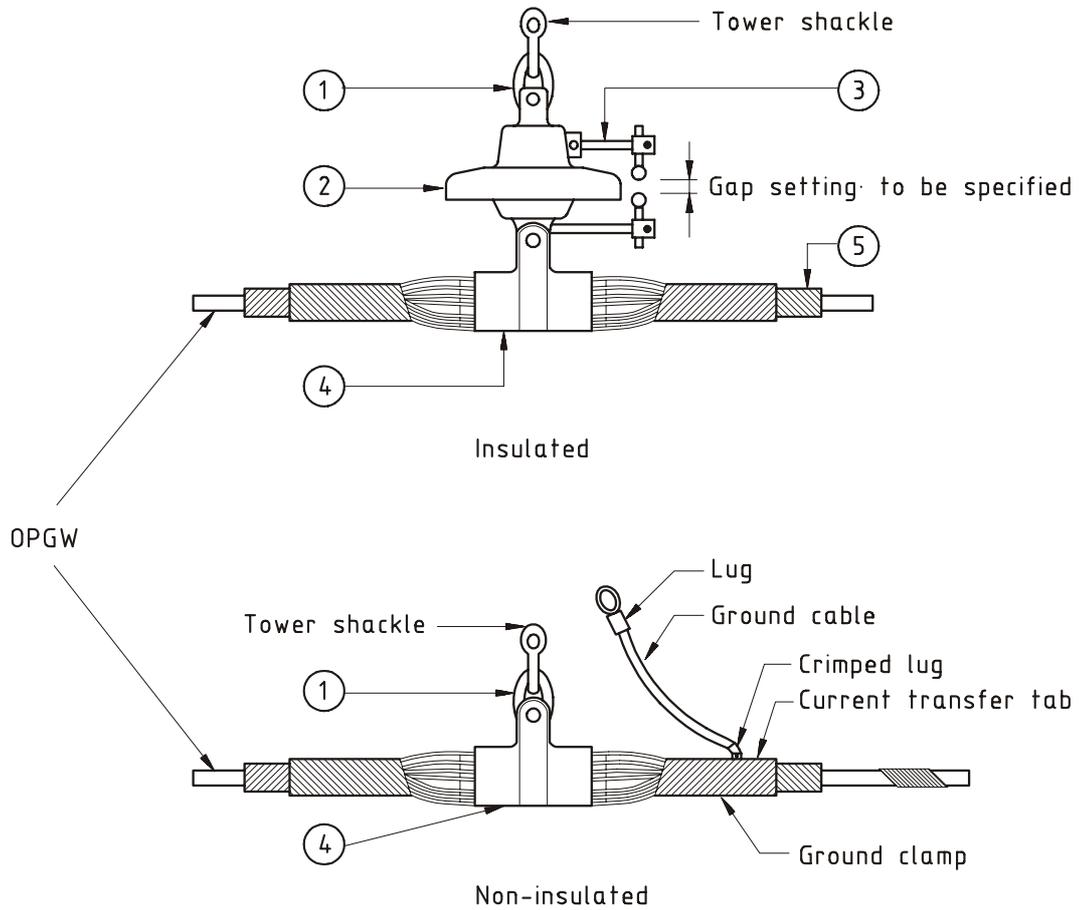


Figure C.6 — Typical installation at insulated splicing tower

Annex C
(continued)



Key

- 1 Chain link
- 2 Glass or composite insulator
- 3 Arcing horns
- 4 AGS type suspension clamp
- 5 Armour rods

Figure C.7 — OPGW standard suspension assemblies

Annex C
(continued)

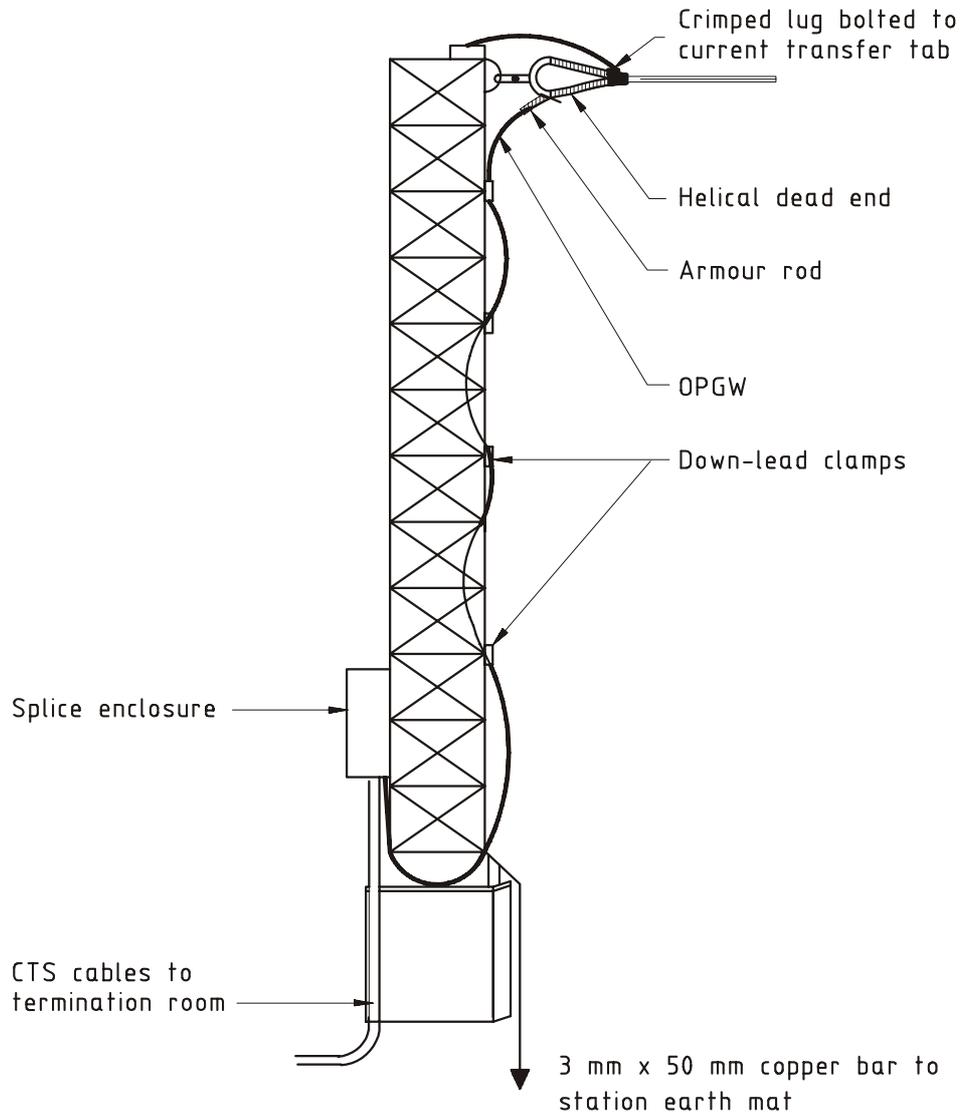


Figure C.8 — Termination and earthing arrangement at gantry

Annex C
(concluded)

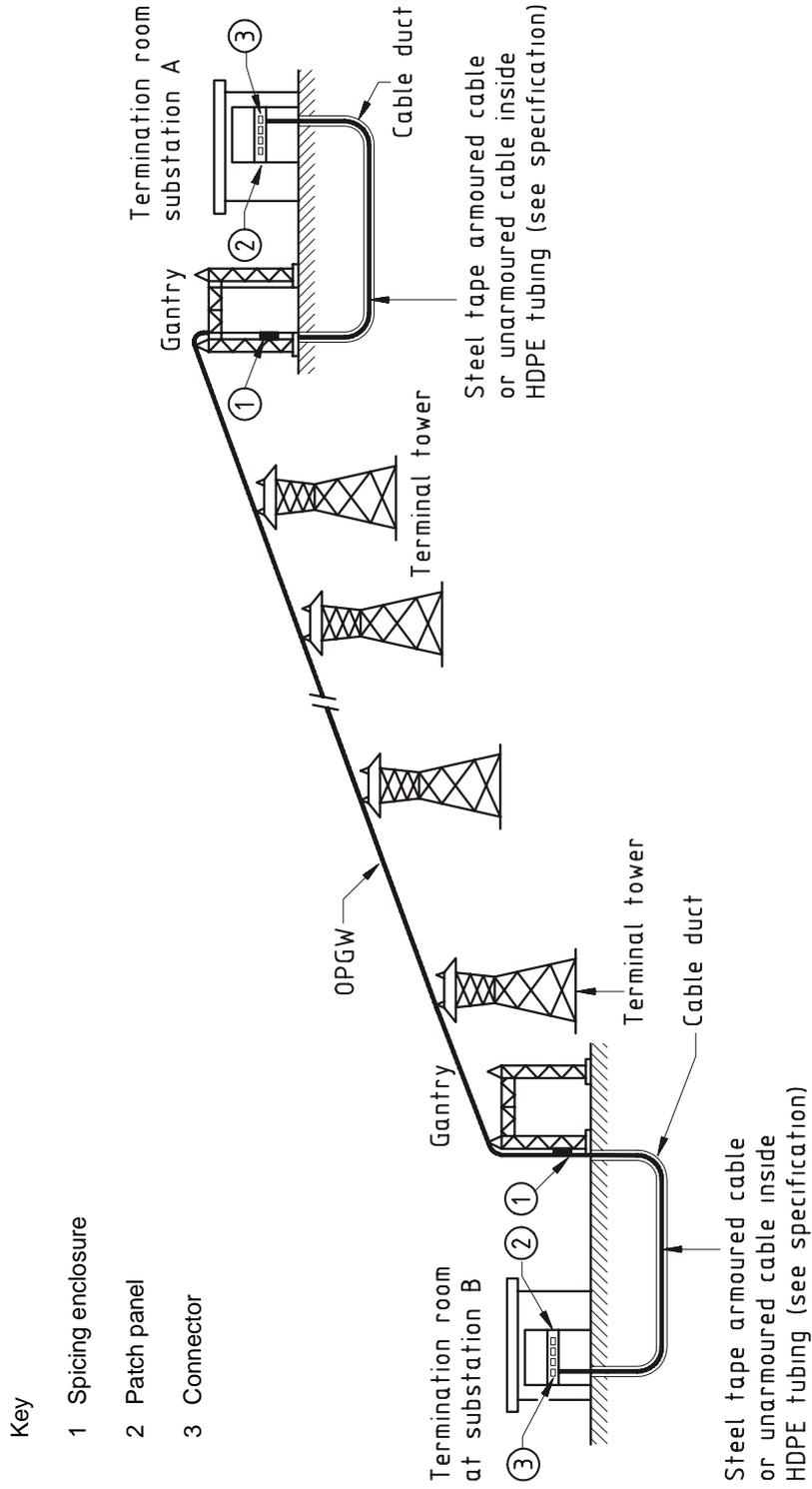


Figure C.9 — Completing OPGW installation to the termination room

Bibliography

SANS 9001/ISO 9001:2000, *Quality management systems – Requirements.*