ICS 33.180.10

ISBN 0-626-17737-5

NRS 078-2:2005

Edition 1

LONG-SPAN ALL-DIELECTRIC SELF-SUPPORTING FIBRE OPTIC CABLES

Part 2: Installation guidelines

N R S

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

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Printed in the Republic of South Africa
by Standards South Africa
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Foreword

This part of NRS 078 was prepared on behalf of the Electricity Suppliers Liaison Committee (ESLC).

This part of NRS 078 was prepared by a working group which, at the time of publication, comprised the following members:

D C Smith (Chairman)	Eskom, Transmission Technology
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The assistance of A. Deitchman in compiling the first draft is gratefully acknowledged.

A Manufacturers' Interest Group (MIG) was consulted on the contents of this part NRS 078 and its comments were incorporated where the working group was in agreement. The MIG comprised the following members:

C Horn	Letacla
G Hughes	MTec
R Phillips	Aberdare Cables

A reference is made in **4.5.1.1** to "legislation" and in **4.5.2.1** and **4.5.2.2(b)** to "legal requirements". In South Africa, this is the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) (as amended from time to time).

NRS 078 consists of the following parts, under the general title *Long-span all-dielectric self-supporting fibre optic cables*:

Part 1: Product specification.

Part 2: Installation guidelines.

Annexes B and C form an integral part of this part of NRS 078. Annex A is for information only.

Introduction

This part of NRS 078 has been prepared to establish and promote uniform requirements for the installation of long-span all-dielectric self-supporting fibre optic cables.

The Electricity Suppliers Liaison Committee expresses the wish that all supply authorities will adopt the text of this part of NRS 078 in so far as their particular conditions will permit. Any differences between the requirements of this part of NRS 078 and the purchaser's requirements should, as far as possible, be clearly indicated in schedules and, where appropriate, be submitted for consideration in future revisions of this part of NRS 078.

Keywords

cables, fibre optic cables, fibre optics, optical fibres.

Contents

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LONG-SPAN ALL-DIELECTRIC SELF-SUPPORTING FIBRE OPTIC CABLES

Part 2: Installation guidelines

1 Scope

This part of NRS 078 identifies the essential methods for stringing, tensioning, jointing and terminating of long-span all-dielectric self-supporting (ADSS) fibre optic cable for use on overhead power lines.

NOTE 1 Summary tables are given in annex A.

NOTE 2 An acceptance procedure for ADSS fibre optic cable systems is given in annex B.

NOTE 3 Installation drawings and fittings are given in annex C.

2 Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this part of NRS 078. All document are subject to revision and, since any reference to a document is deemed to be a reference to the latest edition of that document, parties to agreements based on this specification are encouraged to take steps to ensure the use the most recent editions of the documents listed 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 2: Selection and use.* Information on this publication is available from World Wide Web: <http://www.CIGRE-62.org/site/technical/download>.

NRS 078-1, *Long-span all-dielectric self-supporting fibre optic cables – Part 1: Product specification.*

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

SANS 61230/IEC 61230 (SABS IEC 61230), *Live working – Portable equipment for earthing or earthing and short-circuiting.*

3 Terms, definitions and abbreviations

For the purpose of this part of NRS 078, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

acceptable
acceptable to the customer

electric field plot
diagram that shows the position of the high-voltage conductors, earth wires and ADSS on the structure together with the lines of electric fields around them

ghosting
false reflection that appears at an integral multiple of the distance from the initial (true) reflective event

NOTE For example, if a large reflection occurs at 1 000 m, there could be a ghost at 2 000 m due to reflected light bouncing back and forth within the fibre.

long span
span exceeding a length of 250 m

medium span
span of length 100 m to 250 m

short span
span up to a length of 100 m

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

3.2 Abbreviations

ADSS: all-dielectric self-supporting
CST: corrugated steel tape
GRP: glass-reinforced plastic
HDPE: high-density polyethylene
IP: ingress protection
MFD: mode field diameter
NCS: national calibration standard
ODF: optical distribution frame
OPGW: overhead ground wire with optical fibre
OTDR: optical time domain reflectometer
PMD: polarization mode dispersion
SRL: structural reinforcement layer
SVD: spiral vibration damper

4 Requirements

4.1 General

4.1.1 The guidelines listed in this part of NRS 078 are applicable to the stringing of all-dielectric self-supporting fibre optic cables (ADSS).

4.1.2 This part of NRS 078 should be used in conjunction with the installation procedures laid down by the ADSS manufacturer. In the case of a dispute, the ADSS manufacturer's procedure shall apply.

4.1.3 ADSS fibre optic cable shall comply with the requirements of NRS 078-1.

4.1.4 ADSS cable is a non-metallic cable that is used to transmit optical signals by means of optical fibres. This cable consists of the following two parts:

a) the optical part that consists of a loose tube construction in which the optical fibres are accommodated; and

b) the supporting part that consists of strength elements and an outer sheath.

4.1.5 Due to the actual construction of the ADSS cable, maximum span lengths are defined by each manufacturer, therefore the customer needs to specify his requirements at the time of ordering the ADSS.

4.1.6 The most desirable position to install ADSS on transmission structures will be a location with a low value of electric field. This location can be found by performing an electric field plot per tower.

4.1.7 This part of NRS 078 describes tests (see clause 5) to be done on ADSS cable before and after installation to ensure that no damage has been done to the cable during installation or service. Damage can be inflicted on the cable during stringing and also during service.

4.1.8 Documentation as specified in clause 6 will be required before commencement and on completion of the installation.

4.1.9 All joints shall be of the fusion type and the average loss per splice for the whole route shall be less than that specified in annex B, unless otherwise specified by the customer.

4.2 Preparatory work

4.2.1 To ensure the integrity of the fibre optic cable during service, upfront analyses need to be done to make sure that the cable position, installation procedures and stringing tensions are documented.

4.2.2 The position of the ADSS cable on the tower is very important since this will affect the service life of the cable. The ideal position will be a position where the electric field is at its minimum within the limitations posed by minimum ground clearance and blow-out under difficult environmental conditions. In most cases this position is determined by doing an electric field plot using various programmes.

4.2.3 Once the ADSS cable position has been finalized, a span by span leakage current plot shall be done. It is assumed that the sheath resistance is 100 kΩ/m, i.e. a sheath resistance used in a very polluted area.

4.2.4 The customer shall supply the manufacturer or installer (or both) with all the necessary information to enable them to carry out such plots. This information shall include the following:

a) spanning plans;

b) tower drawings;

c) the conductor size or type (or both);

d) the earth wire size or type (or both); and

e) the phase configuration.

4.2.5 The ADSS cable position shall be checked to verify that no clashing with a phase conductor under different environmental conditions will be experienced. The minimum ground to conductor clearances shall also be adhered to.

4.2.6 The tower or pole strength shall be checked for the extra loading under all environmental conditions that will be experienced by the addition of the ADSS cable. This shall be done with the cable selected for the project. In cases where the tower or pole will be over-stressed, additional strengthening of the structure is required before the cable is strung.

4.2.7 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 they are 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; this will facilitate the handling and loading of drums. The storage area shall be free of grass and other vegetation thereby minimizing the risk of fire.

4.2.8 After selection of suitable locations for the tensioner and puller, ADSS drums, fittings and accessories shall be transported to site and kept in a proper place until their final use.

4.3 ADSS stringing

4.3.1 Special tooling and precautions needed for ADSS stringing

4.3.1.1 The pulling of ADSS cable is done under constant tension. The equipment used for this purpose shall ensure failure-free installation and shall comply with all the installation conditions and requirements specified by the customer. Figure 1 shows the recommended equipment necessary for ADSS stringing.

4.3.1.2 The type and construction of the reel support determine the method and tools to be used for stringing. Reel construction requires that reels be mounted on an axle or be supported by the reel flange. The equipment used shall be rated for the maximum load and shall be able to lift the reel. When the reel stand is not self-loading, a crane, a forklift or some other method of lifting shall be available to lift the reel onto its stand. The reel support design shall incorporate an adjustable brake to supply the necessary back tension needed to properly tension the cable.

4.3.1.3 Capstan and reel type pulling machines with approved adjustable tensioners can be used to install ADSS fibre optic cable. The pulling and braking system employed should operate smoothly to prevent any jerking or bouncing of the cable during installation. All pullers and tensioners shall be equipped with a tension indicator and tension limiting devices. The continuous recording of the pulling tension is preferred and may be specified.

4.3.1.4 All installation equipment, such as winches and tensioners, shall be approved by the cable manufacturer as suitable for installing ADSS fibre optic cables.

4.3.1.5 Sheave diameters of at least 20 times the cable diameter shall be used in all positions except at tension towers or towers where the line angle exceeds 15°. In the latter cases minimum sheave diameters shall be 600 mm, or as specified by the cable manufacturer.

4.3.1.6 The depth and flare of grooves in wheels used are not critical, but should be manufactured from material that does not mar the surface of the cable when stringing is done. The normal depth and width of the sheave grooves should be large enough such that the ADDS cable is not pinched or squeezed.

4.3.1.7 Traveller, sheave, or quadrant blocks used should be in good working condition and properly lubricated. It is preferred that these are not lined since friction between the ADSS sheath and the lining can cause torsion to be introduced into the cable.

4.3.1.8 Tangent supports made of metal with a protective pad can be used as a replacement for stringing blocks. These supports are mounted directly on the structure and open from the top. The protective pads can be removed and the top closed and secured for stringing.

4.3.1.9 At places where an uplift can occur, it is recommended that uplift rollers or hold-down blocks be used.

4.3.1.10 Wire mesh grips or pulling eyes can be used to pull the cable into place through the travellers, sheaves, or quadrant blocks. The mesh grip or pulling eye shall be used in conjunction with a swivel link which will minimize cable twisting which can be introduced by the pull rope. The load rating of the swivel link shall not exceed the maximum pulling tension rating of the cable. All wire mesh grips shall be of a double or triple weave design and shall be rated to match the cable diameter.

4.3.2 Stringing operation and installation methods

4.3.2.1 The pull-back or tension stringing method

4.3.2.1.1 The pull-back or tension stringing method is the preferred way (see figure 1) of installing medium and long-span ADSS fibre optic cables.

NOTE Where short-span installations are to be carried out on low-voltage or telecommunication routes, other methods are permissible.

4.3.2.1.2 The reel is placed on a reel stand or reel trailer at one end of the pull run. A braking device applies minimal braking tension to prevent overrun. The cable reel trailer should be disconnected from the towing vehicle, it shall have the reel levelled and the trailer wheels should be securely chocked.

4.3.2.1.3 This method is based on pulling of the cable with the help of a pulling rope through the sheaves or travellers installed on each of the structures. The sheaves are installed just above or just below the installed cable hardware. The cable hardware shall be attached at the position chosen in terms of 4.2 for suspension, dead end and tangent locations.

4.3.2.1.4 The pulling line shall be of similar diameter as that of the cable. As the pulling line is a light, dielectric rope with low twist, it can be attached to the cable through a swivel link and with a wire mesh grip. In most cases a factory-installed pulling eye can be used instead of the wire mesh grip.

4.3.2.1.5 The ADSS cable is then pulled through at a controlled speed at a tension of not more than 50 % of the maximum final tension of the cable. Care should be taken to avoid excessive sagging of the cable and to ensure that the cable's minimum bending radius is always exceeded. The swivel and wire mesh grip shall be checked to see that they run through the sheaves with no resistance.

4.3.2.1.6 The ADSS cable shall be drawn using a winch at a pulling tension such that neither the draw rope nor the cable infringes on the minimum ground clearance condition. The tension should be carefully maintained using a brake and back tensioner.

4.3.2.1.7 When the entire cable has been pulled through, starting from an end location, each dead-end to dead-end cable length can be sagged and tensioned to levels specified by the cable supplier and support hardware applied. After this procedure has been done for all the spans, the suspension assemblies and vibration dampers can be installed.

4.3.2.1.8 During the ADSS cable installation there shall be good communication in the form of radio links between the puller, the tensioner and the person following the lead end of the ADSS cable in order to ensure the smooth installation of the ADSS cable.

4.3.3 Special conditions during installation

4.3.3.1 If the ADSS cable is installed under live line conditions, the necessary earthing precautions and other safety aspects shall be applied.

4.3.3.2 The location of the tensioner and puller relative to the structure shall be selected so that the structure is not overloaded. A pulling slope of 75° to 80° is recommended.

4.3.3.3 Temporary guys may be required on certain structures to minimize overloading during stringing of the cable. Anchors and pole hardware shall be rated above the expected environmental load of the cable, plus a safety factor.

4.3.3.4 Travellers, sheaves or quadrant blocks are normally attached direct to the support structure. The pole attachment, used to support the traveller, sheave or quadrant block shall be consistent with the working load and rating of the traveller, sheave or quadrant block.

4.3.3.5 The pulling grip shall be rated above the maximum pulling tension anticipated. When properly installed, no special preparation of the cable end or of aramid yarns are required. A matching clevis type swivel should be used to prevent twisting of the cable during pulling. The swivel shall have a breakaway tension of less than or equal to the cable's rated maximum pulling tension.

4.3.3.6 Care shall be taken to ensure that the cable sheath is not scratched or damaged in any way by the ADSS cable being dragged over the ground or over other objects.

4.3.3.7 To prevent any damage to the cable from aeolian vibration, effective resonant or interference type vibration dampers shall be installed on the cable.

4.3.3.8 The ADSS cable manufacturer shall advise on the number, type and fixing position of the vibration dampers to be used.

4.3.4 Jointing and splicing of two sections of ADSS cable

4.3.4.1 The correct number of correctly dimensioned down-lead clamps shall be used on each down-lead cable to ensure that the ADSS cable is securely anchored to the tower in such a way as to eliminate vibrations and cable clashing with the tower. A down-lead clamp shall be installed on each tower member intersection. The maximum distance between down-lead clamps shall be 2 m. Clamp bolts shall be tightened using torque wrenches. The torque that will prevent damaging stress concentrations due to clamping shall be obtained from the ADSS cable and clamp manufacturers. Only clamps approved by the ADSS manufacturer shall be used.

4.3.4.2 Upon completion of section stringing, when the ADSS is hand-fed through the tower structure, the minimum bending radius, specified by the manufacturer, shall not be compromised.

4.3.4.3 At joint structures, sufficient extra cable shall be left to accommodate the lowering of the cable to the ground and splicing of the ends in a splicing van or trailer whilst preserving the manufacturer's recommended minimum bending radius. A further minimum allowance of 5 m shall be provided in each closure to make fibre optic connections.

4.3.4.4 After splicing, all slack cables shall be stored in a proper slack storage cabinet which will cater for the cable to be rolled up to its proper bending radius and stored. These cabinets or holders shall be installed onto the structures with proper mounting brackets. Care shall be taken when this slack cable is being rolled up; it shall be done in such a way that no torsion is imparted to the ADSS cable.

4.3.4.5 If ADSS sagging and jointing cannot be done in a continuous operation, the ends of the ADSS cable shall be sealed using a heat shrinkable end cap that shall remain in place until jointing work starts. Spare lengths of ADSS cable at jointing structures shall be made into coils of diameter that exceed the minimum bending radius, as specified by the ADSS cable manufacturer. The coils shall be securely attached, above the anti-climbing devices, to the tower in order to prevent ADSS cable damage under windy conditions as well as to prevent theft.

4.3.4.6 Well-trained technicians shall carry out the 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 to the tower above the anti-climbing device. Splice losses shall be as specified in annex B, unless otherwise specified by the customer.

4.3.4.7 Splicing shall be done as described in 4.3.4.7.1 to 4.3.4.7.8.

4.3.4.7.1 Fix an adapter for the mounting of the splice enclosure onto the tower: metallic splice closures shall have an earth bond to the tower; this is not necessary in the case of non-metallic splice closures.

4.3.4.7.2 Remove the outer sheath, strength members and inner sheath and expose the fibre units in accordance with the splice enclosure manufacturer's instructions.

4.3.4.7.3 Clamp the ADSS cable in the splice enclosure as specified by the splice enclosure manufacturer (clamping is done to include the central GRP member).

4.3.4.7.4 Fusion splice the optical fibres, colour to colour.

4.3.4.7.5 Reinforce the splice point with heat-shrinkable tube or by other means in accordance with the splice enclosure manufacturer's instructions.

4.3.4.7.6 Secure and lay the optical fibres in the splice organizer inside the enclosure on completion of a permanent splice.

4.3.4.7.7 Close and seal the splice enclosure.

4.3.4.7.8 Loop the excess cable and secure the splice enclosure to the adaptor mounted on the tower, to ensure that the minimum bending radius specified by the ADSS cable manufacturer is adhered to and that there is no torsion applied to the ADSS.

4.3.4.8 Fibre migration can be experienced in the central tube design of ADSS cable. To avoid this, a minimum of two loops shall be installed immediately under the joint enclosure. Alternatively, the ADSS manufacturer may propose a technique for minimizing fibre migration.

4.3.5 Completing the ADSS installation to the termination room

4.3.5.1 Completing the ADSS installation

Completing the ADSS installation to the termination room can be done in two ways, i.e.

a) by taking the ADSS direct to an underground cable, or

b) by taking the ADSS direct to the termination room.

NOTE See figure 2 for a typical installation.

4.3.5.2 Underground cable (see figure 3)

The fibres from the ADSS shall in all cases be spliced direct to the underground duct cable leading to the patch panel in the splice enclosure 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.

The 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, as described in (a) and (b) below.

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 (see 3.2) armoured optical fibre duct cable shall be used for the link between the ADSS splice enclosure installed at the gantry or terminal tower at the line entry and the ODF (see 3.2) 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 ODF 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 customer, unarmoured duct cable laid inside class 6 high-density polyethylene tubing, or similar, of diameter approximately 50 mm, shall be used.

Where a tube is required to house the underground cable, it shall be an HDPE duct. A duct-sealing device shall be used to protect the cable and duct against damage by rodents and ingress of moisture. A general layout is depicted in figure 2.

4.3.5.3 ADSS taken direct to the termination room

Where feasible, the ADSS cable can be taken from the termination on the gantry or termination structure directly to the wall of the termination room. It should then enter the room through the wall and be protected by flexible ducting in the termination room between the point of entry and the ODF. The termination arrangement at the gantry is shown in figure 3.

4.4 Fittings

4.4.1 General

Any hardware provided for use on steel tower structures shall be such that no holes will be drilled into the tower steelwork.

All hardware shall be approved by the ADSS supplier and the customer in accordance with CIGRE TF 22.11.03. Hardware assemblies shall be compatible with the cable to ensure that the system so formed will survive the operating environment for the design life. In order to show compliance with this requirement, all cable and hardware combinations shall be tested for load transfer between the hardware and the ADSS strength members at ambient temperature and at temperatures up to 70 °C. If required, the results of these tests shall be made available to the customer.

All items of hardware shall comply with 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 his responsibility for the adequacy of the design, dimensions and details.

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

4.4.2 Drawings

Drawings of assemblies offered shall be supplied, indicating the following 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 ± 2 % of the dimension. All tolerances shall be subject to the customer's approval. Items of hardware found to exceed tolerances will be rejected.

4.4.4 Installation procedures

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

The basic requirements for hardware at splicing towers and standard towers are depicted in figures 4 and 5. If splicing is required at strain towers or suspension towers (or both), the tension assemblies as shown shall be used.

4.4.5 Performance requirements

The following general performance requirements for ADSS fittings shall be complied with:

a) **Tension assemblies**

1) see annex C, figure 4 for a typical assembly;

2) tension assemblies shall be of the pre-formed dead-end type;

3) excessive stresses, which will affect the fibres of ADSS cable, shall not be applied on the cable; therefore great care shall be taken when hardware for ADSS is being selected;

4) the basic dead-end assembly shall comprise the following items:

- a structural reinforcement layer (SRL), wound directly on the cable;
- a dead-end grip wound on the SRL;
- the proper set of links; and
- thimble clevis.

b) **Suspension assemblies**

1) see annex C, figure 5 for a typical assembly.

2) a suspension assembly shall comprise the following items:

- a clamp body;
- two halves of neoprene insert of “diabolo” shape;
- single spiral rods of SRL layer, may be omitted for medium spans; and
- the proper set of links to attach to the tower or the structure.

c) **Aeolian vibration dampers**

Vibration dampers that are capable of damping any aeolian vibration that the ADSS will experience, shall be offered. The type, size, mass, quantity and spacing of vibration dampers, on a span by span basis, shall be selected to limit the aeolian vibration bending amplitude so that the safe bending amplitude, as prescribed by the ADSS manufacturer, is not exceeded. SVDs (see 3.2) are acceptable.

d) C**lamps**

1) The design of these clamps shall be such that no excessive stresses, which can affect the performance of the ADSS under any circumstances, will be induced. Down-lead clamps will only be used on structures where joints are made.

2) Figures 6(a) and 6(b) show typical clamps for securing the ADSS cable to the structure.

e) **Splicing enclosures (joint boxes)**

Splicing enclosures (joint boxes) shall be subject to the customer’s approval. All construction details and ingress protection (IP) ratings of the proposed units shall be provided. The splicing enclosures, if metallic, shall be supplied with tower earth bonding fixtures. They shall facilitate fibre organization and splicing requirements, and shall be vandal resistant, if specified.

4.5 Safety and environment

4.5.1 General

4.5.1.1 Contractors shall be authorized by the local utility in accordance with legislation (see foreword) to carry out stringing under energized or de-energized conditions.

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

4.5.2 Safety requirements

4.5.2.1 Legal requirements (see foreword) and requirements of the local operating regulations shall apply.

4.5.2.2 The following requirements shall apply.

a) Staff shall comply with prerequisites, and shall be sufficiently trained, evaluated and authorized accordingly.

b) Lifting machines and equipment shall comply with legal requirements (see foreword);

c) Access and keys shall be controlled in accordance with local operating instructions.

d) A permit system or a 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, when live line working, against induction and system fault current in the form of equipotential earthing and bonding shall be enforced. This includes running earths and fenced winch or tensioner operator equipotential zones. 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

The following requirements shall apply:

a) there shall be minimal impact and disturbance of the environment;

b) agreements and relationships with land owners shall be adhered to, this includes notification before arrival and ensuring access gates are left the way they were found; and

c) any excess cable which is not returned to the customer shall be disposed of by cutting into approximately 2 m lengths and taken to a registered waste site. Because of the health risks associated with fibre, the cable shall not be disposed of in a normal municipal waste site.

4.6 Quality control

The quality control requirements shall be specified by the customer. A quality management system based on SANS 9001, and effectively implemented product and process quality plans are essential elements of these requirements.

5 Tests

5.1 ADSS fibre optic cable on-site tests before installation

5.1.1 Test the integrity and attenuation of individual fibres with the ADSS cable still on the drums on site, before stringing. Perform the test for each fibre in the ADSS cable 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 Clearly mark the identity of individual fibres.

5.1.3 Record the results of the tests as shown in table 1. The drum number and the length of the ADSS cable are given in the table headings.

5.1.4 Record the attenuation of each fibre in the table. Produce results on paper and in digital format on disc.

5.1.5 If the test on the ADSS cable (while still on the drum) on site was successful, hand over the drum to the main contractor. In the case of failure, return the drum to the supplier, and all costs associated with the replacement of the defective material will 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 ADSS cable 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.

5.1.7 Store all material received neatly in proper, defined storage areas to facilitate checking of quantities and quality. Forward receipt slips to the customer within two days of delivery. Keep a record of the total quantities of material received and used on site.

Table 1 — Results of tests on optic fibre cable, done on site before installation

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

5.2 Testing after completion of installation

5.2.1 After completion of the installation, test the ADSS cable for integrity and attenuation of the optic fibres. Record and present the test results as shown in A.1.

5.2.2 Perform an end-to-end light source and power meter test and record and present the results as shown in A.2. Perform the final test in accordance with annex B.

NOTE A calibrated light source and a power meter should be used in this test.

5.2.3 Perform PMD (see 3.2) tests requested by the customer, on the terminated ADSS cable to illustrate compliance with the system requirements.

5.2.4 Do commissioning in close co-operation with, and to the full satisfaction of, the customer.

NOTE 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.

6 Documentation

6.1 Before installation

The following documentation shall be given to the customer and shall be approved by the customer before commencement of the ADSS installation:

a) electric field plots for all towers;

b) leakage current plots for all spans;

c) a diagram indicating attachment points on structures; and

d) calculations of structure loading due to the addition of the ADSS cable.

6.2 After completion of installation

The following documentation shall be given to the customer and shall be approved by the customer on completion of the ADSS installation:

a) the test results as given in 5.2;

b) records of installation pulling tensions, preferably in chart form; and

c) a line diagram that shows the positions of all joints, including structure numbers, distances from the main termination room and fibre allocation in the case of spurs, etc.

Annex A
(informative)
Summary tables

A.1 Sample of splice loss summary table

Line : Bloukrans-Venus No. 1
Cable type: ADSS
End 1: Bloukrans substation
End 2: Venus substation
Wavelength: 1 550 nm

Fibre type:
Refractive index: 1,468
Helix factor: 2 %
Back-scatter coefficient:

Table A.1 — Sample of splice loss summary

1	2	3	4	5	6	7	8	9
	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		
FibreNo.	Tested from	Total loss[a]	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		
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	0,04	0,09
2	End 1	5,43	0,00	0,23[b]	0,00	0,00		
2	End 2	5,21	0,00	-0,10[b]	0,00	0,00		
2	Average	5,32	0,00	0,07	0,00	0,00	0,02	0,07
:	:	:	:	:	:	:	:	:
11	End 1	5,41	0,00	-0,07[b]	0,06	0,11		
11	End 2	4,90	0,00	0,09[b]	0,00	0,11		
11	Average	5,15	0,00	0,08	0,03	0,11	0,05	0,11
12	End 1	5,02	0,09	0,00	0,05	0,06		
12	End 2	5,58	0,10	0,17[b]	0,00	0,00		
12	Splice loss	5,30	0,10	0,09	0,03	0,03	0,06	0,10

NOTE 1 The values given in this table are not intended to represent real values, they are given for illustrative purposes only.

NOTE 2 The table has been shortened for the sake of brevity.

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

[b] This value indicates an apparent gain at the joint due to a variation in the MFD of the two fibres.

Annex A
(concluded)

A.2 Sample of light source and power meter summary table

Line : Bloukrans-Venus No. 1
Cable type: ADSS
End 1: Bloukrans substation
End 2: Venus substation
Line length: 21 km
Wavelength: 1 550 nm
Reference: -7,3 dB

Table A.2 — Sample of light source and power meter summary

1	2	3	4	5
Fibre No.	**Tested from**	**dB/km**	**Received level dB**	**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.				

NOTE 1 The table indicates measurements from both sides. This is strictly not necessary as the losses should be the same from either direction or the difference is merely a measurement uncertainty.

NOTE 2 The table has been shortened for the sake of brevity.

Annex B
(normative)

Acceptance procedure for ADSS fibre optic cable systems

B.1 General

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

B.2 Splice acceptance

All joints shall be of the fusion type and shall comply with the requirements in table B.1, or otherwise as agreed upon between the customer and the contractor.

Table B.1 — Splice loss

1	2	3
Splice loss[a]	**Single mode fibre**	**Multimode fibre**
Maximum	≤ 0,10 dB	≤ 0,15 dB
Mean[b]	≤ 0,075 dB	≤ 0,10 dB

[a] The individual 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 that has a measured loss higher than the specified value, shall be broken and redone.

If, after attempting to re-splice for a total of 3 times, the individual splice loss is still above the specified limit, the splice can be accepted provided that the mean splice loss is within the specified limits.

B.3 Fibre optic cable testing

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 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).

Annex B
(continued)

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

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

Indicate on the splice summary table (see table A.1) the back-scatter coefficient for each wavelength as supplied by the cable manufacturer. This information is required for record purposes.

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

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 exceeding 50 km wavelength, tests need only be done at 1 550 nm.

Use launch fibre or dead-zone fibre of at least 200 m and indicate as such in the test results.

Take only bidirectional measurements.

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.

Do the tests in both directions at both 1 310 nm and 1 550 nm windows, as specified in B.3.3

Provide test results on a data disc.

NOTE The best method to determine splice loss 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 under the same test conditions are required to eliminate the effects of back-scatter coefficient differences.

The calculation of loss is done 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

Annex B
(continued)

Insert the following information on each OTDR trace:

a) the date of the test;

b) a description of the fibre optic cable;

c) the fibre number;

d) the end from which the test is performed;

e) the refractive index;

f) the helix factor; and

g) the Rayleigh back-scatter coefficient.

B.4 Documentation

B.4.1 The following data shall be available on request:

a) information on the OTDR instrument (including the make, the model, manuals and also a copy of the trace analysis software);

b) calibration data (central wavelength(s) as verified by an NCS-approved facility);

c) the launch conditions; and

d) information on the splice machine (including the make, the model and manuals).

B.4.2 The information can be summarized and submitted in table form as shown in the example in table A.1.

B.4.3 The supplier shall supply documentation as specified in the contract.

B.4.4 All documentation called for shall be provided in hard-cover ring files that comply with the requirements in B.4.5 to B.4.9 inclusive.

B.4.5 Documentation shall be supplied in English.

B.4.6 Documentation shall be supplied on A4 paper.

B.4.7 The hard-cover ring files shall be of a construction that can open flat on any page.

B.4.8 Any drawings and descriptions included shall conform to the A4 series (295 mm × 220 mm). Larger drawings shall be folded in a single panel along the 200 mm axis of the standard A4 size.

B.4.9 Different sections of the documentation shall be separated by means of thumb-tag separators.

Annex B
(concluded)

B.4.10 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 table A.1;

f) OTDR traces for each fibre in both directions at 1 310 nm or 1 550 nm (or both) windows as appropriate (see B.3.3) (on paper and on an 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 table A.2.

Annex C
(normative)

Installation drawings and fittings

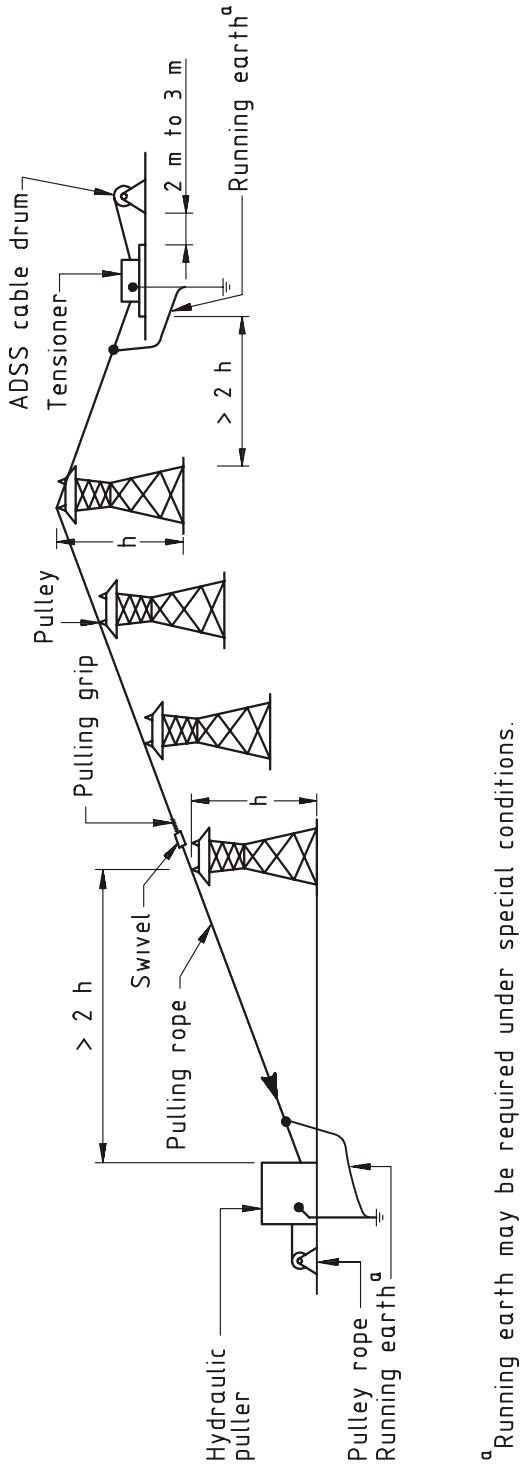

Figure 1 — Standard method of stringing

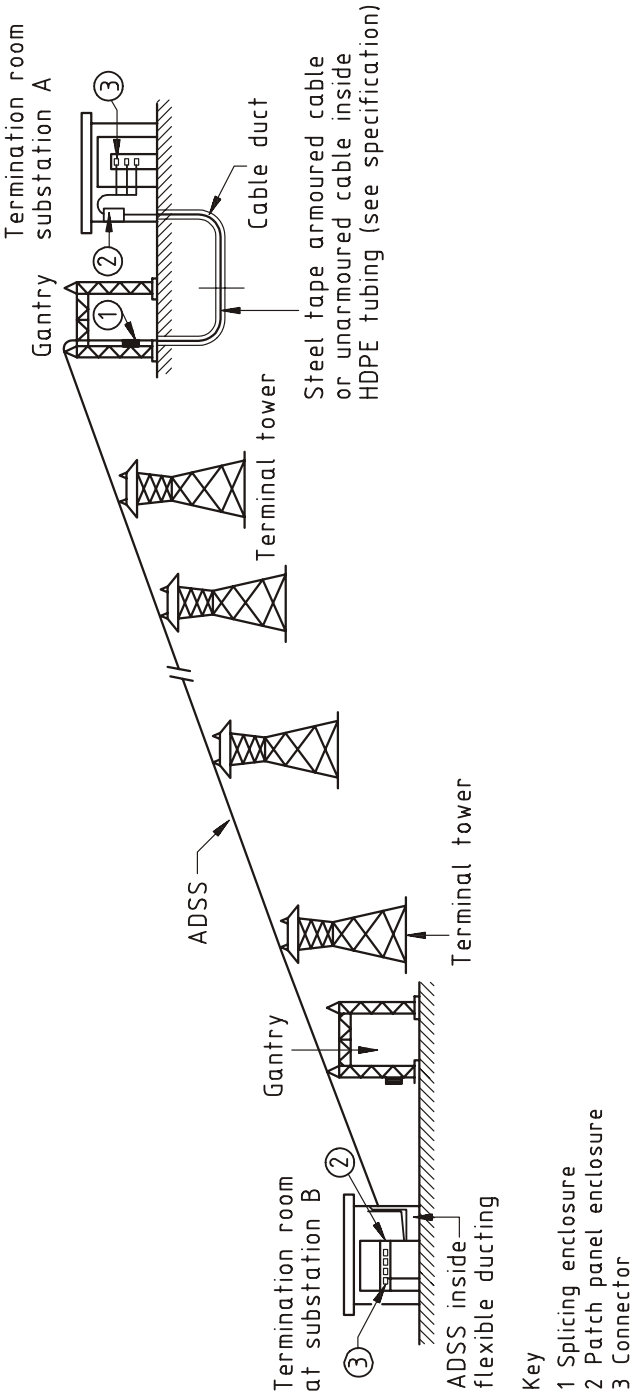

Figure 2 — Completing the ADSS installation to the termination room

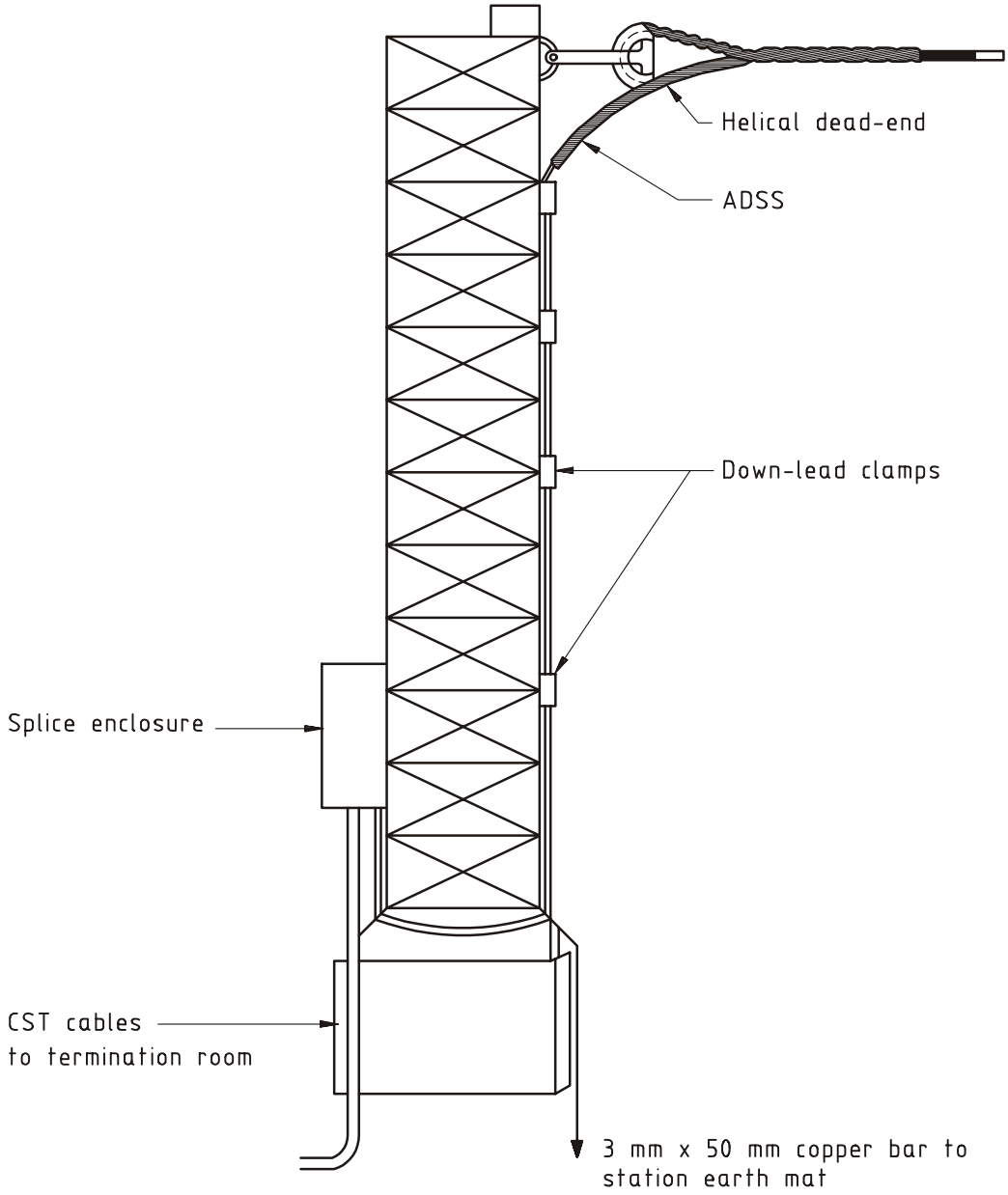

Figure 3 — Termination arrangement at the gantry

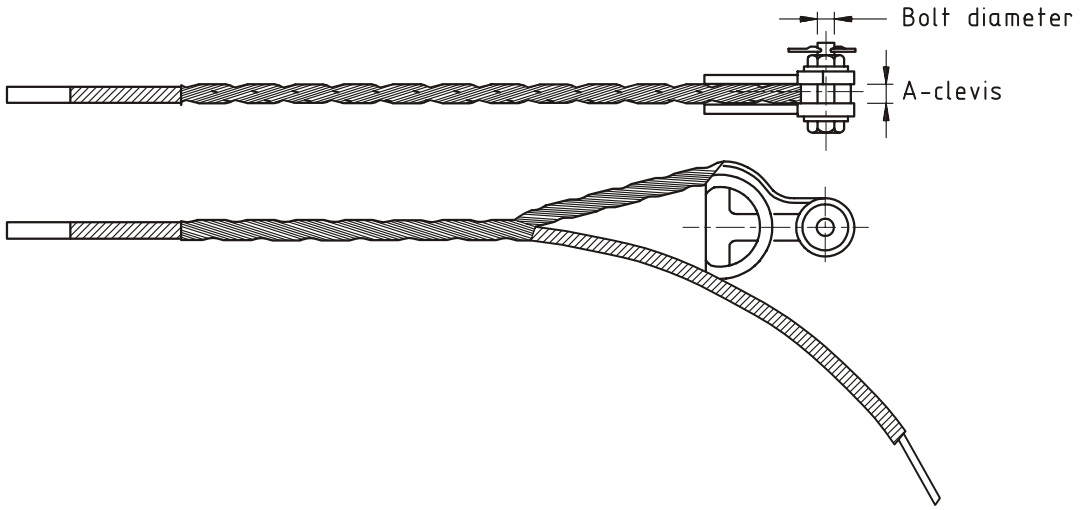

Figure 4 — Dead-end

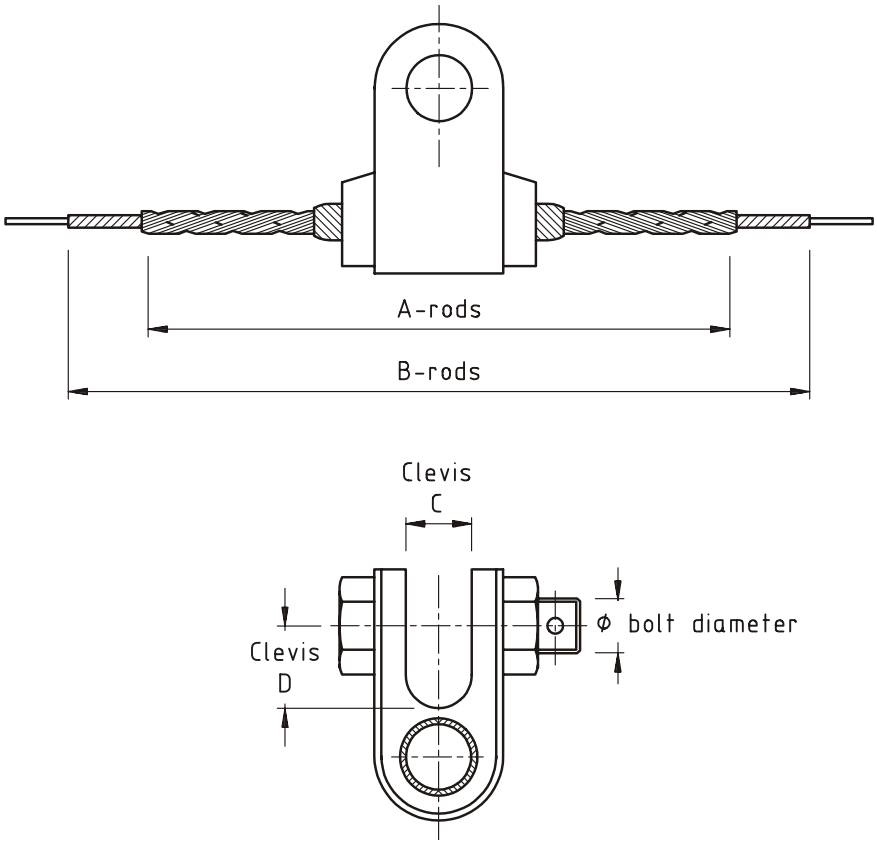

Figure 5 — Suspension unit for long-span ADSS cables

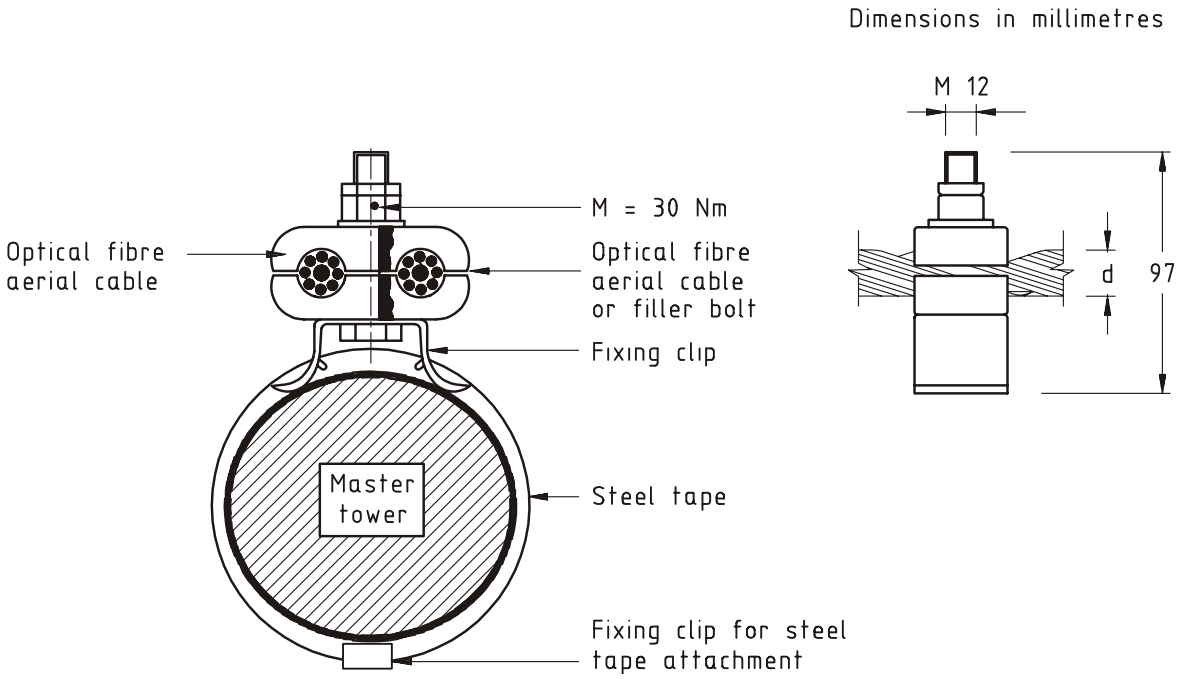

Figure 6(a) — Fixing clamp

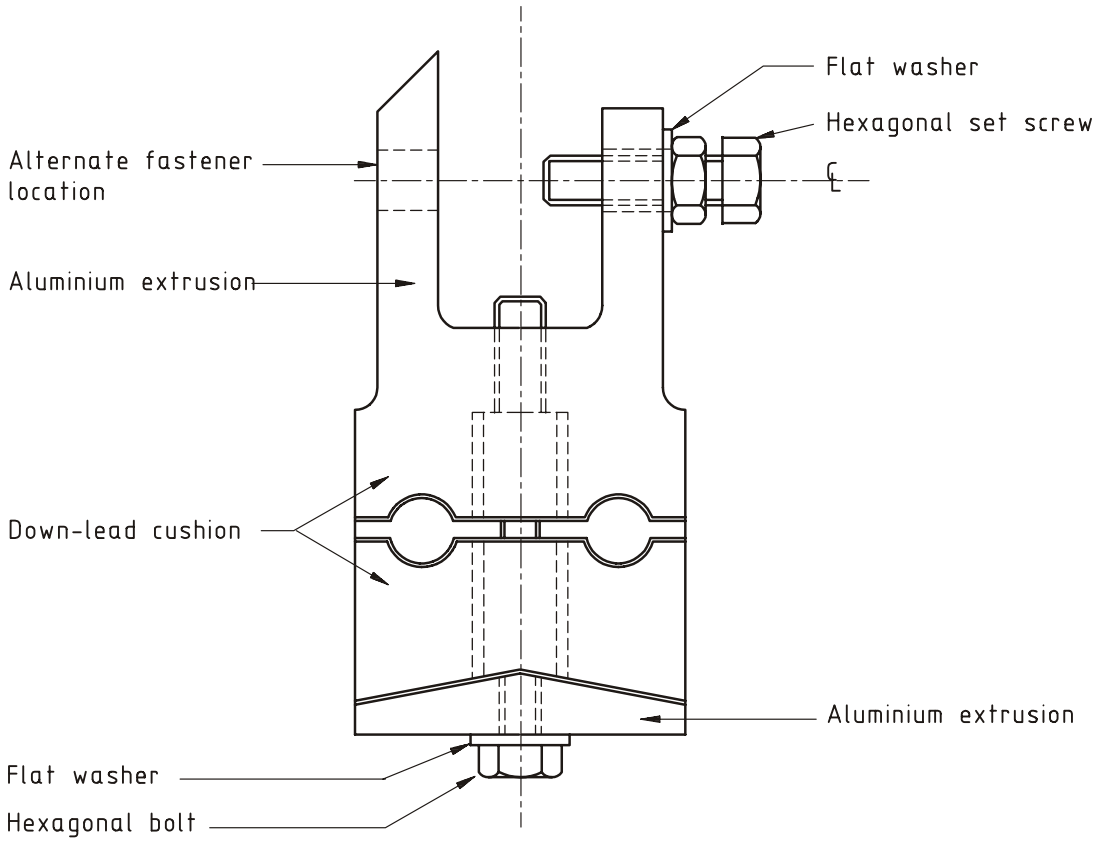

Figure 6(b) — Down-lead cushioned clamp

Figure 6 — Clamps

Bibliography

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