

# **DUCT AND DIRECT-BURIED UNDERGROUND FIBRE-OPTIC CABLE**

## **Part 1: Product specification**

This document does not have the status of a South African National Standard.



## NRS 088-1:2007

This rationalized user specification is issued by  
the Technology Standardization Department (TSD), Eskom,  
on behalf of the  
User Group given in the foreword

**Table of changes**

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## **Foreword**

This part of NRS 088 was prepared on behalf of the Electricity Suppliers Liaison Committee (ESLC) and approved by it for use by supply authorities and other users.

This part of NRS 088 was prepared by a working group which, at the time of publication, comprised the following members:

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The assistance of Rob Phillips in compiling the first draft is gratefully acknowledged.

A Manufacturers' Interest Group (MIG) was consulted on the contents of this part of NRS 088 and its comments were incorporated where the working group was in agreement. The MIG comprised the following members:

G Hughes	MTEC
P v Zyl	ATC cables

NRS 088 consists of the following parts under the general title *Duct and direct-buried underground fibre-optic cable*:

*Part 1: Product specification.*

*Part 2: Installation guidelines.* (In course of preparation.)

Annexes A and B are for information only.

## **NRS 088-1:2007**

### **Introduction**

This part of NRS 088 has been prepared to establish uniform requirements for duct and direct-buried underground fibre-optic cable. This part of NRS 088 is intended to enable purchasers to acquire the specified item without the need for detailed and extensive contract documents.

The ESLC expresses the wish that, in the national interest and in support of government policy to foster local manufacturing industry and stimulate exports, all purchasers will adopt the requirements of this part of NRS 088 in so far as their particular conditions will allow. Any differences between the requirements of this part of NRS 088 and the corresponding purchaser's requirements should, as far as possible, be clearly indicated in schedules A and B, which may be compiled using the draft schedules set out in annex B, and which should, where appropriate, be submitted for consideration in future revisions of this part of NRS 088.

### **Keywords**

duct, single-mode, optical fibres, underground cables.

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## DUCT AND DIRECT-BURIED UNDERGROUND FIBRE-OPTIC CABLE

### Part 1: Product specification

#### 1 Scope

This part of NRS 088 covers the essential construction, performance and acceptance criteria and test requirements for duct and direct-buried underground optical fibre cables.

NOTE 1 The parameters of the optical fibres to be incorporated in the cable are covered in other NRS specifications.

NOTE 2 A guide to purchasers on preparing an enquiry is given in annex A.

NOTE 3 A model form for schedules A and B is given in annex B.

#### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from Standards South Africa.

EIA/TIA 598-C, *Optical fibre cable color coding*.

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*.

NRS 081, *Single-mode non-dispersion shifted optical fibres*.

SANS 1411-6:2001, *Materials of insulated electric cables and flexible cords – Part 6: Armour*.

SANS 1411-7:2003, *Materials of insulated electric cables and flexible cords – Part 7: Polyethylene (PE)*.

SANS 60793-2-50/IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*.

SANS 60794-1-2:2003/IEC 60794-1-2:2003, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*.

#### 3 Terms, definitions and abbreviations

For the purposes of this part of NRS 088, the following terms, definitions and abbreviations apply.

### 3.1 Terms and definitions

**approved****approval**

approved in writing by the purchaser

**armoured cable**

cable that contains metallic armouring elements

**direct-buried underground cable**

cable designed to be installed under the surface of the earth, in direct contact with the soil

**duct cable**

cable designed to be installed under the surface of the earth in a duct that isolates the cable from direct contact with the soil

**SZ**

method of constructing a cable where the direction of rotation of the elements of the cable reverses periodically along the cable

**thixotropic gel**

gel that undergoes a reduction in viscosity when shaken, stirred or otherwise mechanically disturbed and that readily exhibits a stable form at rest

**unarmoured cable**

cable that contains no metallic armouring elements

### 3.2 Abbreviations

CST: corrugated steel tape

D: diameter (outer) of the fibre-optic cable

FRP: fibre reinforced plastic

GRP: glass reinforced plastic

SWA: steel wire armoured

## 4 Requirements

### 4.1 Fibre requirements

**4.1.1** The number and type of fibre to be used in the cable will be specified in schedule A (see annexes A and B).

**4.1.2** The requirements for single-mode fibres shall be in accordance with NRS 081.

### 4.2 Cable requirements

**4.2.1** The cross-section of the cable shall be circular.

**4.2.2** Cables shall be armoured or unarmoured as specified in schedule A (see annex B). Unarmoured cables shall contain no metallic elements. In the case of armoured cables, the armouring shall be either CST or SWA as specified in schedule A (see annex B). SWA shall be in accordance with SANS 1411-6:2001. The armour bedding shall be polyethylene (PE).



**4.2.3** In the case of a stranded buffer tube cable design, a maximum of 12 fibres shall be enclosed in a buffer tube, which shall be filled with a suitable thixotropic gel. The "marker" buffer tube shall be red in colour and the "reference" buffer tube shall be green in colour. The remaining buffer tubes, if required, shall be transparent, and "fillers", if used, yellow in colour.

**4.2.4** In the case of a central tube cable design with more than 12 fibres, a maximum of 12 fibres shall be bundled together by a coloured thread, and each separate bundle shall be clearly identifiable by its thread colour. The tube shall be filled with a suitable thixotropic gel.

**4.2.5** The fibres shall be marked by a coloured coating with up to 12 different colours in accordance with EIA/TIA 598-C. The optical fibre colours shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. The colour coating shall not cause the fibres to stick together.

**4.2.6** The cable shall comply with the requirements of test method F5B in SANS 60794-1-2:2003. All the interstices of the cable shall be completely filled to prevent water ingress of the cable when tested in accordance with 5.2.2. Details of the measures taken shall be provided in schedule B (see annex B).

**4.2.7** All materials used within the cable shall be non-toxic and dermatologically safe. Details shall be provided in schedule B (see annex B).

**4.2.8** The cable sheath shall be PE, type PS4 in accordance with SANS 1411-7:2003. When tested in accordance with 5.2.3, the sheath shall be resistant to ultraviolet radiation.

**4.2.9** Cables shall have a tensile strength that exceeds load value given by  $0,6 \times 9,81 \times M \times 2 \text{ N}$ , where M is the mass of 1 km of cable, in kilograms, or 1 200 N, whichever is the greater. This load shall not produce a strain exceeding 0,2 % in the fibres, nor cause any damage or deformation to the component parts of the cable or the cable sheath when tested in accordance with 5.2.4. The cable tension for 0,2 % fibre strain shall be stated in schedule B (see annex B).

**4.2.10** Only aramid yarn type strength members shall be acceptable. In addition to the aramid yarn, a GRP/FRP central strength member may be used in helical or SZ stranded buffer tube designs.

**4.2.11** The fibre and components parts of the cable shall not suffer permanent damage when subjected to compression loads. When tested in accordance with 5.2.5, the cable shall have sufficient crush resistance capability to withstand a load of 2 000 N.

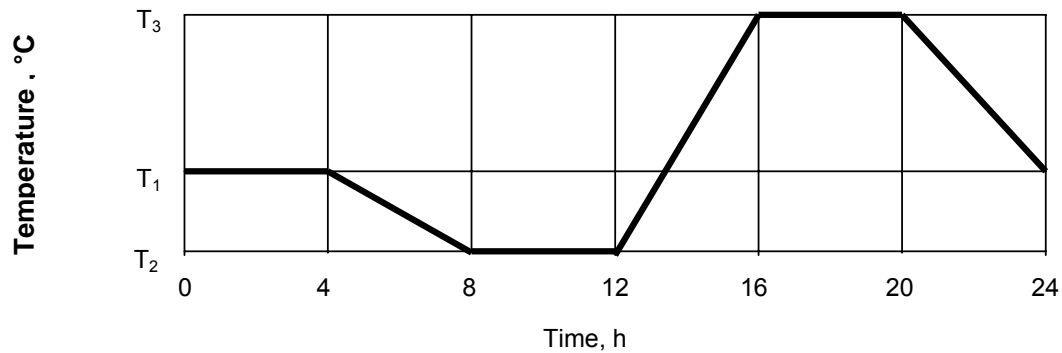
**4.2.12** When tested in accordance with 5.2.6, the cable shall be flexible enough to accommodate a minimum bending radius of 15 D for armoured cable and 10 D for unarmoured cable without damage or change in the cable properties.

**4.2.13** The cable shall be designed to withstand the specified degree of twisting without any damage to either the component parts of the cable or permanent change to the optical transmission properties of the fibres when tested in accordance with 5.2.7. The attenuation increase during the test shall be less than 0,1 dB.

**4.2.14** The cable shall have an impact resistance capability such that, when tested in accordance with 5.2.8 with a single impact of 20 Nm for armoured cable and 30 Nm for unarmoured cable, there shall be no permanent change to the optical transmission performance of any fibre.

**4.2.15** When tested in accordance with 5.2.9, the changes in attenuation over the last four temperature cycles shall not exceed 0,1 dB/km from the mean. The mean attenuation shall be defined as the average attenuation encountered at 20 °C over the last four temperature cycles.

The temperature cycle shall be as shown in figure 1.



$T_1 = + 20\text{ }^{\circ}\text{C}$   
 $T_2 = - 10\text{ }^{\circ}\text{C}$   
 $T_3 = + 70\text{ }^{\circ}\text{C}$

**Figure 1 — Temperature cycle**

**4.2.16** When tested in accordance with 5.2.10 at an ambient temperature of 70 °C, the cable shall comply with the requirements of 17.5 in SANS 60794-1-2:2003.

**4.2.17** There shall be no fibre splices in the length of the cable on each drum or, at any point, attenuation discontinuity of more than 0,1 dB.

### 4.3 Environmental requirements

The cable shall be operated under the following environmental operating conditions:

- a maximum temperature of 70 °C;
- a minimum temperature of -10 °C;
- an altitude of 2 500 m above sea level;
- a relative humidity of 100 %;
- a maximum barometric pressure of 104 kPa; and
- a minimum barometric pressure of 76 kPa.

## **5 Tests**

### **5.1 Routine tests**

#### **5.1.1 General**

Subject the cable to all the manufacturer's standard tests to ensure compliance of the cable with all requirements of this part of NRS 088. Provide the customer with the details of the test performance and the test results. The manufacturer shall keep all routine test certificates for a period of three years. These certificates shall be available on request of the customer.

#### **5.1.2 Optical test**

Each fibre shall be measured by the manufacturer for continuity, length and attenuation once the cable has been placed on the drum after manufacture and before delivery. Check for compliance with 4.2.17. The customer may require an inspector to be present when these final measurements are performed.

NOTE The customer's attendance does not relieve the supplier of his responsibility for the satisfactory performance of the cable during subsequent testing on site and thereafter up to the end of the warranty period.

### **5.2 Type tests**

#### **5.2.1 General**

The mechanical tests given in the part of NRS 088 are considered type tests. Carry out type tests before the delivery of any product to ensure compliance with this part of NRS 088. Should the supplier have the results of type tests done on product similar to those to be supplied, these can then be submitted instead of carrying out new type tests. Carry out new type tests if any change was made to the materials used or to the manufacturing processes. The availability of type test report shall be stated in schedule B (see annex B). The customer reserves the right to request and witness type tests.

#### **5.2.2 Longitudinal water penetration**

Perform the water penetration test detailed in test method F5B in SANS 60794-1-2:2003 and test the cable between the core and the inner sheath. Check for compliance with 4.2.6.

#### **5.2.3 Sheath UV withstand test**

Test the cable in accordance with the requirements of ISO 4892-3. Check for compliance with 4.2.8.

#### **5.2.4 Tensile strength**

Test the cable in accordance with test method E1 in SANS 60794-1-2:2003. Check for compliance with 4.2.9.

#### **5.2.5 Crush resistance**

Perform the test as described in test method E3 in SANS 60794-1-2:2003. The two flat plates shall have dimensions of 50 mm × 50 mm. Apply the load for 1 min. Check for compliance with 4.2.11.

#### **5.2.6 Cable bending**

Test the complete cable in accordance with test method E11 in SANS 60794-1-2:2003. Check for compliance with 4.2.12.

**5.2.7 Cable twist (torsion)**

Test the cable in compliance with test method E7 in SANS 60794-1-2:2003. Check for compliance with 4.2.13.

**5.2.8 Impact resistance**

Test the cable in accordance with test method E4 in SANS 60794-1-2:2003. Check for compliance with 4.2.14.

**5.2.9 Temperature cycling**

Perform this test in accordance with test method F1 in SANS 60794-1-2:2003. Check for compliance with 4.2.15.

**5.2.10 Compound flow (drip)**

Test the cable in accordance with test method E14 in SANS 60794-1-2:2003. Check for compliance with 4.2.16.

**6 Marking, labelling and packaging****6.1 Marking and labelling**

**6.1.1** The following information shall be clearly and permanently marked on the outer sheath of the cable at intervals of 1 m:

- a) the name of the manufacturer;
- b) the year of manufacture;
- c) the type of fibre (coded);
- d) the number of fibres;
- e) a length mark, in metres, taken from the inner end of the cable on the drum; and
- f) any information required by the purchaser.

**6.1.2** The coding for the type of fibre shall be in accordance with SANS 60793-2-50.

**6.1.3** Each cable drum shall be labelled with at least one water-resistant tag, that contains the following minimum information:

- a) the name of the manufacturer;
- b) the place of manufacture;
- c) the number and type of fibres;
- d) the drum length (standard or specified);
- e) the gross tare and net mass;
- f) the drum number;
- g) the order or contract number;
- h) the type of cable (unarmoured, SWA or CST);

- i) the destination;
- j) the stock code (if specified);
- k) the words "Not to be laid flat", unless the manufacturer guarantees that the drum or reel may be laid flat without damage to the cable;
- l) an arrow or the words "Roll this way" (to indicate the direction in which the drum or reel is to be rolled in order to prevent the cable from unwinding) unless the manufacturer guarantees that the drum or reel may be rolled in either direction without damage to the cable; and
- m) any additional information as required by the user.

## 6.2 Packaging

**6.2.1** Cable shall be supplied tightly and uniformly wound onto wooden or returnable steel cable drums. The wound length of the cable on each drum shall be specified in schedule B (see annex B). If a treated wooden drum is required, it shall be stated in schedule A (see annex B).

NOTE Users should be aware of the additional requirements (costs) involved in the disposal of treated drums when compared to untreated wooden drums or steel drums.

**6.2.2** Drums shall be of such a construction that no damage to the cable will occur during shipping and handling. The outer layer of the cable on the reel shall be protected by a water and ultraviolet-resistant wrapping over the exposed surface, to prevent the ingress of moisture or dirt and UV degradation of the cable during shipping and handling.

**6.2.3** Drums shall be sealed with suitable wooden lags nailed between the flanges. The coverage of the lags shall be 100 %. The lags shall also be secured by either one or two steel tape straps suitably fastened around the lags.

**6.2.4** Each end of a cable shall be properly sealed with a heat-shrinkable end cap to prevent the ingress of moisture into the optical fibre unit during shipment or storage.

**6.2.5** Both inner and outer ends of cables shall be accessible for testing purposes. The cable drum shall be designed in such a way that at least 2 m of the inner end of the cable can be fed from the drum to an item of test equipment.

## 7 Documentation

**7.1** At the time of tender, the supplier shall provide

- a) details of the cable construction and design including colour-coding information to enable the positive identification of each fibre. The cable construction drawing numbers shall be stated in schedule B (see annex B),
- b) results of type tests (The results of type tests performed on similar cables can be submitted for approval.), and
- c) details of all the manufacturer's tests performed to ensure the quality of manufacturing.

**7.2** After delivery of the cable, the supplier shall provide

- a) details of the "as-built" cable construction and design including colour-coding information to enable positive identification of each fibre,

- b) results of all routine tests, and
- c) details of the characteristics of all fibres used in the cable, on request from the customer.

**7.3** All documentation required in 7.1 and 7.2 shall be provided in hard-cover ring files and in electronic form on CD, which comply with the following requirements:

- a) the paper shall be of A4 size;
- b) the files shall be of a construction that can open flat at any page;
- c) any drawings and descriptions included shall conform to the A4 series (295 mm × 220 mm);
- d) different sections of the documentation shall be separated by means of thumb-tag separators;  
and
- e) the language used shall be English.

**7.4** The number of copies of documentation required will be specified in the contract documentation.

**7.5** The drawings of the cable construction shall indicate the following:

- a) all dimensions of the various components;
- b) the cross-sectional area of the individual strength member(s);
- c) Young's modulus of the cable; and
- d) the mass per unit length of the cable;

**7.6** The manufacturer shall provide

- a) the results of tests done on each fibre to prove compliance with the optical fibre specifications;
- b) the effective group index of refraction of the fibres at 1 310 nm and 1 550 nm;
- c) the helix factor for the cable; and
- d) the Rayleigh backscatter coefficient of the fibres at 1 310 nm and 1 550 nm.

## **Annex A**

(informative)

### **Guide to purchasers on preparing an enquiry**

#### **A.1 General**

A model form is given in annex B to provide the purchaser with a convenient aid to purchasing. The use of this form is intended to obviate the need for preparing a detailed technical specification.

The purchaser need only specify compliance with this part of NRS 088, provide the tenderers with details of his particular requirements, and set out the information he requires the tenderer to provide, as indicated below.

#### **A.2 Schedules**

##### **A.2.1 General**

The model form in annex B provides the purchaser with examples of a schedule A and a schedule B. In his enquiry, the purchaser should provide his own schedule A and schedule B, based on these examples.

##### **A.2.2 Schedule A**

Schedule A lists the requirements to be specified by the purchaser in enquiries and orders. These requirements include references to the relevant subclauses in this part of NRS 088, to assist in compiling the schedules.

Where the text of any referenced standards stipulates that the purchaser shall indicate his requirements, these requirements should also be specified in schedule A.

The purchaser should set out his particular requirements and choices in his own schedule A.

##### **A.2.3 Schedule B**

The purchaser should draw up his own schedule B (based on the schedule B in the model form in annex B), and require the tenderer to fill in this schedule. By doing this, the tenderer will be stating compliance with this part of NRS 088 and will be providing the information the purchaser has requested.

NOTE 1 Where this part of NRS 088 allows the purchaser to make a choice, the example of schedule A (in the model form in annex B) lists the preferred items/values/quantities. In the interests of standardization, purchasers are encouraged not to deviate from these preferences.

NOTE 2 When preparing his own schedule A and schedule B from the examples in the model form in annex B, the purchaser need include only the items he considers to be relevant or necessary.

NOTE 3 These schedules, when completed, become normative annexes to the enquiry specification.

#### **A.3 Commercial conditions**

A purchaser will furthermore need to indicate the commercial conditions applicable and to draw up a price schedule. Requirements for delivery, storage, packaging and marking should be included in this part of the enquiry.

**Annex A**  
(concluded)**A.4 Quality assurance**

This part of NRS 088 does not cover the purchaser's possible requirements in respect of quality assurance, quality control, inspections, etc., since each purchaser needs to consider the criticality of the application of each component and his own policy towards these matters. Purchasers are referred to SANS 9001 for guidance.

**A.5 Testing**

Attention should be paid to the subject of testing and the related costs. Tests should be carried out by an accredited laboratory and tenderers should be requested to provide assurances in this regard. Price schedules should be so drawn up and covering letters so worded that the costs of all services, such as tests, delivery and spares, are declared and allowed for in the tender.

Before type tests, routine tests and sample tests are carried out, the number of samples used and the frequency of sampling should be agreed upon with the supplier.

**A.6 Revision of standards used as normative references**

This part of NRS 088, as has been indicated, is based on a set of defined standards, which might have been revised or amended. Most purchasers would, in principle, wish to employ the latest standards. The recommended approach is to secure an undertaking from a supplier to review the latest versions and amendments and to incorporate these where possible and agreeable to both parties. A blanket commitment to work to the "latest" versions of standards creates legal difficulties of interpretation and risks for both parties and should be properly assessed. This invariably cannot be done in the time available.



**Annex B**  
(informative)

**Model form for schedules A and B**

This model form is provided as a convenient aid to purchasing. Guidance on preparing an enquiry using this form is given in annex A.

**Schedule A : Purchaser's specific requirements**

**Schedule B: Guarantees and particulars of equipment to be supplied** (to be completed by tenderer)

Item	Sub-clause	Description	Schedule A	Schedule B
1	4.1.1	Number of fibres	_____	_____
2	4.1.1	Type of fibre (e.g. type B 1.1 single-mode fibre as in NRS 081)	_____	_____
3	4.2.2	Armouring required	Yes / No	
4	4.2.2	Type of armouring (CST or SWA)	_____	_____
5	4.2.5	Details of fibre colour coding	As in EIA/TIA 598-C	_____
6	4.2.6	Measures taken to prevent water ingress	xxxxxxxxxxxx	_____
7	4.2.7	Toxicity and dermatological safety	Yes	_____
8	4.2.9	Cable tension for 0,2 % fibre strain N	xxxxxxxxxxxx	_____
9	5.2.1	Availability of type test reports. If not available, specify date when available	xxxxxxxxxxxx	<b>Yes / No</b>  <b>dd/mm/yyyy</b>
10	6.2.1	Wound length of cable on drum m	xxxxxxxxxxxx	_____
11	6.2.1	Treated wooden drum required	Yes/No	_____
12	7.1 (a)	Cable construction drawing number	xxxxxxxxxxxx	_____
13	7.5 (d)	Cable mass per unit length kg/km	xxxxxxxxxxxx	_____
14	7.6 (b)	Effective group index of refraction at 1 310 nm/1 550 nm	xxxxxxxxxxxx	1 310 nm _____ 1 550 nm _____

## **Bibliography**

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