NRS 088-2:2016

Edition 2

DUCT AND DIRECT-BURIED UNDERGROUND FIBRE-OPTIC CABLES

PART 2: INSTALLATION GUIDELINES

This document is not a South African National Standard

NRS Association

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This rationalized user specification is issued by
the Technical Governance Department, 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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Foreword

This part of NRS 088 was prepared on behalf of the NRS Association 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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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:

Horn C	Letacla (Pty) Ltd
Marais F	OptiPower Projects (Pty) Ltd

In 6.1.1, 6.1.3, 6.1.7 and 6.5.1, reference is made to "national regulations and statutory requirements on safety". In South Africa, this means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) (as amended from time to time).

In 4.3.3.2, reference is made to "relevant legislation". In South Africa, this means the Explosives Act, 1956 (Act No. 26 of 1956) (as amended from time to time).

In 6.3.1, reference is made to "relevant legislation". In South Africa, this means the Mines and Works Act, 1956 (Act No. 27 of 1956) (as amended from time to time).

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

Part 1: Product specification.
Part 2: Installation guidelines.

Annex A forms an integral part of this document.
Annex B is for information only.

Introduction

This part of NRS 088 has been prepared to establish uniform requirements for the installation of 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 NRS association 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 permit. 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 the schedules attached to this part of NRS 088 and which should, where appropriate, be submitted for consideration in future revisions of this part of NRS 088.

Keywords

direct-buried, duct, fibre optic cables, single-mode, underground

Contents

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DUCT AND DIRECT-BURIED UNDERGROUND FIBRE-OPTIC CABLE

Part 2: Installation guidelines

1. Scope

This part of NRS 088 identifies the essential methods for civil works, duct and underground optical fibre cable installation, jointing and terminating of duct and direct-buried optical fibre cables.

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 the SABS Standards Division.

IEC 60794-5, *Optical fibre cables - Part 5: Sectional specification - Microduct cabling for installation* by blowing

IEC/TR 62691, *Optical fibre cables - Guide to the installation of optical fibre cables*

SANS 10198-8, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 8: Cable laying and installation.*

SANS 10340-2*, Installation of telecommunication cables – Part 2: Outdoor fibre optic cables.*

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

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

acceptable: acceptable to the customer

cable closure: protective connection of two or more optical fibre cables

duct: pipe, normally of HDPE, into which the optical fibre cable is installed for protection

NOTE These pipes come in a range of outer diameters from 32 mm to 110 mm.

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

Example, If a large reflection occurs at say 1000 m, there could be a ghost at 2000 m due to reflected light bouncing back and forth within the fibre.

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

warning tape: corrosion-proof brightly coloured polymer tape of at least 300 mm width used to caution against presence of fibre optic cables in the ground

NOTE The tape shall also reflect the marking of the fibre owner.

sub-duct: small pipe, normally of HDPE, placed inside a larger duct (either on its own or with others) into which the optical fibre cable is installed in order to protect it and any other cables within

the duct

NOTE These small pipes are usually of 32 mm or 40 mm outer diameter.

3.2 Abbreviations

ADSS: all dielectric self-supporting
HDPE: high density polyethylene
IP: ingress protection
MFD: mode field diameter
NCS: national calibration standard
ODF: optical distribution frame
OPGW: optical ground wire
OTDR: optical time domain reflectometer
PMD: polarisation mode dispersion

4. Civil requirements

4.1 General

4.1.1 The requirements of this part of NRS 088 and SANS 10198-8 are applicable to the civil works associated with the installation of ducts and direct-buried cables.

4.1.2 This part of NRS 088 shall be used in conjunction with the installation procedures laid down by the duct and optical fibre cable manufacturer. In case of a dispute, the duct and optical cable manufacturer's procedure shall apply.

4.1.3 The duct shall be made of HDPE. It shall also be coloured and marked as specified by the customer. The size of duct shall be specified by the customer.

4.1.4 This part of NRS 088 also describes the tests to be done on the ducts after installation, which will ensure there has been no damage to the ducts that could otherwise lead to problems with the optical fibre cable installation.

4.2 Preparatory work

4.2.1 To ensure integrity of the duct, trenches and manholes for the later installation of the fibre-optic cable, an upfront analysis shall be done to ensure that the duct, trenches, manholes and installation procedures are documented.

4.2.2 The installer shall ensure that he/she is aware of the position of all services that could be encountered during the civil works for example water and gas pipes, electric and telecommunication cables.

4.2.3 The installer shall ensure that any wayleaves or permission from private property owners necessary for the civil works to proceed are in place.

4.2.4 Where work is to be carried out on private property or across the access to private property, the property owner/occupier shall be given at least twenty four hours (24 h) notice of the contractor's intention to commence work.

4.2.5 All surfaces, unless otherwise specified, necessarily disturbed in the execution of the works shall be restored by the contractor on completion of the works. Surfaces shall be left in as near original condition as possible and the contractor shall be responsible for maintaining the surface in a usable condition until restoration is complete.

4.2.6 Tree cutting, bush cutting and shrub clearance as deemed necessary for the execution of the work, shall be undertaken by the contractor. The contractor shall also dispose of all cuttings and

cleared materials. Contractors also need to obtain the necessary permits from the relevant authorities.

4.3 Trenches

4.3.1 Trench excavation

Trenches shall be dug by hand (pick and shovel) or by mechanical means (backacter, trenching machine). When trenching in the vicinity of power cables, mechanical means shall not be used within 3 m of any existing service.

4.3.2 Classification of ground conditions

4.3.2.1 Soft and pickable

This type of ground includes all materials that can be excavated by means of pick and shovel, a trenching machine or an excavator, without the use of an independent compressor or pneumatic rock breaking equipment or independent hydraulically operated rock breaking equipment.

4.3.2.2 Hard rock

This type of ground includes all materials that cannot be excavated by a trenching machine or an excavator without blasting, wedging or splitting or, with the use of an independent compressor or pneumatic rock breaking equipment or independent hydraulically operated rock breaking equipment, prior to removal.

4.3.3 Blasting of rock

4.3.3.1 The blasting of rock shall only be allowed if approved by the customer.

4.3.3.2 The transport, storage and the use of explosives shall comply with the provision of the relevant legislation (see foreword). A copy of blasting permits issued to workmen, and permits issued to the contractor to cover the purchase, storage and transport of explosives, shall be given to the customer.

4.3.3.3 When blasting to specified profiles, the contractor shall so arrange the holes and charges that the resulting exposed surfaces are as sound as the nature of the material permits. The contractor shall make good at his own expense any additional excavation necessitated by the shattering of rock in excess of an over break.

4.3.4 Trench width and depth

The width and depth of the trenches for the installation of ducts or direct-buried cables shall be as specified by the customer. The depth of the trench should be such that the distance from the top of the duct to the warning tape shall be at least 300 mm.

4.3.5 Trench floor

The floor of a trench shall offer a firm base such as compacted soil and be free of stones. If rocks or stones are present then a 150 mm layer of compacted bedding soil shall be added. Bedding soil may be obtained by sifting the excavated material (if suitable) using a sieve having a 12 mm (max.) mesh size. Alternatively, suitable bedding soil may be imported and shall comply with the relevant environmental permit requirements.

4.3.6 Back-filling of trenches

4.3.6.1 Once the duct(s) or direct-buried cable has been installed (see 5.6 and 5.8), they shall be covered with a 250 mm layer of compacted blanket soil. Blanket soil may be obtained by sifting the excavated material (if suitable) using a sieve having a 12 mm (max.) mesh size. Alternatively,

suitable bedding soil may be imported. Only hand compaction tools shall be used to compact the blanket soil.

4.3.6.2 When the remainder of trench is back-filled, compacting machinery shall be employed. For cable trenches in roadway zones, back-filling shall comply with local road agency requirements.

4.3.6.3 A warning tape shall be placed at a distance of 300 mm below the ground level or road surface.

4.4 Manholes

4.4.1 The manholes shall be constructed from reinforced concrete or bricks, or shall be pre-manufactured.

4.4.2 The type shall be specified by the customer. A drainage sump and cable tray for excess cable shall also be specified by the customer.

4.4.3 The size of the manholes shall be as specified by the customer.

4.4.4 The type of lids/covers used on the manholes shall be as specified by the customer.

4.4.5 The depth of the lid/cover relative to ground level for example at ground level or below ground level shall be specified by the customer.

4.4.6 The distance between manholes shall be determined by the method of installation of the duct cable.

5. Installation

5.1 Pre-installation procedures

5.1.1 Before installation commences, the installer shall carry out the following checks:

a) establish that the routes defined in the installation specification are accessible and available in accordance with the installation program;

NOTE The installer shall advise the customer of all proposed deviations and handover the proposed line route diagram.

b) establish that the environmental conditions within the routes and the installation methods to be used are suitable for the design of duct and optical cable to be installed;

c) determine any measures necessary to prevent the optical fibre within the optical cable experiencing direct stress following installation;

d) determine the proposed locations at which drums (or reels) are to be positioned for the installation program and establish the accessibility and availability at those locations;

e) ensure that all necessary installation accessories are available;

f) identify proposed location of cable closures and establish their accessibility and availability in accordance with the installation program; and

g) storage and transportation of drums shall be according to the manufacturer's recommendations.

5.1.2 The cable closures shall be positioned such that subsequent repair, expansion or extension of the installed cabling may be undertaken safely and with minimal disruption.

5.2 Pulling-in rope connection and overload protection

5.2.1 The cable/duct connection to the pulling-in rope shall be made by the use of factory or field fitted pulling eyes or by the use of cable grips or socks.

5.2.2 To reduce twisting during installation, the pulling end of the cable/duct shall be connected to the end of the pulling-in rope via a twist compensation device, for example, a rotary shackle or a rope socket with a swivel.

5.2.3 There are two classes of devices that provide the overload protection for the cable: those situated at the primary or intermediate winch and those at the cable/rope interface. Devices at the winch include (depending on winch type) mechanical clutches, stalling motors and hydraulic bypass valves which can be set to a predetermined load and the dynamometer/cable tension monitoring type systems to provide feedback for winch control. Devices at the cable/rope interface include mechanical fuses (tensile or shear) and sensing devices to provide winch control information. All these systems have a common aim of limiting or stopping the winching operation when loads applied on the cable approach a damaging level.

5.3 Bending, guiding system and rollers

5.3.1 To avoid subjecting cables/ducts to unacceptable bending stresses, the manufacturer's recommendations regarding bending diameters shall be observed during pulling and installation. Guiding equipment shall be used at bends in the route and at duct entrances so that the minimum-bending diameter recommended for the particular cable type/duct is observed.

5.3.2 Bending optical fibre cable under tension during installation shall be undertaken with care. Guiding systems and equipment shall be examined for their suitability of purpose and the cable manufacturer's stated bending criteria shall be carefully considered.

NOTE In general, a minimum-bending diameter of around 20 times the cable diameter is considered appropriate, but when being installed under tension, it is suggested that this ratio may be doubled. Most guiding equipment can be used for both optical fibre and metallic cables but long length placing may require many guiding elements and they should all have the properties of lightness and low friction.

5.3.3 When pulling ducts/cable into trenches, the cable/duct shall be protected from damage due to dragging along the trench bottom or sides by the use of rollers. On long length pulls, the number of rollers used shall be taken into account when deciding on the frictional drag that these will impart to the cable/duct.

5.4 Winching, drum holding equipment and ropes

5.4.1 Noting the need for overload protection, most normal speed controlled cable winching equipment and systems are suitable for installing optical cables and ducts. These include end-pull winches, with various types of primary mover, intermediate winches for longer length schemes and, where necessary, powered cable feeding equipment. Where intermediate winches (capstan or caterpillar) or powered cable feeding equipment (or both) are used, a method of synchronization, to prevent excessive strain, shall be employed.

NOTE It should be borne in mind that some intermediate capstan type winches can introduce a twist into the cable/duct.

5.4.2 Cables/ducts shall be placed on drum trailers or jacks with an appropriate braking system, to prevent cable/duct over run, during installation.

5.4.3 Ropes or lines of low specific weight and a high modulus of elasticity are necessary for optical fibre cabling. Steel wires or similar shall never be used for installing duct or optical fibre cables and shall never be used in plastic ducts. Placing long lines or ropes can be difficult but can usually be accomplished by using normal installation methods successively. Lines or ropes shall be placed with care where there are already optical fibre cables in a duct and, knots shall be avoided.

5.4.4 Cable winches shall be capable of providing varying rope speeds, particularly with regard to low starting speeds, and shall be equipped with a calibrated winch-line dynamometer (or a tension sensor or mechanical fuse fitted at the beginning of the cable). The maximum installation force shall be limited to the safe working load of the cable/duct as measured at the winch-line dynamometer or the tension sensor at the beginning of the cable/duct. The winch shall be provided with a tripping device that automatically stops the winch if the installation force exceeds the pre-set tension limit. If a mechanical fuse is used, it shall be designed to break at less than the maximum safe working load of the cable.

5.4.5 If a capstan type intermediate puller is used, the diameter of the capstan shall be greater than or equal to the minimum-bending diameter of the cable/duct.

5.4.6 When pulling the cable/duct with a winch, the pull shall be started with a low rope speed. The pulling speed can gradually be increased up to the maximum speed of 75 m/min when there is no danger that the maximum permissible tensile loading for the cable/duct will be exceeded.

5.4.7 Pulling eyes and cable grips shall not pass around capstans or pulleys whilst the cable/duct is under tensile load.

5.5 Cable friction and lubrication

Special attention shall be paid to friction and lubrication when installing optical fibre cables. The friction forces that should be overcome are related to several factors, primarily the materials and finishes of the cable sheath, duct, pulling-in rope or line and guiding components, and all can contribute significantly to the total installing force required. Lubrication can have beneficial effects in reducing the total installing force needed and attention shall be paid to both the rope and cable/duct end interfaces and steps taken to ensure that the cable/duct attachment point presents a smooth profile. Any lubrication system employed shall have a long-term compatibility with cable, rope and duct material and be safe from an occupational health point of view. Suitable lubrication as recommended by the manufacturer shall be used.

5.6 Installation of underground ducts

5.6.1 Application

5.6.1.1 Underground duct installation by winching or hand pulling

A typical set up for installation by winching or hand pulling is given in annex A of SANS 60794-1-1 and is shown in figure 1.

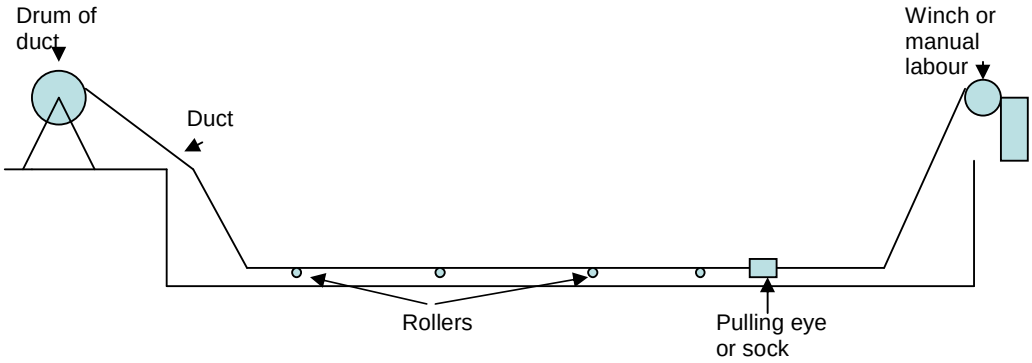

Figure 1 — Underground duct installation by winching

The distance a duct can be hauled in from one point is only dependant on the duct strength and its length.

5.6.1.2 Underground duct installation by roll out

A typical set up for installation by the roll out method is shown in figure 2.

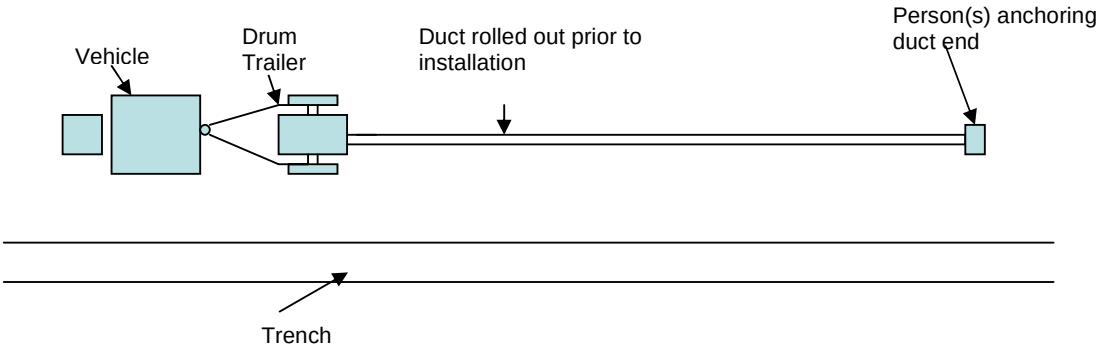

Figure 2 — Underground duct installation by roll out

5.6.1.3 Installation of duct couplers

If duct couplers are to be used during installation, they shall be able to withstand all duct installation tests and maintain integrity under pressure.

5.7 Installation of cable in underground ducts

5.7.1 Application

5.7.1.1 Underground cable installation in ducts by winching

A typical underground duct set up for installation by winching is shown in figure 3.

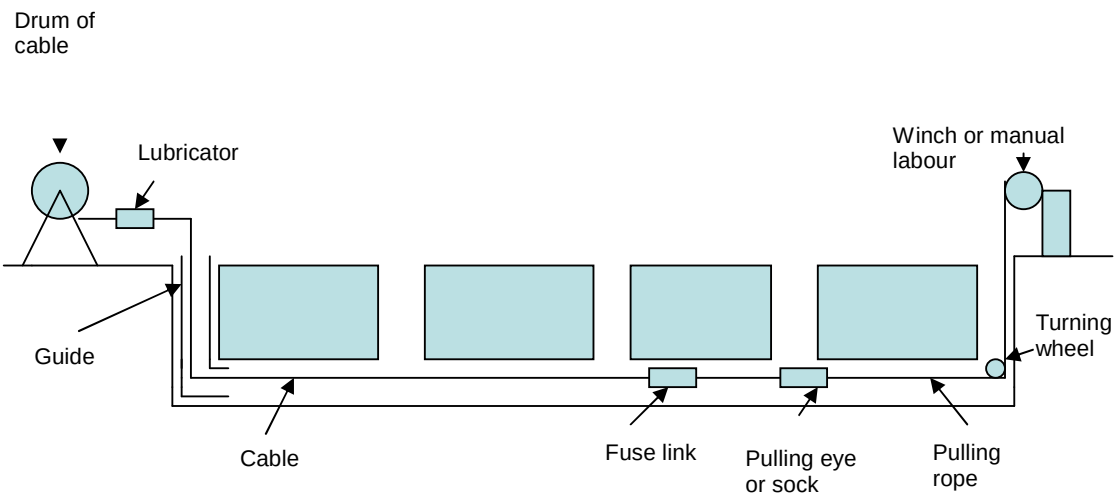

Figure 3 — Underground cable installation in ducts by winching

The distance a cable can be hauled in from one point is only dependant on the cable strength and the friction between the cable and the duct.

5.7.2 Underground cable installation in ducts by blowing

5.7.2.1 The distance a cable can be blown will depend on many factors and all need to be taken into account when deciding what method is the best for the particular route.

The factors influencing the blow distance are as follows:

a) cable weight (the heavier the cable the shorter the distance);
b) cable/duct area ratio (the larger this is the shorter the distance);
c) the shape and the length of the route (the more bends and inclines the shorter the distance);
d) compressor size and air condition (too small a compressor the shorter the distance, the wetter the air the shorter the distance, the drier the air the shorter the distance);
e) cable and duct material (friction);
f) cable construction (the more flexible the cable the shorter the distance); and
g) the ambient conditions.

5.7.2.2 Usually the smaller the duct diameter, the lower the air flow rate and also the shorter the installation length will be for a specific cable design.

5.7.2.3 For ambient conditions above 30℃, it is highly r ecommended to use an air cooler inserted between the compressor and the blowing system.

5.8 Installation of direct-buried cable

5.8.1 Installation methods

Normal buried cable installation methods including ploughing (direct, vibratory or winched), trenching and moling can, in general, be used for direct burial of optical fibre cable provided that the cable is specifically designed for this type of application. The same depth of cover as for metallic cables is usually adequate but traffic capacity or other considerations of security may indicate a requirement for greater depth. Where a trench method is used, backfilling materials and practices may require particular consideration so that fibre strain limits are not reached during this operation.

5.8.2 Cables in trenches

When installing cables in trenches, the following precautions shall be observed:

a) the cable trench shall be as specified in 4.3.4 and 4.3.5;

b) the direct burial of cables under roadways in the longitudinal direction is permitted only in exceptional cases. At the crossings of roadways or installations longitudinally under roads, cables shall be protected by cable pipe ducts encased in 150 mm 15 MPA concrete. When cables run almost parallel to a road, the ducts between trenches shall cross the roadway at an angle of about 45° in order to reduce the pulling f orces;

c) when the cable trench is free of obstacles and where local conditions allow, the cables can be unrolled from the cable transport trailer driven along the trench and laid in the trench;

d) the unrolling of the cable from the drum shall correspond to the forward movement of the vehicle and a suitable braking device can ensure that not too much cable is unrolled. As it is unrolled, the cable shall be moderately tensile loaded, in order to straighten it on the bottom of the trench;

e) if, as a result of location conditions, the cable is laid on the ground prior to trenching, the cable shall be laid out in the shape of a ‘figure eight’, to ensure that no undue bends, twists, kinks, compression or abrasions occur;

f) if the cable is drawn into a cable trench using a cable winch, then cable rollers and corner rollers shall be provided in sufficient quantities to ensure that the cable does not graze the foot of the trench or trench walls and will not be exposed to unacceptable bending stress during installation. Installation tensile force shall be limited to the safe working load of the cable;

g) back-fill of trenches shall be as specified in 4.3.6;

h) sand-encased cables in built-up areas or in areas of increased hazard can be protected against damage with cable protection covers or cable cover plates as specified by the customer; and

i) a warning tape shall be placed at a distance of 300 mm below the ground surface.

5.8.3 Installing cables by ploughing

5.8.3.1 When ploughing methods are used, the design of the guiding equipment between the cable reel and the cable laying guide shall carefully consider specified cable bending criteria and shall have a low friction value to prevent fibre overstrain. Cable tensile overload protection systems are not normally necessary, but where a large ploughing machine is used and there are driven cable reels and guide wheels, a tension device can be incorporated. In-service mechanical protection at road or service crossings or in situations of high vulnerability may be necessary.

5.8.3.2 Generally, a ripping pass or passes should be made to ensure that the path is clear and the required depth can be attained.

5.8.3.3 When required, a duct can be installed by the plough at the same time as the cable. The order of installation is cable deepest, the duct 75 mm (minimum) above this, followed by the warning tape.

5.8.3.4 A warning tape shall be laid simultaneously at a distance of 300 mm below the ground surface.

5.8.4 Jointing and splicing

5.8.4.1 At jointing manholes sufficient extra cable shall be left to accommodate the cable ends being taken out of the manhole for 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 the fibre optic connections.

5.8.4.2 All slack cable shall be coiled neatly into the manhole in a slack box or cabinet, as specified by the customer. Care shall be taken that the manufacturer’s minimum bending radius is adhered to and that no torsion is imparted to the cable. This also applies to installations using cable trays.

5.8.4.3 Accredited technicians shall carry out splicing of optical fibres. Splicing machines shall be capable of creating splices consistently better than 0,05 dB. Splicing machines shall be properly calibrated and tested. Tools and measuring equipment shall be provided and used for each splice. Splice losses shall be as specified in annex A, unless otherwise specified by the customer.

5.8.4.4 The operation of jointing and splicing shall be in accordance with the manufacturer’s instructions and shall follow the following sequence:

a) prepare the fibre optic cable;
b) clamp the cable in the enclosure;
c) fusion splice the optical fibres in accordance TIA 598-C;
d) reinforce the splice point with heat shrinkable tube or by other means
e) secure and lay the optical fibres in the splice organizer inside the enclosure on completion of a permanent splice;
f) close and seal the enclosure; and
g) loop the excess cable and secure the enclosure in the manhole ensuring that the cable manufacturer’s recommended minimum bending radius is adhered to and that there is no torsion applied to the cable.

5.8.4.5 At the termination points the fibres shall be spliced to optical pig tails. Care should be taken to ensure the sequence is in accordance with the customer specified splice plan. The type of pig tail required (primary coated fibre or ruggedised) and the type of connector shall be specified by the customer.

5.8.4.6 Splicing enclosures (joint boxes) shall be subject to customer's approval. All construction details and ingress protection (IP) ratings of the proposed units shall be provided. The splicing enclosures shall facilitate fibre organization and splicing requirements.

5.8.4.7 The bonding through and earthing of the armour/metallic protection shall be as specified by the customer.

6. Safety and the environment

6.1 Safety and personnel

6.1.1 The contractor shall be solely responsible for the safety and welfare of his employees and shall comply fully with the provision of any national regulations and statutory requirements on safety (see foreword).

6.1.2 Staff shall be properly trained, evaluated and authorized accordingly.

6.1.3 Lifting machines and equipment shall comply with the national regulations and statutory requirements on safety (see foreword).

6.1.4 Risks shall be identified, evaluated and eliminated or managed to an acceptable level.

6.1.5 Suitable personal protective equipment shall be used.

6.1.6 Tools and equipment shall be correctly selected and applied.

6.1.7 The contractor shall comply with the national regulations and statutory requirements on safety (see foreword) and any other relevant construction regulations required by the customer.

6.2 Road safety precautions

The contractor shall be solely responsible for the application and maintenance of enforcements of property road safety precautions when working within road reserves. To this end, he shall comply with the requirements of the local authority concerned.

6.3 Safety of foundations, buildings and structures

6.3.1 The contractor shall ensure that excavation does not endanger the foundations of adjacent buildings and shall take all the necessary precautions in the terms of the relevant legislation (see foreword) to prevent subsidence of soil which could result in damage to foundations. The contractor shall bear the responsibility for any claims arising from such damage.

6.3.2 Where excavations will unavoidably endanger the safety or stability (or both) of fences or other structures, the contractor shall at his own expense, remove and replace such fences or structures to the satisfaction of the customer.

6.4 Safety services

6.4.1 The contractor shall ensure that if the safety or stability (or both) of above ground services is unavoidably endangered by excavations, such services will be adequately and suitably supported or stayed (or both) during such operations.

6.4.2 The contractor shall ensure that any underground services exposed during excavation operations are adequately supported to avoid their subsidence and suitably protected against damage.

6.4.3 In the case of both above ground and underground services, the contractor shall liaise with the relevant owners or authorities to obtain their approval of the safeguards being applied.

6.5 Barricading and lighting

6.5.1 In terms of the national regulations and statutory requirements on safety (see foreword), every excavation that is accessible to the public, or that is adjacent to a public road or thoroughfare, or by which the safety of persons may be endangered, shall be

a) adequately protected by a barrier or fence of height at least 1,0 m and as close to the excavation as practicable; and

b) provided with red warning lights at night or any other clearly visible boundary indicators at night or when visibility conditions are poor.

6.5.2 The contractor shall take all measures to ensure that barricades and lights are effective at all times.

6.6 Accommodation of traffic and access to properties

In addition to complying with the relevant requirements as applicable, where the work affects the operation or safety of public traffic, the contractor shall:

a) construct or put in order such by-pass(es) as may be required to deviate traffic from portions of the road that are to be affected by the construction; and

b) provide and allow reasonable access to persons occupying properties that fall within or adjoin the area over which he is working. If, for any reason, such access has to be closed for certain periods during the construction period, the persons affected shall be given at 24 h notice in writing of each construction period.

6.7 Environment

All work shall be performed in compliance with the applicable environmental legislation.

There shall be minimal impact and disturbance of the environment and agreements and relationships with land owners shall be adhered to.

Disposal of fibre off-cuts etc. shall only be sent to authorized disposal sites.

7. Quality control

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

8. Testing

8.1 Ducts

On completion of duct laying and backfilling the ducts shall be proved by pulling through a cylindrical cleaning brush followed by a wooden or Teflon[1)] mandrill 50 mm to 400 mm long, depending on duct size, and 5 mm less in diameter than the bore of the duct.

1) Teflon is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by the NRS Association of this product.

A blown sphere/shuttle or mandrel should not be undertaken without ensuring that provisions have been made to capture the sphere/shuttle or mandrel at the remote end and that the tube to be tested has been positively identified at each end.

The size and diameter of the blown sphere/shuttle should be an agreed percentage of the inner diameter of the duct.

8.1.1 Air test

The purpose of the air test is to verify continuity of the duct under test between two fixed points in the network, for example, manholes.

8.1.1.1 Air test procedure

Fit a catching device to the far end of the duct under test. Personnel between the far end and where the testing will be done much be able to communicate with each other using suitable communication devices.

At the test end, fit all safety devices to ducts and test assembly, connect assembly to compressor via air hose and open gradually once confirmation from the far end has been received that all safety straps are fitted and the catching device is securely fitted to the duct under test.

Allow air to flow through duct at full pressure for at least one minute to remove all loose particles inside ducts.

If air is emerging at far end of test section, close air and proceed to sponge test.

If no air emerges from far end the cause must be identified before any further testing can be done. On new duct installations must the fault be recorded on the DIT report and handed over to the installation contractor to rectify.

Possible causes for the failure of the air test can be pipes missing in sections, pipes not connected through in manholes, pipes damaged between manholes, failure of connectors, pipes connected to different coloured pipes in manholes etc.

8.1.2 Sponge test

The purpose of the sponge test is to clean the ducts of any dirt, insects and water that may have entered into the duct

Any small obstacle can cause the mandrill to get stuck in the ducts and will also damage the low friction lining on the inside of the ducts.

8.1.2.1 Sponge test procedure

The following procedure shall be followed:

a) release the connector from the test assembly attached to the duct after all air is released;

b) insert high-density sponge as described in section 7 d. and reconnect test assembly to duct;

c) inform personnel at far end and open air gradually to full pressure;

d) the sponge should arrive at far end within one minute. If the sponge blows out water and dirt, repeat the test with another sponge until duct is clean;

NOTE Excessive water and dirt may delay the arrival of the sponge.

e) if test is successful, close air and proceed to mandrill test;

f) the sponge can be left in the catching device at the far to reduce the impact of the mandrill;

g) if sponge does not arrive at far end after reasonable time, record fault in DIT test report and hand over to the installation contractor to rectify;

h) on existing installations, locate position of sponge and rectify before continuing to mandrill test; and

i) possible causes for sponge getting stuck are duct blocked by excessive dirt or water, kink in duct and faulty connector.

8.1.3 Mandrill test

The purpose of the mandrill test is to verify that 85 % of the inside diameter of the duct is available throughout the entire test section for the successful installation of an optical fibre cable.

Multiple indentations and sharp bends in the duct will cause accumulated friction on the fibre cable and will limit installation distances drastically.

8.1.3.1 Mandrill test procedure

The following procedure shall be followed:

a) release connector from test assembly to duct after all air is released;

b) insert correct size mandrill in accordance with the manufacturer's instructions and reconnect test assembly to duct;

c) inform personnel at far end and open air gradually to maximum of 3-bar pressure;

d) the mandrill should arrive at the far end within one minute as a guideline for a 1000 m test section;

NOTE On elevated areas of the route can the pressure be increased to a maximum of 5-bar.

f) if the test is successful, close air and proceed to the pressure test;

NOTE The condition of mandrill, visible grooves on the mandrill is an indication of indents in the ducts.

g) if the mandrill does not arrive at the far end after a reasonable time, record fault in DIT test report and hand over to the installation contractor to rectify;

h) on existing installations, locate position of the mandrill and rectify before continuing to the pressure test; and

i) possible causes for mandrill getting stuck are duct inside diameter reduced by pressure on the duct due to rocks or stones in bedding and padding, kinks in duct, deformation of duct, sharp bends and faulty connector in a manhole.

8.1.4 Pressure test

The purpose of the pressure test is to ensure that the duct can hold a continuous pressure of at least 10-bar, which will be introduced into the duct during cable blowing. Pressure of up to 15-bar is used to blow micro cables into micro ducts.

Any leak in the duct can lead to possible damage of the fibre cable, as the cable will follow the path of the biggest airflow. Leaks in ducts will also reduce cable installation distances.

8.1.4.1 Pressure test procedure

The following procedure shall be followed:

a) at the far end of test section, remove catching device once all the air is released;

b) fit a high-pressure stopper to the duct end similar to the end cap fitted onto the catching device and secure duct end inside manhole;

c) once the stopper has been fitted, gradually introduce air into the duct from test end up to 10-bar pressure;

d) hold air feed open into duct until air pressure inside duct has stabilized on 10-bar;

e) close air valve on test assembly and monitor pressure on gauge for 5 minutes;

f) no leakage will be accepted. Any leakage must be detected and rectified;

e) tester must ensure that all couplings to duct are airtight, use soap water with sponge to detect any leaks on couplings; and

f) possible reasons for leaks are damage to ducts during transportation and handling resulting in holes, inferior quality ducts that cracks under pressure, faulty connectors and sharp edges of rocks in the bedding and padding material that can puncture ducts.

8.2 Cables

8.2.1 Cable fibre tests before installations

8.2.1.1 The integrity and attenuation of individual fibres shall be tested with the duct or direct-buried cable still on the drum, before installation. The test shall be performed for each fibre in the cable at two wavelengths, 1310 nm and 1550 nm or 1550 nm and 1625 nm, as specified by the customer from one direction only. When requested, testing shall be witnessed by the customer.

8.2.1.2 The identity of individual fibres shall be clearly marked.

8.2.1.3 The results of the tests shall be produced as shown in the example of table 1. The heading shall contain the drum number and the length of the cable.

8.2.1.4 The table shall record the attenuation of each fibre. Results shall be produced in paper and digital form (disc).

8.2.1.5 If the drum test is successful, the contractor can proceed with the installation. In the case of failure, the drum shall be returned to the customer.

8.2.1.6 Unless otherwise specified in the contract requirements, the contractor shall be held responsible for the proper protection and safe keeping of the optical fibre cable drums until completion of the contract (take over of the cable by the customer) and the return of any surplus material 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 — Example of optic fibre site test results before installation

1	2	3	4	5	6
Project			**Drum number**		
			Loss db/kM		
Tube	**Fibre**	**Colour**	**1310 nm**	**1550 nm**	**Length**
1	1				
	2				
	3				
	4				
	5				
	6				
2	1				
	2				
	3				
	4				
	5				
	6				
NOTE Cables may use different configurations for example central tube design with bundled fibres.					

8.2.2 Testing after completion of installation

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

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

If requested by the customer, PMD tests shall be performed on the terminated optical fibre cable to show compliance with the system requirements.

9. Documentation

After completion of installation, the following documentation shall be given to the customer and approved by him on completion of the duct or direct-buried cable:

a) test results as per 8.2.2;

b) record of installation pulling tensions in chart form;

c) line diagram showing position of cable/ducts and joints, including distance from main termination room and fibre allocation in the case of spurs etc.; and

d) if specified, photographs of completed work shall be provided.

Annex A – Acceptance procedure for fibre optic cable systems

(informative)

A.1 General

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

A.2 Splice acceptance

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

Table A.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.

A.3 Fibre optic cable testing

A.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.

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

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

Annex A
(continued)

A.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 a suitable length and indicate as such in the test results.

Take only bidirectional measurements.

A.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 A.3.3.

Provide test results on a data disc in raw format and pdf copy

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 A.2.

Table A.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) 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.

Annex A
(concluded)

A.4 Documentation

A.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).

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

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

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

A.4.5 Documentation shall be supplied in English.

A.4.6 Documentation shall be supplied on A4 paper.

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

A.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.

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

A.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 (joint locations to be specified by GPS coordinates);

e) a table of joint losses and distances similar to the example in table B.1;

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

Annex B – Summary tables

(normative)

B.1 Sample of splice loss summary table

Route : A to B **Fibre type :**

Cable type : 12 fibre duct **Refractive index :** 1,468

End 1 : A **Helix factor :** 9 %

End 2 : B **Backscatter coefficient :**

Wavelength : 1550 nm

Contractor name:

Table B.1 — Splice loss summary

	Tested from	**Total length**	**Joint 1 distance**	**Joint 3 distance**	**Joint 9 distance**	**Joint 11 distance**
	End1	0	1926	5730	16686	20632
	End 2	21144	19218	15414	4458	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		
1	End 2	5,324	0,06	0,12	0,00	0,00	0,04	0,09
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		
2	End 2	5,21	0,00	-0,10[a]	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[a]	0,06	0,11	0,04	0,11
11	End 2	4,90	0,00	0,09	0,00	0,11		
11	Average	5,15	0,00	0,01	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	Average	5,30	0,10	0,09	0,03	0,03		

NOTE 1 Total loss is the total loss as read off during end to end testing and not only a sum of the joint losses.

NOTE 2 The above table is shortened for the sake of brevity and is not intended to represent real value. It is for illustrative purposes only.

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

Annex B
(concluded)

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

Route : A to B

Cable type : 12 fibre duct

End 1 : A

End 2 : B

Route length : 21 km

Wavelength : 1550 nm

Reference : -7,3 dB

Contractor name:

Table B.2 — Light source and power meter summary

1	2	3	4	5
Fibre No.	**Tested from**	**dB/km**	**Received 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.				
NOTE The table is shortened for the sake of brevity and is not intended to represent real values. It is for illustrative purposes only.				

Bibliography

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

SANS 60794-1-1/IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General.*