BRITISH STANDARD

BS EN 4532:2009

Aerospace series — Cables, optical, single core 200 µm/280 µm fibre, 2,5 mm outer jacket — Technical specification

ICS 49.060

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 4532:2009.

The UK participation in its preparation was entrusted to Technical Committee ACE/6, Aerospace avionic electrical and fibre optic technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Série aérospatiale - Câbles, optiques, fibre 200 µm/280 µm, diamètre extérieur 2,5 mm - Spécification technique

Luft- und Raumfahrt - LWL-Kabel, 200 µm/280 µm Faser, 2,5 mm Aussendurchmesser - Technische Lieferbedingungen

This European Standard was approved by CEN on 5 October 2008.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 4532:2009) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2009, and conflicting national standards shall be withdrawn at the latest by August 2009.

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1 Scope

This standard covers two cable types, Type A and Type B.

Type A, jacketed fibre, is intended for printed circuit board inter-connection applications inside equipment.

Type B, single core, is intended for general airframe and equipment inter-connection cable suitable for installation in all aircraft locations, with exception of power plant compartments.

These cables are particularly suitable for use in military aircraft as well as for general civil aircraft applications.

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.

EN 2591-306, *Aerospace series — Elements of electrical and optical connection — Test methods — Part 306: Mould growth*

EN 2591-316, *Aerospace series — Elements of electrical and optical connection — Test methods — Part 316: Ozone resistance*

EN 3733-001, *Aerospace series — Connector, optical , circular, single channel, coupled by self-locking ring, operating temperature up to 150 °C continuous — Part 001: Technical specification* [1)]

EN 3745-100*, *Aerospace series — Fibres and cables, optical, aircraft use — Test methods — Part 100: General*

ISO 1817, *Rubber, vulcanized — Determination of the effect of liquids*

ISO 2574, *Aircraft — Electrical cables — Identification marking*

IEC 60793-1-1, *Optical fibres — Part 1-1: Measurement methods and test procedures — General and guidance*

IEC 60794-1-2, *Optical fibre cables — Part 1-2: Generic specification — Basic optical cable test procedures*

IEC 60874-1, *Connectors for optical fibres and cables — Part 1: Generic specification*

MIL-HDBK-454B, *General guidelines for electronic equipment*

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* And all applicable parts quoted.

1) Published as ASD Prestandard at the date of publication of this standard.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 3745-100 and the following apply.

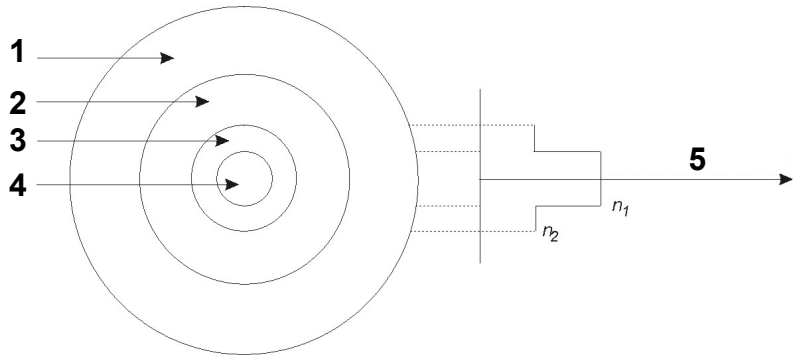
3.1
batch of fibre
a batch of fibre is defined as a continuous pull from a single identifiable preform

3.2
batch of cable
a batch of cable is defined as all cable arising from one continuous extrusion and stranding operation on fibre from a single batch

4 Description

4.1 Construction of type 'A' primary fibre (Jacketed fibre)

The cable shall consist of a single, step-index, multimode, all silica fibre (pure silica core with sufficiently high OH content to meet nuclear radiation hardening requirements) and suitably doped silica cladding which is protected by a primary coating. The cable shall have a tight buffer, all dielectric (non-conducting) construction and have an operating temperature range of – 60 °C to 150 °C. The primary fibre shall consist of core, cladding and primary coating. For a cable end view and side view drawing (3rd angle), see Figure 1.



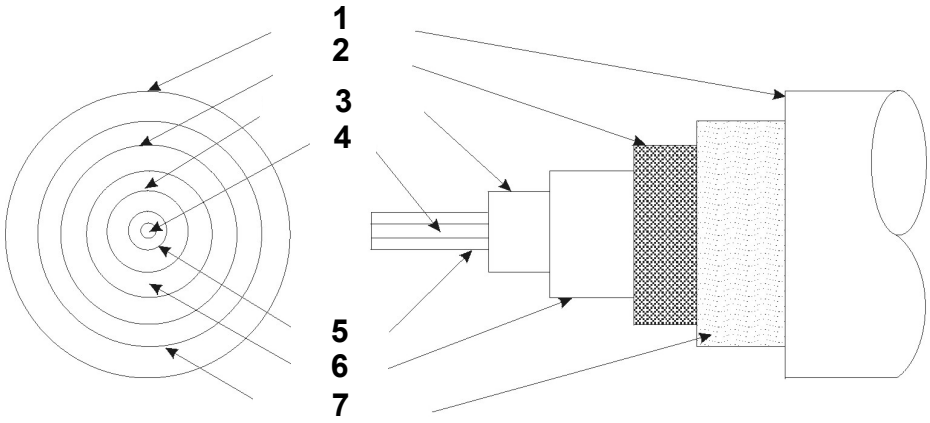
Key

1 Buffer
2 Primary coating
3 Cladding
4 Core
5 Refractive index

Figure 1 — Construction of type 'A' primary fibre

4.2 Construction of type 'B' single core cable

The cable shall consist of a single, step-index, multimode, all silica fibre (pure silica core with sufficiently high OH content to meet nuclear radiation hardening requirements) and suitably doped silica cladding which is protected by a primary coating. The cable shall have a tight buffer, all dielectric (non-conducting) construction, with strength members and outer sheath, and have an operating temperature range of – 60 °C to 150 °C. The cable shall comprise an outer sheath, strength member, inner sheath, buffer, and fibre, which is protected by a primary coating. For a cable end view and side view drawing (3rd angle), see Figure 2.



Key

1 Outer sheath
2 Inner sheath
3 Primary coating
4 Core
5 Cladding
6 Buffer
7 Strength member

Figure 2 — Construction of type 'B' cable

5 Cable characteristics

5.1 Optical performance of cable

5.1.1 Optical isolation of cable jacketing

The cable jacketing shall provide sufficient optical isolation so that any possible ambient light pick up is not more than 1 nW over a length characteristic for the installed fibre-optic network.

5.1.2 Useful installed lifetime

The useful installed lifetime shall be ≥ 25 years.

5.1.3 Mean time between failure (MTBF)

Cable failure rate of 0,02/100 m over 25 years life.

5.2 Construction data of cable (Type B)

5.2.1 Sheath colour

The sheath shall be coloured light violet.

5.2.2 Cable design

Tight buffer, all dielectric construction with strength members suitable for single connectors.

5.3 Mechanical characteristics of cable (Type B)

Minimum cable bend radius:

— during installation: ≥ 12 mm;

— installed long term (≥ 25 years): 30 mm.

The installed cable shall have this narrow bending radius only over shorter distances, which shall add up to a total of not more than 200 mm per individual light path.

6 Fibre characteristics

6.1 Optical and material data of primary fibre

6.1.1 Fibre type

All silica, step index exponent g > 30, multimode.

Deviation from ideal step index profile at a relative core diameter of 0,90 shall be less than 4 % of refractive index difference $n_{co} - n_{cl}$.

In the case of a structured cladding, the region adjacent to the core shall be a homogeneous cladding having an outer diameter of at least $1{,}15 \times D_{core}$, wherein the refractive index variation $n_{max.} - n_{min.}$ is $\leq 14 \times 10^{-4}$.

6.1.2 Refractive index difference of core/cladding

Test method according to IEC 60793-1-A1A. Refractive index difference between core/cladding $N_{co} - N_{cl} = (20 \pm 1{,}2) \times 10^{-3}$ at a wavelength of 633 nm; this value refers to the mean value of N_{cl} in the depressed cladding. Step index g-factor g > 30. Outer diameter of inner cladding: $D_{Dinn.cladd} \geq 1{,}15 \times D_{core}$. Refractive index homogeneity of inner cladding: $n_{max.} - n_{min.} < 14 \times 10^{-4}$.

6.1.3 Numerical aperture (Theoretical)

Defined by $n_{co} - n_{cl}$ based on a refractive index for pure silica, with high OH content, of 1,4571 at a wavelength of 633 nm (Helium neon laser).

$NA_{theor} = 0{,}24 \pm 0{,}01$.

6.1.4 Fibre core material composition

The optical fibre is to be pure silica undoped. The UV-absorption of the fibre shall be measured close to absorption edge, using cut back technique with:

— fibre length = 4 m cut back to 1 m length,

— source $\lambda = (220 \pm 5)$ nm,

— $\alpha < 6{,}0$ dB/m.

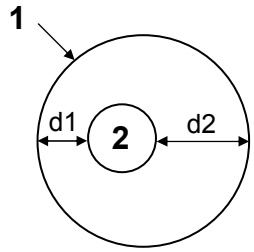
6.1.5 Cladding material composition

The cladding material shall be suitable doped silica. Material analysis by micro probe or corresponding x-ray analysis.

6.2 Geometrical data of primary fibre and concentricity of primary coating

To prevent microbending $d_1/d_2 \geq 0,9$.

Primary coatings shall be easily removable for splice fabrication and connector mounting and compatible with cabling and connector fitting processes. They shall provide a water barrier to ensure long lifetime in humid environments. See Figure 3.



Key

1 Primary coating
2 Fibre

Figure 3 — Concentricity of primary coating

7 Environmental conditions

7.1 Temperature range

The operating temperature shall be – 60 °C to 150 °C.

7.2 Operating pressure range

The operating pressure range shall be 2 000 mbar to 11 mbar.

7.3 Humidity

7.3.1 Operating humidity

Equivalent to a water content of equipment cooling air max. 27 g H_2O per 1 kg air. This water content corresponds to an operative relative humidity which may approach 100 % at medium or lower temperatures.

7.3.2 Storage humidity

Relative humidity max. 75 %.

7.4 Nuclear radiation

After a down-time of 1 msec the induced attenuation is ≤ 15 dB/km at T = 24 °C and ≤ 82 dB/km at T = – 60 °C.

8 Production acceptance (routine) tests

8.1 General

8.1.1 Measurement conditions

Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions.

8.1.2 Recovery conditions

Unless otherwise specified, recovery conditions for the interval after a conditioning test shall be as stated in the relevant test method.

8.1.3 Declaration of design and performance

The qualification approval tests are listed in 8.2, 8.3 and 8.4. At satisfactory conclusion of qualification, a preliminary or a formal Declaration of Design and Performance (DDP) including test results shall be submitted to the approving authority.

8.2 Group A – Production acceptance (routine) tests

8.2.1 Acceptance tests

The acceptance tests shall be carried out routinely during F.O. cable production.

8.2.2 Primary fibre (for cable types 'A' and 'B')

Comprising core, cladding, and primary coating to be measured at each end of a fibre batch. See Table 1.

Table 1 — Acceptance tests on primary fibre (for cable types 'A' and 'B')

Test	Test method	Test performance/conditions
Fibre core diameter	EN 3745-202	(200 ± 3) µm e.g. using a calibrated optical microscope
Non circularity of core	EN 3745-202	≤ 2,5 µm
Fibre cladding diameter	EN 3745-202	(278 ± 2) µm e.g. using a calibrated optical microscope
Non circularity of cladding	EN 3745-202	2,0 µm
Concentricity error of fibre core/cladding	EN 3745-202	(1 ± 1) µm e.g. using a calibrated optical microscope
Fibre proof test	IEC 60793-1-B1	Ambient conditions; ≥ 65 N. 100 % of fibre to be tested. 65 N at fibre which is equivalent to 1,4 % strain at the fibre.
Fibre attenuation	EN 3745-301	Fibre attenuation loss ≤ 15,0 dB/km. Full launch technique. Launching fibre specification: Length = (220 ± 20) m. R = 150 mm. Coupling with micro manipulators. Fibre length = 200 m min. Cut-back = 2 m to 3 m. Source λ = (810 ± 40) nm.

8.2.3 Completed cable (type 'B')

See Table 2.

Table 2 — Acceptance tests on completed cable (for cable type 'B')

Test	Test method	Test performance/conditions/criteria
Cable sheath outside diameter	EN 3745-203	(2,5 ± 0,15) mm.
Cable sheath wall thickness	EN 3745-203	0,2 mm minimum. To be measured at both ends of each batch.
Optical cable attenuation	EN 3745-301: Method A	Cable fibre attenuation: < 20 dB/km. Launching fibre specification: Length = (220 ± 20) m. R = 150 mm. Coupling with micro manipulators. Test sample fibre length = 200 m min. Cut-back = 2 m to 3 m. Source λ = (810 ± 40) nm.
Temperature cycling:	EN 3745-402	
a) Optical attenuation test	EN 3745-301: Method C	10 m of sample length shall be subjected to 10 cycles between – 60 °C and 150 °C. 10 m of the sample shall be loosely coiled within the chamber with radius of R = 150 mm. $\Delta\alpha \leq 0{,}5$ dB max. during cycling. One cycle shall consist of 30 min at – 60 °C and < 60 min of heating period to reach 150 °C; 30 min at 150 °C and < 60 min of cooling to – 60 °C. Recovery within 1 h at ambient temperature to $\Delta\alpha$ 0,2 dB. Measurements shall be made at λ = (810 ± 30) nm and the overfilled launch conditions shall be in accordance with Clause 9, using the test arrangement illustrated in Figure 4.
b) Dimensional stability	EN 3745-205	1 m of sample length shall be subjected to the above temperature cycling test. The length of the fibre being measured before and after the test. $\Delta L/L$ after cycling ≤ 0,1 % measured from fibre tip to fibre tip.
c) Buffer diameter	EN 3745-203	0,90 mm max., in order to match with the requirements of F.O. connector standard EN 3733-001.

8.3 Group B – Production verification (quality) tests

Primary fibre (for cable types 'A' and 'B'), see Table 3.

Table 3 — Verification tests on primary fibre (for cable types 'A' and 'B')

Test	Test method	Test performance/conditions
Stress susceptibility factor (Fibre fatigue test)	IEC 60793-1-B7 A, B or C	Static fatigue test to determine fibre failure under test. Test at ambient temperature and at T = 80 °C. $n \geq 20$ at ambient temperature n at T = 80 °C to be reported.

8.4 Group D – Qualification approval tests (cable type 'B')

For qualification approval tests the samples shall be subjected to the tests in Table 2 and Table 3 followed by tests as listed in Table 4.

Table 4 — Qualification approval tests on cable Type 'B'

Test	Test method	Test performance/conditions
Cable mechanical characteristics:		
Cable mass/unit length	EN 3745-203	Type 'B': 10 g/m max.
Cable tensile strength and elongation	EN 3745-505 Method A	Applied tension 650 N. ≤ 1 % elongation; tested fibre does not break.
Cable twist bend	EN 3745-514	Except that D = 10 × cable diameter (i.e. 25 mm), number of cycles 2 000. Tensile force applied 100 N. Any visible damage to the specimen shall be reported. The number of transmitting cables before and after the test shall be reported.
Cable minimum bend radius	EN 3745-510	Five turns with R = 30 mm. Reversible transient loss increase: ≤ 0,8 dB.
Cable repeated bending (cyclic flexing)	EN 3745-512	Five samples with R = 6,25 mm and 500 cycles at load of 50 N. No fibre break; insertion loss change shall be reported.
Corner bend	EN 3745-510 Method B	Five samples with R = 2 mm and load of 100 N for 1 min. No fibre break.
Cable crush load	EN 3745-513 Method B	Load 150 N for 5 min. Transmission loss at R = 12,5 mm ≤ 0,1 dB. Transmission loss at R = 3 mm ≤ 1 dB.
Cable compressive strength	EN 3745-513 Method A	Initially 500 kg/100 mm then 200 kg/100 mm for 1 min. No breakage; attenuation change ≤ 0,5 dB.
Cable abrasion	EN 3745-503	Load 5 N; 250 cycles at ambient temperature and 100 cycles at maximum operating temperature of 150 °C. No penetration of sheath.
Impact	EN 3745-506	Striking surface radius = 50 mm; 20 impacts with momentum 1 nm; five specimens required each of 3 m length. No splitting or cracking $\Delta\alpha$ after test ≤ 0,2 dB.

continued

Table 4 *(continued)*

Test	Test method	Test performance/conditions
Environmental tests:		
Cold bend test (Low temperature flexibility)	EN 3745-406 Method B	20 turns around R = 12 mm for 4 h at – 60 °C. No visible damage. Insertion loss after recovery ≤ 0,7 dB. NOTE Measurements shall be made at λ = (810 ± 30) nm and the full launch conditions shall be in accordance with Clause 9, using the test arrangement illustrated in EN 3745-406. Any damage caused by the clamps may be cut off as close as possible to the damaged area prior to the final measurement.
Shrinkage and elongation test	EN 3745-205	Permissible shrinkage or elongation, per end ≤ 5 mm. Shrinkage or elongation of the jacket (including any which occurs before ageing has begun) shall be the distance from the end of the fibre to the end of the sheath minus the exact length of the sheath removed prior to conditioning. Using a 350 mm long specimen, (25 ± 5) mm of all sheaths shall be removed from each end of the cable. The specimen shall then be aged at 150 °C for a period of 6 h, after which it shall be allowed to cool to (25 ± 5) °C.
Accelerated ageing:	EN 3745-401	
a) Dimensional stability	EN 3745-205	Five specimens of 10 m length with t = 120 h at T = 150 °C. ΔL after recovery < 0,3 % (measured from fibre tip to fibre tip).
b) Temperature resistance	–	Transfer from oven within 2 min to 3 min to cold chamber at T = – 60 °C for t = 4 h. NOTE The samples may be loosely coiled for fitting in the oven. There shall be no visible damage to the cable. Insertion loss after recovery ≤ 1,2 dB.
c) Humidity resistance	EN 3745-412	10 cycles from 40 °C to 80 °C at 95 % RH. One cycle shall consist of a heating period of 5 h when the temperature is increased from 40 °C to 80 °C, plus a period of 15 h at temperature of 80 °C followed by a cooling period of 5 h to 40 °C, i.e. total cycle time of 25 h. Insertion loss after recovery < 1,2 dB. There shall be no visible damage to the cable.
d) Cold bend test	EN 3745-406	Insertion loss after recovery ≤ 1,2 dB.
Resistance to contamination and aircraft fluids	EN 3745-411	After test no crazing or delamination of the outer sheath. Marking shall be legible, the change in colour shall be slight. Variation of outside diameter shall not exceed 5 %. Optical insertion loss ≤ 0,5 dB. Test Fluids: Liquid B: ISO 1817, Hydraulic fluid: H-515; Liquid 101: ISO 1817, 50 % Ethylene glycol in Water; Solvents: Propane-2-ol. Not less than 24 h of immersion; 10 m samples, loosely coiled with a minimum bend radius of 30 mm. NOTE Some fluids may be replaced by the relevant proprietary fluids, i.e. Ester based lubricating oil R Eng and De-icing fluid Killfrost.

continued

Table 4 *(concluded)*

Test	Test method	Test performance/conditions
Flammability	EN 3745-407	Flame to be applied for 30 s. Burning to cease within 5 s.
Smoke index	EN 3745-601	Index value to be reported.
Toxicity index	EN 3745-602	Index value to be reported.
Mould growth	EN 2591-306	Method A. Duration of test 28 days. No growth. NOTE Materials which are known to be inert (e.g. those listed in MIL-HDBK-454B) need not to be tested.
Colour fastness to light	EN 3745-705	Cable marking should remain readable after light/ exposure.
Nuclear radiation	EN 3745-603	$\Delta\alpha$ max. after specified down time of 1 ms. $\leq$ 15,0 dB/km at T = (23 $\pm$ 5) °C. $\leq$ 82,0 dB/km at T = (– 60 $\pm$ 5) °C.
Susceptibility to ambient light coupling light for (Optical isolation of cable jacketing)	EN 3745-305	With reference to IEC 60874-1, Clause 27.3, it is recommended to use chopped for the test. The light coupling coefficient λ shall not exceed 4×10^{-12} m. The light coupling coefficient λ shall be determined by measuring the pick-up power P_2 in the cable length L under test and using the relation $P_2 = \lambda.I\ L$ with I being the incident light intensity. The cable length under test shall be L = (1 $\pm$ 0,3) m. The cable shall be loosely coiled with a bending radius of 30 mm. In order to prevent shading, the pitch between adjacent turns shall be (20 $\pm$ 4) mm and any supporting structure shall be transparent. The detector sensitivity shall have its maximum in the range between 800 nm and 900 nm and the detector's spectral responsibility, measured in A/W, shall exceed 50 % of its peak value in the range between 500 nm and 1 000 nm. Generally, Si detectors should be used to match this requirement. Preferably a light source is used which has its max. spectral output power close to the peak response of the silicon detector, as for example a tungsten halogen lamp.
Ozone	EN 2591-316	No splitting, cracking or discoloration.

9 Additional test information

9.1 Repeatability of test results

To ensure meaningful and repeatable test results, it is essential that the launch conditions used for certain tests are properly controlled and defined. In particular, it is important that measurements of attenuation during temperature cycling and at low temperatures should employ full launch conditions.

9.2 Definition of full launch conditions

For the purposes of this specification, the definition given in 9.3 applies, together with certain additional, more stringent, requirements.

9.3 Full launch techniques

In the full launch technique, all modes are excited and the light shall be incident on the launch end of the fibre in the form of a spot, centrally located on the fibre core and of a diameter at the 10 % intensity points greater than that of the fibre core diameter. In addition, the numerical aperture NA of the launch beam shall be greater than the maximum theoretical NA of the fibre.

9.4 Additional requirements

9.4.1 Near field intensity profile of launch-spot

The spot diameter at 80 % intensity shall be 1,05 × the fibre core diameter.

9.4.2 Angular dependence of the far field power from launch spot

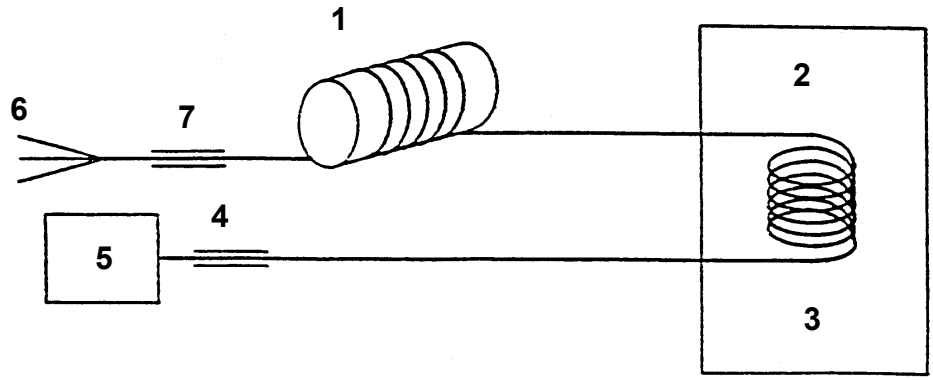
When measured in accordance with the method described by IEC 60794-1-2, the angular dependence of the far field distribution shall vary by less than ± 20 % up to an angle of Sin^{-1} (NA).

9.5 Practical realisation

The above requirements may be met using an incandescent tungsten-halogen light source and an 810 nm narrow-band filter using the arrangement illustrated in IEC 60794-1-2. Alternatively, a large area LED with a uniformly emitting surface, and operating at (810 ± 30) nm, may be placed close to the fibre end to achieve similar over-filled launch conditions.

9.6 Test arrangement for low- and high- temperature tests

In order to remove both cladding modes and leaky modes from the 10 m length of the fibre, in the conditioning chamber, the arrangement shall be in accordance with Figure 4.



Key

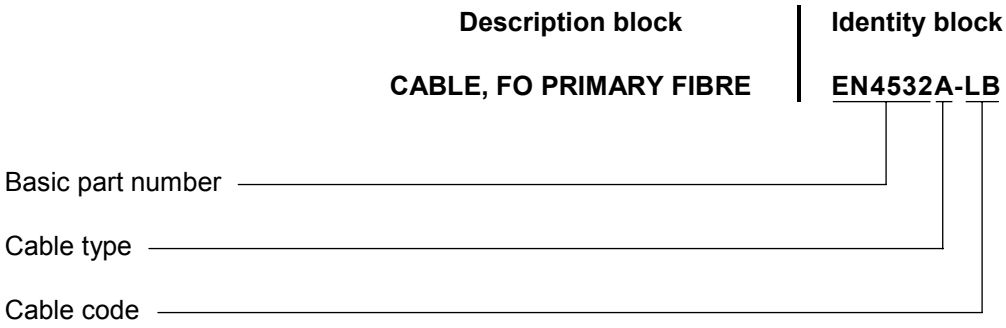
1 5 turns 30 mm radius
2 10 m length loosely coiled 150 mm radius
3 Conditioning chamber
4 Cladding mode stripper
5 Detector
6 Fully filled launch
7 Cladding mode stripper

Figure 4 — Test arrangement for low/high temperature tests

10 Marking and packaging requirements

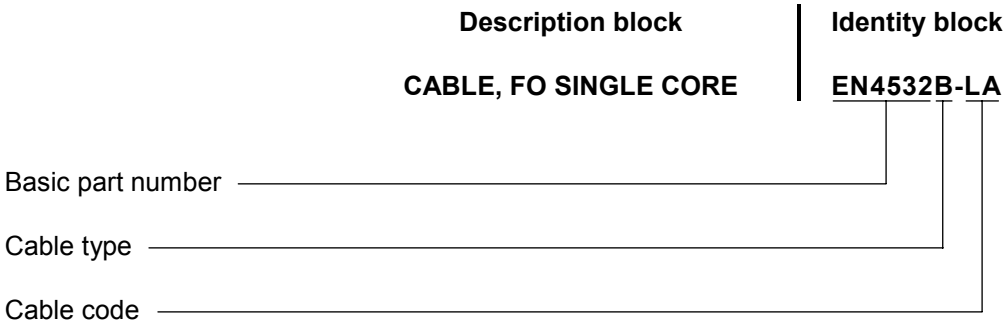
10.1 Designation of type 'A' primary fibre

EXAMPLE



10.2 Designation of type 'B' cable

EXAMPLE



10.3 Marking of cable

10.3.1 General

The cable shall be coloured light violet. The cable shall be provided with a continuous permanent identification, on the outer sheath, of the part number, the country of manufacture, the manufacturer and the year of manufacture in accordance with ISO 2574. These markings shall be at intervals of 250 mm to 300 mm.

10.3.2 Requirements for packaging and labelling

Packaging and labelling shall satisfy the following requirements:

— cables shall be supplied on non-returnable reels;

— the barrel diameter of a reel shall not be less than twice the minimum long term bend radius of the cable that it carries;

— the construction of the reel shall be such that access to both ends of the cable shall be available for measurement and inspection purposes;

— each length of cable shall have the ends sealed using either:

  — a tight fitting polymer end cap fitted to the cable, bound on with waterproof adhesive tape,

  — a heat shrinkable cap, containing a suitable adhesive lining, to the cable end;

— each reel *and* primary packaging shall bear a durable label, one side shall have the following information plainly and permanently printed, the other side of the label being left blank. The information may be written, provided a permanent ink is used and the characters are legible:

  — NATO Stock Number of the cable,

  — Cable, Fibre Optic,

  — Standard number and cable type,

  — Fibre details, i.e. cladding and core diameters, step or graded index and fibre materials,

  — Attenuation for lengths of less than 500 m,

  — Length of cable in metres,

  — Month and year of manufacture,

  — Country of manufacture,

  — Name of manufacturer,

  — Inspection reference,

  — Contract number;

— each reel shall bear a durable label with the following plainly printed or written on it:

  CAUTION This cable is liable to be damaged by moisture. Keep ends sealed and store in a cool dry place.

— each reel *and* primary packaging containing 500 m or greater length of cable shall have attached a waterproof envelope containing an OTDR printout for the fibre within the cable.

When the reel contains more than one piece, each piece shall be marked with an identification number (1, 2, 3, etc.) starting from the bottom of the reel and the length of each piece shall be stated. The label shall be securely attached to the reel flange.

10.4 Ordering information

The following ordering information shall be included when purchasing cable conforming to this standard:

— Quantity required;

— Number of the standard and cable type;

— Packaging and labelling requirements in accordance with this standard.

10.5 Cable length

The delivery length of the cable shall be in accordance with the following requirements in Table 5.

Table 5

Wire code	Delivery length	
–	≥ 100 m	50 m to 99 m
B	85 %	15 %

10.6 Storage reel

The minimum barrel diameter of the storage reel shall be 100 mm.

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