

Technical specification:

**OPTICAL FIBRE DIRECT BURIED AND DUCT CABLES TO BE USED
IN ACCESS AND TRUNK APPLICATIONS IN MULTISERVICE NETWORKS**

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1 Scope

This specification defines the functional requirements of single-mode optical fibre cables to be used in ducts and for directly buried applications.

Class A: Single-mode optical fibre cables for directly buried applications

- cables shall be suitable also for ploughing installation
 - cables shall be for arctic climate when the soil around the cable can be frozen
 - optical fibre quantities 4, 6, 12, 24, 36, 48, 60, 96
- Class A1: optical cables for access network solutions with max 24 optical fibres
- Class A2: optical cables for trunklines or with more than 24 optical fibres

Class B: Single-mode optical fibre cables for duct installations

- cables shall be suitable for duct installations by pulling and air blowing methods
- optical fibre quantities 12, 24, 36, 48, 60, 96, 144, 192

2 Reference documents

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.

ITU-T Rec. G.650, Definition and test methods for the relevant parameters of single-mode fibres.

ITU-T Rec. G.652, Characteristics of single-mode optical fibre and cable.

IEC 60304 Standard colours for insulation for low-frequency cables and wires

IEC 60793 (all parts) Optical fibres

IEC 60794-1-1, Optical fibre cables. Part 1-1: Generic specification. General

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

IEC 60794-3, Optical fibre cables. Part 3: Sectional specification. Outdoor cables

IEC 60794-3-10, Optical fibre cables. Part 3-10: Outdoor cables – Family specification for duct and directly buried optical telecommunication cables.

IEC 60708-1, Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath

IEC 60811-5-1, Common test methods for insulating and sheathing material of electric cables

SFS 5648 Optical fibre cable. Type designation for optical fibre and cable. Fibre identification.
(in Finnish.)

In case of any discrepancies between this specification and other specifications/standards referred, it is the first one to apply.

3 Optical fibre

Single-mode optical fibre used shall be according to the latest ITU-T Rec. G.652, Characteristics of single-mode optical fibre and cable.

3.1 Attenuation

3.1.1 Attenuation coefficient

Fibre type	Single-mode 9/125 μm	Single-mode 9/125 μm	
acc. to specification	ITU-T G.652B IEC 60793-2-50 B 1.1	ITU-T G.652C IEC 60793-2-50 B 1.3	
Attenuation (cabled fibres)	(max./average)	(max./average)	
at 1310 nm	<0.43/0.40	-	dB/km
at 1550 nm	<0.28/0.25	<0.28/0.25	dB/km
at 1625 nm	<0.33/0.30	<0.33/0.30	dB/km
from 1310 nm to 1625 nm	-	<0.43/0.40	
at 1383 nm	-	(Note 1)	

Note 1-The sampled attenuation average at this wavelength shall be less than or equal to the value specified at 1310 nm after hydrogen ageing according to IEC 60793-2-50 regarding B1.3 fibre category.

3.1.2 Attenuation uniformity

The local attenuation coefficient shall not have point discontinuities in excess of 0.10 dB.

For fibre lengths in excess of 1 km the attenuation coefficient of contiguous 1 km lengths shall not vary more than 0.05 dB/km.

Measurement pulse width: 1 μ s

3.2 Cut-off wavelength

The cabled fibre cut-off wavelength (λ_{cc}) shall be less than 1260 nm.

3.3 Polarisation mode dispersion (PMD)

The PMD link design value (PMD_Q) of the cabled fibre shall not exceed the following values:

0.20 ps \sqrt km for fibres according to the ITU-T G.652.B

0.5 ps \sqrt km for fibres according to the ITU-T G.652.C

4 Optical fibre cable

4.1.1 General

The cable shall be designed and manufactured for a predicted operating lifetime of at least 25 years. In this context the attenuation of the installed cable at the operating wavelengths shall not exceed the values agreed. The materials in the cable shall ensure that the increase in attenuation shall not exceed the specified value. This specified value shall include, for example, the effects of hydrogen. The manufacturer shall indicate the attenuation change data of the optical fibre due to hydrogen.

The materials in the cable shall not present a health hazard within its intended use.

All the fibres in the cable shall be of the same type and origin, unless otherwise stated by the user.

There shall be no fibre splices in a cable delivery length.

It shall be possible to identify each individual fibre throughout the length of the cable.

The manufacturer shall state how remaining cable stumps and the cable after its final lifetime shall be scrapped/recycled.

The materials used for a cable shall be selected to be compatible with the other elements in the cable.

4.2 Cable core

4.2.1 General

Generally optical cables comprise several elements or individual constituents, depending on the cable design which takes into account the cable application, operating environment and manufacturing processes, and the need to protect the fibre during handling and cabling.

With the cable set at its minimum bending radius the maximum fibre strain due to the bending of the fibre shall not affect to the predicted lifetime of the cable.

4.2.2 Cable core designs

Following cable core designs are acceptable:

1. Central loose tube design
2. Stranded loose tube design
3. Slotted core design

4.2.2.1 Central loose tube design

Primary coated fibres shall be packaged in loose tube, which shall be filled.

4.2.2.2 Stranded loose tube design

Primary coated fibres shall be packaged in loose tubes, which shall be filled.
Loose tubes shall be SZ-stranded around the non-metallic central element.

4.2.2.3 Slotted core design

The slotted core is obtained by extruding plastic material around the non-metallic central element.
Slots in the slotted core shall pass around the core changing periodically direction (SZ).
Primary coated fibre groups shall be located into slots in a slotted core.

4.2.3 Colour coding

4.2.3.1 Fibre colouring

The primary coated fibres shall be coloured for identification. The coloured coating shall be readily identifiable throughout the lifetime of the cable and shall be reasonable match to IEC 60304. The colouring shall be continuous throughout the whole length of the fibre.

The fibre colouring shall be in accordance with SFS 5648. The following colour sequence shall be used for fibre groups up to 6 fibres. In each fibre group the colour of the first fibre shall always be blue and the colour of the last fibre shall always be red.

Fibre identification colours

fibre	fibre colour
first fibre	blue
2nd	white
3rd	yellow
4th	green
5th	grey
last	red

4.2.3.2 Fibre group identification

The fibre grouping shall be in accordance with SFS 5648.

Optical fibres within a cable shall be grouped and each group shall not contain more than six fibres.

Each fibre group shall be separable from other groups by means of identification yarn or loose tube.

If cable or loose tube contains only six fibres, no group identification is required.

The following colour sequence shall be used for fibre groups up to 6 groups. The colour of the first group shall always be blue and the colour of the last group shall always be red.

If loose tube contains more than 36 fibres, fibre groups can be arranged into fibre units. The colour of the first unit shall always be blue and the colour of the last unit shall always be red.

The following colour sequences shall be used to identify fibre groups and fibre units.

Group and unit identification colours

group/unit	yarn colour
first	blue
2nd	white
3rd	yellow
4th	green
5th	grey
last	red

The following colour sequences shall be used to identify loose tubes.

Tube colours in stranded loose tube cables

tube number	colour
first tube	blue
2 nd , 6 th , 10 th , ect	white
3 rd , 7 th , 11 th , etc	yellow
4 th , 8 th , 12 th , etc	green
5 th , 9 th , 13 th , etc	grey
last	red

All the filler elements (if any) in stranded loose tube design shall be coloured black.

4.2.4 Cable core filling

The cable element(s) and in addition the cable core shall be continuously filled with water blocking compound.

The material shall be non-toxic, free from bad smell and it shall not provide health hazard. The compound shall be easily removed without the use of materials considered to be hazardous or dangerous.

The filling material shall be compatible with the relevant cable elements. Its suitability shall be demonstrated by the use of the following test methods:

- a) the amount of oil separation from the filling compound shall meet the requirements of clause 5 of IEC 60811-5-1
- b) for cables containing metallic elements the filling compound shall be tested for the presence of corrosive components in accordance with clause 8 of IEC60811-5-1

c) the filling compound shall not be liquid at temperatures lower than +60 °C. The determination of the drop point shall be in accordance with clause 4 of IEC 60811-5-1

The compound flow (drip) shall be tested in accordance with IEC 60794-1-2 E14. The test sample shall be laid in vertical position in the oven in 60 °C for 24 hours without preconditioning period. There shall be no sign of filling compound under the sample at the end of the test period.

4.2.5 Strength member in the cable core

The cable shall be designed with sufficient strength members to meet installation and service conditions.

The strength members in the cable core shall be non-metallic.

4.3 Cable sheath and armouring

4.3.1 Inner sheath

A cable inner sheath may be applied.

4.3.2 Armouring (in direct buried cables)

Corrugated steel tape protection shall be provided for all direct buried cables.

For the steel tape protection the nominal overlap shall be 3 mm minimum and the thickness of the steel tape shall be 150 µm.

Tape shall be chrome coated and it shall be covered on both sides with plastic layer.

4.3.3 Outer sheath

The cable shall have a seamless sheath made of U V-stabilized weather resistant polyethylene in accordance with clause 22 of IEC 60708-1.

The minimum sheath thickness shall not be less than 1.5 mm. The minimum sheath thickness outside any strength member shall not be less than 1.0 mm. The overall cable diameter and its variations shall be stated by manufacturer.

4.3.4 Rip cord

The cables with stranded loose tube construction shall be provided with a non-metallic rip cord under the outer sheath.

4.3.5 Sheath marking

The cable shall be marked by a method stated by the manufacturer. The marking shall contain type designation, length marking, name of the manufacturer and year of manufacture. The name of the buyer can included for bigger project deliveries.

The marking shall be done at 1 m intervals.

5 Installation and operating conditions

The installation temperature may vary between -15 - +60 °C.

The operation temperature may vary between -45 - +60 °C.

The minimum bending radius of the cables will be during installation with maximum pull (dynamic) and as permanently installed (static):

	dynamic	static
Class A:	400 mm	300 mm
Class B:	300 mm	200 mm

6 Optical fibre cable tests

The parameters specified in this specification may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to the lack of suitable standards. Acceptance criteria shall be interpreted with respect to this consideration. The total uncertainty of measurement for this specification shall be less than or equal to 0.05 dB for attenuation.

The expression of no change in attenuation means that any change in measurement value, either positive or negative, within the uncertainty of measurement shall be ignored.

The number of fibres tested shall be representative of the cable design and shall be agreed between the user and the manufacturer.

6.1 Tensile performance

The cable shall be tested in accordance with IEC 60794-1-2-E1A and E1B.

Length under tension:	Not less than 50 m.
Diameter of test pulleys:	Not less than the minimum dynamic bending diameter specified for the cable.
Duration (full load):	≥ 5 min.
Wavelength:	1550 nm

Class A1

Load:	5000 N
Acceptance criteria	<p>Under the load:</p> <p>90 % of fibres max. added loss not more than 0.05 dB 100 % of fibres max. added loss not more than 0.15 dB</p> <p>Fibre strain shall not exceed 1/3 of the proof test strain.</p> <p>After removal of the load the attenuation and the fibre strain shall be reversible within the uncertainty of measurement.</p>

Class A2

Load:	5000 N
Acceptance criteria:	<p>Under the load:</p> <p>100 % of fibres max. added loss not more than 0.05 dB.</p> <p>The fibre strain shall not exceed 1/3 of the proof test strain.</p> <p>After removal of the load the attenuation and the fibre strain shall be reversible within the uncertainty of measurement.</p>

Class B

Load:	Weight of 1 km length of cable but not less than 1500 N.
Acceptance criteria:	<p>Under the load:</p> <p>100 % of fibres max. added loss not more than 0.05 dB.</p> <p>The fibre strain shall not exceed 1/3 of the proof test strain.</p> <p>After removal of the load the attenuation and the fibre strain shall be reversible within the uncertainty of measurement.</p>

6.2 Bending under tension

The cable shall be tested in accordance with IEC 60794-1-2-E18.

Diameter of test roller(s):	<p>Category A: 800 mm</p> <p>Category B: 600 mm</p>
Load:	<p>Category A1 and A2: 5000 N</p> <p>Category B: 1 W (W = weight of 1 km length of cable), but not less than 1500 N</p>
Number of cycles:	10
Acceptance criteria:	<p>There shall be no permanent change in attenuation (≤ 0.05 dB). The attenuation shall be measured in the 1550 nm region.</p> <p>Under visual examination without magnification there shall be no damage to the sheath or to the cable elements.</p>

6.3 Repeated bending

The cable shall be tested in accordance with IEC 60794-1-2-E6.

Bending radius:	200 mm
Load:	100 N
Number of cycles:	35
Duration of cycle:	Approximately 2 s
Acceptance criteria:	Under visual examination without magnification there shall be no damage to the sheath or to the cable elements.

6.4 Impact

The cable shall be tested in accordance with IEC 60794-1-2-E4.

Diameter of the striking surface:	50mm
Radius of the striking surface:	300 mm
Impact energy	25 J
Number of impacts:	One in 3 different places spaced not less than 500 mm apart
Acceptance criteria:	Under visual examination without magnification there shall be no damage to the sheath or to the cable elements. The imprint of the anvil is not considered as mechanical damage. The residual increase in attenuation shall be ≤ 0.1 dB at 1550 nm.

6.5 Torsion

The cable shall be tested in accordance with IEC 60794-1-2-E7.

Length under test:	1000 mm
Load:	100 N
Number of turns:	$\pm 180^\circ$
Number of cycles:	5
Acceptance criteria:	<p>Under visual examination without magnification there shall be no damage to the sheath or to the cable elements.</p> <p>The variation on attenuation for each fibre shall be less than or equal to 0.10 dB at 1550 nm.</p> <p>There shall be no permanent change in attenuation after the test.</p>

6.6 Kink

The cable shall be tested in accordance with IEC 60794-1-2-E10.

Diameter of the loop:	300 mm
Temperature:	20°C
Acceptance criteria:	No kink shall occur.

6.7 Cable bend

The cable shall be tested in accordance with IEC 60794-1-2-E11A.

Diameter of mandrel:	20xD (D is the outer diameter of cable)
Number of turns/helix:	4
Number of cycles:	3
Acceptance criteria:	There shall be no change in attenuation ≤ 0.05 dB) when measured in the 1550 nm region. Under visual examination without magnification there shall be no damage to the sheath or to the cable elements.

6.8 Crush

The cable shall be tested in accordance with IEC 60794-1-2-E3.

Load (plate/plate):	Class A1: 6000 N Class A2: 6000 N Class B: 2000 N
Duration of load:	15 minutes
Acceptance criteria:	Under load there shall be no increase in attenuation (≤ 0.05 dB) when measured in the 1550 nm region. Under visual examination without magnification there shall be no damage to the sheath or to the cable elements. The imprint of the plate is not considered as mechanical damage.

6.9 Temperature cycling

The cable shall be tested in accordance with IEC 60794-1-2-F1.

Sample length:	Finished cable length of at least 1000 m
High temperature, T B2:	+60 °C
High temperature, T B1:	+30 °C
Low temperature, T A1:	-15 °C
Low temperature, T A2:	-45 °C
Rate of heating and cooling:	Sufficiently slow that the effect of changing the temperature does not cause temperature shock.
Dwell time, t1:	Time for the cable to reach and stabilise to the specified temperature.
Number of cycles:	2, but additional cycles are required if there is attenuation increase noticed from one cycle to another.
Acceptance criteria:	<p>For T_{A1} to T_{B1} there shall be no change in attenuation (≤ 0.05 dB) when measured in the 1550 nm region or more than 0.03 dB/km when measuring long sample length.</p> <p>For T_{A1} to T_{A2} and T_{B1} to T_{B2} the change in attenuation coefficient shall be ≤ 0.10 dB/km and shall be reversible to ≤ 0.05 dB or to ≤ 0.03 dB/km when measuring long sample length.</p> <p>The measurement shall be made in the 1550 nm region.</p>

6.10 Water penetration

The cable shall be tested in accordance with IEC 60794-1-2-F5B.

Cable length	3 m
Time	24 h
Acceptance criteria:	Under visual examination without magnification, no water shall have leaked from the opposite end of the cable at the end of test period.

7 Quality assurance

The description of the manufacturer's quality system shall be provided as request.. The buyer shall classify the manufacturers and manufacturing processes by using provided information, production process audits and earlier experience. The actual quality assurance method will be determined according to the classification.

7.1 Type test

The manufacturer shall carry out type tests and provide the results to the buyer before delivery if required. The tests will be based to the relevant cable specifications. In principle all the tests applicable shall be carried out to the same cable manufacturing length according to the relevant specifications. The manufacturer shall carry out the type tests according to the quality assurance program as agreed between the buyer and the manufacturer.

7.2 Delivery tests

The manufacturer shall carry out the delivery tests according to the quality assurance program as agreed between the buyer and the manufacturer.

8 Delivery lengths

The primary limits to be taken into account are the weight and the size of the cable drum. The nominal delivery lengths are 4 and 6 km. Shorter delivery lengths shall be stated in the order.

9 Drums and packing

Cables shall be delivered on returnable wooden drums.

The outside diameter of the drum shall not exceed 2.0 m.

The diameter of the drum core shall be more than the minimum bending diameter of the cable. The centre hole in the drum shall be 75 to 100 mm depending on the drum dimension.

The drum shall be without any deformation. The drum core and the inner drum flanges shall be smooth.

The clearance between the outer cable layer and the edge of the drum flange shall be minimum 50 mm.

The cable ends shall be sealed to avoid water penetration into cable.

The cables shall not be delivered on unnecessarily big drums.

The cable drums shall be protected by wooden boarding or by other suitable means.

The cable drums shall be marked with the following information:

- the name of the manufacturer
- the cable type
- the length of the cable

- the cable identification number
- the metre identification of the inner/outer cable end
- the arrow showing the right rolling direction of the drum

10 Installation information

The manufacturer shall give all necessary information for installation including preferred methods for the removal of coating materials of fibres, preferred splicing and reinforcement methods, instructions for fixing the cable pulling eyes, grips or corresponding attachment methods etc. The information shall contain all facts essential for installations.

11 Material safety data

The manufacturer shall list all the materials used in the cables or proposed to be used in installation, which may be hazardous to health or the environment or if they are flammable. The material safety data sheets shall be provided to the purchaser by request.

12 Answering

The tendered cables shall fulfil the requirements according to this technical specification. The Tenderer is request to give a Statement of Compliance for each article and paragraph in this specification by answering the following manner:

- if meeting fully the requirement the Tenderer will make statement: COMPLIANT
- if cannot meet the requirement the Tenderer will make statement: NOT COMPLIANT

The Tenderer shall also state the reason why his offer is Not Compliant.

The statements shall be supported by information and documentation such that the purchaser can validate the degree of compliance offered.

The Statement of Compliance to this technical specification will be part of the contract.

(End of specification)