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INTERNATIONAL STANDARD

Optical fibre cables –
Part 3-60: Outdoor cables – Family specification for drinking water pipe cables and subducts for installation by blowing and/or pulling/dragging/floating in drinking water pipes

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International Standard IEC 60794-3-60 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This standard is to be used in conjunction with IEC 60794-1-1, IEC 60794-1-2 and IEC 60794-3.

The text of this standard is based on the following documents:

FDIS	Report on voting
86A/1232/FDIS	86A/1243/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 60794 series, under the general title *Optical fibre cables,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

OPTICAL FIBRE CABLES –

Part 3-60: Outdoor cables – Family specification for drinking water pipe cables and subducts for installation by blowing and/or pulling/dragging/floating in drinking water pipes

1 Scope

This part of IEC 60794 is a family specification that covers drinking water pipe cables and subducts for installation by blowing and/or pulling/dragging/floating in drinking water pipes. Systems built with components covered by this standard are subject to the requirements of sectional specification IEC 60794-3.

Drinking water pipe cable and subduct constructions have to meet the different requirements of the drinking water companies and/or associations regarding chemical, environmental, operational interactions and in general maintenance conditions.

A table of preferential applications, describing drinking water pipe cable characteristics versus methods of installation is reported in Annex A for drinking water pipe cables.

Clause 4 describes a blank detail specification for drinking water pipe cables and subducts for installation by blowing and/or pulling/dragging/floating in drinking water pipes. It incorporates some minimum requirements.

Detail specifications may be prepared on the basis of this family specification.

The parameters specified in this standard may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to lack of suitable standards. Acceptance criteria should be interpreted with respect to this consideration.

The number of fibres tested is representative of the drinking water line cable and should be agreed between the customer and the supplier.

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.

IEC 60304, 1982: *Standard colours for insulation for low-frequency cables and wires*

IEC 60793-1-20, *Optical fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry*

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

IEC 60793-1-44, *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength*

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode 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 60811-1-1, 1993: *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1-1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*

IEC 60811-5-1,1990: *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 5-1: Methods specific to filling compounds – Drop-point – Separation of oil – Lower temperature brittleness – Total acid number – Absence of corrosive components – Permittivity at 23 °C – DC resistivity at 23 °C and 100 °C*

IEC 62305-1, *Protection against lightning – Part 1: General principles*

3 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

λ_{CC}	cabled fibre cut-off wavelength
d	nominal outer diameter of the cable
d_c	nominal outer diameter of the subduct
DS	detail specification
T_O	threshold tensile load below which no attenuation and/or fibre strain increase should occur in the tensile performance test
T_M	the acceptable amount of short-term tensile load that can be applied to the cable without permanent degradation of the characteristics of the fibres in the tensile performance test
T_{A1}	temperature cycling test low-temperature limit according to IEC 60794-1-2, method F1
T_{A2}	temperature cycling test low-temperature limit according to IEC 60794-1-2, method F1
T_{B1}	temperature cycling test high-temperature limit according to IEC 60794-1-2, method F1
T_{B2}	temperature cycling test high-temperature limit according to IEC 60794-1-2, method F1
t_1	temperature cycling dwell time
n x d	a value times cable outer diameter used for bends, mandrels, etc.
PE	polyethylene
I/O-port	input/output port for launching OF cables into and out of the gas pipe
APL	aluminium/polyethylene laminate
SPL	steel/polyethylene laminate

4 Family specification for drinking water pipe cables and subducts for installation by blowing and/or pulling/dragging/floating in drinking water pipes (blank detail specification and minimum requirements)

4.1 Construction

4.1.1 General

In addition to the constructional requirements of sectional specification IEC 60794-3, the following considerations apply to the drinking water pipe cables and/or subducts.

The drinking water pipe cables and/or subducts shall be designed and manufactured for an expected operating lifetime of at least 10 years. It shall be possible to install or remove the cable in or from the drinking water pipe throughout the operational lifetime. The materials in the drinking water pipe cable and/or as well as accessories including sealing elements, i.e. I/O-ports and subducts shall not present a health hazard within its intended use.

4.1.2 Subducts

In the case of use, the subduct with outer nominal diameters ranging from 10 mm to 100 mm shall be able to resist pressure differences needed for installation by blowing and able to withstand the water pressure within the drinking water pipe. They shall be circular and the outer and inner surfaces a low coefficient of friction. The material shall withstand all possible chemical attacks by the drinking water itself, as for instance the PE tube material used by the water supply companies. Inner- and outer-diameter and overall minimum wall thickness shall be specified.

4.1.3 Drinking water pipe cables

A drinking water pipe cable in accordance with this specification should be suitable for installation in drinking water pipes by the following installation methods, also applicable the access drinking water pipe work:

– blowing and/or pulling into a subduct, previously installed into the drinking water pipe between two I/O-ports;

– direct installation into the drinking water pipe between two adjacent I/O-ports.

The attenuation of the installed cable at the operational wavelength(s) shall not exceed values agreed between the customer and the supplier.

There shall be no fibre splice in a delivery length unless otherwise agreed by the customer and the supplier.

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

4.2 Optical fibres

4.2.1 Single-mode dispersion unshifted (B1.1) optical fibre

Table 1 – Single-mode dispersion unshifted (B1.1) optical fibre

Characteristics (9)	IEC 60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Uncabled optical fibre	5	IEC 60793-2-50		
Attenuation coefficient (cabled fibres)	5.2.1	According to DS	IEC 60793-1-40, method A, B or C	
at 1 310 nm at 1 550 nm and at 1 625 nm[1].		≤ 0,40 dB/km ≤ 0,35 dB/km ≤ 0,40 dB/km		
Attenuation discontinuities at 1 310 nm and 1 550 nm	5.2.2	≤ 0,10 dB	IEC 60793-1-40, method C	
Cabled fibre cut-off wavelength	5.3	$\lambda_{CC} < \lambda$ operational	IEC 60793-1-44, method B	
Fibre colouring	5.4	IEC 60304	Visual inspection	
Outer diameter including colouring	8.2.1.1	IEC 60793-2	IEC 60793-1-20, method D	

4.2.2 Single-mode dispersion shifted (B2) optical fibre

Table 2 – Single-mode dispersion shifted (B2) optical fibre

Characteristics (9)	IEC 60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Uncabled optical fibre	5.1	IEC 60793-2		
Attenuation coefficient (cabled fibres)	5.2.1	According to DS	IEC 60793-1-40, method A, B or C	
at 1 550 nm	5.2.1	≤ 0,35 dB/km		
Attenuation discontinuities at 1 550 nm	5.2.2	≤ 0,10 dB/km	IEC 60793-1-40, method C	
Cabled fibre cut-off wavelength	5.3	$\lambda_{CC} < \lambda$ operational	IEC 60793-1-44, method B	
Fibre colouring	5.4	IEC 60304	Visual inspection	
Outer diameter including colouring	8.2.1.1	IEC 60793-2	IEC 60793-1-20, method D	

[1] Measurements at 1 625 nm are optional.

4.2.3 Single-mode non-zero dispersion (B4) optical fibre

Table 3 – Single-mode non-zero dispersion (B4) optical fibre

Characteristics (9)	IEC 60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Uncabled optical fibre	5.1	IEC 60793-2		
Attenuation coefficient (cabled fibres)	5.2.1	According to DS	IEC 60793-1-40, method A, B or C	
at 1 550 nm	5.2.1	≤ 0,35 dB/km		
at 1 625[2] nm		≤ 0,40 dB/km		
Attenuation discontinuities at 1 550 nm	5.2.2	≤ 0,10 dB/km	IEC 60793-1-40, method C	
Cabled fibre cut-off wavelength	5.3	$\lambda_{CC} < \lambda$ operational	IEC 60793-1-44, method B	
Fibre colouring	5.4	IEC 60304	Visual inspection	
Outer diameter including colouring	8.2.1.1	IEC 60793-2	IEC 60793-1-20, method D	

4.2.4 Single-mode (B6) optical fibre

Table 4 – Single-mode (B6) optical fibre

Characteristics (9)	IEC 60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Uncabled optical fibre	5.1	IEC 60793-2		
Attenuation coefficient (cabled fibres)	5.2.1	According to DS	IEC 60793-1-40, method A, B or C	
at 1 550 nm	5.2.1	≤ 0,30 dB/km		
at 1 625[3] nm		≤ 0,40 dB/km		
Attenuation discontinuities at 1 550 nm	5.2.2	≤ 0,10 dB/km	IEC 60793-1-40, method C	
Cabled fibre cut-off wavelength	5.3	$\lambda_{CC} < \lambda$ operational	IEC 60793-1-44, method B	
Fibre colouring	5.4	IEC 60304	Visual inspection	
Outer diameter including colouring	8.2.1.1	IEC 60793-2	IEC 60793-1-20, method D	

4.2.5 Multimode fibres

Under consideration.

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2 Measurements at 1 625 nm are optional

3 Measurements at 1 625 nm are optional

4.3 Drinking water pipe cable constructions

4.3.1 Cable for installation within subducts (previously installed within the drinking water pipe)

Table 5 – Characteristics – Cable for installation within subducts

Characteristics (9)	IEC 60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Lay-up	7.2	According to DS	Visual inspection	
Drinking water pipe cable core	7.3	According to DS		
Filling compound (if used)		According to DS	Either IEC 60794-1-2, method E14 or IEC 60811-5-1, Clause 4 IEC 60811-5-1, Clause 5 IEC 60811-5-1, Clause 8	
Dry blocking compound	7.3	According to DS	Under consideration	
Strength member	7.4	According to DS	Visual inspection	
- central				
- peripheral				
Moisture barrier	7.5	According to DS		
Metallic tapes (if any):				
Outer cable sheath	7.6			
Material				
Minimum sheath thickness		According to DS	IEC 60811-1-1	
Outer cable diameter		According to DS	IEC 60811-1-1	
Optional protection		According to DS		
Sheath marking	7.7			
Configuration, dimensions		According to DS	Visual inspection	
Abrasion resistance		According to DS	IEC 60794-1-2, method E2B	Method 1 Steel needle diameter d = 1,0 mm load: 4 N Method 2 with felt pad consisting of either a) water soaked wool felt or b) rayon felt with < 30 % wool Weight: > 450 g
Sheath abrasion	9.2.8	According to DS	IEC 60794-1-2, method E2A	
Drinking water pipe cable length			Under consideration	

4.3.2 Cable for direct installation into the drinking water pipes

Table 6 – Characteristics – Cable for direct installation within the high pressure gas pipe

Characteristics (9)	IEC60794-3 Clause/subclause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Lay-up	7.2	According. to DS	Visual inspection	
Drinking water pipe cable core	7.3	According to DS		
Filling compound (if used)		According to DS	Either IEC 60794-1-2, method E14 or IEC 60811-5-1, Clause 4 IEC 60811-5-1, Clause 5 IEC 60811-5-1, Clause 8	
Dry blocking compound	7.3	According to DS	Under consideration	
Strength member	7.4	According to DS	Visual inspection	
- central				
- peripheral				
Moisture barrier	7.5	According to DS		
Metallic tapes:				
Outer cable sheath	7.6			
Material				
Minimum sheath thickness		According to DS	IEC 60811-1-1	
Outer cable diameter		According to DS	IEC 60811-1-1	
Optional protection		According to DS		
Sheath marking	7.7			
Configuration, dimensions		According to DS	Visual inspection	
Abrasion resistance		According to DS	IEC 60794-1-2 method E2B	Method 1 Steel needle diameter d = 1,0 mm load: 4 N Method 2 with felt pad consisting of either a) water soaked wool felt or b) rayon felt with < 30 % wool Weight: > 450 g
Sheath abrasion	9.2.8	According to DS	IEC 60794-1-2 method E2A	
Drinking water pipe cable length			Under consideration	

4.3.3 Subduct construction

Table 7 – Characteristics – Subduct construction

Characteristics (9)	IEC 60794-3 as applicable Clause/sub-clause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Material(s)				
Subduct inner diameter		According to DS	IEC 60811-1-1	
Subduct outer diameter		According to DS	IEC 60811-1-1	
- inner subduct (if any): - subduct wall thickness Moisture barrier (if any): - metallic tapes Additional outer sheath (if any): - thickness	Under consideration	Under consideration	Under consideration	Under consideration
Subduct length			Under consideration	

4.4 Installation and operating conditions

4.4.1 Tests applicable to cables/cable elements

Table 8 – Tests applicable to cables/cable elements

Characteristics (9)	IEC 60794-3 Clause/sub-clause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
General requirements Tests applicable to loose tubes:	8.1	Agreement between customer and supplier		
- Bend test	8.2.1.2	According to DS	IEC 60794-1-2, method G1	
- Tube kinking	8.2.2.1	According to DS	IEC 60794-1-2, method G7	
Tests applicable to ribbons:				
- Dimensions	8.2.3.1	IEC 60794-3, Table 1	IEC 60794-3, 8.2.3.1	
- Separability of individual fibres from ribbon	8.2.3.2.1	IEC 60794-3, 7.2.3.2.1 or according to DS	IEC 60794-1-2, method G5 or according to DS	
- Ribbon stripping	8.2.3.2.2	According to DS		
- Torsion	8.2.3.2.3	According to DS	IEC 60794-1-2, method G6	

4.4.2 Installation conditions

Under consideration.

4.5 Mechanical and environmental tests

4.5.1 Subducts

4.5.1.1 Tests applicable

Tests listed in the following Table 9 are those relevant to IEC 60794-3 as applicable for subducts.

Table 9 – Subducts tests applicable

Characteristics (9)	IEC 60794-3 Clause/sub-clause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Tensile performance	9.1	4.5.1.2.2 and according to DS	IEC 60794-1-2, method E1A and E1B	See 5.6.2.1
Installation capability (selection from the following)	9.2			
- bending under tension	9.2.1	According to DS	IEC 60794-1-2, method E18	
- repeated bending	9.2.2		IEC 60794-1-2, method E6	
- impact	9.2.3	4.5.1.2.5	IEC 60794-1-2, method E4	
- kink	9.2.4	According to DS and 4.5.1.2.3	IEC 60794-1-2, method E10	
- torsion	9.2.5		IEC 60794-1-2, method E7	
Subduct bend	9.3	According to DS	IEC 60794-1-2, method E11	See 5.6.2.5
Crush	9.4	According to DS and 4.5.1.2.4	IEC 60794-1-2, method E3	See 5.6.2.6
Flexibility		4.5.1.2.6		
Ageing	9.6			
- finished subduct	9.6.2	Under consideration		
Pressure		According to DS and 4.5.1.2.1		
Induced voltage (for subducts with metallic elements)	9.9	Under consideration	IEC 62305-1	

4.5.1.2 Details of family requirements and test conditions for subducts

Tests shall be selected from those of Table 9 and the following hereinafter described.

4.5.1.2.1 Pressure

a) Family requirements

Under visual examination, without magnification, there shall be no damage to the subduct.

b) Test conditions

Method: under consideration

All subducts shall resist an air pressure of at least (2,5 × the installation pressure) at a temperature of 20 °C for a period of 30 min.

Additionally, the same performance shall be demonstrated after a sample of subduct has been maintained at 60 °C for a period of 12 weeks.

All subducts shall resist a proof test pressure of at least (1,3 × the installation pressure) at a temperature of 20 °C for a period of 24 h, after tensile and bending tests.

4.5.1.2.2 Tensile performance

a) Family requirements

Under visual examination without magnification, there shall be no damage and the diameter shall not change by more than x %

b) Test conditions

Method:	under consideration
Subduct length under tension:	under consideration
Tensile load on subduct:	under consideration

4.5.1.2.3 Kink

a) Family requirements

Under visual examination, without magnification, there shall be no kink to the subducts.

b) Test conditions

Method:	IEC 60794-1-2, E10
Minimum diameter:	20 times the outer diameter of the subduct

4.5.1.2.4 Crush

a) Family requirements

Under visual examination, without magnification, there shall be no damage to the subduct. There shall be no residual deformation greater than 15 % of the subduct diameter, no splitting or permanent damage after removing load. The imprint of the anvil on the subduct surface is not considered as mechanical damage.

b) Test conditions

Method:	IEC 60794-1-2, E3
Sample length:	250 mm load (plate/plate): $50 \times d_c$ (N) (d_c in mm) or 450 N whichever is lower
Duration time:	60 s
Recovery time:	1 h

4.5.1.2.5 Impact

a) Family requirements

Under visual examination without magnification there shall be no damage to the subduct. There shall be no residual deformation greater than 15 % of the subduct diameter, no splitting or permanent damage. The imprint of the striking surface on the subduct is not considered mechanical damage.

b) Test conditions

Method:	under consideration
Striking surface radius:	10 mm
Impact energy:	1 J
Recovery time:	1 h
Number of impacts:	one in 3 different places spaced not less than 500 mm apart

4.5.1.2.6 Flexibility

a) Family requirements

The outer and inner diameter of the subducts shall show, under visual examination without magnification, no damage and no reduction of diameter greater than 15 %.

b) Tests conditions

Method: ten turns of the subduct shall be wrapped tightly and secure around a mandrel of diameter 12 times the outer diameter of the subduct itself

Duration: 30 min

4.5.2 Cable for installation within subducts (previously installed into the drinking water pipes)

4.5.2.1 Tests applicable

Table 10 – Tests applicable to the cable for installation within subducts

Characteristics (9)	IEC 60794-3 Clause/sub-clause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Tensile performance	9.1	4.5.2.2.1 and according to DS	IEC 60794-1-2, method E1A and E1B	
Installation capability (selection from the following)	9.2			
- bending under tension	9.2.1	According to DS	IEC 60794-1-2, method E18	
- repeated bending	9.2.2	4.5.2.2.2	IEC 60794-1-2, method E6	
- impact	9.2.3	4.5.2.2.6	IEC 60794-1-2, method E4	
- kink	9.2.4	According to DS	IEC 60794-1-2, method E10	
- torsion - blowing	9.2.5	4.5.2.2.3 and according to DS	IEC 60794-1-2, method E7	
Cable bend	9.3	According to DS and 4.5.2.2.4	IEC 60794-1-2, method E11	
Crush	9.4	According to DS and 4.5.2.2.5	IEC 60794-1-2, method E3	
Temperature cycling	9.5	4.5.2.2.7	IEC 60794-1-2, method F1	
Ageing	9.6			
- coating adhesion stability	9.6.1	According to DS	IEC 60794-1-2, method E5	
- finished cable	9.6.2	Under consideration		
Water penetration	9.7	According to DS	IEC 60794-1-2, method F5A, F5B	
Pneumatic resistance	9.8	According to DS (under consideration)	IEC 60794-1-2, method F6	
Induced voltage (for cables with metallic elements)	9.9	Under consideration		

4.5.2.2 Details of family requirements and test conditions for drinking water pipe cable tests

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 uncertainty of measurement for this standard shall be < 0,05 dB for attenuation.

Tests shall be selected from those of Table 10 and the following hereinafter described.

4.5.2.2.1 Tensile performance

a) Family requirements

Under long term tensile load (T_I) the fibre strain shall not exceed 20 % of the fibre proof strain and there shall be no change in attenuation during the test. Under installation load (T_M) the fibre strain shall not exceed 60 % of the fibre proof strain and the attenuation change during test shall be measured and recorded. Other criteria may be agreed between the customer and the supplier.

Under visual examination without magnification there shall be no damage to the sheath or to the cable elements.

There shall be no change after test in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer, at room temperature.

b) Test conditions

Method:	IEC 60794-1-2, E1A and E1B
Cable length under tension:	not less than 50 m. Taking into account the measurement accuracy and end effects, shorter lengths may be used by agreement between the customer and the supplier
Fibre length:	finished cable length
Tensile load on cable:	long term tensile load (T_L) and installation load (T_M). Other loads may be applied in accordance with particular user conditions
Diameter of test pulleys:	1 m but not less than the minimum loaded bending diameter specified for the cable
T_M:	equivalent to weight of 1 km of drinking water pipe cable or 50 N whichever is greater
T_L:	equivalent to weight of 500 m of drinking water pipe cable or 25 N whichever is greater (ffs)

4.5.2.2.2 Repeated bending

a) Family requirements

Under visual examination without magnification, there shall be no damage to the sheath and to the cable elements.

b) Test conditions

Method:	IEC 60794-1-2, E6
Bending radius:	20 *d* or 30 mm whichever is greater
Load:	adequate to assure uniform contact with the mandrel
Number of cycles:	25
Duration of cycle:	approximately 2 s

4.5.2.2.3 Torsion

a) Family requirements

Under visual examination without magnification, there shall be no damage to the sheath or to the cable elements.

The variation on attenuation for each fibre shall be less than, or equal to, 0,10 dB at 1 550 nm, or at the operational wavelength when specified by the customer.

There shall be no permanent change in attenuation after the test.

b) Test conditions

Method:	IEC 60794-1-2, E7
Length under test:	2 m
Number of turns:	one half turn (through 180°) over the length of 2 m in each direction
Number of cycles:	5

4.5.2.2.4 Bend

a) Family requirements

There shall be no change in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer, at room temperature.

The change in attenuation when tested at –30 °C shall be ≤ 0,1 dB if required.

b) Test conditions

Method:	IEC 60794-1-2, E11
Diameter of mandrel:	≤ 40 *d* or 60 mm whichever is greater
Number of turns/helix:	4
Number of cycles:	3

4.5.2.2.5 Crush

a) Family requirements

Immediately after removal of load, there shall be no increase in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer.

Under visual examination, there shall be no damage to the sheath or to the cable elements after removing load. The imprint of the plate or mandrel on the sheath is not considered mechanical damage.

b) Test conditions

Method:	IEC 60794-1-2, E3
Load (plate/plate):	450 N
Duration of load:	1 min

4.5.2.2.6 Impact

a) Family requirements

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

b) Test conditions:

Striking surface radius:	10 mm
Impact energy:	1 J with striking surface radius of 10 mm
Number of impacts:	one in 3 different places spaced not less than 500 mm apart

Under visual examination without magnification, there shall be no damage to the sheath or to the cable elements. The imprint of the anvil on the sheath is not considered as mechanical damage.

4.5.2.2.7 Temperature cycling

a) Family requirements

During the last cycle, there shall be no change in attenuation between the initial room temperature measurement and T_{A1} or T_{B1} For 1 625 nm applications, performance criteria shall be mutually agreed upon between the customer and supplier.

During the last cycle, the attenuation change from the room temperature measurement and T_{A2} or T_{B2} shall be < 0,15 dB/km at 1 550 nm. For 1 625 nm applications, performance criteria shall be mutually agreed upon between the customer and supplier. On completion of the test, there shall be no change in attenuation.

Definition of a cycle: T_{B2} to T_{A2}

Definition of the last cycle: T_{A2}, T_{A1}, T_{B1}, T_{B2} with a final measurement at room temperature.

b) Test conditions

Sample length: finished cable length of at least 1 000 m.

High temperature, T_{B2}: +60 °C to +70 °C, depending on customer requirements

High temperature, T_{B1}: +30 °C to +60 °C, depending on customer requirements

Low temperature, T_{A1}: –10 °C to –15 °C, depending on customer requirements

Low temperature, T_{A2}: T_{A1} to –40 or –45 °C, depending on customer requirements

Rate of heating: sufficiently slow that the effect of changing the cooling temperature does not cause temperature shock

t_1: temperature cycling test dwell time to stable temperature is reached

Number of cycles: 2, but additional cycles may be required in accordance with particular customer requirements

4.5.3 Cables for direct installation into the drinking water pipe

4.5.3.1 Tests applicable

Table 11 – Tests applicable to the cables for direct installation into the drinking water pipe

Characteristics (9)	IEC 60794-3 Clause/sub-clause (10)	Family requirements (11)	Test methods (12)	Remarks (13)
Tensile performance	9.1	4.5.3.2.1 and according to DS	IEC 60794-1-2, method E1A and E1B	
Installation capability (selection from the following)	9.2			
- bending under tension	9.2.1	According to DS	IEC 60794-1-2, method E18	
- repeated bending	9.2.2	4.5.3.2.2	IEC 60794-1-2, method E6	
- impact	9.2.3	4.5.3.2.6	IEC 60794-1-2, method E4	
- kink	9.2.4	According to DS	IEC 60794-1-2, method E10	
- torsion	9.2.5	4.5.3.2.3	IEC 60794-1-2, method E7	
Cable bend	9.3	According to DS and 4.5.3.2.4	IEC 60794-1-2, method E11	
Crush	9.4	According to DS and 4.5.3.2.5	IEC 60794-1-2, method E3	
Temperature cycling	9.5	According to DS and 4.5.3.2.7	IEC 60794-1-2, method F1	
Ageing	9.6			
- coating adhesion stability	9.6.1	According to DS	IEC 60794-1-2, method E5	
- finished cable	9.6.2	Under consideration		
Water penetration	9.7	According to DS	IEC 60794-1-2, method F5A, F5B	
Pneumatic resistance	9.8	According to DS (under consideration)	IEC 60794-1-2, method F6	
Induced voltage (for cables with metallic elements)	9.9	Under consideration	IEC 62305-1	
Mould growth	Under consideration	Under consideration	Under consideration	

4.5.3.2 Details of family requirements and test conditions for drinking water pipe cables

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 uncertainty of measurement for this standard shall be < 0,05 dB for attenuation.

Tests shall be selected from those of Table 11and the following hereinafter described.

4.5.3.2.1 Tensile performance

a) Family requirements

Under long term tensile load (T_L) the fibre strain shall not exceed 20 % of the fibre proof strain and there shall be no change in attenuation during the test. Under installation load (T_M) the fibre strain shall not exceed 60 % of the fibre proof strain and the attenuation change during test shall be measured and recorded. Other criteria may be agreed between the customer and the supplier.

Under visual examination without magnification, there shall be no damage to the sheath or to the cable elements.

There shall be no change after test in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer, at room temperature.

b) Test conditions

Method:	IEC 60794-1-2, E1A and E1B
Cable length under tension:	not less than 50 m. Taking into account the measurement accuracy and end effects, shorter lengths may be used by agreement between the customer and the supplier
Fibre length:	finished cable length
Tensile load on cable:	long term tensile load (T_L) and installation load (T_M). Other loads may be applied in accordance with particular user conditions
Diameter of test pulleys:	1 m but not less than the minimum loaded bending diameter specified for the cable
T_M:	equivalent to weight of 1 km of drinking water pipe cable or 50 N whichever is greater
T_L:	equivalent to weight of 500 m of drinking water pipe cable or 25 N whichever is greater (ffs)

4.5.3.2.2 Repeated bending

a) Family requirements

Under visual examination without magnification, there shall be no damage to the sheath and to the cable elements.

b) Test conditions

Method:	IEC 60794-1-2, E6
Bending radius:	20 *d* or 30 mm whichever is greater
Load:	adequate to assure uniform contact with the mandrel
Number of cycles:	25
Duration of cycle:	approximately 2 s

4.5.3.2.3 Torsion

a) Family requirements

Under visual examination without magnification, there shall be no damage to the sheath or to the cable elements.

The variation on attenuation for each fibre shall be less than, or equal to, 0,10 dB at 1 550 nm, or at the operational wavelength when specified by the customer.

There shall be no permanent change in attenuation after the test.

b) Test conditions

Method:	IEC 60794-1-2, E7
Length under test:	2 m
Number of turns:	one half turn (through 180°) over the length of 2 m in each direction
Number of cycles:	5

4.5.3.2.4 Bend

a) Family requirements

There shall be no change in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer, at room temperature.

The change in attenuation when tested at –30 °C shall be ≤ 0,1 dB if required.

b) Test conditions

Method:	IEC 60794-1-2, E11
Diameter of mandrel:	≤ 40 *d* or 60 mm whichever is greater
Number of turns/helix:	4
Number of cycles:	3

4.5.3.2.5 Crush

a) Family requirements

Immediately after removal of load, there shall be no increase in attenuation when measured in the 1 550 nm region or at the operational wavelength when specified by the customer.

Under visual examination, there shall be no damage to the sheath or to the cable elements after removing load. The imprint of the plate or mandrel on the sheath is not considered mechanical damage.

b) Test conditions

Method:	IEC 60794-1-2, E3
Load (plate/plate):	2 500 N
Duration of load:	1 min

4.5.3.2.6 Impact

a) Family requirements

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

b) Test conditions:

Striking surface radius:	10 mm
Impact energy:	10 J with striking surface radius of 10 mm
Number of impacts:	one in 3 different places spaced not less than 500 mm apart

Under visual examination without magnification, there shall be no damage to the sheath or to the cable elements. The imprint of the anvil on the sheath is not considered as a mechanical damage.

4.5.3.2.7 Temperature cycling

a) Family requirements

During the last cycle, there shall be no change in attenuation between the initial room temperature measurement and T_{A1} or T_{B1}. For 1 625 nm applications, performance criteria shall be mutually agreed upon between the customer and supplier.

During the last cycle, the attenuation change from the room temperature measurement and T_{A2} or T_{B2} shall be < 0,15 dB/km at 1 550 nm. For 1 625 nm applications, performance criteria shall be mutually agreed upon between the customer and supplier. On completion of the test, there shall be no change in attenuation.

Definition of a cycle: T_{B2} to T_{A2}

Definition of the last cycle: T_{A2}, T_{A1}, T_{B1}, T_{B2} with a final measurement at room temperature

b) Test conditions

Sample length: finished cable length of at least 1 000 m

High temperature, T_{B2}: +60 °C to +70 °C, depending on customer requirements

High temperature, T_{B1}: +30 °C to +60 °C, depending on customer requirements

Low temperature, T_{A1}: –10 °C to –15 °C, depending on customer requirements

Low temperature, T_{A2}: T_{A1} to –40 or –45 °C, depending on customer requirements

Rate of heating: sufficiently slow that the effect of changing the cooling temperature does not cause temperature shock

t_1: temperature cycling test dwell time to stable temperature when it is reached

Number of cycles: 2, but additional cycles may be required in accordance with particular customer requirements

Annex A
(informative)

Blank detail specification

A.1 Drinking water pipe cables description

A.1.1 Cable for installation within subducts (previously installed into the drinking water pipe in between two adjacent I/O-ports)

Such drinking water pipe cable has to be blown or pulled into the subduct described in 4.2.2.

Table A.1 – Cable for installation within subducts

(1) Prepared by		(2) Document No.: Issue: Date:
(3) Available from	(4) Generic specifications: IEC 60794-1-1 and IEC 60794-1-2 Sectional specification: IEC 60794-3	
(5) Additional references:		
Construction - Tube – filled Inner sheath (optional) Additional armouring - Non-metallic armouring Metallic armouring Outer sheath Marking identification - Customer requirement - Identification of supplier		Additional remarks
(8) Application information:		
Maximum outer diameter (*d)* Rated maximum tensile load Minimum bending radius for no-load bending Minimum bending radius for rated-load bending Temperature range: - Transport and storage - Installation - Operation Delivery length - Typical - Nominal/tolerances		

A.1.2 Cables for direct installation into the drinking water pipes

Such cables are directly installed into the drinking water pipes with the help of a proper flow of water using a stabilized parachute within the drinking water pipe or other suitable techniques.

The cable should have a low coefficient of friction with respect to the inner surface of the drinking water pipe which consists of steel, cast iron and/or PE.

Table A.2 – Cables for direct installation into the drinking water pipes

(1) Prepared by		(2) Document No.: Issue: Date:
(3) Available from	(4) Generic specifications: IEC 60794-1-1 and IEC 60794-1-2 Sectional specification: IEC 60794-3	
(5) Additional references:		
Construction - Tube – filled Additional armouring - Non-metallic armouring Metallic armouring Outer sheath Additional outer sheath - Marking identification - Customer requirement - Identification of supplier		Additional remarks
(8) Application information:		
Maximum outer diameter (*d*) Rated maximum tensile load Minimum bending radius for no-load bending Minimum bending radius for rated-load bending Temperature range: - Transport and storage - Installation - Operation Delivery length - Typical - Nominal/tolerances		

A.2 Subduct description

Such subducts are directly inserted into the inner space of the drinking water pipe guided by guide tubes to the bottom of the drinking water pipe.

Table A.3 – Subduct description

(1) Prepared by		(2) Document No.: Issue: Date:
(3) Available from	(4) Generic specifications: IEC 60794-1-1 and IEC 60794-1-2 Sectional specification: IEC 60794-3 (all as applicable to sub-ducts)	
(5) Additional references:		
Construction - Single layer wall - Double layer wall Additional armouring - Metallic/non metallic Additional outer sheath - Marking identification - Customer requirement - Identification of the supplier		
8) Application information:		
Maximum outer diameter (*d*) Rated maximum tensile load Minimum bending radius for no-load bending Minimum bending radius for rated-load bending Temperature range: - Transport and storage - Installation - Operation Delivery subduct length - Typical - Nominal/tolerances		

Annex B
(informative)

OF cables for drinking water pipes

Table B.1 – OF cables for drinking water pipes

Cable characteristics versus cable installation methods	**Installation within subducts previously installed into the drinking water pipes**	**Direct installation into the drinking water pipes between two I/O ports**
International specification No.	IEC 60794-3-10	IEC 60794-3
Dimensions max. outer diameter [a]	< 18 mm	< 18 mm
Additional requirements besides the International specification		
Preferential environmental protection	Metallic SPL / APL sheath	Metallic SPL / APL / Al sheath
Need for food and drinkable water contact approval	YES	YES
[a] Cable / subducts maximum outer diameter should also be agreed case by case between the cable supplier and the customer.		

Annex C
(informative)

Examples of subducts and drinking water pipe cables

C.1 Cables for installation in subducts within drinking water pipes

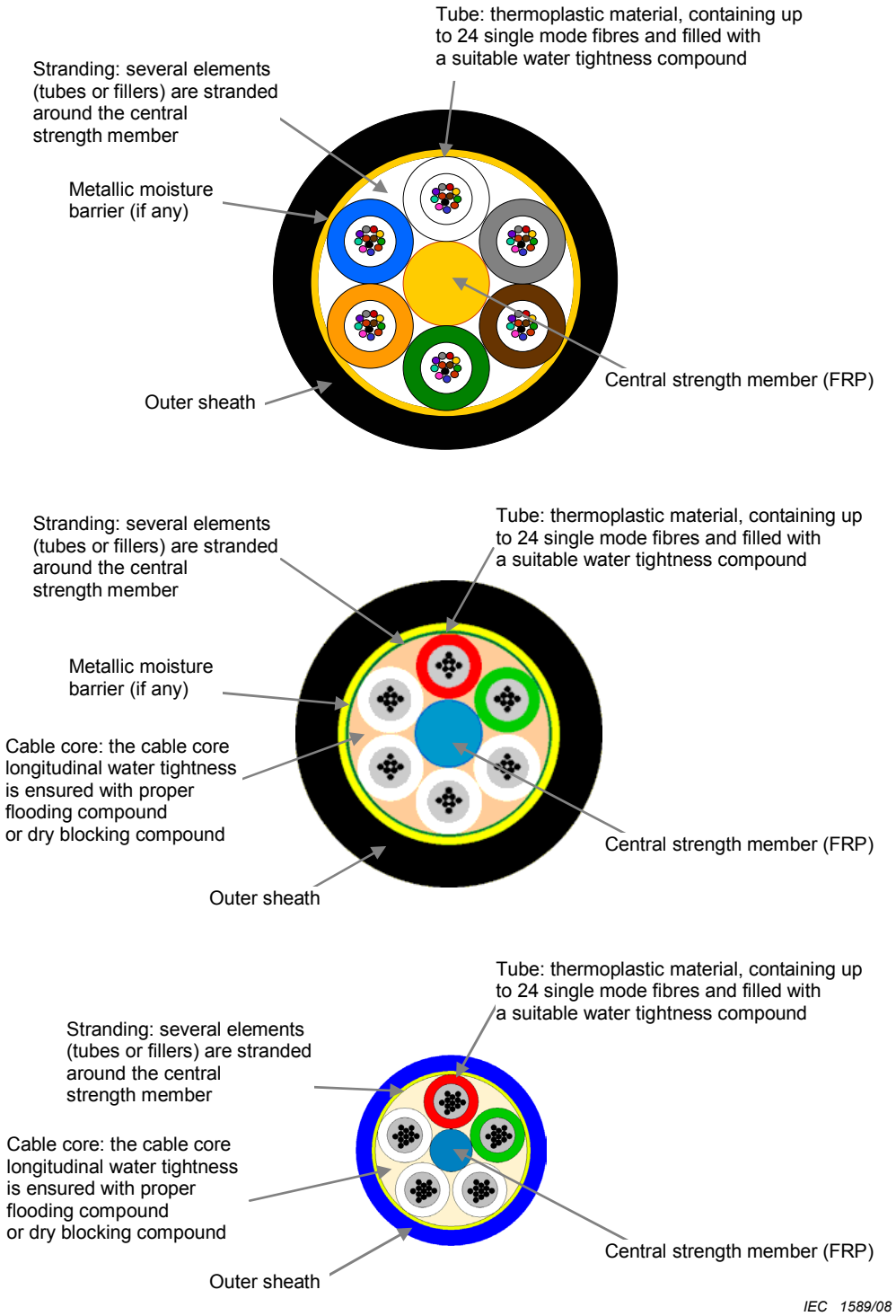


Figure C.1 – Examples of constructions of cables for installation in subducts within drinking water pipes

C.2 Cables for direct installation into drinking water pipes

C.2.1 Drinking water pipe cables

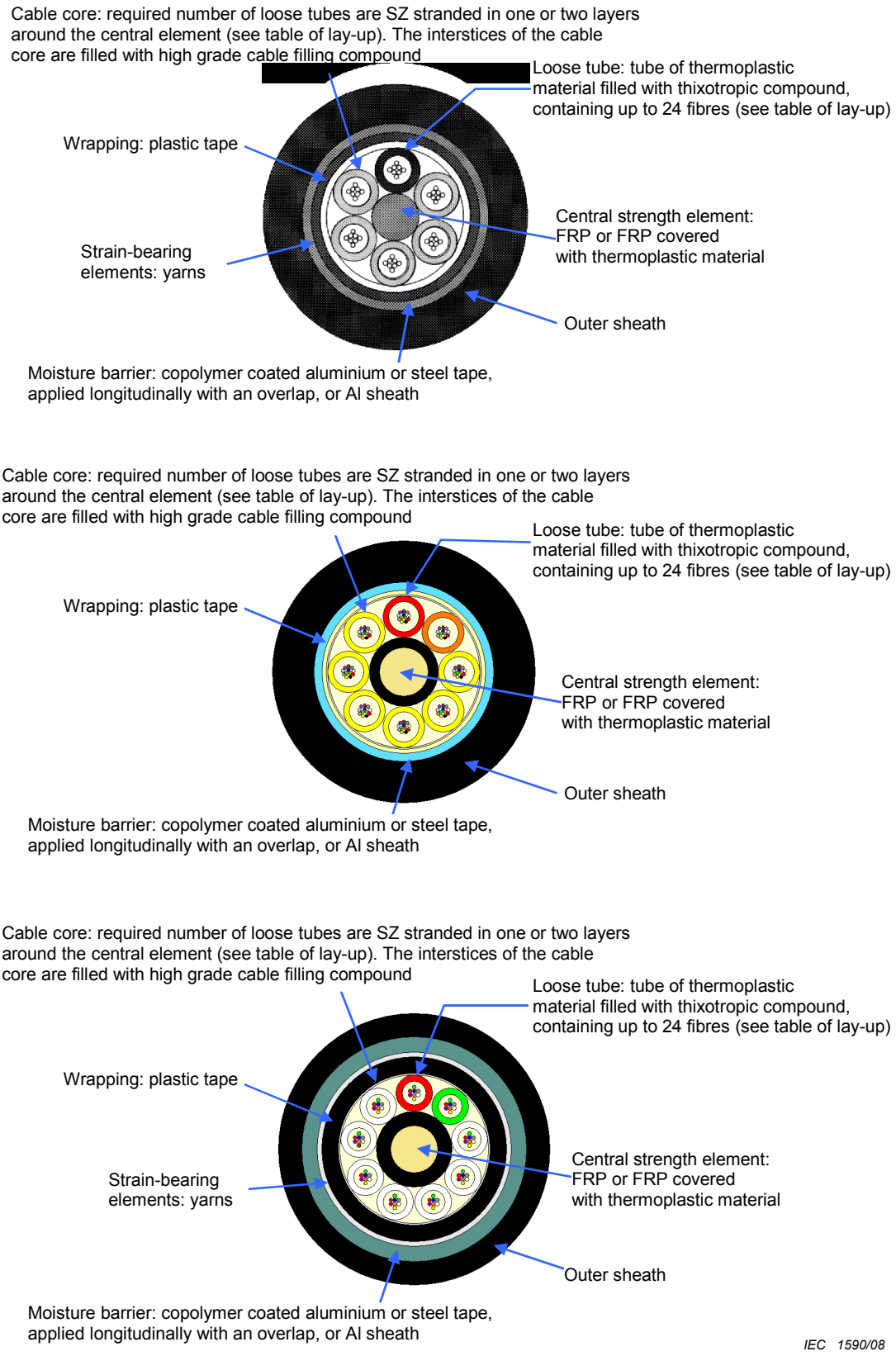


Figure C.2 – Examples of constructions for drinking water pipe cables

Annex D
(informative)

Example for installation schemes of optical fibre cables in drinking water pipes (Fibre in drinking water pipes)

D.1 Steel – drinking water pipes

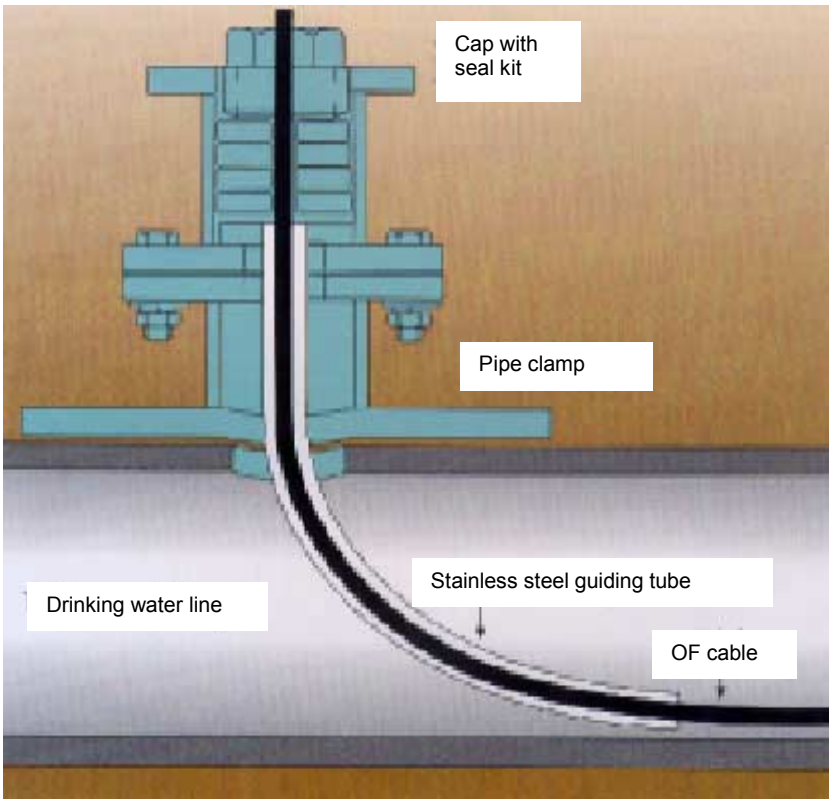
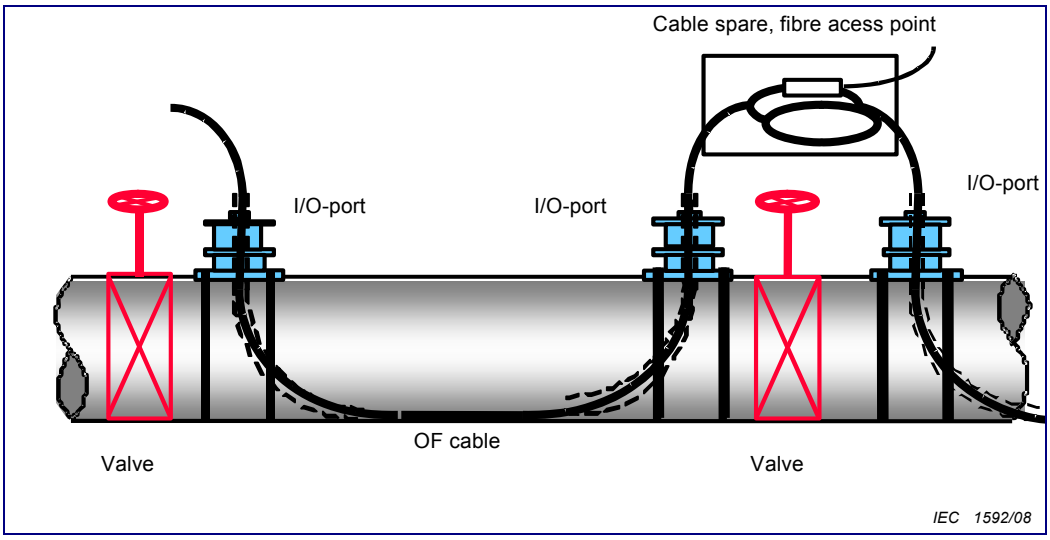


Figure D.1 – Schematic drawing – I/O-port for OF cables into drinking water lines



Explanation

– a pipe clamp with the cap housing the seal kit is used as I/O-port;

– the OF cable is guided by a bent steel tube to the bottom of the line;

– the spare cable bypassing the valve is a potential fibre access point.

Figure D.2 – Schematic drawing – Installation of OF cables in drinking water lines

D.2 PE – drinking water pipes

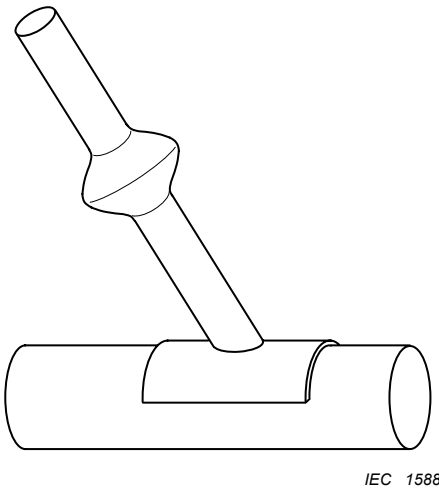


Figure D.3 – Installation of I/O-ports on high pressure PE drinking water pipes

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