IEC 60794-5-10

Edition 1.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Optical fibre cables –
Part 5–10: Family specification – Outdoor microduct optical fibre cables, microducts and protected microducts for installation by blowing

Câbles à fibres optiques –
Partie 5–10: Spécification de famille – Câbles extérieurs à fibres optiques en micro-conduit, micro-conduits et micro-conduits protégés pour installation par soufflage

IEC 60794-5-10:2014-02(EN-FR)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

V

ICS 33.180.01, 33.180.10

ISBN 978-2-8322-1374-2

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OPTICAL FIBRE CABLES –

Part 5–10: Family specification – Outdoor microduct optical fibre cables, microducts and protected microducts for installation by blowing

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CDV	Report on voting
86A/1496/CDV	86A/1542/RVC

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.

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OPTICAL FIBRE CABLES –

Part 5-10: Family specification – Outdoor microduct optical fibre cables, microducts and protected microducts for installation by blowing

1 Scope

This part of IEC 60794 is a family specification that covers outdoor microduct optical fibre cables for installation by blowing and the associated microducts, which together make up a microduct optical fibre cable system. Although primarily designed for use with outdoor microduct applications, the cable products specified herein may be used individually for short lengths in other applications as agreed upon between supplier and customer. These may include short runs inside a building or in other outdoor applications, such as a transition between separate (unconnected) microduct systems, or from a microduct system to some other protective structure such as a cable conduit or tray.

Systems built with components covered by this standard are subject to the requirements of IEC 60794-5 where applicable.

Annex A shows examples of microduct optical fibre cables and microducts. Annex B describes a blank detail specification for outdoor microduct optical fibre cables and the associated microducts, and incorporates some minimum requirements. Detail product specifications may be prepared on the basis of this family specification using Annex B as a guide. Annex C provides normative requirements for microduct optical fibre cables.

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 and microducts tested shall be representative of the microduct optical fibre cable design and should be agreed between customer and supplier.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60793-2-10, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

IEC 60793-2-50, *Optical fibres – Part 2-50: Products specification – Sectional specification for class B single-mode fibres*

IEC 60794 (all parts), *Optical fibre cables*

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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 60794-1-22:2012, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods*

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements test methods*

IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical test methods*[1]

IEC 60794-2, *Optical fibre cables – Part 2: Indoor optical fibre cables – Sectional specification*

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

IEC 60794-4, *Optical fibre cables – Part 4: Sectional specification – Aerial optical cables along electrical power lines*

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

IEC 60794-5-20, *Optical fibre cables – Part 5-20: Family specification – Outdoor microduct fibre units, microducts and protected microducts for installation by blowing*[1]

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

IEC 60811-601, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 601: Physical tests – Measurement of the drop-point of filling compounds*

IEC 60811-602, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 602: Physical tests – Separation of oil in filling compounds*

IEC 60811-604, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 604: Physical tests – Measurement of absence of corrosive components in filling compounds*

ISO/IEC 11801, *Information technology − Generic cabling for customer premises*

3 Symbols

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

ΔD	Minimum wall thickness
ΔD’	Minimum thickness of the outer sheath of the protected microduct
d	Nominal outer diameter of the microduct cable

[1] To be published.

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DS	Detail specification
ID	Nominal inner diameter of the microduct
OD	Nominal outer diameter of the microduct
OD’	Nominal outer diameter of the protected microduct
T_{A1}	Temperature cycling test low-temperature limit (usage and storage) according to IEC 60794-1-22, Method F1
T_{A2}	Temperature cycling test secondary low-temperature limit for extended storage temperature range according to IEC 60794-1-22, Method F1
T_{B1}	Temperature cycling test high-temperature limit (usage and storage) according to IEC 60794-1-22, Method F1
T_{B2}	Temperature cycling test secondary high-temperature limit for extended storage temperature range according to IEC 60794-1-22, Method F1
t_1	Temperature cycling dwell time
$n \times d$	The product of a variable and the cable outer diameter used for determining appropriate sizes for bends, mandrels, etc.
$n \times OD$	The product of a variable and the outer diameter of the microduct used for determining appropriate sizes for bends, mandrels, etc.
$n \times OD'$	The product of a variable and the outer diameter of the protected microduct used for determining appropriate sizes for bends, mandrels, etc.
W	Weight of 1 km of microduct, protected microduct or microduct optical fibre cable

4 General requirements

4.1 Construction

4.1.1 General

In addition to the construction requirements of IEC 60794-5, where applicable, the following considerations apply to outdoor microduct optical fibre cables and their corresponding microducts and protected microducts.

The products covered in this specification shall be designed and manufactured for expected operating lifetimes of at least 20 years. The microduct optical fibre cables are designed to be installed in microducts or protected microducts and in appropriate housings. The microducts and protected microducts that are compatible for use with microduct optical fibre cables are defined in this standard. Microduct optical fibre cables are optimized for installation and operational life in these microducts.

It shall be possible to install or remove the microduct optical fibre cable from microduct or protected microduct by blowing during the operational lifetime, except under the following conditions:

a) products are compromised by multiple installation or removal operations;

b) microducts fouled with sediment, debris or other foreign matter due to inadequate maintenance;

c) microducts subsequently damaged by extrinsic factors such as diggings, earth upheavals, etc.

In such cases, the affected section of microduct shall be cleared or repaired, or products replaced prior to any microduct cable installations.

The microduct fitness should be verified with dimensional clearance and static pressure testing of the microduct route.

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The materials in the microduct optical fibre cable, microduct or protected microduct shall not present a health hazard within its intended use.

4.1.2 Microduct optical fibre cables

Microduct optical fibre cables are suitable for installation by blowing into a microduct. Although not specifically addressed by cable products specifications such as IEC 60794-2, IEC 60794-3 or IEC 60794-4, cable products specifically designed for installation by blowing into microducts may also comply with other such industry standards and specifications. However, they are often not as mechanically robust as traditional outdoor optical fibre cables and, therefore, require the use of suitable installation and handling practices to prevent damage. Ad hoc installation practices could degrade optical performance or reduce the products' operating lifetimes.

4.1.3 Microduct

A microduct suitable for installation of microduct cables is a small, flexible, lightweight tube with an outer diameter typically less than 16 mm. Compared to microduct fibre units (see IEC 60794-5-20), microduct cables are more mechanically robust, but they place greater reliance on microducts and protected microducts or appropriate closures to provide mechanical protection than do traditional cables. Therefore, a microduct shall meet the realistic impact, compression and bending requirements for an application. A protected microduct may be required.

Microducts shall be able to resist pressure differences needed for installation by blowing. The microducts shall be circular and uniform in cross-section throughout their length and their inner surface may have a low coefficient of friction. Inner and outer diameters shall be specified. As an option, a supplier may provide a special lining or lubricating coating on the interior of the microduct to aid installation. These layers should not reduce the specified inside diameter of the microduct.

Microducts generally are intended for benign installation within ducts or as components within a protected microduct as described in 4.1.1.3. In all cases, it shall be possible to identify each individual microduct throughout its length. When using colours they shall conform to IEC 60304.

Microducts installed outdoors and not occupied shall be sealed at each end to prevent the introduction of moisture, debris, insects or other such foreign contaminants that could subsequently hinder the successful installation of cable. Microducts installed outdoors and not immediately occupied shall be tested for obstruction prior to use.

4.1.4 Protected microduct

A protected microduct is one or more microducts surrounded by a protective sheath, a larger protective duct and/or an integral thick sheath such that it complies with the requirements of Clause 7. A protected microduct can provide additional crush and impact protection compared to a stand-alone microduct. This additional protection may be needed for a specific operating environment or installation method. The protective sheath may include an integrated layer of armouring or thicker outer sheath. In all cases, it shall be possible to identify each individual microduct throughout its length. When using colours, they shall conform to IEC 60304.

4.1.5 Microduct fittings

Microduct fittings are components needed to physically align, connect and seal the junction between two or more sections of microduct, or to connect microduct to hardware. Multiple microducts may be connected in series in order to support extended microduct cable installation distances, or connected in a branch-type configuration with multiple output termini for a given input, within the same system. The latter may be employed in campus type local area networks (LANs) or fibre-to-the-premises (FTTP) applications to allow for additional flexibility that can support frequent changes to the physical optical distribution system.

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Fittings should be appropriate to the microduct construction. Mechanical and environmental performance requirements of fittings may also require that such be tested while attached to sections of ducting (or hardware) to ensure intermateability and operational compatibility. The specific physical and material attributes of any fittings used should be agreed between customer and supplier.

Microduct fittings shall be able to resist pressure differences needed for installing microduct cables by blowing. Fittings shall allow for the smooth transition of microduct cables between successive sections of microduct, or between microducts and hardware, and shall be constructed and installed to prevent jamming of the microduct cable at splice, branch or other connection points under maximum installation pressures.

Successive sections of microduct may also be welded or otherwise secured together along the same longitudinal axis without the use of mechanical fittings. Such junctions shall meet the same mechanical and dimensional requirements as for joints made using mechanical fittings.

Translucent or transparent materials may be used to support the identification of populated microducts, and for troubleshooting installation related issues.

4.1.6 Microduct hardware

Microduct hardware includes the housings and closures that support the termination of microduct cables, to include splicing or connectorization. Because microduct cables are generally compatible with traditional outdoor fibre optic cable hardware, accounting for the relatively small size, no specific requirements for microduct hardware are included herein. In some applications, it may be appropriate to use hardware that is compatible with the microducts in order to create a sealed microduct cabling system. One example is when empty microducts are pre-installed in hardware to support future microduct cable placement.

4.2 Optical fibres

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

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

The transmission performance shall be in accordance with Annex D.

4.3 Installation performance tests

4.3.1 Installation conditions

A test route may be used to verify the field performance of a microduct cable, microduct, and/or protected microduct as agreed between customer and supplier. Ambient conditions can affect installation performance and therefore should be monitored. Alternately, the supplier can provide performance data from a specified test route under specific ambient conditions using a specified installation method.

Verifying that a microduct cable or microduct can be installed using a blown installation technique is critical. Any installation performance requirement shall be agreed upon between customer and supplier.

4.3.2 Tests applicable

The tests that are applicable for installation performance are given in Table 1.

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Table 1 – Tests applicable for installation performance

Characteristics	Family requirements	Test methods	Remarks
General requirements	Agreement between customer and supplier		
Route verification test	Agreement between customer and supplier	IEC 60794-1-21, Method E23	
Installation test	Agreement between customer and supplier	IEC 60794-1-21, Method E24	

4.4 Mechanical and environmental tests

Based on the expected operating conditions over the life of the product, including the mechanical loads exerted on the product during installation, the following sections specify product performance for microduct cables, microducts and protected microducts.

5 Microduct optical fibre cable

5.1 Tests applicable

The tests that are applicable for mechanical and environmental performance are given in Table 2.

Table 2 – Tests applicable for mechanical and environmental performance of microduct cable

Characteristics	Family requirements	Test methods	Remarks
Tensile performance	5.2	IEC 60794-1-21, Method E1	
Crush	5.3	IEC 60794-1-21, Method E3	
Impact	5.4	IEC 60794-1-21, Method E4	
Repeated bending	5.5	IEC 60794-1-21, Method E6	
Torsion	5.6	IEC 60794-1-21, Method E7	
Kink	5.7	IEC 60794-1-21, Method E10	
Bend	5.8	IEC 60794-1-21, Method E11B	
Temperature cycling	5.9	IEC 60794-1-22, Method F1	
Water penetration	5.10	IEC 60794-1-22, Method F5B	
Ageing	5.11	IEC 60794-1-22, Method F9	
Fibre ribbons (if used)			
Ribbon stripping	5.12	IEC 60794-1-21, Method E5B	
Separability of individual fibres from ribbon	5.13	IEC 60794-1-23, Method G5	

5.2 Tensile performance

a) Family requirements

Under short-term tensile load the fibre strain shall not exceed 60 % of the fibre proof strain. After removal of load, there shall be no change in attenuation. Other criteria may be agreed between customer and supplier.

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

b) Test conditions

Method:	IEC 60794-1-21, Method E1
Length under tension:	Not less than 50 m. Shorter lengths may be used by agreement between customer and supplier, taking into account the measurement accuracy and end effects
Fibre length:	Finished cable length
Tensile load on cable:	1 × W
Diameter of test pulleys:	Not less than the minimum loaded bending diameter specified for the microduct optical fibre cable

5.3 Crush

a) Family requirements

After removal of the short-term load, there shall be no change in attenuation. Under visual examination, there shall be no damage to the microduct cable. The imprint of the plate or mandrel on the microduct cable is not considered mechanical damage.

b) Test conditions

Method:	IEC 60794-1-21, Method E3A
Load (plate/plate):	500 N
Duration of load:	1 min

5.4 Impact

a) Family requirements

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

The residual increase in attenuation shall be <0,1 dB at 1 550 nm.

b) Test conditions

Method:	IEC 60794-1-21, Method E4
Number of impacts:	One in 3 different places spaced not less than 500 mm apart
Striking surface radius:	300 mm
Impact energy:	1 J

5.5 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 60794-1-21, Method E6
Bending diameter:	40 × d
Load:	Adequate to assure uniform contact with the mandrel
Number of cycles:	25

5.6 Torsion

a) Family requirements

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

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There shall be no change in attenuation after the test.

b) Test conditions

Method: IEC 60794-1-21, Method E7

Length under test: 2 m

5.7 Kink

a) Family requirements

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

b) Test conditions

Method: IEC 60794-1-21, Method E10

Minimum diameter: 40 × d

5.8 Bend

a) Family requirements

There shall be no change in attenuation after the test when measured at room temperature.

If required, the change in attenuation when tested at –30 °C shall be ≤0,1 dB for single-mode fibre and <=0,4 dB for multimode fibre.

b) Test conditions

Method: IEC 60794-1-21, Method E11A

Diameter of mandrel: 40 × d

Number of turns/helix: 4

Number of cycles: 3

5.9 Temperature cycling

a) Family requirements

Attenuation measurements shall be taken during the last cycle.

For T_{A1} to T_{B1} there shall be no change in attenuation as defined in IEC 60794-1-1.

For T_{A1} to T_{A2} and T_{B1} to T_{B2}, the change in attenuation coefficient shall be:

– ≤0,15 dB/km for single-mode fibre and shall be reversible to measurement uncertainty when measured in the 1 550 nm region.

– ≤0,3 dB/km for multimode fibre and shall be reversible to measurement uncertainty when measured in the 1 300 nm region.

b) Test conditions

Method: IEC 60794-1-22, Method F1

Sample length under test: Finished microduct cable, length of at least 1 000 m.

High temperature, TB2: +60 °C to +70 °C, depending on customer requirements.

High temperature, TB1: +30 °C to +60 °C depending on customer requirements.

Low temperature, TA1: –15 °C.

Low temperature, TA2: TA1 to –30 °C or –40 °C depending on customer requirements.

NOTE Other temperature values corresponding to specific climate conditions can be agreed between supplier and customer.

Number of cycles: 2

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5.10 Water penetration

a) Family requirements

The cable shall not propagate water longitudinally according to requirements of IEC 60794-1-2, Method F5B.

b) Test conditions

Method: IEC 60794-1-22, Method F5B

5.11 Ageing

a) Family requirements: according to 11.5 of IEC 60794-1-22:2012, Method F9

b) Test conditions

Method: IEC 60794-1-22, Method F9

5.12 Ribbon strippability

a) Family requirements

At least 25 mm of the ribbon matrix and the fibres' protective coatings shall be removable with commercially available stripping tools with no fibre breakage. Any remaining coating residue shall be readily removable using isopropyl alcohol wipes.

b) Test conditions

Method: IEC 60794-1-21, Method E5B

5.13 Fibre ribbon separability

a) Family requirements

Maximum tear force 4,4 N

b) Test conditions

Method: IEC 60794-1-22, Method G5

6 Microduct

6.1 Tests applicable

Tests shall be selected from Table 3, in accordance with the relevant product specification. If the microduct is only to be used in a protected microduct, some tests may not be relevant.

Table 3 – Tests applicable for mechanical and environmental performance of a microduct

Characteristics	Family requirements	Test methods	Remarks
Tensile performance	6.2	Under consideration, IEC 60794-1-21 Method E1	
Crush	6.3	IEC 60794-1-21 Method E3A	
Impact	6.4	Under consideration, IEC 60794-1-21 Method E4	
Repeated bending	6.5	IEC 60794-1-21 Method E6	
Torsion	6.6	IEC 60794-1-21 Method E7	
Kink	6.7	IEC 60794-1-21 Method E10	

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Characteristics	Family requirements	Test methods	Remarks
Bend	6.8	IEC 60794-1-21 Method E11B	
Microduct route verification test	6.9	IEC 60794-1-21, Method E23	
Microduct pressure withstand	6.10	IEC 60794-1-22, Method F13	
Ageing	6.11	Under consideration	

6.2 Tensile performance

a) Family requirements

Under visual examination without magnification there shall be no damage after the test and the microduct shall pass the inner clearance test (Annex E).

b) Test conditions

Method: Generally IEC 60794-1-21, Method E1

NOTE Use of IEC 60811-501 is under consideration.

Microduct length under tension: >1 m

Tensile load on microduct: 1 × W

Duration of load: 10 min

6.3 Crush

a) Family requirements

Under visual examination, without magnification, there shall be no damage to the microduct. After the recovery time, the microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage. The imprint of the plate is not considered as mechanical damage.

b) Test conditions

Method: IEC 60794-1-21, Method E3A

Sample length: 250 mm

Load (plate/plate): 500 N

Duration time: 1 min

Recovery time: 1 h

6.4 Impact

a) Family requirements

Under visual examination without magnification there shall be no damage to the microducts. The microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage. The imprint of the striking surface on the microduct is not considered mechanical damage.

b) Test conditions

Method: IEC 60794-1-21, Method E4

Striking surface radius: 300 mm

Impact energy: 1 J

Recovery time: 1 h

Number of impacts: One in 3 different places spread not less than 500 mm apart

6.5 Repeated bending

a) Family requirements

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Under visual examination without magnification there shall be no damage to the microducts. The microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage.

b) Test conditions

Method:	IEC 60794-1-21, Method E6
Bending diameter:	40 × OD
Load:	Adequate to assure uniform contact with the mandrel
Number of cycles:	25

6.6 Torsion

a) Family requirements

Under visual examination without magnification there shall be no damage to the microducts. The microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage.

b) Test conditions

Method:	IEC 60794-1-2, Method E7
Maximum gauge length:	2 m

6.7 Kink

a) Family requirements

Under visual examination, without magnification, there shall be no damage to the microducts after the test and shall pass the inner clearance test (Annex E). The microduct shall attain the required minimum diameter without kinking.

b) Test conditions

Method:	IEC 60794-1-21, Method E10
Minimum diameter:	20 × OD

6.8 Bend

a) Family requirements

The outer and inner diameter of the microducts shall show, under visual examination without magnification, no damage and after the test and shall pass the inner clearance test (Annex E).

b) Test conditions

Method:	IEC 60794-1-21, Method E11B
Diameter of mandrel:	40 × OD
Number of cycles:	3

6.9 Microduct route verification test

a) Family requirements

Objects of the required size can be passed through the microduct.

b) Test conditions

Method:	IEC 60794-1-21, Method E23

6.10 Microduct pressure withstand

a) Family requirements

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

b) Test conditions

Method:	IEC 60794-1-22, Method F13

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All microducts shall resist an air pressure of at least 2,5 × the installation pressure at a temperature of 20 °C for a period of 0,5 h.

All microducts shall resist a proof test pressure of at least 1,3 × the installation pressure at a temperature of 40 °C for a period of 24 h.

6.11 Ageing

a) Family requirements

Tests to be performed after the aging period should be agreed between the customer and supplier and may include dimensions, inner clearance test, shrinkage, changes to surface finish, pressurization or installation test of the microduct cable.

b) Test conditions

Method: Under consideration

Ageing condition: Under consideration (+60 °C for 3 months; 7 days at 70 °C; 7 days at 85 °C)

7 Protected microduct(s)

7.1 Tests applicable

Tests shall be selected from Table 4, in accordance with the relevant product specification.

Table 4 – Tests applicable for mechanical and environmental performance of a protected microduct

Characteristics	Family requirements	Test methods	Remarks
Tensile performance	7.2	Under consideration, IEC 60794-1-21, Method E1	
Crush	7.3	IEC 60794-1-21, Method E3A	
Impact	7.4	IEC 60794-1-21, Method E4	
Repeated bending	7.5	IEC 60794-1-21, Method E6	
Kink	7.6	IEC 60794-1-21, Method E10	
Bend	7.7	IEC 60794-1-21, Method E11B	
Microduct route verification test	7.8	IEC 60794-1-21, Method E23	
Microduct pressure withstand	7.9	IEC 60794-1-22, Method F13	
Ageing	7.10	Under consideration	

7.2 Tensile performance

a) Family requirements

Under visual examination, without magnification, there shall be no damage after the test and the test shall pass the inner clearance test (Annex E).

b) Test conditions

Method: Generally to IEC 60794-1-21, Method E1

NOTE Use of IEC 60811-501 is under consideration.

Microduct length under tension: >1 m

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Tensile load on microduct:	1 × W
Duration of load:	10 min

7.3 Crush

a) Family requirements

Under visual examination, without magnification, the microduct shall show no damage. After the recovery time the microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage. The imprint of the plate is not considered as mechanical damage.

b) Test conditions

Method:	IEC 60794-1-21, Method E3A
Sample length:	250 mm
Load:	1 kN (duct); 2 kN (buried)
Duration time:	1 min
Recovery time:	1 h

7.4 Impact

a) Family requirements

Under visual examination without magnification there shall be no damage to the microducts. The microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage. The imprint of the striking surface on the microduct is not considered as mechanical damage.

b) Test conditions

Method:	IEC 60794-1-21, Method E4
Striking surface radius:	300 mm
Impact energy:	3 J (duct); 15 J (buried)
Recovery time:	1 h
Number of impacts:	One in 3 different places spread not less than 500 mm apart

7.5 Repeated bending

a) Family requirements

Under visual examination without magnification there shall be no damage to the microducts. The microduct shall pass the inner clearance test (Annex E) and there shall be no splitting or permanent damage.

b) Test conditions

Method:	IEC 60794-1-21, Method E6
Bending diameter:	40 × OD’
Load:	Adequate to assure uniform contact with the mandrel
Number of cycles:	25

7.6 Kink

a) Family requirements

Under visual examination, without magnification, there shall be no damage to the microducts after the test and shall pass the inner clearance test (Annex E).

The microduct shall attain the required minimum diameter without kinking.

b) Test conditions

Method:	IEC 60794-1-21, Method E10
Minimum diameter:	20 × OD’

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