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Optical fibre cables for duct and tunnel application

Recommendation ITU-T L.10

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Summary

Recommendation ITU-T L.10 describes characteristics, construction and test methods of optical fibre cables for duct and tunnel application. First, in order that an optical fibre demonstrates sufficient performance, characteristics that a cable should possess are described. Then, the method of examining whether a cable has the required characteristics is described. Required conditions may differ according to installation environment. Therefore, detailed conditions of experiments need to be agreed upon between user and supplier on the basis of the environment where a cable is used.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.10	1988-11-25		11.1002/1000/1414
2.0	ITU-T L.10	2002-12-22	6	11.1002/1000/6134
3.0	ITU-T L.10	2015-08-13	15	11.1002/1000/12532

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Optical fibre cables for duct and tunnel application

1 Scope

This Recommendation:

– refers to multi-mode graded index and single-mode optical fibre cables to be used for telecommunication networks in ducts and tunnels;

– deals with mechanical and environmental characteristics of the concerned optical fibre cables. The optical fibre dimensional and transmission characteristics, together with their test methods, should comply with one or more of [ITU-T G.651.1], [ITU-T G.652], [ITU-T G.653], [ITU-T G.654], [ITU-T G.655], [ITU-T G.656] and [ITU-T G.657];

– deals with fundamental considerations related to optical fibre cable from the mechanical and environmental points of view.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.650.1] Recommendation ITU-T G.650.1 (2010), *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*.

[ITU-T G.650.2] Recommendation ITU-T G.650.2 (2007), *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable*.

[ITU-T G.650.3] Recommendation ITU-T G.650.3 (2008), *Test methods for installed single-mode optical fibre cable links*.

[ITU-T G.651.1] Recommendation ITU-T G.651.1 (2007), *Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network*.

[ITU-T G.652] Recommendation ITU-T G.652 (2009), *Characteristics of a single-mode optical fibre and cable*.

[ITU-T G.653] Recommendation ITU-T G.653 (2010), *Characteristics of a dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.654] Recommendation ITU-T G.654 (2012), *Characteristics of a cut-off shifted single-mode optical fibre and cable*.

[ITU-T G.655] Recommendation ITU-T G.655 (2009), *Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.656] Recommendation ITU-T G.656 (2010), *Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport*.

[ITU-T G.657] Recommendation ITU-T G.657 (2012), *Characteristics of a bending-loss insensitive single-mode optical fibre and cable for the access network*.

[ITU-T K.29] Recommendation ITU-T K.29 (1992), *Coordinated protection schemes for telecommunication cables below ground*.

[ITU-T K.47] Recommendation ITU-T K.47 (2012), *Protection of telecommunication lines against direct lightning flashes*.

[ITU-T L.1] Recommendation ITU-T L.1 (1988), *Construction, installation and protection of telecommunication cables in public networks*.

[ITU-T L.27] Recommendation ITU-T L.27 (1996), *Method for estimating the concentration of hydrogen in optical fibre cables*.

[ITU-T L.46] Recommendation ITU-T L.46 (2000), *Protection of telecommunication cables and plant from biological attack.*

[IEC 60331-25] IEC 60331-25 (1999), *Tests for electric cables under fire conditions – Circuit integrity – Part 25: Procedures and requirements – Optical fibre cables*.

[IEC 60332-1-2] IEC 60332-1-2 (2004), *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*.

[IEC 60332-3-24] IEC 60332-3-24 (2000), *Tests on electric and optical fibre cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C*.

[IEC 60754-1] IEC 60754-1 (2011), *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*.

[IEC 60754-2] IEC 60754-2 (2011), *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*.

[IEC 60793-1-1] IEC 60793-1-1 (2008), *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*.

[IEC 60793-1-21] IEC 60793-1-21 (2001), *Optical fibres – Part 1-21: Measurement methods and test procedures – Coating geometry*.

[IEC 60793-1-32] IEC 60793-1-32 (2010), *Optical fibres – Part 1-32: Measurement methods and test procedures – Coating strippability*.

[IEC 60793-2-10] IEC 60793-2-10 (2011), *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*.

[IEC 60793-2-50] IEC 60793-2-50 (2012), *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*.

[IEC 60794-1-1] IEC 60794-1-1(2011), *Optical fibre cables – Part 1-1: Generic specification – General*.

[IEC 60794-1-2] IEC 60794-1-2 (2013), *Optical fibre cables – Part 1-2: Generic specification – Cross references table for optical cable test procedures*.

[IEC 60794-1-21] IEC 60794-1-21 (2015), *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*.

[IEC 60794-1-22] IEC 60794-1-22 (2012), *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*.

[IEC 60794-1-23] IEC 60794-1-23 (2012), *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable element test methods*.

[IEC 60794-3] IEC 60794-3 (2014), *Optical fibre cables – Part 3: Outdoor cables – Sectional specification*.

[IEC 60811-202] IEC 60811-202 (2012), *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] IEC 60811-203 (2012), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*.

[IEC 61034-1] IEC 61034-1 (2005), *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*.

[IEC 61034-2] IEC 61034-2 (2005), *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*.

3 Definitions

3.1 Terms defined elsewhere

For the purpose of this Recommendation, the definitions given in [ITU-T G.650.1], [ITU-T G.650.2], [ITU-T G.650.3] and [ITU-T G.651.1] apply.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

SZ Reverse oscillating stranding

5 Conventions

None.

6 Characteristics of optical fibres and cables

6.1 Optical fibre characteristics

Optical fibres should be used as described in [ITU-T G.651.1], [ITU-T G.652], [ITU-T G.653], [ITU-T G.654], [ITU-T G.655], [ITU-T G.656] or [ITU-T G.657].

6.1.1 Transmission characteristics

The typical transmission characteristics are described for each optical fibre in its respective Recommendation. Unless specified otherwise by the users of the Recommendations, those values apply to the corresponding cabled optical fibre.

6.1.2 Fibre microbending

Severe bending of an optical fibre involving local axial displacement of a few micrometres over short distances caused by localized lateral forces along its length is called microbending. This may be caused by manufacturing and installation strains, and also by dimensional variations of cable materials due to temperature changes during operation.

Microbending can cause an increase in optical loss. In order to reduce microbending loss, stress randomly applied to a fibre along its axis should be eliminated during the incorporation of the fibres into the cable, as well as during and after cable installation.

6.1.3 Fibre macrobending

Macrobending is the resulting curvature of an optical fibre after cable manufacture and installation.

Macrobending can cause an increase in optical loss. The optical loss increases if the bending radius is too small.

NOTE – [ITU-T G.657] optical fibres are optimized for reduced macrobending loss.

6.2 Mechanical characteristics

6.2.1 Bending

Under the dynamic conditions encountered during installation, the fibre is subjected to strain from both cable tension and bending. The strength elements in the cable and the installation bend radius must be selected to limit this combined dynamic strain. Any fibre bend radius remaining after cable installation shall be large enough to limit the macrobending loss or long-term strain limiting the lifetime of the fibre.

6.2.2 Tensile strength

Optical fibre cable is subjected to short-term loading during manufacture and installation, and may be affected by continuous static loading and/or cyclic loading during operation (e.g., temperature variation). Changes in the tension of the cable due to the variety of factors encountered during the service life of the cable can cause the differential movement of the cable components. This effect needs to be considered in the cable design. Excessive cable tensile loading increases the optical loss and may cause increased residual strain in the fibre if the cable cannot relax. To avoid this, the maximum tensile strength determined by the cable construction, especially the design of the strength member, should not be exceeded.

NOTE – Where a cable is subjected to permanent loading during its operational life, the fibre should preferably not experience additional strain.

6.2.3 Crush and impact

The cable may be subjected to crush and impact both during installation and operational life.

Crush and impact may increase the optical loss (permanently, or for the period of time during the application of the stress) and excessive stress may lead to fibre fracture.

6.2.4 Torsion

Under dynamic conditions encountered during installation and operation, the cable may be subjected to torsion, resulting in residual strain of the fibres and/or damage to the sheath. If this is the case, the design of the cable should allow a specified number of cable twists per unit length without an increase in fibre loss and/or damage to the sheath.

6.3 Environmental conditions

6.3.1 Hydrogen gas

In the presence of moisture and metallic elements, hydrogen gas may be generated. Hydrogen gas may diffuse into silica glass and increase optical loss. It is recommended that the hydrogen concentration in the cable, as a result of its component parts, should be low enough to ensure that the long-term effects on the increase of optical loss are acceptable. The method for estimating the concentration of hydrogen in optical cables is given by [ITU-T L.27].

By using dynamic gas pressurization and hydrogen absorbing materials, and by careful material selection and construction, the increase in optical loss can be maintained within acceptable limits during service life.

Further information can be found in [b-IEC TR 62690].

6.3.2 Moisture permeation

When moisture permeates the cable sheath and reaches the cable core, the tensile strength of the fibre diminishes, and the average time to static failure will be reduced. To ensure a satisfactory lifetime of the cable, the long-term strain level of the fibre must be limited.

Various materials can be used as barriers to reduce the rate of moisture permeation. A continuous metallic barrier is effective to prevent moisture permeation; a minimum permeation is achieved by a sealed longitudinal overlapped metallic foil (glued, thermowelded or welded). In metal-free cables, filling compounds are effective in preventing longitudinal water propagation, but do not significantly hinder radial moisture permeation through plastic sheaths.

6.3.3 Water penetration

In the event of damage to the cable sheath or to a splice closure, longitudinal penetration of water in a cable core or between sheaths can occur. The penetration of water causes an effect similar to that of moisture. The longitudinal penetration of water should be minimized or, if possible, prevented. In order to prevent longitudinal water penetration within the cable, techniques such as filling the cable core completely with a compound or with discrete water blocks or swellable components (e.g., tapes, roving) are used. In the case of unfilled cables, dry-gas pressurization can be used.

Water in the cable may be frozen and, under some conditions, can cause fibre crushing with a resultant increase in optical loss and possible fibre breakage.

6.3.4 Lightning

Fibre cables containing metallic elements, such as conventional copper pairs or a metallic sheath are susceptible to lightning strikes.

To prevent or minimize lightning damage, consideration should be given to [ITU-T K.29] and [ITU-T K.47].

6.3.5 Biotic damage

The size and deployment of an optical fibre cable makes it vulnerable to many biological attacks.

This topic is covered in [ITU-T L.46].

6.3.6 Vibration

When optical fibre cables are installed on bridges, they will be subject to relatively high amplitude vibrations of various low frequencies, depending on bridge construction and on the type of traffic density. Cables should withstand these vibrations without failure or signal degradation. Care should be exercised, however, in the choice of installation method.

Underground optical fibre cables may be subject to vibrations from traffic, railways, pile-driving and blasting operations. Here again, cables should be able to withstand vibrations generated by these activities without degradation.

A well-established surveillance routine will identify the vibration activity, allowing for a careful choice of route to minimize this type of problem.

6.3.7 Temperature variations

During their operational lifetime, cables may be subjected to severe temperature variations. In these conditions, the increase of attenuation of the fibres shall not exceed the specified limits.

Cable elements can potentially have different thermal expansion coefficients that can cause differing dimensional changes among the cable elements. This can cause attenuation increases of the optical fibres due to microbending or macrobending effects. Therefore, it is necessary to investigate, in advance, the operating temperature range of the location where the cable is to be laid, and to choose a cable design suitable for that environment.

Due to the differing behaviours of cable materials at various temperatures, it is also necessary to specify the installation temperature range.

6.4 Fire safety

Several large-scale communication failures have been known to occur, because of cables burning in tunnels.

Therefore, in many countries, optical cables for tunnel installations are required to meet fire performance requirements. Requirements for fire performance may differ in each country. Optical cables for tunnels should meet fire safety regulations in each country or in accordance with each telecommunication carrier. The following IEC standards should be considered if no fire safety specifications are provided and selected according to the application: [IEC 60331-25], [IEC 60332-1-2], [IEC 60332-3-24], [IEC 60754-1], [IEC 60754-2], [IEC 61034-1] and [IEC 61034-2].

7 Cable construction

7.1 Fibre coatings

7.1.1 Primary coating

Silica fibre itself has an intrinsically high strength, but its strength is reduced by surface flaws. A primary coating must therefore be applied immediately after drawing the fibre to size.

The optical fibre should be proof-tested. In order to guarantee long-term reliability under service conditions, the proof-test strain may be specified, taking into account the permissible strain and required lifetime.

In order to prepare the fibre for splicing, it should be possible to remove the primary coating without damage to the fibre, and without the use of materials or methods considered to be hazardous or dangerous.

The composition of the primary coating, coloured if required, should be considered in relation to any requirements of local light-injection and detection equipment used in conjunction with fibre jointing methods.

Primary-coated fibres shall comply with the relevant optical fibre specifications in [IEC 60793-2-10] and [IEC 60793-2-50].

NOTE 1 – The optical fibres should be proof tested with a strain equivalent to 1 per cent. For certain applications, a larger proof-test strain may be necessary.

NOTE 2 – Further study is required to advise on suitable testing methods for local light-injection and detection.

7.1.2 Secondary or buffer coating

The tight secondary coating of the fibre, if used, should comply with the requirements given in [IEC 60794-3].

NOTE 1 – When a tight secondary coating is used, it may be difficult to use local light-injection and detection equipment associated with fibre jointing methods.

NOTE 2 – Mechanical coupling between fibre and cable should be carefully designed. While quite low coupling may cause fibre movement during the installation process, high coupling may cause high fibre stress when the cable is bent.

7.1.3 Fibre identification

Fibre should be easily identified by colour/tracer/marker and/or position within the cable core. If a colouring method is used, the colours should be clearly distinguishable and have good colour permanence properties, also in the presence of other materials, during the lifetime of the cable.

7.1.4 Removability of coating

The primary and secondary coatings should be easy to remove and should not hinder the splicing, or fitting of fibre to optical connectors.

7.2 Cable elements

The make-up of the cable core – in particular the number of fibres, their method of protection and identification, the location of strength members and metallic wires or pairs – if required, should be clearly defined.

7.2.1 Fibre ribbon

Optical fibre ribbons consist of optical fibres aligned in a row. Optical fibre ribbons are divided into types, based on the method used to bind the fibres. One example is the edge-bonded type, and another is the encapsulated type, as shown in Figures 1 and 2 respectively. In the case of the edge-bonded type, optical fibres are bound by adhesive material located between the optical fibres. When the encapsulated type is adopted, optical fibres are bound by coating material.

If the flexibility of optical fibre ribbons is required for bending, in conjunction with, for example, a small cable diameter or ease of handling in closures, the partially bonded configuration in the longitudinal direction shown in Figure 3 may be optionally adopted for both the edge-bonded and the encapsulated types.

Optical fibre ribbons shall be capable of mass splicing. The fibres of optical fibre ribbons in the as-manufactured configuration shall be parallel and not cross. Each ribbon in a cable is identified by a printed legend or unique colour. Optical fibre ribbons are specified in [IEC 60794-3].

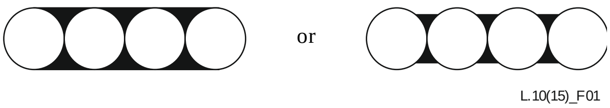

Figure 1 – Cross-section of a typical edge-bonded ribbon

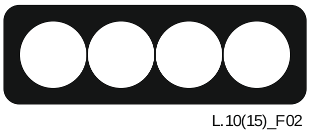

Figure 2 – Cross-section of a typical encapsulated ribbon

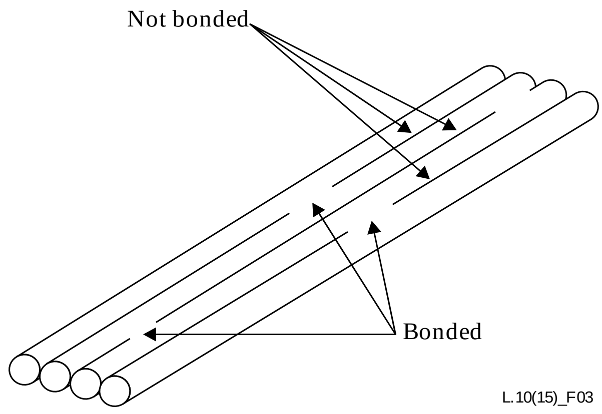

Figure 3 – Example of a typical partially bonded ribbon

7.2.2 Slotted core

In order to avoid direct pressure from the outside of the cable on optical fibres, optical fibres and/or ribbon fibres may be located into slots. Usually, slots are provided in a helical or reverse oscillating stranding (SZ) method configuration on a cylindrical rod. The slotted core usually contains a strength member (metallic or non-metallic). The strength member shall adhere tightly to the slotted core in order to obtain temperature stability and avoid separation when a pulling force is applied during installation. Water-blocking material may be contained in the slots.

7.2.3 Tube

A tube construction, commonly of polymer materials, is frequently used for protecting and gathering optical fibres and/or ribbon fibres. Cable designs incorporating loose tubes are the most widely deployed, offering an optimized package for handling and robustness. They are typically stranded to minimize strain and enable easier mid-span access if the SZ method is utilized. Central tube designs may also be used. Water-blocking material may be contained in the tube, if required.

7.2.4 Micro-module

A micro-module is a thin-walled tubing unit (typically smaller than the tube described in clause 7.2.3). These flexible modules have bending radii similar to the unbundled fibre and are easy to strip without a tool for easy splice preparation and mid-span access. They have no shape memory and may be used directly in an enclosure up to the splicing tray. Water-blocking material may be contained in the micro-module, if required; see Figure 4.

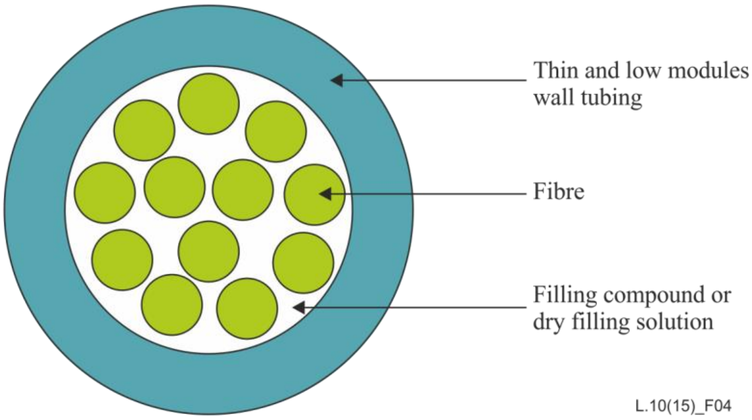

Figure 4 – Example of primary coated fibres protected by micro-module

7.2.5 Strength member

The cable should be designed with sufficient strength members to meet installation and service conditions so that the fibres themselves are not subjected to strain levels in excess of those agreed upon between customer and supplier. The strength member(s) may be either metallic or non-metallic.

When metallic strength members are used, care should be taken to avoid hydrogen generation effects (see clause 6.3.1).

7.2.6 Water-blocking materials

Filling a cable with water-blocking material or wrapping the cable core with layers of water-swellable material are two means of protecting the fibres from water ingress. A water-blocking element (yarns, tapes, filling compound, water-swelling powder or combinations of materials) may be used. Any materials used should not be harmful to personnel. The materials in the cable should be compatible with one another, and in particular should not adversely affect the fibre. These materials should not hinder splicing and/or connection operations.

7.2.7 Pneumatic resistance

If the cable requires dry air pressurization during operation, the pneumatic resistance should be specified.

NOTE – It is intended that a cable can be pressurized only if it allows a flux of air which is in accordance with the criteria defined in Part III of the [b-ITU-T Handbook] (see [ITU-T L.1]).

7.3 Sheath

The cable core shall be covered with a sheath or sheaths suitable for the relevant environmental and mechanical conditions associated with storage, installation and operation. The sheath may be of a composite construction and may include strength members. The selection of the sheath material to optimize the friction forces between the cable sheath and duct should also be considered.

Sheath considerations for optical fibre cables are generally the same as for metallic conductor cables. Consideration should also be given to the amount of hydrogen generated from a metallic moisture barrier (see clause 6.3.1).

NOTE – One of the most commonly used sheath materials is polyethylene. There may, however, be some conditions where it is necessary to use other materials, for example, to limit fire hazards; to protect from rodents and/or termites, etc.

7.4 Armour

Where additional tensile strength or protection from external damage (e.g., crush, impact, rodents) is required armouring should be provided.

Armouring considerations for optical fibre cables are generally the same as for metallic conductor cables. However, hydrogen generation due to corrosion must be taken into consideration. It should be noted that the advantages of optical fibre cables, such as lightness and flexibility, will be reduced when armour is provided.

Armouring for metal-free cables may consist of aramid yarns, glass-fibre-reinforced strands, strapping tape, etc.

7.5 Identification of cable

It is recommended to provide a visual identification of optical fibre cables: this can be done by visibly marking the outer sheath. For identifying cables, embossing, sintering, imprinting, hot foil or ink-jet or laser printing can be used by agreement between user and supplier.

7.6 Cable sealing

It is recommended that an optical fibre cable should be provided with cable end-sealing and protection during cable delivery and storage, as is common for metallic cables. If splicing components have been factory installed, they should be adequately protected. Pulling devices can be fitted to the end of the cable, if required.

7.7 Considerations for duct installation

For installation of duct cables, the filling ratio between duct inner diameter and cable outer diameter shall be considered for determining the sheath outer diameter.

8 Test methods

It is not intended that all tests shall be carried out; the frequency of testing and the relevant severities shall be agreed upon between the customer and supplier.

8.1 Test methods for cable elements

8.1.1 Tests applicable to optical fibres

In this clause, optical fibres test methods related to splicing are described. Mechanical and optical characteristics test methods for optical fibres are described in [ITU-T G.650.1], [ITU-T G.651.1] and [IEC 60793-1-xx] series.

8.1.1.1 Dimensions

For measuring the primary coating diameter, method [IEC 60793-1-21] shall be used.

For measuring tube, slotted core and other ruggedized elements, methods [IEC 60811-202] and [IEC 60811-203] shall be used.

8.1.1.2 Coating strippability

For measuring the strippability of primary or secondary fibre coatings, method [IEC 60793-1-32] shall be used.

8.1.1.3 Compatibility with filling materials

When fibres come into contact with a filling material used for waterproofing, stability of the fibre coating and the filling material should be examined by tests after accelerated ageing.

The stability of the coating stripping force shall be tested in accordance with [IEC 60794-1-21] method E5. Dimensional stability and coating transmissivity should be examined by the test method agreed upon by both user and supplier.

8.1.2 Tests applicable to tubes

8.1.2.1 Tube kink

For measuring kink characteristics of tubes, [IEC 60794-1-23] method G7 shall be used.

8.1.3 Tests applicable to ribbons

8.1.3.1 Dimensions

For measuring ribbon dimensions, three test methods should be used. The first, called a type test, is used to assess and verify the ribbon manufacturing process. The type test shall be carried out in accordance with [IEC 60794-1-23] method G2, the visual measurement method. The two remaining methods are used only for product inspection after the manufacturing process has been carried out. These tests are described in [IEC 60794-1-23] method G3, aperture gauge, and [IEC 60794-1-23] method G4, dial gauge. For inspection purposes, a visual measurement method can also be used.

8.1.3.2 Separability of individual fibres from a ribbon

A separability requirement can be given to a fibre ribbon if agreed upon by user and supplier. When separability is required, the following should be avoided in order to ensure long-term reliability of the fibres:

– damage to mechanical characteristics of fibres;

– removal of the colour coding from each fibre.

In reality, it is difficult to completely avoid such phenomena. However, if the user and supplier agree, [IEC 60794-1-23] method G5 should be used to examine fibre separability. Also, other special test methods can be used when agreed upon between the user and supplier.

8.2 Test methods for mechanical characteristics of the cable

This clause recommends appropriate tests and test methods for verifying the mechanical characteristics of optical fibre cables.

For test methods, reference shall be made to [IEC 60794-1-21]. For specifications, reference is made to appropriate [IEC 60794-3] standards.

8.2.1 Tensile strength

This test method applies to optical fibre cables installed under all environmental conditions.

Measurements are made to examine the behaviour of the fibre attenuation as a function of the load on a cable during installation.

The test shall be carried out in accordance with [IEC 60794-1-21] method E1.

The amount of mechanical decoupling of the fibre and cable can be determined by measuring the fibre strain, using optical phase-shift test equipment, together with the cable elongation. See [IEC 60794-1-21] method E1 for the application of [IEC 60793-1-22] to measure fibre strain in the cable.

This method may be non-destructive if the tension applied is within the operational values.

8.2.2 Bending

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to determine the ability of optical fibre cables to withstand bending around a pulley, simulated by a test mandrel.

This test shall be carried out in accordance with [IEC 60794-1-21] method E11.

8.2.3 Bending under tension

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to determine the ability of an optical fibre cable to withstand bending around rollers or bows during installation, when a specified load is applied.

This test shall be carried out in accordance with [IEC 60794-1-21] method E18A.

8.2.4 Crush

This test method applies to optical fibre cables installed under all environmental conditions.

The appropriate test method for most terrestrial cables is the plate-plate crush method.

This test shall be carried out in accordance with [IEC 60794-1-21] method E3A.

8.2.5 Abrasion

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the permanence of cable printing.

This test shall be carried out in accordance with [IEC 60794-1-21] method E2A.

8.2.6 Torsion

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the ability of optical fibre cables to accommodate torsion associated with normal installation and handling.

This test shall be carried out in accordance with [IEC 60794-1-21] method E7.

8.2.7 Impact

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the ability of optical fibre cables to survive impacts associated with normal installation and handling.

This test shall be carried out in accordance with [IEC 60794-1-21] method E4.

8.2.8 Kink

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the ability of optical fibre cables to undergo normal handling without kinking.

This test shall be carried out in accordance with [IEC 60794-1-21] method E10.

8.2.9 Repeated bending

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the ability of optical fibre cables to undergo repeated bending associated with normal handling and service.

This test shall be carried out in accordance with [IEC 60794-1-21] method E6.

8.3 Test methods for environmental characteristics

This clause recommends the appropriate tests and test methods for verifying the environmental characteristics of optical fibre cables.

For test methods, reference shall be made to [IEC 60794-1-22]. For specifications reference is made to appropriate [IEC 60794-3] standards.

8.3.1 Temperature cycling

This test method applies to optical fibre cables installed under all environmental conditions.

Testing is carried out by temperature cycling to determine the stability of the attenuation of a cable due to temperature changes, which may occur during operation.

This test shall be carried out in accordance with [IEC 60794-1-22] method F1.

8.3.2 Longitudinal water penetration

This test method applies to water-blocked outdoor cables installed under all environmental conditions.

The intention is to check that all the interstices of a cable are sufficiently filled with a compound or water blocking material to prevent water penetration within the cable.

This test shall be carried out in accordance with [IEC 60794-1-22] method F5B or [IEC 60794-1-22] method F5C as appropriate to the design.

8.3.3 Moisture barrier

This test method applies to optical fibre cables installed under all environmental conditions.

This test applies to cables supplied with a longitudinal overlapped metallic foil. The moisture penetration can be tested according to the test method as described in Part I, Chapter III of [b-ITU-T Handbook] (see [ITU-T L.1]).

8.3.4 Freezing

This test method applies to optical fibre cables installed under environmental conditions in which freezing of the ground surrounding the cable may occur.

The purpose of the external freezing test is to simulate freezing of the medium surrounding a buried cable, as in wet earth or water. It is not intended to simulate freezing of a cable in a duct or pipe. This external freezing test is of little use for evaluating outdoor cables, as such cables rarely fail this test. The aggregate of other requirements for outdoor cables results in a cable that is sufficiently robust to easily withstand this test. It may however be useful for evaluating cables that are not normally intended for outdoor installation. Users are encouraged to refer to national standards in effect in applicable regions.

This test shall be carried out in accordance with [IEC 60794-1-22] method F15.

8.3.5 Hydrogen

This test method only applies to optical fibre cable installed in a submarine environment or in higher atmospheric pressure applications.

In the case of a metal-free cable or one employing a moisture barrier sheath with a selection of cable components which are low in the generation of hydrogen, either by themselves or in combination with others (for example, water), the build-up of hydrogen gas within the cable core will not lead to a significant increase in optical loss.

For other cable constructions, [ITU-T L.27] should be consulted.

8.3.6 Nuclear radiation

This test method assesses the suitability of optical fibre cables to be exposed to nuclear radiation.

This test shall be carried out in accordance with [IEC 60794-1-22] method F7.

8.3.7 Vibration

This subject needs further study.

8.3.8 Ageing

This test method applies to optical fibre cables installed under all environmental conditions.

The purpose of this test is to evaluate the reaction of cable components under simulated ageing by applying a high temperature to accelerate ageing.

This test shall be carried out in accordance with [IEC 60794-1-22] method F9.

8.3.9 Pneumatic resistance

If a gas pressurization system is used to protect non-waterproofed optical fibre cables, this test may be appropriate.

The purpose of this test is to assure that an adequate amount of gas flow will pass through the cable.

This test shall be carried out in accordance with [IEC 60794-1-22] method F8.

8.3.10 Lightning

Optionally, when a metallic material is used as a cable element, the lightning protection of a cable may undergo a test described in [ITU-T K.47], subject to agreement between the user and supplier.

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