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Optical fibre cables for buried application

Recommendation ITU-T L.43

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Summary

Recommendation ITU-T L.43 describes characteristics, construction and test methods of optical fibre cables for buried application. First, the characteristics affecting the satisfactory performance of optical fibre cables are described. Then, the methods of examining whether the cables have these required characteristics are described. The conditions required may differ according to the installation environment. Therefore, detailed conditions of experiments need to be agreed upon between a user and a supplier on the basis of the environment where the cable is used.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.43	2002-12-22	6	11.1002/1000/6138
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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.

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Optical fibre cables for buried application

1 Scope

Optical fibre cables are traditionally used in trunk line networks, but their use is expanding rapidly to access networks. Today, many cables are buried in order to respect the environmental landscape, to reduce network construction costs or to reduce the extension of underground facilities like ducts and tunnels.

When they are installed without ducts, tunnels and hard protection, cables should have good resistance characteristics to harsh conditions. Some cables have strong outer armouring, others have outer pipe-systems or special plastic sheaths.

This Recommendation:

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

– considers the mechanical and environmental characteristics of the 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] or [ITU-T G.657];

– considers the fundamental aspects related to optical fibre cable from 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 60793-1-1] IEC 60793-1-1 (2008), *Optical fibres – Part 1-1: Measurement methods and test procedures – General guidance.*

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

[IEC 60793-1-30] IEC 60793-1-30 (2010), *Optical fibres – Part 1-30: Measurement methods and test procedures – Fibre proof test.*

[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 reference 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 elements 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.*

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] 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 the optical fibres and cables

6.1 Optical fibre characteristics

Optical fibres should be used 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 for each type of optical fibre are described in their respective Recommendation. Unless specified by the users of this specific Recommendation, those values are applied for a 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 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 the long-term strains, which shorten the life 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 a variety of factors encountered during the service life of the cable can cause a differential movement of the cable components. This effect needs to be considered in the cable design.

Excessive tensile loading increases the optical loss of the cable 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, and more importantly by 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 during both installation and operational life.

The 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 on the fibres and/or damage of the sheath. If this is the case, the cable design 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 the use of dynamic gas pressurization, hydrogen-absorbing materials and careful material selection and construction (moisture barrier sheath) or elimination of metallic components, the increase in optical loss can be maintained within acceptable limits.

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

6.3.2 Moisture permeation

When moisture permeates the cable sheath and is present in the cable core, deterioration of the tensile strength of the fibre occurs and the 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 employing a sealed longitudinal overlapped metallic foil (glued, thermo-welded 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's 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

Direct buried optical fibre cable may be subject to vibrations from traffic, railways, pile-driving and blasting operations. Cables should withstand vibrations generated by these activities without degradation.

A well-established surveillance routine will identify vibration activity in order to carefully make cable routing choices to minimize this type of problem.

6.3.7 Temperature variations

Cables will be subjected to temperature changes during their entire lifetime.

Thermal variation causes different dimensional changes in each element of the cable, since each element has a different thermal expansion coefficient; these differences can be as large as 100 times between the smallest and the largest values. This difference in thermal behaviour can cause attenuation increase of the optical fibres due to microbending or macrobending. Therefore, it is necessary to investigate, in advance, the temperatures of the location where a cable is to be laid, and to choose a cable design suitable for that environment.

6.3.8 Chemical attack

After installation, contact with several chemical agents may degrade the cable sheath characteristics, leading to the weakening of the cable core protection.

To avoid this problem, cable sheath material should be selected carefully, based on its robustness against chemical agents. First of all, it is important to assess what kind of chemical agents may exist in the area where the cable is to be laid. Then, sheath material durability from these chemical agents should be examined. A combination of suitable materials (metallic and non-metallic) can be selected to prevent chemical attack on a cable based on the environmental criteria.

6.3.9 Mechanical aggression

It is difficult to estimate the level of mechanical aggression that the cable may undergo during its handling, installation and maintenance. However, it is clear that a buried cable is less protected than cables installed in ducts. Therefore, internationally recognized requirements such as impact, alternated flexions, torsion, compression and bending tests should be adhered to. Specific tests or specific conditions for usual tests should be agreed upon by users and suppliers. Usually mechanical protection can be achieved by adjusting the radial sheath thickness and/or the application of armouring which can be implemented as steel wire armour, galvanized steel tape armour or steel braid, or glass yarn/tape armour.

6.4 Installation near high-voltage power line

If a fibre optic cable is buried directly adjacent to high-voltage power lines a special sheath material should be considered to avoid tracking effects. Depending on the conductivity of the soil, a voltage gradient may be generated by the electric field of the power line. Under the variation of conductivity, high-voltage difference may result on the jacket of the optical fibre cable and lead to leakage currents and dry-band arcing, which can damage the jacket over time. One solution, which is typical, is the use of a semiconductive over-jacket. The function of the semiconductive over-jacket is to reduce the high-voltage difference. Another solution is using a track-resistant jacket compound.

7 Cable construction

7.1 Fibre coatings

7.1.1 Primary coating

Silica fibre itself has an intrinsically high strength, however surface flaws reduce its strength. 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 relevant optical fibre specifications in [IEC 60793-2-10] and [IEC 60793-2-50].

NOTE – 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.

7.1.2 Secondary or buffer coating

If using a tight secondary coating for the fibre, it, 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; a low coupling may cause fibre movement during installation process; a high coupling may cause high fibre stress when cable is bent.

7.1.3 Fibre identification

Fibre should be easily identified by colour/tracer/marker 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 protections should be easy to remove and should not hinder the splicing, or the 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 type is edge bonded, another is the encapsulated, as shown in Figures 1 and 2, respectively. In the case of the edge-bonded ribbon, optical fibres are bound by adhesive material located between the optical fibres. When the type is encapsulated, the optical fibres are bound by a coating material.

If the flexibility of optical fibre ribbons for bending is required, 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 ribbon 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].

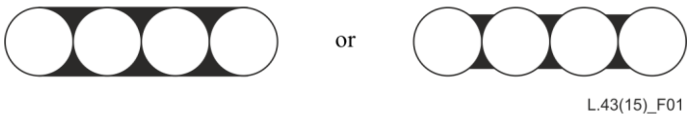

Figure 1 – Cross-section of a typical edge-bonded ribbon

Figure 2 – Cross-section of a typical encapsulated ribbon

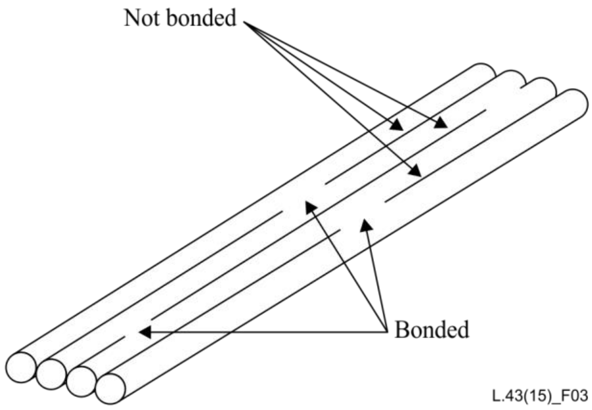

Figure 3 – Example of a typical partially bonded ribbon

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 are located in 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. A 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 using 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, as well as robustness. They are typically stranded to minimise 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.

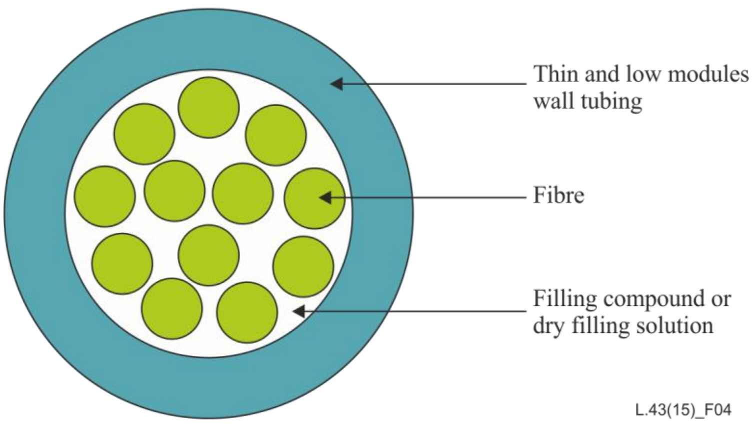

Figure 4 – Example of primary coated fibres protected by micro-module

7.2.5 Strength member

The cable should be designed with sufficient strength members to meet installation and service conditions so that the fibres are not subjected to strain levels in excess of those agreed upon between customers and suppliers.

The strength member(s) may be either metallic or non-metallic. When using metallic strength members, 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. Water-blocking element (e.g., yarns, tapes, filling compounds, water-swelling powders or a combination 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 shall not hinder splicing and/or connection operations.

7.2.7 Pneumatic resistance

If a 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 friction forces encountered in installation should 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 considered. 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, fibre-glass-reinforced strands, strapping tape, etc. The degree of rodent/gopher protection can vary significantly with all-dielectric designs. Optimum protection is generally obtained by the use of metallic tapes.

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 sheath. For identifying cables, embossing, sintering, imprinting, hot foil or ink-jet or laser printing can be used by agreement between the 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.

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 element

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] and [ITU-T G.651.1] and [IEC 60793-1-xx] series.

8.1.1.1 Dimensions

For measuring 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, [IEC 60793-1-32] shall be used.

8.1.1.3 Compatibility with filling material

When fibres come into contact with a waterproofing filling material, stability of the fibre coating and of the filling material should be tested after accelerated ageing.

The stability of 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 between a user and supplier.

8.1.2 Tests applicable to tubes

8.1.2.1 Tube kink

For measuring kink characteristics of tube, [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 properly. The first, called a type test, is used to establish and assure the ribbon manufacturing process. The type test shall be carried out in accordance with method [IEC 60794-1-23] method G2, which is the visual measurement method. The two remaining methods are used only for product inspection after the manufacturing process is established. These test methods are described in [IEC 60794-1-23] method G3, aperture gauge, and [IEC 60794-1-23] method G4, dial gauge. For inspection purposes, the visual measurement method can be also 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 the user and the supplier. When separability is required, the following should be avoided in order to ensure long-time reliability of the fibres:

– damage to the 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 shall 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, with 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 outdoor cables that employ water-blocking methods and are 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 the [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. This external freezing test is of little use for evaluating outdoor cables, as such cables rarely fail the 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 does not apply to buried optical fibre cables.

In some unusual installation situations, such as a cable sealed within a metallic pipe or installed under deep water, hydrogen effects may occur. See clause 6.3.1 and to [ITU-T L.27] and to [b-IEC TR 62690] for guidance.

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 test method assesses the suitability of optical fibre cables for bridge and underground applications.

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 adequate 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 a user and supplier.

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