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Optical fibre cables for aerial application

Recommendation ITU-T L.26

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Summary

Recommendation ITU-T L.26 describes characteristics, construction and test methods of optical fibre cables for aerial application (including lashed cables), but does not apply to optical ground wire (OPGW) cables or metal armour self-supporting (MASS) cables. 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.26	1996-10-18	6	11.1002/1000/3890
2.0	ITU-T L.26	2002-12-22	6	11.1002/1000/6136
3.0	ITU-T L.26	2015-08-13	15	11.1002/1000/12533

* 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

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

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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 aerial application

1 Scope

This Recommendation:

– refers to single-mode optical fibre cables to be used in telecommunication networks for aerial installations in outside plants, excluding optical ground wire (OPGW) and metal armour self-supporting (MASS) cables;

– considers the mechanical and environmental characteristics of the aerial optical fibre cable (self-supporting cable and non self-supporting cable).

  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 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.14] Recommendation ITU-T L.14 (1992), *Measurement method to determine the tensile performance of optical fibre cables under load*.

[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 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 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 60794-3-10] IEC 60794-3-10 (2014), *Optical fibre cables – Part 3-10: Outdoor cables – Family specification for duct, directly buried, and lashed aerial single-mode optical fibre telecommunication cables*.

[IEC 60794-3-20] IEC 60794-3-20 (2009), *Optical fibre cables – Part 3-20: Outdoor cables – Family specification for self-supporting aerial telecommunication cables*.

[IEC 60794-4-20] IEC 60794-4-20 (2012), *Optical fibre cables – Part 4-20: Aerial optical cables along electrical power lines – Family specification for ADSS (All Dielectric Self Supported) optical cables*.

[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*.

[ISO 4892-2] ISO 4892-2 (2013), *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*.

[IEEE 1222] IEEE 1222 (2011), *IEEE Standard for Testing and Performance for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable for Use on Electric Utility Power Lines*.

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

This Recommendation defines the following terms:

3.2.1 all-dielectric self-supporting (ADSS): Cable in which the tensile element is provided by a non-metallic reinforcement (e.g., aramid yarns, glass-fibre-reinforced materials or equivalent dielectric strength members) placed under or within the plastic sheath; the outer shape is circular.

3.2.2 differential movement of cable components: The relative movement of various elements of the cable to one another. This movement can either be reversible or irreversible. It can be induced by temperature or tension variation. An example of this is "fibre grow-out", in which individual fibres begin to protrude from the end of the cable sheath.

3.2.3 lashed cable on messenger wire: Non-metallic or armoured cables installed on a separate suspension catenary and held in position with a binder cord or special preformed spiral clips.

3.2.4 maximum allowable tension: The maximum tensile load that may be applied to the cable without detriment to the tensile performance requirement (optical performance, fibre strain).

3.2.5 rated tensile strength: Summation of the product of nominal cross-sectional area, minimum tensile strength and stranding factor for each load-bearing material in the cable construction.

3.2.6 self-supporting cable: Cable in which the sheath includes a metallic or non-metallic bearing element(s), most commonly forming a figure "8".

3.2.7 strain margin: The amount of strain the cable can sustain without strain on the fibres due to cable elongation.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSS All-Dielectric Self-Supporting

MASS Metal Armour Self-Supporting

OPAC Optical Attached Cable

OPGW Optical Ground Wire

SZ Reverse oscillating stranding

UV Ultraviolet

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] or [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 otherwise by the users of the Recommendation, 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 or 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, which is large relative to the fibre diameter, after cable manufacture and installation.

Macrobending can cause an increase in optical loss. The optical loss increases inversely to the bending radius of the fibre; the macrobending should not be severe enough to significantly increase the optical loss.

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 may be subjected to strain from both cable tension and bending. The strength elements in the cable and the installation bend radii should be selected to limit this combined dynamic strain below the specified maximum allowable fibre strain in order that the cable's predicated lifetime is not reduced.

The fibre bending radii remaining after cable installation shall be large enough not to present macrobending loss.

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). Continuous loading up to the cable limits may be present during the full lifetime of the cable. Fibre strain may be caused by tension, torsion, bending and creep occurring in connection with cable weight, cable installation and/or type of aerial installation and/or environmental conditions, such as a wind and/or ice and/or temperature. Changes in the tension of the cable due to the variety of factors encountered during the service life of the cable can cause differential movement of the cable components. This effect needs to be considered in the cable design.

In order to design tensile characteristics, maximum allowable tension, rated tensile strength and strain margin should be considered.

NOTE – Where a cable is subjected to permanent loading during its operational life, the fibre preferably should 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.

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.

A self-supporting cable structure should be able to withstand compression effects without additional optical loss.

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 twists per unit length without an increase in fibre loss and/or damage to the sheath. The maximum residual fibre strains expected, caused by torsion, tension and bending, should be used to specify the long-term strain limit of the fibre.

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].

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

6.3.2 Moisture permeation

In the case of aerial applications, moisture normally does not represent a significant issue.

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 the cable's 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 under some conditions and 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 metal sheaths, 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].

A fully dielectric cable can minimize the hazardous damage from lightning.

6.3.5 Biotic damage

The size and deployment of optical fibre cables make them vulnerable to many biological attacks.

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

6.3.6 Vibration

Overhead cable vibrations are produced either by laminar wind stream causing curls at the lee side of the cable (i.e., aeolian vibration) or by variations in wind direction relative to the cable axis (i.e., galloping effect). A well-established surveillance routine will identify vibration activity in order to carefully make cable routing choices and to decide installation techniques and/or the use of vibration control devices to minimize this type of problem.

6.3.7 Temperature variations

During storage, installation and operation, cables may be subjected to several temperature variations. Generally, aerial cables are more exposed to significant temperature variations than are underground cables. Therefore, this issue is very important. High-level expansion of cables due to temperature variations may cause a significant reduction in the safe clearance to ground. Shrinkage of cables to a low level, due to temperature variations may cause the maximum working tension of the cable to be reached. Under these conditions, the variation of attenuation of the fibres shall be reversible and shall not exceed the specified limits.

6.3.8 Wind

Fibre strain may be caused by tension, torsion and vibration occurring in connection with wind pressure. Induced dynamic and residual strain in the fibre may cause fibre breakage if the specified long-term strain limit of the fibre is exceeded.

To reduce fibre strain induced by wind pressure, the strength member should be selected to limit strain to safe levels; the cable construction may mechanically decouple the fibre from the sheath to minimize the strain. Alternatively, to reduce fibre strain, the cable may be lashed to a high-strength support strand.

In aerial installations, wind will cause vibrations and, in "figure-of-eight" and suspension wire installations, galloping of the entire span of the cable may occur. In these situations, cables should be designed and/or installed to provide stability of the transmission characteristics and mechanical performance. Cable installations should be designed to minimize the influence of wind.

6.3.9 Snow and ice

Fibre strain may be caused by tension occurring in connection with snow and/or ice load formation around the cable. Induced fibre strain may cause excess optical loss and may cause fibre breakage if the specified long-term strain limit of the fibre is exceeded.

Dynamic strain in the fibre may be induced by vibration caused by the action of snow and/or ice falling from the cable. This may cause fibre breakage.

Under snow and/or ice load, excessive fibre strain may easily be induced by wind pressure.

To suppress the fibre strain caused by snow and/or ice load formation, the strength members should be selected to limit this strain to safe levels, and the cable profile may be selected to minimize snow loading. Alternatively, to suppress fibre strain, the cable may be lashed to a high-strength support strand. Cables should be designed and installed to provide stability of the transmission characteristics, cable sag/tension, fatigue of the strength members and tower/pole loading.

6.3.10 Strong electric fields

Metal-free aerial cables installed in the high-voltage environment of power lines are susceptible to the influence of the electric field of these power lines, which may lead to phenomena such as corona, arcing and tracking of the cable sheath.

To prevent damage, the cable should be installed on the power transmission lines in a position of minimum field strength and/or special cable sheath materials (anti-tracking) may be used depending on the level of the electric field. Also, the effect of sheath marking should not cause deterioration of the sheath in these circumstances. Further guidance on the selection of sheath material depending on the installation position relative to the electric field is given [IEEE 1222].

6.3.11 Ballistic protection

Damage to cables caused by shotguns or other firearms is an occasional occurrence. Due to the variations in this test, it is considered a specialty test for very specific applications.

Further discussion may be found in [IEC 60794-1-21], E13.

7 Cable construction

For aerial applications, special cable structure may be adopted such as self-supporting, all-dielectric self-supporting (ADSS) and cables designed for lashing, including cables described in [b-ITU-T L.10] and [b-ITU-T L.43].

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 should therefore be applied immediately after drawing the fibre size, and may consist of multiple layers.

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 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

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. 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 protections should be easy to remove and should not hinder the splicing, or fitting of fibre to optical connectors.

7.2 Cable elements

The makeup 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 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 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].

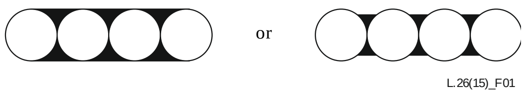

Figure 1 – Cross-section of a typical edge-bonded ribbon

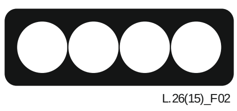

Figure 2 – Cross-section of a typical encapsulated ribbon

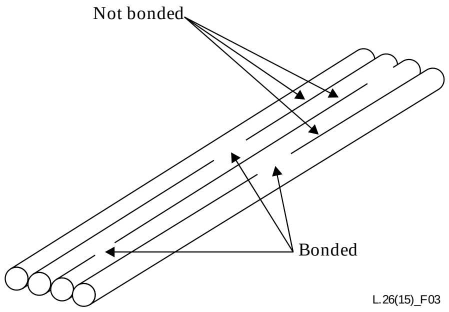

Figure 3 – Example of a typical partially bonded ribbon

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 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.

Particular care to tube robustness must be taken into account for aerial cable design, due to the particular mechanical performances required, especially for ADSS cables in correspondence of the tension and suspension accessories.

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.

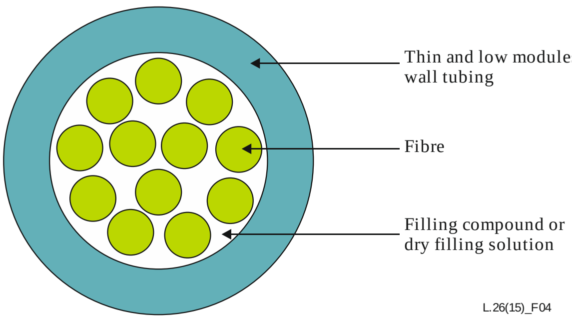

Figure 4 – Example of primary coated fibres protected by micro-module

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 the customer and the supplier. The strength member(s) may be either metallic or non-metallic.

The aerial cable may be classified as self-supporting, when it has, for example, a "figure-of-eight" construction, or when the strength members are located in the cable's core and/or in the sheath. Alternatively, the cable may be supported by attaching it to a supporting strand.

Knowledge of span, sag, wind and ice loads, as well as permitted ground clearances is necessary to design cables for use in aerial applications.

7.2.6 Water-blocking materials

Filling a cable with water-blocking material or wrapping the cable's core with layers of water-swellable material are two means of protecting the fibres from water ingress. Water-blocking elements (e.g., yarns, tapes, filling compounds, water-swelling powders or a combination of materials) may be used. Any material 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.

7.3 Sheath

The cable's core shall be covered with a sheath(s) 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.

The outer sheath should be resistant to degradation due to ultraviolet (UV) radiation and biotic hazards.

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 and bullets; and where the sheath is subjected to strong electric fields (see clause 6.3.10).

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 should 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 or tapes, 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 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 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] and [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, [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, the 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 the 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 appropriately. 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 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 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 the user and the supplier. When separability is required, the following should be avoided in order to ensure long-term reliability of 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 aerial 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 and fibre strain as a function of the load on a cable during installation and under severe weather conditions experienced in service.

The test shall be representative of the cable in service life, and be carried out in accordance with [ITU-T L.14] and [IEC 60794-1-21] method E1.

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 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 only to self-supporting optical fibre cables. Lashed optical cables are not subjected to this test.

This test shall be performed to verify that the installation of the cable will not damage or degrade its performance.

This test shall be carried out in accordance with [IEC 60794-1-21] method E18A for most cable types. For optical attached cable (OPAC) or similar cables, [IEC 60794-1-21] method E18B might be more appropriate.

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. For self-supporting cables, the test should be performed perpendicular to the axis of the bearing element.

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 cabled fibre subjected to temperature changes, which may occur during operation.

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

NOTE – When this Recommendation was revised, there was no international standard test method for sheath movement caused by temperature variation. However, sheath movement can be measured using the same test process for attenuation change caused by temperature variation, if agreed upon by the user and supplier.

8.3.2 Longitudinal water penetration (applicable to filled cables only)

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 the cable construction can prevent water penetration into all the interstices 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 Hydrogen

This test does not apply to aerial non-OPGW cable.

8.3.4 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.

8.3.5 Aeolian vibration

This test method assesses the suitability of optical fibre cables for aerial applications.

The test shall be carried out in accordance with [IEC 60794-1-21] method E19.

8.3.6 Galloping

This test method assesses the suitability of optical fibre cables for aerial applications.

This test assesses the effects of fatigue and strain on self-supporting cables and on the optical characteristics of the fibres when exposed to typical galloping forces, such as those that might be experienced once the cable is installed.

The test shall be carried out in accordance with [IEC 60794-1-21] method E26.

8.3.7 Ultraviolet resistance

This test method applies to aerial optical fibre cables and assesses the suitability of the cable sheath to withstand UV radiation.

This test evaluates the ability of cable sheath materials to maintain their integrity when exposed to UV radiation due to sunlight. This maintenance of integrity is evaluated by measuring the retention of tensile strength and elongation in the sheath of cable samples.

The test method to be utilized is addressed in [ISO 4892-2]. This test is applicable to outdoor cables and other cables, which have significant exposure to sunlight.

This test shall be carried out in accordance with [IEC 60794-1-22] method F14.

8.3.8 Sheath tracking

This test applies to aerial optical fibre cables used on high-voltage power lines.

This subject needs further study.

8.3.9 Shotgun

This method assesses the suitability of optical fibre cables where there is a risk of shotgun damage.

This test shall be carried out in accordance with [IEC 60794-1-21] method E13.

8.3.10 Lightning

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

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