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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Optical fibre cables for aerial application

ITU-T Recommendation L.26

(Previously CCITT Recommendation)

ITU-T L-SERIES RECOMMENDATIONS

CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

For further details, please refer to ITU-T List of Recommendations.

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The 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 Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation L.26, was prepared by ITU-T Study Group 6 (1993-1996) and was approved by the WTSC (Geneva, 9-18 October, 1996).

NOTES

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

2. The status of annexes and appendices attached to the Series L Recommendations should be interpreted as follows:

- an *annex* to a Recommendation forms an integral part of the Recommendation;
- an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

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INTRODUCTION

With the recent progress in optical fibre cable technology, optical fibres for telecommunication use have been applied to trunk and subscriber networks.

There is a need to establish the mechanical and environmental characteristics of optical fibres and cables which will satisfy operational requirements and to advise on suitable testing methods.

This Recommendation advises on optical fibre cables to be used for aerial applications but does not apply to Optical Fibre Ground Wire (OPGW) cables.

Recommendation L.26

OPTICAL FIBRE CABLES FOR AERIAL APPLICATION

(Geneva, 1996)

1 Scope

This Recommendation:

- refers to single-mode optical fibre cables to be used for telecommunications networks in aerial installations of outside plant;
- deals with 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 Recommendations G.650, G.652, G.653 and G.654, which deal with single-mode optical fibres;
- deals with fundamental considerations related to optical fibre cable from the mechanical and environmental points of view;
- acknowledges that some optical fibre cables may contain metallic elements, for which reference should be made to the manual, *Outside plant technologies for public networks* (see Recommendation L.1), and other L-Series and K-Series (e.g. K.25) Recommendations;
- deals with water-blocked cables employing compound filling and/or water-swellable materials;
- considers that fibres are spliced together or connected using connectors.

2 Characteristics of the optical fibres and cables

2.1 Mechanical characteristics

Mechanical effects may influence the cable to cause variations of fibre attenuation. The variations should be reversible and not exceed specified limits.

2.1.1 Fibre microbending

Severe bending of an optical fibre involving local axial displacement of a few micrometers 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 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 fibre's incorporation into the cable, as well as during and after cable installation.

2.1.2 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.

2.1.3 Cable 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 predicated lifetime of the fibre is not reduced.

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

2.1.4 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.

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

2.1.5 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 time of application of the stress) and excessive stress may lead to fibre fracture.

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

2.1.6 Cable 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 of the sheath. If this is the case, the design of cable should allow a specified number of cable 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.

2.2 Environmental conditions

2.2.1 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 Recommendation L.27.

By the elimination of metallic components, or the use of dynamic gas pressurization, hydrogen-absorbing materials, or the careful selection of cable components and construction, e.g. moisture barrier sheath or elimination of metallic components, the increase in optical loss can be maintained within acceptable limits.

2.2.2 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 should be limited.

Various materials can be used as barriers to reduce the rate of moisture permeation.

NOTE – If required, permeation may be minimized by a longitudinal overlapped metallic foil bonded to the sheath. A continuous metallic barrier is effective to prevent moisture permeation.

2.2.3 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. A water-blocking element (tapes, non-toxic filling compound, water swelling non-toxic powder or combination of materials) may be applied to prevent water penetration.

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.

2.2.4 Lightning

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

To prevent or minimize lightning damage, consideration should be given to Recommendation K.25.

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

2.2.5 Biotic damage

The small size of an optical fibre cable makes it more vulnerable to rodent, bird and insect attack. Where rodents cannot be excluded, metallic or special non-metallic protection should be provided. For further information, reference should be made to Part IV-B, Chapter II, of the manual *Outside plant technologies for public network*.

2.2.6 Vibration

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

2.2.7 Temperature variations

During storage, installation and operation, cables may be subjected to several temperature variations. Expansion of the cable due to a variation in temperature to a high level may cause the minimum permitted sag for safe clearance to be reached. Shrinkage of the cable due to a variation in temperature to a low level may cause the maximum working tension to be reached. During these conditions the variation of attenuation of the fibres shall be reversible and shall not exceed the specified limits.

2.2.8 Wind

The 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 any fibre strain induced by wind pressure, the strength member should be selected to limit this strain to safe levels, and 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, winds 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.

2.2.9 Snow and ice

The fibre strain may be caused by tension occurring in connection with snow loading and/or ice 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 the load of snow and/or ice, excessive fibre strain may easily be induced by wind pressure.

To suppress the fibre strain by snow loading and/or ice formation, the strength member 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. Cable should be designed and installed to provide stability of the transmission characteristics, cable sag/tension, fatigue of the strength member and tower/pole loading.

2.2.10 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 at a position of minimum field strength and/or special cable sheath materials may be used depending on the level of the electric field. Also, the affect of sheath marking should not cause a deterioration of the sheath in these circumstances.

3 Cable construction

3.1 Fibre coatings

3.1.1 Primary protection (coatings)

Silica fibre itself has an intrinsically high strength, but its strength is reduced by surface flaws. 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 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.

NOTE 1 – The primary coated fibres should be proof tested with a strain equivalent to 1%. 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.

3.1.2 Secondary protection (coatings)

Secondary protection of the fibre within the cable should be provided. Secondary protection of primary coated fibres are applied using loose packing within a tube or groove, tight polymer coating and ribbon coating.

NOTE 1 – Methods of secondary protection are described in the manual on the construction, jointing and protection of optical fibre cables [1].

NOTE 2 – 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 3 – To limit axial fibre stress, the mechanical coupling between fibre and cable should be minimized.

3.1.3 Fibre identification

Fibre should be easily identified by colour or position within the cable core. If a colouring method is used, the colours should retain good colour-fast properties during the lifetime of the cable.

3.1.4 Fibre preparation and splicing properties

The primary and secondary protections should be easy to remove and should not hinder the splicing procedure, for example fibre splicing and/or fitting of fibre to optical connectors.

Further study is required to advise on suitable fibre alignment methods using local light-injection and detection when fibres are spliced.

3.2 Cable core

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.

3.3 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 excessive strain.

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

A knowledge of span, sag, wind and ice-loading is necessary to design a cable for use in aerial applications.

3.4 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 (tapes, filling compound, water swelling powder or combination of materials) may be used. Any material used should not be harmful to personnel. The materials in the cable should be compatible, one with the other, and in particular should not adversely affect the fibre performance, or any colour identification of the fibres. Filling compound in contact with the fibres should remain soft over the cable operating temperature to guarantee no additional stress to the fibres.

In addition, the material should be non-nutritive to fungus, and be electrically non-conductive, homogeneous and free from contamination.

3.5 Sheath

The cable core should be covered with a sheath 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.

Sheath considerations for optical fibre cables are generally the same as for metallic conductor cables. The minimum acceptable thickness of the sheath should be stated, together with any maximum and minimum allowable overall diameter of the cable.

The outer sheath should be resistant to the degradation due to ultraviolet radiation and biotic hazards.

NOTE – One of the most common sheath materials is polyethylene. There may be however, some environmental conditions where it is necessary to minimize the flammability of a cable and limit the emission of fumes, smoke and corrosive products. Special materials should be used for the cable sheath in these situations and also where the sheath is subjected to strong electric fields (see 2.2.10).

3.6 Armour

Where additional tensile strength or protection from external damage is required, armouring should be provided over the cable sheath.

Armouring considerations for optical fibre cables are generally the same as for metallic conductor cables. However, hydrogen generation due to corrosion should be considered. It should be remembered 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 or strapping tape, etc.

3.7 Identification of the cable

If a visual identification is required to distinguish an optical fibre cable from a metallic cable, this can be done by visibly marking the sheath of the aerial optical fibre cable using print with inks, hot foil, embossing or sintering. The test method of the abrasion resistance of sheath marking should be demonstrated in accordance with IEC Publication 794-3 [2].

4 Test methods

4.1 Test methods for mechanical characteristics

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

4.1.1 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 should be carried out in accordance with Recommendation L.14 and IEC 794-1-E1 [3].

4.1.2 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 should be carried out in accordance with method IEC 794-1-E11 [3].

4.1.3 Bending under tension

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

This subject needs further study.

4.1.4 Crush

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

This test should be carried out in accordance with method IEC 794-1-E3 [3].

4.1.5 Squeezing (abrasion)

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

This subject needs further study, and is currently under consideration in the method IEC 794-1-E2 [3].

4.1.6 Torsion

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

This test should be carried out in accordance with method IEC 794-1-E7 [3].

4.1.7 Impact

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

This test should be carried out in accordance with method IEC 794-1-E4 [3].

4.1.8 Kink

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

This test should be carried out in accordance with method IEC 794-1-E10 [3].

4.2 Test methods for environmental characteristics

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

4.2.1 Temperature cycling

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

Testing is by temperature cycling to determine the stability of the attenuation of a cabled fibre subjected to ambient temperature changes which may occur during storage, transportation and operation.

This test should be carried out in accordance with method IEC 794-1-Fl [3].

4.2.2 Longitudinal water penetration

This test method applies to the outdoor cables, which 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 should be carried out in accordance with method IEC 794-1-F5 [3].

4.2.3 Moisture barrier

This test method applies to the sheath of an optical fibre cable.

The moisture permeation of the sheath can be tested according to the test method as described in Clause 6.3.1, Part I, Chapter III of the manual *Outside plant technologies for public networks*.

4.2.4 Hydrogen

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

In the case of a metal-free cable or one employing a moisture barrier sheath with the selection of cable components that 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, draft Recommendation L.27 should be considered.

4.2.5 Nuclear radiation

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

This subject needs further study and is currently under consideration in the method IEC 794-1-F7 [3].

4.2.6 Vibration

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

The subject needs further study.

4.2.7 Ultraviolet resistance

This test method applies to aerial optical fibre cable and assess the suitability of the cable sheath to withstand ultraviolet radiation.

This subject needs further study.

4.2.8 Sheath tracking

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

This subject needs further study.

4.2.9 Shotgun

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

This test should be carried out in accordance with method IEC 794-1-E13 [4].

References

[1] ITU-T manual, *Construction, installation, jointing and protection of optical fibre cables*, ITU, Geneva, 1994.

[2] IEC 794-3: 1994, *Optical fibre cables – Part 3: Telecommunication cable – Sectional specifications*.

[3] IEC 794-1: 1993, *Optical fibre cables – Part 1: Generic specification*.

[4] IEC 794-1: 1994, *Optical fibre cables – Part 1: Generic specification*.

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