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

Single mode fibre optic connectors

ITU-T Recommendation L.36

(Previously CCITT Recommendation)

ITU-T L-SERIES RECOMMENDATIONS

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

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ITU-T RECOMMENDATION L.36

SINGLE MODE FIBRE OPTIC CONNECTORS

Summary

This Recommendation describes the main features of fibre optic connectors, in terms of types, fields of application, configurations and technical aspects. Further, this Recommendation examines the optical, mechanical and environmental characteristics of fibre optic connectors, advising on general requirements and test methods.

While taking into account Recommendation G.671 as far as the transmission parameters are concerned, this Recommendation is based on the most recent work carried out within IEC 86B Working Groups 4, 6 and 7, namely the future IEC 1753-2-1 and the 61300-series.

Source

ITU-T Recommendation L.36 was prepared by ITU-T Study Group 6 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 9th of October 1998.

FOREWORD

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NOTE

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Recommendation L.36

SINGLE MODE FIBRE OPTIC CONNECTORS

(Geneva, 1998)

1 Scope

This Recommendation:

– gives general information on fundamental types of fibre optic connectors, their field of application and the main requirements about their characteristics in terms of optical, mechanical and environmental behaviour;

– makes a classification of these components in terms of the configurations used into fibre optic plants;

– gives a general description of the basic principles of operation and of technologies of fabrication of fibre optic connectors;

– describes all the most important optical parameters and gives general specifications on the optical, mechanical and environmental performances of fibre optic connectors;

– describes the main test methods of fibre optic connectors.

2 Abbreviations

This Recommendation uses the following abbreviations:

A	Attenuation
APC	Angled Physical Contact
CENELEC	Comité Européen de Normalisation Electrotechnique
IEC	International Electrotechnical Commission
PC	Physical Contact
RL	Return Loss

3 General information

Fibre optic connectors provide a method for jointing the ends of two optical fibres. Such a joint is not a permanent one, but it can be opened and closed several times. The optical connectors are required in the points of the network in which it is necessary to have flexibility in terms of network configuration.

Fibre optic connectors have application in all types of network, at the input and output ports of the transmission systems and are also used to connect test equipment and instrumentation.

The connection can have a plug-adapter-plug or a plug-socket configuration.

The main effects of the introduction of a connector in an optical line are an attenuation on the transmitted signal and a reflection of a part of the signal.

4 Types and configurations

Fibre optic connectors can be classified on the basis of:

– the type of cable;
– the type of fibre;
– the fibre alignment system;
– the fibre end face finish;
– the number of jointed fibres;
– the type of coupling mechanism.

4.1 Fibre types

The type of connector and in particular its grade of mechanical accuracy depend on the type of fibre to be jointed. The fibres to be considered are those specified in Recommendations G.650 to G.655. Particularly, great accuracy is necessary to align two single mode fibres in which the light is guided in a core of about 10 μm.

4.2 Cable types

The connector can be assembled with:

– primary coated fibre (250 μm);
– secondary coated fibre (900 μm); and
– single fibre cable (typically from 2 mm to 3 mm).

4.3 Fibre alignment system

a) **Direct alignment**: In this type of solution the bare fibre is directly aligned by V-groove or capillary tubes.

b) **Secondary alignment**: In this case the fibre is fixed in a structure. These structures are usually cylindrical ferrule for single fibre joint or rectangular section body for multiple fibre joint. These structures are aligned by means of sleeves, pins or other systems.

c) **Lens alignment**: The optical alignment of the fibres is obtained by means of a lens.

4.4 Fibre end face finish

In the case of direct alignment the fibre is simply cut in an accurate and precise way. On the contrary, when the fibre is inserted within a secondary structure its end face is prepared in order to obtain the required grade of finish. It is possible to classify the end face finish in two classes:

a) **Physical Contact (PC)**: This finish is typically used in a single fibre connector. The end face is polished to a spherical shape in order to obtain a perfect contact between the two fibre cores and to improve the transmission performances of the connector. A typical spherical radius is 10-25 mm.

b) **Angled Physical Contact (APC)**: This finish is similar to the PC, but in this case the polished end surface of the ferule is angled with respect to the fibre axis. This solution permits to obtain very low value of reflected power. Typical angles are 8 or 9 degrees for G.652-type fibres.

4.5 Coupling mechanism

The most common systems for mating together two plugs (or the plug and the socket) are:

– push-pull mechanism;

– screw mechanism;

– bayonet mechanism.

5 Characterization parameters

5.1 Optical parameters

The fibre optic connectors are characterized by several parameters; the most important are:

5.1.1 Attenuation

The attenuation introduced by the fibre optic connector is defined as:

$$A = -10 \cdot Log \frac{P_i}{P_0} \text{ dB}$$

where P_0 is the optical power just before the connection and P_i is the optical power just after the connection.

5.1.2 Return loss

The return loss introduced by the fibre optic connector is defined as:

$$RL = 10 \cdot Log \frac{P_r}{P_0} \text{ dB}$$

where P_0 is the optical power measured at the connection interface and P_r is the optical power reflected by the connector.

5.1.3 Classes of wavelength

The components can be manufactured in two wavelength classes:

– Class 1 for standard and obligatory requirements for telecom operation in 1260-1360 nm and 1480-1580 nm bands;

– Class 2 for further extended band pass between 1600-1650 nm for maintenance operation.

5.2 Mechanical and environmental parameters

5.2.1 Vibrations

This parameter assesses the resistance of the connector during the applications of sinusoidal oscillations along three orthogonal axis.

5.2.2 Strength of the coupling mechanism

It is the pulling force withstood by the coupling mechanism just before the disconnection of the connector.

5.2.3 Mechanical resistance of the attachment of the fibre/cable to the plug connector

It is the resistance of the attachment point of the fibre or cable to the plug when it is subjected to mechanical stress as pulling and torsion.

5.2.4 Mechanical endurance

This parameter assesses the number of connections that the connector shall guarantee without deteriorating its optical performances.

5.2.5 Operating temperature

It is the range of temperature in which the performances of the fibre optic connector is guaranteed.

5.2.6 Climatic endurance

In order to asses the environmental performances, the following tests are recommended:

– cold;

– dry heat;

– damp heat;

– change of temperature.

6 Performance criteria and test methods

The confidence level of performance limit measurements is taken as 95% unless otherwise mentioned.

The reference documents for all the requirements, the procedure and the test methods are:

– ITU-T Recommendation G.671 (1996), *Transmission characteristics of passive optical components*.

– IEC 1753-2-1/Ed. 1, *Performance standard of fibre-optic interconnecting devices and passive components* (to be published).

– IEC 61300-series, *Fibre optic interconnecting devices and passive components – Basic Test and Measurement Procedures.*

6.1 Optical performances

6.1.1 Attenuation (IEC 61300-3-4)

Two grades of attenuation can be defined according to the applications:

Grade P: mean ≤ 0.35 dB
maximum ≤ 1.00 dB for ≥ 97% of the mating combinations.

Grade Q: mean ≤ 0.30 dB
maximum ≤ 0.60 dB for ≥ 99% of the mating combinations.

These values are referred to random mating between plugs of production.

6.1.2 Return loss (IEC 61300-3-6)

Four classes of return loss can be defined according to the applications:

– Class S: ≥ 25 dB;

– Class T: ≥ 35 dB;

– Class U: ≥ 50 dB;

– Class V: ≥ 55 dB.

These values are referred to random mating between plugs of the same production.

The S, T, U classes are referred to the PC fibre end face finish while the V class is referred to the APC fibre end face finish.

6.2 Mechanical and environmental performances

6.2.1 Vibration (IEC 61300-2-1)

The variation of the attenuation shall be ≤ 0.20 dB and the RL value shall remain in the specified class during a vibration test with the following characteristics:

– frequency range: 10-55 Hz
– endurance duration per axis: 0.5 hour
– number of axis: three, orthogonal
– number of cycles (10-55-10): 15
– vibration amplitude: 1.5 mm (peak-to-peak)

6.2.2 Strength of the coupling mechanism (IEC 61300-2-6)

The test is performed applying a specified axial load between the plug and the adapter.

The value of the load and the duration of the test are specified according to the specific coupling mechanism and the manufacturer's rating for the specific connector design.

During the test the attenuation shall not increase more than 0.20 dB.

6.2.3 Mechanical resistance of the attachment of the fibre/cable to the plug connector

6.2.3.1 Pulling (IEC 61300-2-4)

The test is performed applying an axial load between the cable and the plug. The load should be the maximum manufacturer's rating for the specific connector design.

During the test, the attenuation shall not increase more than 0.20 dB.

6.2.3.2 Torsion (IEC 61300-2-5)

The test is performed applying a torque on the cable at the distance of 10 cm from the connector; the cable is kept taut by a load. The load should be the maximum manufacturer's rating for the specific connector design.

During the test, the attenuation shall not increase more than 0.20 dB.

6.2.4 Mechanical endurance (IEC 61300-2-2)

The test is carried out connecting 500 times a plug and an adapter (one side of the connector set only in the case of a plug-adapter-plug configuration).

The connector may be cleaned at a specified interval (not less than 10 mating cycles) during the test, and it may be cleaned before measurement on completion of the test.

The variation of the attenuation shall be less than 0.20 dB and the return loss shall not fall below the minimum for the grade.

6.2.5 Operating temperature

The recommended temperature range in which the connector performances should be guaranteed is from –25°C to +70°C.

6.2.6 Climatic endurance

6.2.6.1 Cold (IEC 61300-2-17)

Temperature: –25ºC

Duration: 16 hours

Preconditioning and recovery: 2 hours in room temperature condition.

Attenuation shall be measured before, at a maximum interval of 1 hour during and after the test. Allowable Attenuation variation: ≤ 0.20 dB at 1550 nm.

Return loss shall be measured before, during and after the test and shall satisfy the requirements for the specified class.

6.2.6.2 Dry heat (IEC 61300-2-18)

Temperature: 70ºC

Duration: 96 hours

Preconditioning and recovery: 2 hours in room temperature condition.

Attenuation shall be measured before, at a maximum interval of 1 hour during, and after the test. Allowable Attenuation variation: ≤ 0.20 dB at 1550 nm.

Return loss shall be measured before, during and after the test and shall satisfy the requirements for the specified class.

Strength of coupling mechanism shall be measured on completion of test after recovery procedure.

6.2.6.3 Damp heat (IEC 61300-2-19)

Temperature: 40ºC

Relative humidity: 93 ± 2%

Duration: 96 hours

Preconditioning and recovery: 2 hours in room temperature condition.

Attenuation shall be measured before, at a maximum interval of 1 hour during and after the test; Allowable Attenuation variation: ≤ 0.20 dB at 1550 nm.

Return loss shall be measured before, during and after the test and shall satisfy the requirements for the specified class.

6.2.6.4 Change of temperature (IEC 61300-2-22)

High temperature: 70ºC

Low temperature: –25ºC

Duration at extreme temperature: 1 hour.

Temperature rate of change: 1ºC/min.

Number of cycles: 12

Preconditioning and recovery: 2 hours in room temperature condition.

Attenuation shall be measured before, at a maximum interval of 10 minutes during and after the test. Allowable Attenuation variation: ≤ 0.20 dB at 1550 nm.

Return loss shall be measured before, at a maximum interval of 10 minutes during and after the test and shall satisfy the requirements for the specified class.

7 Connector identification

Taking into account the different types of fibres, cable, end face polishing and attenuation and return loss grades, it is important to standardize a criteria for connector identification.

While no complete international standard is approved at this time, the general trend is to colour code the plastic body connectors to distinguish the PC type from the APC type independently of the return loss performances.

The blue colour is used for the PC and the green one for the APC.

Further study is needed in order to define a suitable way for the identification of metallic body connectors.

Tables I.1 and I.2 show different experiences on this subject.

APPENDIX I

Table I.1 shows the colour code of the various parts of plastic body connectors under study by CENELEC SC 86BXA and adopted by some European countries. Table I.2 shows the colour code of the various parts of plastic body connector that is a goal in specifications of Bellcore and used in the United States. This colour code has been in existence and used for more than six years in the United States, and as such has considerable resistance to change.

It is noted that a colour code standardization for the single fibre cable may also be desirable in order to distinguish the G.652 and G.653 fibres; for example, Italy uses blue and orange respectively for G.652 and G.653 fibres. However, operating companies in some other countries do not use single fibre cables with G.653 fibre and in the United States and Spain, yellow has universally been the colour code for single fibre cables with G.652 fibre ever since G.652 fibre existed.

Table I.1/L.36 – Colour code for optical connectors

Plug type	Attenuation class	Return loss class	Plug Body	Boot	Other element (Note)
PC	P	25 dB 35 dB 50 dB	BLUE	Yellow Blue White	To be defined
PC	Q	25 dB 35 dB 50 dB	BLUE	Yellow Blue White	To be defined
APC 8°	P / Q		GREEN	GREEN	To be defined
APC 9°	P / Q		GREEN	RED	To be defined
NOTE – Another part or element must be defined to distinguish connector of P and Q class. A proposal could be a ring added at the end of the boot marked "P" or "Q".					

Table I.2/L.36 – Colour code for optical connectors (United States of America, Bellcore GR-326)

Plug type	Attenuation	Return loss class	Plug Body	Boot
PC	Not specified	≥ 30 dB ≥ 40 dB ≥ 55 dB	Blue	Red White Dark Blue
APC 8°	Not specified	≥ 60 dB	Green	Green
APC 9°	Not specified	≥ 60 dB	Green	Green

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