INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

G.653

(11/1988)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Testing equipments
Transmission media characteristics
Optical fibre cables

Characteristics of a dispersion-shifted single-mode optical fibre cable

Reedition of CCITT Recommendation G.653 published in the Blue Book, Fascicle III.3 (1988)

NOTES

1 CCITT Recommendation G.653 was published in Fascicle III.3 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation G.653

CHARACTERISTICS OF A DISPERSION-SHIFTED SINGLE-MODE OPTICAL FIBRE CABLE

(Melbourne, 1988)

The CCITT,

considering

(a) that dispersion-shifted optical fibre cables are going to be used widely in telecommunication networks;

(b) that the foreseen potential applications may require several kinds of single-mode fibres differing in operation wavelength geometrical and optical characteristics, and attenuation dispersion and other transmission characteristics,

recommends

a dispersion-shifted single-mode fibre which has the zero-dispersion wavelength in the 1550 nm wavelength region and which is optimized for use at wavelengths around 1550 nm. This fibre may also be used at around 1300 nm subject to the constraints which are outlined in this Recommendation.

Its geometrical, optical and transmission parameters are described below.

The meaning of the terms used in this Recommendation are given in Annex A to Recommendation G.652 and the guidelines to be followed in the measurements to verify the various characteristics are indicated in Annex B to Recommendation G.652. The characteristics of this fibre and the relevant values will be refined as studies and experience progress.

1 Fibre characteristics

Only those characteristics of the fibre providing a minimum essential design framework for fibre manufacture are recommended in § 1. Of these, the cabled fibre cut-off wavelength may be significantly affected by cable manufacture or installation. Otherwise, the recommended characteristics will apply equally to individual fibres, fibres incorporated into a cable wound on a drum, and fibres in an installed cable.

This Recommendation applies to fibres having a nominally circular mode field.

1.1 *Mode field diameter*

The nominal value of the mode field diameter at 1550 nm shall lie within the range of 7.0 to 8.3 µm. The mode field diameter deviation should not exceed the limits of ± 10% of the nominal value.

Note 1 – The choice of a specific value within the above range is not necessarily associated with a specific fibre design.

Note 2 – It should be noted that the fibre performance required for any given application is a function of essential fibre and systems parameters, i.e., mode field diameters, cut-off wavelength, chromatic dispersion, system operating wavelength, and bit rate/frequency of operation, and not primarily of the fibre design.

Note 3 – All the above needs further study.

1.2 *Cladding diameter*

The recommended nominal value of the cladding diameter is 125 µm. The cladding deviation should not exceed the limits of ± 2.4% (± 3 mm).

For some particular jointing techniques and joint loss requirements, other tolerances may be appropriate.

1.3 *Mode field concentricity error*

The recommended mode field concentricity error at 1550 nm should not exceed 1 mm.

Note – For some particular jointing techniques and joint loss requirements, tolerances up to 3 µm may be approrpriate.

1.4 *Non-circularity*

1.4.1 *Mode field non-circularity*

In practice, the mode field non-circularity of fibres having nominally circular mode fields is found to be sufficiently low that propagation and jointing are not affected. It is therefore not considered necessary to recommend a particular value for the mode field non-circularity. It is not normally necessary to measure the mode field non-circularity for acceptance purposes.

1.4.2 *Cladding non-circularity*

The cladding non-circularity should be less than 2%. For some particular jointing techniques and joint loss requirements, other tolerances may be appropriate.

1.5 *Cut-off wavelength*

Under study.

1.6 *1550 nm bend performance*

The loss increase for 100 turns of fibre, loosely wound with a 37.5 mm radius and measured at 1550 nm, shall be less than 0.5 dB.

Note 1 – A qualification test may be sufficient to ensure that this requirement is being met.

Note 2 – The above value of 100 turns corresponds to the approximate number of turns deployed in all splice cases of typical repeater span. The radius of 37.5 mm is equivalent to the minimum bend-radius widely accepted for long-term deployment of fibres in practical systems installations to avoid static-fatigue failure.

Note 3 – If for pratical reasons fewer than 100 turns are chosen to implement this test, it is suggested that not less than 40 turns, and a proportionately smaller loss increase be used.

Note 4 – If bending radii smaller than 37.5 mm are planned to be used in splice cases or elsewhere in the system (for example, R = 30 mm) it is suggested that the same loss value of 0.5 dB shall apply to 100 turns of fibre deployed with this smaller radius.

Note 5 – The 1550 nm bend-loss recommendation relates to the deployment of fibres in practical single-mode fibre installations. The influence of the stranding-related bending radii of cabled single-mode fibres on the loss performance is included in the loss specification of the cabled fibre.

Note 6 – In the event that routine tests are required, a small diameter loop with one or several turns can be used instead of the 100-turn test, for accuracy and measurement ease of the 1550 nm bend sensitivity. In this case, the loop diameter, number of turns, and the maximum permissible bend loss for the several-turn test, should be chosen, so as to correlate with the 0.5 dB loss recommendation of the 37.5 mm radius 100 turn functional test.

1.7 *Material properties of the fibre*

1.7.1 *Fibre materials*

The substances of which the fibres are made should be indicated.

Note – Care may be needed in fusion splicing fibres of different substances. Provisional results indicate that adequate splice loss and strength can be achieved when splicing different high-silica fibres.

1.7.2 *Protective materials*

The physical and chemical properties of the material used for the fibre primary coating, and the best way of removing it (if necessary) should be indicated. In the case of a single jacketed fibre similar indications shall be given.

1.8 *Refractive index profile*

The refractive index profile of the fibre does not generally need to be known: if one wishes to measure it, the Reference Test Method in Recommendation G.651 may be used.

2 Factory length specifications

Since the geometrical and optical characteristics of fibres given in § 1 are barely affected by the cabling process, § 2 will give recommendations mainly relevant to transmission characteristics of cabled factory lengths.

Environmental and test conditions are paramount and are described in the guidelines for Test Methods.

2.1 *Attenuation coefficient*

Optical fibre cables covered by this Recommendation generally have attenuation coefficients in the 1550 nm region below 0.5 dB/km. When they are intended for use in the 1300 nm region, their attenuation coefficient in that region is genrally below 1 dB/km.

Note – The lowest values depend on the fabrication process, fibre composition and design, and cable design. Values in the rage 0.19-0.25 dB/km in the 1550 nm region have been achieved.

2.2 *Chromatic dispersion coefficient*

Under study.

Note 1 – The maximum chromatic dispersion coefficient of single-mode fibres covered in this Recommendation shall be:

Longitud de onda (nm)	Máximo coeficiente de dispersión cromática [ps/(nm.km)]
1525-1575	3,5
Región de 1300 nm	En estudio

Note 2 – The value of 3.5 ps/(nm · km) allows for attenuation limited section lengths at 560 Mbit/s, using suitable multi-longitudinal mode lasers and adequate line coding.

Note 3 – For higher capacity (larger than 560 Mbit/s) or longer length systems, operation closer to the zero-dispersion wavelength is required (unless single-longitudinal mode laser diodes are used). Additional fibre parameters may then have to be specified (such as zero-dispersion wavelength, dispersion-slope, etc.). Further studies are needed to identify these parameters.

Note 4 – It is not necessary to measure the chromatic dispersion coefficient on a routine basis.

3 Elementary cable sections

An elementary cable section usually includes a number of spliced factory lengths. The requirements for factory lengths are given in § 2 of this Recommendation. The transmission parameters for elementary cable section must take into account not only the performance of the individual cable lengths but also amongst the other factors, such things as splice losses and connector losses (if applicable).

3.1 *Attenuation*

The attenuation A of an elementary cable section is given by:

$$A = \sum_{n=1}^{m} a_n \cdot L_n + a_s \cdot X + a_c \cdot y$$

where

a_n = attenuation coefficient of *n*th fibre in elementary cable section,

L_n = length of *n*th fibre,

m = total number of concatenated fibres in elementary cable section,

a = mean splice loss,

X = number of splices in elementary cable section,

a_c = mean loss of line connectors,

y = number of line connectors in elementary cable section (if provided).

A suitable allowance should be allocated for a suitable cable marging for future modifications of cable configurations (additional splices, extra cable lengths, aging effects, temperature variations, etc.). The above equation does not include the loss of equipment connectors.

The mean loss is used for the loss splices and connectors. The attenuation budget used in designing an actual system should account for the statistical variations in these parameters.

3.2 *Chromatic dispersion*

The chromatic dispersion in ps can be calculated from the chromatic dispersion coefficients of the factory lengths, assuming a linear dependence on length, and with due regard for the signs of the coefficients and system source characteristics (see § 2.2).

ANNEX A

(to Recommendation G.653)

Meaning of the terms used in the Recommendation

Most of the definitions contained in Annex A to Recommendation G.652 are in principle applicable also to dispersion-shifted fibre. Because of limited experience with this type of fibre, further study of the suitability of some definitions is needed.

ANNEX B

(to Recommendation G.653)

Test Methods for dispersion-shifted single-mode fibres

The present experience on dispersion-shifted single-mode fibres is rather limited; therefore further study is needed on some Reference and Alternative Test Methods for this type of fibre. Nevertheless, most of the test methods described in Annex B to Recommendation G.652 are in principle applicable also to dispersion-shifted fibres. Therefore, for this Annex, reference is made to the corresponding Test Methods of Annex B in Recommendation G.652; the specifics of each test procedure need further study. It should be noted that the working wavelength for G.653 fibres is in the 1550 nm region.

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	
General definitions	G.100–G.109
General Recommendations on the transmission quality for an entire international telephone connection	G.110–G.119
General characteristics of national systems forming part of international connections	G.120–G.129
General characteristics of the 4-wire chain formed by the international circuits and national extension circuits	G.130–G.139
General characteristics of the 4-wire chain of international circuits; international transit	G.140–G.149
General characteristics of international telephone circuits and national extension circuits	G.150–G.159
Apparatus associated with long-distance telephone circuits	G.160–G.169
Transmission plan aspects of special circuits and connections using the international telephone connection network	G.170–G.179
Protection and restoration of transmission systems	G.180–G.189
Software tools for transmission systems	G.190–G.199
INTERNATIONAL ANALOGUE CARRIER SYSTEM	
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	
Definitions and general considerations	G.210–G.219
General Recommendations	G.220–G.229
Translating equipment used on various carrier-transmission systems	G.230–G.239
Utilization of groups, supergroups, etc.	G.240–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	
Carrier telephone systems on unloaded symmetric cable pairs, providing groups or supergroups	G.320–G.329
Carrier systems on 2.6/9.5 mm coaxial cable pairs	G.330–G.339
Carrier systems on 1.2/4.4 mm coaxial cable pairs	G.340–G.349
Additional Recommendations on cable systems	G.350–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	
General Recommendations	G.400–G.419
Interconnection of radio-relay links with carrier systems on metallic lines	G.420–G.429
Hypothetical reference circuits	G.430–G.439
Circuit noise	G.440–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	
Radiotelephone circuits	G.450–G.469
Links with mobile stations	G.470–G.499
TESTING EQUIPMENTS	
TRANSMISSION MEDIA CHARACTERISTICS	
General	G.600–G.609
Symmetric cable pairs	G.610–G.619
Land coaxial cable pairs	G.620–G.629
Submarine cables	G.630–G.649
Optical fibre cables	**G.650–G.659**
Characteristics of optical components and subsystems	G.660–G.699

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

ITU-T RECOMMENDATIONS SERIES

Series A	Organization of the work of the ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2007