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Optical fibres –

Part 1-42:
Measurement methods and test procedures – Chromatic dispersion

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Part 1-42: Measurement methods and test procedures – Chromatic dispersion

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OPTICAL FIBRES –

Part 1-42: Measurement methods and test procedures – Chromatic dispersion

FOREWORD

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International Standard IEC 60793-1-42 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2001. It constitutes a technical revision. The main changes in this second edition concern the addition of a new Annex E on chromatic dispersion fitting and the applicability to A4 fibres.

This standard is to be read in conjunction with IEC 60793-1.

The text of this standard is based on the following documents:

FDIS	Report on voting
86A/1136/FDIS	86A/1146/RVD

Full information on the voting for the approval of this part can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The list of all parts of the IEC 60793 series, under the general title *Optical fibres*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication will be issued at a later date.

The contents of the corrigendum of June 2007 have been included in this copy.

OPTICAL FIBRES –

Part 1-42: Measurement methods and test procedures – Chromatic dispersion

1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the chromatic dispersion of optical fibre, thereby assisting in the inspection of fibres and cables for commercial purposes.

Chromatic dispersion varies with wavelength. Some methods and implementations measure the group delay as a function of wavelength and the chromatic dispersion and dispersion slope are deduced from the derivatives (with respect to wavelength) of this data. This differentiation is most often done after the data are fitted to a mathematical model. Other implementations can allow direct measurement (of the chromatic dispersion) at each of the required wavelengths.

For some categories of fibre, the chromatic dispersion attributes are specified with the parameters of a specific model. In these cases, the relevant recommendation or standard defines the model appropriate for the definition of the specified parameters. For other fibre categories, the dispersion is specified to be within a given range for one or more specified wavelength intervals. In the latter case, either direct measurements may be made at the wavelength extremes or some fitting model may be used to allow either group delay measurement methods or implementations or storage of a reduced set of parameters that may be used to calculate the interpolated dispersion for particular wavelengths which may not have actual direct measurement values.

Annex E gives a general description of chromatic dispersion fitting and outlines a number of fitting equations suitable for use with any of the measurement methods or fibre categories.

This standard gives four methods for measuring chromatic dispersion:

– method A: phase shift;
– method B: spectral group delay in the time domain;
– method C: differential phase shift;
– method D: interferometry.

Methods A, B, and C apply to the measurement of chromatic dispersion of the following fibres over a specified wavelength range:

– class A1 graded-index multimode fibres;
– category A4f, A4g and A4h multimode fibres;
– class B single-mode fibres (all categories).

Method D applies to the measurement of chromatic dispersion values of single-mode fibres categories B1, B2, B4 and B5 over the 1 000 nm to 1 700 nm wavelength range.

The methods can be applied to laboratory, factory and field measurements of chromatic dispersion, and the wavelength range of the measurements can be tailored as required. Measurements are made at temperature as stated in IEC 60793-1-1, Table 1 – Standard range of atmospheric conditions (Temperature 23 °C ±5 °C).

The methods are suitable for fibre or cable lengths greater than 1 km. They may also be applied to shorter lengths, but accuracy and repeatability may be compromised. Method D is the preferred method for shorter piece fibres (1 m to 10 m).

Information common to all methods is contained in Clauses 1-8, and information pertaining to each individual method appears in Annexes A, B, C, and D, respectively.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-1:2002, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*

IEC 60793-1-41, *Optical Fibres – Part 1-41: Measurement methods and test procedures – Bandwidth*

3 Overview of methods

3.1 Method A, phase shift

This method describes a procedure for determining the chromatic dispersion of all categories of type B single-mode fibres, category A1 graded-index multimode fibres and category A4f, A4g and A4h fibres, over a specified wavelength range using the relative phase shifts among sinusoidally modulated optical sources of different wavelengths. The sources are typically laser diodes or filtered light emitting diodes or filtered amplified spontaneous emission (ASE) sources. Relative phase shifts are converted to relative time delays, and the resultant spectral group delay data are then fitted to an equation defined for each fibre type.

3.2 Method B, spectral group delay in the time domain

This method describes a procedure for determining the chromatic dispersion of all categories of type B single-mode fibres, category A1 graded-index multimode fibres and category A4f, A4g and A4h fibres with the use of a Nd:YAG/fibre Raman laser source or multiple laser diodes operating at a number of wavelengths both greater than and less than the typical zero-dispersion wavelength.

In this method, the time difference of optical pulse delay through a known length of fibre at several wavelengths is measured. A reference set of measurements shall also be taken through a short reference fibre and data are subtracted from data taken from the fibre under test to obtain relative spectral group delay. The resultant spectral group delay data are then fitted to an equation defined for each fibre type.

3.3 Method C, differential phase shift

This method describes a procedure for determining the chromatic dispersion of all categories of type B single-mode fibres, category A1 graded-index multimode fibres and category A4f, A4g and A4h fibres. The dispersion coefficient at a particular wavelength is determined from the differential group delay between two closely spaced wavelengths.

In this procedure, a modulated light source is coupled into the fibre under test, and the phase of the light exiting the fibre at a first wavelength is compared with the phase of the light exiting at a second wavelength. Average chromatic dispersion over the interval between the two wavelengths is determined from differential phase shift, wavelength interval and fibre length.

The chromatic dispersion coefficient at a wavelength medial to the two test wavelengths is assumed to be equal to the average chromatic dispersion over the interval between the two wavelengths. The resultant chromatic dispersion data are then fitted to an equation defined for each fibre type.

3.4 Method D, interferometry

This method describes a procedure for determining the chromatic dispersion of single-mode fibres categories B1, B2, B4 and B5 over the 1 000 nm to 1 700 nm wavelength range. By using this test method, the chromatic dispersion of a short piece of fibre can be measured.

In this test method, the wavelength-dependent time delay between the test sample and the reference path is measured by Mach-Zehnder interferometer. The reference path can be an air path or a single-mode fibre with known spectral group delay.

It should be noted that extrapolation of the chromatic dispersion values derived from the interferometric test in fibres of a few metres length to long fibre sections assumes longitudinal homogeneity of the fibre. This assumption may not be applicable in every case.

4 Reference test methods

4.1 Category A1 and category A4f, A4g and A4h multimode fibres

For category A1 and category A4f, A4g and A4h multimode fibres, method B, spectral group delay in the time domain, is the reference test method (RTM), which shall be the one used to settle disputes.

4.2 Class B single-mode fibres

For all categories of class B single-mode fibres, method A, phase shift, is the reference test method (RTM). Method C, differential phase shift, may also be used to resolve disputes.

5 Apparatus

The following apparatus is common to all measurement methods. Annexes A, B, C, and D include layout drawings and other equipment requirements that individually apply for each of the methods, A, B, C, and D, respectively.

5.1 Launch optics

The output from the signal sources shall be coupled to the fibre under test or the reference fibre such that the physical path length for each source is held constant during the measurement. (This requirement ensures that the relative phases of the sources do not change due to path-length changes.) Suitable devices may include multichannel single-mode optical switches or demountable optical connectors.

For measurement of category A1, A4f, A4g, A4h multimode fibre, launch conditions shall comply with method A, Impulse response, of IEC 60793-1-41.

5.2 High-order mode filter (single-mode)

For measurement of single-mode fibre, use a method to remove high-order propagating modes in the wavelength range of interest. An example of such a high-order mode filter is a single loop of radius sufficiently small to shift cut-off wavelength below the minimum wavelength of interest.

5.3 Input positioning apparatus

Provide means to couple the input of the specimen to the light source. Examples include the use of x-y-z micropositioner stages, or mechanical coupling methods such as connectors, vacuum splices, three-rod splices, etc. The position of the fibre shall remain stable over the duration of the test.

5.4 Output positioning apparatus

Provide means of positioning the output end of the specimen such that the guided optical power is coupled to the system detector. Such coupling may include the use of lenses, or may be a mechanical connection to a detector pigtail.

5.5 Computation equipment

A digital computer may be used for purposes of equipment control, data acquisition, and numerical evaluation of the data.

6 Sampling and specimens

6.1 Specimen length

Methods A, B, and C require the specimen to be a fibre or cable of known length sufficiently long to produce adequate phase measurement accuracy. A typical minimum length is 1 km. Because category A4f, A4g and A4h fibres have higher loss than category A1 fibres, for these A4 fibres a minimum length of 100 m is acceptable.

NOTE Reproducibility is affected when using shorter measuring length. Longer lengths generally yield better reproducibility.

Method D (interferometry) requires a typical specimen length in the range of 1 m to 10 m.

6.2 Specimen end face

Prepare a flat end face, orthogonal to the fibre axis, at the input and output ends of each specimen.

6.3 Reference fibre

A single mode fibre with known dispersion characteristics shall be used to compensate for chromatic delays in the optical sources and other equipment components. The length of this fibre shall be less than or equal to 0,2 % of the specimen length.

In case of A4f, A4g and A4h fibres, the length of the reference fibre shall be less than or equal to 2 m. If this length is longer than 0,2 % of the length of the specimen under test, the chromatic dispersion of the reference fibres shall be taken into account by subtracting its chromatic dispersion value from the results measured on the specimen length.

NOTE The temperature of the specimen should be stable during the measurement within 0,1 °C to 1 °C, depending upon the temporal behaviour due to this change.

7 Procedure

See Annexes A, B, C and D for the procedures for methods A, B, C and D, respectively.

Reference fibre measurements are required for all methods. Reference fibre data can be stored for use in making measurements on the specimens. The reference fibre measurement procedure should be repeated when equipment changes on the source or receive optics or electronics occur.