

Optical fibres —

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

The European Standard EN 60793-1-42:2002 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 60793-1-42:2002. It is identical with IEC 60793-1-42:2001. It partly supersedes BS EN 188000:1994 which will be withdrawn upon publication of the full BS EN 60793-1 series.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/1, Optical fibres and cables, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

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This British Standard, having been prepared under the direction of the Electrotechnical Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 6 June 2002

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Part 1-42: Measurement methods and test procedures -
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Fibres optiques
Partie 1-42: Méthodes de mesure
et procédures d'essai -
Dispersion chromatique
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Teil 1-42: Messmethoden
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This European Standard was approved by CENELEC on 2001-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 86A/671/FDIS, future edition 1 of IEC 60793-1-42, prepared by SC 86A, Fibres and cables, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60793-1-42 on 2001-10-01.

This European Standard supersedes subclause 4.15 (test method 308) and subclause 4.16 (test method 309) of EN 188000:1992.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2002-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-10-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annexes A, B, C, D and ZA are normative.
Annex ZA has been added by CENELEC.

Compared to IEC 60793-1:1989 and IEC 60793-2:1992, IEC/SC 86A has adopted a revised structure of the new IEC 60793 series: The individual measurement methods and test procedures for optical fibres are published as "Part 1-XX"; the product standards are published as "Part 2-XX".

The general relationship between the new series of EN 60793 and the superseded European Standards of the EN 188000 series is as follows:

EN	Title	supersedes
EN 60793-1-XX	Optical fibres -- Part 1-XX: Measurement methods and test procedures	Individual subclauses of EN 188000:1992
EN 60793-2-XX	Optical fibres -- Part 2-XX: Product specifications	EN 188100:1995 EN 188101:1995 EN 188102:1995 EN 188200:1995 EN 188201:1995 EN 188202:1995

EN 60793-1-4X consists of the following parts, under the general title: Optical fibres:

- Part 1-40: Measurement methods and test procedures – Attenuation
- Part 1-41: Measurement methods and test procedures – Bandwidth
- Part 1-42: Measurement methods and test procedures – Chromatic dispersion
- Part 1-43: Measurement methods and test procedures – Numerical aperture
- Part 1-44: Measurement methods and test procedures – Cut-off wavelength
- Part 1-45: Measurement methods and test procedures – Mode field diameter
- Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance
- Part 1-47: Measurement methods and test procedures – Macrobending loss
- Part 1-48: Measurement methods and test procedures – Under consideration
- Part 1-49: Measurement methods and test procedures – Under consideration

Endorsement notice

The text of the International Standard IEC 60793-1-42:2001 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

Publications in the IEC 60793-1 series concern measurement methods and test procedures as they apply to optical fibres.

Within the same series several different areas are grouped, as follows:

- parts 1-10 to 1-19: General
- parts 1-20 to 1-29: Measurement methods and test procedures for dimensions
- parts 1-30 to 1-39: Measurement methods and test procedures for mechanical characteristics
- parts 1-40 to 1-49: Measurement methods and test procedures for transmission and optical characteristics
- parts 1-50 to 1-59: Measurement methods and test procedures for environmental characteristics.

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.

Four methods are described 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;
- class B single-mode fibres (all categories).

Method D applies to the measurement of chromatic dispersion values of single-mode fibres categories B1 to B3 in 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 temperatures as stated in IEC 60793-1-1.

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 three methods is contained in clauses 1 to 8, and information pertaining to each individual method appears in annexes A, B, C and D, respectively.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60793. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60793 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60793-1-31, *Optical fibres – Part 1-31: Measurement methods and test procedures – Tensile strength of optical fibres*

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, and category A1 graded-index multimode 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. 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 and category A1 graded-index multimode fibres with the use of an 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 is subtracted from data taken from the fibre under test to obtain relative spectral group delay. The resultant spectral group delay data is 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 and category A1 graded-index multimode 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 of categories B1 to B3 in the over 1 000 nm to 1 700 nm wavelength range. By using this test method, the chromatic dispersion of a short piece 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 the 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 multimode fibres

For category A1 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.

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.

When this method is used for category A1 multimode fibre, launch conditions shall comply with method A, impulse response, of this standard.

5.2 High-order mode filter (single-mode)

When using this measurement method for single-mode fibre, use a method to remove high-order propagating modes in the wavelength range concerned. 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. 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 fibre of the same type as the specimen 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.

NOTE The temperature of the specimen should be stable during the measurement time, i.e. within 0,1 °C to 1 °C, depending upon the temporal behaviour of 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.

8 Calculations

The calculation of relative delay appropriate for each method is given in annexes A, B, C and D, respectively.

The remainder of this clause describes the numerical fit that can be applied for all methods to the spectral group delay data normalized by length, $\tau(\lambda)$.