IEC 60793-1-22

Edition 2.0 2024-06
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Optical fibres –
Part 1-22: Measurement methods and test procedures – Length measurement

IEC 60793-1-22:2024-06 CMV(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 60793-1-22

Edition 2.0 2024-06
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Optical fibres –
Part 1-22: Measurement methods and test procedures – Length measurement

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.10

ISBN 978-2-8322-9346-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

OPTICAL FIBRES –

Part 1-22: Measurement methods and test procedures – Length measurement

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This commented version (CMV) of the official standard IEC 60793-1-22:2024 edition 2.0 allows the user to identify the changes made to the previous IEC 60793-1-22:2001 edition 1.0. Furthermore, comments from IEC SC 86A experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60793-1-22 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics. It is an International Standard.

This second edition cancels and replaces the first edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Inclusion of category C single mode fibres in Table 1;
b) Inclusion of a new informative Annex F on Brillouin frequency shift test method to determine the tensile strain applied to a fibre.

The text of this International Standard is based on the following documents:

Draft	Report on voting
86A/2456/FDIS	86A/2474/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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~~
- IEC 60793-1-20 to IEC 60793-1-29: *Measurement methods and test procedures for dimensions*
- IEC 60793-1-30 to IEC 60793-1-39: *Measurement methods and test procedures for mechanical characteristics*
- IEC 60793-1-40 to IEC 60793-1-49: *Measurement methods and test procedures for transmission and optical characteristics*
- IEC 60793-1-50 to IEC 60793-1-59: *Measurement methods and test procedures for environmental characteristics*.
- IEC 60793-1-60 to IEC 60793-1-69: *Measurement methods and test procedures for polarization-maintaining fibres*.

IEC 60793-1-2X consists of the following parts, under the general title: Optical fibres:

- Part 1-20: Measurement methods and test procedures – Fibre geometry
- Part 1-21: Measurement methods and test procedures – Coating geometry
- Part 1-22: Measurement methods and test procedures – Length measurement

OPTICAL FIBRES –

Part 1-22: Measurement methods and test procedures – Length measurement

1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the length and elongation of optical fibre (typically within cable).

The length of an optical fibre is ~~one of the most~~ a fundamental value~~s and shall be known~~ for the evaluation of transmission characteristics such as losses and bandwidths.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60793-1-40, *Optical fibres – Part 1-40: Attenuation measurement methods ~~and test procedures – Attenuation~~*

IEC 60793-1-42, *Optical fibres – Part 1-42: Measurement methods and test procedures – Chromatic dispersion*

~~IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General*~~

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

BOTDA	Brillouin optical time domain analysis
BOTDR	Brillouin optical time domain reflectometry
FWHM	full-width half-maximum
OTDR	optical time domain reflectometer
RMSW	root-mean-squared width
RTM	reference test method

4 Overview of method

4.1 General

This document gives five methods for measuring length, which are presented in Table 1.

Table 1 – Measurement methods

Method		Characteristics covered	Fibre categories covered	~~Former designation~~
A	Delay measuring	Length	All A1, B, and ~~all B~~ C 1	~~IEC 60793-1-A6~~
B	Backscattering	Length	All A1, B, and ~~all B~~ C	~~IEC 60793-1-C1C~~
C	Fibre elongation [a]	Fibre elongation [c]	A1, B1 [b], and C	~~IEC 60793-1-A7~~
D	Mechanical	Length	All	~~IEC 60793-1-A5~~
E	Phase shift	Length	All A1, B, and ~~all B~~ C	~~IEC 60793-1-A8~~

[a] The measurement of fibre elongation~~, method C,~~ is ~~part of several measurement methods for fibres and fibre optic cables, such as those~~ used in IEC 60794-1-1.

[b] This measurement is applicable unreservedly to type B single-mode fibres. For type A1 multimode fibres, take particular care when interpreting the results because the results of this measurement ~~may~~ can be influenced by interfering modal effects, for example, due to the occurrence of non-longitudinal stresses on the fibre. Application of the measurement to A2 to A4 multimode fibres is under consideration.

[c] Informative Annex F has been added to determine the tensile strain applied to a fibre. It uses Brillouin reflectometry (BOTDR) or so-called Brillouin analysis (BOTDA), which are single-sided and double-sided methods respectively.

Information common to all measurements is contained in Clause 2 to Clause 8. Information on specific application appears in Annex A, Annex B, Annex C, Annex D, and Annex E for methods A, B, C, D and E, respectively.

4.2 Method A – Delay measuring

The delay measuring method applies to measurements of the fibre length by the measurement of the propagation time of an optical pulse or a pulse train based on a known value of the group index of the fibre.

Alternatively, this method is suitable for measuring the group index of a fibre of known length. Therefore, in practice this fibre length measurement method is calibrated against a known length of fibre of the same type.

4.3 Method B – Backscattering

The backscattering method, which is a single-sided measurement, uses an optical time domain reflectometer (OTDR), and measures the optical power backscattered from different points in the fibre to the beginning of the fibre.

4.4 Method C – Fibre elongation

This measurement method describes a procedure for determining the fibre elongation. It does not measure absolute strain, but instead measures the changes in strain from one loading condition to another.

4.5 Method D – Mechanical length

This measurement method describes a procedure for determining the fibre length by winding a fibre around a fixed diameter calibrated wheel that rotates. The length is determined by the number of revolutions of the wheel.

4.6 Method E – Phase shift

The phase shift method describes a procedure for determining the fibre length. The length is determined from the phase shift that occurs when a predetermined modulation frequency f_{max} is applied.

4.7 Reference test method

The reference test method (RTM), which shall be the one used to settle disputes, varies depending on whether the fibre is cabled or not, such as

– uncabled fibre: method D;
– length of fibre within cable: method B;
– elongation of fibre within cable: method C;
– elongation of uncabled fibre: method C.

5 Apparatus

Annex A, Annex B, Annex C, Annex D, and Annex E include layout drawings and other equipment requirements for each of the methods A, B, C, D and E, respectively.

6 Sampling ~~and specimens~~ 2

See the appropriate Annex A, Annex B, Annex C, Annex D or Annex E for specific requirements. General requirements follow.

Prepare a flat end face, perpendicular to the fibre axis, at the input and output ends of each ~~specimen~~ sample for measurements based on optical delay measurements.

7 Procedure

See the appropriate Annex A, Annex B, Annex C, Annex D or Annex E for specific requirements.

8 Calculations

See the appropriate Annex A, Annex B, Annex C, Annex D or Annex E for specific requirements.

9 Results

The following information shall be provided with each measurement:

– date and title of measurement;
– identification and description of ~~specimen~~ sample, including whether fibre or cable;
– ~~specimen~~ sample length, or elongation;
– measurement method used: A, B, C, D or E;

– other results, as required by the appropriate Annex A, Annex B, Annex C, Annex D or Annex E.

The following information shall be available upon request:

– description of measurement apparatus arrangement;
– type and wavelength of measurement source;
– launch conditions;
– details of computation technique;
– date of latest calibration of equipment.

See Annex A, Annex B, Annex C, Annex D and Annex E for any additional information that shall be available upon request.

10 Specification information

The detail specification shall specify the following information:

– type of fibre (or cable) to be measured;
– failure or acceptance criteria;
– information to be reported;
– deviations to the procedure that apply.

Annex A
(normative)

Requirements specific to method A – Delay measuring

A.1 General

Use this method to measure the length of optical fibre by itself or installed in cable. If the ~~specimen~~ sample is a fibre in a cable, determine the value of group index N under conditions applicable to the ~~specimen~~ sample under measurement (for example, tension, temperature). This is done by inverting Formula (A.1) and the measurements on a ~~specimen~~ sample with a known length.

A.2 Principle

An optical pulse travelling through an optical fibre with length L and average group index N experiences a ~~travelling/delay time~~ time delay, Δt:

$$\Delta t = \frac{NL}{C} \tag{A.1}$$

where

Δt is the time delay;

N is the average group index;

C is the velocity of light in vacuum.

If N is known, the measurement of Δt gives L. On the other hand, the measurement of Δt gives the value of N when L is known.

A.3 Apparatus

A.3.1 Two techniques

There are two techniques for measuring the propagation time of an optical pulse:

– time measurement of the transmitted pulse (Δt measured);

– time measurement of the reflected pulse ($2\Delta t$ measured).

See Figure A.1 and Figure A.2 for two different arrangements corresponding to the two techniques applying a sampling oscilloscope.

Instead of the sampling oscilloscope, backscattering equipment, or a counter with separate start-stop gate and averaging capability (e.g. at least 10^4 counts), can be used.