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INTERNATIONAL STANDARD

colour inside

Optical fibres –
Part 1-47: Measurement methods and test procedures – Macrobending loss

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Part 1-47: Measurement methods and test procedures – Macrobending loss

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.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60793-1-47 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This fourth edition cancels and replaces the third edition published in 2009. It constitutes a technical revision.

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

a) former Annex A has been renumbered to Annex D;

b) introduction of new Annex A on the transmitted power monitoring technique;

c) introduction of Annex B on the cut-back technique;

d) introduction of Annex C on the requirements for the optical source characteristics of A1 multimode measurement;

e) introduction of Annex E on parallel plate (2-point) macrobend loss approximation.

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

FDIS	Report on voting
86A/1823/FDIS	86A/1828/RVD

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

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

This standard is to be read in conjunction with IEC 60793-1-1:2017.

A list of all parts of 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 "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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, but all numbers are possibly not used, 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 1-47: Measurement methods and test procedures – Macrobending loss

1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the macrobending loss of single-mode fibres (~~category~~ class B) at 1 550 nm or 1 625 nm, category A1 multimode fibres at 850 nm or 1 300 nm, and category A3 and A4 multimode fibres at 650 nm, 850 nm or 1 300 nm, thereby assisting in the inspection of fibres and cables for commercial purposes.

This document gives two methods for measuring macrobending sensitivity:

- Method A – Fibre winding, pertains to ~~category~~ class B single-mode fibres and category A1 multimode fibres.
- Method B – Quarter circle bends, pertains to category A3 and A4 multimode fibres.

For both of these methods, ~~the optical power is measured using either~~ the macrobending loss can be measured utilizing general fibre attenuation techniques, for example the power monitoring technique (see Annex A) or the cut-back technique (see Annex B). Methods A and B are expected to produce different results if they are applied to the same fibre. This is because the key difference between the two methods is the deployment, including the bend radius and ~~amount~~ length of fibre that is bent. The reason for the difference is that A3 and A4 multimode fibres are expected to be deployed in short lengths with ~~relatively fewer~~ a smaller number of bends per unit fiber length compared to single-mode and category A1 multimode fibres.

In this document, the "curvature radius" is defined as the radius of the suitable circular shaped support (e.g. mandrel or guiding groove on a flat surface) on which the fibre can be bent.

In addition, informative Annex E has been added to approximate bend loss for class B single-mode fibres across a broad wavelength range at various effective bends.

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 (all parts), *Optical fibres – Measurement methods and test procedures*

IEC 60793-1-1:2017, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*

~~IEC 60793-1-40: *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*~~

~~IEC 60793-1-46: *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*~~

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 60793-2-10, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

IEC 61280-1-4, *Fibre optic communication subsystem test procedures – Part 1-4: General communication subsystems – Light source encircled flux measurement method*

IEC 61280-4-1, *Fibre-optic communication subsystem test procedures – Part 4-1: Installed cable plant~~ and links~~ – Multimode~~ fibre-optic cable plant~~ attenuation measurement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-2, IEC 60793-1 (all parts) and IEC 60793-1-1 apply.

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

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

NOTE General definitions for fibres are provided in IEC 60793-2, definitions of the specified attributes are contained in the relevant test methods standard of IEC 60793-1 (all parts), and general definitions for testing are provided in IEC 60793-1-1.

4 Apparatus

4.1 Method A – Fibre winding

The apparatus consists of a tool (e.g. a mandrel or a guiding groove on a flat surface) able to hold the sample bent with a radius as stated in the appropriate optical fibre sectional product specification~~ (e.g. 30 mm for single-mode fibres and 37,5 mm for multimode fibres)~~ and a loss measurement instrument. Determine the macrobending loss at the wavelength as stated in the appropriate sectional product specification~~ (e.g. 850 nm or 1 300 nm for multimode fibres, 1 550 nm or 1 625 nm for singlemode fibre)~~ by using either the transmitted power monitoring technique (~~method A of IEC 60793-1-46~~ Annex A) or the cut-back technique (~~method A of IEC 60793-1-40~~ Annex B), taking care of the appropriate launch condition for the specific fibre type.

4.2 Method B – Quarter circle bends

The apparatus consists of one or more plates, each containing one or more "guide grooves", and a loss measurement instrument. The plates shall be designed to be stacked during the test without contacting the sample fibre in a lower or higher plate; such contact will affect the measurement results. Each guide groove shall have a quarter circle segment (i.e. 90°) as shown in Figure 1. The bend radius r, i.e. the radius of the quarter circle segment, shall be stated in the detail specification. The width of each guide groove~~ shall be at least 0,4 mm greater than the diameter of the fibre~~ is recommended to be 40 % broader than the outer fibre diameter.

Determine the macrobending loss at the wavelength as stated in the appropriate sectional product specification~~ (e.g. 650 nm, 850 nm, or 1 300 nm)~~ by using either the transmitted power monitoring technique (~~method A of IEC 60793-1-46~~ Annex A) or the cut-back technique (~~method A of IEC 60793-1-40~~ Annex B), taking care of the appropriate launch condition for the specific fibre type.

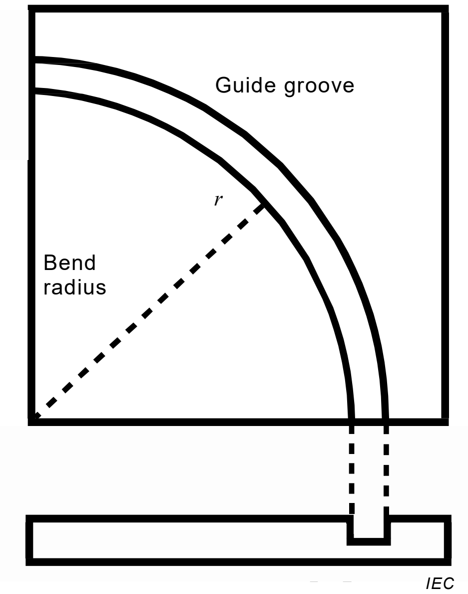

Figure 1 – Quarter circle guide groove in plate

4.3 Input system

4.3.1 Optical source

Use a suitable radiation source, such as a lamp, laser or light emitting diode. The choice of source depends upon the type of measurement. The source shall be stable in position, intensity and wavelength over a time period sufficiently long to complete the measurement procedure. Specify the spectral line width (between the 50 % optical intensity power points of the sources used) such that the line width is narrow, for example less than 10 nm, compared with any features of the fibre spectral attenuation. Align the fibre to the launch cone, or connect it coaxially to a launch fibre.

4.3.2 Optical launch arrangement

4.3.2.1 General

Figure 2 shows the general launch arrangement used for all fibres. Apply the appropriate launch arrangement to produce a full or restricted launch, depending on the parameter being measured. See 4.3.2.3 to 4.3.2.4 for further details as they apply to specific categories of single-mode and multimode fibres.

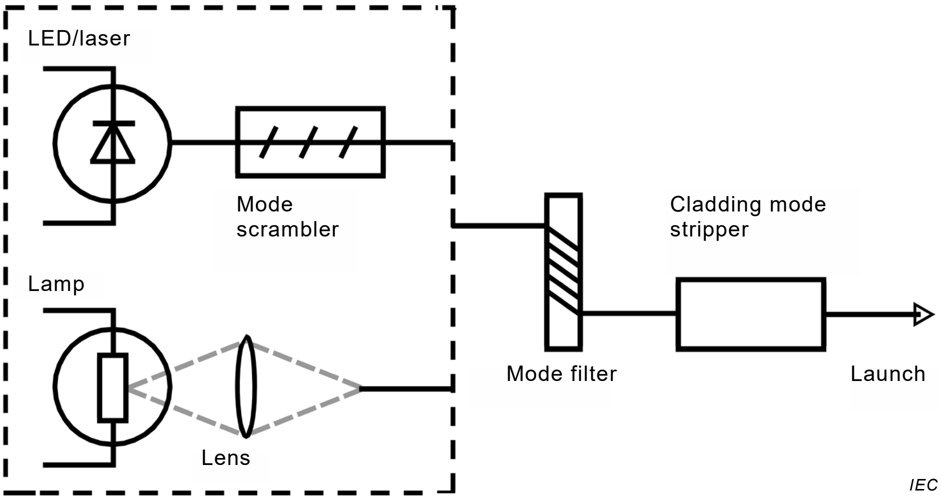

Figure 2 – General launch arrangement

4.3.2.2 Launch arrangement for single-mode fibres

4.3.2.2.1 General

An optical lens system or fibre pigtail may be employed to excite the test fibre. The power coupled into the fibre shall be stable for the duration of the measurement (see Figure A.1 or Figure B.1).

4.3.2.2.2 Fibre pigtail

If using a pigtail, it may be necessary to use index-matching material between the source pigtail and test fibre to eliminate interference effects.

4.3.2.2.3 Optical lens system

If using an optical lens system, provide a means of stably supporting the input end of the fibre, such as a vacuum chuck. Mount this support on a positioning device so that the fibre end can be repeatedly positioned in the input beam. A method of making the positioning of the fibre less sensitive is to overfill the fibre end spatially and angularly.

4.3.2.2.4 High-order mode filter

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 the cut-off wavelength below the minimum wavelength of interest, but not so small as to induce wavelength-dependent oscillations.

Another option commonly employed on bend insensitive single mode fibres and other single mode fibres with little or no cut-off response to bend is the use of a standard single mode fibre as a mode filter.

4.3.2.2.5 Cladding mode stripper

Use suitable techniques to remove optical power propagating in the cladding where this would significantly influence the received signal. The cladding mode stripper ensures that no radiation modes, propagating in the cladding region, will be detectable after a short distance along the fibre. The cladding mode stripper often consists of a material having a refractive index equal to or greater than that of the fibre cladding. This may be an index-matching fluid applied directly to the uncoated fibre near its ends; under some circumstances, the fibre coating itself will perform this function.

4.3.2.3 Launch arrangement for A1 multimode fibres

The required launch for measuring the macrobending loss of A1 multimode fibres shall be an encircled flux launch. The requirements for the optical source characteristics for A1 multimode measurement are included in Annex C.

The encircled flux emitted by the launching cord depends on the characteristic of the light source emerging from the face of the socket, the connection of the launching cord to the socket, the optical fibre within the launch cord, and any applied mode conditioning.

The test equipment manufacturer should provide specifications for the test cord that are compatible with the particular source implementation used. When the specification on the cord is met and used with the test equipment, the encircled flux (EF) requirements should be assured.

4.3.2.4 Launch arrangements for A2 to A4 multimode fibres

Below are some examples of generic launching arrangements for short-distance fibres described in Figure 3, Figure 4 and Figure 5.

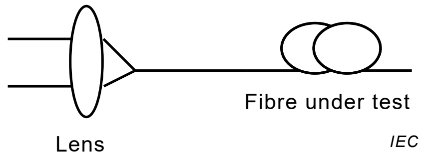

Figure 3 – Lens system

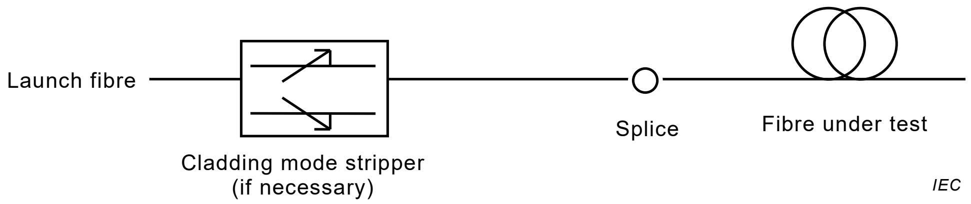

Figure 4 – Launch fibre

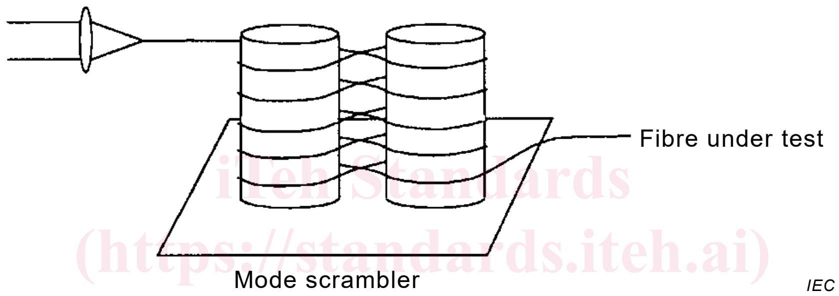

Figure 5 – Mode scrambler (for A4 fibre)

The reproducibility of the attenuation measurements of step-index fibres is critical. Therefore, a well-defined launching set-up description is necessary. Such a set-up can be achieved by using commercially available optical components and shall be able to provide spot sizes and launch numerical apertures (NAs) as given in Table 1. In addition, the measurement wavelength shall be calibrated to within ±10 nm.