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Optična vlakna - 1-45. del: Merilne metode in postopki preskušanja - Premer polja načina

Optical fibres - Part 1-45: Measurement methods and test procedures - Mode field diameter

Lichtwellenleiter - Teil 1-45: Messmethoden und Prüfverfahren - Modenfelddurchmesser

Fibres optiques - Partie 1-45 : Méthodes de mesure et procédures d'essai - Diamètre du champ de mode

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86A/2300/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

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IEC SC 86A : FIBRES AND CABLES	
SECRETARIAT: France	SECRETARY: Mr Laurent Gasca
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT	☐ QUALITY ASSURANCE ☐ SAFETY
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE:

Optical fibres - Part 1-45: Measurement methods and test procedures - Mode field diameter

PROPOSED STABILITY DATE: 2027

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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OPTICAL FIBRES –
Part 1-45: Measurement methods and test procedures –
Mode field diameter

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International Standard IEC 60793-1-45 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition published in 2017. This edition constitutes a technical revision.

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

a) Modification of the minimum distance between the fiber end and the detector for the direct far field scan (Annex A).

b) Generalization of the requirement for the minimum dynamic range for all fibre types (Annex A).

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

CDV	Report on voting
86A/1758/CDV	86A/1802/RVC

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.

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 "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.

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OPTICAL FIBRES –

Part 1-45: Measurement methods and test procedures – Mode field diameter

1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the mode field diameter (MFD) of single-mode optical fibre, thereby assisting in the inspection of fibres and cables for commercial purposes.

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 60793-1-40:2001, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

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

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3 Terms and definitions

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No terms and definitions are listed in this document.

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

4 General consideration about mode field diameter

The mode field diameter measurement represents a measure of the transverse extent of the electromagnetic field intensity of the guided mode in a fibre cross section, and it is defined from the far-field intensity distribution as a ratio of integrals known as the Petermann II definition. See Equation (1).

The definitions of mode field diameter are strictly related to the measurement configurations. The mathematical equivalence of these definitions results from transform relationships between measurement results obtained by different implementations summarized in Figure 1 as follows.

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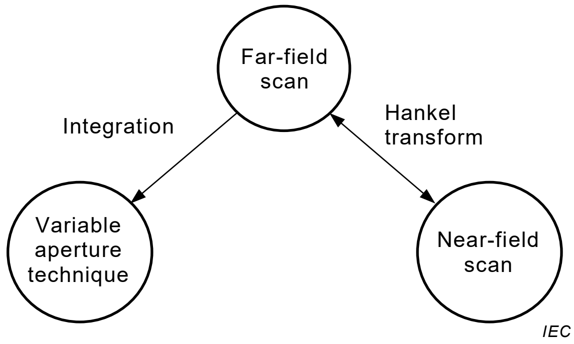

Figure 1 – Transform relationships between measurement results

Four methods are described for measuring mode field diameter:

– method A: direct far-field scan;
– method B: variable aperture in the far field;
– method C: near-field scan;
– method D: bi-directional backscatter using an optical time domain reflectometer (OTDR).

All four methods apply to all categories of type B single-mode fibre shown in IEC 60793-2 and operating near 1 310 nm or 1 550 nm. Method D is not recommended for the measurement of fibres of unknown type or design.

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Information common to all four methods is contained in Clauses 1 to 11, and information pertaining to each individual method appears in annexes A, B, C and D, respectively.

5 Reference test method

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Method A, direct far-field scan, is the reference test method (RTM), which shall be the one used to settle disputes.

6 Apparatus

6.1 General

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

6.2 Light source

For methods A, B and C, use a suitable coherent or non-coherent light source, such as a semiconductor laser or a sufficiently powerful filtered white light source. The source shall produce sufficient radiation at the intended wavelength(s) and be stable in intensity over a time period sufficient to perform the measurement.

A monochromator or interference filter(s) may be used, if required, for wavelength selection. The detail specification shall specify the wavelength of the source. The full width half maximum (FWHM) spectral line width of the source shall be less than or equal to 10 nm, unless otherwise specified.

See Annex D for method D.

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6.3 Input optics

For method A, B, and C, an optical lens system or fibre pigtail may be employed to excite the specimen. It is recommended that the power coupled into the specimen be relatively insensitive to the position of its input end face. This can be accomplished by using a launch beam that spatially and angularly overfills the input end face.

If using a butt splice, employ index-matching material between the fibre pigtail and the specimen to avoid interference effects. The coupling shall be stable for the duration of the measurement.

See Annex D for method D.

6.4 Input positioner

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

6.5 Cladding mode stripper

Use a device that extracts cladding modes. Under some circumstances, the fibre coating will perform this function.

6.6 High-order mode filter

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Use a means to remove high-order propagating modes in the wavelength range that is greater than or equal to the cut-off wavelength of the specimen. For example, a one-turn bend with a radius of 30 mm on the fibre is generally sufficient for most B-652, B-653, B-654, B-655, B-656 and B-657 fibres. For some B-657 fibres, smaller radius, multiple bends or longer specimen length can be applied to remove high-order propagating modes.

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6.7 Output positioner

Provide a suitable means for aligning the fibre output end face in order to allow an accurate axial adjustment of the output end, such that, at the measurement wavelength, the scan pattern is suitably focused on the plane of the scanning detector. Such coupling may include the use of lenses, or may be a mechanical connector to a detector pigtail.

Provide means such as a side-viewing microscope or camera with a crosshair to locate the fibre at a fixed distance from the apertures or detectors. It may be sufficient to provide only longitudinal adjustment if the fibre is constrained in the lateral plane by a device such as a vacuum chuck (this depends mainly upon the size of the light detector).

6.8 Output optics

See the appropriate annex: A, B, C or D.

6.9 Detector

See the appropriate annex: A, B, C or D.

6.10 Computer

Use a computer to perform operations such as controlling the apparatus, taking intensity measurements, and processing the data to obtain the final results. For individual details, see the appropriate annex: A, B, C or D.

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7 Sampling and specimens

7.1 Specimen length

For methods A, B and C, the specimen shall be a known length, typically 2 m ± 0,2 m for most B-652, B-653, B-654, B-655, B-656 and B-657 fibres. For some B-657 fibres, longer specimen length can be used to avoid high-order propagating modes, 22 m for example.

For method D, OTDR, the sample shall be long enough to exceed (or be positioned beyond) the dead zone of the OTDR, with both ends accessible, as described in the backscatter test method IEC 60793-1-40.

7.2 Specimen end face

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

8 Procedure

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

9 Calculations

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9.1 Basic equations

The basic equations for calculating mode field diameter by methods A, B and C are given below. For additional calculations, see the appropriate annex: A, B, C or D. Sample data sets for methods A, B and C are included in Annex E.

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9.2 Method A – Direct far-field scan

The following equation defines the mode field diameter for method A in terms of the electromagnetic field emitted from the end of the specimen.

Calculate the mode field diameter by scanning the far-field data and evaluating the Petermann II integral, which is defined from the far-field intensity distribution:

$$2W_0 = \frac{\lambda\sqrt{2}}{\pi}\left[\frac{\int_0^{\pi/2} P_F(\theta)\sin(\theta)\cos(\theta)d\theta}{\int_0^{\pi/2} P_F(\theta)\sin^3(\theta)\cos(\theta)d\theta}\right]^{1/2} \quad (1)$$

where

$2W_0$ is the mode field diameter in μm;

$P_F(\theta)$ is the far-field intensity distribution;

λ is the wavelength of measurement in μm;

θ is the angle in the far-field measurement from the axis of the fibre.

NOTE 1 The integration limits are shown to be from zero to $\pi/2$, but it is understood that the integrands approach zero with increasing argument so that, in practice, the integrals can be truncated.

NOTE 2 P_F is $F^2(\theta)$ in ITU-T documents.

The far-field method for obtaining the mode field diameter of a single-mode fibre is a two-step procedure. First, measure the far-field radiation pattern of the fibre. Second, use a mathematical