



REDLINE VERSION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.10

ISBN 978-2-8322-5059-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD	5
INTRODUCTION	
1 Scope	8
2 Normative references	8
3 Terms and definitions	8
4 General consideration about mode field diameter	8
5 Reference test method	9
6 Apparatus	9
6.1 General	9
6.2 Light source	9
6.3 Input optics	10
6.4 Input positioner	10
6.5 Cladding mode stripper	10
6.6 High-order mode filter	10
6.7 Output positioner	10
6.8 Output optics	10
6.9 Detector	10
6.10 Computer	10
7 Sampling and specimens	11
7.1 Specimen length	11
7.2 Specimen end face	11
8 Procedure	11
9 Calculations	11
9.1 Basic equations	11
9.2 Method A – Direct far-field scan	11
9.3 Method B – Variable aperture in the far field	12
9.4 Method C – Near-field scan	13
10 Results	13
10.1 Information to be provided available with each measurement	13
10.2 Information available upon request	14
11 Specification information	14
Annex A (normative) Requirements specific to method A – Mode field diameter by direct far-field scan	15
A.1 Apparatus	15
A.1.1 General	15
A.1.2 Scanning detector assembly – Signal detection electronics	15
A.1.3 Computer	15
A.2 Procedure	16
A.3 Calculations	16
A.3.1 Determine folded power curve	16
A.3.2 Compute the top (T) and bottom (B) integrals of Equation (1)	16
A.3.3 Complete the calculation	16
A.4 Sample data	17
Annex B (normative) Requirements specific to method B – Mode field diameter by variable aperture in the far field	18

B.1	Apparatus	18
B.1.1	General	18
B.1.2	Output variable aperture assembly	18
B.1.3	Output optics system	19
B.1.4	Detector assembly and signal detection electronics	19
B.2	Procedure	19
B.3	Calculations	19
B.3.1	Determine complementary aperture function	19
B.3.2	Complete the integration	20
B.3.3	Complete the calculation	20
B.4	Sample data set	20
Annex C (normative) Requirements specific to method C – Mode field diameter by near-field scan		21
C.1	Apparatus	21
C.1.1	General	21
C.1.2	Magnifying output optics	21
C.1.3	Scanning detector	21
C.1.4	Detection electronics	22
C.2	Procedure	22
C.3	Calculations	22
C.3.1	Calculate the centroid	22
C.3.2	Fold the intensity profile	23
C.3.3	Compute the integrals	23
C.3.4	Complete the calculation	23
C.4	Sample data	24
Annex D (normative) Requirements specific to method D – Mode field diameter by optical time domain reflectometer (OTDR)		25
D.1	General	25
D.2	Apparatus	25
D.2.1	OTDR	25
D.2.2	Optional auxiliary switches	25
D.2.3	Optional computer	26
D.2.4	Test sample	26
D.2.5	Reference sample	26
D.3	Procedure	26
D.3.1	Orientation and notation	26
D.4	Calculations	27
D.4.1	Reference fibre mode field diameter	27
D.4.2	Computation of the specimen mode field diameter	28
D.4.3	Validation	28
Annex E (informative) Sample data sets and calculated values		30
E.1	General	30
E.2	Method A – Mode field diameter by direct far-field scan	30
E.3	Method B – Mode field diameter by variable aperture in the far field	31
E.4	Method C – Mode field diameter by near-field scan	31
Figure 1 – Transform relationships between measurement results		9
Figure A.1 – Far-field measurement set		15
Figure B.1 – Variable aperture by far-field measurement set		18

Figure C.1 – Near-field measurement set-ups	21
Figure D.1 – Optical switch arrangement	26
Figure D.2 – View from reference fibre A	27
Figure D.3 – View from reference fibre B	27
Figure D.4 – Validation example – Comparison of methods.....	28
Table E.1 – Sample data, method A – Mode field diameter by direct far-field scan.....	30
Table E.2 – Sample data set, method B – Mode field diameter by variable aperture in the far field.....	31
Table E.3 – Sample data set, method C – Mode field diameter by near-field scan.....	31

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

DISCLAIMER

This Redline version is not an official IEC Standard and is intended only to provide the user with an indication of what changes have been made to the previous version. Only the current version of the standard is to be considered the official document.

This Redline version provides you with a quick and easy way to compare all the changes between this standard and its 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 60793-1-45 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. This edition constitutes a technical revision.

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

- a) improvement of the description of measurement details for B6 fibre;
- b) correction of Equations (1), (2), (5) and (6);
- c) correction of Table E.1, Table E.2 and Table E.3.

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.

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 publication 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~~
- ~~— 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 1-45: 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:~~1998~~, *Optical fibres – Part 2: Product specifications – General*

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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



CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	7
3 Terms and definitions	7
4 General consideration about mode field diameter	7
5 Reference test method	8
6 Apparatus	8
6.1 General	8
6.2 Light source	8
6.3 Input optics	9
6.4 Input positioner	9
6.5 Cladding mode stripper	9
6.6 High-order mode filter	9
6.7 Output positioner	9
6.8 Output optics	9
6.9 Detector	9
6.10 Computer	9
7 Sampling and specimens	10
7.1 Specimen length	10
7.2 Specimen end face	10
8 Procedure	10
9 Calculations	10
9.1 Basic equations	10
9.2 Method A – Direct far-field scan	10
9.3 Method B – Variable aperture in the far field	11
9.4 Method C – Near-field scan	11
10 Results	12
10.1 Information available with each measurement	12
10.2 Information available upon request	12
11 Specification information	12
Annex A (normative) Requirements specific to method A – Mode field diameter by direct far-field scan	14
A.1 Apparatus	14
A.1.1 General	14
A.1.2 Scanning detector assembly – Signal detection electronics	14
A.1.3 Computer	14
A.2 Procedure	15
A.3 Calculations	15
A.3.1 Determine folded power curve	15
A.3.2 Compute the top (T) and bottom (B) integrals of Equation (1)	15
A.3.3 Complete the calculation	15
A.4 Sample data	16
Annex B (normative) Requirements specific to method B – Mode field diameter by variable aperture in the far field	17
B.1 Apparatus	17

B.1.1	General	17
B.1.2	Output variable aperture assembly	17
B.1.3	Output optics system	18
B.1.4	Detector assembly and signal detection electronics	18
B.2	Procedure	18
B.3	Calculations	18
B.3.1	Determine complementary aperture function	18
B.3.2	Complete the integration	19
B.3.3	Complete the calculation	19
B.4	Sample data	19
Annex C (normative)	Requirements specific to method C – Mode field diameter by near-field scan	20
C.1	Apparatus	20
C.1.1	General	20
C.1.2	Magnifying output optics	20
C.1.3	Scanning detector	20
C.1.4	Detection electronics	21
C.2	Procedure	21
C.3	Calculations	21
C.3.1	Calculate the centroid	21
C.3.2	Fold the intensity profile	22
C.3.3	Compute the integrals	22
C.3.4	Complete the calculation	22
C.4	Sample data	23
Annex D (normative)	Requirements specific to method D – Mode field diameter by optical time domain reflectometer (OTDR)	24
D.1	General	24
D.2	Apparatus	24
D.2.1	OTDR	24
D.2.2	Optional auxiliary switches	24
D.2.3	Optional computer	25
D.2.4	Test sample	25
D.2.5	Reference sample	25
D.3	Procedure	25
D.3.1	Orientation and notation	25
D.4	Calculations	26
D.4.1	Reference fibre mode field diameter	26
D.4.2	Computation of the specimen mode field diameter	27
D.4.3	Validation	27
Annex E (informative)	Sample data sets and calculated values	29
E.1	General	29
E.2	Method A – Mode field diameter by direct far-field scan	29
E.3	Method B – Mode field diameter by variable aperture in the far field	30
E.4	Method C – Mode field diameter by near-field scan	30
Figure 1	– Transform relationships between measurement results	8
Figure A.1	– Far-field measurement set	14
Figure B.1	– Variable aperture by far-field measurement set	17

Figure C.1 – Near-field measurement set-ups	20
Figure D.1 – Optical switch arrangement	25
Figure D.2 – View from reference fibre A	26
Figure D.3 – View from reference fibre B	26
Figure D.4 – Validation example – Comparison of methods.....	27
Table E.1 – Sample data, method A – Mode field diameter by direct far-field scan.....	29
Table E.2 – Sample data set, method B – Mode field diameter by variable aperture in the far field	30
Table E.3 – Sample data set, method C – Mode field diameter by near-field scan.....	30

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60793-1-45 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. This edition constitutes a technical revision.

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

- a) improvement of the description of measurement details for B6 fibre;
- b) correction of Equations (1), (2),(5) and (6);
- c) correction of Table E.1, Table E.2 and Table E.3.

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.

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*