IEC TR 62284

Edition 2.0 2025-12

TECHNICAL REPORT

Effective area measurements of single-mode optical fibres - Guidance

ICS 33.180.10

ISBN 978-2-8327-0896-5

IEC TR 62284:2025-12(en)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2025 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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 It also gives information on projects, replaced and withdrawn publications.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.

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

CONTENTS

FOREWORD 3
1 Scope 5
2 Normative references 5
3 Terms and definitions 6
4 Abbreviated terms 6
5 Apparatus 6
5.1 General 6
5.2 Light source 6
5.3 Input optics 6
5.4 Cladding mode stripper 6
5.5 High-order mode filter 6
5.6 Computer 6
6 Sampling and specimens 7
6.1 Specimen length 7
6.2 Specimen end faces 7
7 Procedure 7
8 Calculation or interpretation of results 7
8.1 General 7
8.2 Near-field 7
8.3 Direct far-field 7
8.4 Variable aperture in the far-field 8
9 Documentation 8
9.1 Essential information 8
9.2 Information available upon request 8
Annex A (normative) Direct far-field method measurement specifics 9
A.1 Apparatus 9
A.1.1 General 9
A.1.2 Detector and aperture 9
A.1.3 Scanning apparatus 10
A.2 Procedure 10
A.3 Calculations 10
Annex B (normative) Variable aperture in the far-field method measurement specifics 14
B.1 Apparatus 14
B.1.1 General 14
B.1.2 Output variable aperture assembly 14
B.1.3 Output positioner 15
B.1.4 Output optics 15
B.1.5 Detector assembly and signal detection electronic 15
B.2 Procedure 15
B.3 Calculations 15
Annex C (normative) Near-field method measurement specifics 18
C.1 Apparatus 18
C.1.1 General 18
C.1.2 Output optics 18
C.1.3 Positioning apparatus 18
C.1.4 Detector assembly – Signal detection electronics 18

C.2 Procedure 18
C.2.1 Specimen alignment 18
C.2.2 Power level adjustment 19
C.2.3 Signal acquisition 19
C.3 Calculation 19
C.3.1 General 19
C.3.2 Calculate the centroid 19
C.3.3 Fold the intensity profile 19
C.3.4 Compute the integrals from Formula (2) 19
C.3.5 Complete the calculation 20
Annex D (informative) Sample data and calculations 21
D.1 Data from method A 21
D.2 Data from method B 23
Annex E (informative) Comparison between this document and ITU recommendations 24
Annex F (informative) Treatment of side lobes in far-field data 25
Annex G (informative) Method for computing effective area from variable aperture data 26
G.1 General 26
G.2 Relationship between the fundamental mode field and the aperture power flow 26
G.3 Numerical approximation of the fundamental mode field 31
G.4 Computation of effective area 36
G.5 Summary 38
Bibliography 39

Figure A.1 – Test set-up for the direct far-field measurement 9
Figure B.1 – Test set-up for the variable aperture in the far-field measurement 14
Figure B.2 – Apparatus set-up measurements 15
Figure C.1 – Near-field method test set-up 18
Figure D.1 – Far-field intensity 21
Figure D.2 – Near-field intensity 21
Figure F.1 – Typical far-field plot displaying side lobes 25
Figure G.1 – Measurement geometry of the variable aperture method 27
Figure G.2 – Co-ordinate system used to evaluate the diffraction field 27
Figure G.3 – Polar co-ordinates of $\vec{r}$ 28
Figure G.4 – Geometry for the evaluation of Formula (G.12) 30
Figure G.5 – Example of the fit to aperture power flow data 34
Figure G.6 – Fit in the presence of decreasing data 35
Figure G.7 – Mode field from the data in Figure G.5 36
Figure G.8 – Change in A_{eff} with r_{max}, from the data in Figure G.6 37

Table A.1 – Estimates of error 10
Table D.1 – Sample measured and calculated data 21
Table D.2 – Sample measured and calculated data 23
Table G.1 – Comparison of exact and computed effective areas 37

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

Effective area measurements of single-mode optical fibres - Guidance

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.

IEC TR 62284 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2003. 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 B-657 fibre;
b) modification of the minimum distance between the fibre end and the detector for the direct far field scan (Annex A);
c) deletion of Annex H.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86A/2619/DTR	86A/2641/RVDTR

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 Technical Report 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.

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.

1 Scope

This document applies to single-mode optical fibres. Its object is to document the methods for measuring the effective area (A_{eff}) of these fibres.

It defines three methods of measuring A_{eff}. Information common to all the methods is found in the body of this document. Information specific to each method is found in the annexes. The three methods are:

a) direct far-field (DFF);

b) variable aperture in the far-field (VAMFF);

c) near-field (NF).

The reference method, used to resolve disputes, is method A, direct far-field.

Effective area is an optical attribute that is specified for single-mode fibres and used in system designs probably affected by the non-linear refractive index coefficient, n_2. There is agreement in both national and international standards bodies concerning the definition used in this document. Methods A, B, and C have been recognised as providing equivalent results, provided that good engineering is used in implementation.

The direct far-field is the reference method because it is the most direct method and is named as the reference method for mode field diameter in IEC 60793-1-45 and ITU-T Recommendation G.650.1.

A mapping function is a formula by which the measured results of one attribute are used to predict the value of another attribute on a given fibre. For a given fibre type and design, the mode field diameter (MFD) (IEC 60793-1-45) can be used to predict the effective area with a mapping function. A mapping function is specific to a particular fibre type and design. Mapping functions are generated by doing an experiment in which a sample of fibre is chosen to represent the spectrum of values of MFD and in which the fibres in the sample are measured for both MFD and A_{eff}. Linear regression can be used to determine the fitting coefficient, k, as defined by the following:

$$A_{\text{eff}} = k\pi\left(\frac{\text{MFD}}{2}\right)^2 \tag{1}$$

NOTE 1 Other mathematical models can be used if they are generally more accurate.

NOTE 2 See Annex E for more information.

2 Normative references

There are no normative references in this document.

Bibliography

[1] RALSTON, A. and RABINOWITZ, P. *A First Course in Numerical Analysis*. McGraw-Hill Book Company, New York, 1978

[2] HALLAM, A*. Determination of Effective Area of Single-mode Fibre Using the VAFF Technique.* Technical Note 66 1a, Measurements Standards Dept., Photon Kinetics, 1999

[3] HOTATE, K. and OKOSHI, T. Measurement of refractive-index profile and transmission characteristics of a single-mode optical fibre from its exit-radiation pattern. *Applied Optics* 18, 1979, p. 3265

[4] FREUDE, W. and SHARMA, A. Refractive-Index Profile and Modal Dispersion Prediction for a Single-Mode Optical Waveguide from its Far-Field Radiation Pattern*. IEEE Journal of Lightwave Technology* 3, 1985, p. 628

[5] JACKSON, J.D. *Classical Electrodynamics* (second edition). John Wiley & Sons, New York, 1975

[6] STAKGOLD, I. *Green's Functions and Boundary Value Problems*. John Wiley & Sons, New York, 1979

[7] DEBOOR, C., *A Practical Guide to Splines.* Springer-Verlag Inc., New York, 1978

[8] GILL, P., MURRAY, W., and WRIGHT, M. *Practical Optimization*. Academic Press Inc., San Diego, 1981

[9] PRESS, W., TEUKOLSKY, S., VETTELING, W. and FLANNERY, B. *Numerical Recipes in Fortran (*second edition). Cambridge University Press, 1992

[10] IEC 60793-1-45, *Optical fibres - Part 1-45: Measurement methods and test procedures - Mode field diameter*

[11] ITU-T Recommendation G.650.1:2024, *Definition and test methods for linear, deterministic attributes of single-mode fibre and cable*

[12] ITU-T Recommendation G.650.2:2015, *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable*

_____