

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Optical fibres –  
Part 1-43: Measurement methods and test procedures – Numerical aperture  
Measurement**

**Fibres optiques –  
Partie 1-43: Méthodes de mesure et procédures d'essai – Mesure de l'ouverture  
numérique**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

---

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC -

[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



---

**Optical fibres –  
Part 1-43: Measurement methods and test procedures – Numerical aperture  
Measurement**

**Fibres optiques –  
Partie 1-43: Méthodes de mesure et procédures d'essai – Mesure de l'ouverture  
numérique**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

---

ICS 33.180.10

ISBN 978-2-8322-7387-6

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references .....	6
3 Overview of method.....	6
4 Reference test method .....	7
5 Apparatus.....	8
5.1 Input system .....	8
5.1.1 Light source.....	8
5.1.2 Input optics.....	8
5.1.3 Fibre input end support and alignment.....	8
5.1.4 Cladding mode stripper.....	8
5.2 Output system and detection.....	8
5.2.1 General .....	8
5.2.2 Technique 1 – Angular scan (see Figure 2).....	9
5.2.3 Technique 2 – Angular scan (see Figure 3).....	10
5.2.4 Technique 3 – Scan of the spatial field pattern (see Figure 4).....	10
5.2.5 Technique 4 – Inverse far-field measurement (see Figure 5, applicable to subcategory A4d fibres).....	12
6 Sampling and specimens .....	13
6.1 Specimen length .....	13
6.2 Specimen endface .....	13
7 Procedure.....	13
8 Calculations.....	13
8.1 Far-field versus maximum theoretical value .....	13
8.2 Threshold intensity angle, $\theta_k$ .....	14
8.3 Numerical aperture, $NA_{ff}$ .....	14
8.4 Calculating far-field intensity pattern when using Technique 3 .....	15
8.5 Calculating NA when using Technique 4 .....	15
9 Results .....	15
9.1 Information available with each measurement.....	15
9.2 Information available upon request .....	16
10 Specification information .....	16
Annex A (informative) Mapping NA measurement to alternative lengths .....	17
A.1 Introductory remark.....	17
A.2 Mapping long length $NA_{ff}$ measurement to short length $NA_{ff}$ measurement.....	17
Annex B (normative) Product specific default values for NA measurement.....	18
B.1 Introductory remark.....	18
B.2 Table of default values used in NA measurement for multimode products .....	18
Figure 1 – Representative refractive index profile for a graded index multimode fibre .....	7
Figure 2 – Technique 1 – Angular scan.....	9
Figure 3 –Technique 2 – Angular scan.....	10
Figure 4 – Technique 3 – Scan of the spatial field pattern.....	11

Figure 5 – Technique 4 – Inverse far-field method ..... 13

Figure 6 – Example of a far-field NA measurement ..... 14

Figure 7 – Sample output of an A4d fibre measured using Technique 4 ..... 15

  

Table B.1 – Default values for parameters used in the far-field NA measurement of multimode fibres ..... 18

# INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

## OPTICAL FIBRES –

### **Part 1-43: Measurement methods and test procedures– Numerical aperture 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) 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 60793-1-43 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This bilingual version (2019-09) corresponds to the monolingual English version, published in 2015-03.

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

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

- expansion of the scope to include A1, A2, A3 and A4 multimode fibre categories;
- addition of measurement parameters of sample length and threshold values, product specific to the variables that are now found in the product specifications;

- a new Annex B entitled "Product specific default values for NA measurement";
- addition of a new Technique 4 for measuring NA of A4d fibres;
- a new Annex A entitled "Mapping NA measurement to alternative lengths" that gives a mapping function to correlate shorter sample length measurements to the length suggested in the reference test method  $Na_{ff}$ .

This International Standard is to be used in conjunction with IEC 60793-1-1, IEC 60793-1-21 and IEC 60793-1-22.

The text of this standard is based on the following documents:

CDV	Report on voting
86A/1566/CDV	86A/1622/RVC

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

The French version of this standard has not been voted upon.

This publication 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 publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication 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.**

## OPTICAL FIBRES –

### Part 1-43: Measurement methods and test procedures– Numerical aperture measurement

#### 1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the numerical aperture of optical fibre, thereby assisting in the inspection of fibres and cables for commercial purposes.

The numerical aperture (NA) of categories A1, A2, A3 and A4 multimode fibre is an important parameter that describes a fibre's light-gathering ability. It is used to predict launching efficiency, joint loss at splices, and micro/macrobending performance.

The numerical aperture is defined by measuring the far-field pattern ( $NA_{ff}$ ). In some cases the theoretical numerical aperture ( $NA_{th}$ ) is used in the literature, which can be determined from measuring the difference in refractive indexes between the core and cladding. Ideally these two methods should produce the same value.

#### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60793-1-21, *Optical fibres – Part 1-21: Measurement methods and test procedures – Coating geometry*

IEC 60793-1-22, *Optical fibres – Part 1-22: Measurement methods and test procedures – Length measurement*

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

IEC 60793-2-20, *Optical fibres – Part 2-20: Product specifications – Sectional specification for category A2 multimode fibres*

IEC 60793-2-30, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

#### 3 Overview of method

This test procedure describes a method for measuring the angular radiant intensity (far-field) distribution from an optical fibre. The numerical aperture of multimode optical fibre can be