

INTERNATIONAL STANDARD

NORME INTERNATIONALE

End-face image analysis procedure for the calibration of optical fibre geometry test sets

Procédure d'analyse d'image d'extrémité pour l'étalonnage de dispositifs d'essais de géométrie des fibres optiques





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 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
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions 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

65 000 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.

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: csc@iec.ch.

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.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

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

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

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions 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

65 000 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.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.



IEC 61745

Edition 2.0 2017-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

End-face image analysis procedure for the calibration of optical fibre geometry test sets

Procédure d'analyse d'image d'extrémité pour l'étalonnage de dispositifs d'essais de géométrie des fibres optiques

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.180.01

ISBN 978-2-8322-4614-6

**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.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	8
4 General information and preparation for calibration	11
4.1 Geometrical parameters of optical fibres	11
4.2 Description of geometry test sets	11
4.3 Calibration standard requirements	12
5 Calibration.....	12
5.1 General.....	12
5.2 Rationale for calibration of geometry test sets.....	12
5.2.1 General	12
5.2.2 Verification of calibration state.....	13
5.3 Calibration procedure.....	14
5.3.1 General advice and organization.....	14
5.3.2 Test requirements.....	14
5.3.3 Calibration standard requirements	14
5.3.4 Determination of calibration factors.....	14
5.4 Check calibration procedure.....	16
5.5 Spatial linearity	16
5.6 Calibration of core/cladding concentricity error measurement.....	17
5.7 Calibration of non-circularity measurement	17
6 Evaluation of uncertainties	17
6.1 General.....	17
6.2 Evaluation of uncertainty in test set calibration	18
6.2.1 General	18
6.2.2 Uncertainty in scaling factor.....	18
6.2.3 Uncertainty in offset correction factor	19
6.3 Evaluation of uncertainty in fibre measurement	20
6.3.1 General	20
6.3.2 Determination of $u_{Op,I,F}$	21
6.3.3 Determination of $u'_{I,F}$	21
6.4 Evaluation of uncertainty in chromium mask measurement.....	21
6.4.1 General	21
6.4.2 Determination of $u_{Op,I,C}$	21
6.4.3 Determination of $u'_{I,C}$	21
6.5 Summary	22
7 Documentation	22
7.1 Records	22
Annex A (normative) Mathematical basis for measurement uncertainty calculations	23
A.1 General.....	23
A.2 Type A evaluation of uncertainty	23
A.3 Type B evaluation of uncertainty	23
A.4 Determining the combined standard uncertainty.....	24
A.5 Reporting	25

Annex B (informative) Derivation of calibration factors	26
B.1 Derivation of scaling factors	26
B.2 Derivation of correction offset factor	27
Annex C (informative) Examples for the determination of calibration factors	29
C.1 Example of determination of scaling factor	29
C.2 Example of determination of offset correction factor	29
Annex D (informative) Calculation of uncertainties	30
D.1 General.....	30
D.1.1 Overview	30
D.1.2 Examples of type B evaluation of uncertainty.....	30
D.2 Combining sources of uncertainty	30
D.2.1 General	30
D.2.2 Example of combining several sources of uncertainty	31
D.3 Student's t distribution	31
Annex E (informative) Worked examples for the determination of uncertainties	33
E.1 General.....	33
E.2 Example of determination of scaling factor uncertainty.....	33
E.3 Example of determination of correction offset uncertainty	33
E.4 Example of determination of fibre measurement uncertainty.....	34
E.5 Example of determination of chromium mask measurement uncertainty	34
Annex F (informative) Generation of working standards	35
F.1 Generation of working standards.....	35
F.1.1 General	35
F.1.2 Measurement conditions	35
F.2 Procedure for generation of working standards	35
F.2.1 In the case where the infant artefact is a fibre.....	35
F.2.2 In the case where the infant artefact is a chromium-on-glass artefact	35
Annex G (informative) Estimation of uncertainty in the measurement of core/cladding concentricity error.....	36
G.1 Method of estimating uncertainty in concentricity error measurement.....	36
G.1.1 General	36
G.1.2 Determination of u	36
G.1.3 Determination of u_{OP}	36
G.1.4 Determination of CB	36
G.1.5 Determination of u_{CB}	38
G.2 Correcting for concentricity bias.....	38
Annex H (informative) Estimation of uncertainty in the measurement of non-circularity	39
H.1 Method of estimating uncertainty in non-circularity measurement.....	39
H.2 Determination of u	39
H.3 Determination of u_{Op}	39
H.4 Determination of NCB	39
H.4.1 General	39
H.4.2 Method A: uncalibrated artefact	40
H.4.3 Method B: calibrated artefact	40
H.5 Determination of u_{NCB}	40
Bibliography.....	41
Figure 1 – Example of a calibration chain and the accumulation of uncertainties.....	13

Figure B.1 – Representation of a grid calibration mask	26
Figure B.2 – Representation of an annulus calibration mask	27
Figure B.3 – Derivation of correction offset	28
Table D.1 – Values of t for specified confidence level	32
Table G.1 – Measured values for angular positions	37

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**END-FACE IMAGE ANALYSIS PROCEDURE FOR THE CALIBRATION
OF OPTICAL FIBRE GEOMETRY TEST SETS**

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 61745 has been prepared by IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition, published in 1998, and constitutes a technical revision.

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

- a) removal of the limitation of single mode optical fibre geometry test sets to include multimode;
- b) addition of a new annex as mathematical basis.

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

CDV	Report on voting
86/510/CDV	86/516/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.

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.

INTRODUCTION

In the research and production environments, there exists a range of test methods for characterizing the geometry of optical fibres. Furthermore, each test method may determine one or more of the many parameters required for complete geometrical characterization. IEC 61745 describes the calibration of test sets that perform end-face image analysis, also known as "near-field" or "grey-scale" analysis. The principles, however, may be applied to test sets of a different type.

END-FACE IMAGE ANALYSIS PROCEDURE FOR THE CALIBRATION OF OPTICAL FIBRE GEOMETRY TEST SETS

1 Scope

This document describes the calibration of test sets that perform end-face image analysis, also known as "near-field" or "grey-scale" analysis. The principles, however, can be applied to test sets of a different type.

The procedures outlined are performed by calibration laboratories and by the manufacturers or users of geometry test sets, for the purpose of calibrating geometry test sets and for evaluating the uncertainties in measurements made on calibrated test sets. The calibration of fibre coating or cable measurement test sets is not covered by this document.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purpose of this International Standard, the following definitions 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>

3.1

accredited calibration laboratory

calibration laboratory authorized by an appropriate national organization to issue calibration certificates that demonstrates traceability to national standards

3.2

artefact

object that is measured on or used to calibrate a geometry test set

EXAMPLE An optical fibre and a chromium-on-glass pattern are examples of artefacts.

3.3

calibration

set of operations that establish, under specified conditions, the relationship between the values of quantities indicated by a measuring instrument and the corresponding values realized by standards

Note 1 to entry: The results of a calibration permit either the assignment of measurand values to the indications or the determination of corrections with respect to the indications.

Note 2 to entry: A calibration may also determine other metrological properties such as the effects of influence quantities.

Note 3 to entry: The result of a calibration may be recorded in a document, called a "calibration certificate" or a "calibration report".