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INTERNATIONAL STANDARD

colour inside

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 1: General and guidance

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Part 1: General and guidance

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CONTENTS

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 1: General and guidance

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61300-1 edition 5.1 contains the fifth edition (2022-04) [documents 86B/4582/FDIS and 86B/4602/RVD] and its amendment 1 (2024-04) [documents 86B/4865/FDIS and 86B/4900/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

IEC 61300-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fifth edition constitutes a technical revision.

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

a) addition of the information of measurement uncertainties in 4.2.1;
b) change of the requirements for attenuation variation in 4.2.2;
c) addition of the multimode launch conditions of other fibres than A1-OM2, A1-OM3, A1-OM4, A1-OM5 and A3e in 10.4;
d) addition of the multimode launch conditions of the planar waveguide in 10.6;
e) splitting Annex A for EF and Annex B for EAF;
f) correction of errors in the definitions of encircled flux and encircled angular flux.

The language used for the development of this International Standard 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/standardsdev/publications.

A list of all parts in the IEC 61300 series, published under the general title, *Fibre optic interconnecting and passive components – Basic test and measurement procedures*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment 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.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

INTRODUCTION

The publications in IEC 61300 series [1][1] contain information on mechanical and environmental testing procedures and measurement procedures relating to fibre optic interconnecting devices and passive components. They are intended to be used to achieve uniformity and reproducibility in environmental testing procedures and measurement procedures.

The term "test procedure" refers to procedures commonly known as mechanical and environmental tests. The expressions "environmental conditioning" and "environmental testing" refer to the environments to which components or equipment may be exposed so that an assessment may be made of their performance under the conditions of use, transport and storage.

The term "measurement procedure" refers to those measurements which are necessary to assess the physical and optical characteristics of a component and may also be used before, during or after a test procedure to measure the effects of environmental conditioning or testing. The return loss and attenuation tests are examples of measurement procedures.

The requirements for the performance of components or equipment subjected to the test and measurement procedures described in this document are not included. The relevant specification for the device under test defines the allowed performance limits.

When drafting a specification or purchase contract, only those tests which are necessary for the relevant components or equipment taking into account the technical and economic aspects should be specified.

The mechanical and environmental test procedures are contained in IEC 61300-2 (all parts) and the measurement procedures in IEC 61300-3 (all parts). Each test or measurement procedure is published as a stand-alone publication so that it may be modified, expanded or cancelled without having an effect on any other test or measurement procedure. However, it should be noted that, where practical, reference is made to other standards as opposed to repeating all or part of already existing standards. As an example, the cold test for fibre optic apparatus refers to IEC 60068-2-1 [2], but it also provides other needed information such as purpose, recommended severities and a list of items to be specified.

Multiple methods may be contained in a test or measurement procedure. As an example, several methods of measuring attenuation are contained in the attenuation measurement procedure.

If more than one method is contained in a test or measurement procedure, the reference method may be identified.

The tests in this document permit the performance of components or equipment to be compared. To assess the overall quality of a production lot, the test procedures should be applied in accordance with a suitable sampling plan and may be supplemented by appropriate additional tests, if necessary.

To provide tests appropriate to the different intensities of an environmental condition, some of the test procedures have a number of degrees of severity. These different degrees of severity are obtained by varying the time, temperature or some other determining factor separately or in combination.

[1] Numbers in square bracket refer to the Bibliography.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 1: General and guidance

1 Scope

This part of IEC 61300 provides general information and guidance for the basic test and measurement procedures defined in IEC 61300-2 (all parts) and IEC 61300-3 (all parts) for interconnecting devices, passive components, mechanical splices, fusion splice protectors, fibre management systems and protective housings.

This document is used in combination with the relevant specification which defines the tests to be used, the required degree of severity for each of them, their sequence, if relevant, and the permissible performance limits. In the event of conflict between this document and the relevant specification, the latter takes precedence.

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 60050-731, *International Electrotechnical Vocabulary – Part 731: Optical fibre communication* (available at www.electropedia.org)

IEC 60617, *Graphical symbols for diagrams* (available at http://std.iec.ch/iec60617)

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

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

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCSs)*

IEC 61280-1-4, *Fibre optic communication subsystem test procedures – Part 1-4: General communication subsystems – Light source encircled flux measurement method*

IEC 61280-4-1, *Fibre-optic communication subsystem test procedures – Part 4-1: Installed cabling plant – Multimode attenuation measurement*

IEC 61300-2 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2: Tests*

IEC 61300-3 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3: Examinations and measurements*

IEC 61300-3-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements – Visual examination*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and 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

3.1.1
test
technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure and normally consists of the following steps:

a) preparation (where required);
b) preconditioning (where required);
c) initial examination and measurement (where required);
d) conditioning;
e) recovery (where required);
f) final examination and measurement

3.1.2
device under test
DUT
interconnecting device, passive component, equipment or other item designated to be tested

3.1.3
preparation
preparing the DUT according to the manufacturer’s instructions or as specified in the relevant specification

3.1.4
preconditioning
treatment of a DUT with the object of removing or partly counteracting the effects of its previous environmental history or acclimatisation of the test specimen to standard atmospheric conditions

3.1.5
conditioning
exposure of a DUT to environmental or mechanical conditions for a specified duration in order to determine the effects of such conditions on the DUT

3.1.6
recovery
treatment of a DUT after conditioning in order that the properties of the DUT may stabilise before measurement

3.1.7
examination
visual and/or mechanical inspection of a DUT made with or without the use of special equipment

Note 1 to entry: Examination is usually carried out before and after the test, and/or during the test.

3.1.8
measurement
process of obtaining one or more values that can reasonably be attributed to a quantity

[SOURCE: IEC 60050-112:2010, 112-04-01, modified – The adverb "experimentally" has been removed from the definition, as well as the notes.]

3.1.9
uncertainty of measurement
quantified doubt about the result of a measurement

Note 1 to entry: ISO/IEC Guide 98-3:2008 [3] defines uncertainty of measurement.

Note 2 to entry: IEC TR 61282-14 [4] provides the information of measurement uncertainties.

3.1.10
encircled flux
EF
fraction of cumulative near-field power to the total output power as a function of radial distance from the optical centre of the core, defined by Formula (1):

$$EF(r)=\frac{\int_0^r xI(x)dx}{\int_0^R xI(x)dx} \tag{1}$$

where

$I(x)$ is the near-field intensity profile as a function of radial position x;

R is the maximum range of integration

Note 1 to entry: The encircled flux shall be measured according to IEC 61280-1-4.

3.1.11
encircled angular flux
EAF
fraction of cumulative far-field power to the total output power as a function of incident angle θ from the optical central axis of the far-field pattern, defined by Formula (2):

$$EAF(\theta')=\frac{\int_0^{2\pi}\int_0^{\theta'} I(\theta,\varphi)\frac{\sin(\theta)}{\cos^3(\theta)}d\theta d\varphi}{\int_0^{2\pi}\int_0^{\theta_{\max}} I(\theta,\varphi)\frac{\sin(\theta)}{\cos^3(\theta)}d\theta d\varphi} \tag{2}$$

where

$I(\theta,\varphi)$ is the far-field intensity profile as a function of radial angle and circular angle;

r is the radial distance from the origin corresponding to an angle between one ray emitted from the multimode waveguide and the optical axis of the multimode waveguide, calculated by $d_f \tan\theta$;

φ is a circular angle in polar coordinates;

θ is an angle between one ray emitted from the multimode waveguide and the optical axis;

θ_{max} is the maximum ray angle, which is approximately 30° for category A3 multimode fibre for example;

d_f is the distance between the end of multimode optical waveguide and far field pattern (FFP) screen.

Note 1 to entry: The encircled angular flux is measured according to IEC 61300-3-53 [5].

3.1.12
differential mode attenuation
DMA
variation in attenuation among the propagating modes of a multimode optical fibre

[SOURCE: IEC TR 62614-2:2015 [6], 3.4]

3.1.13
standard uncertainty
uncertainty of a measurement result expressed as a standard deviation

Note 1 to entry: For further information, see the ISO/IEC Guide 98-3.

3.1.14
uncertainty type A
type of uncertainty obtained by a statistical analysis of a series of observations, such as when evaluating certain random effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.1.15
uncertainty type B
type of uncertainty obtained by means other than a statistical analysis of observations, for example an estimation of probable sources of uncertainty, such as when evaluating systematic effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.1.16
measurement repeatability
measurement precision under a set of repeatability conditions of measurement

3.1.17
measurement reproducibility
reproducibility measurement precision under reproducibility conditions of measurement

3.1.18
stability
ability of a measuring instrument to keep its performance characteristics within a specified range during a specified time interval, all other conditions being the same

3.1.19
repeatability condition
condition of measurement that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time

3.1.20
reproducibility condition
condition of measurement that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects

3.2 Abbreviated terms

DMA	differential mode attenuation
DUT	device under test
EAF	encircled angular flux
EF	encircled flux
FFP	far field pattern
FP-LD	Fabry-Perot laser diode
GI	graded index
LED	light emitting diode
NA	numerical aperture
SI	step index
VCSEL	vertical cavity surface emitting laser

4 Requirements for IEC 61300-2 (all parts) and IEC 61300-3 (all parts)

4.1 Requirements for IEC 61300-2 (all parts) (tests)

IEC 61300-2 (all parts) shall contain the following items:

– test apparatus;
– test procedures;
– severities;
– details to be specified and reported.

4.2 Requirements for IEC 61300-3 (all parts) (examinations and measurement procedures)

4.2.1 General requirements

IEC 61300-3 (all parts) shall contain the following items:

– measurement apparatus;
– measurement procedures;
– method of calculation (where required);
– consideration of measurement uncertainty;
– details to be specified and reported.

NOTE 1 The measurement uncertainty herein means the measurement uncertainty of the physical value of the performance parameters of DUT, not that for measurement apparatus (instruments).

NOTE 2 The measurement uncertainty is expressed as an absolute value not using "±".

The measurement accuracy, linearity, stability and repeatability of each measurement apparatus are possible to affect the measurement uncertainty. The relation of those factors on the measurement uncertainty should be described. When the reference value, such as the setting values, the initial values, the nominal values, can be defined, the sign "±" can be adopted for the deviation from the reference values (refer to 6.2 and 6.3).

4.2.2 Requirements for attenuation variation

For interconnecting devices and passive optical components, the attenuation variation is defined as a plus or minus (±) deviation from the original value at the start of the test, unless otherwise specified.

4.2.3 Requirements for test sample configuration in environmental test chamber

Annex C defines example configuration of the test sample, and specifies the fibre, pigtail, or cable length inside the environmental test chamber for different test sample types.

5 Standard atmospheric conditions

Standard atmospheric conditions shall be controlled within some range to ensure proper correlation of data obtained from measurements and tests conducted in various facilities. Test and measurement procedures shall be conducted under the following atmospheric conditions unless otherwise specified. In some cases, special ambient conditions may be needed and can be specified in the relevant specification.

The standard range of atmospheric conditions for carrying out measurements and tests is set out in Table 1.

Table 1 – Standard atmospheric conditions

Temperature	Relative humidity	Air pressure
18 °C to 28 °C	25 % to 75 %	86 kPa to 106 kPa
NOTE Some dimensional measurements require a tighter temperature range of 18 °C to 22 °C as defined in ISO 1 [7].		

Variations in ambient temperature and humidity shall be kept to a minimum during a series of measurements.

6 Significance of the numerical value of a quantity

6.1 General

The numerical values of quantities for the various parameters (temperature, humidity, stress, duration, optical power levels, etc.) given in the basic methods of environmental and optical testing constituting IEC 61300-2 (all parts) and the optical and physical measurements constituting IEC 61300-3 (all parts) are expressed in different ways according to the needs of each individual test.

The two cases that most frequently arise are as follows:

a) the quantity is expressed as a nominal value with a tolerance;

b) the quantity is expressed as a range of values.

For these two cases, the significance of the numerical value is discussed in 6.2 and 6.3.

6.2 Quantity expressed as nominal value with tolerance

Examples of two forms of presentation are:

a) 40 mm ± 2 mm

2 s ± 0,5 s

0,3 dB ± 0,1 dB

b) 93 % $^{+3}_{-2}$ %

The expression of a quantity as a numerical value indicates the intention that the test should be carried out at the stated value. The object of stating tolerances is to take account of the following factors in particular:

- the difficulties in regulating some devices and their drift (undesired slow variation) during the test;
- uncertainties of instrument;
- non-uniformity of environmental parameters, for which no specific tolerances are given, in the test space in which the DUTs are located.

These tolerances are not intended to allow latitude in the adjustment of the values of the parameter within the test space. Hence, when a quantity is expressed by a nominal value with a tolerance, the test apparatus shall be adjusted so as to obtain this nominal value making allowance for the uncertainties of instrument.

In principle, the test apparatus shall not be adjusted to maintain a limiting value of the tolerance zone, even if its uncertainty is so small as to ensure that this limiting value would not be exceeded.

EXAMPLE If the quantity is expressed numerically as 100 ± 5, the test apparatus is adjusted to maintain the target value of 100 making allowance for the uncertainties of instrument and in no case is adjusted to maintain a target value of 95 or 105.

In order to avoid any limiting value applicable to the DUT during the carrying out of the test, it may be necessary in some cases to set the test apparatus near to one tolerance limit.

In the particular case where the quantity is expressed by a nominal value with a unilateral tolerance (which is generally the case unless justified otherwise by special conditions, for example, a non-linear response), the test apparatus shall be set as close as possible to the nominal value (which is also a tolerance limit) taking account of the uncertainty of measurement, which depends on the apparatus used for the test (including the instruments used to measure the values of the parameters).

EXAMPLE If the quantity is expressed numerically as 100 % $^{+0}_{-5}$ % and the test apparatus is capable of an overall uncertainty in the control of the parameter of ±1 %, then the test apparatus is adjusted to maintain a target value of 99 %. If, on the other hand, the overall uncertainty is ±2,5 %, then the adjustment is set to maintain a target value of 97,5 %.

6.3 Quantity expressed as a range of values

Examples of forms of presentation:

a) From 18 °C to 28 °C

   Relative humidity from 80 % to 100 %

   From 1 h to 2 h

b) Return loss ≥ 55 dB

   Attenuation ≤ 0,50 dB

The use of words in expressing a range leads to ambiguity; for example, the phrase "from 80 % to 100 %" is recognised as "excluding the values of 80 and 100" by some readers, as "80 and 100 are included" by others. The use of symbols, for example > 80 or ≥ 80, is generally less likely to be ambiguous and shall therefore be preferred.

The expression of a quantity as a range of values indicates that the value to which the test apparatus is adjusted has only a small influence on the result of the test.

Where the uncertainty of the control of the parameter (including uncertainties of instrument) permits, any desired value within the given range may be chosen. For example, if it is stated that the temperature shall be from 18 °C to 28 °C, any value within this range can be used (but it is not intended that the temperature should be programmed to vary over the range).

7 Graphical symbols and terminology

The terminology used in the interpretation and preparation of fibre optic test and measurement procedures shall be taken from IEC 60050-731.

Graphical symbols used for the preparation and interpretation of fibre optic test and measurement procedures shall be selected where possible from IEC 60617.

8 Safety

As far as laser radiation is concerned, the precautions for carrying out fibre optic measurements as given in IEC 60825-1 shall be used. Fibre optic components and systems may emit hazardous radiation. This may occur

a) at sources,
b) in transmission systems during installation, during service or intentional interruption and failure or unintentional interruption, and
c) while measuring and testing.

For hazard evaluation, precautions and manufacturer's requirements, IEC 60825-1 and IEC 60825-2 shall be used.

Other safety aspects are referred to in applicable test methods and other standards.

9 Calibration

9.1 General

The equipment used shall have a valid calibration certificate in accordance with the applicable quality system for the period over which the testing is done. Preferably international or national standards should be adopted (e.g. IEC 61315 [8]). The calibration should be traceable to a national standard if available.

In cases where no calibration standard exists, the manufacturer or laboratory carrying out the test shall state the uncertainty of the test equipment to their best knowledge.

9.2 Round robin calibration procedure

Where the uncertainty is unknown, it may be necessary to evaluate the uncertainty with use a round robin calibration procedure for calibrating measuring instruments (e.g. gauges).

10 Launch conditions

10.1 General

The loss characteristics of a component frequently depend, to a very significant extent, on how the light is launched into the input fibre. The launch conditions should be used for all optical measurements. In order to obtain repeatable measurements, it is necessary to use standard launch conditions, which are clearly defined, and can be duplicated easily and precisely.

To achieve consistent results, first inspect and, if necessary, clean and inspect again all connector plugs and adaptors prior to measurement. Visual examination shall be undertaken in accordance with IEC 61300-3-1. Additionally, end-faces of optical connectors shall be inspected in accordance with IEC 61300-3-35.

The power in the fibre shall be set high enough, within the power level, not to generate non-linear scattering effects.

Precautions shall be taken to ensure that cladding modes do not affect the measurement. Cladding modes shall be eliminated either as a natural function of the fibre coating in the input and output fibres, or by adding cladding mode eliminators if specified in the relevant specification.

Precautions shall be taken to ensure that excessive bending of the fibres on either the input or output fibre, which could affect the measurement, does not occur. The fibres should remain fixed in position during the measurement.

The stability of the launch shall be suitable for the measurement to be undertaken. The stability shall be maintained over the measurement time and operational temperature range.

10.2 Multimode launch conditions for A1 fibres

Annex A provides a procedure for establishing the launch conditions for multimode fibre of category A1 defined in IEC 60793-2-10. The launch conditions are defined by tolerance bands on a target encircled flux (EF) metric.

NOTE 1 IEC 62614-1 [9] and IEC TR 62614-2 provide useful information on multimode launch condition.

These tolerance bands have been created for testing installed fibre optic links according to IEC 61280-4-1, to limit the variation in measured attenuation. The expected tolerances for links (with multiple connectors) are different to those for a single connection. When the measured EF of the source is within the specified tolerance bands, the expected uncertainty for the measured attenuation value of a single connection for A1-OM2, A1-OM3, A1-OM4 and A1-OM5 fibres, in dB, is according to Table 2.

NOTE 2 Multimode optical interfaces are provided in IEC 63267 (all parts)[2] [10].

Table 2 – Expected variation of attenuation due to mode variation of single connections for A1-OM2, A1-OM3, A1-OM4 and A1-OM5 fibres

Fibre nominal core diameter µm	Wavelength nm	Expected variation of attenuation due to mode variation dB
50	850	±0,08

Table 2 is valid for attenuation values ≤ 0,75 dB due to launch condition and modal variation.

When calculating the total uncertainty of the multimode attenuation measurement, the uncertainty due to the modal variations shall be included.

10.3 Multimode launch conditions for A3e fibre

Annex B provides a procedure for establishing the launch conditions for category A3e multimode fibre defined in IEC 60793-2-30. The launch condition is defined by tolerance band on a target encircled angular flux (EAF) metric.

2 Under preparation.

NOTE IEC 61300-3-53 provides useful information on multimode launch condition for step index (SI) fibre, defined in IEC 60793-2-30 and IEC 60793-2-40 [11].

These tolerance bands have been created for testing connecting devices, to limit the variation in measured attenuation. When the measured EAF of the source is within the specified tolerance band, the expected uncertainty for the measured attenuation value of a single connection, in dB, is according to Table 3.

Table 3 – Expected variation of attenuation due to mode variation of single connections for A3e fibre

Fibre nominal core diameter µm	NA	Wavelength nm	Expected variation of attenuation due to mode variation dB
200	0,37	850	±0,2

Table 3 is valid for attenuation values ≤ 2,0 dB due to launch condition and modal variation.

When calculating the total uncertainty of the multimode attenuation measurement, the uncertainty due to the modal variations shall be included.

10.4 Multimode launch conditions for the other multimode fibres

For multimode fibres the other than A1 fibres and A3e fibres, the measurement launch condition shall be determined between suppliers and users. Unless otherwise specified, the recommended launch condition is EF for graded index fibres and EAF for SI fibres.

10.5 Single-mode launch conditions

For single-mode components, the wavelength of the source (including the total spectral width) shall be longer than the cut-off wavelength of the fibre. The deployment and length of the fibre on the input shall be such that any higher order modes that may initially be launched are sufficiently attenuated.

For polarization sensitive devices, the state of polarization of input power may be significant and, when required, shall be specified in the relevant specification.

10.6 Multimode planar waveguide launch conditions

For multimode planar waveguide components, the measurement launch condition shall be determined between suppliers and users. It is recommended to apply the launch conditions of EF for the graded index (GI) waveguides and EAF for the SI waveguides.

Typically, the launch angles and/or beam diameters of the horizontal axis (X-axis) and the vertical axis (Y-axis) are not the same, for example the beam shape is not circular symmetric. The launch conditions of EF and EAF are applied assuming the circular symmetric beam. It should be taken into consideration that the measurement launch conditions of EF or EAF is possible to be different from actual launch conditions in application.

The following items of the measurement launch condition for the application should be considered:

- direction of transmission of the light (i.e. GI to SI or SI to GI);
- the launch angle of the light source (i.e. vertical cavity surface emitting laser (VCSEL), Fabry-Perot laser diode (FP-LD), light emitting diode (LED) and so on);
- numerical aperture (NA) of the waveguides;
- the length of the waveguide and the fibres.

Annex A
(normative)

Multimode launch condition requirement for measuring attenuation of components terminated on IEC 60793-2-10 type A1 fibres

A.1 General

Annex A describes the general multimode launch condition requirements used for measuring attenuation. The purpose of these requirements is to ensure consistency of field measurements with factory measurements and consistency of factory or field measurements when different types of test equipment are used.

Use of these launch conditions should ensure that, when a component is factory tested, it meets the requirements of field testing after installation of the product in the field.

For multimode step index (SI) fibre, defined by IEC 60793-2-30 and IEC 60793-2-40, encircled angular flux (EAF) measurement method, defined by IEC 61300-3-53, is used. See Annex B.

A.2 Technical background

Light sources, typically used in measuring attenuation, may have varying modal distributions when launched into multimode fibre. These differing modal distributions, combined with the differential mode attenuation (DMA) inherent in most multimode components, commonly cause measurement variations when measuring attenuation of multimode components. For example, attenuation measurement variations can occur when two similar light sources or different launch cords are used.

In the past, legacy (LED based) applications had a wide power budget which in most cases masked the variance in result between the factory and field measurement.

As technology has evolved, the system requirements for attenuation have become more stringent. Demanding application requirements are driving the need for accurate and reproducible multimode attenuation measurements over a variety of field-test instruments. Attenuation measurement experiments with different field-test instruments having the same standards-compliant set-up produce measurement variations that are induced by their differing launch conditions.

A.3 EF template

A.3.1 Applicable types of optical fibres

These guidelines are suitable for 50 µm and 62,5 µm core fibres, both with 125 µm cladding diameter.

A.3.2 Encircled flux

The EF is determined from the near field measurement of the light coming from the end of the reference grade launching cord.

A.3.3 EF template example

An example of an encircled flux template for 50 µm core fibre at 850 nm is shown in Figure A.1.

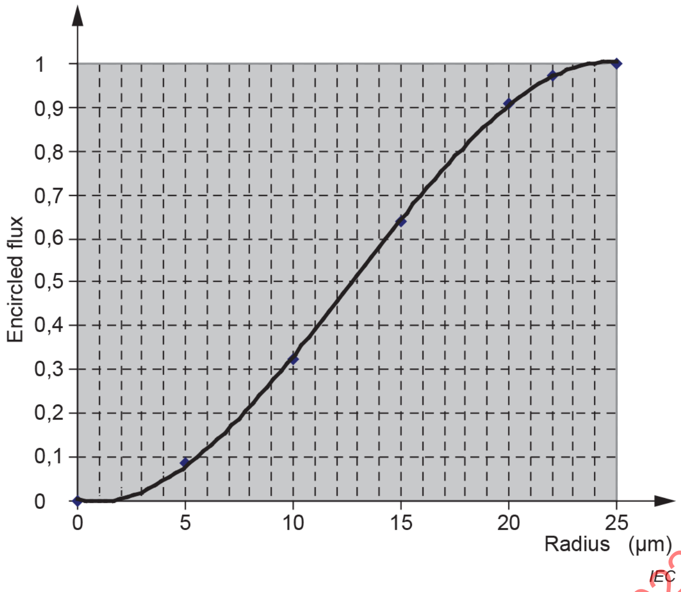


Figure A.1 – Encircled flux template example

A.4 Target launch and upper and lower tolerance bands for attenuation measurements of A1-OM2 to A1-OM5 and A1-OM1 optical fibre connections

A.4.1 General

The specified launch condition in this document is valid for attenuation measurement of multimode fibre optic connections. The launch condition for attenuation measurements for multimode connectors shall meet the EF requirements of Table A.1 to Table A.4 when measured at the output of the reference connector.

A.4.2 Limits on EF

The limits for the EF are derived from a target near field and a set of boundary conditions designed to constrain the variation in attenuation induced by variations in the source to within ±10 % or ±X dB, whichever is largest, of the value that would be obtained if the target launch were used. The variable X is a tolerance threshold that varies with fibre core size and wavelength according to the values in Table 2. The limits are derived from theoretical considerations.

Table A.1 – EF requirements for 50 µm core fibre at 850 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,278 5	0,335	0,391 5
15	0,598 0	0,655	0,711 9
20	0,910 5	0,919 3	0,929 5
22	0,969 0	0,975 1	0,981 2

Table A.2 – EF requirements for 50 µm core fibre at 1 300 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,279 2	0,336 6	0,394 0
15	0,599 6	0,656 7	0,713 8
20	0,907 2	0,918 6	0,930 0
22	0,966 3	0,972 8	0,979 3

Table A.3 – EF requirements for 62,5 µm fibre at 850 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,168 3	0,210 9	0,253 5
15	0,369 5	0,439	0,508 5
20	0,633 7	0,692 3	0,750 9
26	0,924 5	0,935	0,945 5
28	0,971 0	0,978 3	0,985 6

Table A.4 – EF requirements for 62,5 µm fibre at 1 300 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,168 0	0,211 9	0,255 8
15	0,369 9	0,440 9	0,511 9
20	0,636 9	0,694 5	0,752 1
26	0,925 4	0,935 7	0,946 0
28	0,970 8	0,978 2	0,985 6

Annex B
(normative)

Multimode launch condition requirement for measuring attenuation of components terminated on IEC 60793-2-30 type A3e fibres

B.1 EAF template

B.1.1 Applicable types of optical fibres

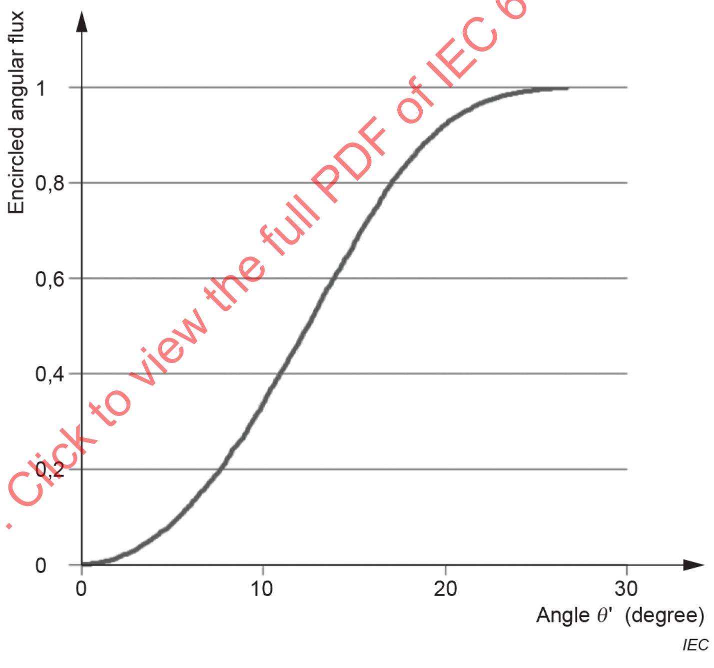
These guidelines are suitable for 200 µm core fibres with 230 µm cladding diameter.

B.1.2 Encircled angular flux

The EAF is determined from the far field measurement of the light coming from the end of the reference grade launching cord.

B.1.3 EAF template example

An example of an encircled angular flux template for 200 µm core fibre at 850 nm is shown in Figure B.1.



NOTE Although the unit for Formula (2), which is the definition of EAF, is radian, the unit for the horizontal axis is degree.

Figure B.1 – Encircled angular flux template example

B.2 Target launch and upper and lower tolerance bands for attenuation measurements of A3e optical fibre connections

B.2.1 General

The specified launch condition in this document is valid for attenuation measurement of multimode fibre optic connections. The launch condition for attenuation measurements for multimode connectors shall meet the EAF requirements of Table B.1 when measured at the output of the reference connector.

B.2.2 Limits on EAF

The limits for the EAF is derived from a target far field and a set of boundary conditions designed to constrain the variation in attenuation induced by variations in the source to within ±10 % or ±X dB, whichever is largest, of the value that would be obtained if the target launch were used. The variable X is a tolerance threshold that varies with fibre core size and wavelength according to the values in Table 3. The limits are derived from theoretical considerations.

Table B.1 – EAF requirements for NA of 0,37 and 200 µm core fibre at 850 nm

Radiation angle degree[a]	EAF lower bound	EAF upper bound
5	0,075 3	0,119 7
10	0,293 4	0,445 4
15	0,606 9	0,832 9
20	0,870 8	0,987 1

[a] Although the unit for Formula (2), which is the definition of EAF, is radian, the unit of the radiation angle is degree.

Annex C
(normative)

Test sample configuration in environmental test chamber

C.1 General

Annex C defines the configurations of the test samples and the fibre, pigtail, or cable lengths inside the environmental test chamber for the different test sample types, such as:

- pigtail,
- hardened connector pigtail,
- patchcord,
- non-connectorized passive component,
- connectorized passive component,
- plug-receptacle style passive component,
- fibre management system,
- protective housing without looped cable,
- protective housing with looped cable,
- combined protective housing test sample with looped cable,
- mechanical splice or fusion splice.

An environmental test chamber is used for temperature cycling, dry heat, cold, damp heat, and similar tests.

The test sample configuration and the fibre, pigtail, or cable lengths inside the environmental test chamber shall be as given in clauses C.2 to C.12, unless otherwise specified in the relevant IEC 61753 performance standard and IEC 62005 reliability document.

The method of storage shall not affect the optical fibre with respect to expansion or contraction. Tight coiling on a rigid cable reel shall not be used. The overlength of the fibres, pigtails, or cables of the sample inside the chamber shall be routed in large diameter loose coils or bends. The diameter of the coils or bends shall be larger than the minimum bending diameter specified for the cable in service. The fibre, pigtail, or cable coils shall be loosely fixed in a way that the cable elements are not under stress and are free to move.

The test sample or the additional pigtails should have unterminated leads of sufficient length to allow termination (splicing, connecting, etc.) to the optical monitoring equipment located outside of the environmental test chamber. The deployment of the fibre, pigtail, or cable outside the chamber shall not affect the results.

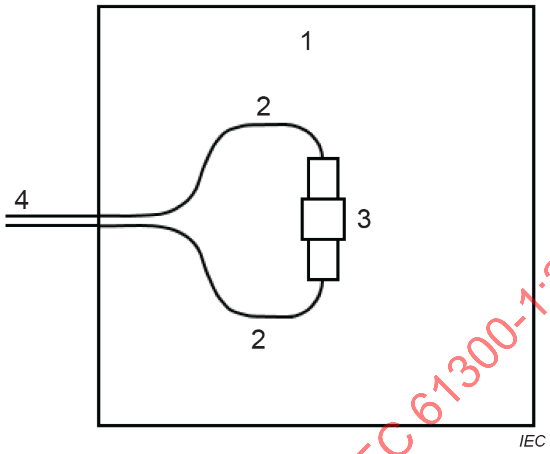
The configurations are shown with one incoming and one outgoing fibre, pigtail, or cable of a test sample in Figure C.1 to Figure C.12 for illustrative purposes. Different types of test samples exist having one or more incoming and one or more outgoing fibres, pigtails, or cables, or even an incoming fibre, pigtail, or cable only. The test sample configurations and length specifications for such test samples shall be applied analogously.

When several test samples are tested in the same chamber, the test samples shall be placed in such a way that they do not influence each other and do not exert any load on other test samples. The test samples can be placed side-by-side or on different height levels. Care should be taken to ensure that either the specified temperature or humidity, or both, is present for all samples. The test sample configuration and length specification for multiple test samples shall be applied analogously.

NOTE When using a protective housing test sample configuration from C.10 to C.11, experience shows that the test samples can successfully meet the temperature change requirements outlined in the IEC 61753 series in this configuration, provided the cables are suitable for the specified operating temperature range. This means that the fibre protrusion after temperature changes is ≤20 mm at the terminated cable ends in the housings.

C.2 Pigtail test sample

The pigtail test sample should be placed inside the environmental test chamber as shown in Figure C.1. This configuration should be used for connectors terminated on pigtails and is intended for non-hardened connectors. For hardened connectors see C.3.



Key

1 environmental test chamber

2 pigtail

3 adaptor, if required

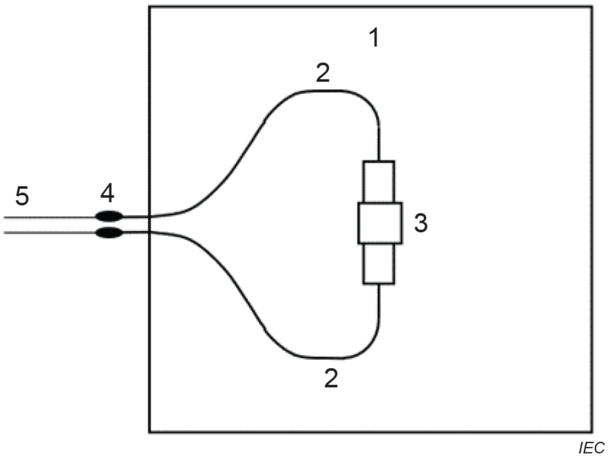
4 incoming and outgoing pigtails whose fibres are connected to the measurement equipment

Figure C.1 – Example configuration of a pigtail test sample

Each pigtail should be ≥3 m in length and a length of ≥1,5 m shall be located inside the environmental test chamber. The end of the sheath and strength members of the reinforced cable may be outside or inside the environmental test chamber. An adaptor is required if a connector plug-adaptor-plug type is used. If a connector plug-socket type is used, no adaptor is required.

C.3 Hardened connector pigtail test sample

The hardened connector pigtail test sample should be placed inside the environmental test chamber as shown in Figure C.2. This configuration should be used for hardened connectors terminated on cables.



Key

1 environmental test chamber

2 hardened connector pigtail

3 adaptor, if required

4 all cable elements fixed of each pigtail

5 buffered format, if present, or otherwise the primary coated fibres with fibre ends connected to measurement equipment

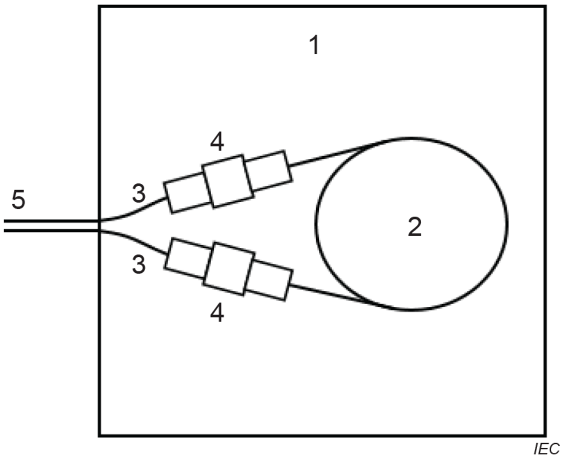
Figure C.2 – Example configuration of a hardened connector pigtail test sample

Each hardened connector pigtail shall be a length of ≥5 m inside the environmental test chamber. Just outside the environmental test chamber, all cable elements shall be fixed by clamps, glue, or other effective means. If present, the buffered fibres, or otherwise the primary coated fibres should be routed outside the environmental test chamber where the fibre ends are connected to the measurement equipment.

An adaptor is required if a hardened connector of the plug-adaptor-plug type is used. If a hardened connector of the plug-socket type is used, no adaptor is required.

C.4 Patchcord test sample

The patchcord test sample should be placed inside the environmental test chamber as shown in Figure C.3. This configuration can be used for non-hardened and hardened connectors.



Key

1 environmental test chamber

2 patchcord

3 pigtail

4 adaptor, if required

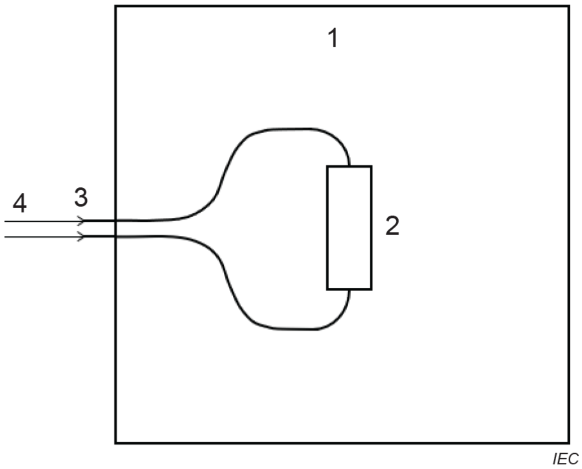
5 incoming and outgoing pigtails whose fibres are connected to the measurement equipment

Figure C.3 – Example configuration of a patchcord test sample

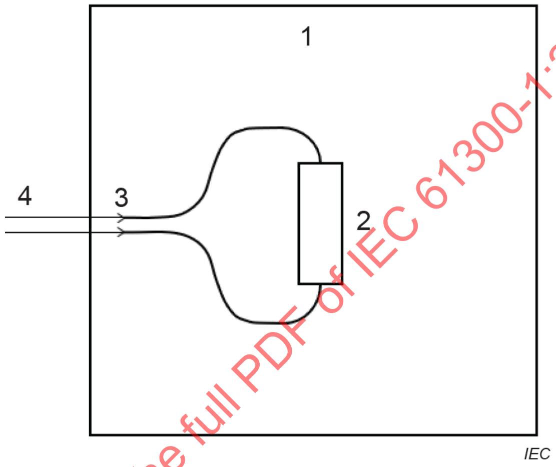
The length of the patchcord shall be 5,0 m ± 0,5 m. The length of each pigtail inside the environmental test chamber should be as short as possible. It is not necessary to use the same cable type for the pigtails and the patchcord. The pigtail cable type should not contribute to the change in attenuation. Adaptors are required if a connector of the plug-adaptor-plug type is used. If a connector of the plug-socket type is used, no adaptors are required.

C.5 Non-connectorized passive component test sample

Clause C.5 shows an example of a non-connectorized passive component test sample. For illustrative purposes, a non-connectorized passive component with one incoming and one outgoing fibre or cable is shown in Figure C.4 a) and Figure C.4 b). For passive component with only one incoming and no outgoing fibre, and either two or more incoming or two or more outgoing fibres, or both, the configuration should be as shown in Figure C.4 a) or Figure C.4 b), and the configuration should be recorded in a test report. The non-connectorized passive component test sample should be placed inside the environmental test chamber as shown in Figure C.4 a) or Figure C.4 b).



a) **Sheath and strength members of the reinforced cable outside the environmental test chamber**



b) **Sheath and strength members of the reinforced cable inside the environmental test chamber**

Key

1 environmental test chamber

2 non-connectorized passive component with fibre or cable ends

3 end of complete reinforced cable of each pigtail where all cable elements are loose and not fixed to each other

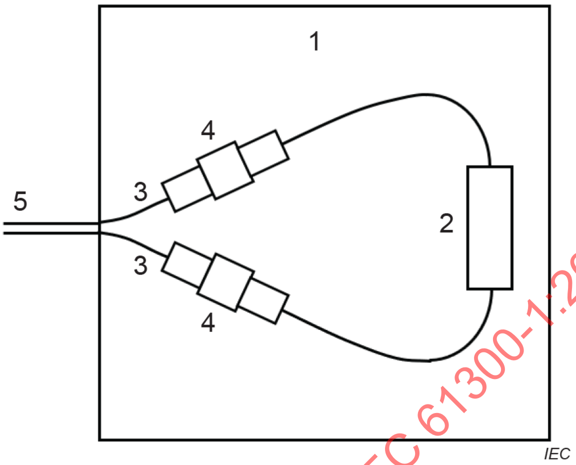
4 buffered fibres or primary coated fibres with fibre ends connected to measuring equipment

Figure C.4 – Example configuration of a non-connectorized passive component test sample

The end of the sheath and strength members of the reinforced cable may be outside or inside the environmental test chamber as shown in Figure C.4 a) and Figure C.4 b). If the configuration in Figure C.4 a) is used, a fibre or cable length of ≥0,75 m on each side of the passive component shall be located inside the environmental test chamber. If the configuration in Figure C.4 b) is used, a cable length of ≥0,75 m from the end of the sheath and strength members of the reinforced cable to each side of the passive component shall be located inside the environmental test chamber.

C.6 Connectorized passive component test sample

This clause shows an example of a connectorized passive component test sample. For illustrative purposes, a connectorized passive component with one incoming and one outgoing fibre or cable is shown in Figure C.5. For passive component with only one incoming and no outgoing fibre, and either two or more incoming or two or more outgoing fibres, or both, the configuration should be similar as shown in Figure C.5 and the configuration should be recorded in test report. The connectorized passive component test sample should be placed inside the environmental test chamber as shown in Figure C.5.



Key

1 environmental test chamber

2 connectorized passive component

3 pigtail

4 adaptor, if required

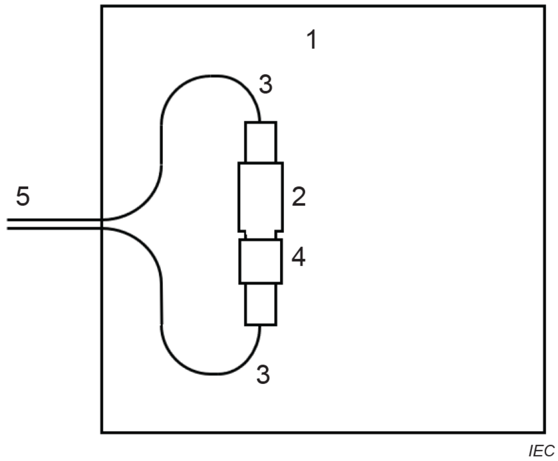
5 incoming and outgoing pigtails for connection to measurement equipment

Figure C.5 – Example configuration of a connectorized passive component test sample

The length of each pigtail inside the environmental test chamber should be as short as possible. It is not necessary to use the same cable type for the pigtails and the passive component. The pigtail cable type should not contribute to the change in attenuation. Adaptors are required if a connector of the plug-adaptor-plug type is used. If a connector of the plug-socket type is used, no adaptors are required.

C.7 Plug-receptacle style passive component test sample

The plug-receptacle style passive component test sample should be placed inside the environmental test chamber as shown in Figure C.6. For illustrative purposes, a plug-receptacle style passive component with one incoming and one outgoing fibre port is shown in Figure C.6.



Key

1 environmental test chamber

2 plug-receptacle style passive component

3 pigtail

4 adaptor

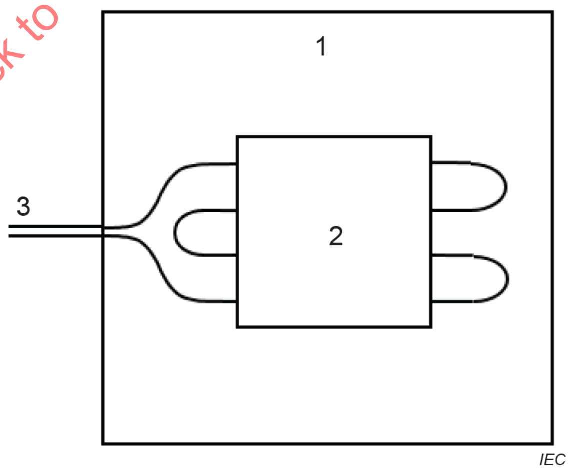
5 incoming and outgoing pigtails for connection to measurement equipment

Figure C.6 – Example configuration of a plug-receptacle style passive component test sample

The length of each pigtail inside the environmental test chamber should be as short as possible. The pigtail cable type should not contribute to the change in attenuation.

C.8 Fibre management system test sample

The fibre management system test sample should be placed inside the environmental test chamber as shown in Figure C.7.



Key

1 environmental test chamber

2 fibre management system with incoming, outgoing and looped fibres

3 incoming and outgoing fibres for connection to measurement equipment

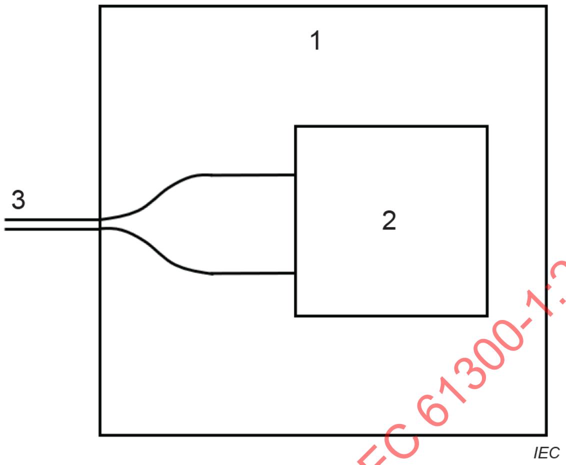
Figure C.7 – Example configuration of a fibre management system test sample

The length of each incoming and outgoing fibre inside the environmental test chamber shall be ≥1,5 m.

C.9 Protective housing test sample without looped cable

The protective housing test sample should be placed inside the environmental test chamber as shown in Figure C.8.

NOTE This configuration corresponds to those for the track joint closures, boxes and ODFM in the IEC 61753 series.



Key

1 environmental test chamber

2 protective housing with incoming and outgoing cables

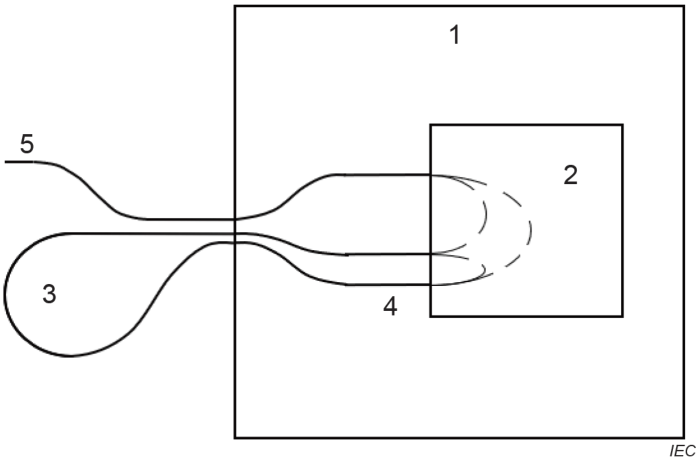
3 incoming and outgoing cables whose fibres are connected to the measurement equipment

Figure C.8 – Example configuration of a protective housing test sample without looped cable

The length of each incoming and outgoing cable inside the environmental test chamber shall be ≥5 m.

C.10 Protective housing test sample with looped cable

Two possible configurations can be used to test a protective housing with looped cable. The protective housing test sample with looped cable should be placed inside the environmental test chamber as shown in Figure C.9 or Figure C.10.



Key

1 environmental test chamber

2 protective housing with incoming and outgoing cables and looped cable

3 looped cable

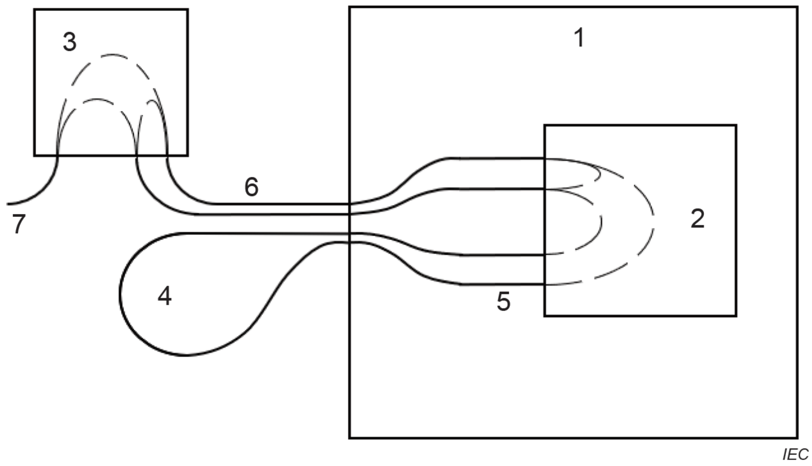
4 cable ends of the looped cable fixed at the protective housing

5 cable containing incoming and outgoing fibres that are connected to the measurement equipment

NOTE This configuration corresponds to that for the track or spur joint closures in the IEC 61753-111 series.

Figure C.9 – Example configuration I of a protective housing test sample with looped cable

The length of the cable containing incoming and outgoing fibres and the length of each cable end of the looped cable fixed at the protective housing inside environmental test chamber shall be ≥5 m.



Key

1 environmental test chamber

2 distribution protective housing with cables

3 track or spur protective housing with cables

4 looped cable

5 cable ends of the looped cable fixed at the distribution protective housing

6 test cable partly looped in distribution protective housing

7 cable containing incoming and outgoing fibres that are connected to the measurement equipment

NOTE 1 The function of the track or spur protective housing outside the environmental test chamber is to allow all cable elements of the test cable to be fixed in one place.

NOTE 2 This configuration corresponds to those for distribution joint closures in the IEC 61753-111 series.

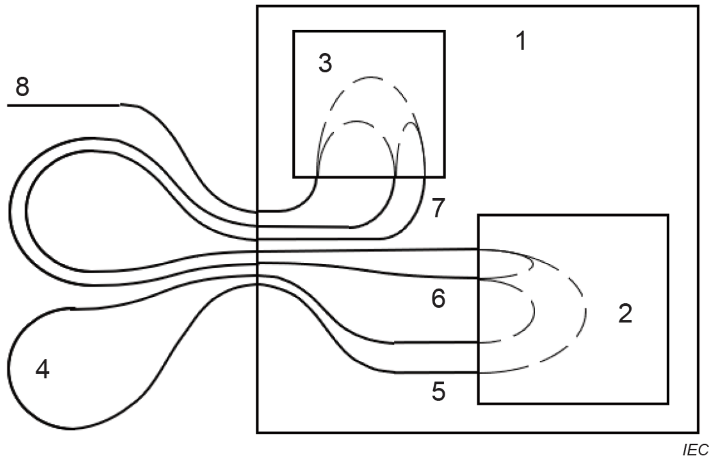
Figure C.10 – Example configuration II of a protective housing test sample with looped cable

The length of test cable partly looped in distribution protective housing and the length of each cable end of the looped cable fixed at the distribution protective housing inside environmental test chamber shall be ≥5 m.

C.11 Combined protective housing test sample with looped cable

Both distribution and track or spur configurations can be tested at the same time by placing both protective housings inside the environmental test chamber as test sample as shown in Figure C.11.

NOTE This configuration corresponds to those for the distribution and track or spur joint closures in the IEC 61753-111 series.



Key

1 environmental test chamber

2 distribution protective housing with cables

3 track or spur protective housing with cables

4 looped cable

5 cable ends of the looped cable fixed at the distribution protective housing

6 test cable partly looped in distribution protective housing

7 test cable ends fixed in track or spur protective housing

8 cable containing incoming and outgoing fibres that are connected to the measurement equipment

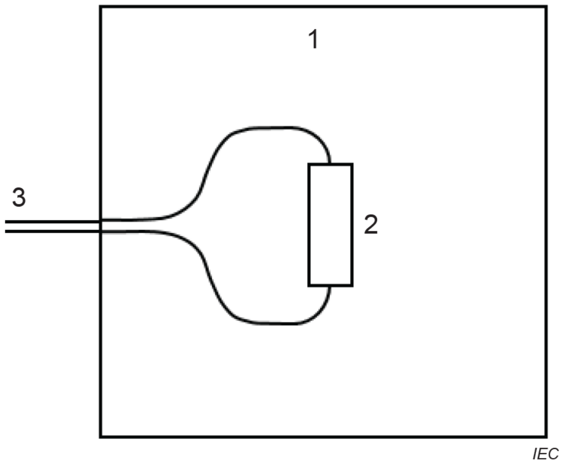
NOTE The orientation of the protective housings is for illustrative purposes and the protective housings can be arranged differently.

Figure C.11 – Example configuration of a combined distribution and track or spur protective housing test sample with looped cable

The length of the cable containing incoming and outgoing fibres, the length of each test cable fixed at the distribution and track or spur protective housing, and the length of each cable end of the looped cable fixed at the distribution protective housing inside the environmental test chamber shall be ≥5 m.

C.12 Mechanical splice or fusion splice test sample

The mechanical splice or fusion splice test sample should be placed inside the environmental test chamber as shown in Figure C.12. The splices are protected within protection housings or other means.



Key

1 environmental test chamber

2 mechanical splice or fusion splice with fibre ends

3 incoming and outgoing fibres for connection to measurement equipment

Figure C.12 – Example configuration of a mechanical splice or fusion splice test sample

A fibre length of ≥1,5 m on each side of the mechanical splice or fusion splice shall be located inside the environmental test chamber.

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[9] IEC 62614-1, *Fibre optics – Multimode launch conditions – Part 1: Launch condition requirements for measuring multimode attenuation*

[10] IEC 63267 (all parts), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for enhanced macro bend loss multimode fibres*[3]

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

[12] IEC 60050-112, *International Electrotechnical Vocabulary (IEV) – Part 112: Quantities and units* (available at www.electropedia.org)

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3 Under preparation.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 1: General and 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.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61300-1 edition 5.1 contains the fifth edition (2022-04) [documents 86B/4582/FDIS and 86B/4602/RVD] and its amendment 1 (2024-04) [documents 86B/4865/FDIS and 86B/4900/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

IEC 61300-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fifth edition constitutes a technical revision.

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

a) addition of the information of measurement uncertainties in 4.2.1;
b) change of the requirements for attenuation variation in 4.2.2;
c) addition of the multimode launch conditions of other fibres than A1-OM2, A1-OM3, A1-OM4, A1-OM5 and A3e in 10.4;
d) addition of the multimode launch conditions of the planar waveguide in 10.6;
e) splitting Annex A for EF and Annex B for EAF;
f) correction of errors in the definitions of encircled flux and encircled angular flux.

The language used for the development of this International Standard 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/standardsdev/publications.

A list of all parts in the IEC 61300 series, published under the general title, *Fibre optic interconnecting and passive components – Basic test and measurement procedures*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment 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.

INTRODUCTION

The publications in IEC 61300 series [1][1] contain information on mechanical and environmental testing procedures and measurement procedures relating to fibre optic interconnecting devices and passive components. They are intended to be used to achieve uniformity and reproducibility in environmental testing procedures and measurement procedures.

The term "test procedure" refers to procedures commonly known as mechanical and environmental tests. The expressions "environmental conditioning" and "environmental testing" refer to the environments to which components or equipment may be exposed so that an assessment may be made of their performance under the conditions of use, transport and storage.

The term "measurement procedure" refers to those measurements which are necessary to assess the physical and optical characteristics of a component and may also be used before, during or after a test procedure to measure the effects of environmental conditioning or testing. The return loss and attenuation tests are examples of measurement procedures.

The requirements for the performance of components or equipment subjected to the test and measurement procedures described in this document are not included. The relevant specification for the device under test defines the allowed performance limits.

When drafting a specification or purchase contract, only those tests which are necessary for the relevant components or equipment taking into account the technical and economic aspects should be specified.

The mechanical and environmental test procedures are contained in IEC 61300-2 (all parts) and the measurement procedures in IEC 61300-3 (all parts). Each test or measurement procedure is published as a stand-alone publication so that it may be modified, expanded or cancelled without having an effect on any other test or measurement procedure. However, it should be noted that, where practical, reference is made to other standards as opposed to repeating all or part of already existing standards. As an example, the cold test for fibre optic apparatus refers to IEC 60068-2-1 [2], but it also provides other needed information such as purpose, recommended severities and a list of items to be specified.

Multiple methods may be contained in a test or measurement procedure. As an example, several methods of measuring attenuation are contained in the attenuation measurement procedure.

If more than one method is contained in a test or measurement procedure, the reference method may be identified.

The tests in this document permit the performance of components or equipment to be compared. To assess the overall quality of a production lot, the test procedures should be applied in accordance with a suitable sampling plan and may be supplemented by appropriate additional tests, if necessary.

To provide tests appropriate to the different intensities of an environmental condition, some of the test procedures have a number of degrees of severity. These different degrees of severity are obtained by varying the time, temperature or some other determining factor separately or in combination.

1 Numbers in square bracket refer to the Bibliography.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 1: General and guidance

1 Scope

This part of IEC 61300 provides general information and guidance for the basic test and measurement procedures defined in IEC 61300-2 (all parts) and IEC 61300-3 (all parts) for interconnecting devices, passive components, mechanical splices, fusion splice protectors, fibre management systems and protective housings.

This document is used in combination with the relevant specification which defines the tests to be used, the required degree of severity for each of them, their sequence, if relevant, and the permissible performance limits. In the event of conflict between this document and the relevant specification, the latter takes precedence.

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 60050-731, *International Electrotechnical Vocabulary – Part 731: Optical fibre communication* (available at www.electropedia.org)

IEC 60617, *Graphical symbols for diagrams* (available at http://std.iec.ch/iec60617)

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

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

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCSs)*

IEC 61280-1-4, *Fibre optic communication subsystem test procedures – Part 1-4: General communication subsystems – Light source encircled flux measurement method*

IEC 61280-4-1, *Fibre-optic communication subsystem test procedures – Part 4-1: Installed cabling plant – Multimode attenuation measurement*

IEC 61300-2 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2: Tests*

IEC 61300-3 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3: Examinations and measurements*

IEC 61300-3-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements – Visual examination*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and 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

3.1.1
test
technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure and normally consists of the following steps:

a) preparation (where required);

b) preconditioning (where required);

c) initial examination and measurement (where required);

d) conditioning;

e) recovery (where required);

f) final examination and measurement

3.1.2
device under test
DUT
interconnecting device, passive component, equipment or other item designated to be tested

3.1.3
preparation
preparing the DUT according to the manufacturer's instructions or as specified in the relevant specification

3.1.4
preconditioning
treatment of a DUT with the object of removing or partly counteracting the effects of its previous environmental history or acclimatisation of the test specimen to standard atmospheric conditions

3.1.5
conditioning
exposure of a DUT to environmental or mechanical conditions for a specified duration in order to determine the effects of such conditions on the DUT

3.1.6
recovery
treatment of a DUT after conditioning in order that the properties of the DUT may stabilise before measurement

3.1.7
examination
visual and/or mechanical inspection of a DUT made with or without the use of special equipment

Note 1 to entry: Examination is usually carried out before and after the test, and/or during the test.

3.1.8
measurement
process of obtaining one or more values that can reasonably be attributed to a quantity

[SOURCE: IEC 60050-112:2010, 112-04-01, modified – The adverb "experimentally" has been removed from the definition, as well as the notes.]

3.1.9
uncertainty of measurement
quantified doubt about the result of a measurement

Note 1 to entry: ISO/IEC Guide 98-3:2008 [3] defines uncertainty of measurement.

Note 2 to entry: IEC TR 61282-14 [4] provides the information of measurement uncertainties.

3.1.10
encircled flux
EF
fraction of cumulative near-field power to the total output power as a function of radial distance from the optical centre of the core, defined by Formula (1):

$$EF(r) = \frac{\int_0^r xI(x)dx}{\int_0^R xI(x)dx} \quad (1)$$

where

$I(x)$ is the near-field intensity profile as a function of radial position x;

R is the maximum range of integration

Note 1 to entry: The encircled flux shall be measured according to IEC 61280-1-4.

3.1.11
encircled angular flux
EAF
fraction of cumulative far-field power to the total output power as a function of incident angle θ from the optical central axis of the far-field pattern, defined by Formula (2):

$$EAF(\theta') = \frac{\int_0^{2\pi}\int_0^{\theta'} I(\theta,\varphi)\frac{\sin(\theta)}{\cos^3(\theta)}d\theta d\varphi}{\int_0^{2\pi}\int_0^{\theta_{\max}} I(\theta,\varphi)\frac{\sin(\theta)}{\cos^3(\theta)}d\theta d\varphi} \quad (2)$$

where

$I(\theta,\varphi)$ is the far-field intensity profile as a function of radial angle and circular angle;

r is the radial distance from the origin corresponding to an angle between one ray emitted from the multimode waveguide and the optical axis of the multimode waveguide, calculated by $d_f \tan\theta$;

φ is a circular angle in polar coordinates;

θ is an angle between one ray emitted from the multimode waveguide and the optical axis;

θ_{max} is the maximum ray angle, which is approximately 30° for category A3 multimode fibre for example;

d_f is the distance between the end of multimode optical waveguide and far field pattern (FFP) screen.

Note 1 to entry: The encircled angular flux is measured according to IEC 61300-3-53 [5].

3.1.12
differential mode attenuation
DMA
variation in attenuation among the propagating modes of a multimode optical fibre

[SOURCE: IEC TR 62614-2:2015 [6], 3.4]

3.1.13
standard uncertainty
uncertainty of a measurement result expressed as a standard deviation

Note 1 to entry: For further information, see the ISO/IEC Guide 98-3.

3.1.14
uncertainty type A
type of uncertainty obtained by a statistical analysis of a series of observations, such as when evaluating certain random effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.1.15
uncertainty type B
type of uncertainty obtained by means other than a statistical analysis of observations, for example an estimation of probable sources of uncertainty, such as when evaluating systematic effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.1.16
measurement repeatability
measurement precision under a set of repeatability conditions of measurement

3.1.17
measurement reproducibility
reproducibility measurement precision under reproducibility conditions of measurement

3.1.18
stability
ability of a measuring instrument to keep its performance characteristics within a specified range during a specified time interval, all other conditions being the same

3.1.19
repeatability condition
condition of measurement that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time

3.1.20
reproducibility condition
condition of measurement that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects

3.2 Abbreviated terms

DMA	differential mode attenuation
DUT	device under test
EAF	encircled angular flux
EF	encircled flux
FFP	far field pattern
FP-LD	Fabry-Perot laser diode
GI	graded index
LED	light emitting diode
NA	numerical aperture
SI	step index
VCSEL	vertical cavity surface emitting laser

4 Requirements for IEC 61300-2 (all parts) and IEC 61300-3 (all parts)

4.1 Requirements for IEC 61300-2 (all parts) (tests)

IEC 61300-2 (all parts) shall contain the following items:

– test apparatus;
– test procedures;
– severities;
– details to be specified and reported.

4.2 Requirements for IEC 61300-3 (all parts) (examinations and measurement procedures)

4.2.1 General requirements

IEC 61300-3 (all parts) shall contain the following items:

– measurement apparatus;
– measurement procedures;
– method of calculation (where required);
– consideration of measurement uncertainty;
– details to be specified and reported.

NOTE 1 The measurement uncertainty herein means the measurement uncertainty of the physical value of the performance parameters of DUT, not that for measurement apparatus (instruments).

NOTE 2 The measurement uncertainty is expressed as an absolute value not using "±".

The measurement accuracy, linearity, stability and repeatability of each measurement apparatus are possible to affect the measurement uncertainty. The relation of those factors on the measurement uncertainty should be described. When the reference value, such as the setting values, the initial values, the nominal values, can be defined, the sign "±" can be adopted for the deviation from the reference values (refer to 6.2 and 6.3).

4.2.2 Requirements for attenuation variation

For interconnecting devices and passive optical components, the attenuation variation is defined as a plus or minus (±) deviation from the original value at the start of the test, unless otherwise specified.

4.2.3 Requirements for test sample configuration in environmental test chamber

Annex C defines example configuration of the test sample, and specifies the fibre, pigtail, or cable length inside the environmental test chamber for different test sample types.

5 Standard atmospheric conditions

Standard atmospheric conditions shall be controlled within some range to ensure proper correlation of data obtained from measurements and tests conducted in various facilities. Test and measurement procedures shall be conducted under the following atmospheric conditions unless otherwise specified. In some cases, special ambient conditions may be needed and can be specified in the relevant specification.

The standard range of atmospheric conditions for carrying out measurements and tests is set out in Table 1.

Table 1 – Standard atmospheric conditions

Temperature	Relative humidity	Air pressure
18 °C to 28 °C	25 % to 75 %	86 kPa to 106 kPa
NOTE Some dimensional measurements require a tighter temperature range of 18 °C to 22 °C as defined in ISO 1 [7].		

Variations in ambient temperature and humidity shall be kept to a minimum during a series of measurements.

6 Significance of the numerical value of a quantity

6.1 General

The numerical values of quantities for the various parameters (temperature, humidity, stress, duration, optical power levels, etc.) given in the basic methods of environmental and optical testing constituting IEC 61300-2 (all parts) and the optical and physical measurements constituting IEC 61300-3 (all parts) are expressed in different ways according to the needs of each individual test.

The two cases that most frequently arise are as follows:

a) the quantity is expressed as a nominal value with a tolerance;

b) the quantity is expressed as a range of values.

For these two cases, the significance of the numerical value is discussed in 6.2 and 6.3.

6.2 Quantity expressed as nominal value with tolerance

Examples of two forms of presentation are:

a) 40 mm ± 2 mm

2 s ± 0,5 s

0,3 dB ± 0,1 dB

b) 93 % $^{+3}_{-2}$ %

The expression of a quantity as a numerical value indicates the intention that the test should be carried out at the stated value. The object of stating tolerances is to take account of the following factors in particular:

- the difficulties in regulating some devices and their drift (undesired slow variation) during the test;
- uncertainties of instrument;
- non-uniformity of environmental parameters, for which no specific tolerances are given, in the test space in which the DUTs are located.

These tolerances are not intended to allow latitude in the adjustment of the values of the parameter within the test space. Hence, when a quantity is expressed by a nominal value with a tolerance, the test apparatus shall be adjusted so as to obtain this nominal value making allowance for the uncertainties of instrument.

In principle, the test apparatus shall not be adjusted to maintain a limiting value of the tolerance zone, even if its uncertainty is so small as to ensure that this limiting value would not be exceeded.

EXAMPLE If the quantity is expressed numerically as 100 ± 5, the test apparatus is adjusted to maintain the target value of 100 making allowance for the uncertainties of instrument and in no case is adjusted to maintain a target value of 95 or 105.

In order to avoid any limiting value applicable to the DUT during the carrying out of the test, it may be necessary in some cases to set the test apparatus near to one tolerance limit.

In the particular case where the quantity is expressed by a nominal value with a unilateral tolerance (which is generally the case unless justified otherwise by special conditions, for example, a non-linear response), the test apparatus shall be set as close as possible to the nominal value (which is also a tolerance limit) taking account of the uncertainty of measurement, which depends on the apparatus used for the test (including the instruments used to measure the values of the parameters).

EXAMPLE If the quantity is expressed numerically as 100 % $^{+0}_{-5}$ % and the test apparatus is capable of an overall uncertainty in the control of the parameter of ±1 %, then the test apparatus is adjusted to maintain a target value of 99 %. If, on the other hand, the overall uncertainty is ±2,5 %, then the adjustment is set to maintain a target value of 97,5 %.

6.3 Quantity expressed as a range of values

Examples of forms of presentation:

a) From 18 °C to 28 °C

Relative humidity from 80 % to 100 %

From 1 h to 2 h

b) Return loss ≥ 55 dB

Attenuation ≤ 0,50 dB

The use of words in expressing a range leads to ambiguity; for example, the phrase "from 80 % to 100 %" is recognised as "excluding the values of 80 and 100" by some readers, as "80 and 100 are included" by others. The use of symbols, for example > 80 or ≥ 80, is generally less likely to be ambiguous and shall therefore be preferred.

The expression of a quantity as a range of values indicates that the value to which the test apparatus is adjusted has only a small influence on the result of the test.

Where the uncertainty of the control of the parameter (including uncertainties of instrument) permits, any desired value within the given range may be chosen. For example, if it is stated that the temperature shall be from 18 °C to 28 °C, any value within this range can be used (but it is not intended that the temperature should be programmed to vary over the range).

7 Graphical symbols and terminology

The terminology used in the interpretation and preparation of fibre optic test and measurement procedures shall be taken from IEC 60050-731.

Graphical symbols used for the preparation and interpretation of fibre optic test and measurement procedures shall be selected where possible from IEC 60617.

8 Safety

As far as laser radiation is concerned, the precautions for carrying out fibre optic measurements as given in IEC 60825-1 shall be used. Fibre optic components and systems may emit hazardous radiation. This may occur

a) at sources,
b) in transmission systems during installation, during service or intentional interruption and failure or unintentional interruption, and
c) while measuring and testing.

For hazard evaluation, precautions and manufacturer's requirements, IEC 60825-1 and IEC 60825-2 shall be used.

Other safety aspects are referred to in applicable test methods and other standards.

9 Calibration

9.1 General

The equipment used shall have a valid calibration certificate in accordance with the applicable quality system for the period over which the testing is done. Preferably international or national standards should be adopted (e.g. IEC 61315 [8]). The calibration should be traceable to a national standard if available.

In cases where no calibration standard exists, the manufacturer or laboratory carrying out the test shall state the uncertainty of the test equipment to their best knowledge.

9.2 Round robin calibration procedure

Where the uncertainty is unknown, it may be necessary to evaluate the uncertainty with use a round robin calibration procedure for calibrating measuring instruments (e.g. gauges).

10 Launch conditions

10.1 General

The loss characteristics of a component frequently depend, to a very significant extent, on how the light is launched into the input fibre. The launch conditions should be used for all optical measurements. In order to obtain repeatable measurements, it is necessary to use standard launch conditions, which are clearly defined, and can be duplicated easily and precisely.

To achieve consistent results, first inspect and, if necessary, clean and inspect again all connector plugs and adaptors prior to measurement. Visual examination shall be undertaken in accordance with IEC 61300-3-1. Additionally, end-faces of optical connectors shall be inspected in accordance with IEC 61300-3-35.

The power in the fibre shall be set high enough, within the power level, not to generate non-linear scattering effects.

Precautions shall be taken to ensure that cladding modes do not affect the measurement. Cladding modes shall be eliminated either as a natural function of the fibre coating in the input and output fibres, or by adding cladding mode eliminators if specified in the relevant specification.

Precautions shall be taken to ensure that excessive bending of the fibres on either the input or output fibre, which could affect the measurement, does not occur. The fibres should remain fixed in position during the measurement.

The stability of the launch shall be suitable for the measurement to be undertaken. The stability shall be maintained over the measurement time and operational temperature range.

10.2 Multimode launch conditions for A1 fibres

Annex A provides a procedure for establishing the launch conditions for multimode fibre of category A1 defined in IEC 60793-2-10. The launch conditions are defined by tolerance bands on a target encircled flux (EF) metric.

NOTE 1 IEC 62614-1 [9] and IEC TR 62614-2 provide useful information on multimode launch condition.

These tolerance bands have been created for testing installed fibre optic links according to IEC 61280-4-1, to limit the variation in measured attenuation. The expected tolerances for links (with multiple connectors) are different to those for a single connection. When the measured EF of the source is within the specified tolerance bands, the expected uncertainty for the measured attenuation value of a single connection for A1-OM2, A1-OM3, A1-OM4 and A1-OM5 fibres, in dB, is according to Table 2.

NOTE 2 Multimode optical interfaces are provided in IEC 63267 (all parts)[2] [10].

Table 2 – Expected variation of attenuation due to mode variation of single connections for A1-OM2, A1-OM3, A1-OM4 and A1-OM5 fibres

Fibre nominal core diameter µm	Wavelength nm	Expected variation of attenuation due to mode variation dB
50	850	±0,08

Table 2 is valid for attenuation values ≤ 0,75 dB due to launch condition and modal variation.

When calculating the total uncertainty of the multimode attenuation measurement, the uncertainty due to the modal variations shall be included.

10.3 Multimode launch conditions for A3e fibre

Annex B provides a procedure for establishing the launch conditions for category A3e multimode fibre defined in IEC 60793-2-30. The launch condition is defined by tolerance band on a target encircled angular flux (EAF) metric.

2 Under preparation.

NOTE IEC 61300-3-53 provides useful information on multimode launch condition for step index (SI) fibre, defined in IEC 60793-2-30 and IEC 60793-2-40 [11].

These tolerance bands have been created for testing connecting devices, to limit the variation in measured attenuation. When the measured EAF of the source is within the specified tolerance band, the expected uncertainty for the measured attenuation value of a single connection, in dB, is according to Table 3.

Table 3 – Expected variation of attenuation due to mode variation of single connections for A3e fibre

Fibre nominal core diameter µm	NA	Wavelength nm	Expected variation of attenuation due to mode variation dB
200	0,37	850	±0,2

Table 3 is valid for attenuation values ≤ 2,0 dB due to launch condition and modal variation.

When calculating the total uncertainty of the multimode attenuation measurement, the uncertainty due to the modal variations shall be included.

10.4 Multimode launch conditions for the other multimode fibres

For multimode fibres the other than A1 fibres and A3e fibres, the measurement launch condition shall be determined between suppliers and users. Unless otherwise specified, the recommended launch condition is EF for graded index fibres and EAF for SI fibres.

10.5 Single-mode launch conditions

For single-mode components, the wavelength of the source (including the total spectral width) shall be longer than the cut-off wavelength of the fibre. The deployment and length of the fibre on the input shall be such that any higher order modes that may initially be launched are sufficiently attenuated.

For polarization sensitive devices, the state of polarization of input power may be significant and, when required, shall be specified in the relevant specification.

10.6 Multimode planar waveguide launch conditions

For multimode planar waveguide components, the measurement launch condition shall be determined between suppliers and users. It is recommended to apply the launch conditions of EF for the graded index (GI) waveguides and EAF for the SI waveguides.

Typically, the launch angles and/or beam diameters of the horizontal axis (X-axis) and the vertical axis (Y-axis) are not the same, for example the beam shape is not circular symmetric. The launch conditions of EF and EAF are applied assuming the circular symmetric beam. It should be taken into consideration that the measurement launch conditions of EF or EAF is possible to be different from actual launch conditions in application.

The following items of the measurement launch condition for the application should be considered:

– direction of transmission of the light (i.e. GI to SI or SI to GI);
– the launch angle of the light source (i.e. vertical cavity surface emitting laser (VCSEL), Fabry-Perot laser diode (FP-LD), light emitting diode (LED) and so on);
– numerical aperture (NA) of the waveguides;
– the length of the waveguide and the fibres.

Annex A
(normative)

Multimode launch condition requirement for measuring attenuation of components terminated on IEC 60793-2-10 type A1 fibres

A.1 General

Annex A describes the general multimode launch condition requirements used for measuring attenuation. The purpose of these requirements is to ensure consistency of field measurements with factory measurements and consistency of factory or field measurements when different types of test equipment are used.

Use of these launch conditions should ensure that, when a component is factory tested, it meets the requirements of field testing after installation of the product in the field.

For multimode step index (SI) fibre, defined by IEC 60793-2-30 and IEC 60793-2-40, encircled angular flux (EAF) measurement method, defined by IEC 61300-3-53, is used. See Annex B.

A.2 Technical background

Light sources, typically used in measuring attenuation, may have varying modal distributions when launched into multimode fibre. These differing modal distributions, combined with the differential mode attenuation (DMA) inherent in most multimode components, commonly cause measurement variations when measuring attenuation of multimode components. For example, attenuation measurement variations can occur when two similar light sources or different launch cords are used.

In the past, legacy (LED based) applications had a wide power budget which in most cases masked the variance in result between the factory and field measurement.

As technology has evolved, the system requirements for attenuation have become more stringent. Demanding application requirements are driving the need for accurate and reproducible multimode attenuation measurements over a variety of field-test instruments. Attenuation measurement experiments with different field-test instruments having the same standards-compliant set-up produce measurement variations that are induced by their differing launch conditions.

A.3 EF template

A.3.1 Applicable types of optical fibres

These guidelines are suitable for 50 µm and 62,5 µm core fibres, both with 125 µm cladding diameter.

A.3.2 Encircled flux

The EF is determined from the near field measurement of the light coming from the end of the reference grade launching cord.

A.3.3 EF template example

An example of an encircled flux template for 50 µm core fibre at 850 nm is shown in Figure A.1.

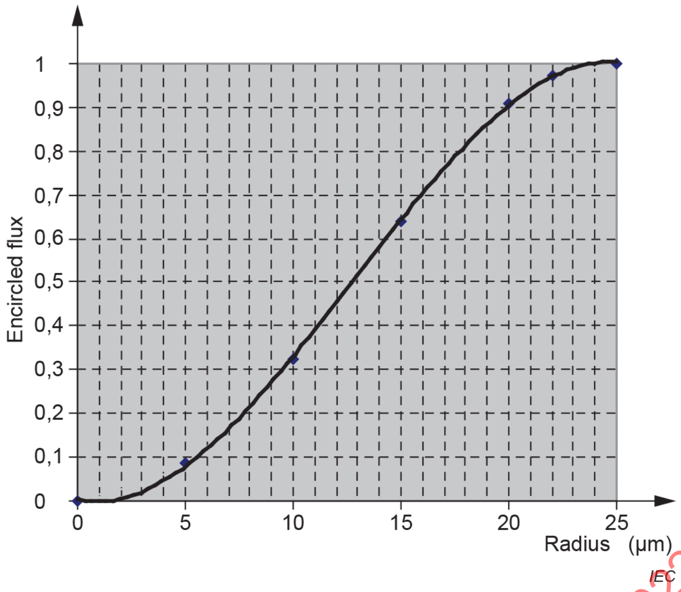


Figure A.1 – Encircled flux template example

A.4 Target launch and upper and lower tolerance bands for attenuation measurements of A1-OM2 to A1-OM5 and A1-OM1 optical fibre connections

A.4.1 General

The specified launch condition in this document is valid for attenuation measurement of multimode fibre optic connections. The launch condition for attenuation measurements for multimode connectors shall meet the EF requirements of Table A.1 to Table A.4 when measured at the output of the reference connector.

A.4.2 Limits on EF

The limits for the EF are derived from a target near field and a set of boundary conditions designed to constrain the variation in attenuation induced by variations in the source to within ±10 % or ±X dB, whichever is largest, of the value that would be obtained if the target launch were used. The variable X is a tolerance threshold that varies with fibre core size and wavelength according to the values in Table 2. The limits are derived from theoretical considerations.

Table A.1 – EF requirements for 50 µm core fibre at 850 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,278 5	0,335	0,391 5
15	0,598 0	0,655	0,711 9
20	0,910 5	0,919 3	0,929 5
22	0,969 0	0,975 1	0,981 2

Table A.2 – EF requirements for 50 µm core fibre at 1 300 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,279 2	0,336 6	0,394 0
15	0,599 6	0,656 7	0,713 8
20	0,907 2	0,918 6	0,930 0
22	0,966 3	0,972 8	0,979 3

Table A.3 – EF requirements for 62,5 µm fibre at 850 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,168 3	0,210 9	0,253 5
15	0,369 5	0,439	0,508 5
20	0,633 7	0,692 3	0,750 9
26	0,924 5	0,935	0,945 5
28	0,971 0	0,978 3	0,985 6

Table A.4 – EF requirements for 62,5 µm fibre at 1 300 nm

Radial offset µm	EF lower bound	EF target bound	EF upper bound
10	0,168 0	0,211 9	0,255 8
15	0,369 9	0,440 9	0,511 9
20	0,636 9	0,694 5	0,752 1
26	0,925 4	0,935 7	0,946 0
28	0,970 8	0,978 2	0,985 6

Annex B
(normative)

Multimode launch condition requirement for measuring attenuation of components terminated on IEC 60793-2-30 type A3e fibres

B.1 EAF template

B.1.1 Applicable types of optical fibres

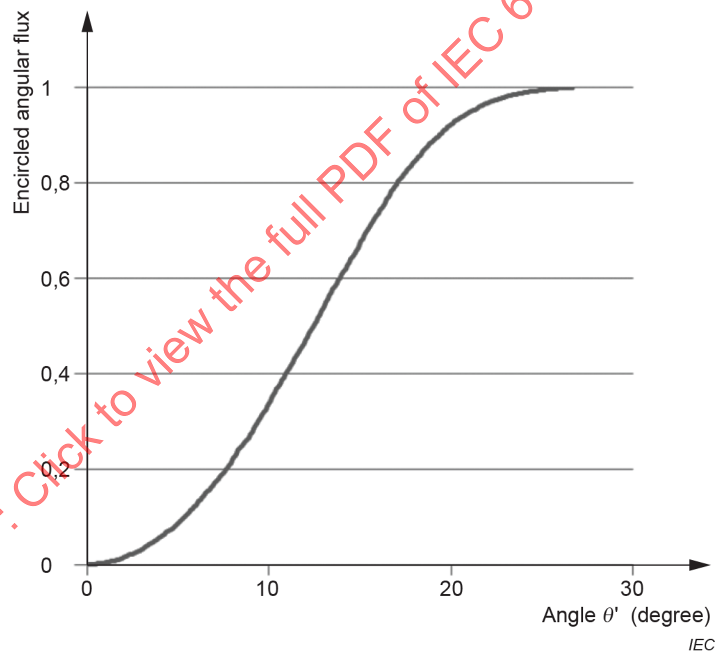
These guidelines are suitable for 200 µm core fibres with 230 µm cladding diameter.

B.1.2 Encircled angular flux

The EAF is determined from the far field measurement of the light coming from the end of the reference grade launching cord.

B.1.3 EAF template example

An example of an encircled angular flux template for 200 µm core fibre at 850 nm is shown in Figure B.1.



NOTE Although the unit for Formula (2), which is the definition of EAF, is radian, the unit for the horizontal axis is degree.

Figure B.1 – Encircled angular flux template example

B.2 Target launch and upper and lower tolerance bands for attenuation measurements of A3e optical fibre connections

B.2.1 General

The specified launch condition in this document is valid for attenuation measurement of multimode fibre optic connections. The launch condition for attenuation measurements for multimode connectors shall meet the EAF requirements of Table B.1 when measured at the output of the reference connector.

B.2.2 Limits on EAF

The limits for the EAF is derived from a target far field and a set of boundary conditions designed to constrain the variation in attenuation induced by variations in the source to within ±10 % or ±X dB, whichever is largest, of the value that would be obtained if the target launch were used. The variable X is a tolerance threshold that varies with fibre core size and wavelength according to the values in Table 3. The limits are derived from theoretical considerations.

Table B.1 – EAF requirements for NA of 0,37 and 200 µm core fibre at 850 nm

Radiation angle degree[a]	EAF lower bound	EAF upper bound
5	0,075 3	0,119 7
10	0,293 4	0,445 4
15	0,606 9	0,832 9
20	0,870 8	0,987 1

[a] Although the unit for Formula (2), which is the definition of EAF, is radian, the unit of the radiation angle is degree.

Annex C
(normative)

Test sample configuration in environmental test chamber

C.1 General

Annex C defines the configurations of the test samples and the fibre, pigtail, or cable lengths inside the environmental test chamber for the different test sample types, such as:

- pigtail,
- hardened connector pigtail,
- patchcord,
- non-connectorized passive component,
- connectorized passive component,
- plug-receptacle style passive component,
- fibre management system,
- protective housing without looped cable,
- protective housing with looped cable,
- combined protective housing test sample with looped cable,
- mechanical splice or fusion splice.

An environmental test chamber is used for temperature cycling, dry heat, cold, damp heat, and similar tests.

The test sample configuration and the fibre, pigtail, or cable lengths inside the environmental test chamber shall be as given in clauses C.2 to C.12, unless otherwise specified in the relevant IEC 61753 performance standard and IEC 62005 reliability document.

The method of storage shall not affect the optical fibre with respect to expansion or contraction. Tight coiling on a rigid cable reel shall not be used. The overlength of the fibres, pigtails, or cables of the sample inside the chamber shall be routed in large diameter loose coils or bends. The diameter of the coils or bends shall be larger than the minimum bending diameter specified for the cable in service. The fibre, pigtail, or cable coils shall be loosely fixed in a way that the cable elements are not under stress and are free to move.

The test sample or the additional pigtails should have unterminated leads of sufficient length to allow termination (splicing, connecting, etc.) to the optical monitoring equipment located outside of the environmental test chamber. The deployment of the fibre, pigtail, or cable outside the chamber shall not affect the results.

The configurations are shown with one incoming and one outgoing fibre, pigtail, or cable of a test sample in Figure C.1 to Figure C.12 for illustrative purposes. Different types of test samples exist having one or more incoming and one or more outgoing fibres, pigtails, or cables, or even an incoming fibre, pigtail, or cable only. The test sample configurations and length specifications for such test samples shall be applied analogously.

When several test samples are tested in the same chamber, the test samples shall be placed in such a way that they do not influence each other and do not exert any load on other test samples. The test samples can be placed side-by-side or on different height levels. Care should be taken to ensure that either the specified temperature or humidity, or both, is present for all samples. The test sample configuration and length specification for multiple test samples shall be applied analogously.