



BSI Standards Publication

Fibre-optic communication subsystem test procedures

Part 4-1: Installed cabling plant — Multimode attenuation measurement

National foreword

This British Standard is the UK implementation of EN IEC 61280-4-1:2019+A1:2022. It is identical to IEC 61280-4-1:2019 incorporating corrigendum April 2020, amendment 1:2021, and corrigendum December 2022. It supersedes BS EN IEC 61280-4-1:2019, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee GEL/86/3, Fibre optic systems and active devices.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2023

ISBN 978 0 539 25403 7

ICS 33.180.01

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2019.

Amendments/corrigenda issued since publication

Date	Text affected
31 May 2020	Implementation of IEC corrigendum April 2020: last paragraph of I.4.1 replaced
31 May 2022	Implementation of IEC amendment 1:2021 with CENELEC endorsement A1:2022
31 May 2023	Implementation of IEC corrigendum December 2022: first paragraph of 6.3 amended

English Version

Fibre-optic communication subsystem test procedures - Part 4-1:
Installed cabling plant - Multimode attenuation measurement
(IEC 61280-4-1:2019)

Procédures d'essai des sous-systèmes de
télécommunication fibroniques - Partie 4-1: Installation
câblée - Mesure de l'affaiblissement en multimodal
(IEC 61280-4-1:2019)

Prüfverfahren für Lichtwellenleiter-
Kommunikationsuntersysteme - Teil 4-1: Lichtwellenleiter-
Kabelanlagen - Mehrmoden-Dämpfungsmessungen
(IEC 61280-4-1:2019)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 86C/1575/FDIS, future edition 3 of IEC 61280-4-1, prepared by SC 86C "Fibre optic systems and active devices" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61280-4-1:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-03-26
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-06-26

This document supersedes EN 61280-4-1:2009 and all of its amendments and corrigenda (if any)

This edition constitutes a technical revision including the following significant technical changes with respect to the previous edition:

- a) changes to Annex F on encircled flux to harmonise with IEC TR 62614-2, but keeping the encircled flux limits defined in Tables F.2 to F.5 unchanged;
- b) addition of an equipment cord method in Annex D;
- c) inclusion of testing bend insensitive multimode optical fibre;
- d) updates to measurement uncertainty;
- e) definition of additional cabling configurations;
- f) changes to Table 5 on spectral requirements.

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

Endorsement notice

The text of the International Standard IEC 61280-4-1:2019 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60793-1-40	NOTE	Harmonized as EN IEC 60793-1-40
IEC 60793-2	NOTE	Harmonized as EN 60793-2
IEC 60793-2-10	NOTE	Harmonized as EN 60793-2-10
IEC 60793-2-50	NOTE	Harmonized as EN IEC 60793-2-50
IEC 60794-2-21	NOTE	Harmonized as EN IEC 60794-2-21
IEC 61300-3-6	NOTE	Harmonized as EN 61300-3-6
IEC 61300-3-45	NOTE	Harmonized as EN 61300-3-45
IEC 61745	NOTE	Harmonized as EN 61745
IEC 61755-6-2	NOTE	Harmonized as EN IEC 61755-6-2
IEC 62664-1-1	NOTE	Harmonized as EN 62664-1-1
IEC 62614:2010	NOTE	Harmonized as EN 62614:2010 (not modified)

European foreword to amendment A1

The text of document 86C/1720/CDV, future IEC 61280-4-1/AMD1, prepared by SC 86C "Fibre optic systems and active devices" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61280-4-1:2019/A1:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-10-13
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2025-01-13

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Annex ZA
(normative)

**Normative references to international publications
with their corresponding European publications**

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60825-2	-	Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCS)	EN 60825-2	-
IEC 61280-1-3	-	Fibre optic communication subsystem test procedures - Part 1-3: General communication subsystems - Central wavelength and spectral width measurement	EN 61280-1-3	-
IEC 61280-1-4	-	Fibre optic communication subsystem test procedures - Part 1-4: General communication subsystems - Light source encircled flux measurement method	EN 61280-1-4	-
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	EN 61300-3-35	-
IEC 61315	-	Calibration of fibre-optic power meters	EN IEC 61315	-
IEC 61746-2	-	Calibration of optical time-domain reflectometers (OTDR) - Part 2: OTDR for multimode fibres	EN 61746-2	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE-OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –**Part 4-1: Installed cabling plant – Multimode attenuation measurement****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61280-4-1 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition, published in 2009. This edition constitutes a technical revision.

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

- a) changes to Annex F on encircled flux to harmonise with IEC TR 62614-2, but keeping the encircled flux limits defined in Tables F.2 to F.5 unchanged;
- b) addition of an equipment cord method in Annex D;
- c) inclusion of testing bend insensitive multimode optical fibre;
- d) updates to measurement uncertainty;
- e) definition of additional cabling configurations;
- f) changes to Table 5 on spectral requirements.

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

FDIS	Report on voting
86C/1575/FDIS	86C/1592/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61280 series, published under the general title *Fibre optic communication subsystem test procedures*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

The contents of the corrigendum of April 2020 have been included in this copy.

FIBRE-OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 4-1: Installed cabling plant – Multimode attenuation measurement

1 Scope

This part of IEC 61280 is applicable to the measurement of attenuation of installed optical fibre cabling plant using multimode optical fibre. This cabling plant can include multimode optical fibres, connectors, adapters, splices, and other passive devices. The cabling can be installed in a variety of environments including residential, commercial, industrial, and data centre premises, as well as outside plant environments. The test equipment used in this document has one single fibre connector interface or two single fibre connector interfaces.

In this document, the optical fibres that are addressed include sub-categories A1-OMx, where $x = 2, 3, 4$ and 5 ($50/125\ \mu\text{m}$) and A1-OM1 ($62,5/125\ \mu\text{m}$) multimode optical fibres, as specified in IEC 60793-2-10. The attenuation measurements of the other multimode categories can be made using the approaches of this document, but the source conditions for the other categories have not been defined.

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

IEC 61280-1-3, *Fibre optic communication subsystem test procedures – Part 1-3: General communication subsystems – Central wavelength and spectral width measurement*

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

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*

IEC 61315, *Calibration of fibre-optic power meters*

IEC 61746-2, *Calibration of optical time-domain reflectometers (OTDR) – Part 2: OTDR for multimode fibres*

3 Terms, definitions, graphical symbols and abbreviated terms

For the purposes of this document, the following terms, definitions, graphical symbols and abbreviated terms 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 Terms and definitions

3.1.1

attenuation

A

reduction of optical power induced by transmission through a medium such as cabling

$$A = 10 \log(P_{\text{in}}/P_{\text{out}})$$

where

P_{in} and P_{out} are the power, typically measured in mW, into and out of the cabling

Note 1 to entry: Attenuation is expressed in dB.

3.1.2

light source power meter

LSPM

test system consisting of a light source (LS) and power meter (PM) used to measure the attenuation of installed cabling plant

3.1.3

optical time domain reflectometer

OTDR

test system consisting of an optical time-domain reflectometer instrument used to characterize and measure the attenuation of installed cabling plant and specific elements within that cabling plant

Note 1 to entry: This note applies to the French language only.

3.1.4

test cord

terminated optical fibre cord used to connect the optical source or detector to the cabling, or to provide suitable interfaces to the cabling under test

Note 1 to entry: There are five types of test cords:

- launch cord: used to connect the light source to the cabling;
- receive cord: used to connect the cabling to the power meter (LSPM only);
- tail cord: attached to the far end of the cabling when an OTDR is used at the near end. This provides a means of evaluating attenuation of the whole of the cabling including the far end connection;
- adapter cord: used to transition between sockets or other incompatible connectors in a required test configuration;
- substitution cord: a test cord used within a reference measurement which is replaced during the measurement of the attenuation of the cabling under test.

3.1.5

bi-directional measurement

two measurements of the same optical fibre, made by launching light into opposite ends of that fibre

3.1.6

configuration

form or arrangements of parts or elements such as terminations, connections and splices

3.1.7

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

[SOURCE: IEC 62614:2010, 3.2]

3.1.8

reference-grade termination

connector and plug with tightened tolerances terminated onto an optical fibre with tightened tolerances such that the expected attenuation of a connection formed by mating two such assemblies is lower and more repeatable than a standard-grade termination

Note 1 to entry: An adapter, required to assure the reduced attenuation, may be considered as part of the reference-grade termination where required by the test configuration.

Note 2 to entry: IEC 61755-6-2 defines reference-grade terminations for 50/125 µm fibre.

3.1.9

connector

component normally attached to an optical cable or piece of apparatus for the purpose of providing frequent optical interconnection/disconnection of optical fibres or cables

[SOURCE: IEC TR 61931:1998, 2.6.1, modified – The words in brackets, "optical" and "fibre", have been omitted from the term.]

3.1.10

plug

male-type part of a connector

[SOURCE: IEC TR 61931:1998, 2.6.2]

3.1.11

adapter

female-type part of a connector in which one or two plugs are inserted and aligned

[SOURCE: IEC TR 61931:1998, 2.6.4]

3.1.12

socket-style connector

connector for which the adapter, including any alignment device, is integrated with and permanently attached to the connector plug on one side of the connection

Note 1 to entry: Examples include many harsh environment connectors.

3.1.13

reference test method

RTM

test method for measuring a given characteristic strictly according to the definition of this characteristic, and giving results which are accurate, reproducible and relatable to practical use

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC TR 61931:1998, 2.8.1, modified – The words in brackets, "for optical fibres", have been omitted from the term.]

3.1.14

alternative test method

ATM

test method for measuring a given characteristic in a manner consistent with the definition of this characteristic and giving results which are reproducible and relatable to the reference test method and to practical use

[SOURCE: IEC TR 61931:1998, 2.8.2, modified – The alternative term, "practical test method (for optical fibres)" has been omitted from the term.]

3.1.15

measurement bias

estimate of a systematic measurement error

Note 1 to entry: A systematic error is a component of measurement error that in repeated measurements remains constant or varies in a predictable manner.

[SOURCE: ISO/IEC Guide 99:2007, 2.18, modified – Note 1 to entry has been added.]

3.1.16

reference plane

theoretical plane without thickness or tolerances

Note 1 to entry: The reference plane is used to define spaces in mechanical structures.

[SOURCE: IEC 60050-581:2008, 581-25-30]

3.1.17

channel

end-to-end transmission path connecting any two pieces of application-specific equipment

[SOURCE: ISO/IEC 11801-1:2017, 3.1.26]

3.2 Graphical symbols

The graphic symbols showed in Figure 1 and Figure 2 for different connection options have been adapted from IEC TR 61930.

NOTE 1 In Figure 1b and elsewhere in this document, the plugs are shown with different sizes to indicate directionality where the cabling has adapters pre-attached and the test cord does not, or vice versa. In Figure 1b, the plug on the left has the adapter pre-attached.

NOTE 2 Where used in all figures in this document, including those in the annexes, reference-grade terminations and adapters are shaded with grey.

NOTE 3 A simplified two-block connection used in Annex G is shown in Figure 1e.

NOTE 4 A simplified connection for pinned to unpinned and socketed connections used in Annex H is shown in Figure 1f.

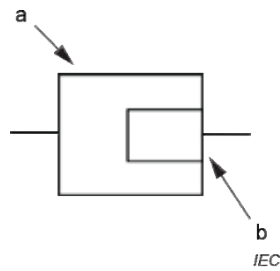


Figure 1a – Socket and plug assembly

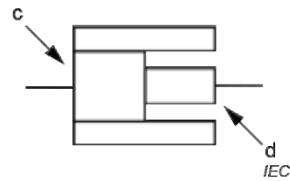


Figure 1b – Connector set (plug, adapter, plug)

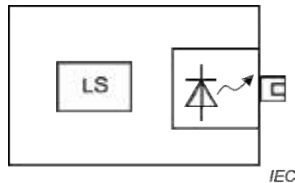


Figure 1c – Light source

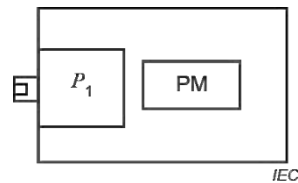


Figure 1d – Power meter



Figure 1e – Generic connection

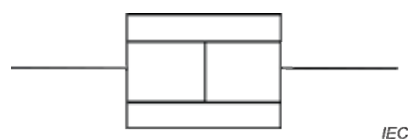


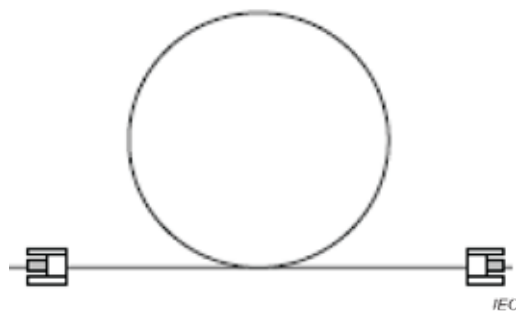
Figure 1f – Pinned/unpinned connection

Key

a	socket	d	plug inserted into plug-adapter assembly
b	plug	LS	light source
c	plug-adapter assembly	PM	power meter

Figure 1 – Connector symbols

In the figures that illustrate the measurement configurations in Annexes A through D and in Annex I, the cabling under test, illustrated by the loop, may contain splices, connectors or other passive components. Note that for purposes of measuring the attenuation of this cabling, the attenuation associated with the terminal connectors is considered separately from that of the cabling itself.



NOTE Cabling is shown with adapters pre-attached, and the plugs going into them are associated with reference-grade test cord plugs.

Figure 2 – Symbol for cabling under test

3.3 Abbreviated terms

ATM	alternative test method
BIMMF	bend-insensitive multimode optical fibre
EF	encircled flux
LSA	least squares approximation
LSPM	light source power meter
OTDR	optical time domain reflectometer
PM	power meter
RTM	reference test method

4 Test methods

4.1 General

Five test methods are designated. The five test methods use test cords to interface to the cabling plant and are designated as follows:

- one-cord method (Annex A);
- three-cord method (Annex B);
- two-cord method (Annex C);
- equipment cord method (Annex D);
- optical time domain reflectometer (OTDR) method (Annex E).

The first four methods use an optical light source and power meter (LSPM) to measure input and output power levels of the cabling under test to determine the attenuation. The main functional difference between these methods is the way the input power level, known as the reference power level, is measured and hence the inclusion or exclusion of the attenuation associated with the connections to the cabling under test, and the associated uncertainties of these connections. The process of measuring the input power level is commonly referred to as "taking the reference power level", or "normalization".

The one-cord method includes the attenuation associated with connections at both ends of the cabling under test. The three-cord method is designed to exclude the attenuation of the connections of both ends of the cabling under test. The two-cord method includes the attenuation associated with one of the connections of the cabling under test.

The equipment cord method includes the attenuation associated with the connections between the equipment cords and the fixed cabling, but excludes the attenuation associated with the connectors that will be connected into the equipment.

The maximum allowed cabling attenuation specified (e.g., optical power budget or channel attenuation) for a transmission system normally excludes the connections made to the transmission equipment. It is, therefore, appropriate to use the equipment cord method (if possible) where the cabling under test is intended to be connected directly to transmission equipment.

The OTDR method emits short light impulses into the cabling and measures the backscattered power as a function of propagation time delay or length along the optical fibre. This method allows the measurement of the attenuation of both installed cabling plant and the attenuation of individual cabling components such as connectors and lengths of optical fibre cable. It does not require a separate reference measurement to be completed. Requirements for the launch cord and tail cord are defined in Annex E. In addition to commissioning new cabling plant, the OTDR method is useful for optical fibre cabling testing during trouble-shooting and maintenance, since the cabling plant can be characterized by a detailed mapping (the OTDR trace) that can be analysed to highlight any changes.

General requirements for apparatus, procedures and calculations common to all methods are given in Clauses 6, 7, and 8. Requirements that are specific to each particular method are documented in Annexes A through E. Clause 6 also includes related procedures such as connector end face cleaning and inspection.

4.2 Cabling configurations and applicable test methods

This document assumes that the installed cabling takes one of four forms shown in Table 1 and Figures 3, 4, 5, and 6. If the cabling is terminated with an adapter, the test cord shall be terminated with a plug and vice versa.

Table 1 – Cabling configurations

Configuration	Description	End connections attenuation included
A	Adapters attached to plugs or sockets attached to both ends of the cabling	Two
B	Plugs on both ends	None
C	Mixed, where one end of the cabling is terminated with an adapter and the other end is terminated with a plug	One (terminated with an adapter)
D	Plugs on both ends utilizing equipment cords	None

The variations in test method used to measure the cabling are dependent on the cabling configuration. For example, a common cabling configuration is that of having adapters or sockets on both ends of the cabling (e.g., within patch panels) awaiting connection to electronic equipment with an equipment cord. This corresponds to configuration A. In this case, the one-cord method is used to include the attenuation associated with both end connectors of the cabling. Another example is a cabling configuration where ruggedized pigtails have been spliced onto the ends of the main cable, and the connectors on the pigtails are to be directly connected into the transmission equipment. This corresponds to configuration B. In this case, a three-cord method is used to exclude the attenuation of the end plug connections. A further example is a cabling configuration for which equipment cords are installed on both ends of the cabling and are awaiting connection to electronic equipment. This corresponds to configuration D. In this case, the equipment cord method (or, where this is not practical, the three-cord method) is used to exclude the attenuation of the end plug connections.

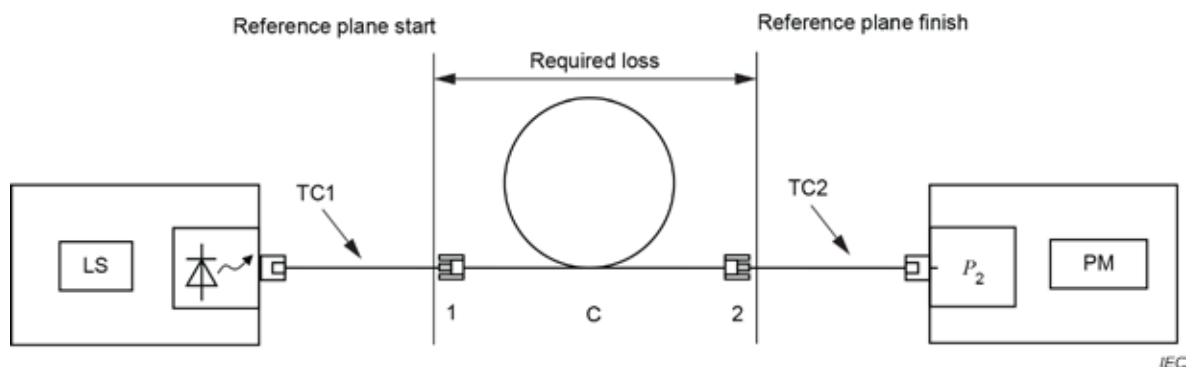
The cabling configuration defines the test methods that should be applied, as described in Table 2. The reference test method (RTM) offers the best measurement accuracy. The alternative test method (ATM) may be required in specific circumstances or by other International Standards but is subject to reduced measurement accuracy compared with the reference test method. Unless otherwise agreed, resolutions of dispute shall employ the appropriate RTM in conjunction with the applicable reference-grade terminations and adapters, as described in 6.3, 6.4, 6.5, and 6.9.

Table 2 – Test methods and configurations

Configuration	RTM	ATM
A	Annex A (1-cord)	Annex B (3-cord), Annex E (OTDR), Annex C (2-cord)
B	Annex B (3-cord)	Annex E (OTDR)
C	Annex C (2-cord)	Annex B (3-cord), Annex E (OTDR)
D	Annex D (equipment cord)	Annex B (3-cord), Annex E (OTDR)

Figures 3 through 6 show the reference planes for cabling under test using LSPM test equipment. The relevant results and discussions of uncertainty are described in Clause I.1 with examples provided in Clause I.4. The same reference planes apply to OTDR test equipment

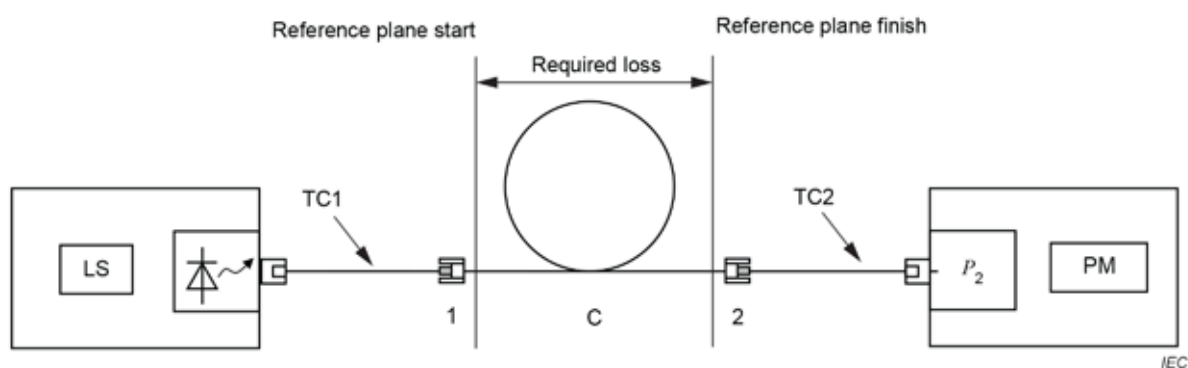
(the OTDR would replace the LS in Figures 2 through 5, and the PM would not be present). The relevant results and discussions of uncertainty are described in Annex I.



Key

LS	light source	TC2	receive cord
TC1	launch cord	PM	power meter
C	cabling under test	1, 2	connector sets

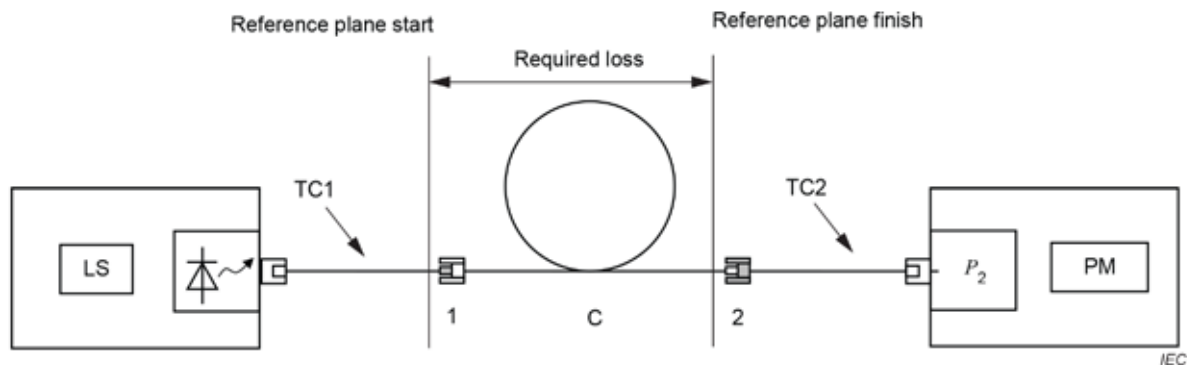
Figure 3 – Reference plane for configuration A tested with the 1-cord method



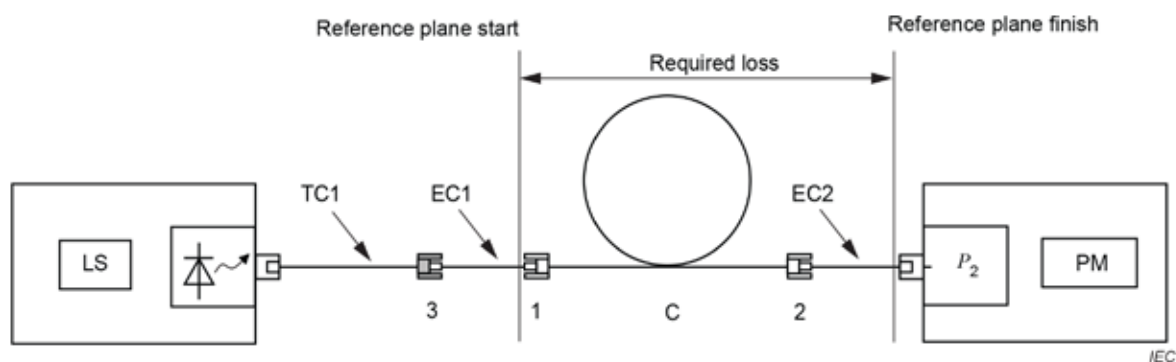
Key

LS	light source	TC2	receive cord
TC1	launch cord	PM	power meter
C	cabling under test	1, 2	connector sets

Figure 4 – Reference plane for configuration B tested with the 3-cord method

**Key**

LS	light source	TC2	receive cord
TC1	launch cord	PM	power meter
C	cabling under test	1, 2	connector sets

Figure 5 – Reference plane for configuration C tested with the 2-cord method**Key**

LS	light source	EC1	equipment launch cord
TC1	launch cord	PM	power meter
C	cabling under test	EC2	equipment receive cord
		1, 2, 3	connector sets

Figure 6 – Reference plane for configuration D tested with the EC method**5 Overview of uncertainties****5.1 General**

The measurement uncertainties should be determined using the calculation in IEC TR 61282-14.

Even if a calculation spreadsheet is provided, this full calculation is relatively complex due to the large quantity of considered parameters. Subclauses 5.2 to 5.5 are an alternative to this calculation.

5.2 Sources of significant uncertainties

For typical conditions, calculations using IEC TR 61282-14 show that significant sources of uncertainties are limited to those generated by launch conditions, source instability, optical source wavelength and, depending on the measurement method, connector mating reproducibility.

Other sources of uncertainties, such as measurement resolution, PM (power meter) linearity, etc., are less significant and do not impact measurements, because the accumulation of uncertainties is a quadratic summation.

5.3 Consideration of the PM

The power meter should have a detector large enough to capture the entire incident light. In this way, the attenuation and uncertainty associated with coupling the receive cord to the power meter is minimal.

5.4 Consideration of test cord connector grade

Test cords may be reference grade or standard grade in which case two measurement conditions need to be considered. Using reference-grade connectors on test cords introduces measurement bias that shall be taken into account but reduces measurement uncertainty. Standard-grade connectors introduce no bias but have higher measurement uncertainty sometimes exceeding the actual attenuation measurement (see Table 3).

Table 3 – Measurements bias related to test cord connector grade

Test cord termination grade	Cabling and equipment cord termination grade	Measurement bias	Total uncertainty
MM reference grade	MM standard grade	Most of the case measurement is optimistic except for configuration B (see Table I.1)	Can be estimated using IEC TR 61282-14 default values
MM standard grade	MM standard grade	None	Uncertainty values are higher than the values estimated using the IEC TR 61282-14 default values (see Table 4)

5.5 Typical uncertainty values

Typical uncertainty values were calculated using IEC TR 61282-14, assuming the following conditions:

- PM: use of one PM only;
- use of grade B standard grade connectors;
- source centroidal wavelength, reference IEC 61280-1-3: 850 nm $\pm$ 25 nm;
- source stability of $\pm 0,10$ dB ($k = 2$);
- source level: -20 dBm (0,01 mW);
- optical fibre: IEC 60793-2-10 sub-category A1-OMxa.

Results of calculation can be used to report measurement results and conformity assessment.

Table 4 reproduces the results of the calculation for a selection of cable lengths and attenuations when using different test methods in this document and different test cord connector grades.

Table 4 – Uncertainty for a given attenuation at 850 nm

Measured cabling attenuation dB	Uncertainty values at 95 % using test cords with reference-grade connectors dB			Uncertainty values at 95 % using test cords with standard-grade connectors dB		
	Annex A (1-cord)	Annex C (2-cord)	Annex B (3-cord)	Annex A (1-cord)	Annex C (2-cord)	Annex B (3-cord)
0,5	0,25	0,28	0,31	1,24	1,52	1,75
1,0	0,25	0,28	0,31	1,24	1,52	1,75
1,5	0,27	0,30	0,32	1,25	1,52	1,76
2,0	0,30	0,32	0,35	1,25	1,53	1,76
2,5	0,34	0,36	0,38	1,26	1,53	1,76
3,0	0,39	0,40	0,42	1,27	1,54	1,77
3,5	0,44	0,45	0,46	1,28	1,55	1,78
When the uncertainty is larger than the measured attenuation, the measured value is either meaningless or the value considered should be the uncertainty. See Annex I for the IEC standard that specifies reference and standard grade connectors. For the purpose of this table, the attenuation of the fibre represents 23,5% of the total attenuation.						

6 Apparatus

6.1 General

Apparatus requirements specific to particular methods are found in Annexes A through E. Some of the requirements common to the apparatus of LSPM methods are included in Clause 6.

6.2 Light source

6.2.1 Stability

The performance of the light source is defined at the output of the launch cord. This is achieved by transmitting the output of a suitable radiation source, such as a laser or light emitting diode into the launch cord. The source used shall be stable in position, wavelength and power over the duration of the entire measurement procedure. Power stability should be $\pm 0,05$ dB typically to minimize uncertainty.

6.2.2 Spectral characteristics (LSPM measurement)

The spectral width of the light source shall meet the requirements of Table 5 when measured in accordance with IEC 61280-1-3. These requirements are compatible with LED devices.

Table 5 – Spectral requirements

Centroidal wavelength nm	RMS spectral width range nm
850 ± 25	10^a to 38
1 280 to 1 330	10^a to 75
^a The spectral width range applies to LSPM methods only.	

6.3 Launch cord

Except for the OTDR method, the launch cord shall be 2 m to 10 m in length.

The requirements on the near-field profile emitted from the launch cord in Annex F shall be met. The required launch conditions can be achieved by including appropriate equipment inside the light source, or by applying mode controlling or conditioning devices on or in series with the launch cord.

The connector and adapter terminating the launch cord shall be compatible with the cabling and should be of reference grade to minimize the uncertainty of measurement results.

The optical fibres supported by this document are defined in IEC 60793-2-10 as A1-OMx, where x = 2, 3, 4 and 5 (e.g., A1-OM3) with the following sub-categories:

- A1-OM1 (62,5/125 µm);
- A1-OM2 (legacy 50/125 µm);
- A1-OM3 (1st generation laser optimised 50/125 µm);
- A1-OM4 (2nd generation laser optimised 50/125 µm);
- A1-OM5 (wide band 50/125 µm).

A1-OMx fibres are further subdivided as:

- A1-OMxa, where x is a value between 2 and 5 (designating traditional macrobend $\overline{A_1}$ loss $\overline{A_1}$ performance levels);
- A1-OMxb, where x is a value between 2 and 5 (designating $\overline{A_1}$ enhanced macrobend loss performance levels $\overline{A_1}$ – referred to as BIMMF).

The optical fibre within the launch cord at the connection to the cabling under test shall be of the same nominal fibre core size as the optical fibre within the cabling under test.

$\overline{A_1}$ When undertaking LSPM testing of A1-OMxa or A1-OMxb optical fibres, the launch cord can contain optical fibres of sub-division A1-OMxa or A1-OMxb (BIMMF). $\overline{A_1}$

Additional care is needed when selecting test cords. $\overline{A_1}$ Some equipment requires the launch cord to be matched to the light source to provide the required encircled flux launch. $\overline{A_1}$

6.4 Receive or tail cord

$\overline{A_1}$ Except for the OTDR method, the receive cord shall be 2 m to 10 m in length. See Annex E for the length of the OTDR receive cord. $\overline{A_1}$

The connector and adapter terminating the $\overline{A_1}$ receive cord $\overline{A_1}$ shall be compatible with the cabling and should be of reference grade to minimize the uncertainty of measurement results.

The termination of the receive cord at the connection to the power meter shall be compatible with that of the power meter.

Where bi-directional testing is carried out, the tail cord becomes the launch cord (see Annex G) and shall comply with 6.3.

With reference to 6.3:

- the optical fibre within the receive or tail cord at the connection to the cabling under test shall be of the same nominal fibre core size as the optical fibre within the cabling under test;
- $\overline{A_1}$ when undertaking LSPM testing of A1-OMxa or A1-OMxb optical fibres, the receive cord can contain optical fibres of sub-division A1-OMxa or A1-OMxb (BIMMF). $\overline{A_1}$

6.5 Substitution cord

The connector and adapter terminating the $\boxed{A_1}$ substitution cord $\boxed{A_1}$ shall be compatible with the cabling and should be of reference grade to minimize the uncertainty of measurement results.

Ⓐ The length of substitution cord shall be 2 m to 10 m in length. Ⓐ

With reference to 6.3:

- the optical fibre within the substitution cord shall be of the same nominal fibre core size as the optical fibre within the cabling under test;
- **A1** when undertaking LSPM testing of A1-OMxa or A1-OMxb optical fibres, the substitution cord can contain optical fibres of sub-division A1-OMxa or A1-OMxb (BIMMF). **A1**

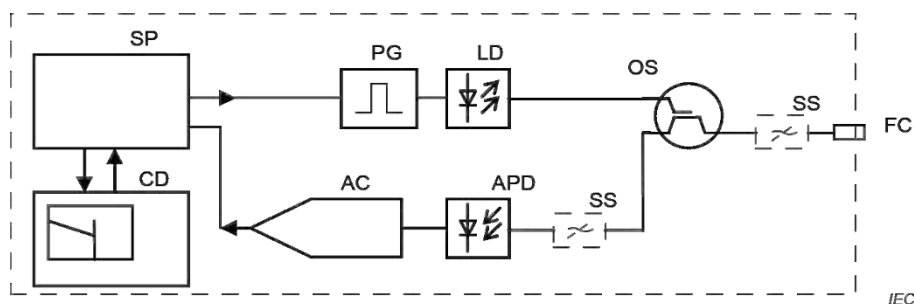
6.6 Power meter – LSPM methods only

The power meter shall be capable of measuring the range of power normally associated with the cabling, including considerations on the power launched into the cabling. The power meter shall meet the calibration requirements of IEC 61315. The meter shall have a detecting surface of sufficient size to capture all the power coming from the optical fibre that is put into it. If a pigtail is used, the pigtailed optical fibre shall be sufficiently large to capture all the power coming from the test cord.

6.7 OTDR apparatus

Figure 7 is a schematic of the OTDR apparatus shown with a simple attachment point. Annex E has some more detailed requirements for the length of the launch cord and other aspects related to the OTDR measurement. The other requirements of 6.1 apply.

For high precision and repeatable measurements, it is recommended to use, either before or after the splitter, a speckle scrambler functionally equivalent to the optical fibre shaker described in IEC 61280-1-4 in order to minimize the effects of coherence modal noise.



Key

PG	pulse generator
LD	laser diode
OS	optical splitter
SS	speckle scrambler (optional)
FC	front panel connector
APD	avalanche photo diode
AC	amplifier and converter
SP	signal processor
CD	control and display

Figure 7 – OTDR schematic