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Interested committees:

Title: Draft BS EN 50174-4 Information technology - Cabling installation. Part 4: Testing of installed optical fibre cabling.

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Full document details: 24/30497792 DC

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

July 2024

ICS 35.110

English Version

Information technology - Cabling installation - Part 4: Testing of installed optical fibre cabling

Technologies de l'information - Installation de câblage -
Partie 4: Essais d'une installation de câblage à fibres
optiques

Informationstechnik - Installation von
Kommunikationsverkabelung - Teil 4: Messung von
installierter Lichtwellenleiterverkabelung

This draft European Standard is submitted to CENELEC members for enquiry.
Deadline for CENELEC: 2024-10-18.

It has been drawn up by CLC/TC 215.

If this draft becomes a European Standard, CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CENELEC in three official versions (English, French, German).
A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



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

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European foreword

This document (prEN 50174-4:2024) has been prepared by Technical Committee CLC/TC 215, "Electrotechnical aspects of telecommunication equipment". It is based on ISO/IEC 14763-3:2024.

This document is currently submitted to the Enquiry.

The following dates are proposed:

- latest date by which the existence of this document has to be announced at national level (doa) dor + 6 months
- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) dor + 12 months
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) dor + 36 months (to be confirmed or modified when voting)

EN 50174 comprises four parts. All for parts support the specification, implementation, operation and qualification of information technology cabling. There are specific requirements for cabling systems that are in accordance with the design requirements of the EN 50173 series. However, the three parts also apply to cabling systems of any design including those in accordance with standards such as EN 50700.

This part, prEN 50174-4, is concerned with the measurement and visual inspection of installed optical fibre cabling.

Introduction

The importance of services delivered by information technology cabling infrastructure is similar to that of utilities such as heating, lighting and electricity supplies. As with those utilities, interruptions to service can have a serious impact. Poor quality of service due to lack of planning, use of inappropriate components, incorrect installation, poor administration or inadequate support can threaten an organization's effectiveness.

There are four phases in the successful implementation of information technology cabling. These are:

- a) design;
- b) specification – the detailed requirement for the cabling, including the planning of its accommodation and associated building services addressing specific environments (e.g. electromagnetic) together with the quality assurance requirements to be applied;
- c) installation – in accordance with the requirements of the specification;
- d) operation – the management of connectivity and the maintenance of transmission performance during the life of the cabling.

This European Standard is in four parts and addresses the specification, installation, operational aspects and measurement of installed cabling. The EN 50173 series and other application standards cover design issues.

This document details the inspection and test procedures for optical fibre cabling designed in accordance with premises cabling standards including the EN 50173 series and installed in accordance with the requirements and recommendations of EN 50174-2 and EN 50174-3. This document has been prepared in support of EN 50173 series.

Users of this document should be familiar with relevant premises cabling standards and the other documents of the EN 50174 series.

EN 50174-1 is used during the specification phase. EN 50174-2 and EN 50174-3 are intended to be used by the personnel directly involved in the planning aspects (of the specification phase) and installation phase. EN 50174-2 is applicable inside buildings and EN 50174-3 is applicable outside buildings.

This European Standard is also relevant to:

- main contractors;
- designers, suppliers, installers, inspectors (auditors), maintainers and owners of information technology cabling;
- end users.

Figure 1 and Table 1 show the schematic and contextual relationships between the standards produced by CLC/TC 215 for information technology cabling, namely:

- 1) this and other parts of the EN 50174 series;
- 2) generic cabling design (EN 50173 series);
- 3) application dependent cabling design (e.g. EN 50700);
- 4) bonding requirements (EN 50310).

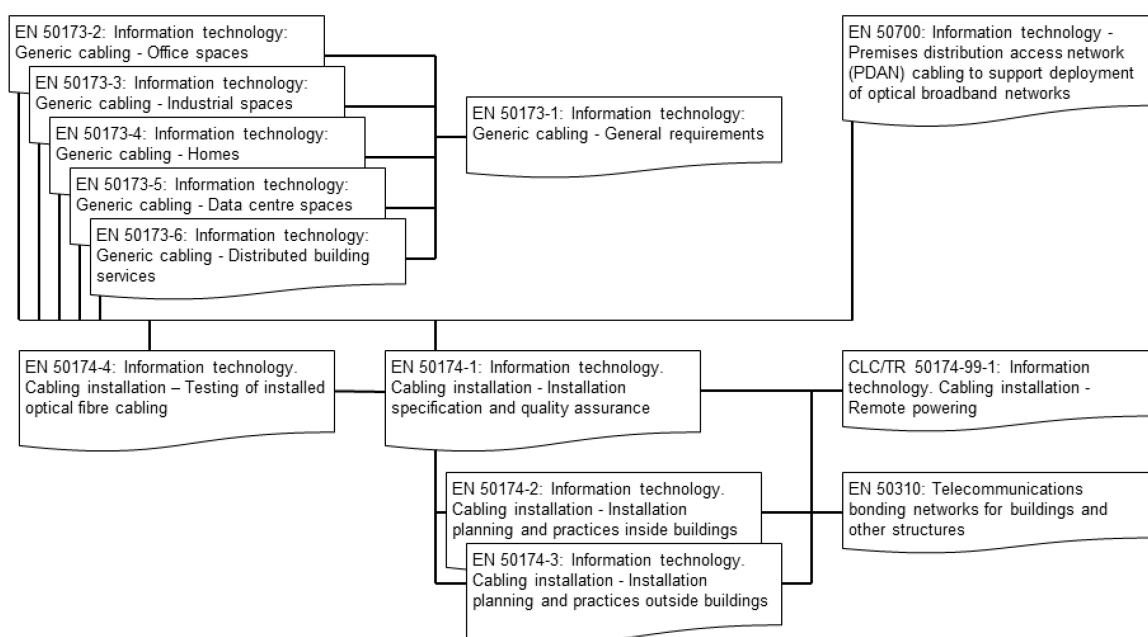


Figure 1 — Schematic relationship between the EN 50174 series and other relevant standards

Table 1 — Contextual relationship between EN 50174 series and other standards relevant for information technology cabling systems

Building design phase	Generic cabling design phase	Specification phase	Installation phase	Operation phase
EN 50310	EN 50173-2 EN 50173-3 EN 50173-4 EN 50173-5 EN 50173-6 EN 50173-20 (these ENs reference general requirements of EN 50173-1)	EN 50174-1	EN 50174-2 EN 50174-3 EN 50174-4 EN 50310 EN 50697	EN 50174-1

The quality plan for each installation will define the acceptance tests and sampling levels selected for that installation. Requirements and recommendations for the development of a quality plan are given in EN 50174-1.

1 Scope

This document specifies systems and methods for the inspection and testing of installed optical fibre cabling designed in accordance with premises cabling standards including the EN 50173 series. The test methods refer to existing standards-based procedures where they exist.

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.

EN 50173-1, *Information technology - Generic cabling systems - Part 1: General requirements*

EN 50174-1, *Information technology - Cabling installation - Part 1: Installation specification and quality assurance*

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

EN IEC 61280-1-3, *Fibre optic communication subsystem test procedures - Part 1-3: General communication subsystems - Measurement of central wavelength, spectral width and additional spectral characteristics (IEC 61280-1-3)*

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

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

EN IEC 61280-4-5, *Fibre-optic communication subsystem test procedures - Part 4-5: Installed cabling plant - Attenuation measurement of MPO terminated fibre optic cabling plant using test equipment with MPO interfaces (IEC 61280-4-5)*

EN 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 61300-3-35)*

EN 61300-3-42, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-42: Examinations and measurements - Attenuation of single mode alignment sleeves and or adaptors with resilient alignment sleeves (IEC 61300-3-42)*

EN 61755-2-4, *Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 2-4: Connection parameters of non-dispersion shifted single-mode physically contacting fibres - Non-angled for reference connection applications (IEC 61755-2-4)*

EN 61755-2-5, *Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 2-5: Connection parameters of non-dispersion shifted single-mode physically contacting fibres - Angled for reference connection applications (IEC 61755-2-5)*

EN 61755-3-1, *Fibre optic connector optical interfaces - Part 3-1: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia PC ferrule, single mode fibre (IEC 61755-3-1)*

EN 61755-3-2, *Fibre optic connector optical interfaces - Part 3-2: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia ferrules for 8 degrees angled-PC single mode fibres (IEC 61755-3-2)*

EN 61755-3-31, *Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 3-31: Connector parameters of non-dispersion shifted single mode physically contacting fibres - Angled polyphenylene sulphide rectangular ferrules* (IEC 61755-3-31)

EN IEC 62614-1, *Fibre optics - Multimode launch conditions - Part 1: Launch condition requirements for measuring multimode attenuation* (IEC 62614-1)

IEC 60050-731, *International Electrotechnical Vocabulary (IEV) - Part 731: Optical fibre communication*

IEC TR 61282-14, *Fibre optic communication system design guidelines - Part 14: Determination of the uncertainties of attenuation measurements in fibre plants*

IEC PAS 63267-3-31, *Fibre optic interconnecting devices and passive components – Fibre optic connector optical interfaces – Part 3-31: End face geometry – Flat PC PPS rectangular ferrule multimode fibres*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50173-1, IEC 60050-731 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1.1

adaptor

device that enables interconnection between terminated optical fibre cables

3.1.2

attenuation

A

reduction in optical power induced by transmission through a medium such as optical fibre, given as $A = -10 \log (P_{\text{out}}/P_{\text{in}})$, where P_{in} and P_{out} are the power, typically measured in mW, into and out of the cabling

Note 1 to entry: The values of A are in decibel (dB).

3.1.3

attenuation dead zone

<reflective or non-reflective event> region on an OTDR after the event where the displaced trace deviates from the undisturbed backscatter trace by more than a given vertical distance ΔF

Note 1 to entry: ΔF is commonly accepted to be a value of 0,5 dB

[SOURCE: EN 61746-1:2011, and EN 61746-2:2011, 3.3, modified – The note has been changed and Figure 1 has not been included.]

3.1.4

bi-directional measurement

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

3.1.5

cable sheath

covering over the optical fibre or conductor assembly that can include one or more metallic members, strength members or jackets

Note 1 to entry: Sometimes simply referred to as “sheath”.

3.1.6

connection

mated device including terminations connecting two cables or cable elements

3.1.7

encircled flux

fraction of cumulative near-field power to the total output power as a function of radial distance from the optical centre of the core

3.1.8

fail result

measured value which fails to meet the specified requirement and where the absolute value of the difference between the measured value and the specified requirement is greater than the stated measurement uncertainty

3.1.9

launch test cord

cable assembly used to connect from a light source to the cabling under test or as part of a test reference measurement

3.1.10

light source and power meter

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

3.1.11

marginal result

measured value which differs from the specified requirement by an amount not exceeding the stated measurement uncertainty

3.1.12

multimode fibre

optical fibre along whose core the radiation of two or more bound modes can propagate at the wavelength of interest

Note 1 to entry: A typical multimode fibre propagates 100 modes or more.

[SOURCE: IEC 60050-731:1991, 731-02-03, modified – The definition has been slightly changed and Note 1 to entry added.]

3.1.13

optical fibre

waveguide shaped as a filament, made of dielectric materials for guiding optical waves

[SOURCE: IEC 60050-151:2001/AMD3:2019, 151-12-35]

3.1.14

optical time domain reflectometer

OTDR

test system consisting of an optical time-domain reflectometer and associated test cords used to characterize and measure the attenuation of installed cable plant and specific elements within that cable plan

3.1.15**pass result**

measured value which meets the specified requirements and where the absolute value of the difference between the measured value and the specified requirement is greater than the stated measurement uncertainty, provided any apparent gain does not exceed the measurement uncertainty

3.1.16**pin conversion test cord****PCTC**

cord used to change the mated connector from pinned to unpinned, and vice versa when there is a pinning incompatibility between the launch test cord and link under test

3.1.17**reference adaptor**

adaptor with tighter tolerances (single-mode adaptors), to ensure reference connections can be attained

3.1.18**reference connector**

connector with tightened tolerances terminated onto an optical fibre that can require tightened tolerances such that the expected attenuation formed by mating two such assemblies is less than or equal to a specified value that is lower than the normal expected attenuation

3.1.19**reference measurement**

measurement of the output power of the light source that is used to determine the input power level to the cabling under test

3.1.20**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]

3.1.21**single-mode fibre**

optical fibre which supports only one mode of light transmission

3.1.22**substitution test cord**

test cord used within a reference measurement which is replaced during the measurement of the attenuation of the cabling under test

3.1.23**tail test cord**

cable assembly used to connect from a power meter to the cabling under test or as part of a test reference measurement

3.1.24**test cord**

cable assembly used either to connect test equipment to the cabling under test or as part of a test reference measurement

3.1.25**test operator**

skilled person who tests in accordance with instructions provided by the test system designer

3.1.26

test system

test equipment, test cords and adaptors necessary to undertake a given test in accordance with the requirements of this document

3.1.27

defect

surface feature such as pits, scratch, chips and loose debris

3.1.28

loose debris

particles and debris on the surface that can be removed by cleaning

3.1.29

pit

permanent non-linear surface damage

3.1.30

scratch

permanent linear surface damage

3.2 Abbreviated terms

For the purposes of this document, the abbreviated terms of EN 50173-1 and the following apply.

APC	angled physical contact
BIMMF	bend insensitive multimode fibre referred to as enhanced macrobend loss fibre
CP	consolidation point
DUT	device under test
EQP	equipment
E2E	end-to-end
EC	equipment cord
ffs	for further study
IOR	index of refraction
LC	LC connector
LTC	launch test cord
LS	light source
MF	multi fibre
MM	multimode
MMF	multimode fibre
MPO	multi-fibre push on (based on rectangular ferrule)
MPTL	modular plug terminated link
N/A	not applicable
OTDR	optical time domain reflectometer
PC	physical contact
PCTC	pin conversion test cord
PM	power meter
RL	return loss

RMS	root mean square
SC	subscriber connector
SF	single fibre
SFC	single fibre connector
SM	single-mode
SMF	single-mode fibre
STC	substitution test cord
TTC	tail test cord

3.3 Symbols

For the purposes of this document the following symbols apply.

	Optical fibre connector (general)
	Optical fibre connector on installed cabling
	Optical fibre connector with reference termination
	Optical fibre adaptor (general)
	Optical fibre adaptor embedded in cabling
	Optical fibre reference adaptor
	Splice

4 Conformance

To test installed cabling in accordance with this document:

- a) the reference connectors shall conform to the requirements of 5.6;
- b) the requirements of Clause 6 shall be met;
- c) the test equipment and test cords shall conform to the requirements of Clause 5;
- d) the test method, as appropriate, and treatment of results shall conform to Clauses 6 and 7;
- e) information about the test equipment shall be documented in accordance with 5.2;
- f) the test results shall be documented in accordance with Clause 6 and Clause 8.

To inspect installed cabling in accordance with this document:

- 1) the inspection equipment shall conform to the requirements of 5.8;
- 2) the inspection method, as appropriate, shall conform to 6.8.

This document does not specify which test or sampling level is to be adopted as this is specified in the quality plan (see Annex B) meeting the requirements of EN 50174-1. This document does define the test method and equipment to be utilized for specific tests.

Laser safety is outside the scope of this document, and is covered by other standards and by regulations. However, information given by this document can be of assistance.

5 Test equipment

5.1 General requirements

The test equipment and particularly the adaptors, test cords terminated with reference connectors and reference connectors, affect the uncertainty of the attenuation measurement for a given component, link or channel.

The test equipment shall be calibrated using standardized procedures (e.g. EN IEC 61315 for optical power meter and EN 61746 series for OTDR), or tester manufacturer's documented procedures, as appropriate.

The test operator shall have evidence, in the form of a valid calibration certificate, to support the use of the test equipment at the time the tests are carried out.

Index matching materials (gels or fluids) between the polished end faces of connectors shall not be used.

5.2 Documentation

Test equipment used for conformance testing should include apparatus specific documentation, certificates of compliance to specific standards (i.e. encircled flux), test cord test data, and the factory calibration date.

5.3 Apparatus

Apparatus requirements apply to single-fibre and multi-fibre LSPM and OTDR devices. An LSPM uses a light source and power meter at each end of the fibre cabling. An OTDR makes a measurement single-ended, from either fibre end.

5.4 Light source and power meter

5.4.1 Light source

5.4.1.1 General

The light source shall be capable of producing a stable optical output power and an optical interface compatible with the single fibre ferrule test reference cords.

For a multimode MPO interfaced light source, the connector shall have a PC or APC end face. For single-mode MPO ported light source, the connector shall have an APC end face.

5.4.1.2 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 source, such as a laser or light emitting diode, into the launch cord. The source shall be stable in position, wavelength and power over the duration of the entire measurement procedure. Power stability should be high to minimize uncertainty. When verified using the method described in IEC TR 61282-14, power stability shall be $\leq 0,20$ dB.

5.4.1.3 Launch condition

For single-mode fibre cabling, no specific launch condition is required.

For multimode fibre cabling (MMF), the launch modal condition shall meet the requirements of EN IEC 62614-1, EN IEC 61280-4-1, and EN IEC 61280-4-5 at either:

- a) the output of the launch test cord; or
- b) the output of the bulkhead of the light source when the associated test cords achieve launch modal condition at the output of the launch test cord by design; or

c) the output of the bulkhead of the light source for MPO light sources if the following conditions are met:

- 1) the measurement uncertainty is known and documentation is available as specified in 5.2;
- 2) the agreed quality plan supports the test method and associated measurement uncertainty as required by EN 50174-1;
- 3) the measurement uncertainty for the tests is documented within the test result documentation as required by Clause 8 and EN 50174-1.

NOTE A controlled encircled flux, defined by target and limits, is the standardized distribution of light in fibre required for multimode attenuation measurements. For a light source that produces a uniform or overfilled mode power distribution and using a test cord that has an integrated mode filter, the output of the test cord is measured to be compliant. For test cords that have a mode scrambler and mode filter, capable of attaching to any light source, the output of the test cord is measured to be compliant. For devices that use a test cord without a mode scrambler or mode filter, modal transparency is dependent on matching the core diameter and numerical aperture of the fibre inside the light source to the test cord fibre; this is the case for example with MPO test cords. This could have an impact on the launch modal condition, measured attenuation, and uncertainty.

The specified encircled flux modal condition shall be achieved by:

- use of conformant equipment including a mode conditioner and a corresponding test cord;
- use of equipment with unknown modal condition but use of a conformant modal conditioning device in the launch test cord;
- use of equipment with a source that requires mode filtering and a controlled output at reference connector with launch modal condition that has been measured in accordance with EN IEC 61280-1-4.

Launch test cords shall include reference grade connectors in accordance with 5.6.

The following launch conditions are considered normative for MMF cabling:

- 850 nm for 50 µm core diameter;
- 1 300 nm for 50 µm core diameter;
- 850 nm for 62,5 µm core diameter;
- 1 300 nm for 62,5 µm core diameter.

5.4.1.4 Spectral characteristics

For required test wavelengths, see EN 50173-1 and EN 50174-1. LEDs and Fabry–Pérot lasers should be used for multimode and single-mode testing, respectively. VCSELs should not be used.

Light sources for testing MMF cabling and components shall conform to the spectral characteristics of Table 2 when measured in accordance with EN IEC 61280-1-3. The MMF supported by this document are defined in EN IEC 60793-2-10.

Table 2 — MMF spectral requirements

Centroidal wavelength nm	Spectral width range ^a nm
850 ± 25 (on A1-OMx fibre)	10 to 38 (RMS)
1 280 to 1 330 (on A1-OMx fibre)	10 to 75 (RMS)
^a The spectral width range applies only to the LSPM apparatus.	

Light sources for testing single-mode fibre (SMF) shall conform to the spectral characteristics of Table 3 when measured in accordance with EN IEC 61280-1-3. The SMF supported by this document are defined in EN IEC 60793-2-50.

Table 3 — SMF spectral requirements

Centroidal wavelength nm	Spectral width range nm
1 310 ± 30 (on B-652 and B-657 fibre)	≤ 5 (RMS) for laser diode
1 550 ± 30 (on B-652 and B-657 fibre)	≤ 5 (RMS) for laser diode

5.4.2 Power meter

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 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 fibre pigtail is used, the pigtailed optical fibre core and numerical aperture (NA) shall be sufficiently large to capture all the power coming from the test cord.

The receiver connector of the power meter shall be the same connector used in the system under test at the end of the link where the light source is to be attached.

The power meter having an MPO compatible port, either pinned or unpinned, shall interface with either an MPO multimode plug or MPO/APC single-mode plug.

Caution is advised when interfacing to the power meter MPO port, since it can be pinned or unpinned.

Further information on power meter features for MPO connectors can be found in IEC TR 61282-15.

The power meter shall enable optical power measurements to be recorded to at least two significant digits in the decimal place (e.g. -14,32 dBm, 2,19 dB).

5.5 OTDR

5.5.1 General

OTDR equipment for testing MMF cabling and components shall conform to the centroidal wavelengths of Table 2.

OTDR equipment for testing SMF cabling shall conform to the centroidal wavelengths of Table 3.

OTDR characterization shall be undertaken using a launch test cord and a tail test cord. The LTC and TTC shall be terminated with reference grade test connectors.

For testing optical fibre cabling terminated with MPO connectors, an optical switch is needed. It can be installed within the OTDR mainframe and provide a single MPO interface port. Alternatively, the optical switch can be implemented outside of the OTDR mainframe with a single fibre to multi-fibre interface. Where an optical switch is not available, suitable MPO to single fibre link can be utilized.

5.5.2 OTDR requirements

5.5.2.1 General

The OTDR shall be capable of supporting a range of pulse widths and averaging times to achieve measurements for a given fibre length with sufficient signal-to-noise ratio. The OTDR should have a short attenuation dead zone following a standard connector to adequately measure connector attenuation and return loss at connections to the installed cabling under test.

5.5.2.2 OTDR characterization using test cords

Characterization of cabling using an OTDR with a launch test cord and a tail test cord:

- a) produces a unidirectional characterization of the form shown in Figure 2;
- b) provides a continuity measurement for the cabling under test;
- c) provides information about the general quality of both the local and remote interface to the cabling under test, the quality of the cabled fibre like in the EN 50173 series and any embedded connecting hardware;
- d) provides a quantitative measurement of the local (i.e. near-end) and remote (i.e. far-end) interfaces to the cabling under test when using measurements taken in each direction (i.e. bi-directional);
- e) provides a quantitative measurement of the channel or link (see Clause 6) attenuation when the measurement is taken in one direction provided that the backscattering characteristics of the optical fibre within the launch test cord and tail test cord are the same;
- f) provides a quantitative attenuation measurement of the channel, or link embedded connecting hardware (see Clause 6) when the measurement is taken from two directions provided that:
 - attenuation measurements of permanent links, channel or embedded connecting hardware are derived by averaging the associated bi-directional test results;
 - the distance between embedded connecting hardware is not less than the dead zone of the OTDR (see 7.3.5).

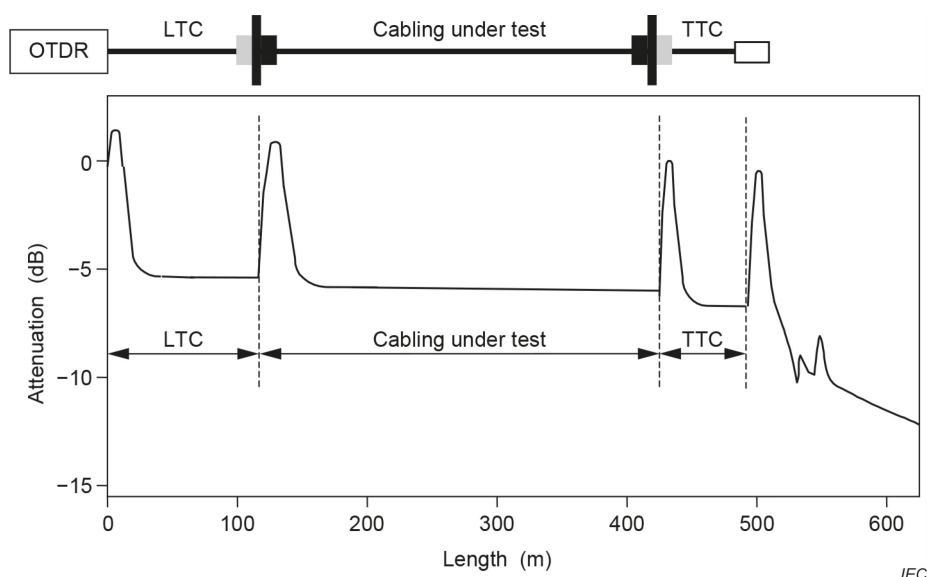


Figure 2 — OTDR characterization using a launch test cord and a tail test cord

5.6 Test cord connectors

5.6.1 Connecting hardware at test interfaces

The connecting hardware to be connected to the cabling under test (i.e. launch test cords and tail test cords) together with the hardware that terminates the substitution test cords and any connecting hardware adaptors are specified as part of the test methods specified by this document and are called reference connectors.

Reference connectors are used to reduce the measurement uncertainty for the attenuation measurements and are used for multimode and single-mode in single fibre (i.e. LC connector) and multi-fibre connectors (e.g. MPO connectors).

The multimode LC and MPO reference connectors are terminated on 50 µm fibre and are in accordance with EN IEC 63267-2-1 for LC and other single fibre connectors. EN IEC 63267-2-2 specifies requirements for MPO connectors.

5.6.2 Connecting hardware attenuation requirements

The key performance requirements of different connector types are listed in Table 4. The attenuation value of the reference to reference connector in a reference adaptor shall be met in order to achieve the attenuation values of EN 50173-1.

Table 4 — Connector identification and attenuation test limits

Mode	Connector identification	Connector type	Reference to reference test limit dB	Reference to standard grade test limit dB
Multimode	Rm1 ^a	MM SF	0,10	0,45
	Rm12 ^a	MM MF12	0,15	0,45
	Rm24 ^a	MM MF24	0,20	0,45
	Rm16 ^a	MM MF16	0,15	0,45
	Rm16A ^a	MM MF16 APC	0,15	0,45
Single-mode	Rs1-Grade 2 ^b	SM SF	0,2	0,7
	Rs12 ^b	SM MF12 APC	0,35	0,7
^a Rmxx: reference connector MM xx number of fibres				
^b Rsxx: reference connector SM xx number of fibres				

5.6.3 Mechanical requirements for reference connectors

5.6.3.1 Requirements for MM LC and other MM single fibre reference connectors

The key performance related requirements for multimode LC and other single fibre reference connectors are (see Table 5).

Table 5 — Single fibre MM reference connector requirements

No.	Parameter	Value	Unit
1	core diameter of the used fibre	50 ± 0,5	µm
2	numerical aperture of the used fibre	0,200 ± 0,002	
3	tolerance of the outer diameter of the 1,25 mm ferrule	1,2485 to 1,2495	mm
	tolerance of the outer diameter of the 2,5 mm ferrule	2,4990 to 2,4995	mm
4	eccentricity of centre of ferrule and centre of fibre	≤ 0,5	µm

All requirements of Table 5 shall be met. The attenuation requirement in Table 4 is met by design if the parameters No. 1 to 4 are met.

5.6.3.2 Requirements for SM LC and other single fibre reference connectors

The single-mode LC and other single fibre reference connectors shall meet the requirements of EN 61755-2-4 for PC and EN 61755-2-5 for APC.

The key performance related requirements for single-mode LC and other single fibre reference connectors are (see Table 6).

Table 6 — Single fibre single-mode reference connector requirements

No.	Parameter	Value	Unit
1	mode field diameter of the used fibre (1310 nm)	$9,2 \pm 0,1$	μm
2	tolerance of the outer diameter of the 1,25 mm ferrule	1,248 5 to 1,249 5	mm
	tolerance of the outer diameter of the 2,5 mm ferrule	2,499 0 to 2,499 5	mm
3	eccentricity of centre of ferrule and centre of fibre	$\leq 0,5$	μm

All requirements of Table 6 shall be met. The attenuation requirement in Table 4 is met by design if the parameters No. 1 to 3 are met.

5.6.3.3 End-face geometry for LC and other single fibre reference connectors

The function of LC and other single fibre reference connectors is based on physical contact of the reference connector and the DUT connector of link and channel to be tested. To ensure physical contact and the required performance, the end-face geometry of the polished ferrule shall be in accordance with the requirements of:

- EN 61755-3-1 for MM PC reference connectors;
- EN 61755-3-1 for SM PC reference connectors;
- EN 61755-3-2 for SM APC reference connectors.

5.6.3.4 Requirements for MM MPO and other multi-fibre connectors

The key performance related requirements for multimode MPO and other multi-fibre reference connectors are (see Table 7).

Table 7 — Multi-fibre MM reference connector requirements

No.	Parameter	Value	Unit
1	core diameter of the used fibre	$50 \pm 0,5$	μm
2	numerical aperture of the used fibre	$0,200 \pm 0,002$	
3	true position of centre of fibre	$\leq 2,0$	μm

All requirements of Table 7 shall be met. The attenuation requirement in Table 4 is met by design if the parameters No. 1 to 3 are met.

5.6.3.5 Requirements for SM MPO and other multi-fibre connectors

The key mechanical requirements for single-mode MPO and other multi-fibre reference connectors are given in Table 8.

Table 8 — Multi-fibre single-mode reference connector requirements

No.	Parameter	Value	Unit
1	mode field diameter of the used fibre (1 310 nm)	$9,2 \pm 0,1$	μm
2	true position of fibre core	$\leq 1,6$	μm

All requirements of Table 8 shall be met. The attenuation requirement in Table 4 is met by design if the parameters No. 1 and 2 are met.

5.6.3.6 End-face geometry requirements for MPO and other multi-fibre connectors

The end-face geometry of single-mode MPO reference connectors shall meet the requirements of EN 61755-3-31. The end-face geometry of the multimode MPO reference connectors shall meet the end-face geometry requirements as specified in IEC PAS 63267-3-31.

5.6.4 Reference adaptors at test interfaces

All reference adaptors used for testing are of single-mode quality and shall be equipped with ceramic alignment sleeve that, when tested in accordance with EN 61300-3-42 with SM APC reference connectors, have an attenuation $\leq 0,2$ dB. Testing multimode reference connectors in a reference adaptor shall have an attenuation $< 0,1$ dB.

MPO and other multi-fibre reference adaptors shall have an attenuation in accordance with Table 4 tested with reference connectors

5.7 Test cord characteristics

5.7.1 General

Each test cord should have the following characteristics:

- for multimode, contain an optical fibre of the same nominal characteristics (i.e. core diameter, numerical aperture) as the optical fibre under test. The optical fibre in the test cords may be BIMMF or non-BIMMF, but the tolerances of the core diameter and numerical aperture are tighter specified in order to minimize uncertainty of the measured attenuation and provide the correct launch condition. See 5.6.3 for details of the reference fibre as part of the reference connector. Test cord attenuation verification shall be in accordance with Annex A.
- for single-mode, contain a fibre with a selected mode field diameter of $9,2 \pm 0,1 \mu\text{m}$ at 1 310 nm as defined in EN 61755-2-4 for single-mode PC and EN 61755-2-5 for single-mode APC. See 5.6.3 for details of the reference fibre as part of the reference connector;
- be labelled by having a unique identifier with each connector labelled as indicated in Figure 3.

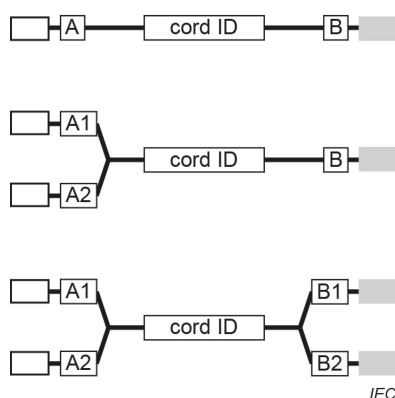


Figure 3 — An example of test cord labelling and identification

5.7.2 LSPM launch test cord

The launch test cord (LTC) shall be:

- terminated at one end with one or more connectors suitable for attachment to the light source;
- terminated at the other end with one or more reference connectors and adaptors compatible with the interface to the installed cabling;

c) 2 m to 5 m in length.

NOTE Use of test cords with reference grade connectors at both ends minimizes measurement uncertainty.

5.7.3 LSPM tail test cord

The tail test cord (TTC) shall be:

- a) terminated at one end with one or more connectors suitable for attachment to the power meter;
- b) terminated at the other end with one or more reference connectors and adaptors compatible with the interface to the installed cabling;
- c) 2 m to 5 m in length.

NOTE Use of test cords with reference grade connectors at both ends minimizes measurement uncertainty.

5.7.4 LSPM substitution test cord

The substitution test cord (STC) shall be terminated at both ends with reference connectors compatible with the interfaces to the installed cabling.

The substitution test cord shall be 2 m to 5 m in length.

5.7.5 OTDR launch test cord

The launch test cord shall be:

- a) terminated at one end with one or more connectors suitable for attachment to the OTDR;
- b) terminated at the other end with one or more reference connectors and adaptors compatible with the interface to the installed cabling;
- c) of the same type, in terms of core diameter, numerical aperture, or mode field diameter as the optical fibre within the cabling under test. Reference grade connectors should be used.

The length of the launch cord shall be longer than the dead zone created by the pulse width selected for a particular length of fibre to be measured. Suppliers of OTDR equipment should recommend lengths. In addition, these lengths shall be long enough for a reliable straight line fit of the backscatter trace that follows the attenuation dead zone with standard connector reflectance. Launch cords shall not include any splice when shorter than 15 m. If there is no recommendation for launch test cord length, the minimum length should be 100 m for multimode and 150 m for single-mode, or the minimum launch cord recommended length guidance of the OTDR manufacturer.

The OTDR launch test cord should provide the specified launch modal distribution (see 5.4.1.3). For the MM OTDR launch test cord, if the OTDR is not known to provide the specified launched modal distribution, then the launch test cord shall contain a suitable mode-controlling device to ensure that the specified launched modal distribution is maintained.

The length of optical fibres used to create OTDR launch test cords often requires that they be protected within an enclosure (see Figure 4).

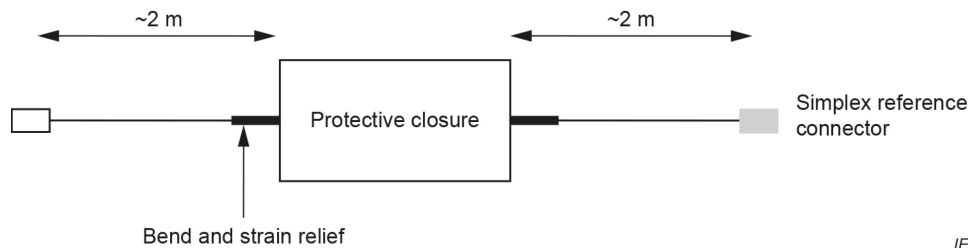


Figure 4 — OTDR launch test cord and tail test cord schematic

5.7.6 OTDR tail test cord

The tail test cord shall be:

- a) longer than the attenuation dead zone of the OTDR (see 3.1.3 and 7.3.5). If there is no recommendation for tail test cord length, the minimum length should be 100 m for multimode and 150 m for single-mode, or the minimum tail cord recommended length guidance of the OTDR manufacturer. Tail cords shall not include any splice when shorter than 15 m;
- b) long enough for a reliable straight-line fit to be made to the backscatter trace following the dead zone (C3 to C4 in Figure 31), so that reliable attenuation measurements can be carried out;
- c) terminated at one end with one or more reference connectors compatible with the interface to the installed cabling;
- d) of the same type, in terms of core diameter, numerical aperture, or mode field diameter as the optical fibre within the cabling under test. Reference grade fibre should be used.

For best practice, reference connectors should be used on both ends.

The length of optical fibres used to create OTDR tail test cords often requires that they be protected within an enclosure (see Figure 4).

5.8 Visual inspection equipment

The inspection equipment shall meet the requirements of EN IEC 61300-3-35.

All possible connectors in multimode and single-mode fibre configurations specified in structured cabling standards shall be inspected for contamination with a low-resolution microscope. Low resolution means that the microscope shall have a field of view of at least 250 µm. The fibre shall be a maximum 50 % of the image on the microscope in the vertical axis.

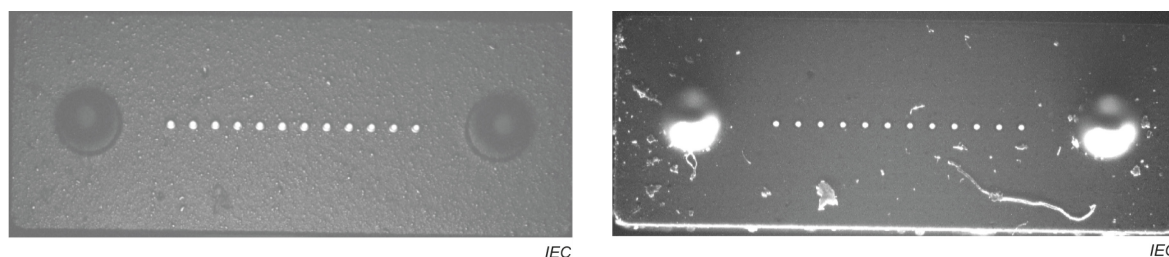
The capability of the microscope for detecting 2 µm targets and the correct field of view can be determined by use of, for example, a chrome on glass artefact with 2 µm targets and a 250 µm circle. The user should contact the equipment supplier for such an artefact. Other artefacts that determine the capability of the microscopes to detect 2 µm defects and 3 µm scratches may be used.

There are different types of microscope available on the market. Direct viewing microscopes are in general lower cost. The microscope shall contain a built-in laser safety filter to prevent accidental eye damage. Do not use direct view microscopes on live fibre systems if there is no filter. This is important during inspection of installed connector end faces where the remote end is not under control of the inspector.

The laser filter is used to control the energy which is directed into the eye from active sources emitted from the cabling. When direct viewing is used it shall be ensured that no laser or equipment with lasers is active on the cabling. Laser safety of optical fibre communication systems shall be in accordance with EN 60825-2.

Video microscopes contain a lens which transfers via a camera the magnified image on a display. Video microscopes provide more laser safety than direct viewing microscopes.

745 All microscope systems show system-to-system variability and a 100 % match between inspection
 746 results of multiple microscopes in accordance with EN IEC 61300-3-35 is not achievable at this moment.
 747 This is even the case when microscopes of the same brand and type are compared.



748 **Figure 5 — Normal illumination (left) and illumination with floodlight (right)**

749 NOTE Some microscopes are available with floodlight (side illumination); these are particularly handy when
 750 inspecting MPOs for dirt (see Figure).

751 For rectangular ferrules, the entire ferrule surface (6,4 mm × 2,5 mm) should be visible (see Figure 5)
 752 and shall be inspected for contamination. The microscope shall be fitted with suitable fixtures that retain
 753 the connector in a stable position, thereby allowing careful inspection.

754 Do not use direct view microscopes on live fibre systems.

755 **6 Testing**

756 **6.1 General**

757 Clause 6 specifies the reference planes, the visual inspection for cleanliness and the testing procedures
 758 and uncertainty for channels, links, permanent links, E2E links and MPLT measured with LSPM or
 759 OTDR.

760 Although permanent links are referred to in Clause 6, EN 50173-1 has defined requirements for sub-
 761 links that can be tested in accordance with this document.

762 **6.2 Reference planes**

763 EN 50173-1 and equivalent documents define transmission limits for channels, links or permanent links,
 764 E2E links and MPLT for which the representative reference planes are shown in Figure 6.