ISO/IEC 14763-3

Edition 1.1 2011-02

INTERNATIONAL STANDARD

colour inside

Information technology – Implementation and operation of customer premises cabling –
Part 3: Testing of optical fibre cabling

ISO/IEC 14763-3:2006+A1:2009(E)

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Information technology – Implementation and operation of customer premises cabling –
Part 3: Testing of optical fibre cabling

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **CA**

ICS 35.200

ISBN 978-2-88912-361-2

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INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 3: Testing of optical fibre cabling

FOREWORD

1) ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards. Their preparation is entrusted to technical committees; any ISO and IEC National Committee interested in the subject dealt with may participate in this preparatory work. International governmental and non-governmental organizations liaising with ISO and IEC also participate in this preparation.

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5) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

This consolidated version of ISO/IEC 14763-3 consists of the first edition (2006) and its amendment 1 (2009). It bears the edition number 1.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

ISO/IEC 14763-3 has been prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This International Standard replaces ISO/IEC TR 14763-3, first edition, published in 2000, and constitutes a technical revision.

This standard incorporates innovations and recent developments including guidance in the proper use of uni-directional and bi-directional OTDR testing, the three-jumper method as default test method, fibre end-face inspection and criteria for scratches, return loss values for SC and non-SC connectors and the normative use of reference connectors. However, the most substantial change is the application of the 2 parameters which are used to determine the two repeatable multimode launch conditions “modal power distribution” and “coupled power ratio”.

This International Standard has been approved by vote of the member bodies, and the voting results can be obtained from the address given on the title page.

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

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 publication using a colour printer.

INTRODUCTION

This document is one of three prepared in support of International Standard ISO/IEC 11801.

Figure 1 below shows the inter-relationship between ISO/IEC 11801, these associated Technical Reports/Standards and other related standards.

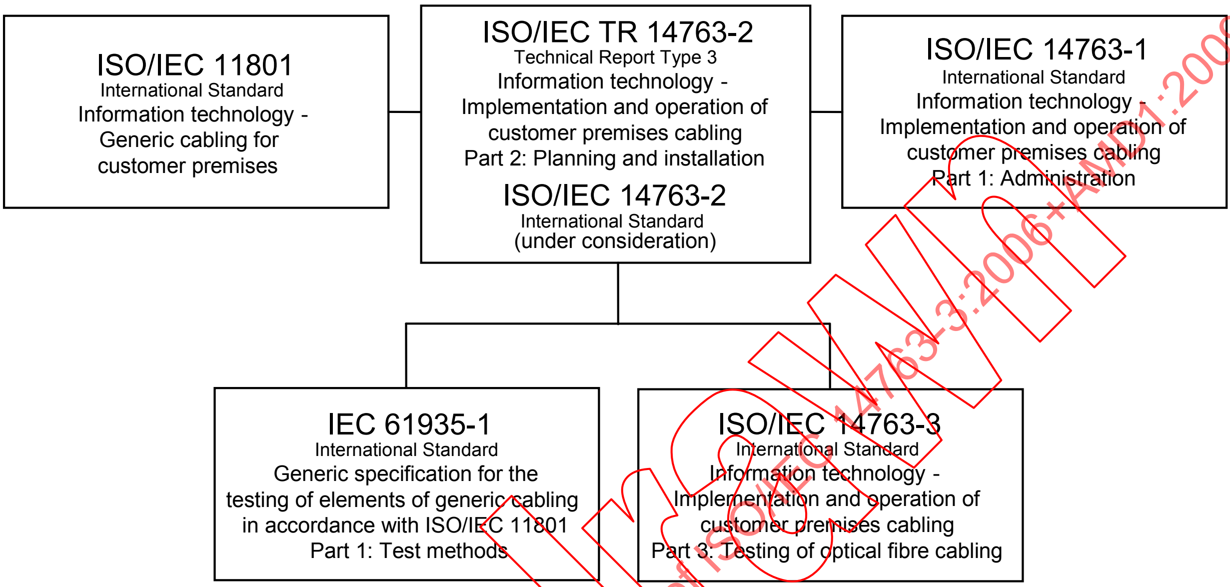


Figure 1 – Document relationships

Part 3 of ISO/IEC 14763 details inspection and test procedures for optical fibre cabling

- designed in accordance with ISO/IEC 11801 and equivalent standards and
- installed according to the requirements and recommendations of ISO/IEC 14763-2 (under consideration).

Users of this International Standard should be familiar with both ISO/IEC 11801 and ISO/IEC 14763-2.

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 described in ISO/IEC 14763-2 (under consideration).

INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 3: Testing of optical fibre cabling

1 Scope

This part of ISO/IEC 14763 specifies systems and methods for the inspection and testing of optical fibre cabling designed in accordance with ISO/IEC 11801 or equivalent standards. The test methods refer to existing standards-based procedures where they exist.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

ISO/IEC TR 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*[1]

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

~~IEC 60793-1-20, *Optical fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry*~~

IEC 60793-1-45, *Optical fibres – Part 1-45: Measurement methods and test procedures – Mode field diameter*

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

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

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

IEC 60874-14-1, *Connectors for optical fibres and cables – Part 14-1: Detail specification for fibre optic connector type SC/PC standard terminated to multimode fibre type A1a, A1b*

IEC 60874-14-2, *Connectors for optical fibres and cables – Part 14-2: Detail specification for fibre optic connector type SC/PC tuned terminated to single-mode fibre type B1*

IEC 60874-14-3, *Connectors for optical fibres and cables – Part 14-3: Detail specification for fibre optic adaptor (simplex) type SC for single-mode fibre*

IEC 60874-19, *Connectors for optical fibres and cables – Part 19: Sectional specification for fibre optic connector – Type SC-D(uplex)*

IEC 60874-19-1, *Connectors for optical fibres and cables – Part 19-1: Fibre optic patch cord connector type SC-PC (floating duplex) standard terminated on multimode fibre type A1a, A1b - Detail specification*

[1] ISO/IEC 14763-2 is planned to become an International Standard.

IEC 60874-19-2, *Connectors for optical fibres and cables – Part 19-2: Fibre optic adaptor (duplex) type SC for single-mode fibre connectors – Detail specification*

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: Cable plant and links – Multimode fibre-optic cable plant attenuation measurement*

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 61300-3-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examinations and measurements – Attenuation*

IEC 61300-3-6, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-6: Examinations and measurements – Return loss*

~~IEC/PAS 61300-3-43, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-43: Examination and measurements – Mode Transfer Function Measurement for fibre optic sources*~~

IEC/PAS 62614, *Fibre optics – Launch condition requirements for measuring multimode attenuation*

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this document the following definitions apply in addition to those of ISO/IEC 11801 and IEC 60050-731.

3.1.1
adapter
device that enables interconnection between terminated optical fibre cables

3.1.2
cabling interface adapter
test cords and other components used to connect test equipment to the cabling under test

3.1.3
connection
mated device or combination of devices including terminations connecting two cables or cable elements

3.1.4
cable sheath
covering over the optical fibre or conductor assembly that may include one or more metallic members, strength members or jackets

~~**3.1.5**~~
~~**coupled power ratio (CPR)**~~
~~ratio of power coupled in a MMF to the power coupled in SMF which is related to the modal power distribution of the light in MMF~~

3.1.6
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

3.1.7
field calibration cord
test cord used for referencing when using the ~~3-jumper~~ three test cord reference test method

3.1.8
marginal result
measured value which differs from the specified requirement by an amount not exceeding the stated measurement uncertainty

3.1.9
multimode optical fibre (MMF)
optical fibre which supports multiple paths of light transmission

3.1.10
optical fibre
any filament made of dielectric materials that guides light

3.1.11
optical time domain reflectometer (OTDR)
instrument used to characterise optical fibre cabling by measuring the backscatter and reflection of injected light pulses as a function of time

3.1.12
pass result
measured value which meets 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

3.1.13
reference connector
tighter tolerances or selected connector component which is used for measuring purposes

NOTE The characteristics or selection procedures are given in the relevant connecting hardware specification.

[IEC 60874-1, 1.3.14, modified]

~~**3.1.14**~~
~~**relative power distribution**~~
~~metric used to determine launch conditions in terms that are relative to a light source's overall launched power~~

3.1.15
sheath
see cable sheath

3.1.16
single-mode optical fibre (SMF)
optical fibre which supports only one mode of light transmission

3.1.17
test cord
cable assembly used either to connect test equipment to the cabling under test or as part of a test reference measurement

3.1.18
test operator
skilled person testing in accordance with instructions provided by the test system designer

3.1.19
test system
test equipment and cabling interface adapters necessary to undertake a given test/measurement in accordance with the requirements of this standard

3.1.20
attenuation
reduction of optical power induced by transmission though a medium such as optical fibre; this is sometimes called insertion loss, L, and is given in dB as $L = 10 \log_{10}(P_{in}/P_{out})$, where P_{in} and P_{out} are the power, typically measured in mW, into and out of the cabling

3.1.21
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

3.1.22
OTDR dead zone
distance in which an OTDR cannot detect an event following a reflective event

3.2 Abbreviations

For the purposes of this document the following abbreviations apply in addition to those of ISO/IEC 11801 and IEC 60050-731.

APC	Angled physical contact
~~CPR~~	~~Coupled power ratio~~
EF	Encircled flux
IOR	Index of refraction
LMD	Launched modal distribution
LSA	Least squares average
LSPM	Light source and power meter
MMF	Multimode optical fibre
~~MPD~~	~~Modal power distribution~~
na	not applicable
OTDR	Optical time domain reflectometer
~~RPD~~	~~Relative power distribution~~
SMF	Single-mode optical fibre

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
▭	Joint

4 Conformance

To test installed cabling according to this International Standard:

- the general requirements of clauses 5 and 8 shall be met;
- the test equipment and test cords shall conform to the requirements of Clause 6;
- the test method, as appropriate, and treatment of results shall conform to Clauses 9 and 10;
- the test results shall be documented in accordance with 5.4;
- the requirements of IEC 60825-2 shall be met.

To inspect installed cabling according to this International Standard:

- the inspection equipment shall conform to the requirements of Clause 7;
- the inspection method, as appropriate, shall conform to Clause 11;
- the requirements of IEC 60825-2 shall be met.

Relevant national and local regulations covering safe working practices shall be observed.

5 General requirements

5.1 Test system

The test systems defined in this International Standard comprise local test equipment and remote test equipment (where required) together with cabling interface adapters which enable the connection of the test equipment to the cabling under test (see Figure 2).

The cabling interface adapters take the form of test cords together with any connecting hardware adapters that are required at the test interfaces.

The test system and, particularly the cabling interface adapters, affect the uncertainty of measurement for a given parameter.

Temporary index matching materials (gels and/or fluids) between the polished end faces of connectors shall not be used.

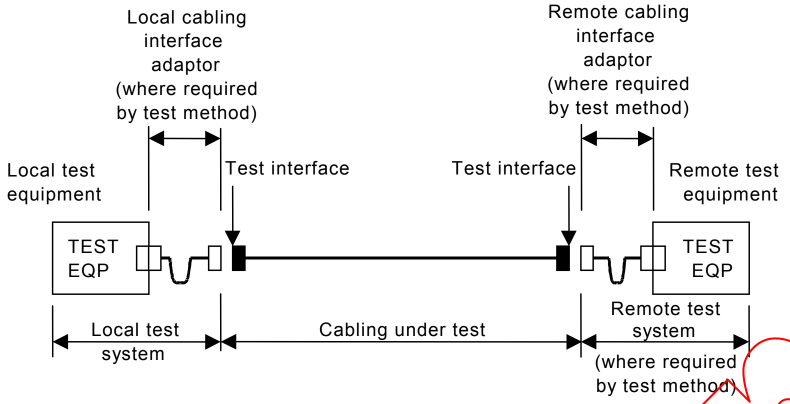


Figure 2 – The test system and the cabling under test

5.2 Normalisation and calibration

Normalisation processes are specified, where appropriate, to enable the test system to achieve the stated measurement uncertainty.

Test equipment should be calibrated using standardised procedures (e.g. IEC 61315 and IEC 61746), 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 undertaken.

5.3 Environmental conditions

5.3.1 Protection of transmission and terminal equipment

Transmission and terminal equipment shall be disconnected from the cabling under test before any testing or inspection according to this Standard is carried out.

5.3.2 Contamination

Dust, dirt and other contaminants at the interfaces to the cabling under test or at interfaces of the cabling interface adapter and at the interface to the test equipment may produce misleading results and in some cases damage the cabling under test.

Materials to clean the connections (such as 98 % reagent grade alcohol, appropriate cleaning solvents, lint-free wipes and clean compressed air) shall be available and used in accordance with suppliers' instructions.

Any connecting hardware adapters used together with all connector end-faces on the test cords comprising the cabling interface adapter and the cabling under test shall be cleaned according to the instructions provided by the manufacturer of the connectors. Cleaning shall be repeated every time a test cord is connected to the cabling or component under test.

Connections should be inspected with a microscope after cleaning, to verify that they are uncontaminated.

5.3.3 Use of test equipment

External effects (for example, environmental, electromagnetic or physical) can affect the test equipment and thereby influence the measured results. Test equipment shall be operated as per manufacturer's specifications.

5.3.4 Relevance of measurement

Measurements shall either

a) be made under environmental conditions which are representative of the intended operational environment,

b) have correction factors applied to the measured results in accordance with manufacturers' specifications in order to reflect the intended operating environment, or

c) be documented as being performed under non-representative conditions.

5.3.5 Treatment of marginal test results

Marginal results may be treated in a number of ways including

a) verification of the normalisation of the test system,

b) acceptance of all marginal results,

c) repetition of the measurement using a test system with improved measurement uncertainty.

Further guidance for the treatment of marginal results is found in ISO/IEC 14763-2.

5.4 Documentation

The documentation for each parameter shall include

a) identification and details of the parameter,

b) whether channel or permanent link is being tested,

c) test equipment:

   1) type and manufacturer;

   2) serial number and calibration status;

   3) nominal wavelength,

d) ~~optical fibre details (fibre core size/MFD, fibre type e.g. OM1, OM2, OM3, OS1)~~, optical fibre cabling details (fibre core size/MFD; fibre type, e.g. A1a, A1b, A1a.2, B1.1, B1.3)

e) details of the cabling connector type(s),

f) the configuration of the cabling test equipment during the test,

g) the measured result,

h) the applicable requirements,

i) details of the reference numbers and direction of test,

j) the date of the test (the time may also be recorded),

k) the test operator,

l) the calculated measurement uncertainty of the test system.

6 Test equipment

6.1 LSPM

6.1.1 General

Derived from IEC 61280-4-1, IEC 61280-4-2 and IEC 61300-3-4, the following has been adapted to the requirements of ISO/IEC 11801 for link and channel attenuation measurements with an LSPM.

6.1.2 Light sources

Light sources for testing multimode optical fibre (MMF) cabling and components shall conform to the spectral characteristics of Table 1.

Table 1 – MMF light source characteristics

Centre wavelength nm
850 ± 30
1 300 ± 30

Light sources for testing single-mode optical fibre (SMF) shall conform to the spectral characteristics of Table 2.

Table 2 – SMF light source characteristics

Centre wavelength nm
1 310 ± 30
1 550 ± 30

6.1.3 Power meters

The equipment shall be capable of measuring relative or absolute optical power (such as an optical power meter) and shall be designed in such a way as to make power measurements independent of modal distribution. The equipment shall enable optical power measurements to be recorded to at least one significant digit in the decimal place (for example, –14,3 dBm, 10,1 mW).

When the test set-up (LSPM) is used for a link or channel attenuation, the measurement uncertainty shall not be greater than ±0,02 dB.

When the test set-up (LSPM) is used for a field check of the reference connectors by measuring the attenuation, the measurement uncertainty should be <0,02 dB.

NOTE It is therefore recommended to use a power meter with a power resolution of at least 2 decimal places.

If the power meter consists of an optoelectronic detector with a demountable adapter then the adapter shall be fitted to the meter in accordance with the instructions provided by the supplier of the power meter.

6.1.4 Test system stability

The stability of the light source contributes directly to measurement variability. A light source shall be used in such a way that any variation in output power from the normalised values (see 5.2) shall be as specified in ISO/IEC 14763-2.

A power meter with adequate equipment temperature stability and optical power linearity to meet the desired measurement uncertainty shall be used.

NOTE Non-linearity between the measured and incident optical power may cause measurement errors. Also, equipment with internal waveguides may exhibit measurement variability with varying modal conditions.

6.2 OTDR

6.2.1 General

OTDR equipment for testing multimode optical fibre (MMF) cabling and components shall conform to the central wavelengths of Table 1.

OTDR equipment for testing single-mode optical fibre (SMF) shall conform to the central wavelengths of Table 2.

See Annex C for further information on optical fibre time domain reflectometry.

6.2.2 OTDR characterization using a launch cord only

Characterization of cabling using an OTDR with a launch cord only

- produces a characterization of the form shown in Figure 3,

  NOTE There may not be a remote interface reflection if the far end of the optical fibre is broken or terminated with an angled interface.

  – SMF may not produce a remote interface reflection if the optical fibre is broken,
  – APC connectors may not produce a discernable reflective event,
- does not provide any continuity measurement for the cabling under test,
- provides information about the general quality of the local interface to the cabling under test, the quality of the installed cable and any embedded joints within the cabling under test,
- does not allow any quantitative measurement of the local interface to the cabling under test unless the scattering characteristics of the optical fibre within the launch cord are the same as those of the optical fibre under test,
- does not allow any quantitative measurement of embedded connecting hardware joints within the cabling under test unless the scattering characteristics of the optical fibres on either side of the embedded connecting hardware are identical or unless measurements are taken in each direction,
- cannot be used for measurement of the channel or link (see 8.1) attenuation/insertion loss as it does not provide optical attenuation measurement for the remote connector and therefore cannot provide an optical attenuation measurement for the channel or permanent link under test.

6.2.3 OTDR characterization using a launch cord and a tail cord

Characterization of cabling using an OTDR using a launch cord and a tail cord

- produces an unidirectional characterization of the form shown in Figure 4 (two traces need to be combined and evaluated),
- provides a continuity measurement for the cabling under test,
- provides information about the general quality of both the local and remote interface to the cabling under test, the quality of the installed cable and any embedded connecting hardware,
- provides quantitative measurement of the local and remote interfaces to the cabling under test using measurements taken in each direction,
- provides quantitative measurement of the channel or link (see 8.1) attenuation when the measurement is taken in one direction provided that

- the channel or link only contains a single fixed cable and terminating connectors,
- the scattering characteristics of the optical fibre within the launch and tail cords are the same,

• provides quantitative attenuation measurement of the channel, or link embedded connecting hardware (see 8.1) 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 ODTR.

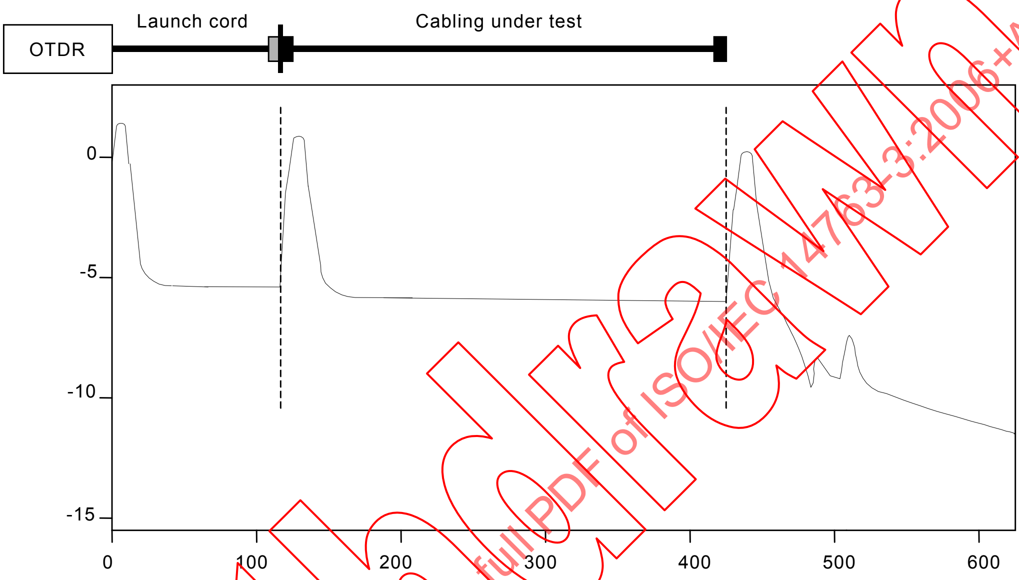


Figure 3 – OTDR characterization using a launch cord only

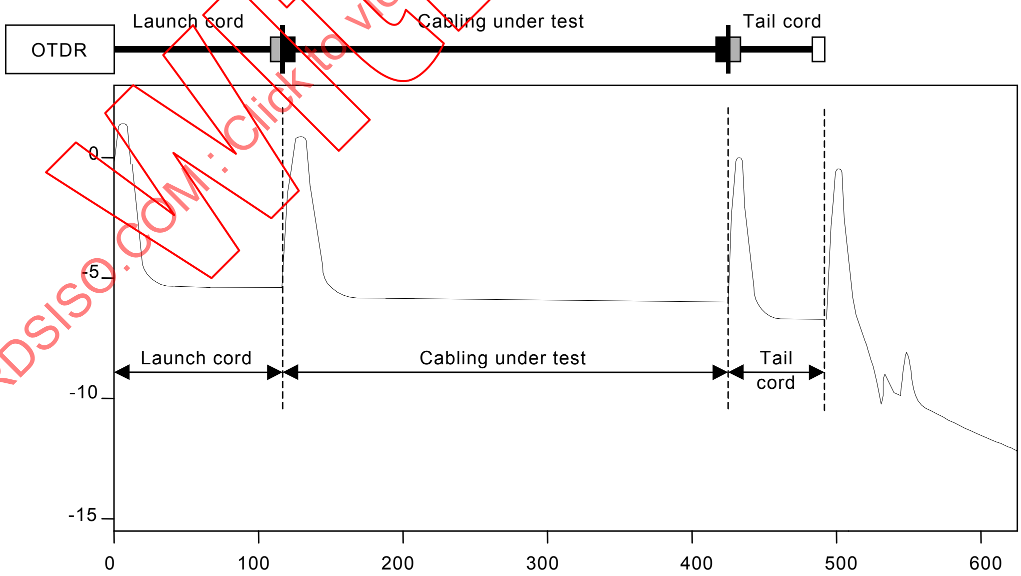


Figure 4 – OTDR characterization using a launch cord and a tail cord

6.3 Cabling interface adapters

6.3.1 Connecting hardware at test interfaces

The connecting hardware to be connected to the cabling under test (i.e. launch cords and tail cords) together with the hardware that terminates the field calibration cords and any connecting hardware adapters used as part of the test methods specified by this international Standard shall

- have the same product specification as the hardware terminating the cabling under test,
- have a controlled end face for radius, dome offset and fibre position,
  - for the duplex SC connector for MMF as specified in IEC 60874-19-1,
  - for the simplex SC connector for SMF as specified in IEC 60874-14-2,
- be of the same product as defined by the supplier where IEC specifications do not guarantee interoperability (the only interfaces specified to be interoperable are IEC 60874-14 and IEC 60874-19),
- where used, connecting hardware adapters shall be reference adapters in accordance with the relevant IEC product specification,
  - for SC MMF (duplex) as specified in IEC 60874-19-2,
  - for SC SMF (simplex) as specified in IEC 60874-14-3.

The inspection and testing of test cords and connecting hardware adapters shall be done in accordance with Annex D prior to any normalisation process being undertaken.

6.3.2 Reference connector requirements

The requirements for multimode SC reference connectors are given in IEC 60874-14-1. The requirements for single-mode SC reference connectors are given in IEC 60874-14-2.

The requirements for reference connectors of other (non-SC) cylindrical and rectangular styles are given in Table 3.

Table 3 – Non-SC reference connector requirements

	Cylindrical connector styles		Rectangular connector styles	
	MMF	SMF	MMF	SMF
Eccentricity of core centre to ferrule outer diameter	<1 µm	<0,3 µm	na	na
True position of the fibre core	na	na	<1 µm	<0,3 µm
Exit angle	≤0,2 °	≤0,2 °	≤0,2 °	≤0,2 °
Accuracy of ferrule diameter	±0,5 µm	±0,5 µm	na	na
Attenuation between 2 reference connectors	≤0,10 dB	≤0,20 dB	≤0,10 dB	≤0,20 dB

When the test set-up (LSPM) is also used for a link or channel attenuation the measurement uncertainty should be <0,2 dB.

When the test set-up (LSPM) is used for a field check of the reference connectors by measuring the attenuation, the measurement uncertainty should be <0,02 dB.

NOTE It is therefore recommended to use a power meter with a power resolution of at least 2 decimal places.

6.3.3 MMF test cords

6.3.3.1 General

Each test cord shall

- contain optical fibre of the same nominal characteristics (core/cladding diameters, numerical aperture) as the optical fibre under test,
- be labelled by having a unique identifier with each connector labelled as indicated in Figure 5.

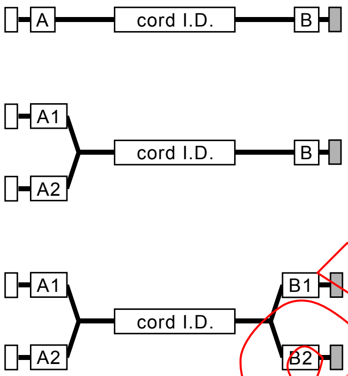


Figure 5 – Test cord labeling and identification

6.3.3.2 LSPM launch cord

The launch cord shall be

- between 1 m and 5 m in length,
- 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 compatible with the interface to the installed cabling.

If the light source is not known to provide the specified launched modal distribution (see 6.4) then the launch cord shall contain a mandrel or other mode-conditioning devices to ensure that the specified launched modal distribution is maintained.

6.3.3.3 LSPM tail cord

The tail cord shall be

- between 1 m and 5 m,
- terminated at one end with one or more connectors suitable for attachment to the power meter,
- terminated at the other end with one or more reference connectors compatible with the interface to the installed cabling.

6.3.3.4 LSPM combination launch/tail cord

A duplex launch/tail cord shall be

- between 1 m and 5 m in length,
- terminated at one end with one or more connectors suitable for attachment to the LSPM equipment,

- terminated at the other end with one or more reference connectors compatible with the interface to the installed cabling.

6.3.3.5 LSPM field calibration cord

The field calibration cord shall

- not exceed 2 m in length,
- be terminated at both ends with reference connectors compatible with the interfaces to the installed cabling.

6.3.3.6 OTDR launch cord

The OTDR shall provide the specified launch modal distribution (see 6.4).

The launch cord shall be

- longer than the attenuation dead zone of the OTDR (see Annex C for further details),
- long enough for a reliable straight-line fit to be made to the backscatter trace following the dead zone (C1 to C2 in Figure 11) so that reliable insertion loss measurements may be carried out. For example, in multimode fibre installations the length of the launch cord should be at least 75 m,
- terminated at one end with one or more connectors suitable for attachment to the OTDR,
- terminated at the other end with one or more reference connectors compatible with the interface to the installed cabling.

The length of optical fibres used to create test cords often requires that they be protected within a closure (see Figure 6) which may also include any launched modal distribution devices.

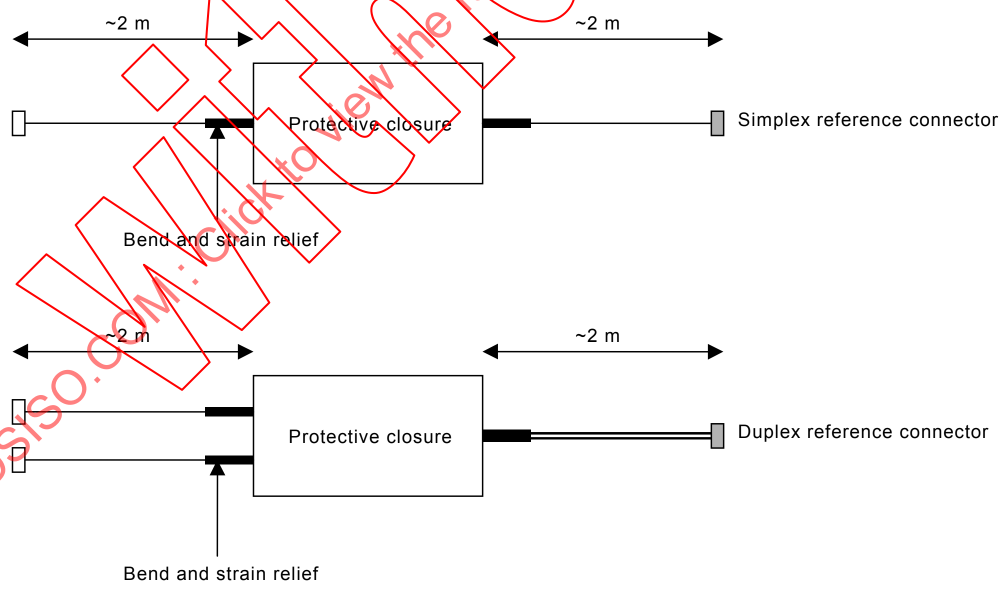


Figure 6 – OTDR launch cord schematic

Where the interface to the cabling or component under test is duplex, the launch cord shall contain two optical fibres enabling the testing of both optical fibres by switching the OTDR connections rather than re-connecting cords at the interface under test. The OTDR connections shall be uniquely identified with markers as shown in Figure 5.

6.3.3.7 OTDR tail cord

The tail cord shall be

- of a different length than the corresponding launch cord (but longer than the attenuation dead zone of the OTDR, see Annex C for further details),
- long enough for a reliable straight-line fit to be made to the backscatter trace following the dead zone (C3 to C4 in Figure 11), so that reliable insertion loss measurements may be made). For example, in multimode installations the length of the tail cord should be at least 75 m,
- terminated at one end with one or more reference connectors compatible with the interface to the installed cabling.

The termination of the other end(s) is optional.

The length of optical fibres used to create test cords often requires that they be protected within a closure (see Figure 6).

Where the interface to the cabling or component under test is duplex, the two optical fibres shall both be shorter than the corresponding launch cord (but longer than the attenuation dead zone of the OTDR) but shall be of different lengths in order to determine the maintenance of polarity in the cabling under test.

6.3.4 SMF test cords

6.3.4.1 General

Each test cord shall

- contain optical fibre of the same nominal characteristics (mode field and cladding diameters) as the optical fibre under test,
- be labelled with a unique identifier with each connector labelled as indicated in Figure 5.

6.3.4.2 LSPM launch cord

The launch cord shall be

- between 1 m and 5 m in length,
- 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 single-mode reference connectors compatible with the interface to the installed cabling.

6.3.4.3 LSPM tail cord

The tail cord shall be

- between 1 m and 5 m in length,
- 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 single-mode reference connectors compatible with the interface to the installed cabling.

6.3.4.4 LSPM combination launch/tail cord

A duplex launch/tail cord shall be

- between 1 m and 5 m in length,

- terminated at one end with one or more connectors suitable for attachment to the LSPM equipment,
- terminated at the other end with one or more single-mode reference connectors compatible with the interface to the installed cabling.

6.3.4.5 LSPM field calibration cord

The field calibration cord shall

- not exceed 2 m in length,
- each end shall be terminated with single-mode reference connectors compatible with the interfaces to the installed cabling.

6.3.4.6 OTDR launch cord

The launch cord shall be

- longer than the attenuation dead zone of the OTDR,
- long enough for a reliable straight-line fit to be made to the backscatter trace following the dead zone (C1 to C2 in Figure 11), so that reliable insertion loss measurements may be carried out. For example, in single-mode installations the length of the launch cord should be at least 150 m,
- terminated at one end with one or more connectors suitable for attachment to the OTDR, see Annex C for further details,
- terminated at the other end with one or more single-mode reference connectors compatible with the interface to the installed cabling.

The length of optical fibres used to create test cords often requires that they be protected within a closure (see Figure 6).

Where the interface to the cabling or component under test is duplex, the launch cord shall contain two optical fibres enabling the testing of both optical fibres by switching the OTDR connections rather than re-connecting cords at the interface under test. The OTDR connections shall be uniquely identified as shown in Figure 5.

6.3.4.7 OTDR tail cord

The tail cord shall be

- of a different length than the corresponding launch cord (but longer than the attenuation dead zone of the OTDR, see Annex C for further details),
- long enough for a reliable straight-line fit to be made to the backscatter trace following the dead zone (C3 to C4 in Figure 11), so that reliable insertion loss measurements may be carried out. For example, in single-mode installations the length of the tail cord should be at least 150 m,
- terminated at one end with one or more reference connectors compatible with the interface to the installed cabling.

The termination of the other end(s) is optional.

The length of optical fibres used to create test cords often requires that they be protected within a closure (see Figure 6).

Where the interface to the cabling or component under test is duplex, the two optical fibres shall both be shorter than the corresponding launch cord (but longer than the attenuation dead zone of the OTDR), but shall be of different lengths in order to determine the maintenance of polarity in the cabling under test.

6.4 MMF launched modal distribution (LMD)

The LMD at the point of connection to the cabling under test shall be as defined in Annex A.

This required LMD shall be achieved by the use of the appropriate light source or by incorporating a mode conditioning device within the launch cord.

6.5 SMF launched modal distribution (LMD)

The provision of a single-mode launch condition requires that launch cords contain a minimum of two single air-coiled turns or mandrel wraps of 35 mm to 50 mm in diameter.

7 Inspection equipment

7.1 Connecting hardware end-face

7.1.1 General

Microscopes used for the inspection of connector end-faces shall have a minimum capability of ×100 magnification for MMF and ×200 magnification for SMF, as shown in Table B.2.

The microscope shall be fitted with suitable fixtures that retains the connector in a stable position thereby allowing careful inspection.

7.1.2 Optical, direct vision microscope

The microscope shall be fitted with suitable infra-red filter mechanisms to prevent accidental eye damage. This is particularly important during the inspection of installed connector end-faces where the remote end is not under the control of the inspector.

7.1.3 CCD microscope

See IEC 61300-3-35.

8 Cabling under test

8.1 Channels and permanent links

8.1.1 General

Although permanent links are referred to in this clause, ISO/IEC 11801 has defined requirements for generic links that can be tested according to this standard.

8.1.2 Reference planes

ISO/IEC 11801 and equivalent standards define transmission limits for channels and permanent links for which the representative reference planes are shown in Figure 7.

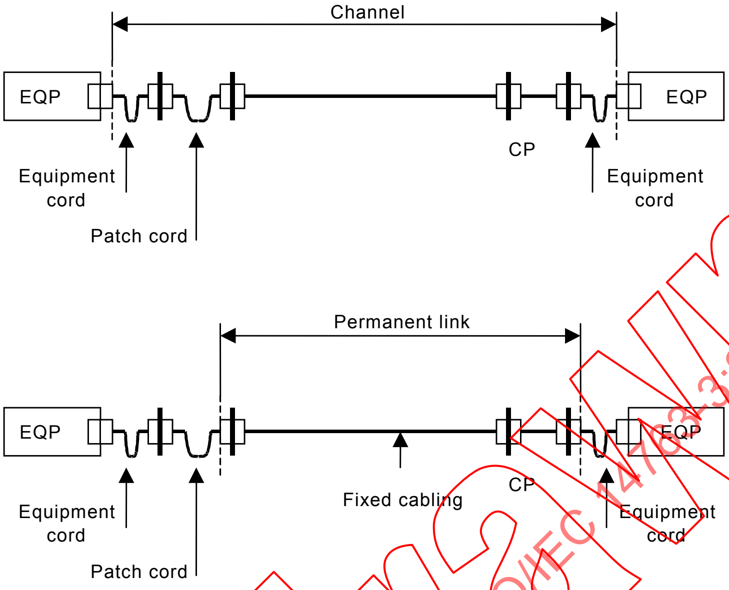
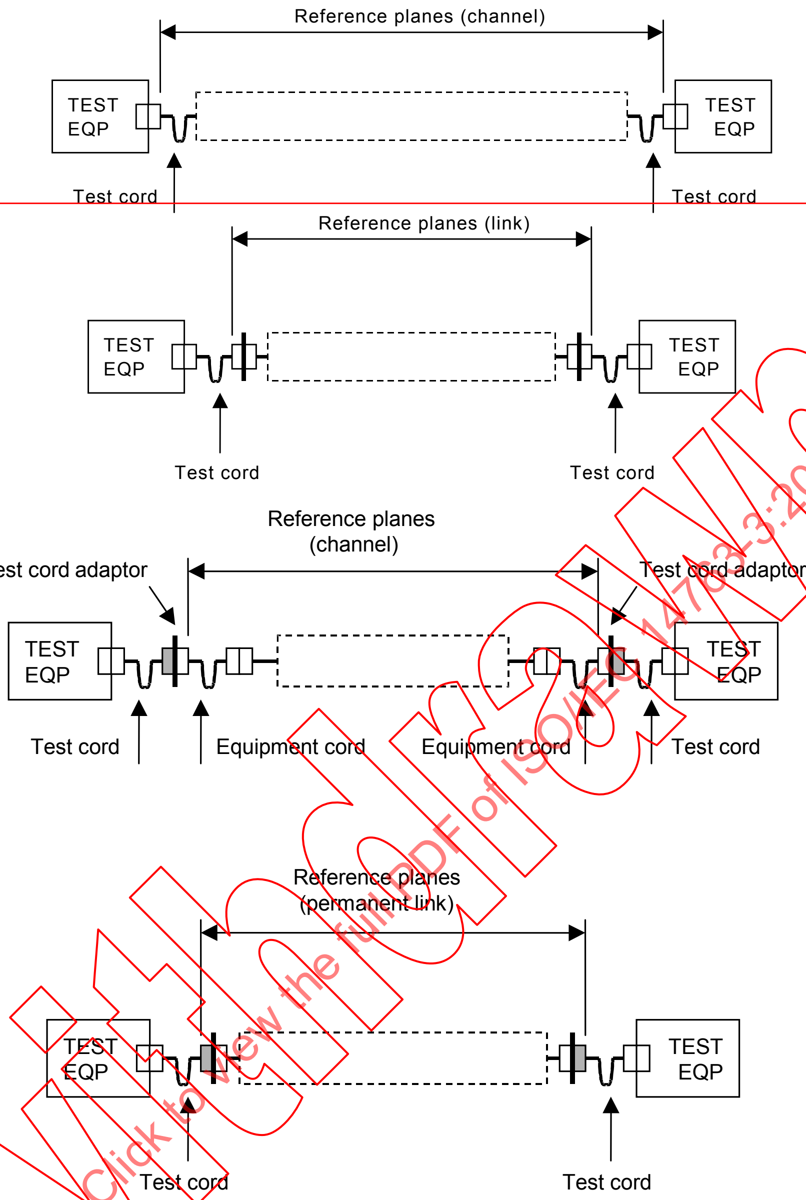


Figure 7 – Channels and permanent links in accordance with ISO/IEC 11801 and equivalent standards

The accuracy of a test system established to measure the optical characteristics of a channel and/or a permanent link is defined at its reference plane.

~~The test configuration reference plane at each end of a channel is within the equipment cable next to, but excluding, the connection of the equipment cable into the test equipment (see Figure 8). The test configuration reference plane of a permanent link is within the test cord cable next to, and including, the test cord connection which mates to the termination point of the permanent link under test (see Figure 8).~~

The test configuration reference planes of a channel are within the equipment cords next to, but excluding, the connections of the equipment cords into the test cords (see Figure 8). The test configuration reference planes of a permanent link are within the test cords next to, and including, the test cord connections which mate to the termination points of the permanent link under test (see Figure 8).



NOTE The dotted area contains cable and may contain splices and additional connections.

Figure 8 – Channel and permanent link test configuration

It should be noted that

- optical fibre and connector hardware conditions at the interface between the test cords and a permanent link under test produce variations in measured results,
- for short lengths ~~this variable factor~~ these variations may be significant in comparison with the value being measured. This defines a minimum length limit below which attenuation cannot be measured accurately,
- to reproduce a given measurement it is necessary to reproduce the test conditions including the configuration of the test cords used. Changing the test set-up may produce inconsistent results,
- the optical signal loss of end connectors (one half of the mated pair at each end) is not taken into account in ISO/IEC 11801.

8.1.3 Wavelength of measurement

In order to comply with the requirements of ISO/IEC 11801 and equivalent standards and unless otherwise agreed, the measurements of transmission performance (attenuation/ insertion loss and return loss) detailed in clauses 9 and 10 shall be carried out at the following nominal wavelengths:

- for MMF, 850 nm and 1 300 nm (see Table 1);
- for SMF, 1 310 nm and 1 550 nm (see Table 2).

8.1.4 Direction of measurement

The methods detailed in clauses 9 and 10 specify the requirements for uni-directional or bi-directional measurement. For compliance testing of a channel or link composed of known and unknown components bi-directional testing shall be conducted.

9 Testing of installed cabling

9.1 Attenuation/insertion loss

9.1.1 LSPM

9.1.1.1 General

Derived from IEC 61280-4-1, IEC 61280-4-2 and IEC 61300-3-4, the following has been adapted specifically in support of ISO/IEC 11801 for link and channel attenuation measurements with a LSPM.

9.1.1.2 Test method

The default test method for attenuation measurement of links and channels for this standard is the ~~3-jumper~~ three test cord reference method as shown in Figure 9. More information on this test method and the rationale for its use is given in Annex A.

For link measurements an alternative method may be used. This method is called the ~~1-jumper~~ one test cord reference method, as shown in Figure 10. This method may only be used for simplex connecting hardware (or connecting hardware that can be tested as such) on the cabling under test and when the connector in the link is the same interface as the connector on the power meter.

For MMF, the normalisation process requires a reference measurement as shown in Figure 9 to be made between the light source and power meter by the connection of

- a launch cord in accordance with 6.3.3.2 (or 6.3.3.4),
- a field calibration cord in accordance with 6.3.3.5,
- a tail cord in accordance with 6.3.3.3 (or 6.3.3.4).

For SMF, the normalisation process requires a reference measurement, as shown in Figure 9, to be made between the light source and power meter by the connection of

- a launch cord in accordance with 6.3.4.2 (or 6.3.4.4),
- a field calibration cord in accordance with 6.3.4.5,
- a tail cord in accordance with 6.3.4.3 (or 6.3.4.4).

The reference measurement, P_0, shall be recorded in watts or ~~decibel metres~~ dBm.

The reference measurement uses two connecting hardware adapters in accordance with 6.3.1. Following the reference measurement, P_0 (dB), the field calibration cord shall be removed. If the cabling under test is a channel as defined in 8.1, these adapters shall remain connected to the launch and tail cords. If the cabling under test is a permanent link as defined in 8.1, these adapters shall remain connected to the field calibration cord.

Reference power measurements shall be repeated periodically as necessary. Situations requiring the re-establishment of reference conditions include optical power changes, temperature fluctuations, a move to a different location, powering off and field calibration cord or adapter replacement due to degradation. Sufficient time should be given for stabilization of laser sources during any repeated reference power measurement.

The launch cord and tail cord shall remain connected to the light source and power meter respectively.

The cabling under test shall be connected between the launch and tails cords and the test measurement, P_1, shall be recorded in watts or ~~decibel metres~~ dBm.

For permanent links comprising a single fixed cable and terminating connectors it is required to test in one direction only.

Where the permanent link or channel is of more complex construction, or where there is a risk that components within the cabling under test cause differences in the attenuation depending on the direction of transmission, bi-directional measurements shall be carried out.

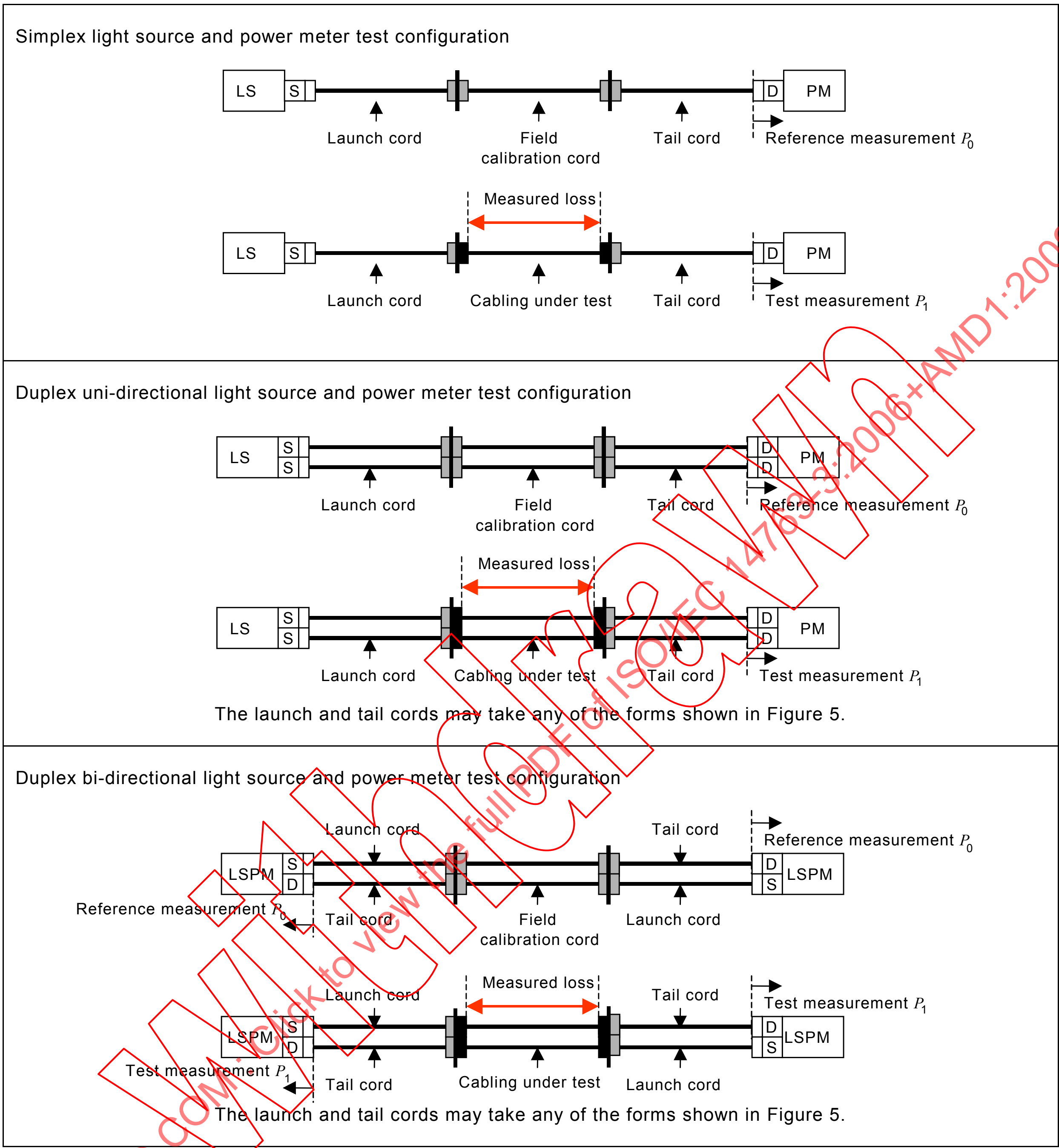


Figure 9 – ~~LSPM 3-jumper~~ SSPM three test cord attenuation measurement of installed cabling

Simplex light source and power meter test configuration

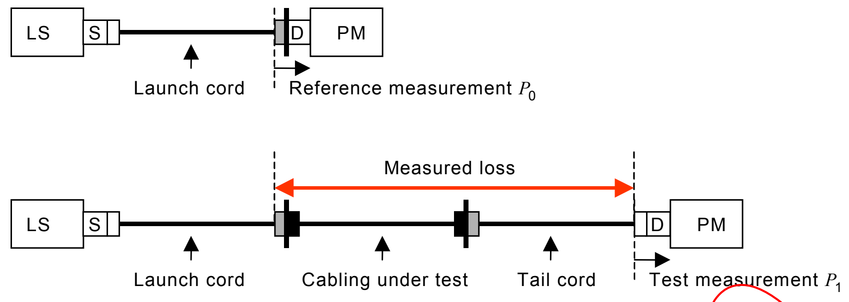


Figure 10 – ~~LSPM 1-jumper~~ SSPM one test cord attenuation measurement of installed ~~link~~ cabling

9.1.1.3 Test result

For a given wavelength and in a given direction, measured loss is calculated using P_0 and P_1 as follows:

$$L = P_0 - P_1 \quad \text{(dB)} \qquad (1)$$

where P_1 and P_0 are expressed in ~~decibel metre~~ dBm.

If P_1 and P_0 are expressed in W, then the measured loss can be calculated as follows:

$$L = -10\log_{10}\left(\frac{P_1}{P_0}\right) \quad \text{(dB)} \qquad (2)$$

For example, if the reference power level P_0 is −20 dBm (0,01 mW) and the measured power level P_1 is −23 dBm (0,005 mW) then the loss is 3 dB.

In the case of bi-directional results the higher of the two measured results shall be considered as the overall measured result.

9.1.1.4 Test system measurement uncertainty

The measured attenuation/insertion loss of a channel or permanent link is effected by the alignment of the two optical fibres on either side of the test interfaces. The test method of 9.1.1.2 replaces the field calibration cord with the cabling under test and introduces an unavoidable measurement uncertainty that is twice that of the worst case variation for a single connection.

The use of test cords with reference connectors as required by this International Standard provides a reduced variation and as a result a more accurate result.

In order to determine measurement uncertainty, the following information shall be given for the connectors terminating the cabling under test:

- for MMF, the worst case insertion loss of a MMF connection against a multimode reference termination;
- for SMF, the worst case insertion loss of a SMF connection against a single-mode reference termination.

Normative values for connecting hardware in accordance with ISO/IEC 11801 are stated in Table 4.

Table 4 – Connecting hardware insertion loss

	MMF		SMF	
Connecting hardware	Insertion loss (random mated)	Insertion loss (mated against reference)	Insertion loss (random mated)	Insertion loss (mated against reference)
IEC 60874-19-1	0,75 dB max.	0,3 dB max.		
IEC 60874-14-2			0,75 dB max.	0,5 dB max.

6.3.2 and Table 3 define requirements for the maximum insertion loss of a connection of two reference terminations.

9.1.1.5 Treatment of channel test results

The use of reference terminations on the test cords affects the calculation of limits of testing for channel attenuation. The referencing procedure involves the interconnection of reference terminations in accordance with Table 2. The measurement of the channel includes connection of the test cords to non-reference terminations, which for ISO/IEC 11801 compliant connecting hardware, are specified in Table 4.

Using the default three test cord reference method specified in 9.1.1.2, the limit of testing for channel attenuation is

- for MMF: Limit = 0,4 dB + Σ (cable attenuation) + Σ (embedded connection attenuation);
- for SMF: Limit = 0,6 dB + Σ (cable attenuation) + Σ (embedded connection attenuation).

NOTE Where the performance of the interfaces to the cabling under test is not in accordance with ISO/IEC 11801, information should be sought from the manufacturers of the interfaces to determine the relevant information for Table 3 and Table 4. The general formula for the value = 2 × {(reference/embedded) − (reference/reference)}.

Examples of these calculations are shown in Annex G.

Where compliance with a specified value is required the measured result shall be termed a pass, a fail or a marginal result.

9.1.1.6 Treatment of permanent link test results

~~The use of a single test method as defined in 9.1.1.2 which excludes the permanent link connections requires the permanent link limits to be modified, as detailed in 9.1.1.6.~~

~~Comparison of the measured loss in Figure 9 and the permanent link reference planes in 8.1 shows that the attenuation/insertion loss limit defined for the permanent link in ISO/IEC 11801 or equivalent standards shall be the sum of the specified maximum attenuation values for the~~

- ~~connections at the interfaces to the cabling under test, with a maximum allowance as specified when mated to a reference connector,~~
- ~~embedded connections within the cabling under test,~~
- ~~cable(s) within the cabling under test (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).~~

The use of reference terminations on the test cords affects the calculation of limits of testing for permanent link attenuation. The referencing procedure involves the interconnection of reference terminations in accordance with Table 2. The measurement of the channel includes connection of the test cords to non-reference terminations, which for ISO/IEC 11801 compliant connecting hardware, are specified in Table 3.

Using the default three test cord reference method specified in 9.1.1.2, the limit of testing for permanent link attenuation is

- for MMF: Limit = 0,4 dB + Σ (cable attenuation) + Σ (embedded connection attenuation);
- for SMF: Limit = 0,6 dB + Σ (cable attenuation) + Σ (embedded connection attenuation).

NOTE 1 Where the performance of the interfaces to the cabling under test is not in accordance with ISO/IEC 11801, information should be sought from the manufacturers of the interfaces to determine the relevant information for Tables 3 and 4. The general formula for the value = 2 × {(reference/random) – (reference/reference)}.

Using the alternative one test cord reference method specified in 9.1.12, the limit for testing for permanent link attenuation is

- for MMF: Limit = 0,6 dB + Σ (cable attenuation) + Σ (embedded connection attenuation);
- for SMF: Limit = 1,0 dB + Σ (cable attenuation) + Σ (embedded connection attenuation).

NOTE 2 Where the performance of the interfaces to the cabling under test is not in accordance with ISO/IEC 11801, then information should be sought from the manufacturers of the interfaces to determine the relevant information for Table 4. The general formula for the value = 2 × (reference/embedded).

Examples of these calculations are shown in Annex G.

Where compliance with a specified value is required the measured result shall be termed a pass, a fail or a marginal result.

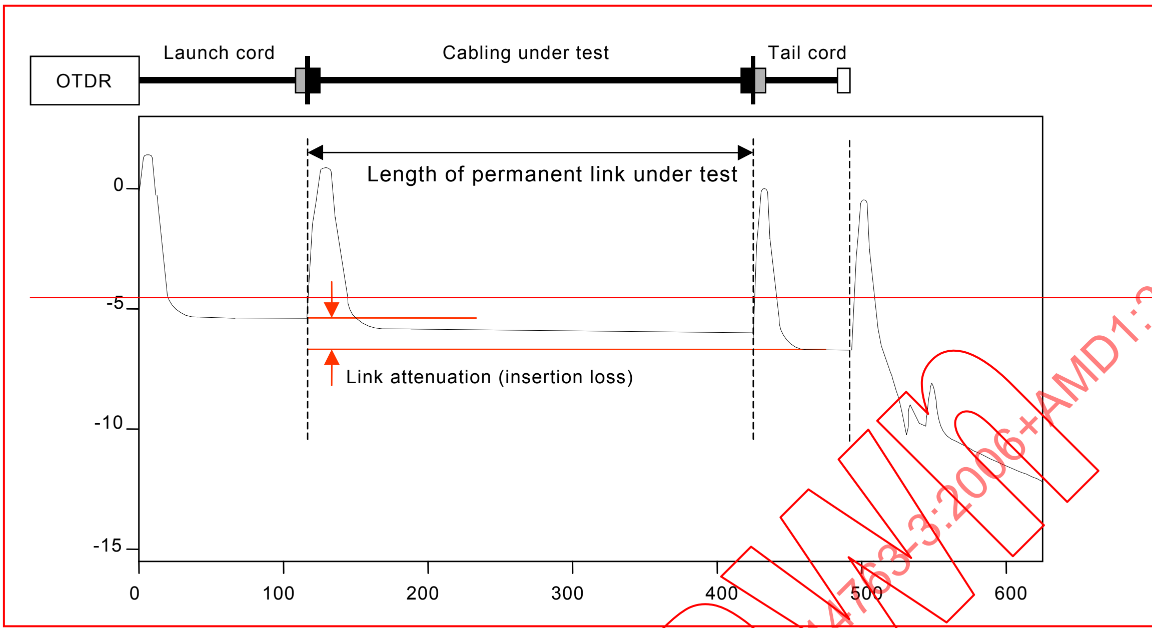
9.1.2 OTDR

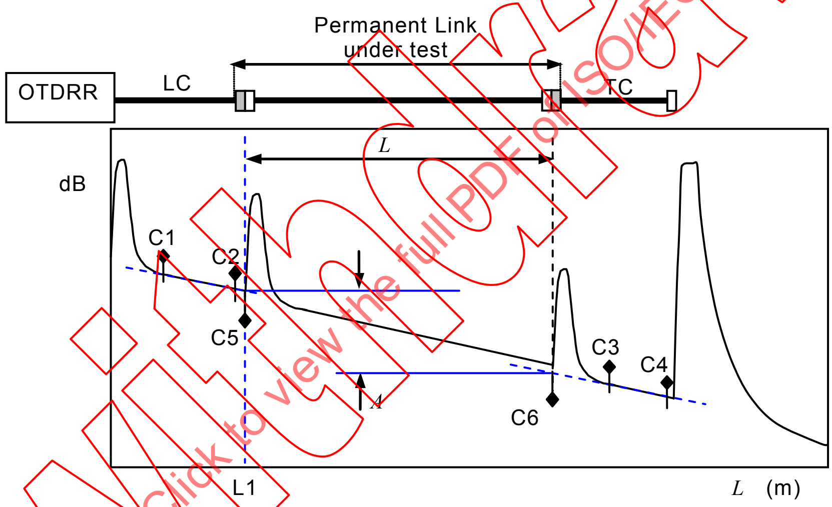
9.1.2.1 Test method

A launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test. A tail cord in accordance with 6.3.3.7 (MMF) or 6.3.4.7 (SMF) shall be connected to the remote end of the cabling under test.

The OTDR/optical source shall be selected for the mode/wavelength as defined in Annex C and the appropriate settings established ~~for hockey as it is its assistance in his~~:

- range;
- pulse width;
- IOR;
- averaging time.

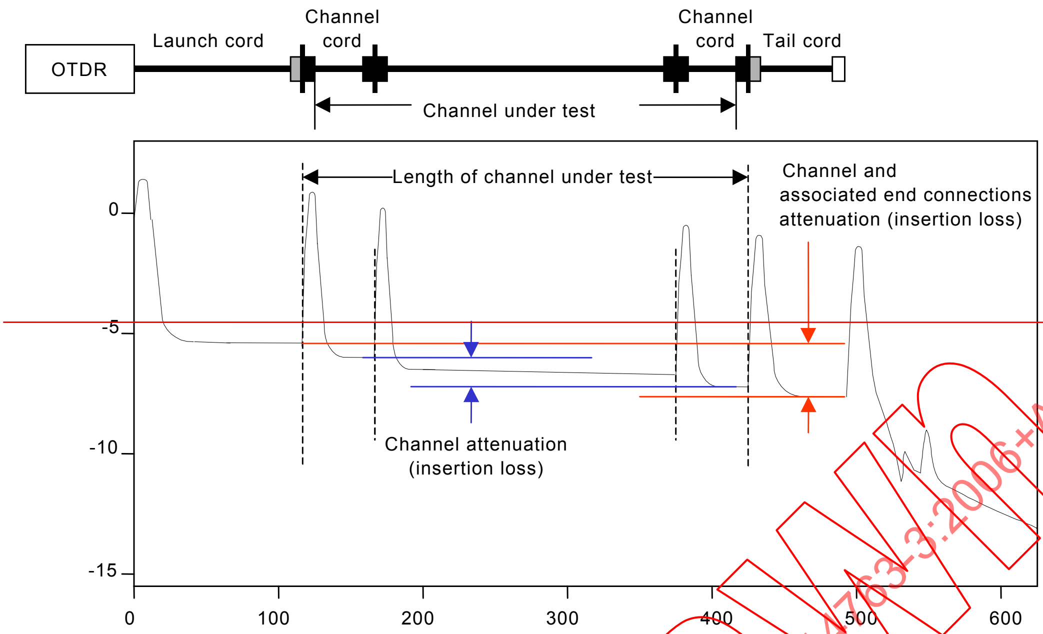


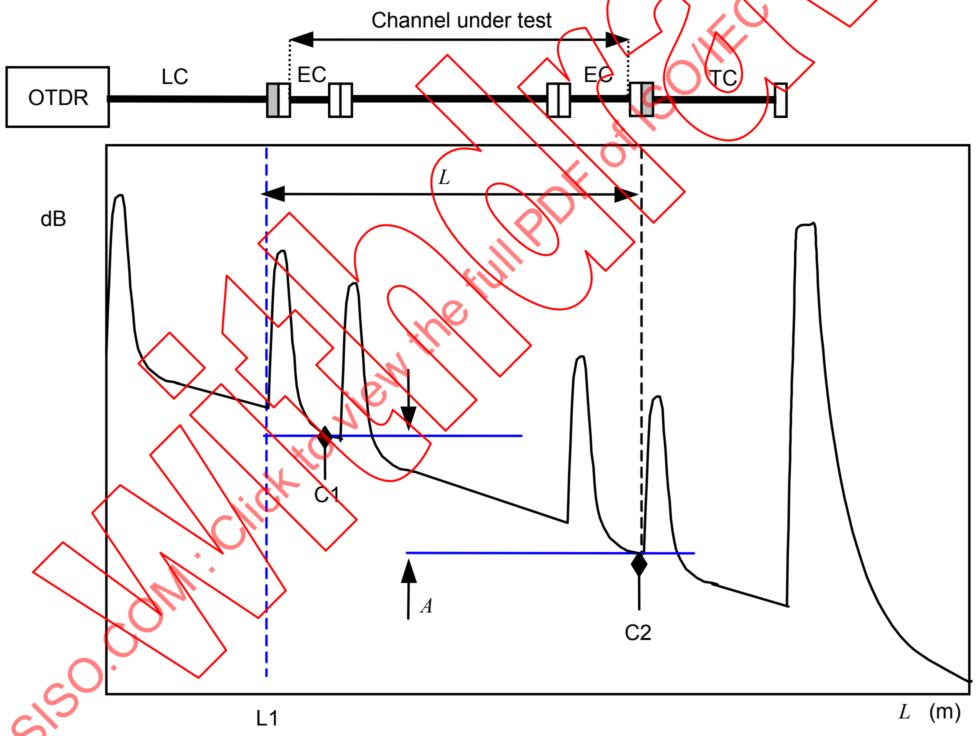


Key

LC	Launch cord
TC	Tail cord
C1, C2, C3, C4	Cursors for linear regression definition
C5, C6	Cursors at attenuation location
A	Attenuation/Insertion loss of permanent link
L	Length of permanent link

Figure 11 – OTDR measurement of installed cabling (permanent link)

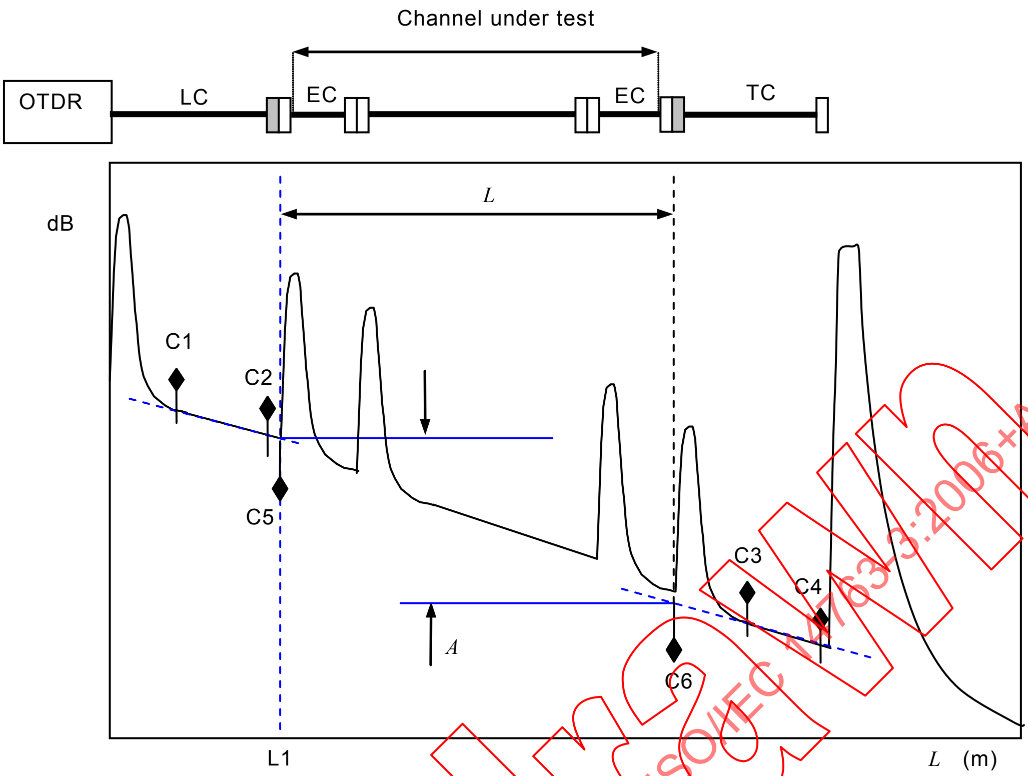




Key

LC	Launch cord
TC	Tail cord
EC	Equipment cord
C1, C2	Cursors for 2-point channel insertion loss/attenuation measurement
A	Attenuation/Insertion loss of channel plus equipment connectors
L	Length of channel

Figure 12a – Alternative a



Key

LC	Launch cord
TC	Tail cord
EC	Equipment cord
C1, C2, C3, C4	Cursors for linear regression definition
C5, C6	Cursors at attenuation location
A	Attenuation/Insertion loss of channel plus equipment connectors
L	Length of channel

Figure 12b – Alternative b

Figure 12 – OTDR measurement of installed cabling (channel)

9.1.2.2 Test system measurement uncertainty

The measured attenuation/insertion loss of a channel or permanent link to this is effected by the alignment of the two optical fibres on either side of the test interfaces.

The use of test cords with reference connectors as required by this standard provides a reduced variation and as a result a more accurate result.

In order to determine measurement uncertainty, the following information shall be given for the connectors terminating the cabling under test:

- for MMF, the worst case insertion loss of a MMF connection against a reference termination;
- for SMF, the worst case insertion loss of a SMF connection against a single-mode reference termination.

Normative values for connecting hardware in accordance with ISO/IEC 11801 are shown in Table 4.

9.1.2.3 Treatment of channel test results

~~Figure 12 shows the points at which the attenuation/insertion loss of the installed cabling shall be measured. It should be noted that if patch cord is shorter than attenuation dead zone, multiple events may not be individually discernable.~~

~~Where the channel contains short equipment cords at one or more ends it may be impossible to make a measurement since the connections of the cords to the permanent link will be disguised within the end interface reflections.~~

The attenuation/insertion loss of the installed cabling shall be measured either as shown in Figure 12a or as shown in Figure 12b.

Figure 12a shows the 2 points at which the attenuation/insertion loss of the installed cabling shall be measured. If the equipment cords are very short and/or the OTDR dead zone is long, then it may reduce the accuracy of the insertion loss measurement.

It should be noted that

- it is not possible to carry out the more accurate five point insertion loss measurement where two reflective events are in close proximity as there is unlikely to be sufficient length of optical fibre in the equipment connection cords to obtain a linear fit to these sections around C1 and C2;
- if the equipment connection cords are very short and/or the OTDR dead zone is long then it may not be possible to measure the channel attenuation.

Figure 12b shows the alternative approach where the attenuation of the channel is measured plus the insertion loss of the equipment connectors.

The result for channel attenuation/insertion loss is obtained by carrying out the measurement in both directions and calculating the mean of the two results. This is not necessary where the optical fibres of the cabling under test comprises a single length of fixed cabling with terminating connectors and where the optical fibre of the launch and tail cords have the same scattering characteristics.

Where compliance with a specified value is required the measured result shall be indicated as pass or fail.

9.1.2.4 Treatment of permanent link test results

Figure 11 shows the points at which the attenuation/insertion loss of the installed cabling shall be measured.

The result for permanent link attenuation/insertion loss is obtained by measuring in both directions and calculating the mean of the two results. This is not necessary where the cabling under test comprises a single length of fixed cabling with terminating connectors and where the optical fibres of the launch and tail cords have the same scattering characteristics.

Comparison of the measured loss in Figure 9 and the permanent link reference planes in 8.1 shows that the attenuation/insertion loss limit defined for the permanent link within ISO/IEC 11801 or equivalent standards shall be the sum of the specified maximum attenuation values for the

- attenuation/insertion loss (mated against reference) for the interface connections at the interfaces to the cabling under test,
- embedded connections within the cabling under test,
- cable(s) within the cabling under test (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

Where compliance with a specified value is required a pass or fail result should be indicated with reference to the measured result.

9.2 Propagation delay

9.2.1 Test method

Optical fibres shall be tested using equipment capable of measuring optical signal propagation in the time domain such as optical time domain reflectometers and certain types of optical power source/optical power meter equipment. This type of equipment also supplies calculations of length. ~~The propagation delay can be calculated using a typical delay of 5,0 ns/m.~~

Propagation delay may be calculated as follows:

Propagation delay T = optical fibre length $\times$ n/c

where

c = speed of light in a vacuum (3×10^8 ms^{-1})

n = group refractive index of the optical fibre

NOTE As n ~ 1,5 for all optical fibres the formula can be approximated to T = optical fibre length $\times$ 5 (ns).

9.2.2 Treatment of results

Where compliance with a specified value is required a pass or fail result should be indicated with reference to the measured result.

9.3 Length

9.3.1 Test method

The optical fibres should be tested using equipment capable of measuring propagation delay (i.e. an OTDR) (see 9.2.1).

9.3.2 Measurement uncertainty

The measured length of the transmission path contained within the cabling under test is the length of the optical fibre (assuming that the correct effective group IOR has been used) rather than the physical length of the cable. The optically measured length of an optical fibre may differ from the physical length of the cable. Within a given length of cable containing multiple optical fibres each individual optical fibre may have a different length.

The optical fibre length will always be equal to, or greater than that of the cable itself. The difference between the two lengths is dependent upon cable construction. The cable manufacturer should be consulted if specific information is required.

9.3.3 Treatment of results

The limits and restrictions indicated in 9.3.2 shall be included within the statement of measurement uncertainty.

Where compliance with a specified value is required a pass or fail result should be indicated with respect to the measured result.

NOTE The propagation velocity or the group refractive index, provided by the manufacturer of the optical fibre cable under test, is required by the test equipment in order to calculate optical fibre length. If another value is used because no value was indicated by the manufacturer (e.g. the verification of unknown cabling), the impact of any errors introduced should be recognised and agreed between the installer and the user.

10 Testing of cabling components within installed cabling

10.1 Attenuation/insertion loss (optical fibre cable)

10.1.1 Test method

In order to test a channel or permanent link (see 8.1), a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test.

In order to test an unterminated optical fibre, a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) but without a test interface connector shall be connected between the OTDR and the optical fibre under test.

The OTDR/optical source shall be selected for the mode/wavelength as defined in Annex C and the appropriate settings established for

- range,
- pulse width,
- IOR,
- averaging time.

This method may also be used to assess the uniformity of attenuation of cabled optical fibres in accordance with IEC 60793-2-10 (MMF) and IEC 60793-2-50 (SMF).

The cabling under test shall be measured in one direction.

10.1.2 Measurement uncertainty

The measurement shall be over a section of the optical fibre away from the attenuation dead zone of the OTDR (see Annex C) and shall not contain connecting hardware.

The attenuation coefficient is calculated by the OTDR by dividing the difference of backscattering power between any two points (the loss) by the distance between the two points. For short values of distance the calculation can produce huge uncertainties of the attenuation coefficient, even if the uncertainties of the loss are small.

For example, if the distance is 50 m, a loss uncertainty of ±0,05 dB leads to an attenuation coefficient uncertainty of ±1 dB/km. For this reason the attenuation coefficient should not be determined for short distances of fibre.

Alternatively, the attenuation coefficient can be calculated using a linear regression over the backscattering signal (LSA method).

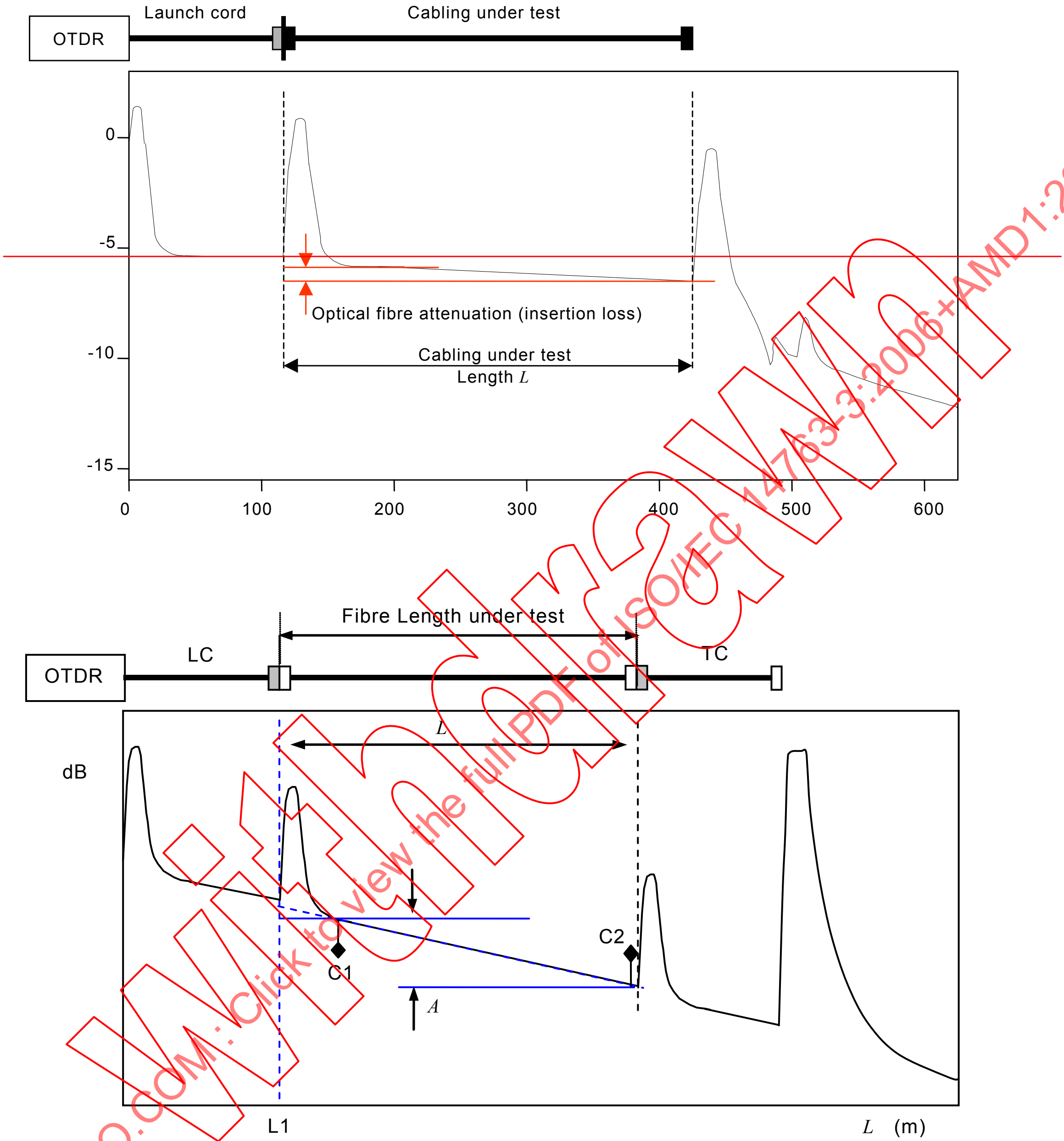
The minimum fibre lengths will differ for MMF and SMF measurements and for the operating wavelengths used. The OTDR manufacturer shall be consulted to determine their recommendations for the minimum fibre lengths over which the attenuation coefficient may be measured reliably.

10.1.3 Treatment of results

Figure 13 shows the points at which the attenuation/insertion loss of the optical fibre within the cabling under test shall be measured.

The result may be provided as a simple loss value (in decibel) or as an attenuation coefficient (in decibel per kilometre).

Where compliance with a specified value is required a pass, fail or marginal result should be indicated with respect to the measured result.



Key

LC	Launch cord
TC	Tail cord
C1, C2	Cursors for linear regression definition
A	Attenuation/Insertion loss of optical fibre
L	Length of optical fibre

Figure 13 – OTDR measurement of optical fibre attenuation

10.2 Attenuation/insertion loss (local and remote test interfaces)

10.2.1 Test method

A launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test. A tail cord in accordance with 6.3.3.7 (MMF) or 6.3.4.7 (SMF) shall be connected to the remote end of the cabling under test.

The OTDR/optical source shall be selected for the mode/wavelength as defined in Annex C and the appropriate settings established for

- range,
- pulse width,
- IOR,
- averaging time.

The cabling under test shall be measured in both directions.

10.2.2 Test system measurement uncertainty

The measured attenuation/insertion loss of a channel or permanent link depends upon the alignment of the two optical fibres on either side of the test interfaces.

The use of test cords with reference connectors as required by this international standard provides reduced variation thereby generating a more accurate result.

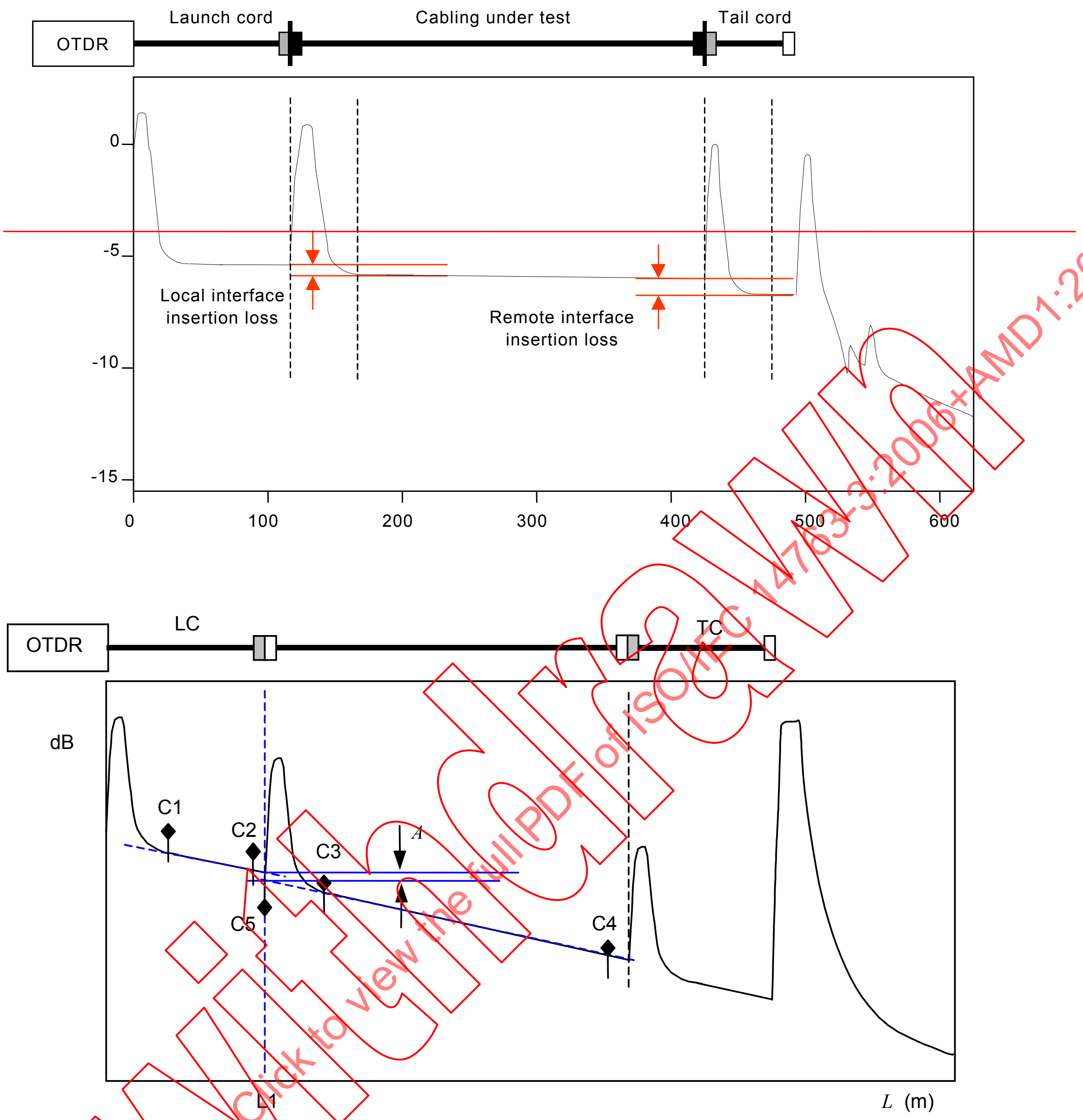
In order to determine measurement uncertainties, the following information shall be stated for the connectors terminating the cabling under test

- for MMF, the worst case insertion loss of a MMF connection against a multimode reference termination,
- for SMF, the worst case insertion loss of a SMF connection against a single-mode reference termination.

Normative values for connecting hardware in accordance with ISO/IEC 11801 are shown in Table 4.

10.2.3 Treatment of results

Figure 14 shows the points at which the attenuation/insertion loss of the interfaces to the cabling under test shall be measured. The installed cabling may be either a channel or a permanent link (see 8.1). However, where the channel contains short equipment cords at one or more ends, it may be impossible to make a measurement since the connections of the cords to the permanent link will be disguised within the end interface reflections.



Key

LC	Launch cord
TC	Tail cord
C1, C2, C3, C4	Cursors for linear regression definition
C5	Cursor at attenuation location
A	Attenuation/Insertion loss of measured connection

Figure 14 – OTDR measurement of ~~interface~~ connection insertion loss

The insertion loss of the local interface is shown as the interface loss (dB). However, this is not a true measurement since the backscatter coefficient (k) may be different in the launch cord and the cabling under test. If the backscatter coefficient of the launch cord is higher than that of the cabling under test then the result will be overstated. If the scattering coefficient of the cabling under test is higher than that of the launch cord then the result will be understated (sometimes, but very rarely, producing an apparent amplification).

For this reason the result shall be the mean of the measurements in each direction.

The limiting constraint for the interface shall be the maximum insertion loss (mated against reference). See Table 4.

Where compliance with a specified value is required the measured result shall additionally be termed a pass, a fail or a marginal result.

10.3 Insertion loss (connecting hardware)

10.3.1 Test method

In order to test a channel or permanent link (see 8.1), a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test.

In order to test connecting hardware within an unterminated optical fibre, a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) but without a test interface connector shall be connected between the OTDR and the optical fibre under test.

The OTDR/optical source shall be selected for the mode/wavelength as defined in Annex C and the appropriate settings established for

- range,
- pulse width,
- IOR,
- averaging time.

The cabling under test shall be measured in both directions.

10.3.2 Treatment of results

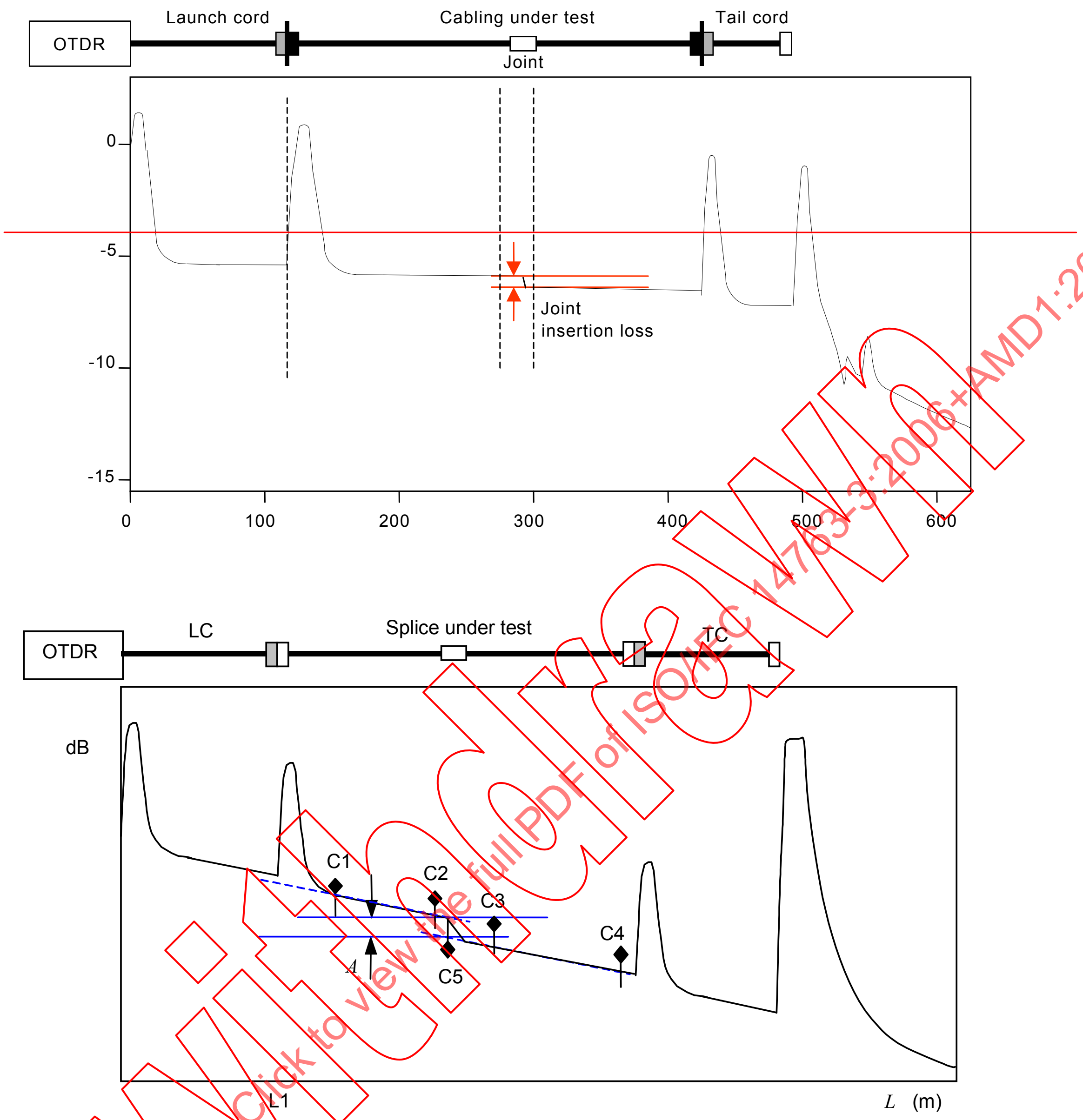
Figure 15 shows the points at which the insertion loss of connecting hardware within the cabling under test shall be measured.

A joint, particularly a fusion splice, should not contain an air-gap so reflective peaks are not normally seen. Instead, the optical power received simply displays a “drop” or “step” at the joint position.

If the scattering coefficients of the optical fibres on either side of the embedded connecting hardware are different then the results of measurement in each direction will differ (sometimes producing an apparent amplification in one direction).

For this reason, the result shall be the mean of the measurements in each direction.

Where compliance with a specified value is required a pass, fail or marginal result should be indicated with respect to the measured result.



Key

LC	Launch cord
TC	Tail cord
C1, C2, C3, C4	Cursors for linear regression definition
C5	Cursor at attenuation location
A	Insertion loss of non-reflective event under test

Figure 15 – OTDR measurement of joint insertion loss

10.4 Return loss (connecting hardware)

10.4.1 Test method (in accordance with IEC 61300-3-6, method 2)

A launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test.

If the return loss of the remote connection in the cabling under test is to be measured then a tail cord in accordance with 6.3.3.7 (MMF) or 6.3.4.7 (SMF) shall be connected to the remote end of the cabling under test.

In order to test embedded connecting hardware within an unterminated optical fibre, a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) but without a test interface connector shall be connected between the OTDR and the optical fibre under test.

An attenuator at the OTDR receiver input may be required to reduce the optical power to a level that does not saturate the OTDR receiver.

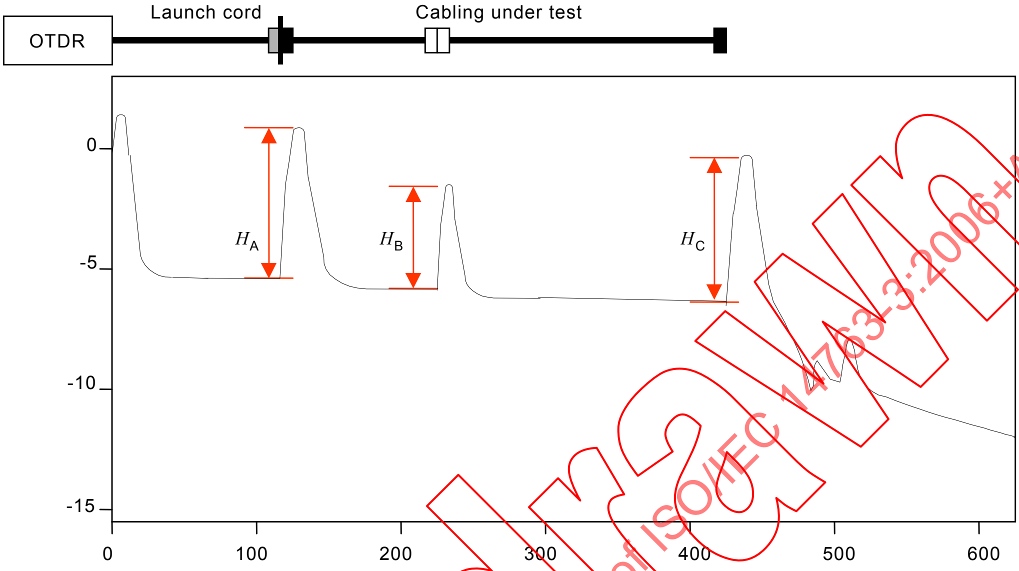


Figure 16 – OTDR measurement of return loss

10.4.2 Treatment of results

The return loss of a cabling component under test is calculated from the height of the reflected peak (H_A or H_B in Figure 16) as follows:

$$RL = -10 \cdot \log_{10}\left(10^{H/5} - 1\right) - 10 \cdot \log_{10} d + k \qquad \text{(dB)} \qquad (3)$$

where $H > 5$ dB

$$RL \approx 2 \cdot H - 10 \cdot \log_{10} d + k \qquad \text{(dB)} \qquad (4)$$

where

H is the height of peak (H_A or H_B) (dB),

d is the pulse width (ns),

k is the backscatter coefficient of the optical fibre (dB).

Typical values of scattering coefficient for MMF and SMF are included in Annex C.

NOTE 1 Most OTDRs automatically measure RL using instrument settings set by the manufacturer. However, in this case, it is also important to pay attention to the measurement uncertainty consideration as set out in 10.4.3.

NOTE 2 The detector in some OTDRs saturates at large values of H (as shown in H_C in Figure 16) so that measurement uncertainty is lost in measuring small values of return loss. This type of signal saturation is avoided by adding a variable attenuator between the OTDR and the cabling component under test.

Where compliance with a specified value is required a pass, fail or marginal result should be indicated with respect to the measured result.

10.4.3 Measurement uncertainty

Different sources of uncertainties shall be considered in reflectance measurement.

Instrument related uncertainties such as errors on the pulse amplitude or uncertainties on the shape or on the true value of the pulse width shall be considered if they are not corrected by the instrument, otherwise the maximum uncertainty value provided by the manufacturer shall be taken into account.

Fibre related uncertainties directly impact the reflectance uncertainties; (e.g. ±2 dB uncertainty on the backscattering coefficient leads to exactly ±2 dB uncertainty on the reflectance.) Typical uncertainty values included in Annex C may be used.

10.5 Optical fibre length

10.5.1 Test method

In order to test a channel or permanent link (see 8.1), a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) shall be connected between the OTDR and the cabling under test.

In order to test an unterminated optical fibre, a launch cord in accordance with 6.3.3.6 (MMF) or 6.3.4.6 (SMF) but without a test interface connector shall be connected between the OTDR and the optical fibre under test.

The OTDR/optical source shall be selected for the mode/wavelength as Annex C and the appropriate settings established for

- range,
- pulse width,
- IOR,
- averaging time.

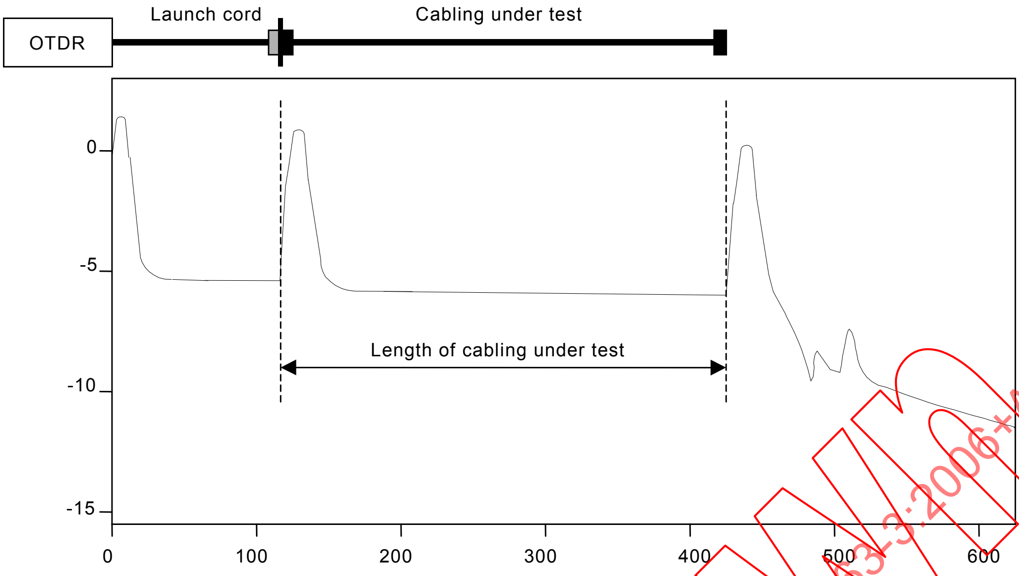


Figure 17 – Determination of length using an OTDR

Figure 17 shows the points at which the length of the transmission path contained within the installed cabling shall be measured (SMF may not produce a remote interface reflection). The installed cabling may be either a channel or a permanent link (see 8.1).

A break in a MMF permanent link would also be characterized by the presence of the reflection peak. However, unlike MMF and as shown in Figure 18, a break in a SMF may not always be characterized by a reflection peak.

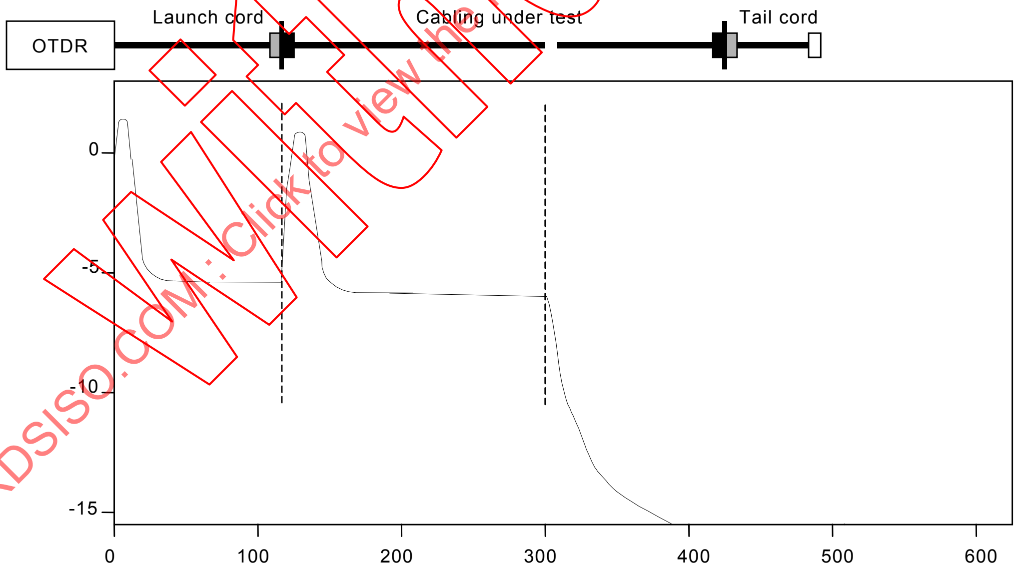


Figure 18 – OTDR characterization of a SMF permanent link containing a break

An installation error (e.g an installed cable bend radius below that specified in the relevant product standard or manufacturers/supplier information) causes a macrobend in the optical fibre in the cable. This macrobend introduces an attenuation of the transmitted light in the optical fibre and may show as an step change in attenuation on the OTDR trace (see Figure 19).

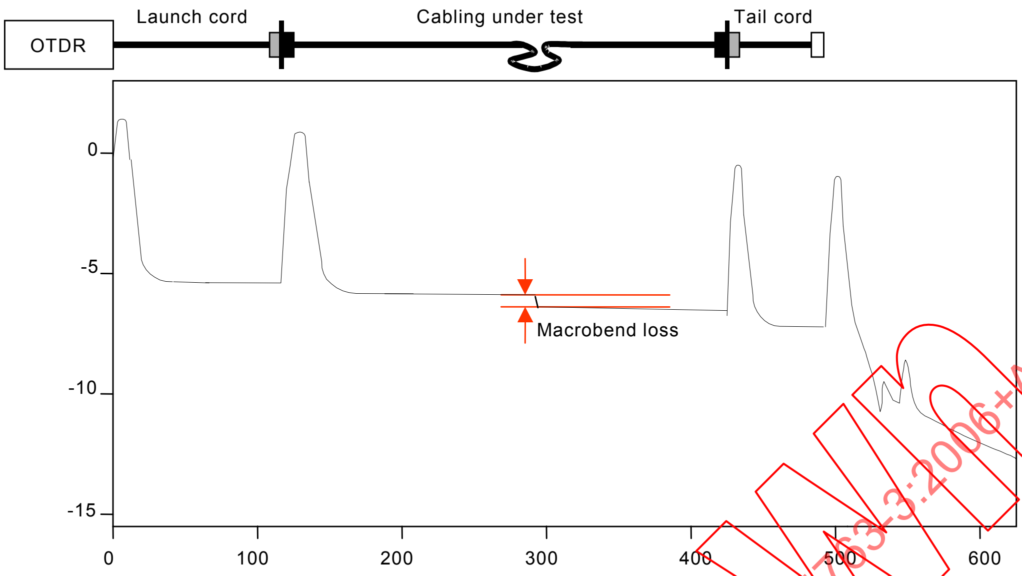


Figure 19 – OTDR characterization of an permanent link containing a macrobend

10.5.2 Measurement uncertainty

The measured length of the transmission path contained within the cabling under test is the length of the optical fibre (assuming that the correct effective group IOR has been used) rather than the physical length of the cable. The optically measured length of an optical fibre may differ from the physical length of the cable. Within a given length of cable containing multiple optical fibres each individual optical fibre may have a different length.

The optical fibre length will always be equal to, or greater than that of the cable itself. The difference between the two lengths is dependent upon cable construction. The cable manufacturer should be consulted if specific information is required.

10.5.3 Treatment of results

The limits and restrictions indicated in 10.5.2 should be included within the statement of measurement uncertainty.

The lengths measured shall be checked for consistency with the optical fibres supplied and installed (subject to the uncertainty of the measurement).

NOTE The propagation velocity or the group refractive index, provided by the manufacturer of the optical fibre cable under test, is required by the test equipment to calculate optical fibre length. If another value is used due to lack of information (e.g. the verification of unknown cabling), the impact of any errors introduced should be recognised and agreed between the installer and the user.

10.6 Attenuation/insertion loss (cords)

10.6.1 Test method

For MMF, the normalisation process requires a reference measurement as shown in Figure 20 to be made between the light source and power meter by the connection of a launch cord in accordance with 6.3.3.2 (or 6.3.3.4).

For SMF, the normalisation process requires a reference measurement as shown in Figure 20 to be made between the light source and power meter by the connection of a launch cord in accordance with 6.3.4.2 (or 6.3.4.4).

Launch cords should be tested at both ends to verify that they meet manufacturer's specifications.

The reference measurement, P_0, shall be recorded in ~~watts or decibel metres~~ W or dBm.

~~Reference power measurements shall be repeated periodically as necessary. Situations requiring the re-establishment of reference conditions include optical power changes, temperature fluctuations, a move to a different location, powering off, and field calibration cord or adapter replacement due to degradation. Sufficient time should be given for stabilization of laser sources during any repeated reference power measurement.~~

The cord under test shall be connected between the launch cord and the power meter and the test measurement, P_1, shall be recorded in W or dBm.

The launch cord shall remain connected to the light source.

The cord under test shall be connected between the launch cord and the power meter and the test measurement, P_1, shall be recorded in watts or decibel metres.

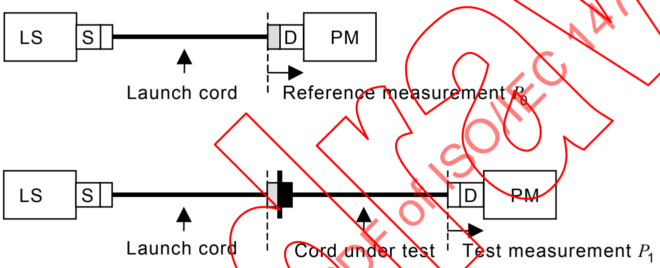


Figure 20 – Measurement of cord interface attenuation/insertion loss

The insertion loss measurement method is detailed in IEC 61300-3-4.

10.6.2 Treatment of results

For a given wavelength~~, the and in a~~ given direction, measured loss is calculated using P_0 and P_1 as follows:

$$L = P_0 - P_1 \quad \text{(dB)} \tag{5}$$

where P_1 and P_0 are expressed in ~~decibel metre~~ dBm.

If P_1 and P_0 are expressed in watts, then the measured loss can be calculated as follows:

$$L = -10\log_{10}\left(\frac{P_1}{P_0}\right) \quad \text{(dB)} \tag{6}$$

The measured result for a connection shall be recorded and may be termed as pass or fail against the limit defined in the relevant IEC product specification in comparison to a reference connector (see Table 4 for SC connecting hardware).

10.7 Return loss (cords)

See IEC 61300-3-6, method 1.

11 Inspection of cabling and cabling components

11.1 Optical fibre continuity

Continuity of an optical fibre between two interfaces may be verified using LSPM equipment or with an OTDR if a tail cord is used. Verification of continuity of an optical fibre shall be documented using a visible light source.

11.2 Cabling polarity

The desired polarity of the cabling system may be verified using LSPM equipment or with an OTDR if a tail cord is used. Verification of polarity of the cabling system shall be documented using a visible light source.

11.3 Optical fibre cable length

Optical fibre cable length may be obtained from cable sheath markings.

This may not agree with any measurement of optical fibre length carried out using an OTDR or equipment having the functions of an OTDR. The differences may be due to the nature of the cable construction and any error in the determination of the effective group IOR of the optical fibre.

11.4 Inspection of optical fibre end-faces

See Annex B.

11.5 Optical fibre core size

The inspection of the optical fibre end-faces under conditions of front illumination (see Annex B) allows the optical fibre core size to be determined by consideration of the relative diameters of the core and cladding.

Annex A
(normative)

Launched modal distribution (LMD)

~~A.1 Distribution of optical power within a MMF~~

~~Optical power is transmitted along a MMF in distinct paths called modes. Modes are arranged in Mode Groups ranging from Mode Group 01 to XX where the total number of mode groups (XX) depends upon~~

- ~~the design of the optical fibre,~~
- ~~the wavelength of transmission,~~
- ~~the number of modes per mode group is proportional to the mode group number.~~

~~The relative amount of power in each mode at the point of connection of the test source to the cabling or component under test is critical to the consistency and uncertainty of the measurements.~~

~~There are two independent metrics used within this standard for determining the launch condition. The first one is based upon a measurement of the mode transfer function (see A.2) and is called the Modal Power Distribution (MPD) as defined in A.3, the second is called the Coupled Power Ratio (CPR) and is defined in A.4. Requirements of both metrics shall be fulfilled.~~

~~These are measured at the output end of a launch cord attached to the test source. The launch cord contains optical fibre of the same type used in the cabling or component under test.~~

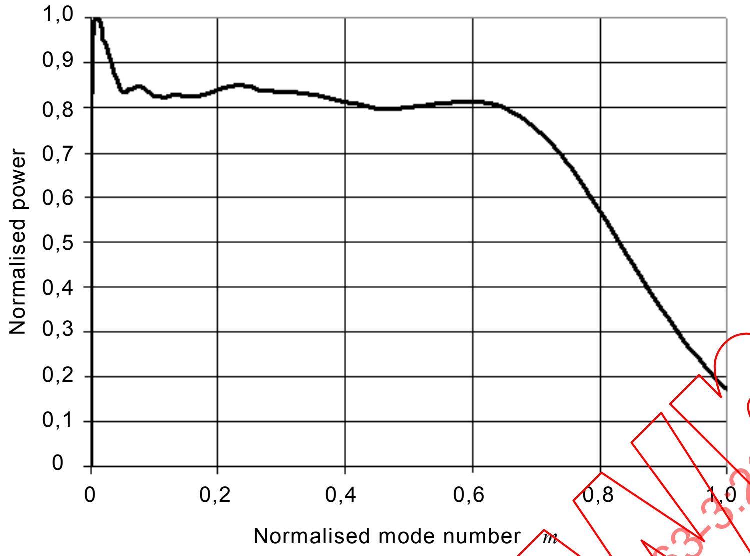
~~The mode transfer function (presented as MPD) is the definitive metric for determining the compliance of the launch condition. MPD is measured with near-field measurement equipment, usually under laboratory conditions. The CPR should only be considered as a simple means of checking the launch in the field to get an approximate indication of its launch condition.~~

~~A.2 Modal transfer function~~

~~The near field radiation pattern of the output end of a patch cord attached to the source shall be measured according to the procedure defined in IEC 60793-1-20. The derivative of the near field with respect to radial position shall be calculated as defined in IEC/PAS 61300-3-43, but without dividing the result by a reference data set. The resultant Mode Transfer Function (MTF) indicates the power distribution amongst all the modes,~~ ~~m~~~~.~~

~~A sample MTF is shown in Figure A.1. The information is normalised to display on vertical and horizontal scales that span from 0 to 1.~~

~~This information is converted to MPD in order to establish compliance limits in a way that is meaningful to loss measurements while affording flexibility in meeting the requirements with various launch conditions.~~

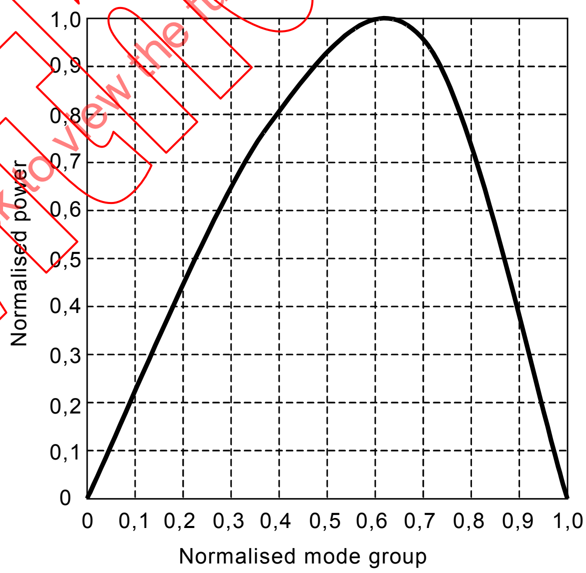


~~**Figure A.1 – Example of a characteristic MTF**~~

~~A.3 MPD (modal power distribution)~~

~~A.3.1 General~~

~~The MPD is a graphical representation of the relative power in each of the mode groups within a MMF as shown in Figure A.2.~~



~~**Figure A.2 – Example of a characteristic MPD**~~

~~The normalised mode group (x-axis) represents the mode group as a fraction of the highest mode group number.~~

~~For a 50/125 µm OM2 MMF (as defined in ISO/IEC 11801):~~

- ~~at 850 nm there are approximately 19 mode groups, for example a NMG value of 0,42 0,42 represents a mode group number of 08,~~

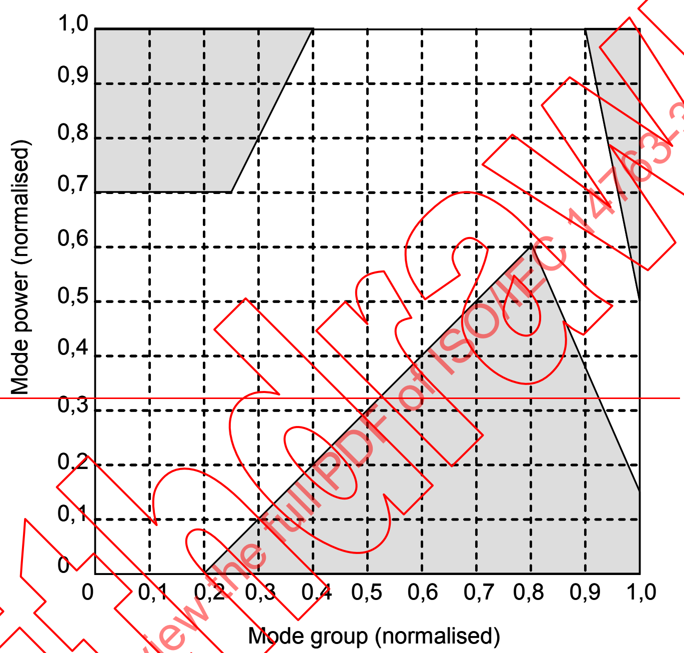
- ~~at 1 300 nm there are approximately 12 mode groups, for example a NMG value of 0,42 represents a mode group number of 05.~~

~~For a 62,5/125 µm OM1 MMF (as defined in ISO/IEC 11801):~~

- ~~at 850 nm there are approximately 31 mode groups, for example a NMG value of 0,42 0,42 represents a mode group number of 13.~~
- ~~at 1 300 nm there are approximately 19 mode groups, for example a NMG value of 0,42 represents a mode group number of 08.~~

~~A.3.2 Requirements~~

~~The MPD shall meet the requirements of Figure A.3, based on IEC/PAS 61300-3-43.~~



Template (x,y) coordinates
Upper left keepout: (0,0; 1,0) (0,4; 1,0) (0,25; 0,7) (0,0; 0,7)
Lower keepout: (0,2; 0,0) (0,8; 0,6) (1,0; 0,15) (1,0; 0,0)
Upper right keepout: (0,9; 1,0) (1,0; 1,0) (1,0; 0,5)

~~Figure A.3 – MPD (modal power distribution) specification~~

~~A.4 CPR (coupled power ratio)~~

~~A.4.1 General~~

~~The CPR coefficient is a measure of the relative power contained in mode group 01 as a fraction of the total power at the point of connection to the cabling or component under test. CPR measurements are easy to perform and give quantitative, repeatable results.~~

~~The CPR measurement may be applied either to a light source, via a test cord as detailed in A.4.3 or to a launch cord attached to a light source in accordance with 6.3.3.2, 6.3.3.4 or 6.3.3.6.~~

~~A.4.2 Test system~~

~~A.4.2.1 Power meter~~

~~The preferred power meter parameters for multimode detectors type D1 are given in IEC 61300-3-4.~~

~~A.4.2.2 MMF CPR test cord~~

~~Each test cord shall~~

- ~~contain optical fibre of the same nominal characteristics (core/cladding diameters, numerical aperture) as the optical fibre for which CPR is to be determined,~~
- ~~be approximately 2 m in length,~~
- ~~be terminated at one end with one or more connectors suitable for attachment to the light source for which CPR is to be determined,~~
- ~~be terminated at the other end with one or more reference connectors compatible with the interface to the SMF CPR tail cord,~~
- ~~have coatings that strip cladding light,~~
- ~~be labelled with a unique identifier with each connector labelled as indicated in Figure 5.~~

~~A.4.2.3 SMF CPR tail cords~~

~~Each test cord shall~~

- ~~be approximately 2 m in length,~~
- ~~terminated at one end with one or more connectors suitable for attachment to the power meter,~~
- ~~terminated at the other end with a single-mode connector compatible with the launch cord (or MMF CPR test cord, as appropriate),~~
- ~~have coatings that strip cladding light,~~
- ~~be labelled with a unique identifier with each connector labelled as indicated in Figure 5.~~

~~The cords shall contain optical fibre that has single-mode behaviour at the wavelength at which the CPR is to be determined. These fibres should have a mode field diameter of 9,0 µm ±1,0 µm for 1 300 nm (in accordance with IEC 60793-1-45 Type B1.1) and 5,0 µm ± 0,5 µm for 850 nm.~~

~~A.4.2.4 Connecting hardware~~

~~It is assumed that the connecting hardware will provide an insertion loss <0,5 dB in the relevant wavelength band (λ = 1 300 nm and λ = 850 nm), as measured by IEC 61300-3-4, insertion method (B).~~

~~A.4.3 Test method~~

~~A.4.3.1 Pre-conditioning~~

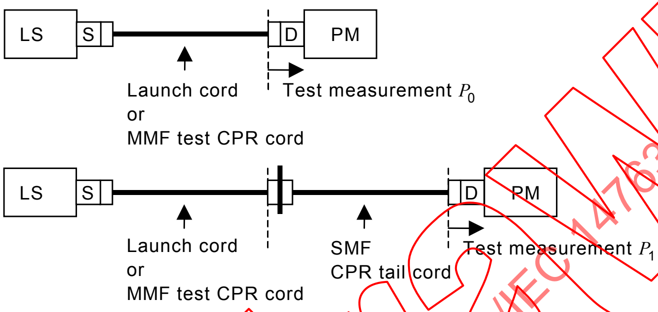
~~Any connecting hardware adapters used together with all connector end-faces on the test cords and the cabling under test shall be cleaned according to the instructions provided by the manufacturer of the interfaces. This shall be repeated every time a test cord is connected to the cabling or component under test.~~

~~Suitable materials for the cleaning of connectors (such as 98 % reagent grade alcohol and clean compressed air) shall be available and shall be used in accordance with suppliers' instructions.~~

~~A.4.3.2 Measurements~~

~~The light source and power meter shall be connected by either the launch cord for which the determination of the CPR is to be made or a MMF CPR test cord in accordance with A.4.2.2. The cord shall be deployed in such a way as to minimize changes in deployment during the test which could affect the modal power distribution. Bend radii of less than 50 mm shall be avoided.~~

~~The measurement, P_0 , shall be recorded in watts or decibel metres.~~



~~**Figure A.4 – CPR measurement method**~~

~~The cord shall be disconnected from the power meter and the SMF CPR tail cord inserted. The SMF cord shall be deployed with two loops of between 35 mm to 50 mm in diameter.~~

~~The measurements, P_0 and P_1, shall be recorded in watts or decibel metres.~~

~~For a given wavelength and in a given direction, the measured CPR is calculated using P_0 and P_1 as follows:~~

$$CPR = P_0 - P_1 \quad \text{(dB)} \qquad \text{(A.6)}$$

~~where P_1 and P_0 are expressed in decibel metres.~~

~~If P_1 and P_0 are expressed in watts, then the measured loss can be calculated as follows:~~

$$CPR = -10\log_{10}\left(\frac{P_1}{P_0}\right) \quad \text{(dB)} \qquad \text{(A.7)}$$

~~A.4.3.3 Requirements for 62,5/125 MMF~~

~~In the 850 nm wavelength region defined in Table 1 the LMD shall meet the following requirements:~~

- ~~a *CPR* of 25,5 dB ±0,5 dB;~~

~~In the 1 300 nm wavelength region defined in Table 1 the LMD shall meet the following requirements:~~

- ~~*CPR* of 21,5 dB ± 0,5 dB.~~

~~**A.4.3.4 Requirements for 50/125 MMF**~~

~~In the 850 nm wavelength region defined in Table 1 the LMD shall meet the following requirements:~~

- ~~a *CPR* of 20,5 dB ±0,5 dB.~~

~~In the 1 300 nm wavelength region defined in Table 1 the LMD shall meet the following requirements~~

- ~~*CPR* of 16,5 dB ± 0,5 dB.~~

A.1 General

This annex describes the general launch condition requirements used for measuring attenuation. The purpose of these requirements is to ensure consistency of field measurements when different types of test equipment are used.

This annex is based on the encircled flux metric and describes the target to achieve the above.

The material of this annex is extracted from IEC/PAS 62614 and IEC 61280-4-1.

A.2 Description

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. This document provides launch condition options and requirements for test instrument suppliers, component manufacturers and installers.

A.3 Background on multimode launch conditions

For background on the development of the launch condition from coupled power ratio and modal power distribution, see IEC/PAS 62614.

A.4 Test source launch

A.4.1 General

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

A.4.2 Encircled flux

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

The near field measurement is conducted in accordance with IEC 61280-1-4. The measured near field result is a function, $I(r)$, of radius, r, away from the optical center of the core, which is used to generate the Encircled Flux (EF) function as

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

A.4.3 EF template example

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

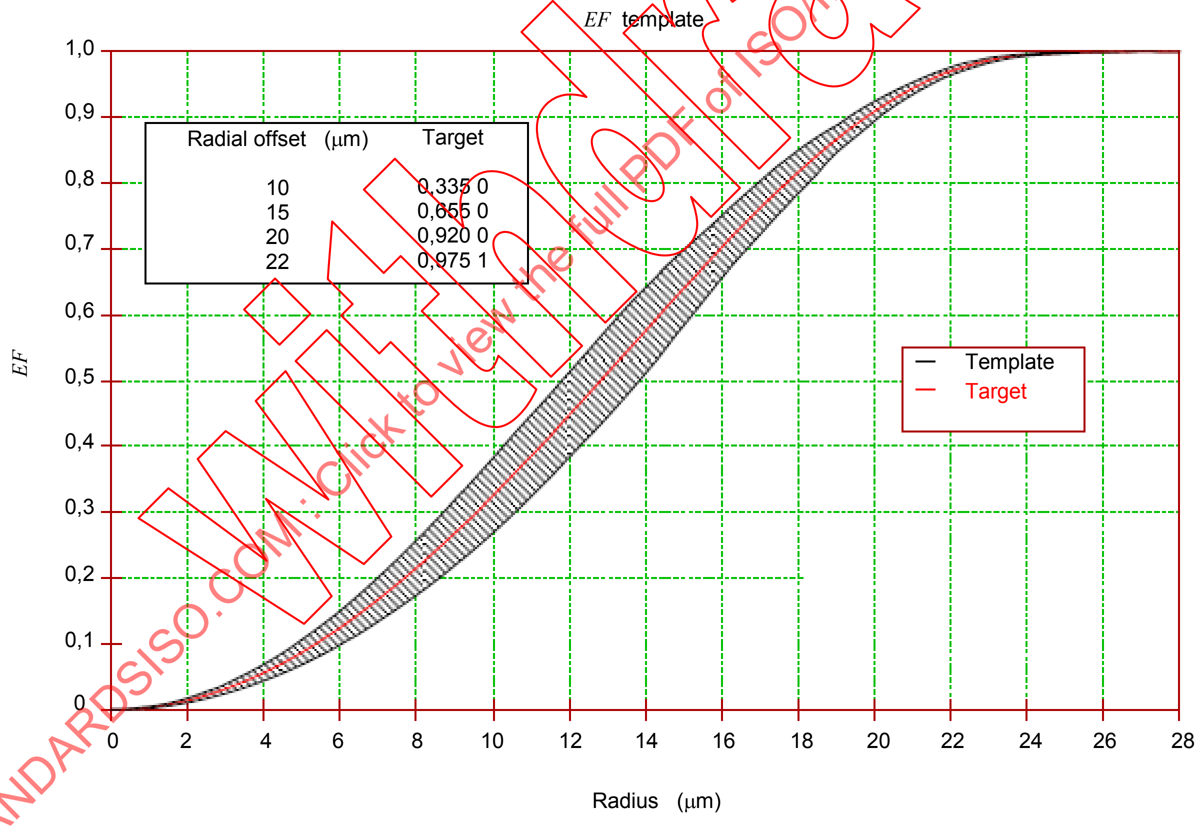


Figure A.1 – Encircled flux template example

A.4.4 EF target of the multimode launch condition for attenuation measurement

The EF requirements are defined as a collection of limiting values for a set of particular radial control points for each of four combinations of fibre core diameter and wavelength, as tabulated in Table A.1 to Table A.4.

Table A.1 – EF target for 50 µm core fibre at 850 nm (see Figure A.1)

Radial offset µm	Target
10	0,335 0
15	0,655 0
20	0,919 3
22	0,975 1

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

Radial offset µm	Target
10	0,336 6
15	0,656 7
20	0,918 6
22	0,972 8

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

Radial offset µm	Target
10	0,210 9
15	0,439 0
20	0,692 3
26	0,935 0
28	0,978 3

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

Radial offset µm	Target
10	0,211 9
15	0,439 0
20	0,692 3
26	0,935 0
28	0,978 3

A.5 Adjustments to the raw near field data

Use IEC 61280-1-4 as the basis for the near field measurement. This annex documents adjustments that need to be made to IEC 61280-1-4 for the purposes of qualifying launch cord output near fields.

A.6 Target launch and upper and lower tolerance bands for attenuation measurements of multimode optical fibre cabling

A.6.1 General

The specified launch condition in this annex is valid for attenuation measurements of multimode fibre optic cabling. The launch condition for field attenuation of multimode fibre optic cabling shall meet the encircled flux requirements of Table A.5 to Table A.8 when measured at the output of the reference connector.

A.6.2 Limits on encircled flux

The limits for the encircled flux 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 no greater than the larger of ±10 % (on a dB basis) or the threshold value. For example, a threshold value of 0,08 dB means that the loss variation is expected to be within ±10 % for losses equal to, or greater than 0,8 dB, and within 0,08 dB for losses less than 0,8 dB. The various threshold values are given in the titles of Table A.5 to Table A.8.

Table A.5 – EF requirements for 50 µm core fibre at 850 nm
(For threshold = 0,08 dB)

Radial offset µm	EF lower bound	EF upper bound
10	0,278 5	0,391 5
15	0,598 0	0,711 9
20	0,910 5	0,929 5
22	0,969 0	0,981 2

Table A.6 – EF requirements for 50 µm core fibre at1 300 nm
(For threshold = 0,12 dB)

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

Table A.7 – EF requirements for 62,5 µm fibre cabling at 850 nm
(For threshold = 0,10 dB)

Radial offset µm	EF lower bound	EF upper bound
10	0,168 3	0,253 5
15	0,369 5	0,508 5
20	0,.633 7	0,750 9
26	0,924 5	0,945 5
28	0,971 0	0,9856

Table A.8 – EF requirements for 62,5 µm fibre cabling at 1 300 nm
(For threshold = 0,15 dB)

Radial offset µm	EF lower bound	EF upper bound
10	0,168 0	0,255 8
15	0,369 9	0,511 9
20	0,636 9	0,752 1
26	0,925 4	0,946 0
28	0,9708	0,985 6

Annex B
(normative)

Visual inspection criteria for connectors

B.1 Connector end-face definitions

B.1.1 General

The condition of the connector end-faces is a significant factor in the long term operation of the network. This annex defines recommended requirements for the inspection of terminated optical fibres.

B.1.2 End-face zone definitions

With reference to Figure B.1 the connector end-face is subdivided into a core region and a cladding region.

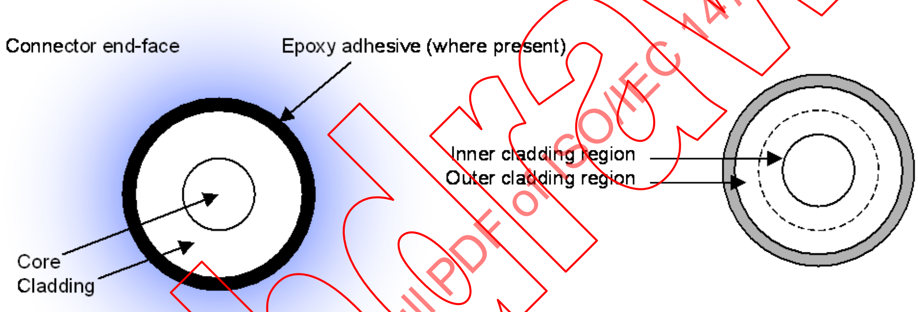


Figure B.1 – Connector end-face region definitions

For inspection purposes the cladding region is further sub-divided into imaginary inner and outer regions as shown in Figure B.1 and as defined in Table B.1.

Table B.1 – Connector end-face regions

Optical fibre design µm	Core diameter µm	Inner cladding diameter µm	Outer cladding diameter µm
SM	8 to 10	58	125
50/125	50	88	125
62,5/125	62,5	94	125

B.1.3 Modified inspection criteria

The subdivision of cladding regions defined in B.1.2 reflects a basic industry specification that has been proven to provide products of satisfactory operational lifetime. Modified standards may be adopted following their definition within an installation specification and quality plan.

B.2 Inspection of terminated optical fibre

B.2.1 General

The connector end-faces shall be subjected to visual inspection using a microscope as defined in 7.1 and shall meet the following visual standards providing a finished product capable of meeting the specified system lifetime. See IEC 61300-3-1 for details of visual inspection.

B.2.2 Scratch and pit defects

Inspection shall be carried out under front illumination conditions.

The core region shall not exhibit scratches and pits that exceed the requirements of Table B.2 while using the surface finishing techniques recommended by the manufacturers of the connectors used.

Table B.2 – Requirements for visual end-face inspection

	~~**MMF (100× magnification)**~~	~~**SMF (200× magnification)**~~
~~Number of scratches (max.)~~	~~10 (between 2,0 µm and 5,0 µm)~~	~~2 (≤3,0 µm)~~
	~~0 (>5,0 µm)~~	~~0 (>3,0 µm)~~
~~Number of pits/chips (max.)~~	~~10 (between 2,0 µm and 5,0 µm)~~	~~2 (≤3,0 µm)~~
	~~0 (>5,0 µm)~~	~~0 (>3,0 µm)~~

~~Note It is assumed that, at the required magnification, phenomena within the size ranges in Table B.2 are easily visible. The size of the phenomenon can be approximated by comparison to the visible core diameter.~~

	MMF minimum 100× magnification	**SMF** minimum 200× magnification
Number of scratches (maximum)	10 (between 2 µm and 5 µm)	2 (≤3 µm)
	0 (>5 µm)	0 (>3 µm)
Number of pits/chips (maximum)	10 (between 2 µm and 5 µm)	2 (≤3 µm)
	0 (>5 µm)	0 (>3 µm)

It is assumed that the inspection equipment has a minimum total magnification to offer a field of view of at least 250 µm is capable of detecting low contrast defects of 2 µm in diameter. With such equipment, phenomena within the size ranges in Table B.2 are easily visible. The size of the phenomenon can be approximated by comparison to the visible core diameter.

NOTE Text from, and references to, IEC 61300-3-35 are intended to be included at the circulation.

B.2.3 Chip defects

Inspection for chip defects shall be carried out under front illumination conditions.

The core region and the inner cladding region shall be free from defects (either as flaws within the fibre or cracks intersecting the surface).

The outer cladding region shall be free from defects that extend for more than 25 % of the cladding circumference (either as flaws within the fibre or cracks intersecting the surface). Refer to Figure B.2.