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REDLINE VERSION

INTERNATIONAL STANDARD

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Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-45: Examinations and measurements – Attenuation of random mated multi-fibre connectors

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IEC 61300-3-45 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

a) addition of sample size for > 12-fibre connector measurement;

b) inclusion of guidance for multimode measurement.

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

Draft	Report on voting
86B/4757/FDIS	86B/4774/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

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

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- replaced by a revised edition, or
- amended.

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

Part 3-45: Examinations and measurements – Attenuation of random mated multi-fibre connectors

1 Scope

The purpose of this part of IEC 61300 is to describe the procedure required to measure the statistical distribution and mean attenuation for random mated optical connectors with physical contact (PC) and angled physical contact (APC) polished ~~1-row~~ multi-fibre rectangular ferrules as defined in the IEC 61754 series. This measurement method is applicable to cable assemblies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

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

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

IEC 61754 (all parts), *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces*

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

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 General description

4.1 Test methods

Two test methods are described for measuring the attenuation of random mated optical connectors. Both provide an estimate of the expected average performance that a group of cable assemblies (including an adaptor, if applicable) ~~selected from a batch~~ will exhibit when used in an optical system. The device under test (DUT) is a cable assembly with on one side a plug with pins (pinned plug) and on the other side a plug without pins (unpinned plug). The cable assemblies, and any adaptors, ~~must~~ shall be chosen at random to ensure that the measurements provide a statistically unbiased estimate.

Method 1 describes a procedure using a sample of cable assemblies and adaptors specified in Table 1. In this case the pinned plugs ~~(with pins)~~ are used as ~~“reference” plugs~~ "launch test plugs” and the unpinned plugs ~~(without pins)~~ are tested against them sequentially. The results, based on the number of measurements specified in Table 1, are recorded in the test matrix shown in Figure 3 to Figure 5.

~~Method 1 is intended to be part of a design approval exercise that may involve one or more suppliers. Once approval is achieved, Method 2 would be relied on to maintain process control. However, in the event of a dispute, Method 1 shall act as the reference measurement method.~~

Method 2 describes a procedure for the measurement of a sample of cable assemblies and adaptors specified in Table 2. ~~Three cable assemblies are selected from the sample as “reference” cable assemblies and pins are fitted. The other test cable assemblies (without pins) are tested against each of the three “reference cable assemblies” sequentially.~~ Three cable assemblies are selected from the sample as "launch test cords” and the remaining cable assemblies are grouped as “receive test cords”. First, the pinned plugs of the launch test cords are used as launch test plugs and the unpinned plugs of the receive test cords are tested against them sequentially. Then the unpinned plugs of the launch test cords are used as launch test plugs and the pinned plugs of the receive test cords are tested. This produces the number of measurements specified in Table 2 and the results are recorded in the test matrix shown in Figure 10 to Figure 12.

Method 1 is intended to be part of a design approval exercise that can involve one or more suppliers. It is recognised that the number of measurements required by Method 1 ~~may~~ can be excessive for day-to-day routine checking of either in-house or supplier produced products. In this case, ~~as indicated above~~ once approval is achieved, Method 2 ~~may~~ would be relied on to maintain process control as an alternative option. However, in the event of a dispute, Method 1 shall act as the reference measurement method.

NOTE ~~In this measurement method, the terms “reference” plug or “reference” cord are used to define those components chosen at random from a batch, against which a number of comparative measurements are made.~~ In this measurement method, the term “launch test cord” is used to define one of the mated DUTs which is installed on the light source side. On the other hand, the other DUT which is installed on the detector side is defined as “receive test cord”. In the same way, the plugs mated at the connection point under test are defined as “launch test plug” and “receive test plug”, respectively. "Launch test plug” and "launch test cord” are used to define those components chosen at random from the sample, against which a number of comparative measurements are made. It is not intended that the terms ~~should~~ imply specially chosen or manufactured components, such as those used, for example, in screen testing.

Table 1 – Sample size for Method 1

Connectors (*n*-fibre connector)	Sample sizes		
	Cords and adaptors	Measurements	Fibres
2-fibre connector	15	210	420
4-fibre connector	12	132	528
8-fibre connector	10	90	720
10-fibre connector	10	90	900
12-fibre connector	10	90	1 080
> 12-fibre connector	10	90	90*n
NOTE Parameter n is the number of fibres in the connector.			

Table 2 – Sample size for Method 2

~~Connector (n-fibre connector)~~	~~Sample size~~				
	~~Cord and adaptors~~			~~Measurements~~	~~Fibres~~
	~~Total~~	~~Reference~~	~~Test :N~~		
~~2-fibre connector~~	~~12~~	~~3~~	~~9~~	~~54~~	~~108~~
~~4-fibre connector~~	~~8~~	~~3~~	~~5~~	~~30~~	~~120~~
~~8-fibre connector~~	~~6~~	~~3~~	~~3~~	~~18~~	~~144~~
~~10-fibre connector~~	~~6~~	~~3~~	~~3~~	~~18~~	~~180~~
~~12-fibre connector~~	~~6~~	~~3~~	~~3~~	~~18~~	~~216~~

Connectors (*n*-fibre connector)	Sample sizes					
	Cords			Adaptors	Measurements	Fibres
	Total	Launch test cord	Receive test cord			
2-fibre connector	12	3	9	3	54	108
4-fibre connector	8	3	5	3	30	120
8-fibre connector	6	3	3	3	18	144
10-fibre connector	6	3	3	3	18	150
12-fibre connector	6	3	3	3	18	216
> 12-fibre connector	6	3	3	3	18	18*n
NOTE Parameter n is the number of fibres in the connector.						

4.2 Precautions

The following test requirements shall be met.

a) ~~Precautions shall be taken to ensure that~~ The cladding modes ~~do~~ shall not affect the measurement. Cladding modes shall be stripped as a function of the fibre coating.

~~b) Precautions shall be taken to ensure that the position of the fibres in the test remains fixed between the measurement of P_1 and P_2 to avoid changes in attenuation due to bending losses.~~

b) The fibres in the test shall remain fixed between the reference power measurement and the corresponding attenuation measurements to avoid changes in attenuation due to bending losses.

b) The stability performance of the test equipment shall be ≤ 0,05 dB or 10 % of the attenuation to be measured, whichever is the lower value. The stability shall be maintained over the measurement time and operational temperature range. The required measurement resolution shall be 0,01 dB for both multimode and single-mode.

c) To achieve consistent results, clean and inspect all connectors and adaptors prior to the setup of the measurement system and if contaminated clean them. During measurement steps, inspect all connectors and adaptors except those in the unchanged connections and if contaminated clean them before mating. Visual examination shall be undertaken in accordance with IEC 61300-3-1 and IEC 61300-3-35.

NOTE A cladding mode stripper usually comprises a material having a refractive index equal to or greater than that of the fibre cladding.

5 Apparatus

5.1 Launch conditions and light source (LS)

The source consists of an optical emitter, the means to connect to it and associated drive electronics. In addition to meeting the stability and power level requirements, the source shall have the following characteristics:

– Centre wavelength, as detailed in the performance and product standard;

– Spectral width, filtered light emitting diode (LED) ≤ 150 nm full width half maximum (FWHM);

– Spectral width, laser diode (LD) < 10 nm FWHM.

For multimode fibres, broadband sources such as an LED shall be used.

For single mode fibres either an LED or LD may be used.

The source unit consists of an optical emitter, the associated drive electronics, and fibre pigtail (if any). Preferred source conditions are given in Table 3. The stability of the single-mode fibre source at 23 °C shall be ±0,01 dB over the duration of the measurement. The stability of the multimode fibre source at 23 °C shall be ±0,05 dB over the duration of the measurement. The source output power shall be ≥ 20 dB above the minimum measurable power level.

Table 3 – Preferred source conditions

No.	Type	Central wavelength nm	Spectral width (RMS) nm	Source type
S1	Multimode	660 ± 30	≥ 10	Monochromator or LED
S2	Multimode	780 ± 30	≥ 10	Monochromator or LED
S3	Multimode	850 ± 30	≥ 10	Monochromator or LED
S4	Multimode	1 300 ± 30	≥ 10	Monochromator or LED
S5	Single-mode	1 310 ± 30	To be reported	Laser diode, monochromator, or LED
S6	Single-mode	1 550 ± 30	To be reported	Laser diode, monochromator, or LED
S7	Single-mode	1 625 ± 30	To be reported	Laser diode, monochromator, or LED

It is recognized that some components, for example for coarse wavelength division multiplexing (CWDM), can require the use of other source types such as tunable lasers. It is therefore recommended in these cases that the preferred source characteristics are specified on the basis of the component to be measured.

NOTE Central wavelength and spectral width are defined in IEC 61280-1-3.

The launch condition shall be specified in accordance with IEC 61300-1. In case the specified launch condition is not obtained by the original light from the source, an appropriate apparatus for launch condition control (E) shall be used.

~~NOTE~~ The interference of modes from a coherent source will create speckle patterns in multimode fibres. These speckle patterns give rise to speckle or modal noise and are observed as power fluctuations, since their characteristic times are longer than the resolution time of the detector. As a result, ~~it may be impossible to achieve~~ stable launch conditions cannot be achieved using coherent sources for multimode measurements. Consequently, lasers, including optical time domain reflectometer (OTDR) sources, should be avoided in favour of LEDs or other incoherent sources for measuring multimode components.

~~4.2 Launch conditions (E)~~

~~The launch condition shall be specified in accordance with IEC 61300-1.~~

5.2 Detector (D)

The detector consists of an optical detector, the means to connect to it and associated electronics. The connection to the detector will be an adaptor that accepts a connector plug of the appropriate design. The detector shall capture all light emitted by the connector plug.

In addition to meeting the stability and resolution requirements, the detector shall have the following characteristics:

– linearity of multimode, ≤ ±0,25 dB (over −5 dBm up to −60 dBm);
– linearity of single-mode, ≤ ±0,1 dB (over −5 dBm up to −60 dBm).

~~NOTE~~ The ~~power meter~~ detector linearity should be referenced to a power level of −23 dBm at the operational wavelength.

Where the connection to the detector is broken between the reference power measurement ~~of P_1~~ and ~~P_2~~ the corresponding attenuation measurements, the measurement repeatability shall be within 0,05 dB or 10 % of the attenuation to be measured, whichever is the lower value. A large sensitive area detector ~~may~~ can be used to achieve this.

The precise characteristics of the detector shall be compatible with the measurement requirements. The dynamic range of the ~~power meter~~ detector shall be capable of measuring the power level exiting from the device under test (DUT) at the wavelength being measured.

6 Procedure

6.1 Method 1

~~a) Randomly select the sample number of cable assemblies specified in Table 1. Sequentially label the plugs under test as shown in Figures 3 to 5.~~

~~b) Randomly select the sample size of adaptors as specified in Table 1. Sequentially label the adaptors under test as shown in Figures 3 to 5.~~

~~c) Set up the measurement system as shown in Figure 1, with cord 1as the “reference” cord and with plug 1 as the “reference” plug. Measure power $P_{1\text{-}1}$ to $P_{1\text{-}n}$ for all fibres in the cord.~~

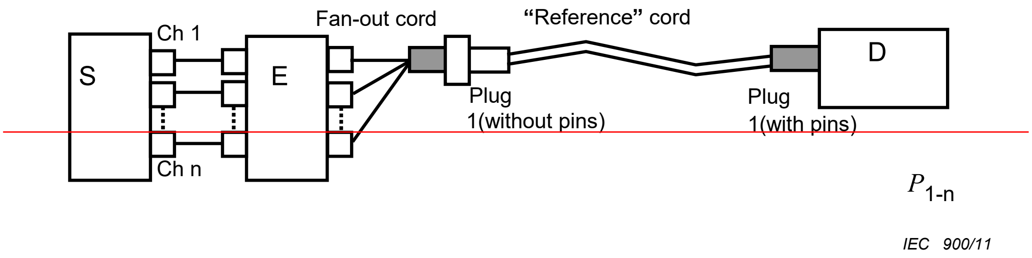


Figure 1 – "Reference" cord measurement – Method 1

d) Connect test cord 2 and adaptor 1 to the system and mate plug 1 (with pins) to plug 2 (without pins) as shown in Figure 2. Measure the power P_{2-1} to P_{2-n} for all fibres in the cord.

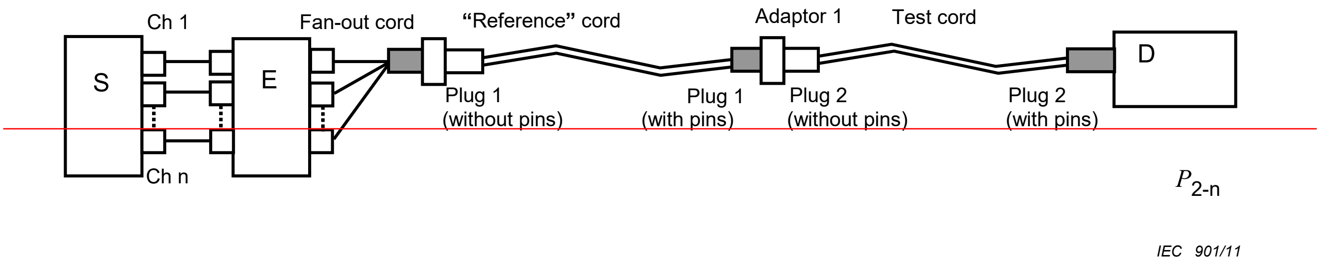


Figure 2 – Test cord measurement – Method 1

e) Calculate the attenuation of the mated plug pair 1 (with pins) / 2 (without pins) with adaptor 1, using Equation (1):

$$\text{Attenuation} = [-10 \log (P_{2-i}/P_{1-i})] - (A \times L) \text{ dB} \quad (1)$$

Where

i is fibre number of Test cord.

A is fibre attenuation per km;

L is length of fibre in km.

NOTE The product $A \times L$ may be ignored for both single mode and multimode [50/125 µm and 62,5/125 µm] where the cord length is small, i.e. < 10 m.

f) Record the attenuation results for each fibre into an appropriate matrix format.

NOTE An example of record table (for 4 fibre connectors) is shown in Figure 13.

g) Keeping plug 1 (with pins) and adaptor 1 as the "reference" configuration, replace test cord 2 by test cord 3 and mate plug 3 (without pins) with plug 1 (with pins).

h) Measure the power P_{3-1} to P_{3-n} and record the attenuation results for each fibre.

i) Repeat steps g) and h) until all the plugs (without pins) of the remaining test cable assemblies have been tested against the "reference" plug 1 (with pins).

j) After step i) has been completed, replace the "reference" plug and adaptor so that plug 2 (with pins) and adaptor 2 are the "reference" configuration.

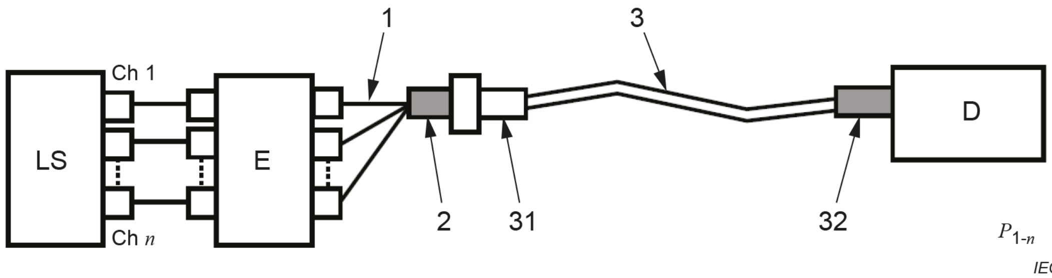
k) Measure the attenuation for all plugs against "reference" plug 2 (with pins) and adaptor 2.

l) Continue this process until all allocated plugs have been used as "reference" plugs.

a) Randomly select the sample number of cable assemblies specified in Table 1. Sequentially label the cable assemblies and plugs under test as shown in Figure 3 to Figure 5.

b) Randomly select the sample size of adaptors as specified in Table 1. Sequentially label the adaptors under test as shown in Figure 3 to Figure 5.

c) Set up the reference power measurement system as shown in Figure 1, with cord 1 as the launch test cord and plug 1 (pinned) as the launch test plug. Measure power $P_{1\text{-}1}$ to $P_{1\text{-}n}$ for all fibres in the cord. For multimode measurement, tight tolerance fibre and tight tolerance plug as specified in Annex A shall be used for the launch plug. The launch condition at the launch plug shall comply with IEC 61300-1.

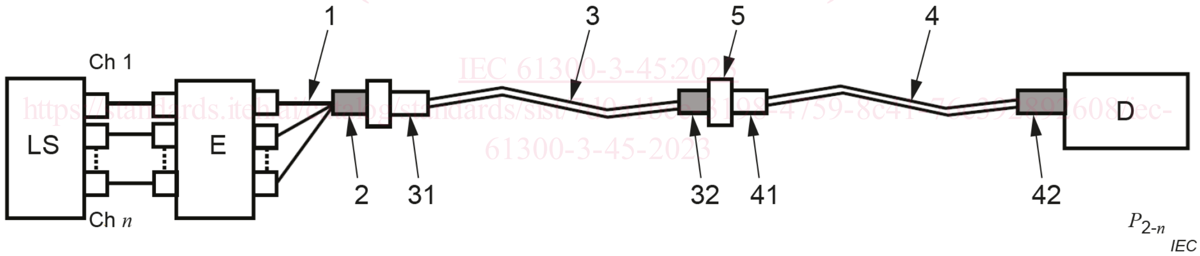


Key

LS	light source	3	launch test cord
E	launch condition control	31	unpinned plug of launch test cord
1	fan-out cord	32	pinned plug of launch test cord (launch test plug)
2	launch plug		

Figure 1 – Reference power measurement system – Method 1

d) Pick up cord 2 as the receive test cord. Mate plug 1 (pinned) to plug 2 (unpinned) using adaptor 1 as shown in Figure 2. Measure the power $P_{2\text{-}1}$ to $P_{2\text{-}n}$ for all fibres in the cord.



Key

LS	light source	4	receive test cord
E	launch condition control	41	unpinned plug of receive test cord (receive test plug)
1	fan-out cord	42	pinned plug of receive test cord
2	launch plug	5	adaptor
3	launch test cord		
31	unpinned plug of launch test cord		
32	pinned plug of launch test cord (launch test plug)		

Figure 2 – Attenuation measurement system – Method 1

e) Calculate the attenuation A of the mated plug pair 1 (pinned)/2 (unpinned) with adaptor 1, using Formula (1):

$$A = \left[-10\log\left(\frac{P_{2-i}}{P_{1-i}}\right)\right] - \left(A_f \times L\right) \text{ dB} \tag{1}$$

where

A is the attenuation;

i is the number of fibres of the test cord;

A_f is the fibre attenuation per kilometre;

L is the length of the fibre in kilometre.

The product $A_f \times L$ depends on the fibre attenuation level and can be neglectable when it is small enough compared to the connection losses.

f) Record the attenuation results for each fibre into an appropriate matrix format.

g) Keeping plug 1 (pinned) as the launch test plug, replace cord 2 with cord 3 and mate plug 3 (unpinned) to plug 1 (pinned) using adaptor 1.

h) Measure the power $P_{3\text{-}1}$ to $P_{3\text{-}n}$ and record the attenuation results for each fibre.

i) Repeat steps g) and h) until all the unpinned plugs of the remaining cable assemblies have been tested against the launch test plug 1 (pinned).

j) After step i) has been completed, replace the launch test cord and the adaptor so that plug 2 (pinned) is used as the launch test plug. Measure the reference power for the configuration.

k) Measure the attenuation for all plugs (unpinned) against the launch test plug 2 (pinned) using adaptor 2.

l) Continue this process until all allocated plugs (pinned) have been used as launch test plugs.