IEC 61755-2-4

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INTERNATIONAL STANDARD

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

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Dispositifs d'interconnexion et composants passifs fibroniques – Interfaces optiques de connecteurs – Partie 2-4: Paramètres de connexion de fibres unimodales à dispersion non décalée en contact physique – Sans angle pour applications en tant que connecteurs de référence



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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – CONNECTOR OPTICAL INTERFACES –

Part 2-4: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Non-angled for reference connection applications

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International Standard IEC 61755-2-4 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This bilingual version (2019-08) corresponds to the monolingual English version, published in 2015-01.

The text of this standard is based on the following documents:

FDIS	Report on voting
86B/3845/FDIS	86B/3866/RVD

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

The French version of this standard has not been voted upon.

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

A list of all parts in the IEC 61755 series, published under the general title *Fibre optic interconnecting devices and passive components –Connector optical interfaces*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – CONNECTOR OPTICAL INTERFACES –

Part 2-4: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Non-angled for reference connection applications

1 Scope

This part of IEC 61755 defines a set of prescribed conditions that should be maintained in order to satisfy the requirements of non-angled polished reference connections.

The prescribed conditions include dimensional limits and optical fibre requirements of the optical interface to meet specific requirements for reference connection (plugs and adaptors) used for attenuation measurements.

Two different grades for reference connections are defined in this standard. The use of each of these grades depends on the application and on the targeted attenuation measurement uncertainty. The model uses a Gaussian distribution of light intensity over the specified restricted mode field diameter (MFD) range.

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The reference connector plug is specified for B1.1, B1.3 and B6 fibres as specified in IEC 60793-2-50.

The use of the reference connector plug would not be recommended where classification of fibre is difficult, for example construction and maintenance of cable plant.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

IEC 61755-2-1, *Fibre optic interconnecting devices and passive components –Connector optical interfaces – Part 2-1: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Non-angled*

IEC 61755-2-2, *Fibre optic interconnecting devices and passive components –Connector optical interfaces – Part 2-2: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Angled*

IEC 61755-3 (all parts), *Fibre optic interconnecting devices and passive components – Connector opticla interfaces – Part 3-x: Connector parameters of non-dispersion shifted single-mode physically contacting fibres*

IEC TR 62627-04, *Fibre optic interconnecting devices and passive components – Technical report – Part 04: Example of uncertainty calculation: Measurement of the attenuation of an optical connector*

3 Performance grades

Performance grades for PC polished reference connectors are given in Table 1. The specified attenuation for each grade is obtained when the reference plugs are connected to each other with the reference adaptor.

Table 1 – Single-mode attenuation grades at 1 310 nm

Reference grade [a]	Attenuation [a] dB	Contribution to measurement uncertainty [b] dB
R1	≤0,1	±0,1
R2	≤0,2	±0,2

[a] Under the assumption of worst case alignment with identical connector plug. Expected attenuation measured when connecting two plugs of the same grade may be higher due to significant measurement uncertainty.

[b] As described in Clause 8.

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4 Description

Optical reference connector plugs are connector plugs manufactured with restricted tolerances for dimensions relevant to lateral and angular offset. These connector plugs are used for attenuation measurement purposes according to IEC 61300-3-4, and shall be considered as part of the measurement set-up since they strongly contribute to its measurement uncertainty (for example see IEC TR 62627-04). The attenuation measurement uncertainty contributions for both grades of reference connectors are listed in Table 3.

The principal performance of a reference connector plug is given by its contribution to measurement uncertainty (estimated based on the reproducibility of an attenuation measurement of the same device performed using multiple different reference connector plugs of the same grade) which is determined by the accuracy with which the core of the optical fibre is aligned to the optical datum target and determines the random attenuation performance of a reference connector population.

The main parameters influencing the performance of the reference connector plugs are fibre core location, fibre core axis angle and mode field diameter variability. Figure 1 represents the fibre alignment tolerances for the two different reference grades described in this standard, under the assumption of using selected reference fibre, described in Table 2.

The design curves given in Figure 1 each represent maximum allowable combinations of a given specific fibre core location and an associated fibre core axis angle to not exceed the specified attenuation of any single considered connection. The design curves shown represent the determination of the parameters under a worst case mismatch of the mode field diameter of the selected fibres as given in Table 3, i.e. 9,1/9,3 µm and a wavelength of 1 310 nm. These mode field diameter ranges are selected within the IEC 60793-2-50 family specification for single mode non-dispersion shifted fibres as given in Table 2.

5 Criteria for a fit within performance grades

5.1 General

Figure 1 and Table 2 give the criteria for meeting the performance grades listed above in Table 1. The parameters chosen for the criteria definition are based on the degree of significance in affecting the performance under test.

5.2 Attenuation grades and criteria

Considering a beam with a Gaussian distribution, the coupling efficiency, η, of two, single-mode fibres is given by Equation (1). The mode field diameters and the nominal index of refraction of the fibre core are given in Table 2.

Table 2 – Mode field diameter and fibre core nominal index of refraction for fibre to be used in reference connector plugs

Fibre type	Nominal wavelength nm	MFD [a] µm		n_0
		Min.	Max.	
Dispersion unshifted fibre	1 310	9,1	9,3	1,452 0

[a] MFD as specified here has a narrow tolerance compared to the tolerance field in IEC 60793-2-50.

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The attenuation (also referred to as insertion loss, IL, or coupling efficiency) of the fibres equals η_{combined}. Attenuation η_{combined} is expressed as in Equation (1) below.

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$$\eta_{\text{combined}} = -10\log\left[\frac{(2\omega_2\omega_1)^2}{\left(\omega_2{}^2+\omega_1{}^2\right)^2}\exp\left[\frac{-2\times d^2}{\omega_2{}^2+\omega_1{}^2}-2\pi^2\frac{n_0{}^2}{\lambda^2}\frac{\left(\omega_2{}^2\omega_1{}^2\right)}{\left(\omega_2{}^2+\omega_1{}^2\right)}\sin^2(\theta)\right]\right] \quad (1)$$

where

d is the total lateral offset;

θ is the angular misalignment between fibre cores;

λ is the wavelength of transmitted light in vacuum;

n_0 is the index of refraction of the fibre core;

ω_1 is the transmit fibre mode field radius;

ω_2 is the receive fibre mode field radius.

The definition of reference connector grades is based on worst case calculation (unlike the other level 2 optical interface standards, IEC 61755-2-1 and IEC 61755-2-2, where the definition of performance grades is based on a statistical approach defining parameter values to reach the given random attenuation in 97 % of the connections).

Equation (2) which has been used to calculate the curves displayed in Figure 1 is derived from Equation (1) where the total lateral offset (d) has been replaced by the double of the fibre core location ($2\times F$) and the angular misalignment by the double of the fibre core axis angle ($2\times E$), the input fibre has maximum fibre mode field radius (4,65 µm) and the output fibre the minimum fibre mode field radius (4,55 µm) specified in Table 2. That way, Equation (2) calculated the attenuation in the case of worst case alignment of identical plugs. It shall be noted that Figure 1 can be used as a design graph for reference connector plugs, from where fibre core location and angular misalignment can be directly read. For the definition of fibre core location and fibre core axis angle, refer to the relevant level 3 optical inferface standards (see the IEC 61755-3 series).

$$\eta_{\text{combined}} = -10\log\left[\frac{(2\omega_2\omega_1)^2}{\left(\omega_2{}^2+\omega_1{}^2\right)^2}\exp\left[\frac{-2\times(2\times F)^2}{\omega_2{}^2+\omega_1{}^2}-2\pi^2\frac{n_0{}^2}{\lambda^2}\frac{\left(\omega_2{}^2\omega_1{}^2\right)}{\left(\omega_2{}^2+\omega_1{}^2\right)}\sin^2(2\times E)\right]\right] \quad (2)$$

where

F is the fibre core location (μm);

E is the fibre core axis angle (rad);

λ is the wavelength of transmitted light in vacuum (here 1,310 μm);

n_0 is the index of refraction of the fibre core (here 1,452 0);

ω_1 is the transmit fibre mode field radius (here 4,55 μm);

ω_2 is the receive fibre mode field radius (here 4,65 μm).

The shown design curves represent the determination of the parameters under a worst case mismatch of the mode field diameter of the selected fibres as given in Table 2, i.e. 9,1/9,3 μm and a wavelength of 1 310 nm. These mode field diameter ranges are selected within the IEC 60793-2-50 product specification for single-mode, non-dispersion shifted fibres as given in Table 2. The equation is also applicable to 1 550 nm and 1 625 nm, but the design curves are not shown in Figure 1.

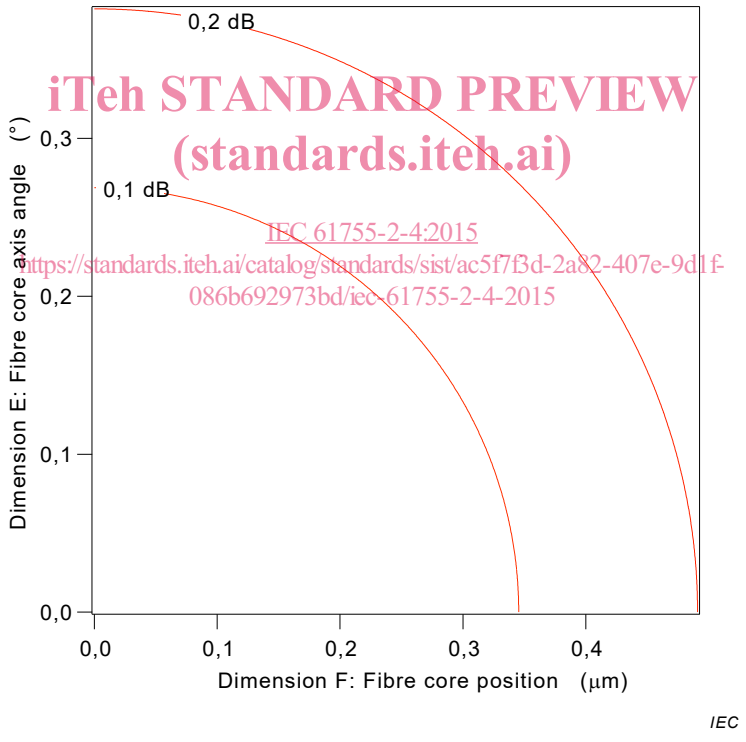

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Figure 1 – Representation of fibre core position of single connector plug under the assumption of worst case alignment with identical connector plug

The performance presented in Figure 1 can only be achieved when limiting the ferrule diameter tolerance to

- 1,249 0 to 1,249 5 mm for 1,25 mm ferrules, and
- 2,499 0 to 2,499 5 mm for 2,5 mm ferrules.

6 Use of selected fibre to assemble reference connector plugs

In order to limit the variability of attenuation measurement using reference connectors, it is mandatory to use selected fibre with restricted tolerances on mode field diameter (MFD) to 9,2 μm ±0,1 μm, measured at 1 310 nm. Using this type of fibre and the tolerance parameters published in this standard, it is possible to reach measurement values that are repeatable within ±0,1 dB when randomly varying the reference connector plug (valid for reference Grade 1).

7 Reference adaptor

In case of a cylindrical ferrule connector, selected reference adaptors shall be used. It is recommended to use reference connector plugs and measure them according to IEC 61300-3-42 with an attenuation variation smaller than 0,03 dB.

8 Attenuation measurement uncertainty contribution

When performing an attenuation measurement using a reference connector plug and adaptor, these shall be considered as part of the measurement set-up. The goal of a reference measurement is to qualify a device under test (DUT) (which may be an optical connector or another optical component that has an input connector) by measuring the attenuation of the DUT connected to the reference connector plug and adaptor. Since the reference connector plug and adaptor properties vary as a function of measurement situation, this variability has to be considered as a contribution to the attenuation measurement uncertainty of such a set-up.

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Following contributions have been determined as a function of reference connector grade:

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Table 3 – Measurement uncertainty contribution of reference connectors

Reference grade	Contribution to measurement uncertainty dB	Remarks
R1	±0,1	a, b
R2	±0,2	b

[a] Value has been calculated and experimentally verified using selected fibre as described in the Table 2.

[b] The integration of the reference connector contribution to the overall measurement uncertainty contribution of the attenuation measurement has been discussed in detail in IEC TR 62627-04.