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BSI Standards Publication

Fibre optic interconnecting devices and passive components — Connector optical interfaces

Part 3-32: Connector parameters of non-dispersion shifted single mode physically contacting fibres — Angled thermoset epoxy rectangular ferrules

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National foreword

This British Standard is the UK implementation of EN 61755-3-32:2016. It is identical to IEC 61755-3-32:2015. It supersedes DD IEC/PAS 61755-3-32:2007 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/2, Fibre optic interconnecting devices and passive components.

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

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English Version

Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 3-32: Connector parameters of non-dispersion shifted single mode physically contacting fibres - Angled thermoset epoxy rectangular ferrules (IEC 61755-3-32:2015)

Dispositifs d'interconnexion et composants passifs à fibres optiques - Interfaces optiques de connecteurs - Partie 3-32: Paramètres de connecteurs pour fibres unimodales à dispersion non décalée, en contact physique - Férules rectangulaires avec angle en époxy thermodurcissable (IEC 61755-3-32:2015)

Lichtwellenleiter - Verbindungselemente und passive Bauteile - Teil 3-32: Optische Schnittstelle rechteckige duroplastische Epoxid-Ferrule 8 Grad abgewinkelt physikalischer Kontakt für Einmodenfasern (IEC 61755-3-32:2015)

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European foreword

The text of document 86B/3889/FDIS, future edition 1 of IEC 61755-3-32, prepared by SC 86B "Fibre optic interconnecting devices and passive components" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61755-3-32:2016.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-09-11
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2019-03-11

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

IEC 61753-1	NOTE	Harmonized as EN 61753-1.
IEC 61754-10:2005	NOTE	Harmonized as EN 61754-10:2005.
IEC 61755-2-1	NOTE	Harmonized as EN 61755-2-1.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

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

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

Publication	Year	Title	EN/HD	Year
IEC 60793-2-50	-	Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres	EN 60793-2-50	-
IEC 61300-3-30	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-30: Examinations and measurements - Polish angle and fibre position on single ferrule multifibre connectors	EN 61300-3-30	-
IEC 61300-3-52	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-52: Examinations and measurements - Guide hole and alignment pin deformation constant, CD for 8 degree angled PC rectangular ferrule, single mode fibres	EN 61300-3-52	-
IEC 61754	Series	Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces	EN 61754	Series
IEC 61754-5	2005	Fibre optic connector interfaces - Part 5: Type MT connector family	EN 61754-5	2005
IEC 61754-7	2008	Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 7: Type MPO connector family	EN 61754-7	2008
IEC 61754-7-1	2014	Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 7-1: Type MPO connector family - One fibre row	EN 61754-7-1	2014
IEC 61755-1	-	Fibre optic connector optical interfaces - Part 1: Optical interfaces for single mode non-dispersion shifted fibres - General and guidance	EN 61755-1	-

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

Part 3-32: Connector parameters of non-dispersion shifted single mode physically contacting fibres – Angled thermoset epoxy rectangular ferrules

FOREWORD

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International Standard IEC 61755-3-32 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This first edition cancels and replaces IEC PAS 61755-3-32 published in 2007. This edition constitutes a technical revision.

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

FDIS	Report on voting
86B/3889/FDIS	86B/3915/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.

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

A list of all parts of the IEC 61755 series, 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.

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

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

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

Part 3-32: Connector parameters of non-dispersion shifted single mode physically contacting fibres – Angled thermoset epoxy rectangular ferrules

1 Scope

This part of IEC 61755 defines certain dimensional limits of an angled PC rectangular thermoset (TS) ferrule optical interface in order to meet specific requirements for fibre-to-fibre interconnection. Ferrules made from the material specified in this standard are suitable for use in categories C, U, E, and O as defined in IEC 61753-1.

Ferrule interface dimensions and features are contained in the IEC 61754 series, which deals with fibre optic connector interfaces.

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 61300-3-30, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-30: Examinations and measurements – Polish angle and fibre position on single ferrule multifibre connectors*

IEC 61300-3-52, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-52: Examinations and measurements – Guide hole and alignment pin deformation constant, C_D for 8 degree angled PC rectangular ferrule, single mode fibres*

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

IEC 61754-5:2005, *Fibre optic connector interfaces – Part 5: Type MT connector family*

IEC 61754-7:2008, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 7: Type MPO connector family*

IEC 61754-7-1:2014, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 7-1: Type MPO connector family – One fibre row*

IEC 61755-1, *Fibre optic connector optical interfaces – Part 1: Optical interface for single mode non dispersion shifted fibres – General and guidance*

3 Description

The performance of a single mode angled PC rectangular ferrule optical interface is determined by the accuracy with which the optical datum targets of two mating ferrules are aligned with each other. There are three conditions affecting the alignment of the optical datum targets: lateral offset, angular offset, and longitudinal offset.

Parameters influencing the lateral and angular offset of the optical fibre axes include the following:

– fibre hole deviation from designated location;
– fibre cladding diameter relative to fibre hole clearance;
– fibre hole angular misalignment;
– fibre core concentricity relative to the cladding diameter;
– alignment pin diameter relative to the guide hole clearance.

Parameters influencing the longitudinal offset of the optical fibre axes include the following:

– fibre protrusion;
– fibre array minus coplanarity;
– adjacent fibre height differential;
– end face angle in the x-axis;
– end face angle in the y-axis;
– end face radius in the x-axis;
– end face radius in the y-axis;
– fibre tip spherical radii;
– axial force on ferrule end face;
– ferrule and fibre material constants;
– frictional force of alignment pins in ferrule guide holes.

4 Interface parameters

This standard defines the dimensional limits of angled PC rectangular ferrules with a single row of up to 12 fibres. The fibre centres are spaced with a nominal alignment pitch of 0,25 mm. Interface variants, which identify nominal ferrule cross-sections and applicable fibre counts, are given in Table 1. The fibre numbering conventions are illustrated in Figure 1.

Optical interface dimensions related to lateral and angular offset are defined in Figure 2 and the alignment pin geometry is shown in Figure 3. The end face geometry parameters that influence longitudinal offset are outlined in Figure 4.

The parameter values related to lateral and angular offset are given in Table 2. End face geometry limits associated with longitudinal offset are specified in Table 3.

Table 1 – Optical interface variant information

Variant number [b,c]	Nominal ferrule cross section [a] mm × mm	Number of fibres
2112	2,45 × 6,4	12

[a] Refer to the applicable IEC 61754 series fibre optic connector interface standard for dimensional requirements.

[b] The four-digit variant code describes a combination of material type, nominal ferrule cross-section and number of fibres. The first digit defines 1 for PPS ferrule materials and 2 for thermoset materials; the second digit represents 2,45 mm × 4,4 mm with 0 and 2,45 mm × 6,4 mm with 1; and the last two digits designates the number of fibres.

[c] All ferrule materials for rectangular type ferrules are intended to be intermateable, in the lowest specified performance category as described in IEC 61755-1, provided that the last three digits of the variant number are the same. It is also possible to mate ferrules with different fibre counts, in which case all mating fibres shall meet the designated performance category.

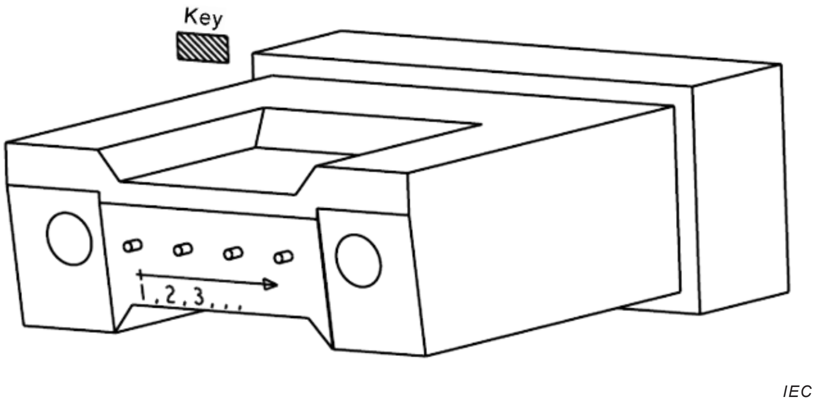


Figure 1 – Fibre numbering conventions

To provide optical fibre-to-fibre interconnection, mating ferrules have to be correctly keyed. Refer to the applicable IEC 61754 series document to ensure correct key orientation.

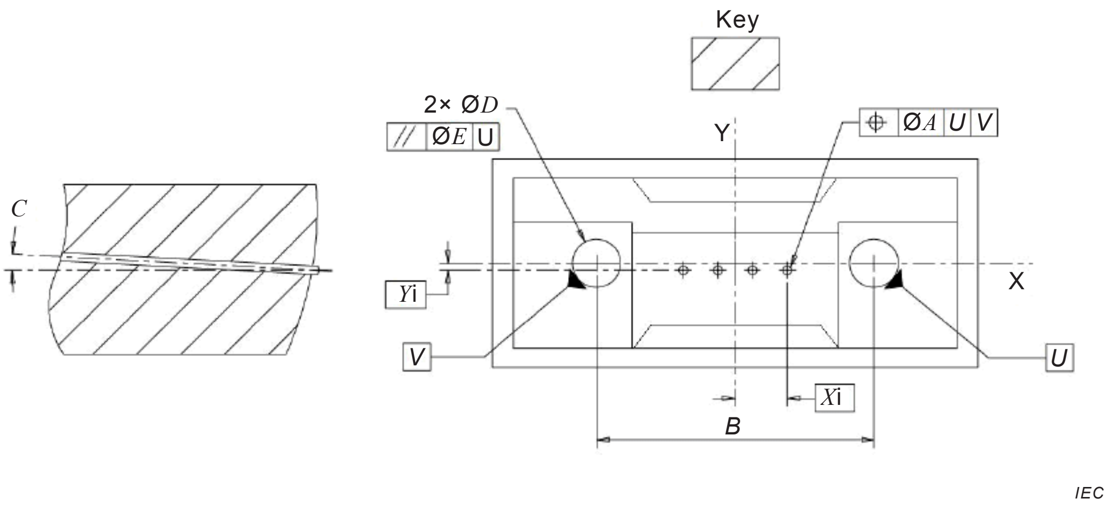


Figure 2 – Interface dimensions related to lateral and angular offset

The optical interface coordinate system is established with an x-axis, which passes through the guide hole centres and a perpendicular y-axis that passes through the midpoint of the line connecting the guide hole centres.

The basic x-location, Xi, for each fibre core centre is defined as:

$$Xi = (2i - n - 1)\ 0{,}125$$

where, i corresponds to the i^{th} fibre per the numbering conventions outlined in Figure 1 and n is the total number of fibres in the array.

The basic y-location, Yi, for each fibre core centre is defined as follows:

$$Y\mathrm{i} = \alpha \frac{D_\mathrm{o} - D_\mathrm{i}}{2} + C_\mathrm{D}$$

The basic alignment pin dimension, D_i, is 0,698 5 mm and the basic guide hole dimension, D_o, is a nominal value based on the manufacturer designed average hole size. The constant, α, relates to differences in guide pin pitch and varies between 0 and 1. The term C_D is a deformation constant based on ferrule structure, material, and moulding condition. Typical values C_D are between 0,3 μm and 0,6 μm. Refer to IEC 61300-3-52 for information on how to measure and define Yi.

To ensure compatibility when mating rectangular ferrules with alternative Yi targets, manufacturers of ferrules shall report their specified values for Yi, α, D_o, and C_D.

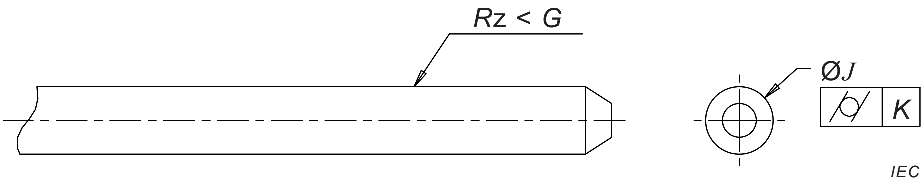
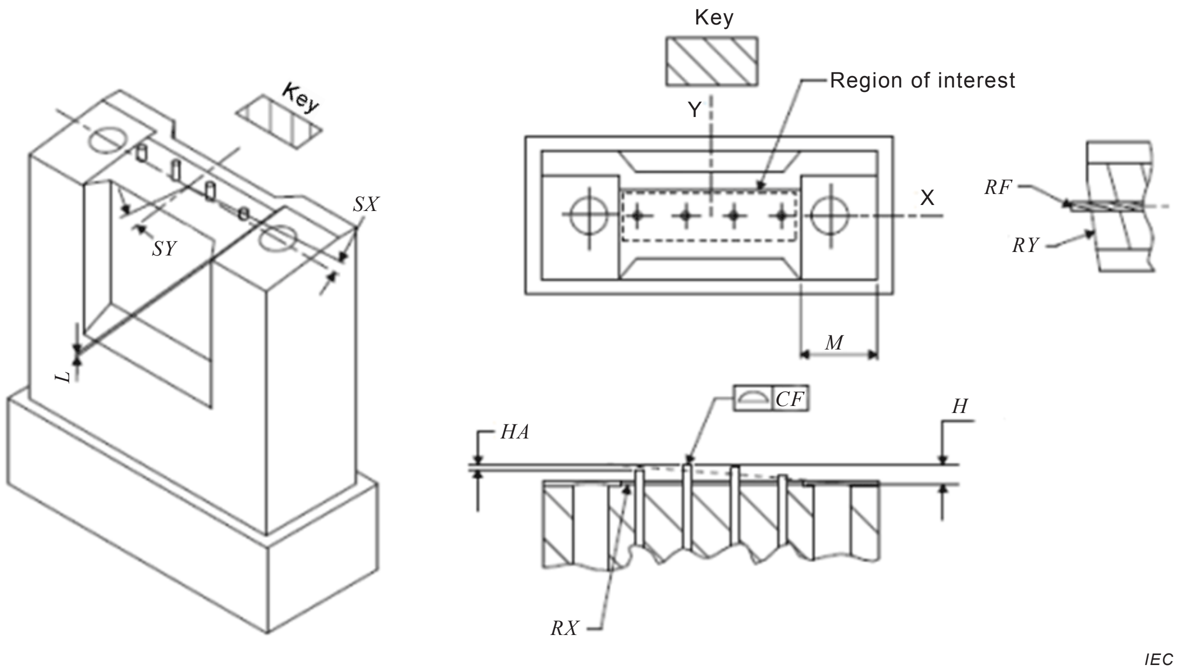


Figure 3 – Alignment pin geometry



NOTE Just four fibres shown for simplicity.

Figure 4 – Interface dimensions related to longitudinal offset

The optical interface coordinate system is established with an x-axis, which passes through the guide hole centres, a perpendicular y-axis that passes through the midpoint of the line connecting the guide hole centres, and an orthogonal z-axis pointing away from the ferrule. All parameters are illustrated as positive values with respect to the defined coordinate system. Concave ferrule radii are indicated by negative values.

Table 2 – Optical interface dimensions related to lateral and angular offset for optical interface variant 2112

Ref.	Parameter values						Units	Remarks
	Grade B		Grade C		Grade D			
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum		
A			–	0,002 0			mm	Core position [a,b]
B *C*			4,598	4,602			mm	Hole pitch
C			–	0,2			°	Fibre angle error
D			0,699 0	0,699 6			mm	Diameter [c]
E			–	0,012			mm	Hole parallelism [d]
G			–	200			nm	RMS roughness
J			0,698 0	0,699 0			mm	Diameter
K			–	0,000 5			mm	Cylindricity
L			0,010	0,350			mm	Recess Depth
M			1,4	1,5				Recess Width

NOTE 1 The core location and tilt angle values specified in this standard have been calculated to ensure that the attenuation values specified in IEC 61755-2-1 are met, under all circumstances, at the single channel level. Refer to Annex A for the relationship between per channel and per connector loss statistics.

NOTE 2 Refer to Figure 2 and Figure 3 for dimensional references.

[a] Variation in fibre core centre location, as controlled by true position tolerance $\varnothing A$, is composed of several parameters including the fibre hole deviation, clearance between fibre cladding and hole, and relative fibre core-to-cladding concentricity. Wherever possible, inspection of the core centre shall be directly measured. Where this is not possible, due to inspection system capability or other constraints, the relevant component features may be independently measured and superimposed to establish a resultant fibre core true position.

[b] If the fibre core centre location is not directly measured for grade C performance, the fibre hole true position target shall be less than 0,001 6 mm for ferrules terminated to IEC 60793-2-50 compliant fibre with a fibre hole diameter ranging between 0,125 5 mm and 0,126 5 mm.

[c] Each guide hole shall accept a gauge pin as shown in Figure 2 of IEC 61754-5:2005 and Figure 5 of IEC 61754-7-1:2014 to a depth of 5,5 mm with a maximum force of 1,7 N. In addition, two guide holes shall accept a gauge as shown in Figure 6 of IEC 61754-5:2005 and Figure 5 of IEC 61754-7:2008 to a depth of 5,5 mm with a maximum force of 3,4 N.

[d] Parallelism tolerance applies over a hole depth of 3,3 mm.

Table 3 – Optical interface end face geometry dimensions related to physical contact for optical interface variant 2112

Ref.	Parameter values		Units	Remarks
	Minimum	Maximum		
CF	–	0,30	µm	Minus coplanarity [a]
SX	–0,15	0,15	°	Ferrule surface x-angle [b]
SY	7,8	8,2	°	Ferrule surface y-angle [c]
H	1	3,5	µm	Fibre height [d]
HA	0	0,5	µm	Adjacent fibre height
RF	1	–	mm	Fibre tip spherical radius[e]
RX	2 000 (convex) │–10 000│ (concave)	–	mm	Ferrule surface x-radius
RY	5	–	mm	Ferrule surface y-radius
GL	–	13,9		Geometry limit[f]

NOTE 1 End face parameter requirements apply to performance grades B, C, and D.

NOTE 2 Refer to Figure 4 for dimensional references.

NOTE 3 End face geometry to be measured in accordance with IEC 61300-3-30.

NOTE 4 The values in Table 3 above to be specified in the central surface region surrounding fibres of 2,900 mm wide and 0,675 mm high. Furthermore, the outside surface region is lower than the central surface region of interest.

NOTE 5 The values in Table 3 above apply for thermoset (TS) ferrules with a Young’s modulus of 20 GPa to 25 GPa. Ferrule compression force: 7,8 N minimum and 11,8 N maximum.

[a] Refer to Annex B for a description of minus coplanarity.

[b] X-angle represents the slope of the ferrule surface as defined by a bi-parabolic fit in accordance with IEC 61300-3-30.

[c] Y-angle represents the slope of the ferrule surface as defined by a bi-parabolic fit in accordance with IEC 61300-3-30.

[d] A positive value indicates a fibre protrusion.

[e] Fibre tip spherical radii fitting region is defined within IEC 61300-3-30.

[f] Refer to Annex C for a description of parameter *GL*.

Annex A
(informative)

Theoretical worst-case connector attenuation yield percentage

Rectangular ferrule connector core alignment specifications are defined at the single channel level. A population of fibre links interconnected with Grade C rectangular ferrules will yield ≤ 0,5 dB attenuation for ≥ 97 % of all channels with a mean of ≤ 0,25 dB. The intra-connector channel grouping of fully populated multi-fibre connectors results in the following theoretical, worst-case connector attenuation yield percentage for a completely random core alignment distribution:

$$\text{Multi-fibre connector attenuation yield \%} = \{\text{single channel attenuation yield \%}\}^{n} \quad \text{(A.1)}$$

where n is the total number of populated fibres per ferrule.

A population of channels individually along with the theoretical worst case performance by connector for Grade C 2 fibre ferrules is illustrated in Figure A.1. Based on the Monte Carlo simulation, attenuation yield percentages for Grade B are given in Table A.1.

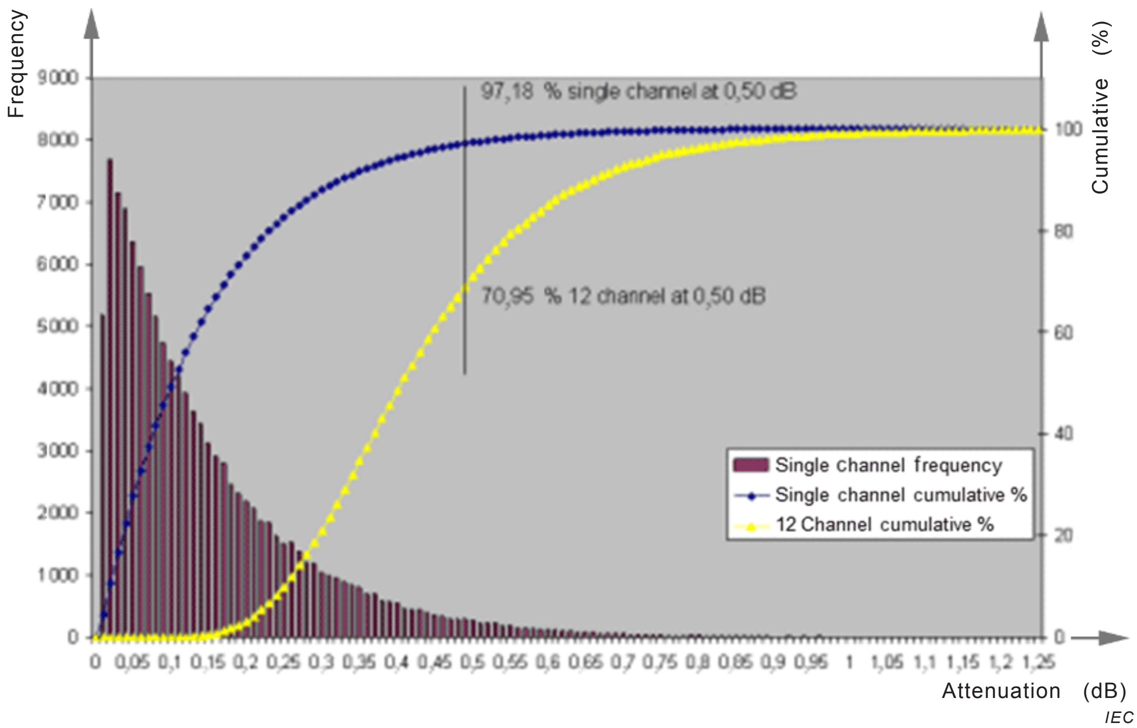


Figure A.1 – Monte Carlo simulation of Grade C performance for 12-fibre connectors

Table A.1 – Grade C single channel vs. multi-fibre connector performance

Attenuation dB	**Single channel cumulative** %	**4 fibre cumulative** %	**8 fibre cumulative** %	**12 fibre cumulative** %
0,5	97,18	89,19	79,55	70,95
0,55	98,08	92,54	85,63	79,24
0,6	98,66	94,75	89,77	85,05
0,65	99,06	96,29	92,72	89,29
0,7	99,37	97,50	95,07	92,70
0,75	99,57	98,29	96,61	94,96
0,8	99,69	98,77	97,55	96,34
0,85	99,79	99,16	98,33	97,51
0,9	99,85	99,40	98,81	98,21
0,95	99,90	99,60	99,20	98,81
1	99,93	99,72	99,44	99,16

NOTE Mean = 0,14 dB.

Annex B
(informative)

Minus coplanarity

The fibre protrusion distribution for rectangular ferrules is characterized by a parameter referred to as minus coplanarity. This metric represents the unilateral distance from a least squares fit line through the array of protrusions, known as the fibre line, to the minimum height fibre as illustrated in Figure B.1

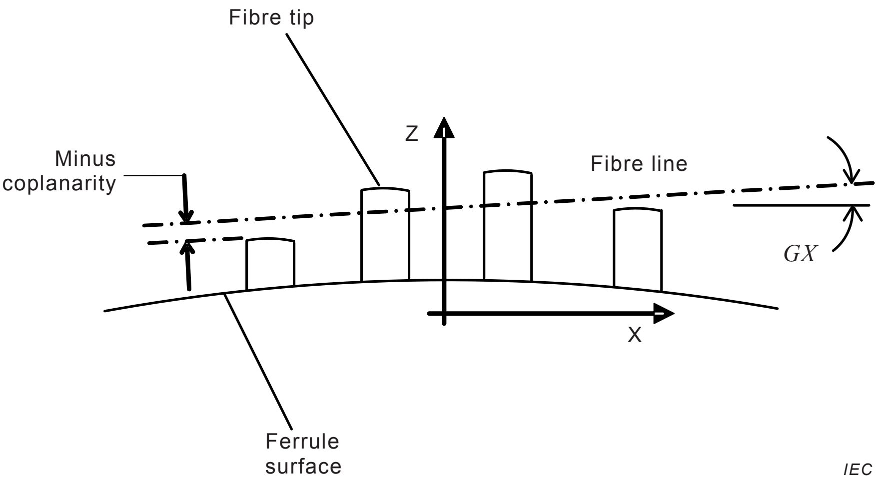


Figure B.1 – Illustration of fibre line and minus coplanarity parameters

The fibre line, which provides a single characterization of the height distribution, takes the form:

$$z(\mathrm{x}) = \tan(GX) \cdot x + \beta \quad \text{(B.1)}$$

The angle of the array, GX, denotes the x-slope angle. A measure of the average fibre height at the x-origin of the coordinate system is given by the intercept of the fit, β.

Minus coplanarity, CF, can be defined as:

$$CF = \max(z_i(\mathrm{x}) - Z_i) \quad \text{(B.2)}$$

where

$z_i(\mathrm{x}) - Z_i$ represents the deviation of each fibre tip, i, from the fibre line. The physical significance of minus coplanarity is that it indicates the requisite axial displacement of the fibre line needed to ensure physical contact across the fibre array under worst case mating conditions.

Annex C
(informative)

Minimum normal force required to achieve physical contact

To establish limits of acceptance on end face geometry, a mathematical system model was developed to estimate the minimum normal force required to achieve physical contact across an array of mated fibres. This model takes into account various factors including:

– fibre tip compression and axial stiffness;
– elastic, foundational deflection of the ferrule structure;
– rotational stiffness of the system;
– frictional resistance between the alignment pins and holes;
– variation in end face geometry dimensions.

For a ferrule with a single row of fibres, there are three dominant end face dimensions that influence the minimum mating force needed to assure physical contact:

– X-slope angle of the end face, SX;
– minus coplanarity of the fibre array, CF;
– Fibre tip spherical radius of curvature, RF.

These parameters were systematically varied to determine their interrelationships with mating force. As a result of the analysis, a geometry limit, GL, can be used to quantitatively assess the acceptability of an end face. This term is a calculated merit function, which relates X-slope angle, coplanarity, and fibre tip radii in comparison to the defined ferrule compression force. For a specific end face condition, lower calculated values for GL indicate a better geometry. For instance, GL is zero for interfaces with perfectly coplanar fibres and null X-slope angle. A maximum allowable limit can therefore be placed on GL to serve as a bound for unacceptable geometries. Furthermore, the magnitude of the limit may be different depending on the number of fibres or the ferrule material type.

To develop the relationship between GL, CF, and SX, end faces with flat fibre tips ($RF = \infty$) were initially studied as summarized in Figure C.1.

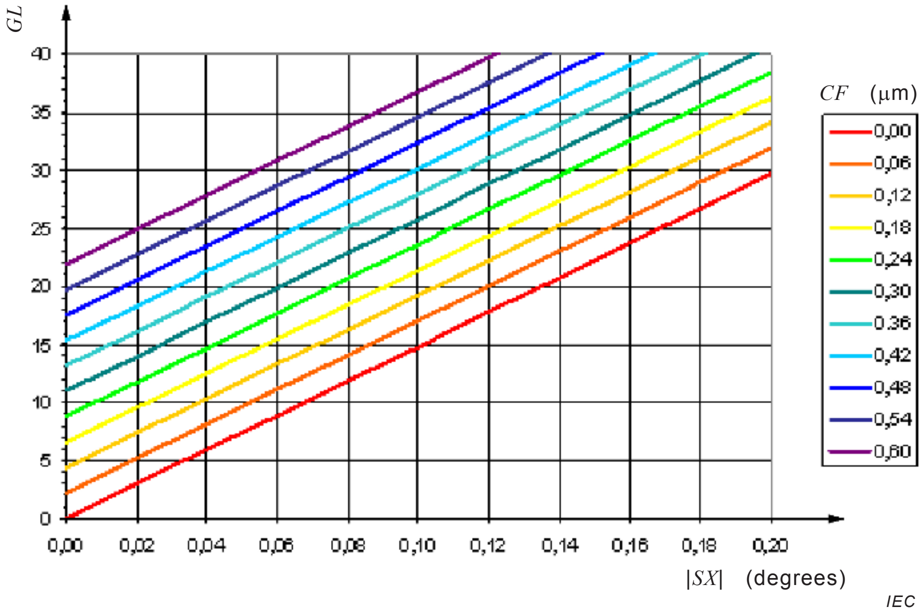


Figure C.1 – Geometry limit (GL), needed to mate 12 fibres, as a function of absolute X-angle, $|SX|$ for different magnitudes of minus coplanarity and flat fibre tips

Inspection of the results indicates that the family of curves are linear with equal slopes and constant offsets between their y-axis intercepts. This gives a functional relationship of the form:

$$GL(SX, CF, RF = \infty) = B \cdot |SX| + D \cdot CF \quad Fmax(SX, CF, RF = \infty) = B \cdot |SX| + D \cdot CF \qquad \text{(C.1)}$$

When the fibre tips have finite radii of curvature, there is slight nonlinearity and the slopes of the curves steepen with increasing CF. Additionally, the value of GL when $|SX| = 0$ is no longer directly proportional to CF as illustrated in Figure C.2.

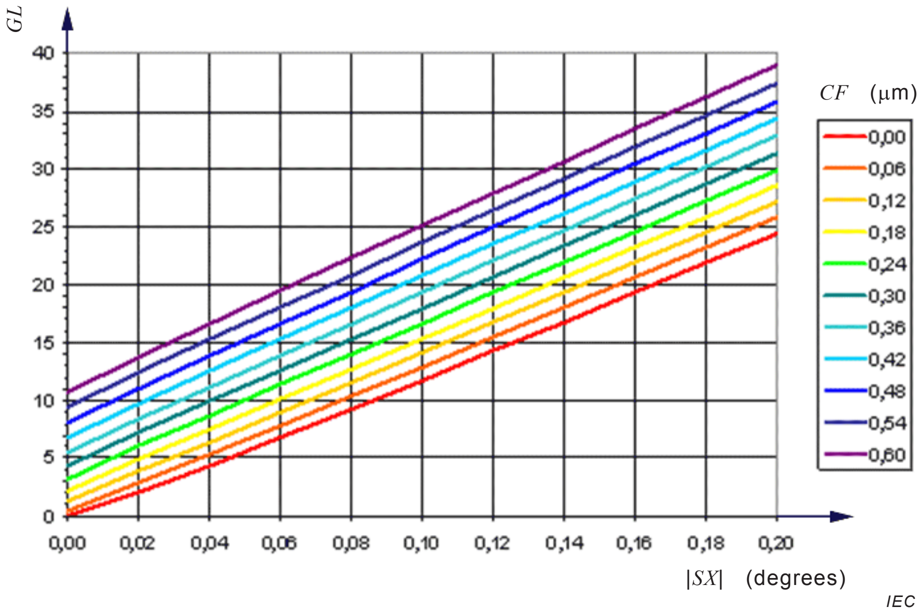


Figure C.2 – Geometry limit (GL), needed to mate 12 fibres, as a function of absolute X-angle, $|SX|$ for different magnitudes of minus coplanarity and 1 mm fibre tips

A function that fits this behaviour can be expressed as

$$GL(SX,CF) = [(A_0 - A_1)\cdot e^{-A_q \cdot CF} + A_1]\cdot(e^{-n\cdot|SX|} - 1) + [(B_0 - B_1)\cdot e^{-B_q \cdot CF} + B_1]\cdot|SX| + C\cdot(e^{-p\cdot CF} - 1) + \ldots D\cdot CF \qquad \text{(C.2)}$$

where the parameter constants, A_0, A_1, A_q, n, B_0, B_1, B_q, C, p and D are related to the fibre tip radius of curvature, RF, as defined by

$$f(RF) = (f_1 - f_0)\cdot e^{-\frac{f_q}{RF}} + f_0 \qquad \text{(C.3)}$$

The letter f given in Equation (C.3) represents any of the parameter constants. The resultant function, when Equation (C.2) and Equation (C.3) are combined, is constructed such that $GL = 0$ when $CF = 0$ and $SX = 0$. Furthermore, the function degenerates to the simple linear form given in Equation (C.1) when RF approaches infinity.

There are 30 constants that define the relationship among GL, SX, CF, and RF. When fully expanded the function takes the form of

$$GL(SX,CF,RF) = \left[\left(\left((A_{01} - A_{00})\cdot e^{-\frac{A_{0q}}{RF}} + A_{00}\right) - \left((A_{11} - A_{10})\cdot e^{-\frac{A_{1q}}{RF}} + A_{10}\right)\right)\cdot e^{-\left((A_{q1} - A_{q0})\cdot e^{-\frac{A_{qq}}{RF}} + A_{q0}\right)\cdot CF} + (A_{11} - A_{10})\cdot e^{-\frac{A_{1q}}{RF}} + A_{10}\right]\cdot\left(e^{-\left((n_1 - n_0)\cdot e^{-\frac{n_q}{RF}} + n_0\right)\cdot|SX|} - 1\right) + \left[\left(\left((B_{01} - B_{00})\cdot e^{-\frac{B_{0q}}{RF}} + B_{00}\right) - \left((B_{11} - B_{10})\cdot e^{-\frac{B_{1q}}{RF}} + B_{10}\right)\right)\cdot e^{-\left((B_{q1} - B_{q0})\cdot e^{-\frac{B_{qq}}{RF}} + B_{q0}\right)\cdot CF} + (B_{11} - B_{10})\cdot e^{-\frac{B_{1q}}{RF}} + B_{10}\right]\cdot|SX| + \left((C_1 - C_0)\cdot e^{-\frac{C_q}{RF}} + C_0\right)\cdot\left(e^{-\left((p_1 - p_0)\cdot e^{-\frac{p_q}{RF}} + p_0\right)\cdot CF} - 1\right) + \left((D_1 - D_0)\cdot e^{-\frac{D_q}{RF}} + D_0\right)\cdot CF$$

(C.4)

For incorporation with end face inspection algorithms, this function can also be expressed with Unicode text

GL(SX,CF,RF) = [(((A_01 − A_00) · e^(−A_0q/RF) + A_00) − ((A_11 − A_10) · e^(−A_1q/RF)
+ A_10)) · e^(−((A_q1 − A_q0) · e^(−A_qq/RF) + A_q0) · CF) + (A_11 − A_10)
· e^(−A_1q/RF) + A_10] · (e^(−((n_1 − n_0) · e^(−n_q/RF) + n_0) · |SX|) − 1)
+ [(((B_01 − B_00) · e^(−B_0q/RF) + B_00) − ((B_11 − B_10) · e^(−B_1q/RF)
+ B_10)) · e^(−((B_q1 − B_q0) · e^(−B_qq/RF) + B_q0) · CF) + (B_11 − B_10)
· e^(−B_1q/RF) + B_10] · |SX| + ((C_1 − C_0) · e^(−C_q/RF) + C_0) · (e^(−((p_1
− p_0) · e^(−p_q/RF) + p_0) · CF) − 1) + ((D_1 − D_0) · e^(−D_q/RF) + D_0) · CF

The parameter constants are dependent on the optical interface variant and are summarized in Tables C.1 to C.3. Thresholds for GL are provided in Table 5 to Table 7.

Table C.1 – Parameter constants for 4-fibre optical interface variant K2

	A_0	A_1	A_q	B_0	B_1	B_q	C	D	N	p
f_0	2,334	1,049	0,000	20,930	0,000	0,402	2,470	12,402	0,000	4,296
f_1	0,000	0,000	4,907	84,717	84,717	139,916	0,000	18,072	19,663	27,813
f_q	6,676	8,306	0,000	0,393	0,000	12,201	3,575	2,135	0,000	7,108

Table C.2 – Parameter constants for 8-fibre optical interface variant K3

	A_0	A_1	A_q	B_0	B_1	B_q	C	D	n	p
f_0	3,117	–0,372	0,000	122,558	0,000	–0,439	2,109	15,227	0,000	6,253
f_1	0,000	0,000	4,779	151,602	151,602	–0,441	0,000	27,043	14,698	15,980
f_q	5,504	56,276	0,000	1,095	0,000	–4,844	10,334	2,216	0,000	7,994

Table C.3 – Parameter constants for 12-fibre optical interface variant K4

Anglais	**Français**									
	A_0	A_1	A_q	B_0	B_1	B_q	C	D	n	p
f_0	0,563	–0,313	0,000	120,677	0,000	0,000	3,452	20,367	0,000	4,874
f_1	0,000	0,000	10,082	148,540	148,540	2,481	0,000	36,545	69,299	8,685
f_q	110,476	78,066	0,000	3,129	0,000	0,000	11,688	1,800	0,000	5,860

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