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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~~ Endface geometry of rectangular ferrule

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CONTENTS

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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~~ Endface geometry of rectangular ferrule

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International Standard IEC 61300-3-30 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

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

a) measurement of the individual fibre tip radii;
b) introduction of the geometry limit (GL) metric;
c) introduction of the minus coplanarity metric;
d) new method for measuring the core dips;
e) all measurement regions are now identical for MM and SM fibres;
f) the ferrule surface angle sign convention has been changed.

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

FDIS	Report on voting
86B/4357/FDIS	86B/4378/RVD

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

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

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 "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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

Part 3-30: Examinations and measurements – ~~Polish angle and fibre position on single ferrule multifibre connectors~~ Endface geometry of rectangular ferrule

1 Scope

This part of IEC 61300 describes a ~~procedure to assess~~ method of measuring the end face geometry ~~in guide pin based multifibre ferrules and connectors~~ of rectangular multifibre ferrules having an IEC defined optical interface. The primary attributes are fibre position relative to the end face, either ~~undercut~~ withdrawal or protrusion, end face angle relative to the guide pin bores, fibre tip radii and core dip for multimode fibres.

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.~~

There are no normative references in this document.

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

Guide pin based multifibre connector~~s~~ plugs typically have a rectangular end face with a long axis and a short axis. Ideally, a flat polish is desired on the end face with the fibres protruding slightly and all in the same plane to assure physical contact of the fibre cores when two connectors are intermated. In practice, the end face typically has two different curvatures across the surface along the long and short axis. Since mated ferrules are aligned by pins in the guide holes, the end face of the ferrule ~~must~~ shall be properly oriented (~~X and Y angle~~ S_x and S_y angles) with respect to the guide holes to achieve positive contact. The end face angle S_x in the x axis and the end face angle S_y in the y axis are measured by finding the best fit plane based on a percentage of the highest points in a specified region of interest. The highest points typically show the greatest modulation from an interferometric standpoint. This allows for more robust measurements and greater repeatability between different interferometers.

The angle of the best fit plane is calculated by comparing it to the reference plane which is perpendicular to the axis of each guide hole. ~~The fibre protrusion, (+p), or undercut, (−p), of the~~

~~fibres is a planar height defined as the distance between the fibre end face and the best fit planar surface previously described. Core dip is specific to multimode fibres because the large core is softer than the edge of the fibre and tends to polish away faster. Core dip is calculated by subtracting the average height of the core area from the average height of an annular area near the edge of the fibre.~~ The height H (positive is a protrusion) of the fibres is a planar height defined as the distance between the fibre end face and the best fit plane. Core dip is of more relevance to multimode fibres because the large core is softer than the cladding of the fibre and tends to polish away faster. Core dip is calculated using the paraboloid method described in Annex E.

One method is described for ~~this procedure~~ measuring polish angle and fibre position for a single ferrule multifibre connector by analysing the endface with a three-dimensional interferometry type surface analyser.

5 Measurement regions

The following regions shall be defined on the ferrule end face.

a) Region of interest (ROI): the ROI is set on the ferrule surface and defined by a rectangular region having a long axis (x axis) of length, L, and a short axis (y axis) of height, H. The region of interest is chosen to cover the intended contact zone of the ferrule end face when the ferrules are mated. The region of interest shall be centred on the fibre array. See Figure 1. Refer to Table 1 for measurement areas to be used for different connectors.

b) Extracting region: the extracting region, which includes the fibre end face regions and the associated adhesive regions, is defined by circles having a diameter E, centred on each fibre;

c) Averaging region: the averaging region is set on the fibre surfaces to be used to calculate the fibre height, and is defined by a circle having a diameter F. The averaging region is the same for singlemode (SM) fibres and multimode (MM) fibres.

d) Core dip region: the core dip region is set on the fibre surfaces to be used to calculate the fibre core-dip using the paraboloid method, and is defined by circles having a diameter CD, centred on each fibre.

Core dip adjustment constant: the calculated core dip amplitude following the fit of a paraboloid function to the fibre endface is adjusted by means of constant R_1.

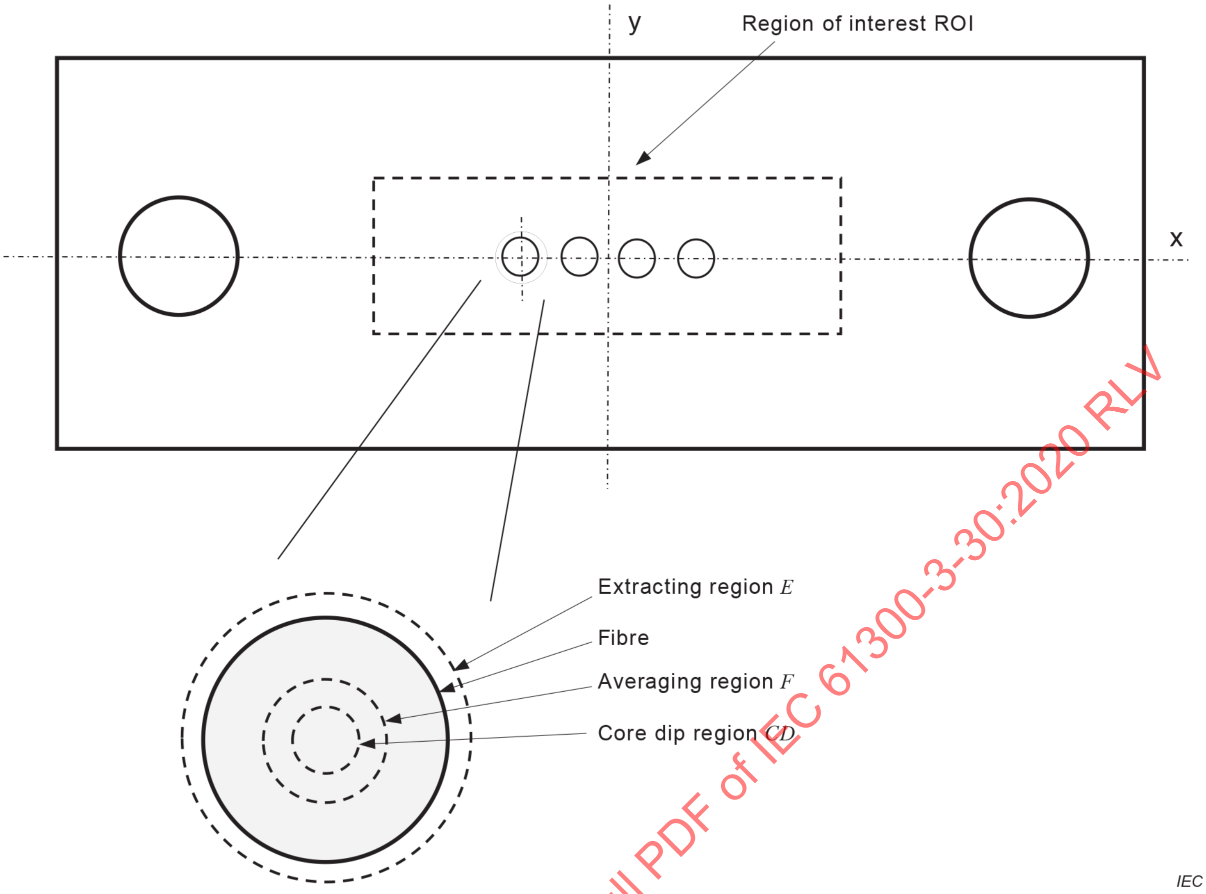


Figure 1 – Measurement regions on ferrule and fibre

Table 1 – Ferrule measurement areas and parameters

Ferrule type (variant number) [a]	Description	Region of interest, ROI ($L \times H$) mm²	% top pixels excluded	Next % top pixels used	Extracting region (diameter E) mm	Averaging region-SM + MM (diameter F) mm	Core dip fitting region (diameter CD) mm	Core dip adjustment constant R_1 (see Annex E)
x104	MT-04	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x108	MT-08	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x112	MT-12	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x124	MT-24	2,900 × 1,160	3	20	0,140	0,05	0,03	0,03
1002	MiniMT	0,900 × 0,675	3	20	0,140	0,05	0,03	0,03

[a] The x defines 1 for polyphenylene sulfide (PPS) resin 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 (see Table 1 of IEC 61755-3-31:2015 and Table 1 of IEC 61755-3-32:2015).

6 Apparatus

~~Three-dimensional surface analysis by an interferometer system.~~

~~The apparatus shown in Figure 1 consists of a suitable ferrule holder, a positioning stage and a three-dimensional interferometry analyser capable of analyzing rough surfaces and step heights.~~

6.1 General

The apparatus shown in Figure 2 consists of a positioning stage, a ferrule holder, an interferometric video microscope, a Personal Computer based fringe interpretation unit and a monitor to view the ferrule endface interferogram and display the analysis results.

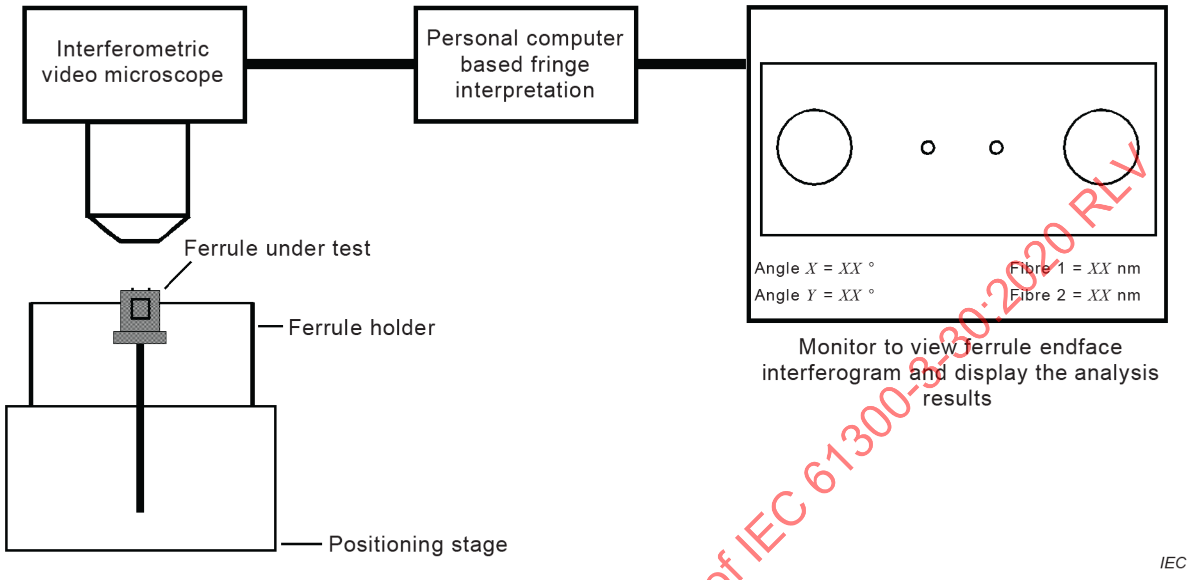


Figure 2 – Measurement setup

6.2 Ferrule holder

The ferrule holder is a suitable device to hold the ferrule in a fixed position, either vertical or horizontal, or in a tilted position in the case of an angled ferrule type. Some method ~~must~~ shall be used to ~~reference~~ determine the axis of each guide hole and the average plane perpendicular ~~angle to them, which shall be considered the ideal end face angle~~ to the guide hole axes. ~~This will typically entail the use of guide pins inserted into the guide holes or similar devices to transfer the axis of each guide hole to a measurable surface angle.~~ This plane shall be considered as the reference plane P for reference to subsequent measurements.

6.3 Positioning stage

The ferrule holder is fixed to the positioning stage, which shall enable the ferrule holder to be moved to the appropriate position. The stage shall have ~~enough~~ sufficient rigidity ~~so as~~ to allow measurement of the ferrule end face parameters within the required ~~accuracy~~ uncertainties detailed in 6.4.

6.4 Three-dimensional interferometry analyser

The three-dimensional interferometry analyser shall have the ability to measure the fibre heights on the ferrule end face with an ~~accuracy of~~ uncertainty better than ±50 nm and the core dips with an uncertainty better than ±20 nm. The analyser shall consist of an interferometric video microscope unit, a Personal Computer based fringe interpretation (surface data processing) unit and a monitor.

The interferometric video microscope unit shall consist of an interference microscope, a phase shift actuator, an image detector and ~~a frame grabber~~ an image acquisition and processing setup. The interference microscope equipped with an objective is arranged so as to view the end face of the ferrule.

~~The surface data processing unit shall be able to process the surface height information so as to measure the radius of curvature in the X and Y axis, the angle of the end face in the X and~~

~~Y axis and the protrusion or undercut of the fibres from the best fit planar surface. A flatness deviation shall be calculated to determine if the connector has too great a curvature to consider the surface a plane.~~

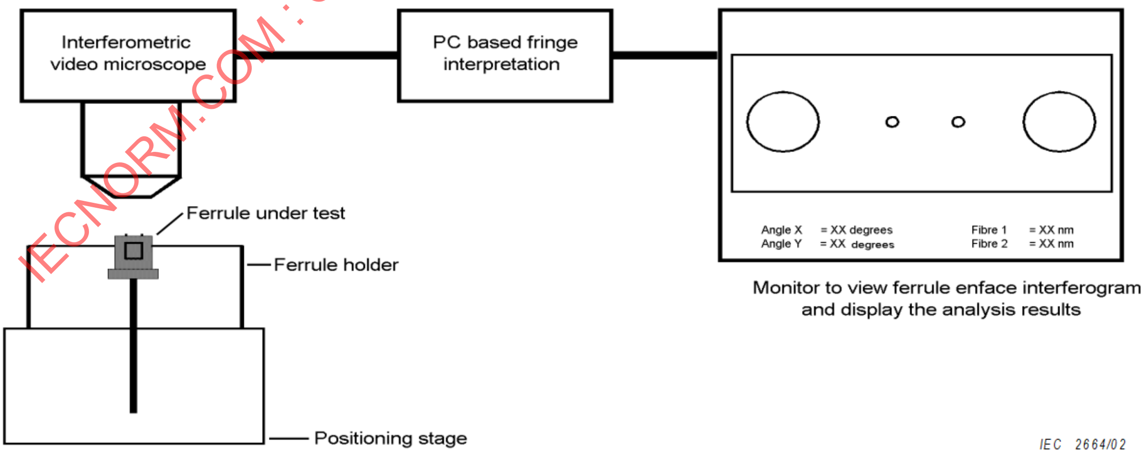
The following parameters of the interference microscope shall be calibrated:

– optical magnification of the microscope;
– Z travel of the phase shift actuator;
– ferrule holder tilt angle in the case of an angled ferrule type.

The surface data processing unit shall be able to process the surface height information so as to measure the following parameters:

– ferrule surface x-angle S_x (refer to Figure B.1 a) for the sign convention);
– ferrule surface y-angle S_y (refer to Figure B.1 b) for the sign convention;
– fibre array minus coplanarity CF;
– fibre plane x-angle G_x;
– fibre plane y-angle G_y;
– fibre tip spherical radii RF (some conditions apply; see Clause 7, m); refer to Figure C.1 for fibre counting convention);
– core dip CD (some conditions apply; see Clause 7, l); refer to Figure C.1 for fibre counting convention);
– geometry limit GL;
– ferrule surface x-radius R_x;
– ferrule surface y-radius R_y;
– fibre height H (refer to Figure C.1 for fibre counting convention);
– adjacent fibre height differential HA (refer to Figure C.1 for fibre counting convention);

The monitor shall display the measured and calculated surface profiles along each axis.



~~Figure 1 – Three-dimensional interferometry analyser~~

7 Procedure

~~5.1 Measurement regions~~

~~The following regions shall be defined on the ferrule end face for the measurement.~~

a) *Region of interest (ROI):* the ROI is set on the ferrule surface and defined by a rectangular region having a long axis (X axis) of length, L, and a short axis (Y axis) of height, H; The region of interest is chosen to cover the intended contact zone of the ferrule end face when the ferrules are mated. The region of interest shall be centred on the fibre array. See Figure 2. Refer to Table 1 for measurement areas to be used for different connectors.

b) *Extracting region:* the extracting region, which includes the fibre end face regions and the associated adhesive regions, are defined by circles having a diameter E, centred on each fibre;

c) *Fitting region:* the fitting region is the region of interest excluding the extracting regions and is the data set used in making calculations for the ferrule surface. It is assumed that the surface points on the ferrule outside the fitting region will be lower than the surface points in the fitting region.

d) *Averaging region:* the averaging region is set on the fibre surfaces to be used to calculate the fibre height, and is defined by a circle having a diameter F. The averaging region is different for singlemode (SM) fibres and multimode (MM) fibres.

e) To assess core dip in MM fibres, two averaging regions are used. The first is the *core fitting region* with a diameter D_{core}. The second region is an *annular area* bound by a maximum annular ring of diameter D_{max} and a minimum annular ring of D_{min}. See Figure 3. Refer to Table 2 for measurement areas.

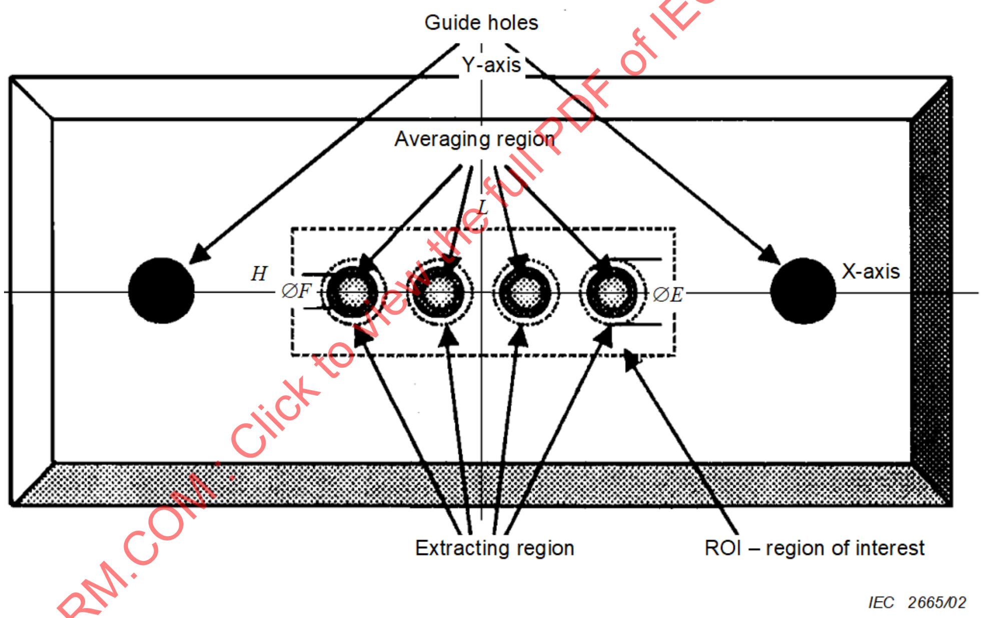
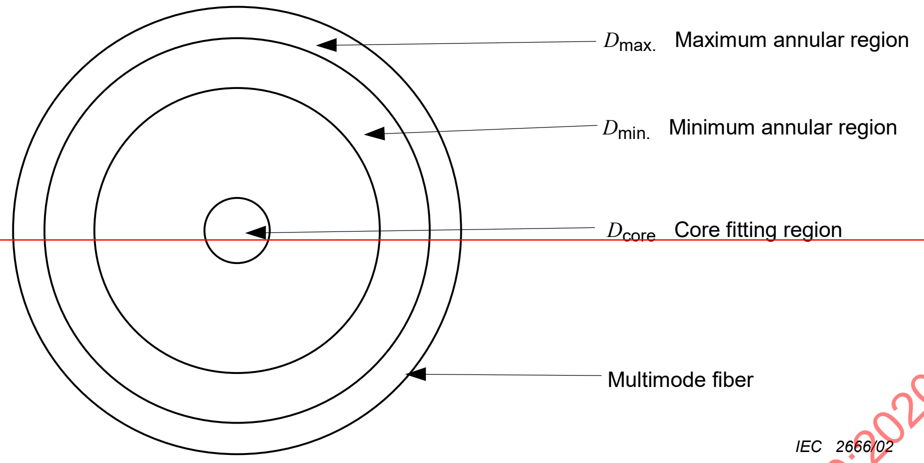


Figure 2 – Measurement regions on ferrule



~~**Figure 3 – Multimode fibre core dip regions**~~

~~5.2 Method for analysis~~

~~**5.2.1** Affix the ferrule in the ferrule holder so that the end face is held sufficiently steady with respect to the interferometer.~~

~~**5.2.2** Focus the microscope and/or the sample until the fringes are in position to scan the surface.~~

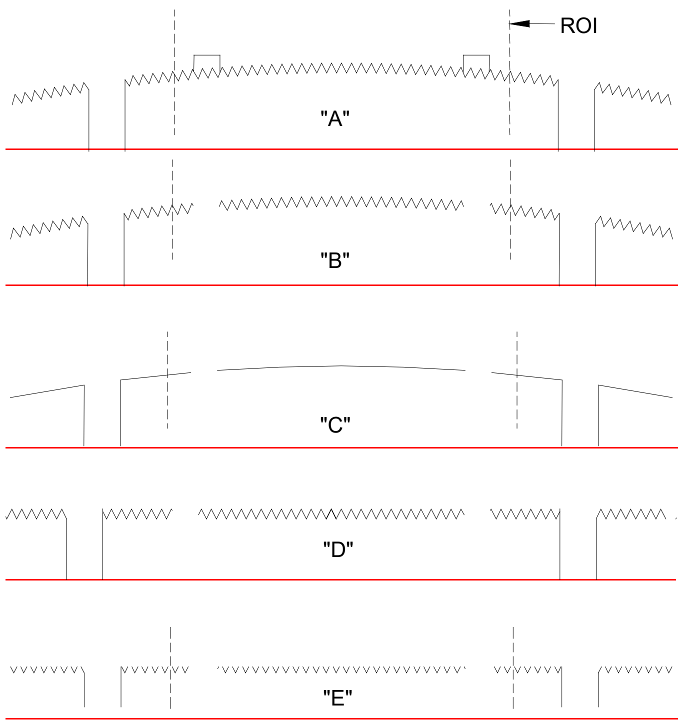
~~**5.2.3** Map the surface of the ferrule. To create data set "A", use only the pixels contained within the ROI.~~

~~**5.2.4** Create data set "B" by removing the extraction regions around the fibres.~~

~~**5.2.5** Create surface "C" by fitting a biparabolic curve to data set "B". (See Annex A for a suggested curve fitting routine.)~~

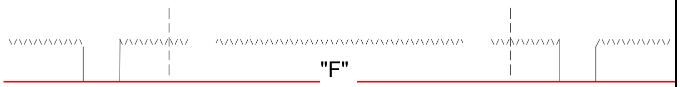
~~**5.2.6** Create data set "D" by subtracting surface "C" from data set "B".~~

~~**5.2.7** Create data set "E" by removing the highest 3 % of all pixels in data set "D". This removes any small points that are extremely high compared to the others. It is assumed these will break off when the connectors contact.~~



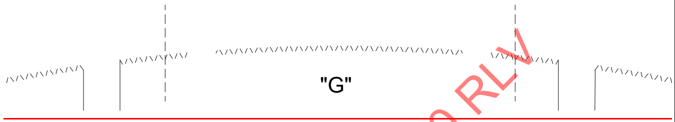
NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

5.2.8 Create data set “F” by identifying the highest 20 % of all pixels in data set “E”.

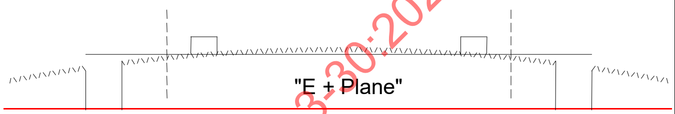


NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

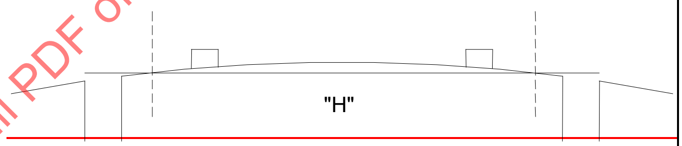
5.2.9 Create data set “G” by eliminating all pixels from data set “A” except for those identified in data set “F”.



5.2.10 Fit a plane to data set “G” and use the plane to calculate X and Y angles using the average of the guide pin bore axis as a reference. (See Annex B for end face angle sign conventions.) “Add” the extraction regions back in. Calculate the fibre heights as the distance normal to the plane at the corresponding fibre centre locations. (See Annex C for fibre counting conventions.)



5.2.11 Create surface “H” by fitting a biparabolic curve to data set “G”. Calculate the flatness deviation. To find the flatness deviation, first draw a plane through the points where the biparabolic curve intersects a projection of the region of interest. Flatness deviation is the distance from the apex of the biparabolic curve to the plane. Calculate the X and Y radius values.



NOTE Ferrule end faces are typically flat. The curvature in these drawings has been exaggerated for illustrative purposes.

5.2.12 Determine the MM core dip.

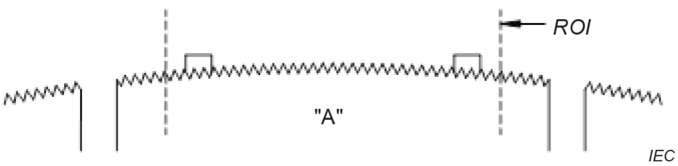
This is accomplished by subtracting the average height of the core fitting region D_{core} from the average height of the annular area, defined by diameters D_{min} and D_{max}.

The following procedure shall be used for this measurement.

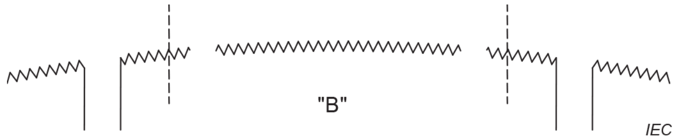
a) Affix the ferrule in the ferrule holder so that the end face is held sufficiently steady with respect to the interferometer.

b) Focus the microscope and/or the sample until the fringes are in position to scan the surface.

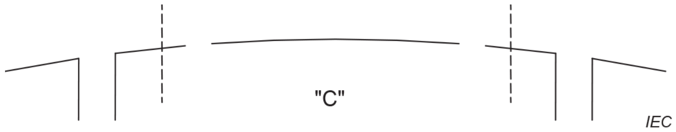
c) Map the surface of the ferrule. To create data set "A", use only the pixels contained within the ROI.



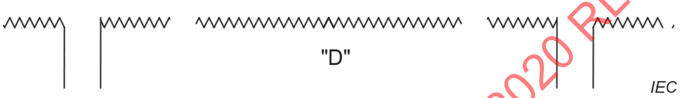
d) Create data set "B" by removing the extracting regions around the fibres.



e) Create surface "C" by fitting a bi-parabolic curve to data set "B" (see Annex A for the curve fitting routine).



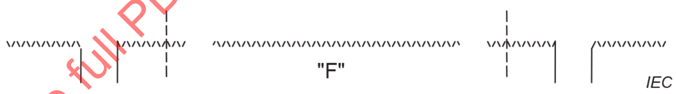
f) Create data set "D" by subtracting surface "C" from data set "B"



g) Create data set "E" by removing the highest 3 % of all pixels in data set "D". This removes any small points that are extremely high compared to the others. It is assumed these will break off when the connectors contact.

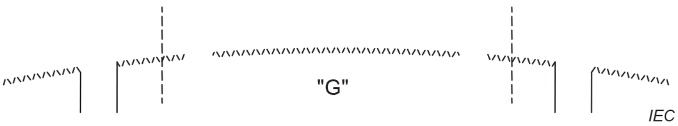
NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

h) Create data set "F" by identifying the highest 20 % of all pixels in data set "E".

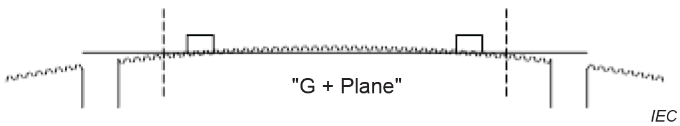


NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

i) Create data set "G" by eliminating all pixels from data set "A" except for those identified in data set "F".



j) Fit a plane to data set "G" and use the plane to calculate S_x and S_y angles using plane P as a reference (see Annex B for end face angle sign conventions). "Add" the extracting regions back in.



Calculate the fibre heights H as the distance normal to the plane at the corresponding fibre centre locations (see Annex C for fibre counting conventions). Calculate the adjacent fibre height differential HA for each fibre. For a given fibre, HA is the largest height difference to the two (single row ferrule case) or four (multi row ferrule case) neighbour fibres.

k) Fit a bi-parabolic curve to data set "G" (see Annex A for the curve fitting routine). Calculate the ferrule surface R_X and R_Y radii values.

l) Determine the core dip (for multi-mode and singlemode fibres) *CD* of each fibre. See Annex E for a detailed procedure.

If *CD* of a given fibre is positive and larger than 10 nm, report *CD* and skip step m) for that given fibre.

If *CD* of a given fibre is negative or smaller than 10 nm, do not report *CD* for that given fibre and proceed to step m).

m) Determine the radius *RF* of a given fibre tip. This is accomplished by fitting a sphere to the surface points of the averaging region of the fibre (see Annex A for the curve fitting routine). The radius of the fitted sphere is then taken as the fibre tip radius.

n) Determine the minus coplanarity *CF*. See Annex D for a detailed procedure. Use the fibre plane to calculate G_X and G_Y angles using the average of the guide pin bore axes as a reference (see Annex B for end face angle sign conventions).

o) If *CD* is negative or smaller than 10 nm for more than 50 % of the fibres, determine the geometry limit *GL* using the median value of the *RF* values of the fibres which exhibited a negative *CD*. See Annex F.

8 Details to be specified

~~Three-dimensional interferometry analysis.~~

~~The following measurements will be displayed:~~

~~a) end face angle in the X-axis;~~

~~b) end face angle in the Y-axis;~~

~~c) individual fibre positions – undercut (–*p*) or protrusion (+*p*) for all fibres;~~

~~d) maximum difference in fibre height among all fibres;~~

~~e) maximum adjacent fibre height differential;~~

~~f) flatness deviation over the region of interest;~~

~~g) maximum core dip for fibres.~~

~~**Table 1 – Ferrule measurement areas**~~

~~Ferrule type~~	~~Region of interest ROI ($L \times H$) mm²~~	~~% Top pixels excluded~~	~~Next % top pixels used~~	~~Extraction region (diameter *E*) mm~~	~~Averaging region-MM (diameter *F*) mm~~	~~Averaging region-SM (diameter *F*) mm~~
~~MT~~	~~2,900 × 0,675~~	~~3~~	~~20~~	~~0,140~~	~~0,100~~	~~0,50~~
~~MiniMT~~	~~0,900 × 0,675~~	~~3~~	~~20~~	~~0,140~~	~~0,100~~	~~0,50~~

~~**Table 2 – Multimode core dip areas**~~

~~Core averaging region~~	~~Annular region~~	
~~D_{core}~~	~~D_{min}~~	~~D_{max}~~
~~20 µm~~	~~70 µm~~	~~90 µm~~

The following items shall be specified for this measurement:

– type of interferometry;

– nominal angle of tilt, for example Physical contact (PC)/angled PC (APC);
– any deviation from this method;
– measurement uncertainty.

Annex A
(informative normative)

Formulae for calculating approximating the end face geometry

A.1 Approximation of the ferrule surface

The ideal ferrule surface being calculated for multifibre connectors is described by Formula (A.1):

$$Z = -X^2/(2R_x) - Y^2/(2R_y) + S_x X + S_y Y + C$$

$$Z = -X^2/(2R_X) - Y^2/(2R_Y) - S_X \times X + S_Y \times Y + C \quad \text{(A.1)}$$

The coefficients for this formula which result in the best fitting ideal surface are found using a matrix computation method known as Cholesky Decomposition least square approximation. R_x and R_y are the radius radii of curvatures for a bi-parabolic surface along the x and y axes: S_x provides the x-axis surface angle value, while S_y provides the y-axis surface angle value. C is the constant that identifies the relative height. By setting the squared terms to zero, a planar surface is defined.

A.2 Approximation of the fibre tip radii

The ideal surface being calculated for each fibre tip is a sphere and is described by Formula (A.2):

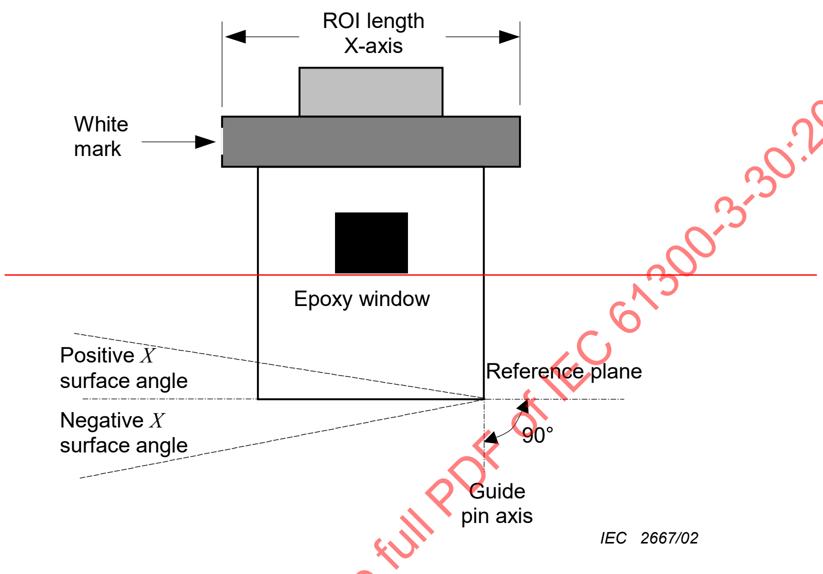
$$(X - X_0)^2 + (Y - Y_0)^2 + (Z - Z_0)^2 = RF^2 \quad \text{(A.2)}$$

The coefficients for this formula which result in the best fitting ideal surface are found using a least square approximation. RF is the radius of curvature of the fitted sphere. X_0, Y_0 and Z_0 are the coordinates of the centre of the fitted sphere, which may not necessarily be centred on the fibre core (apex offset).

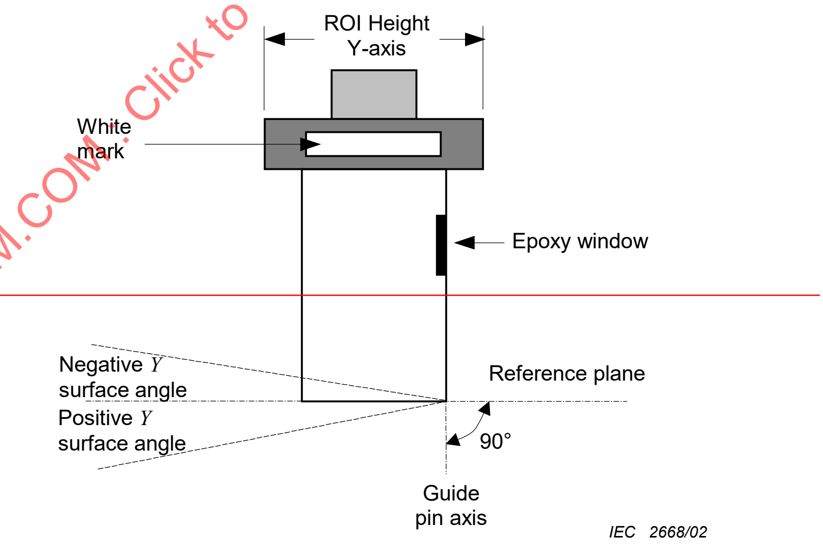
Annex B
(normative)

Surface angle sign convention (shown graphically)

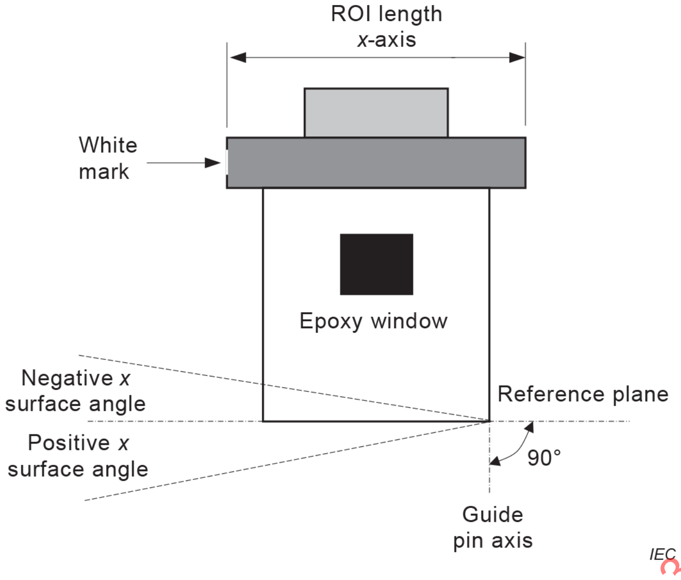
Annex B describes surface angle sign convention graphically. Figure B.1 a) shows the x-axis view, and Figure B.1 b) shows the y-axis view.



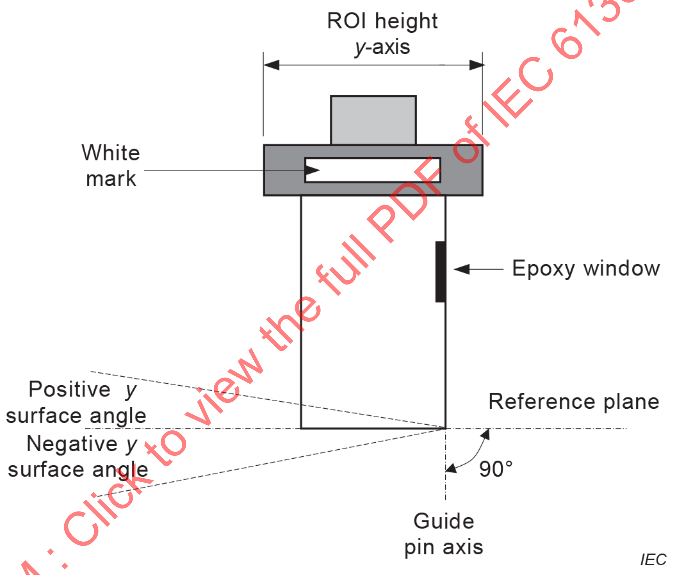
~~Figure B.1a – X-axis view~~



~~Figure B.1b – Y-axis view~~



a) **X-axis view**



b) **Y-axis view**

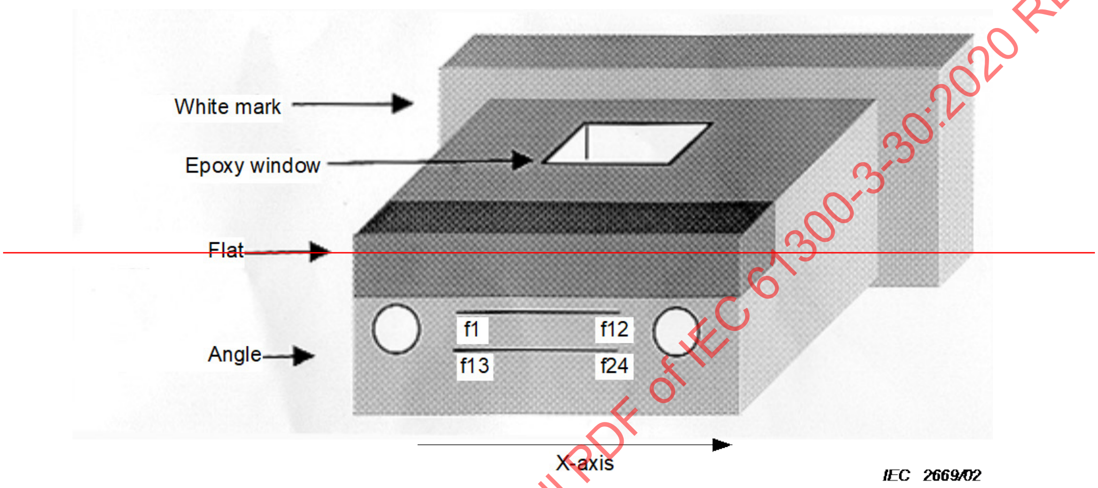
NOTE The optical interface coordinate system is established with an x axis, which passes through the guide hole centres, a perpendicular y axis that passes through the midpoint of the line connecting the guide hole centres, and an orthogonal z axis pointing away from the ferrule.

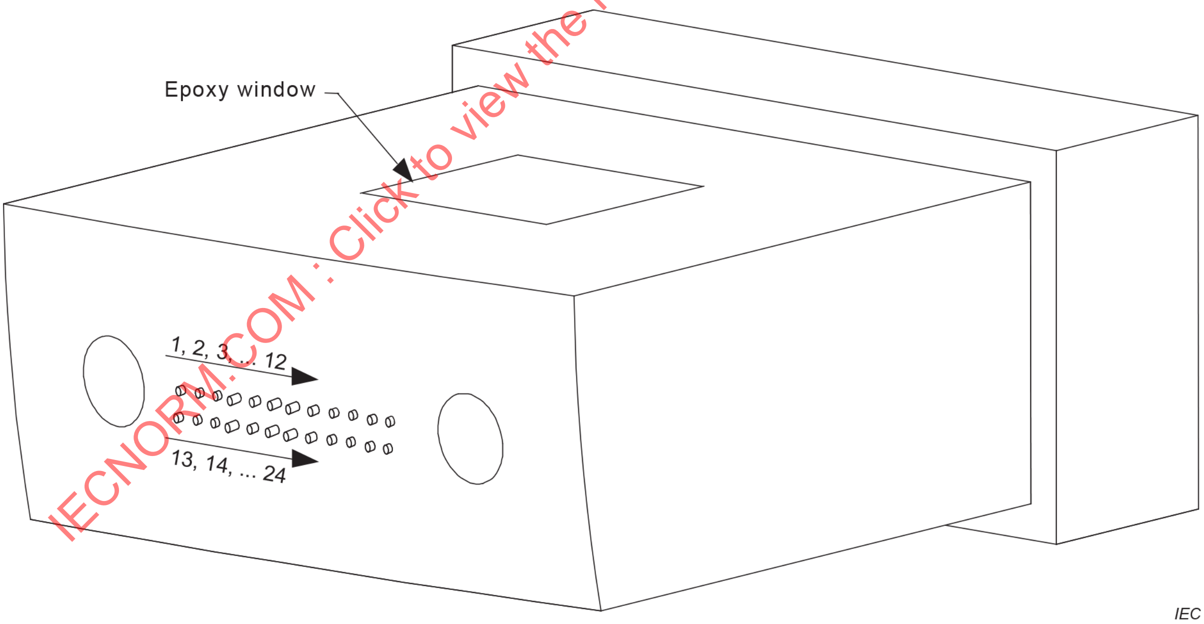
Figure B.1 – Surface angle sign convention

Annex C
(normative)

Fibre counting convention (shown graphically)

Annex C describes fibre counting convention as shown in Figure C.1.





NOTE Fibre counting convention is applicable for all variants: flat or angled.

Figure C.1 – Fibre counting convention

Annex D
(normative)

Minus coplanarity and fibre plane angle determination

D.1 Overview

D.1.1 General

Annex D describes three additional parameters to be calculated and reported for measurements made in accordance with this document.

D.1.2 Minus coplanarity

Minus coplanarity is the greatest parallel offset between the best fit plane (or line in the case of single row ferrules) of the fibre ends (the average elevation of the averaging regions) and a fibre end below that plane (or line).

D.1.3 Fibre plane x-axis and y-axis angles

The relative tilt of the best fit plane of D.1.2 relative to the average of the guide pin bore axes.

D.2 Method for analysis

D.2.1 Single row ferrules

Create an array of X and Z values where X is the fibre location and Z is the fibre height determined in Clause 7 j). Fit a least squares line $z(X)$ to this data. Calculate the array minus coplanarity CF as:

$$CF = \max(z(X_i) - Z_i) \quad \text{(D.1)}$$

where

$z(X_i) - Z_i$ is the deviation of each fibre tip, i, from the fibre line.

Calculate the x-axis G_X angle of the least squares fit line (the fibre line) using a line perpendicular to the guide pin bores axes as a reference.

D.2.2 Multi-row ferrules

Create an array of X, Y and Z values where X and Y are the fibre locations and Z is the fibre height determined in Clause 7 j). Fit a least squares plane $z(X,Y)$ to this data. Calculate the array minus coplanarity as:

$$CF = \max(z(X_i, Y_i) - Z_i) \quad \text{(D.2)}$$

where

$z(X_i, Y_i) - Z_i$ is the deviation of each fibre tip, i, from the fibre line.

Calculate the x-axis G_X and y-axis G_Y angles of the least squares fit plane (the fibre plane) using a plane perpendicular to the guide pin bores axes as a reference.

D.3 Documentation

In addition to the requirements of Clause 8, report:

– minus coplanarity;

– x-axis angle G_X of the fibre line (or plane if parts have more than one row);

– y-axis angle G_Y of the fibre plane (if parts have more than one row).

Annex E
(normative)

Calculation of core dip using the paraboloid method

E.1 General

Annex E describes the core dip parameter to be calculated and reported for measurements made in accordance with this document. Core dip is a measurement of the fibre core elevation compared to the cladding elevation at its endface.

E.2 Method for analysis

Fit to each fibre endface surface points located inside zone CD a paraboloid function of type:

$$Z = AX^2 + BY^2 + CX + DY + E \quad \text{(E.1)}$$

The coefficients for Formula (E.1) which result in the best fitting ideal surface are found using a least square approximation. Figure E.1 shows the fitting manner graphically.

For each fibre, the core dip CD is then:

$$CD = (A + B)R_1^2 / 2 \quad \text{(E.2)}$$

NOTE See Table 1 for the value of R_1.

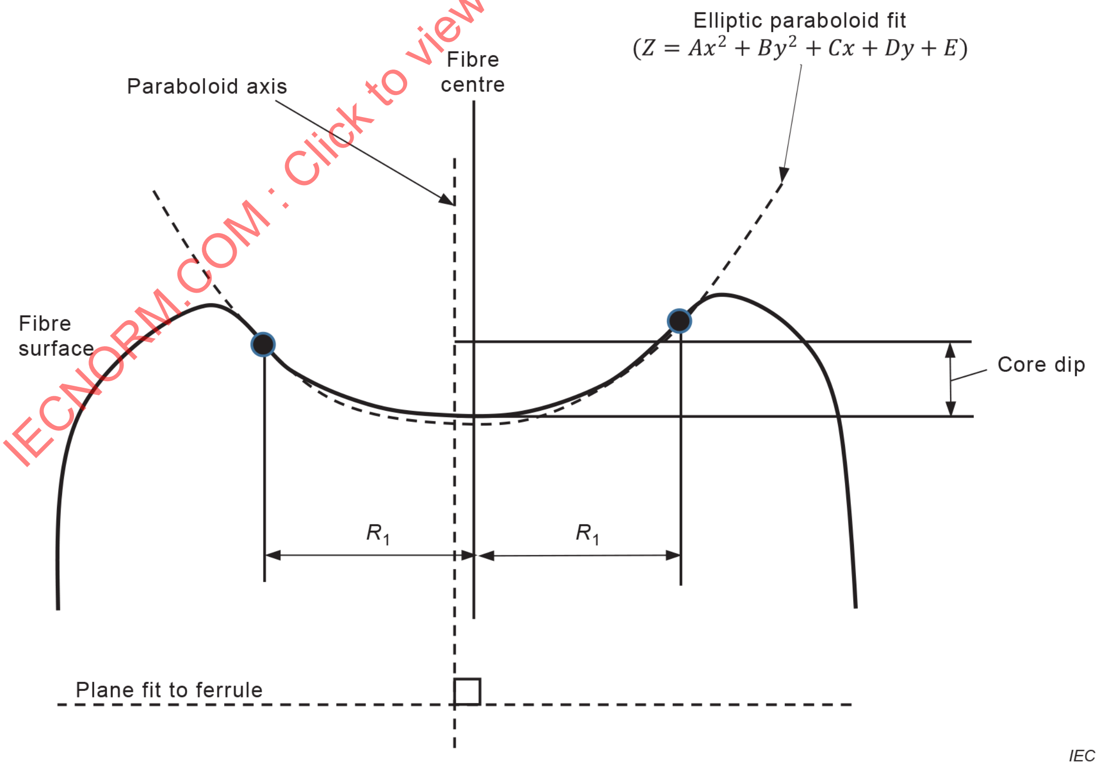


Figure E.1 – Paraboloid fit to a fibre endface exhibiting core dip

Annex F
(normative)

Calculation of *GL* parameter

F.1 General

Annex F describes the *GL* parameter to be calculated and reported for measurements made in accordance with this document. *GL* is used to quantitatively assess the acceptability of an end face geometry.

F.2 Method for analysis

For single-row ferrules, this term is a calculated merit function, which relates x-slope angle, S_x, minus coplanarity, CF, and fibre tip radii, RF. There are 30 constants that define the relationship among these parameters. When fully expanded, the function takes the form of Formula (F.1):

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

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

GL(*S*_x,*CF*,*RF*) = [(((*A*_01 – *A*_00) · e^(–*A*_0*q*/*RF*) + *A*_00) – ((*A*_11 – *A*_10) · e^(–*A*_1*q*/*RF*) + *A*_10)) · *e*^(–((*A*_*q*1 – *A*_*q*0) · *e*^(–*A*_*qq*/*RF*) + *A*_*q*0) · *CF*) + (*A*_11 – *A*_10) · *e*^(–*A*_1*q*/*RF*) + *A*_10] · (*e*^(–((*n*_1 – *n*_0) · e^(–*n*_*q*/*RF*) + *n*_0) · |*S*_x|) – 1) + [(((*B*_01 – *B*_00) · *e*^(–*B*_0*q*/*RF*) + *B*_0) – ((*B*_11 – *B*_10) · *e*^(–*B*_1*q*/*RF*) + *B*_10)) · *e*^(–((*B*_*q*1 – *B*_*q*0) · *e*^(–*B*_*qq*/*RF*) + *B*_*q*0) · *CF*) + (*B*_11 – *B*_10) · *e*^(–*B*_1*q*/*RF*) + *B*_10] · |*S*_x| + ((*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 number of fibres as summarized in Table F.1 to Table F.3[1].

1 *GL* and coplanarity parameters are not defined for the 1002 ferrule type.

Table F.1 – Parameter constants for 4-fibre ferrules

	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 F.2 – Parameter constants for 8-fibre ferrules

	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 F.3 – Parameter constants for 12-fibre ferrules

	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

NOTE Other fibre counts are under development.

Bibliography

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

~~IEC 61753-1-1, *Fibre optic interconnecting devices and passive components performance standard – Part 1-1: General and guidance – Interconnecting devices (connectors)*~~

IEC 61755-3-31:2015, *Fibre optic interconnecting devices and passive components – Connector optical interfaces – Part 3-31: Connector parameters of non-dispersion shifted single mode physically contacting fibres – Angled polyphenylene sulphide rectangular ferrules*

IEC 61755-3-32:2015, *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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IEC 61300-3-30

Edition 2.0 2020-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-30: Examinations and measurements – Endface geometry of rectangular ferrule**

**Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures –
Partie 3-30: Examens et mesures – Géométrie de la face terminale de la ferrule rectangulaire**

IEC 61300-3-30:2020-12(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3-30: Examinations and measurements – Endface geometry of rectangular ferrule

FOREWORD

International Standard IEC 61300-3-30 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

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

a) measurement of the individual fibre tip radii;
b) introduction of the geometry limit (GL) metric;
c) introduction of the minus coplanarity metric;
d) new method for measuring the core dips;
e) all measurement regions are now identical for MM and SM fibres;

f) the ferrule surface angle sign convention has been changed.

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

FDIS	Report on voting
86B/4357/FDIS	86B/4378/RVD

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

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

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 "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

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

Part 3-30: Examinations and measurements – Endface geometry of rectangular ferrule

1 Scope

This part of IEC 61300 describes a method of measuring the end face geometry of rectangular multifibre ferrules having an IEC defined optical interface. The primary attributes are fibre position relative to the end face, either withdrawal or protrusion, end face angle relative to the guide pin bores, fibre tip radii and core dip for multimode fibres.

2 Normative references

There are no normative references in this document.

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

Guide pin based multifibre connector plugs typically have a rectangular end face with a long axis and a short axis. Ideally, a flat polish is desired on the end face with the fibres protruding slightly and all in the same plane to assure physical contact of the fibre cores when two connectors are intermated. In practice, the end face typically has two different curvatures across the surface along the long and short axis. Since mated ferrules are aligned by pins in the guide holes, the end face of the ferrule shall be properly oriented (S_x and S_y angles) with respect to the guide holes to achieve positive contact. The end face angle S_x in the x axis and the end face angle S_y in the y axis are measured by finding the best fit plane based on a percentage of the highest points in a specified region of interest. The highest points typically show the greatest modulation from an interferometric standpoint. This allows for more robust measurements and greater repeatability between different interferometers.

The angle of the best fit plane is calculated by comparing it to the reference plane which is perpendicular to the axis of each guide hole. The height H (positive is a protrusion) of the fibres is a planar height defined as the distance between the fibre end face and the best fit plane. Core dip is of more relevance to multimode fibres because the large core is softer than the cladding of the fibre and tends to polish away faster. Core dip is calculated using the paraboloid method described in Annex E.

One method is described for measuring polish angle and fibre position for a single ferrule multifibre connector by analysing the endface with a three-dimensional interferometry type surface analyser.

5 Measurement regions

The following regions shall be defined on the ferrule end face.

a) Region of interest (ROI): the ROI is set on the ferrule surface and defined by a rectangular region having a long axis (x axis) of length, L, and a short axis (y axis) of height, H. The region of interest is chosen to cover the intended contact zone of the ferrule end face when the ferrules are mated. The region of interest shall be centred on the fibre array. See Figure 1. Refer to Table 1 for measurement areas to be used for different connectors.

b) Extracting region*:* the extracting region, which includes the fibre end face regions and the associated adhesive regions, is defined by circles having a diameter E, centred on each fibre;

c) Averaging region*:* the averaging region is set on the fibre surfaces to be used to calculate the fibre height, and is defined by a circle having a diameter F. The averaging region is the same for singlemode (SM) fibres and multimode (MM) fibres.

d) Core dip region*:* the core dip region is set on the fibre surfaces to be used to calculate the fibre core-dip using the paraboloid method, and is defined by circles having a diameter CD, centred on each fibre.

Core dip adjustment constant*:* the calculated core dip amplitude following the fit of a paraboloid function to the fibre endface is adjusted by means of constant R_1.

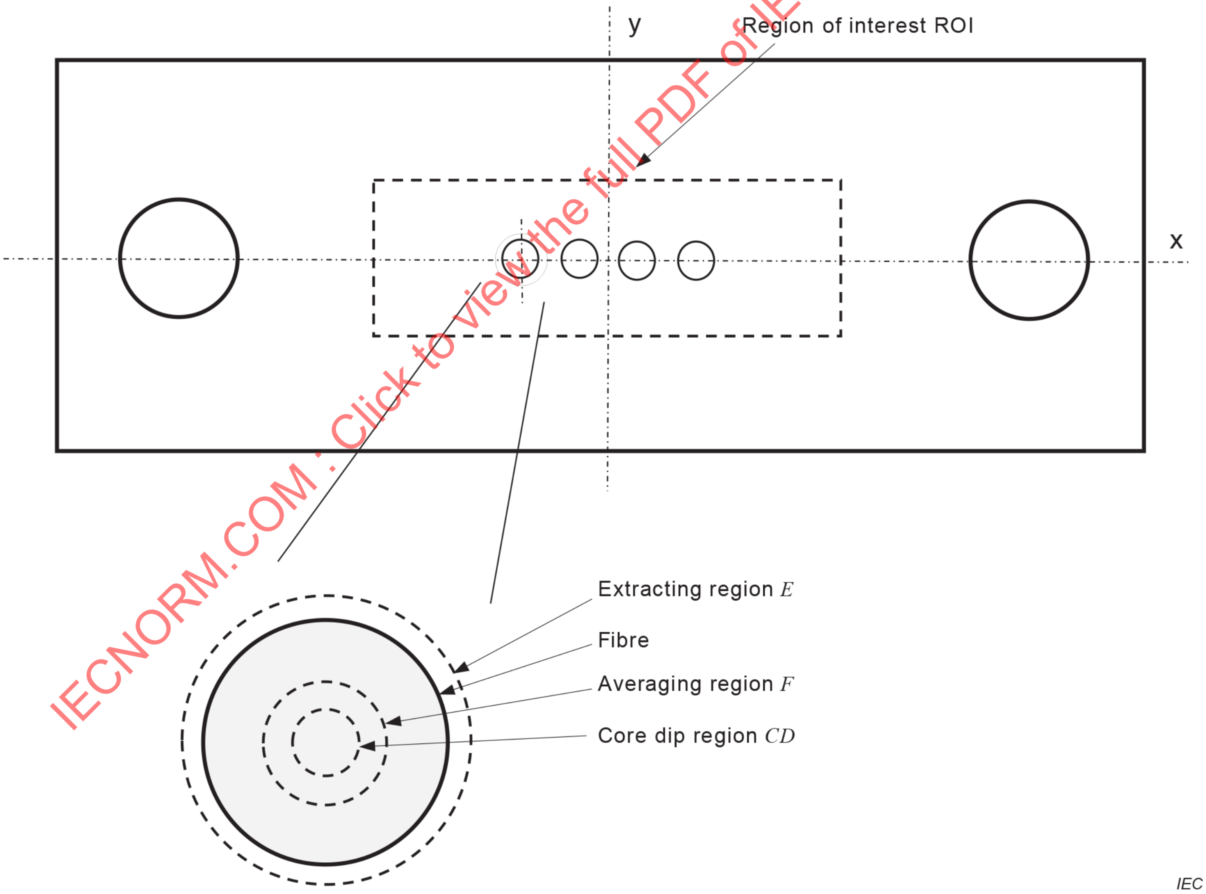


Figure 1 – Measurement regions on ferrule and fibre

Table 1 – Ferrule measurement areas and parameters

Ferrule type (variant number) [a]	Descrip-tion	Region of interest, ROI ($L \times H$) mm²	% top pixels excluded	Next % top pixels used	Extracting region (diameter E) mm	Averaging region- SM + MM (diameter F) mm	Core dip fitting region (diameter CD) mm	Core dip adjustment constant R_1 (see Annex E)
x104	MT-04	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x108	MT-08	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x112	MT-12	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x124	MT-24	2,900 × 1,160	3	20	0,140	0,05	0,03	0,03
1002	MiniMT	0,900 × 0,675	3	20	0,140	0,05	0,03	0,03

[a] The x defines 1 for polyphenylene sulfide (PPS) resin 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 (see Table 1 of IEC 61755-3-31:2015 and Table 1 of IEC 61755-3-32:2015).

6 Apparatus

6.1 General

The apparatus shown in Figure 2 consists of a positioning stage, a ferrule holder, an interferometric video microscope, a Personal Computer based fringe interpretation unit and a monitor to view the ferrule endface interferogram and display the analysis results.

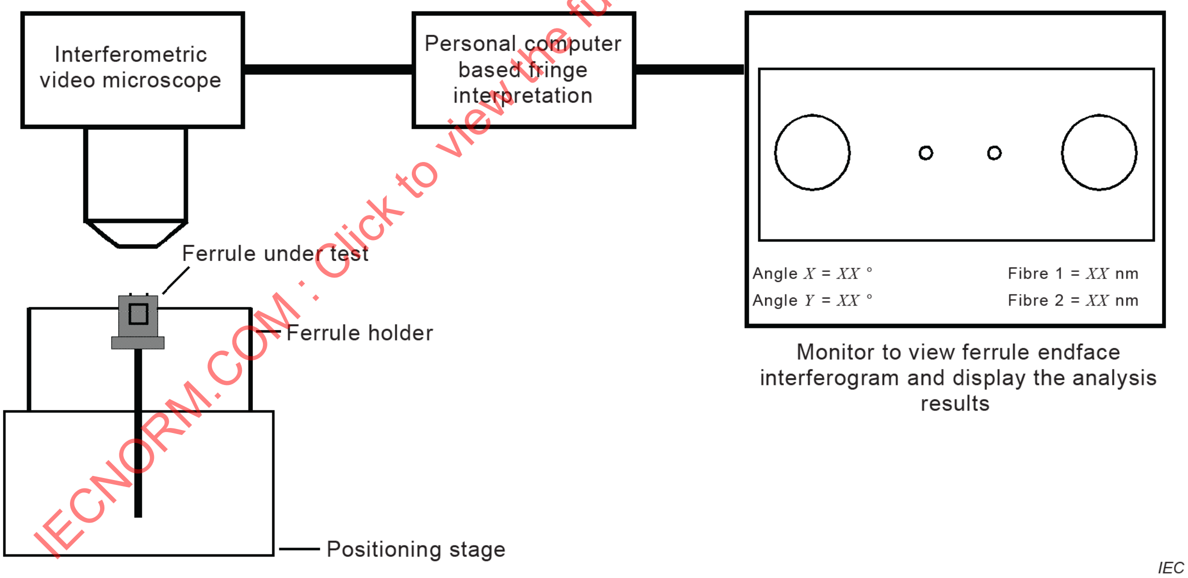


Figure 2 – Measurement setup

6.2 Ferrule holder

The ferrule holder is a suitable device to hold the ferrule in a fixed position, either vertical or horizontal, or in a tilted position in the case of an angled ferrule type. Some method shall be used to determine the axis of each guide hole and the average plane perpendicular to the guide hole axes. This plane shall be considered as the reference plane P for reference to subsequent measurements.

6.3 Positioning stage

The ferrule holder is fixed to the positioning stage, which shall enable the ferrule holder to be moved to the appropriate position. The stage shall have sufficient rigidity to allow measurement of the ferrule end face parameters within the required uncertainties detailed in 6.4.

6.4 Three-dimensional interferometry analyser

The three-dimensional interferometry analyser shall have the ability to measure the fibre heights on the ferrule end face with an uncertainty better than ±50 nm and the core dips with an uncertainty better than ±20 nm. The analyser shall consist of an interferometric video microscope unit, a Personal Computer based fringe interpretation (surface data processing) unit and a monitor.

The interferometric video microscope unit shall consist of an interference microscope, a phase shift actuator, an image detector and an image acquisition and processing setup. The interference microscope equipped with an objective is arranged so as to view the end face of the ferrule.

The following parameters of the interference microscope shall be calibrated:

– optical magnification of the microscope;
– Z travel of the phase shift actuator;
– ferrule holder tilt angle in the case of an angled ferrule type.

The surface data processing unit shall be able to process the surface height information so as to measure the following parameters:

– ferrule surface x-angle S_x (refer to Figure B.1 a) for the sign convention);
– ferrule surface y-angle S_y (refer to Figure B.1 b) for the sign convention;
– fibre array minus coplanarity CF;
– fibre plane x-angle G_x;
– fibre plane y-angle G_y;
– fibre tip spherical radii RF (some conditions apply; see Clause 7, m); refer to Figure C.1 for fibre counting convention);
– core dip CD (some conditions apply; see Clause 7, l); refer to Figure C.1 for fibre counting convention);
– geometry limit GL;
– ferrule surface x-radius R_x;
– ferrule surface y-radius R_y;
– fibre height H (refer to Figure C.1 for fibre counting convention);
– adjacent fibre height differential HA (refer to Figure C.1 for fibre counting convention);

The monitor shall display the measured and calculated surface profiles along each axis.

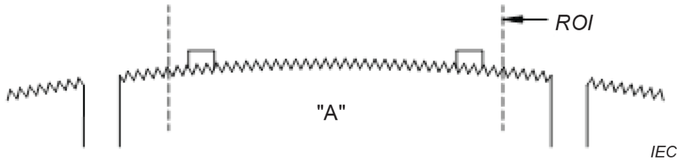
7 Procedure

The following procedure shall be used for this measurement.

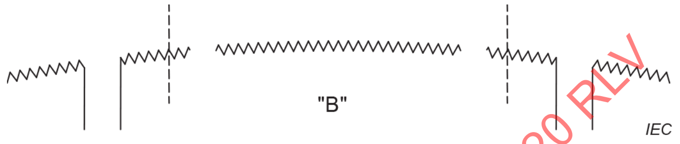
a) Affix the ferrule in the ferrule holder so that the end face is held sufficiently steady with respect to the interferometer.

b) Focus the microscope and/or the sample until the fringes are in position to scan the surface.

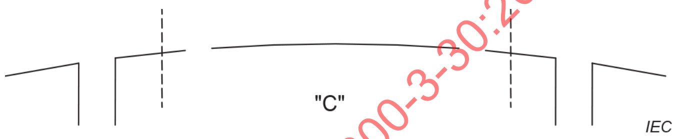
c) Map the surface of the ferrule. To create data set "A", use only the pixels contained within the ROI.



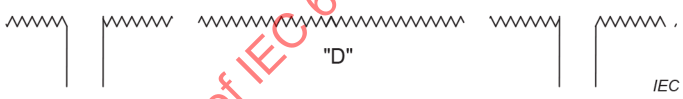
d) Create data set "B" by removing the extracting regions around the fibres.



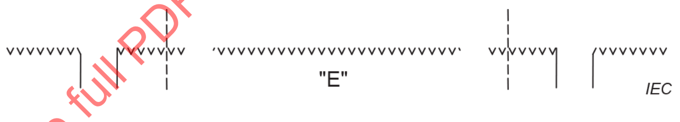
e) Create surface "C" by fitting a bi-parabolic curve to data set "B" (see Annex A for the curve fitting routine).



f) Create data set "D" by subtracting surface "C" from data set "B"

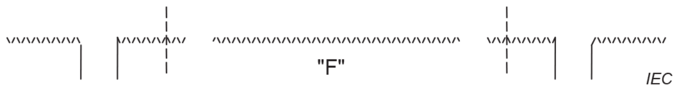


g) Create data set "E" by removing the highest 3 % of all pixels in data set "D". This removes any small points that are extremely high compared to the others. It is assumed these will break off when the connectors contact.



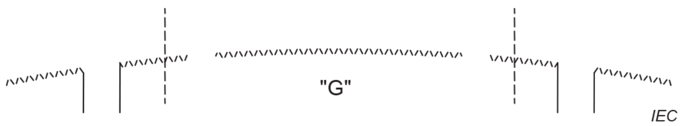
NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

h) Create data set "F" by identifying the highest 20 % of all pixels in data set "E".

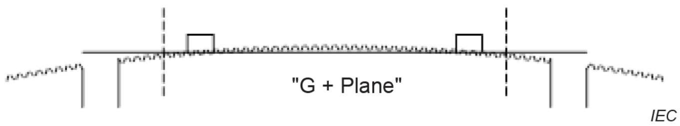


NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

i) Create data set "G" by eliminating all pixels from data set "A" except for those identified in data set "F".



j) Fit a plane to data set "G" and use the plane to calculate S_x and S_y angles using plane P as a reference (see Annex B for end face angle sign conventions). "Add" the extracting regions back in.



Calculate the fibre heights H as the distance normal to the plane at the corresponding fibre centre locations (see Annex C for fibre counting conventions). Calculate the adjacent fibre height differential HA for each fibre. For a given fibre, HA is the largest height difference to the two (single row ferrule case) or four (multi row ferrule case) neighbour fibres.

k) Fit a bi-parabolic curve to data set "G" (see Annex A for the curve fitting routine). Calculate the ferrule surface R_X and R_Y radii values.

l) Determine the core dip (for multi-mode and singlemode fibres) CD of each fibre. See Annex E for a detailed procedure.

   If CD of a given fibre is positive and larger than 10 nm, report CD and skip step m) for that given fibre.

   If CD of a given fibre is negative or smaller than 10 nm, do not report CD for that given fibre and proceed to step m).

m) Determine the radius RF of a given fibre tip. This is accomplished by fitting a sphere to the surface points of the averaging region of the fibre (see Annex A for the curve fitting routine). The radius of the fitted sphere is then taken as the fibre tip radius.

n) Determine the minus coplanarity CF. See Annex D for a detailed procedure. Use the fibre plane to calculate G_X and G_Y angles using the average of the guide pin bore axes as a reference (see Annex B for end face angle sign conventions).

o) If CD is negative or smaller than 10 nm for more than 50 % of the fibres, determine the geometry limit GL using the median value of the RF values of the fibres which exhibited a negative CD. See Annex F.

8 Details to be specified

The following items shall be specified for this measurement:

– type of interferometry;
– nominal angle of tilt, for example Physical contact (PC)/angled PC (APC);
– any deviation from this method;
– measurement uncertainty.

Annex A
(normative)

Formulae for approximating the end face geometry

A.1 Approximation of the ferrule surface

The ideal ferrule surface being calculated for multifibre connectors is described by Formula (A.1):

$$Z = -X^2/(2R_X) - Y^2/(2R_Y) - S_X \times X + S_Y \times Y + C \quad \text{(A.1)}$$

The coefficients for this formula which result in the best fitting ideal surface are found using a least square approximation. R_x and R_y are the radii of curvature for a bi-parabolic surface along the x and y axes: S_x provides the x-axis surface angle value, while S_y provides the y-axis surface angle value. C is the constant that identifies the relative height. By setting the squared terms to zero, a planar surface is defined.

A.2 Approximation of the fibre tip radii

The ideal surface being calculated for each fibre tip is a sphere and is described by Formula (A.2):

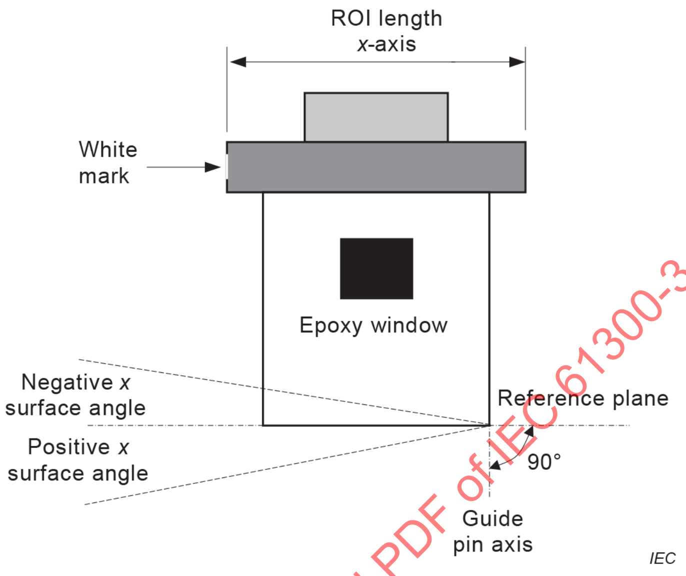
$$(X - X_0)^2 + (Y - Y_0)^2 + (Z - Z_0)^2 = RF^2 \quad \text{(A.2)}$$

The coefficients for this formula which result in the best fitting ideal surface are found using a least square approximation. RF is the radius of curvature of the fitted sphere. X_0, Y_0 and Z_0 are the coordinates of the centre of the fitted sphere, which may not necessarily be centred on the fibre core (apex offset).

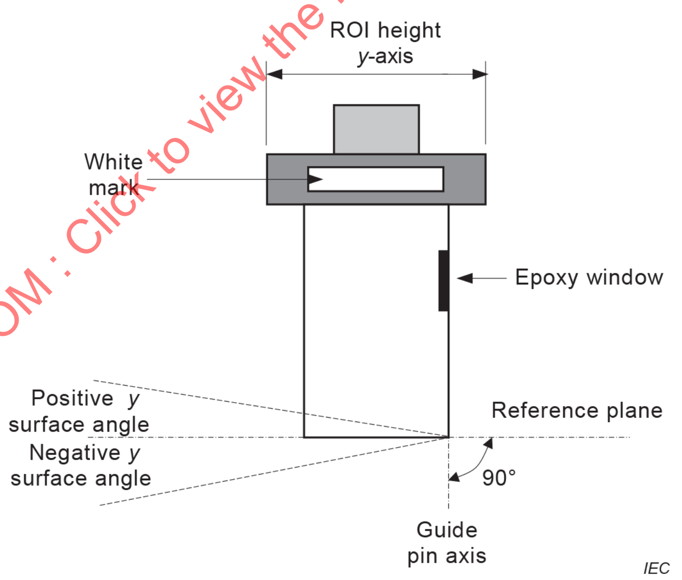
Annex B
(normative)

Surface angle sign convention (shown graphically)

Annex B describes surface angle sign convention graphically. Figure B.1 a) shows the x-axis view, and Figure B.1 b) shows the y-axis view.



a) X-axis view



b) Y-axis view

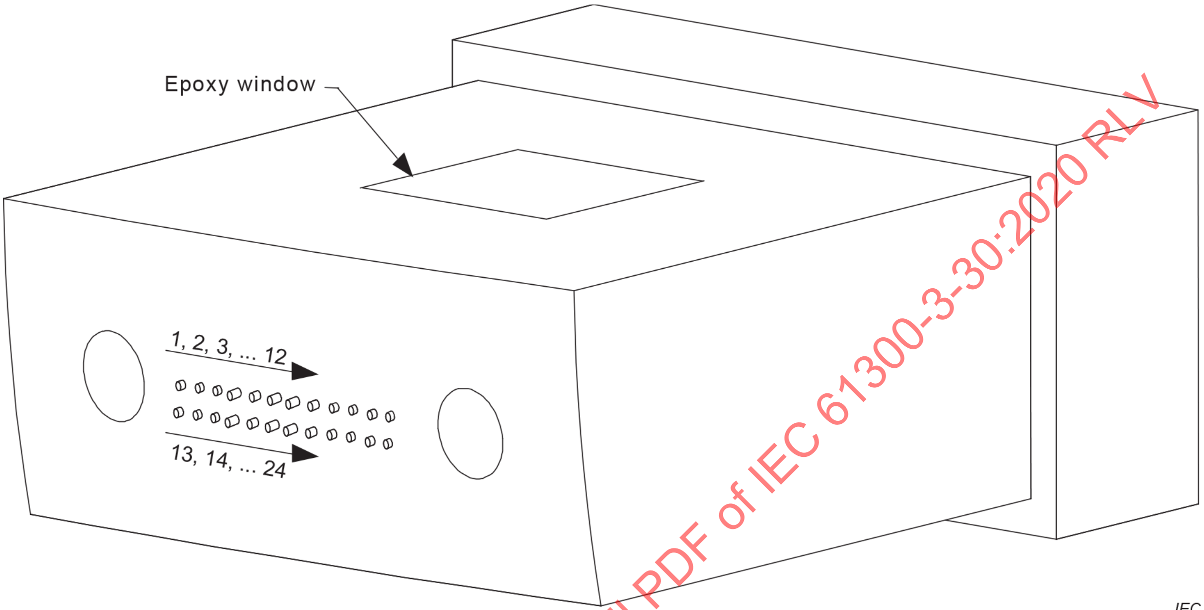
NOTE The optical interface coordinate system is established with an x axis, which passes through the guide hole centres, a perpendicular y axis that passes through the midpoint of the line connecting the guide hole centres, and an orthogonal z axis pointing away from the ferrule.

Figure B.1 – Surface angle sign convention

Annex C
(normative)

Fibre counting convention (shown graphically)

Annex C describes fibre counting convention as shown in Figure C.1.



NOTE Fibre counting convention is applicable for all variants: flat or angled.

Figure C.1 – Fibre counting convention

Annex D
(normative)

Minus coplanarity and fibre plane angle determination

D.1 Overview

D.1.1 General

Annex D describes three additional parameters to be calculated and reported for measurements made in accordance with this document.

D.1.2 Minus coplanarity

Minus coplanarity is the greatest parallel offset between the best fit plane (or line in the case of single row ferrules) of the fibre ends (the average elevation of the averaging regions) and a fibre end below that plane (or line).

D.1.3 Fibre plane x-axis and y-axis angles

The relative tilt of the best fit plane of D.1.2 relative to the average of the guide pin bore axes.

D.2 Method for analysis

D.2.1 Single row ferrules

Create an array of X and Z values where X is the fibre location and Z is the fibre height determined in Clause 7 j). Fit a least squares line $z(X)$ to this data. Calculate the array minus coplanarity CF as:

$$CF = \max(z(X_i) - Z_i) \tag{D.1}$$

where

$z(X_i) - Z_i$ is the deviation of each fibre tip, i, from the fibre line.

Calculate the x-axis G_X angle of the least squares fit line (the fibre line) using a line perpendicular to the guide pin bores axes as a reference.

D.2.2 Multi-row ferrules

Create an array of X, Y and Z values where X and Y are the fibre locations and Z is the fibre height determined in Clause 7 j). Fit a least squares plane $z(X,Y)$ to this data. Calculate the array minus coplanarity as:

$$CF = \max(z(X_i, Y_i) - Z_i) \tag{D.2}$$

where

$z(X_i,Y_i) - Z_i$ is the deviation of each fibre tip, i, from the fibre line.

Calculate the x-axis G_X and y-axis G_Y angles of the least squares fit plane (the fibre plane) using a plane perpendicular to the guide pin bores axes as a reference.

D.3 Documentation

In addition to the requirements of Clause 8, report:

- minus coplanarity;
- x-axis angle G_X of the fibre line (or plane if parts have more than one row);
- y-axis angle G_Y of the fibre plane (if parts have more than one row).

Annex E
(normative)

Calculation of core dip using the paraboloid method

E.1 General

Annex E describes the core dip parameter to be calculated and reported for measurements made in accordance with this document. Core dip is a measurement of the fibre core elevation compared to the cladding elevation at its endface.

E.2 Method for analysis

Fit to each fibre endface surface points located inside zone CD a paraboloid function of type:

$$Z = AX^2 + BY^2 + CX + DY + E \tag{E.1}$$

The coefficients for Formula (E.1) which result in the best fitting ideal surface are found using a least square approximation. Figure E.1 shows the fitting manner graphically.

For each fibre, the core dip CD is then:

$$CD = (A + B)R_1^2 / 2 \tag{E.2}$$

NOTE See Table 1 for the value of R_1.

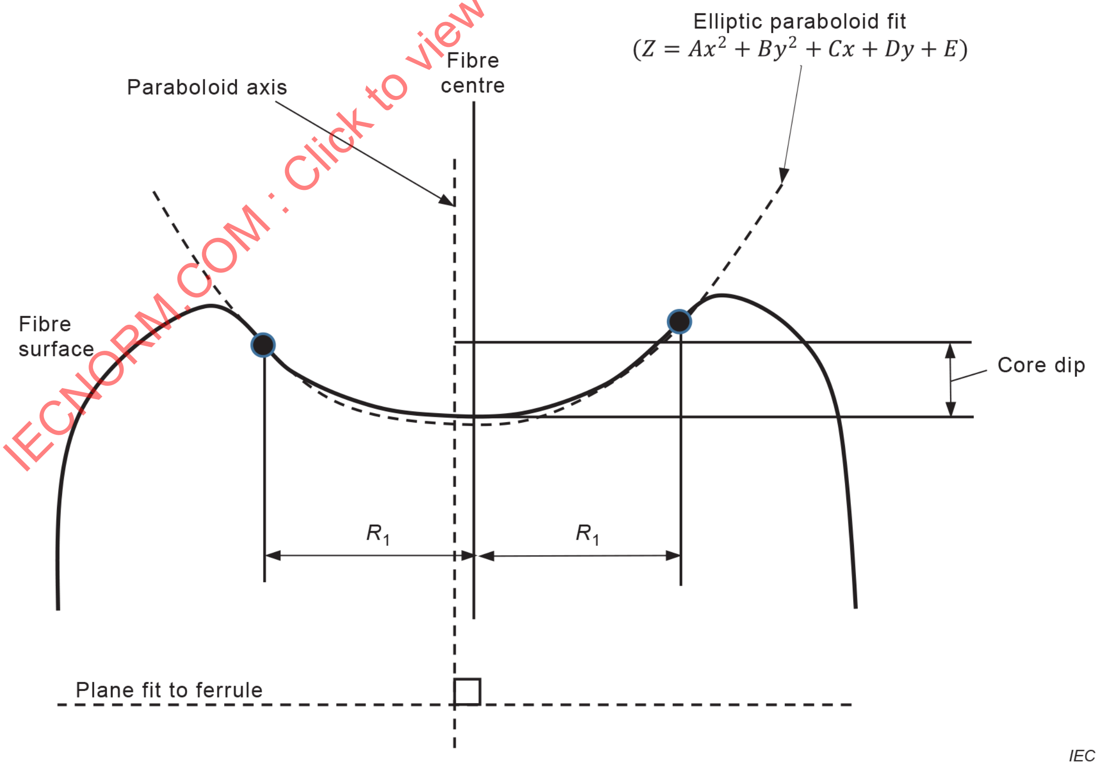


Figure E.1 – Paraboloid fit to a fibre endface exhibiting core dip

Annex F
(normative)

Calculation of GL parameter

F.1 General

Annex F describes the GL parameter to be calculated and reported for measurements made in accordance with this document. GL is used to quantitatively assess the acceptability of an end face geometry.

F.2 Method for analysis

For single-row ferrules, this term is a calculated merit function, which relates x-slope angle, S_x, minus coplanarity, CF, and fibre tip radii, RF. There are 30 constants that define the relationship among these parameters. When fully expanded, the function takes the form of Formula (F.1):

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

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

GL(S_x,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) · |S_x|) – 1) + [(((B_01 – B_00) · e^(–B_0q/RF) + B_0) – ((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] · |S_x| + ((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 number of fibres as summarized in Table F.1 to Table F.3[1].

Table F.1 – Parameter constants for 4-fibre ferrules

	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 F.2 – Parameter constants for 8-fibre ferrules

	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 F.3 – Parameter constants for 12-fibre ferrules

	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

NOTE Other fibre counts are under development.

1 *GL* and coplanarity parameters are not defined for the 1002 ferrule type.

Bibliography

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

IEC 61755-3-31:2015, *Fibre optic interconnecting devices and passive components – Connector optical interfaces – Part 3-31: Connector parameters of non-dispersion shifted single mode physically contacting fibres – Angled polyphenylene sulphide rectangular ferrules*

IEC 61755-3-32:2015, *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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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

DISPOSITIFS D’INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – PROCÉDURES FONDAMENTALES D’ESSAIS ET DE MESURES –

Partie 3-30: Examens et mesures – Géométrie de la face terminale de la ferrule rectangulaire

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La Norme internationale IEC 61300-3-30 a été établie par le sous-comité 86B: Dispositifs d'interconnexion et composants passifs à fibres optiques, du comité d'études 86 de l'IEC: Fibres optiques.

Cette deuxième édition annule et remplace la première édition parue en 2003. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mesurage des rayons des pointes individuelles des fibres;
b) introduction de la métrique de limite de géométrie (GL);
c) introduction de la métrique de coplanarité négative;
d) nouvelle méthode de mesure de l'inclinaison du cœur;
e) toutes les régions de mesurage sont désormais identiques pour les fibres MM et SM;
f) la convention du signe de l'angle de surface de la ferrule a été modifiée.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
86B/4357/FDIS	86B/4378/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61300, publiées sous le titre général *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures*, peut être consultée sur le site Internet de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, le document sera

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DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – PROCÉDURES FONDAMENTALES D'ESSAIS ET DE MESURES –

Partie 3-30: Examens et mesures – Géométrie de la face terminale de la ferrule rectangulaire

1 Domaine d'application

Cette partie de l'IEC 61300 décrit une méthode de mesure de la géométrie de la face terminale des ferrules rectangulaires multifibres ayant une interface optique définie par l'IEC. Les attributs primaires sont la position relative de la fibre par rapport à la face terminale, soit en enfoncement, soit en excroissance, et l'angle relatif de la face terminale par rapport aux forages de la broche de guidage, les rayons des pointes des fibres et l'inclinaison du cœur pour des fibres multimodales.

2 Références normatives

Le présent document ne contient aucune référence normative.

3 Termes et définitions

Aucun terme n'est défini dans le présent document.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/;
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp.

4 Description générale

Les fiches de connecteurs multifibres basés sur la broche de guidage possèdent généralement une face terminale rectangulaire avec un axe long et un axe court. Idéalement, un polissage plat est souhaité sur la face terminale avec une légère excroissance des fibres, toutes dans le même plan pour assurer un contact physique des cœurs des fibres lorsque deux connecteurs sont accouplés. En pratique, la face terminale a généralement deux courbures différentes à travers la surface le long des axes long et court. Etant donné que les ferrules accouplées sont alignées par des broches dans des trous de guidage, la face terminale de la ferrule doit être orientée de façon appropriée (angles S_x et S_y) par rapport aux trous de guidage pour atteindre un contact positif. L'angle S_x de la face terminale dans l'axe X et l'angle S_y de la face terminale dans l'axe Y sont mesurés en trouvant le plan du meilleur ajustement fondé sur un pourcentage des points les plus élevés dans une région spécifiée considérée. Les points les plus élevés présentent généralement la modulation la plus grande d'un point vue interférométrique. Cela permet des mesurages plus solides et une répétabilité plus importante entre les différents interféromètres.

L'angle du plan du meilleur ajustement est calculé en le comparant au plan de référence qui est perpendiculaire à l'axe de chaque trou de guidage. La hauteur H (si positive, elle désigne une excroissance) de la fibre est une hauteur plane définie comme la distance entre la face terminale de la fibre et le plan du meilleur ajustement. L'inclinaison du cœur est plus importante pour les fibres multimodales parce que le cœur large est plus tendre que la gaine de la fibre et tend à s'user plus vite. L'inclinaison du cœur est calculée à l'aide de la méthode paraboloïde décrite à l'Annexe E.

Une méthode est décrite pour mesurer l'angle de la face polie et la position de la fibre sur la ferrule unique des connecteurs multifibres. Elle consiste en l'analyse de la face terminale avec un analyseur de surface de type interférométrie tridimensionnelle.

5 Régions de mesurage

Les régions suivantes doivent être définies sur la face terminale de la ferrule.

a) Région considérée (ROI): la région considérée est réglée sur la surface de la ferrule et est définie par une région rectangulaire possédant un axe long (axe X) de longueur L et un axe court (axe Y) de hauteur H. La région considérée est choisie de façon à couvrir la zone de contact prévue de la face terminale de la ferrule lorsque les ferrules sont accouplées. La région considérée doit être centrée sur le groupe de fibres. Voir Figure 1. Se référer au Tableau 1 pour les zones de mesurage à utiliser pour les différents connecteurs.

b) Région d'extraction*:* la région d'extraction, qui inclut les régions des faces terminales des fibres et les régions adhésives associées, est définie par des cercles possédant un diamètre E, centrés sur chaque fibre.

c) Région moyenne*:* la région moyenne est définie sur les surfaces des fibres à utiliser pour le calcul de la hauteur de la fibre et est définie par un cercle de diamètre F. La région moyenne est la même pour les fibres unimodales (SM) et les fibres multimodales (MM).

d) Région d'inclinaison du cœur*:* la région d'inclinaison du cœur est définie sur les surfaces de fibre à utiliser pour le calcul de l'inclinaison du cœur de la fibre à l'aide d'une méthode paraboloïde, et est définie par des cercles ayant un diamètre CD, centrés sur chaque fibre.

Constante d'ajustement de l'inclinaison du cœur*:* l'amplitude calculée de l'inclinaison du cœur suivant l'ajustement d'une fonction paraboloïde à la face terminale de la fibre est ajustée à l'aide de la constante R_1.

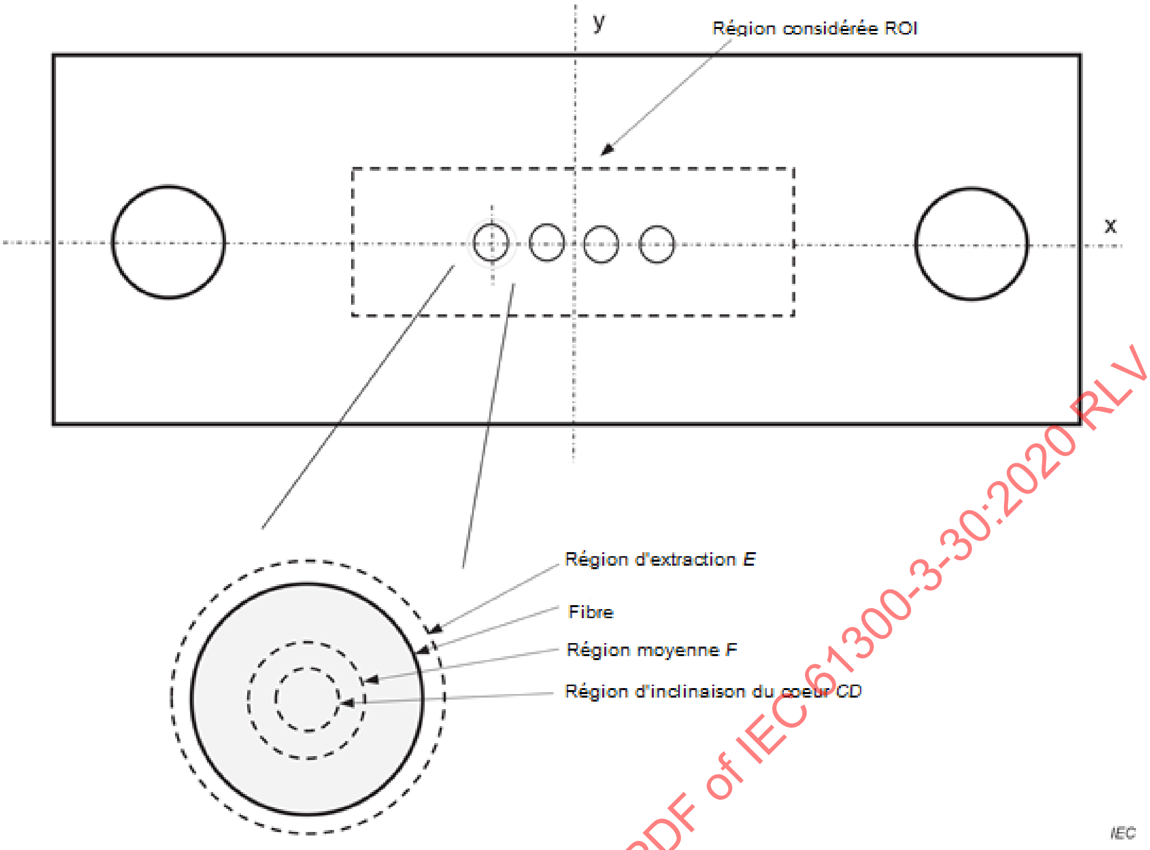

Figure 1 – Régions de mesurage sur la ferrule et la fibre

Tableau 1 – Zones et paramètres de mesurage des ferrules

Type de ferrule (numéro de variante) [a]	Descrip-tion	Région considérée, ROI ($L \times H$) mm²	% de pixels supé-rieurs exclus	Prochain % de pixels supé-rieurs utilisés	Région d'extraction (diamètre E) mm	Région moyenne - SM + MM (diamètre F) mm	Région d'ajustement de l'inclinaison du cœur (diamètre CD) mm	Constante d'ajustement de l'inclinaison du cœur R_1 (voir Annexe E)
x104	MT-04	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x108	MT-08	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x112	MT-12	2,900 × 0,675	3	20	0,140	0,05	0,03	0,03
x124	MT-24	2,900 × 1,160	3	20	0,140	0,05	0,03	0,03
1002	MiniMT	0,900 × 0,675	3	20	0,140	0,05	0,03	0,03

[a] Si le x est égal à 1, il définit les matériaux de ferrule à base de résine de poly(sulfure de phénylène) (PPS). S'il est égal à 2, il indique les matériaux thermodurcissables; le deuxième chiffre représente 2,45 mm × 4,4 mm avec 0 et 2,45 mm × 6,4 mm avec 1; les deux derniers chiffres désignent le nombre de fibres (voir le Tableau 1 de l'IEC 61755-3-31:2015 et le Tableau 1 de l'IEC 61755-3-32:2015).

6 Appareillage

6.1 Généralités

L'appareillage représenté à la Figure 2 se compose d'un étage de positionnement, d'un support de ferrule, d'un microscope vidéo interférométrique, d'une unité d'interprétation des franges basée sur un ordinateur personnel et d'un moniteur permettant de visualiser l'interférogramme de la face terminale de la ferrule et d'afficher les résultats de l'analyse.

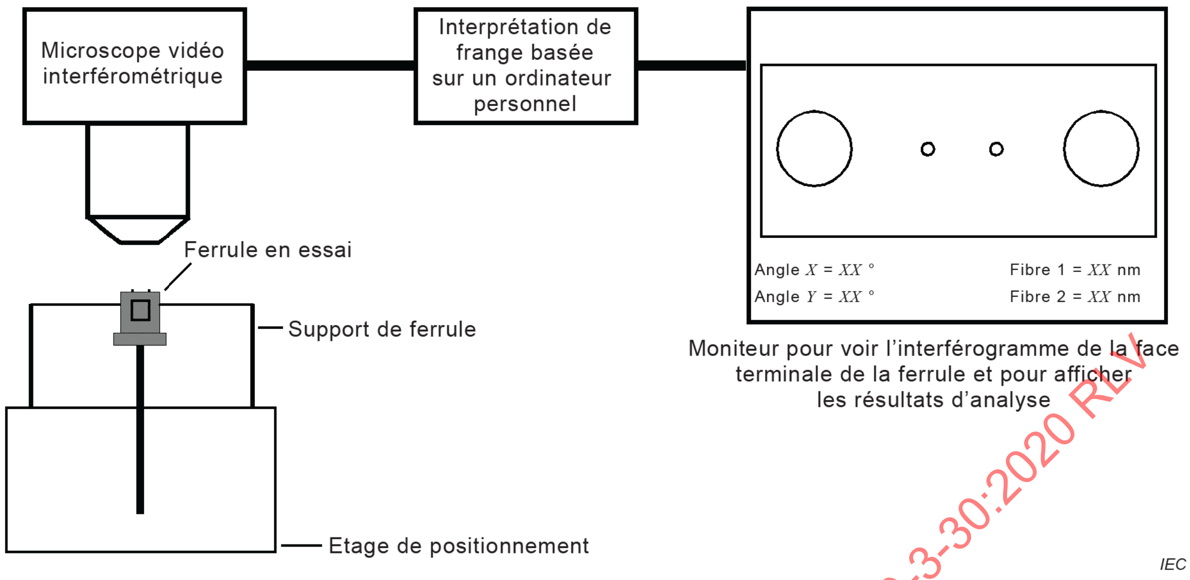

Figure 2 – Configuration de mesurage

6.2 Support de ferrule

Le support de ferrule est un dispositif adapté au maintien de la ferrule en position fixe, soit verticale, soit horizontale, ou en position inclinée dans le cas d'un type de ferrule avec angle. Certaines méthodes doivent être utilisées pour déterminer l'axe de chaque trou de guidage et le plan moyen perpendiculaire aux axes des trous de guidage. Ce plan doit être pris en compte comme étant le plan de référence P pour référence aux mesurages suivants.

6.3 Etage de positionnement

Le support de ferrule est fixé à l'étage de positionnement, qui doit permettre au support de ferrule d'être déplacé pour atteindre la position appropriée. L'étage doit posséder une rigidité suffisante de façon à permettre le mesurage des paramètres de la face terminale de la ferrule en respectant les incertitudes exigées décrites en 6.4.

6.4 Analyseur d'interférométrie tridimensionnelle

L'analyseur d'interférométrie tridimensionnelle doit posséder l'aptitude de mesurer les hauteurs de fibre sur la face terminale de la ferrule avec une incertitude supérieure à ±50 nm et l'inclinaison des cœurs avec une incertitude supérieure à ±20 nm. L'analyseur doit être composé d'un microscope vidéo interférométrique, d'une unité d'interprétation de frange basée sur un ordinateur personnel (traitement de données de surface) et d'un moniteur.

Le microscope vidéo interférométrique doit être constitué d'un microscope à interférences, d'un organe de commande de déphasage, d'un détecteur d'images et d'un dispositif d'enregistrement et de traitement d'images. Le microscope à interférences équipé d'un objectif est disposé de manière à visualiser la face terminale de la ferrule.

Les paramètres suivants du microscope d'interférence doivent être étalonnés:

– grossissement optique du microscope;
– course Z de l'organe de commande de déphasage;
– angle d'inclinaison du support de ferrule dans le cas d'une ferrule avec angle.

L'unité de traitement des données de surface doit pouvoir traiter les informations de hauteur de surface de manière à mesurer les paramètres suivants:

– angle x S_x de la surface de la ferrule (voir Figure B.1 a) pour la convention du signe);