INTERNATIONAL STANDARD

IEC 61300-3-30

First edition
2003-01

**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**

*Dispositifs d'interconnexion et composants passifs à fibres optiques –
Méthodes fondamentales d'essais et de mesures –*

*Partie 3-30:
Examens et mesures –
Angle de la face polie et position de la fibre sur l'embout des connecteurs multifibres*

Reference number
IEC 61300-3-30:2003(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**
- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (http://www.iec.ch/searchpub/cur_fut.htm) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (http://www.iec.ch/online_news/justpub/jp_entry.htm) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

Email: custserv@iec.ch
Tel: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 61300-3-30

First edition
2003-01

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

Dispositifs d'interconnexion et composants passifs à fibres optiques –
Méthodes fondamentales d'essais et de mesures –

Partie 3-30:
Examens et mesures –
Angle de la face polie et position de la fibre sur l'embout des connecteurs multifibres

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

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.

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

FDIS	Report on voting
86B/1747/FDIS	86B/1773/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 3.

IEC 61300 consists of the following parts, under the general title *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures:*

– Part 1: General and guidance
– Part 2: Tests
– Part 3: Examinations and measurements

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication 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 – Polish angle and fibre position on single ferrule multifibre connectors

1 Scope

This part of IEC 61300 describes a procedure to assess end face geometry in guide pin based multifibre ferrules and connectors. The primary attributes are fibre position relative to the end face, either undercut or protrusion, end face angle relative to the guide pin bores, 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.

None.

3 General description

Guide pin based multifibre connectors 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 be properly oriented (X and Y angle) with respect to the guide holes to achieve positive contact. The end face angle in the X-axis and the end face angle 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.

One method is described for this procedure. Analysing the endface with a three-dimensional interferometry type surface analyser.

4 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.

4.1 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 be used to reference the axis of each guide hole and the average perpendicular angle to them, which shall be considered the ideal end face angle. 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.

4.2 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 rigidity so as to allow measurement of the ferrule end face with the required accuracy.

4.3 Three-dimensional interferometry

The three-dimensional interferometry analyser shall have the ability to measure the fibre heights on the ferrule end face with an accuracy of better than ±50 nm. The analyser shall consist of a microscope unit, a surface data processing unit and a monitor.

The microscope unit shall consist of an interference microscope, a phase shift actuator, an image detector and a frame grabber. 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 monitor shall display the measured and calculated surface profiles along each axis.

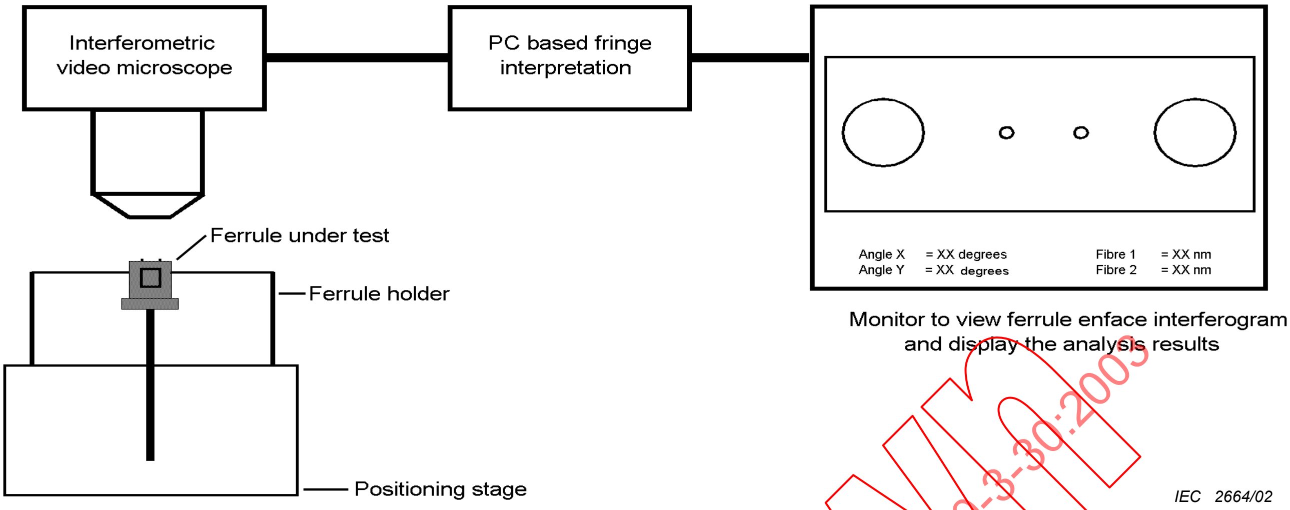


Figure 1 – Three-dimensional interferometry analyser

5 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.

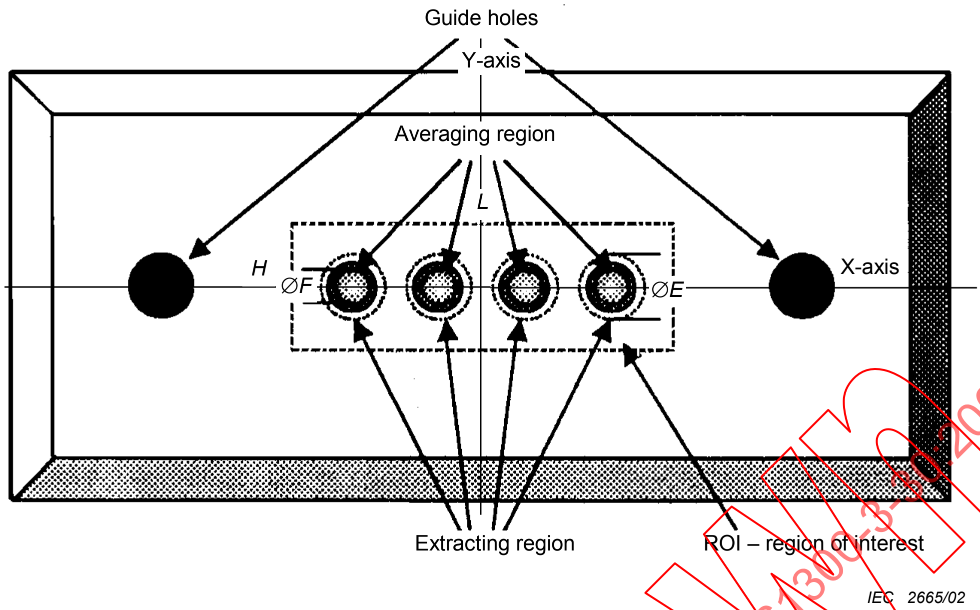


Figure 2 – Measurement regions on ferrule

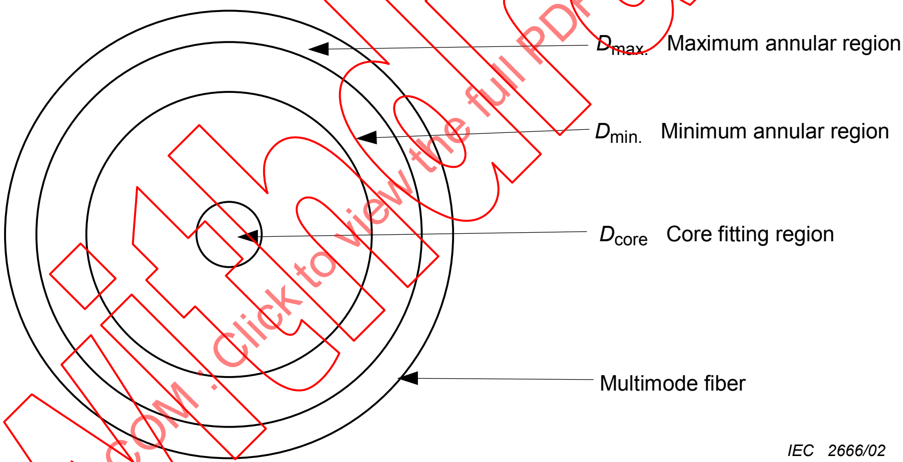


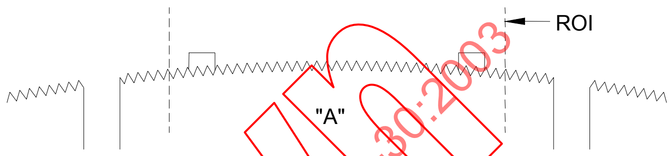
Figure 3 – Multimode fibre core dip regions

5.2 Method for analysis

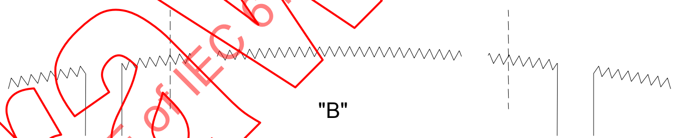
5.2.1 Affix the ferrule in the ferrule holder so that the end face is held sufficiently steady with respect to the interferometer.

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

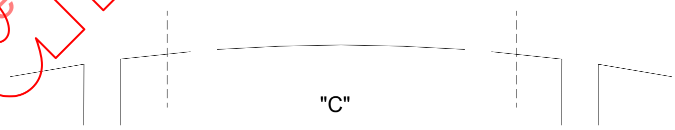
5.2.3 Map the surface of the ferrule. To create data set "A", use only the pixels contained within the ROI.



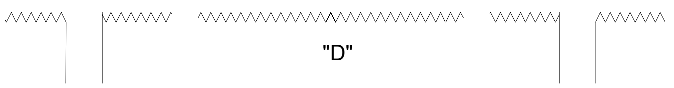
5.2.4 Create data set "B" by removing the extraction regions around the fibres.



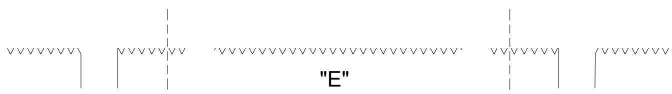
5.2.5 Create surface "C" by fitting a biparabolic curve to data set "B". (See Annex A for a suggested curve fitting routine.)



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



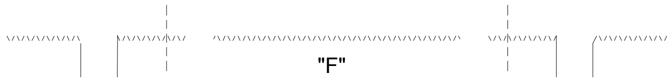
5.2.7 Create data set "E" by removing the highest 3 % of all pixels in data set "D". This removes any small points that are extremely high compared to the others. It is assumed these will break off when the connectors contact.



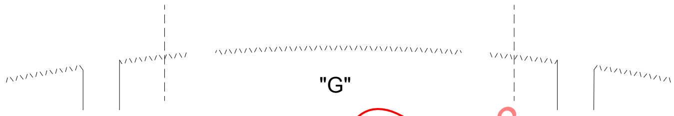
NOTE Points are selected as a percentage of the total area which includes pixels for which heights could not be determined.

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.

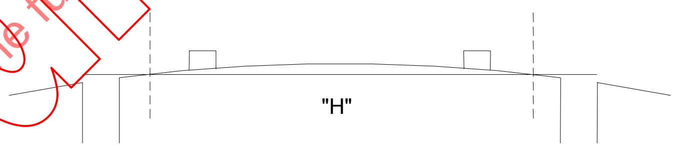


5.2.9 Create data set "G" by eliminating all pixels from data set "A" except for those identified in data set "F".



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}.

6 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

Annex A
(informative)

Formula for calculating end face geometry

The ideal surface being calculated for multifibre connectors is described by the following equation:

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

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

Annex B
(normative)

Surface angle sign convention (shown graphically)

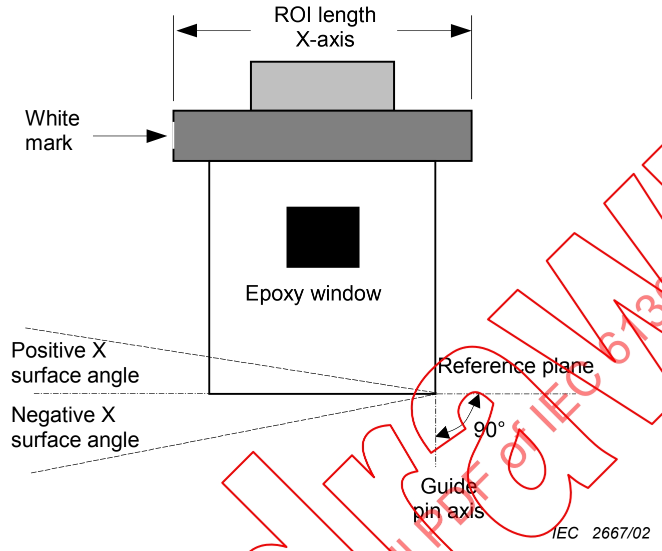


Figure B.1a – X-axis view

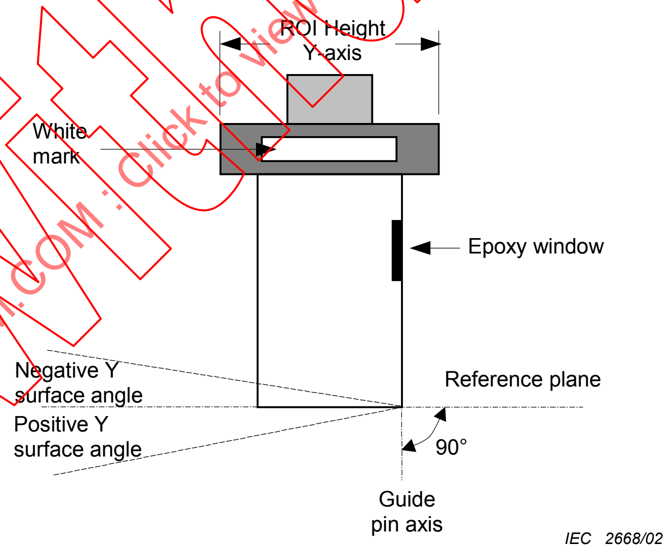


Figure B.1b – Y-axis view

Figure B.1 – Surface angle sign convention

Annex C
(normative)

Fibre counting convention (shown graphically)

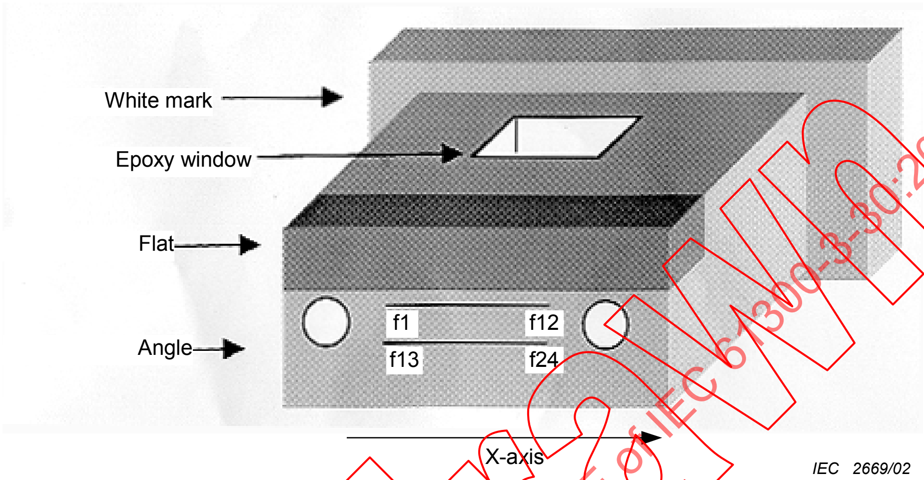


Figure C.1 – Fibre counting convention