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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Aerospace series - Fibres and cables, optical, aircraft use - Test methods - Part 100: General

Série aérospatiale - Fibres et câbles optiques à usage
aéronautique - Méthodes d'essais - Partie 100 :
Généralités

Luft- und Raumfahrt - Faseroptische Leitungen für
Luftfahrzeuge - Prüfverfahren - Teil 100: Allgemeines

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee ASD-STAN.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European foreword

This document (prEN 3745-100:2024) has been prepared by ASD-STAN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 3745-100:2008.

This document includes the following significant technical changes with respect to EN 3745-100:2008:

- integration of all the latest EN 3745 series documents, including their disposal of comments in the prEN 3745-100 document;
- integration in the document of the revisions of current tests –306, –412, –510 et –801;
- integration of NWP proposal on tests –516 and –603.

1 Scope

This document defines terms, definition and all test methods for optical fibres and cable.

In this document test methods items have been kept according to the historical references.

2 Normative references

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

EN 2591-100:2024, *Aerospace series - Elements of electrical and optical connection - Test methods - Part 100: General*

EN 2591-601:2001, *Aerospace series - Elements of electrical and optical connection - Test methods - Part 601: Optical elements - Insertion loss*

EN 2591-602:2001, *Aerospace series - Elements of electrical and optical connection - Test methods - Part 602: Optical elements - Variation of attenuation and optical discontinuity*

EN 3475-601, *Aerospace series - Cables, electrical, aircraft use - Test methods - Part 601: Smoke density*

EN 3475-602, *Aerospace series - Cables, electrical, aircraft use - Test methods - Part 602: Toxicity*

EN 4056-003, *Aerospace series - Cable ties for harnesses - Part 003: Plastic cable ties - Operating temperatures - 65 °C to 105 °C and - 65 °C to 150 °C - Product standard*

EN 4533-004, *Aerospace series - Fibre optic systems - Handbook - Part 004: Repair, maintenance, cleaning and inspection*

EN IEC 60793-1-40:2019, *Optical fibres - Part 1-40: Attenuation measurement methods (IEC 60793-1-40)*

EN IEC 60793-1-41, *Optical fibres - Part 1-41: Measurement methods and test procedures - Bandwidth (IEC 60793-1-41)*

EN IEC 60793-2, *Optical fibres - Part 2: Product specifications – General (IEC 60793-2)*

EN 60794 (all parts), *Optical fibre cables*

EN 61754-20, *Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family*

IEC 61300-3-47, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 3-47: Examinations and measurements — End face geometry of PC/APC spherically polished ferrules using interferometry*

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 4046, *Paper, board, pulp and related terms — Vocabulary*

ISO 7724-1, *Paints and varnishes — Colorimetry — Part 1: Principles*

AMS 1476C, *Deodorant, Aircraft Toilet*

ASTM-D740,¹ *Standard Specification for Methyl Ethyl Ketone*

ASTM-D3032,¹^{Error! Bookmark not defined.} *Standard Test Methods for Hookup Wire Insulation*

CIE 015,² *Colorimetry*

MIL-PRF-87937,³ *Performance specification: Cleaning compound, aerospace equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

optical fibre

dielectric waveguide whose core consists of optically transparent material of low attenuation and whose cladding consists of optical transparent material of lower refractive index than that of the core (see Figure 1)

Note 1 to entry: In general the optical fibre is furnished with a primary coating (see Figure 1).

3.2

core

central region of an optical fibre through which most of the optical power is transmitted (see Figure 1)

3.3

cladding

dielectric material surrounding the core of the optical fibre (see Figure 1)

3.4

fibre coating

first protective coating directly applied to the fibre during its manufacture (see Figure 1)

Note 1 to entry: Its purpose is to maintain original optical performance of the fibre and to provide minimum mechanical properties.

3.5

optical cable

assembly consisting of optical fibre, inner sheath and where applicable strength members and jacket (see Figure 1)

3.6

multiple fibre cable

construction in which a number of fibres are placed together in a cable

¹ Published by American Society for Testing and Materials (ASTM International), available at: <https://www.astm.org/>.

² Published by CIE Central Bureau - Kegelgasse 27 - A-1030 Wien - Austria.

³ Published by Department of Defense (DoD), available at: <https://assist.dla.mil/online/start/>.

3.7**buffer**

material which surrounds and is immediately adjacent to a primary coating and provides mechanical protection (see Figure 1)

3.8**strength members**

protective envelope added to the inner sheath when necessary to improve the properties of mechanical resistance (see Figure 1)

3.9**jacket**

external protective covering (see Figure 1)

3.10**refractive index profile**

distribution of the refractive index along the diameter of an optical fibre

Note 1 to entry: The refractive index profile for simple structures can be approximated by:

$$n(r) = n_1 \sqrt{1 - 2\Delta(r/a)^g} \text{ for } r < a$$

$$n(r) = n_2 = n_1 \sqrt{1 - 2\Delta} \text{ for } r \geq a$$

$$\text{with } \Delta = (n_1^2 - n_2^2) / 2 n_1^2$$

where

- r is the radial distance from the centre of fibre;
- n_1 is the maximum refractive index value of the core material;
- n_2 is the refractive index value of the cladding material;
- a is the core radius;
- g is the profile parameter which defines the form of the profile:
 - $10 \leq g < \infty \rightarrow$ step index profile
 - $1 \leq g < 3 \rightarrow$ graded index profile
 - $3 \leq g < 10 \rightarrow$ quasi step index profile.

3.11**core diameter**

Ø cr

diameter of the circle which best fits the core area

Note 1 to entry: For a cross section of an optical fibre, the core area is that within which the refractive index everywhere (excluding any index dip) exceeds that of the innermost homogeneous cladding by a given fraction of the difference between the maximum of the refractive index of the core (n_1) and the refractive index of the innermost homogeneous cladding (n_2).

Note 2 to entry: It is contained within the focus of points where the refractive index n_3 is given by:

$$n_3 = n_2 + k (n_1 - n_2)$$

where

n_1 = maximum refractive index value of core;

n_2 = refractive index value of the innermost homogeneous cladding;

k = a constant (unless otherwise specified a k value of 0,05 is assumed).

3.12

cladding diameter

$\varnothing cd$

physical diameter of the optical fibre

3.13

concentricity error core/cladding

distance between the centre point of the core and the centre point of the cladding divided by the core diameter

3.14

non circularity of core

difference between the longest and the shortest chords passing through the core centre, divided by the core diameter

3.15

non circularity of cladding

difference between the longest and the shortest chords passing through the cladding centre, divided by the cladding diameter

3.16

attenuation

attenuation A at the wavelength λ between two cross sections 1 (input) and 2 (output) separated by the distance L of the fibre is defined by:

$$A = 10 \log_{10} (P_1/P_2) \text{ (dB)}$$

P_1 = optical power traversing the cross section 1

P_2 = optical power traversing the cross section 2

Attenuation coefficient:

$$\alpha \text{ (alpha)} = A/L \text{ (dB/unit length)}$$

Note 1 to entry: For practical use, generally, these parameters are given under modal equilibrium conditions (this is not normally the case in avionic applications where lengths are short).

3.17**numerical aperture****NA**

maximum theoretical numerical aperture defined by:

$$NA = \sqrt{n_1^2 - n_2^2}$$

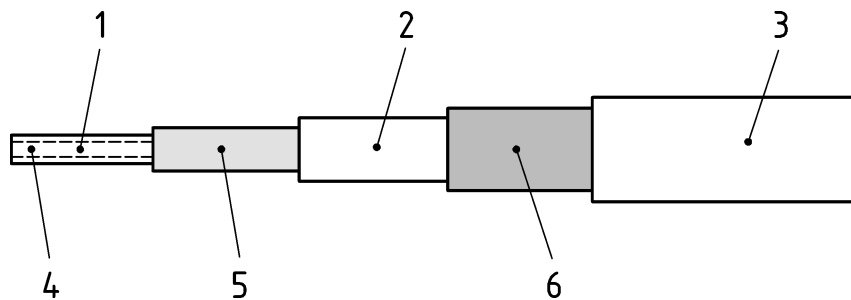
where

n_1 = maximum of the refractive index value of the core;

n_2 = the refractive index value of the innermost homogeneous cladding

3.18**bandwidth**

value numerically equal to the lowest frequency at which the magnitude of the baseband transfer function of an optical fibre decreases to a specified fraction, generally to one half (3 dB), of the zero frequency value

**Key**

- 1 cladding
 - 2 buffer (if present)
 - 3 jacket
 - 4 core
 - 5 fibre coating
 - 6 strength members (if present)
- } optical fibre

Figure 1 — Optical cable

3.19**contrast**

ratio of reflecting light (here: reflecting light of cable identification marking and cable surface)

3.20**illuminance**

reflection of visible light

3.21**measuring range**

maximum effective range of measurement

4 Test conditions

Unless stated otherwise in the test methods, the technical specification or the product standard the test conditions shall be:

- temperature: (20 ± 5) °C;
- atmospheric pressure: 86 KPa to 106 KPa;
- relative humidity: 45 % to 75 %.

The temperature and humidity shall remain constant during a series of measurement.

5 List of test methods

Table 1 — General designation

EN 3745 part	Test designation
Subclause 6.1	Test 201: Visual examination
Subclause 6.2	Test 202: Fibre dimensions
Subclause 6.3	Test 203: Cable dimensions
Subclause 6.4	Test 205: Cable longitudinal dimensional stability

Table 2 — Optical tests

EN 3745 part	Test designation
Subclause 7.1	Test 301: Attenuation
Subclause 7.2	Test 302: Numerical aperture
Subclause 7.3	Test 303: Bandwidth
Subclause 7.4	Test 305: Immunity to ambient light coupling
Subclause 7.5	Test 306: Variation of attenuation during temperature cycling

Table 3 — Environmental tests

EN 3745 part	Test designation
Subclause 8.1	Test 401: Accelerated ageing
Subclause 8.2	Test 402: Temperature cycling
Subclause 8.3	Test 404: Thermal shock
Subclause 8.4	Test 405: Low/High temperature bend test
Subclause 8.5	Test 406: Cold bend test
Subclause 8.6	Test 407: Flammability
Subclause 8.7	Test 410: Thermal life
Subclause 8.8	Test 411: Resistance to fluids
Subclause 8.9	Test 412: Humidity resistance

Table 4 — Mechanical tests

EN 3745 part	Test designation
Subclause 9.1	Test 501: Optical fibre proof test
Subclause 9.2	Test 502: Tensile strength for short length of optical fibres
Subclause 9.3	Test 503: Scrape abrasion
Subclause 9.4	Test 504: Micro bending test
Subclause 9.5	Test 505: Cable tensile strength
Subclause 9.6	Test 506: Impact resistance
Subclause 9.7	Test 507: Cut-through
Subclause 9.8	Test 508: Torsion
Subclause 9.9	Test 509: Kink test
Subclause 9.10	Test 510: Bending test
Subclause 9.11	Test 511: Cable to cable abrasion
Subclause 9.12	Test 512: Flexure endurance
Subclause 9.13	Test 513: Crush resistance
Subclause 9.14	Test 514: Cable twist bend
Subclause 9.15	Test 515: Remove buffer
Subclause 9.16	Test 516: "Severe" cable bend test
Subclause 9.17	Test 517: Cable tie clamping test

Table 5 — Sundry tests

EN 3745 part	Test designation
Subclause 10.1	Test 601: Smoke density
Subclause 10.2	Test 602: Toxicity
Subclause 10.3	Test 603: Nuclear radiation

Table 6 — Cable implementation tests

EN 3745 part	Test designation
Subclause 11.1	Test 701: Strippability
Subclause 11.2	Test 703: Durability of manufacturer's marking
Subclause 11.3	Test 705: Contrast measurement
Subclause 11.4	Test 801: Fibre movement under compression

6 Serie 2xx: General designation

6.1 General

Test series -20x corresponds to test methods allowing to measure general fibre and cable characteristics.

6.2 Test 201: Visual inspection of optical fibres and optical cables

6.2.1 General

This clause a method for the visual inspection of optical fibres and optical cables.

6.2.2 Test 201: Characteristics to be examined

6.2.2.1 Test 201: General

The type and length of cable/fibre from which the specimen is taken shall be as specified in the product specification.

6.2.2.2 Test 201: Optical fibre

6.1.1.2.1 The fibre shall have the correct identification colour coating if specified in the product standard.

6.1.1.2.2 The coating shall be continuous and free of visible defects such as lumps, abrasions, cracks, splits, or blisters.

6.2.2.3 Test 201: Optical cable

6.1.1.3.1 The cable shall have the correct identification colour if specified in the product standard.

6.1.1.3.2 The cable shall be marked in accordance with the product standard.

6.1.1.3.3 The cable shall be free from discoloration due to overheating or foreign materials such as dust, grease, or oil.

6.1.1.3.4 The cable jacket (sheath) and/or coating shall not be scorched.

6.1.1.3.5 The cable jacket and/or coatings shall be free from delaminations and voids.

6.1.1.3.6 The cable shall be free from deformities in the jacket that increase, or decrease, the cable diameter in excess of the specified maximum or minimum outside diameter.

6.1.1.3.7 The cable shall be free from metallic or gritty particles in the jacket and/or coating.

6.1.1.3.8 The cable shall show no cracking or crazing.

6.2.3 Test 201: Apparatus

A lamp which can provide an illumination of 500 lx to 700 lx on a flat workbench shall be used.

A 10x magnifying lens or microscope shall be used.

6.2.4 Test 201: Method A

Unless otherwise stated in the product standard, visual examination shall be made by the following methods:

- by a 10x magnifying lens for the inspection of optical fibres;
- by a naked eye of normal vision, or normally corrected, for the inspection of optical cables.

The test specimen shall be placed flat on the workbench. The test specimen shall be visually examined at a distance of not more than 0,3 m, if not using a magnifying device.

6.3 Test 202: Fibre dimensions

6.3.1 General

This clause specifies several methods for measuring the diameter of an optical fibre or cable, the non-circularity and the concentricity of the fibre core/cladding on an optical fibre. If no method is mentioned, method A applies.

6.3.2 Test 202: Preparation of specimens

6.3.2.1 The specimen shall comprise a length of the optical fibre or cable to be measured. The fibre ends shall be prepared in accordance with EN 2591-100. The length of specimen shall be $(3 \pm 0,5)$ m unless otherwise specified in the product standard.

If not yet at standard test conditions, the specimens shall be subjected to standard test conditions and stabilized at these conditions for 24 h as defined in Clause 4 (Test conditions).

6.3.2.2 The following detail shall be specified if not already included in the product standard:

- type of fibre/cable from which the specimen was taken.

6.3.3 Test 202: Apparatus

For method B, the Light Launch System used shall be as specified in EN 2591-100 with an angular size > 110 % of the fibre numerical aperture and a spot size > 110 % of fibre core diameter.

6.3.4 Test 202: Method

6.3.4.1 Test 202: Method A: Refracted near field

6.3.4.1.1 Test 202 Method A: Object

- The refracted near-field measurement is straightforward, accurate and measures directly the refractive index variation the fibre (core and cladding). The measurement is capable of good resolution and can be calibrated to give absolute values of refractive indexes. It can be used to obtain profiles of both single-mode and multimode fibre.

6.3.4.1.2 Test 202 Method A: Test apparatus

6.3.4.1.2.1 General

A schematic diagram of the test apparatus is shown in Figure 2 and Figure 3.

6.3.4.1.2.2 Test 202 Method A: Source

- A stable laser giving a few milliwatts of power in the TEM₀₀ mode is required.
- A HeNe laser, which has a wavelength of 633 nm, may be used, but a correction factor shall be applied to the results for extrapolation at different wavelengths. It shall be noted that measurement at 633 nm shall not give complete information at longer wavelengths; in particular non-uniform fibre doping can affect the correction.
- A quarter-wave plate is introduced to change the beam from linear to circular polarization because the reflectivity of light at an air-glass interface is strongly angle and polarization dependent.
- A pinhole placed at the focus of lens 1 acts as a spatial filter.

6.3.4.1.2.3 Test 202 Method A: Launch optics

The launch optics, which are arranged to overfill the NA of the fibre, brings a beam of light to a focus on the flat end of the fibre. The optical axis of the beam of light should be within 1° of the axis of the fibre. The resolution of the equipment is determined by the size of the focused spot, which should be as small as possible in order to maximize the resolution, for example less than $1,5\text{ }\mu\text{m}$. The equipment enables to focused spot to be scanned across the fibre diameter.

6.3.4.1.2.4 Test 202 Method A: Liquid cell

The liquid in the liquid cell shall have a refractive index slightly higher than that of the fibre cladding.

6.3.4.1.2.5 Test 202 Method A: Sensing

The refracted light is collected and brought to the detector in any convenient manner provided that all the refracted light is collected. By calculation, the required size of disc and its position along the central axis can be determined.

6.3.4.1.3 Test 202: Sample preparation

A length of fibre of about 1 m is required.

All fibre coating shall be removed from the clause of fibre immersed in the liquid cell.

The fibre ends shall be clean, smooth and perpendicular to the fibre axis.

6.3.4.1.4 Test 202 Method A: Procedure

6.3.4.1.4.1 General

Refer to the schematic diagram of the test apparatus (Figure 3).

6.3.4.1.4.2 Test 202 Method A: Fibre index profile plot

The launch end of the fibre to be measured is immersed in a liquid cell whose refractive index is slightly higher than that of the fibre cladding. The fibre is back illuminated by light from a tungsten lamp. Lenses 2 and 3 produce a focused image of the fibre.

The position of lens 3 is adjusted to centre and focus the fibre image, and the laser beam is simultaneously centred and focused on the fibre.

The disc is centred on the output cone. For multimode fibre, the disc is positioned on the optical axis to just block the leaky mode. For single-mode fibre, the disc is positioned to give optimum resolution.

Refracted modes passing the disc are collected and focused onto a photodiode. The focused laser spot is traversed across the fibre end and a plot of fibre refractive index variation is directly obtained.

6.3.4.1.4.3 Test 202 Method A: Equipment calibration

The equipment is calibrated with the fibre removed from the liquid cell. During the measurement the angle of the cone of light varies according to the refractive index seen at the entry point to the fibre (hence the change of power passing the disc). With the fibre removed and the liquid index and cell thickness known, this change in angle can be simulated by translating the disc along the optic axis. By moving the disc to a number of predetermined positions the profile can be scaled in terms of relative index. Absolute indices, i.e. n_1 and n_2 , can only be found if the cladding index or the liquid index, at the measurement wavelength and temperature is known accurately.

6.3.4.1.4.4 Test 202 Method A: Results

The following details shall be presented:

- test arrangement and wavelength correction procedure;
- relative humidity and ambient temperature;
- fibre identification. Depending on specification requirement:
 - profile through core and cladding centres calibrated for a given wavelength;
 - profile along the core major and minor axes calibrated for a given wavelength;
 - profiles along the cladding major and minor axes calibrated for a given wavelength.

By the raster scan of the cross-section of the profile, the following quantities may be calculated:

- diameter of core;
- diameter of cladding;
- concentricity error core/cladding;
- non-circularity of core;
- non-circularity of cladding;
- maximum theoretical numerical aperture;
- index difference;
- relative index difference;
- indication of accuracy and reproducibility.

6.3.4.2 Test 202: Method B: Near field light distribution

6.3.4.2.1 Test 202: Method B: Object

The following test is for incoming and/or outgoing inspection. Imaging is made on a cross section at the end of the fibre under test.

The image is magnified by an output optics, for example microscope and various kinds of sensors can be used (direct examination, photographic camera, digital video analyser, scanning detector, etc.).

6.3.4.2.2 Test 202: Method B: Sample preparation

The sample shall be a short length of the optical fibre to be measured. This length shall be noted. The fibre ends shall be clean, smooth and perpendicular to the fibre axis.

6.3.4.2.3 Test 202: Method B: Apparatus

6.3.4.2.3.1 Test 202: Method B: Light source

The core illumination source shall be incoherent, adjustable in intensity and the type shall be noted. A second light source can be used to illuminate the fibre for cladding measurement purposes. The light source selected shall be stable for the required period of measurement.

6.3.4.2.3.2 Test 202: Method B: Detection systems

Different detection systems can be used depending on the type of measurement to be done (visual inspection, photography, calculation on the complete pattern).

6.3.4.2.3.3 Test 202: Method B: Microscope

An inverted metallurgical microscope or a biological microscope with a resolution near the diffraction limit shall be used (for example it should have a calibrated magnification of up to 600x and be equipped with the filar micrometre).

6.3.4.2.3.4 Test 202: Method B: Microscope with a photographic camera

The microscope described in 6.2.4.2.3.3 (Test 202: Method B: Microscope) may be equipped with a camera for micro photography. A suitable scale shall be used to calibrate the dimensions in the photograph.

6.3.4.2.3.5 Test 202: Method B: Video analyser

The microscope described in 6.2.4.2.3.3 (Test 202: Method B: Microscope) may be equipped with a TV camera. The output signal of the camera can be sent to a TV monitor for visual inspection or to a video analyser in order to record the complete output near of the fibre.

6.3.4.2.3.6 Test 202: Method B: Scanning detector

The TV camera described in 6.2.4.2.3.5 (Test 202: Method B: Video analyser) can be replaced by a pinhole photodetector, to make one or several scans of the fibre output near field. The signal of the detector is sent to a XY recorder.

6.3.4.2.4 Test 202: Method B: Procedure

6.3.4.2.4.1 General

- a) The end of the sample from which the image will be produced shall be prepared and so set as to make the end face perpendicular to the axis of the sample.
- b) The numerical aperture and hence the resolving power of the objective lens shall be compatible with the measuring accuracy required. The magnification shall be selected to be compatible with the fibre size and the field of view.
- c) The light source shall be attached to the other end of the sample, which may be prepared in the same way as the first end, and adjusted so that the fibre end image will be substantially free of any missing or unclear part. If necessary, index matching fluid shall be used couple the optical power between source and sample.

6.3.4.2.4.2 Test 202: Method B: Microscope technique with visual inspection

- a) The microscope shall be calibrated by measuring the length of an object of already known dimensions.
- b) The parameters of the sample to be measured may be determined by means of the filar micrometre and the known calibration. The minimum and maximum diameter shall be measured by rotating the image or the scale.

6.3.4.2.4.3 Test 202: Method B: Microscope technique with photography

- a) The intensity of the front and back illumination, the shutter speed, f" stop and a film shall be selected to obtain a clear photograph, for example clearly showing the boundary between core and cladding.
- b) The overall image magnification shall be determined by photographing a scale of known calibration such as a stage micrometre.
- c) The size of the photographic image shall be more than 30 mm xx30 mm the parameter to be measured shall be determined from the size of the image and the magnification.
- d) When using a scale as described in 6.2.4.2.3.4 (Test 202: Method B: Microscope with a photographic camera), a transparent scale be placed upon the photographs and judged.

6.3.4.2.4.4 Test 202: Method B: Microscope technique with a video analyser

- a) The output filed of the microscope is processed with a digital video analyser controlled by a computer, such as a scanning vidicon, charge coupled device (CCD) or other pattern intensity recognition device.
- b) The complete image is monitored and the line being processed is indicated, for example by a cursor.
- c) The boundaries are found by contrast level and referenced to a standard grating to give the geometrical parameters to be measured.

6.3.4.2.4.5 Test 202: Method B: Microscope technique with a pinhole scanning detector

- a) Focus a magnified image of the sample core onto a plane.
- b) Determine the intensity of the magnified near filed patterns. As examples, any of the following techniques may be used:
 - 1) scanning detector with pinhole;
 - 2) scanning mirror with fixed pinhole aperture detector.
- c) Record the intensity as a function of detector position.
- d) Use a phase-locked amplifier system (or equivalent apparatus) to amplify the low level signal.
- e) Scan fibre core image or pinhole detector by mean of a stepping motor translation stage or a scanning mirror.
- f) Record intensity (signal) a signal a function of position of the core diameter.
- g) The microscope shall be calibrated by measuring the length of an object of already known dimensions.

6.3.4.2.5 Test 202: Method B: Documentation

The following data shall be presented:

- fibre identification;

- number of samples;
- relative humidity and ambient temperature;
- description of apparatus;
- magnification;
- parameters measured;
- photographic images or video analyser print out if applicable.

6.3.4.3 Test 202: Method C: Four concentric circles

6.3.4.3.1 Test 202: Method C: Object

The following is compliance test for optical fibre dimensional parameters and tolerance. It is not valid for measuring the actual value of core and cladding diameter, non-circularity and concentricity errors.

This method gives evidence of compliance with the set of dimensional specification value. It should be used as an incoming and/or outgoing inspection.

The four concentric circles form two rings with the diameters:

$$D_{CL} + \Delta D_{CL} \quad \text{for the cladding}$$

$$D_{CL} + \Delta D_{CL}$$

$$D_{CO} + \Delta D_{CO} \quad \text{for the cladding}$$

$$D_{CO} + \Delta D_{CO}$$

Which define the tolerance field.

A fibre will pass this test if a position of fibre and tolerance can be found where both the cladding contour and the core contour lie completely inside the two rings. Values for D_{CL} and ΔD_{CL} , D_{CO} and ΔD_{CO} , should be taken from the detail specification.

6.3.4.3.2 Test 202: Method C: Sample preparation/selection

The sample should be a short length of the optical fibre to be measured. This length should be noted.

6.3.4.3.3 Test 202: Method C: Apparatus

6.3.4.3.3.1 Test 202: Method C: Light source

The core illumination source shall be incoherent, adjustable in intensity and the type shall be noted. A second light source can be used to illuminate the fibre for cladding measurement purposes. The light source selected shall be stable for the required period of measurement.

6.3.4.3.3.2 Test 202: Method C: Microscope

An inverted metallurgical microscope or a biological microscope with a resolution near the diffraction limit shall be used (for example it should have a calibrated magnification of up to 600x and be equipped with the filar micrometre).

6.3.4.3.3.3 Test 202: Method C: Microscope with a photographic camera

The microscope described in 6.2.4.2.3.3 (Test 202: Method B: Microscope) may be equipped with a camera for micro photography. A suitable scale shall be used to calibrate the dimensions in the photograph.

6.3.4.3.3.4 Test 202: Method C: Video analyser

The microscope described in 6.2.4.2.3.3 (Test 202: Method B: Microscope) may be equipped with a TV camera. The output signal of the camera can be sent to a TV monitor for visual inspection or to a video analyser in order to record the complete output near of the fibre. The comparison between the given four circles and core and cladding limits may be done by computation, visual or printed display.

6.3.4.3.3.5 Test 202: Method C: Scanning detector

The TV camera described in 6.2.4.2.3.4 (Test 202: Method B: Microscope with a photographic camera) can be replaced by a pinhole photodetector, to make one or several scans of the fibre output near field. The signal of the detector is sent to a XY recorder.

6.3.4.3.3.6 Test 202: Method C: Mask

A mask with four concentric circles should be provided and inserted in the optical measuring system. The accuracy of the mark shall be such that the accuracy given in the detail specification can be obtained on the sample.

One of the following methods can be applied:

- a mask in the ocular of the microscope;
- a transparent mark upon the photograph;
- two separate objectives in the microscope for mark and sample respectively.

NOTE For a video analyser hardware mark is not required.

6.3.4.3.4 Test 202: Method C: Procedure

The prepared sample is fixed in the sample holder and illuminated by the light source in such a way that the core and cladding contours are as clear as possible. By manipulating the sample, the contours of core and cladding are brought inside the two rings. If this possible the fibre has passed the test. If so desired a photograph is taken to indicate the test results (passed/not passed).

6.3.4.3.5 Test 202: Method C: Documentation

The following data shall be presented:

- fibre identification;
- number of samples;
- relative humidity and ambient temperature;
- (photography);
- description of apparatus type of microscope and mask;
- test result: passed/not passed.

6.3.4.4 Test 202: Method D: Mechanical diameter measurement

6.3.4.4.1 Test 202: Method D: Object

The following method applies to the mechanical measurement of the cladding diameter of an optical glass or silica fibre. In practice for smooth and substantially circular fibres, it gives a similar result to that obtained by methods A and B, in which case non-circularity of fibre can also be determined. This method can also be used for the measurement of the coating diameter of some types of coated or buffered fibres. In this method both sides of the object are contacted with flat parallel surface, and the separation of the surfaces is accurately measured.

6.3.4.4.2 Test 202: Method D: Scope

The diameter of a fibre and coated fibre are fundamental values and shall be known for subsequent procedures such as handling, splicing, connectorization, cabling and measurements.

6.3.4.4.3 Test 202: Method D: Test apparatus

6.3.4.4.3.1 Test 202: Method D: General

The measurement used two anvils with very flat faces to contact each side of the fibre. The faces of the anvils shall be parallel to each other and the contact force which the anvils apply to the fibre shall be precisely controlled to prevent physical distortion of the specimen or the anvils.

6.3.4.4.3.2 Test 202: Method D: Apparatus

Refer to the schematic diagram of the test apparatus (Figure 4).

Test 202: Method D: Anvils

There are two anvils, one fixed and the other mounted on a precision stage. The anvil faces are parallel to each other and perpendicular to the stage movement direction. They are made of a hard non-corrosive material, for example stainless steel or fused silica.

Test 202: Method D: Precision stage

The precision stage holds the moveable anvil and the retroreflector for the electronic micrometre system. The stage is moved by a micrometre screw; the stage is held against the screw by springs. The springs act to pull the anvils together.

Test 202: Method D: Electronic micrometre system

An electronic micrometre system, such as a double-pass Michelson interferometer, may be used with a retroreflector to measure accurately the movement of the stage and thus the moveable anvil.

Test 202: Method D: Specimen supports

These support the specimen between the faces of the anvils.

6.3.4.4.3.3 Test 202: Method D: Procedure

6.2.4.4.3.3.1 Test 202: Method D: Principle of measurement

The diameter of the specimen is measured by contacting opposite sides with the anvils. The contact force, which is controlled by the stage spring tension and the anvil contact surface, is adjusted so that negligible distortion of the specimen or anvils occurs. Values for individual materials shall be agreed between supplier and user.

For example, for a 125 µm diameter fused silica fibre this force is typically 0,2 N for anvils with a length of contact of 1 mm along the fibre.

The separation of the anvils is accurately measured with the electronic micrometre.

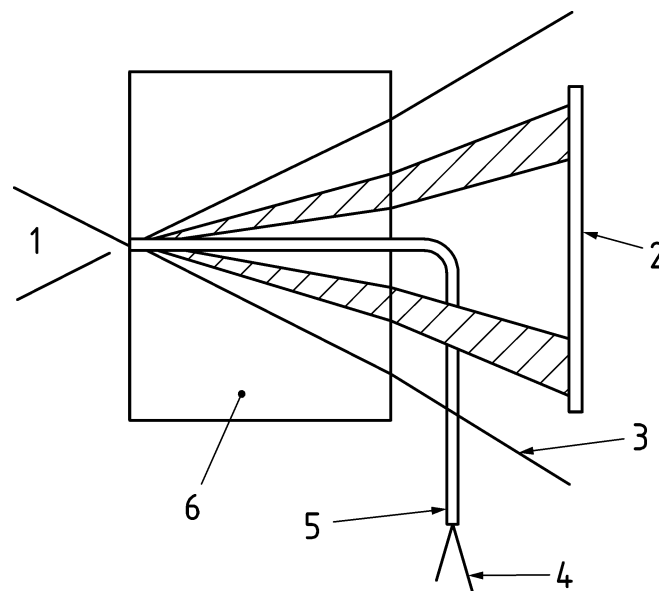
6.2.4.4.3.3.2 Test 202: Method D: Measurement

The anvil faces are cleaned and the micrometre screw turned to bring the anvil faces into contact with each other. The micrometre screw is turned an extra amount so that the anvils are held together by the spring tension only. The electronic micrometre distance reading is recorded. The micrometre is next adjusted so that the gap between the anvil faces is larger than the specimen diameter. The specimen fibre is placed on the supports between the anvil faces. The micrometre screw is turned slowly to bring the anvil faces into contact with the fibre so that the anvils are held against the fibre by the spring tension only. The electronic micrometre distance reading is recorded. The difference between the first and second reading is the specimen diameter. The measurement should be repeated a few times to ensure repeatability.

6.3.4.4.3.4 Test 202: Method D: Results

The specimen average diameter and standard deviation derived from a number of measurement should be given to indicate measurement repeatability.

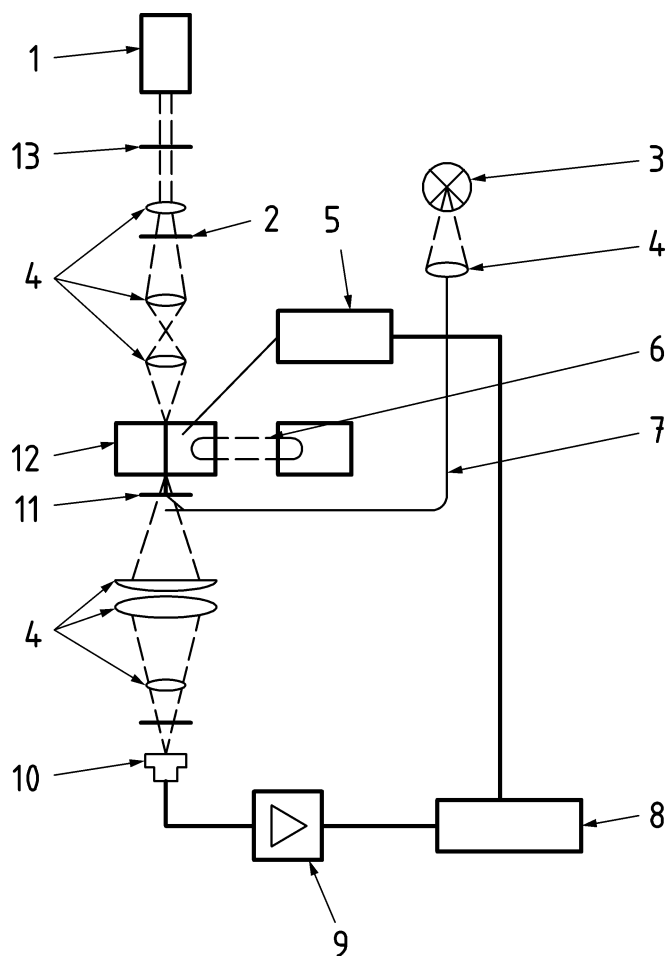
Non-circularity of fibre can be determined by a series of measurement in which the fibre rotated between each measurement.



Key

- 1 incident light overfilling the numerical aperture of the fibre
- 2 disc
- 3 refracted modes only
- 4 guided power
- 5 optical fibre
- 6 liquid cell

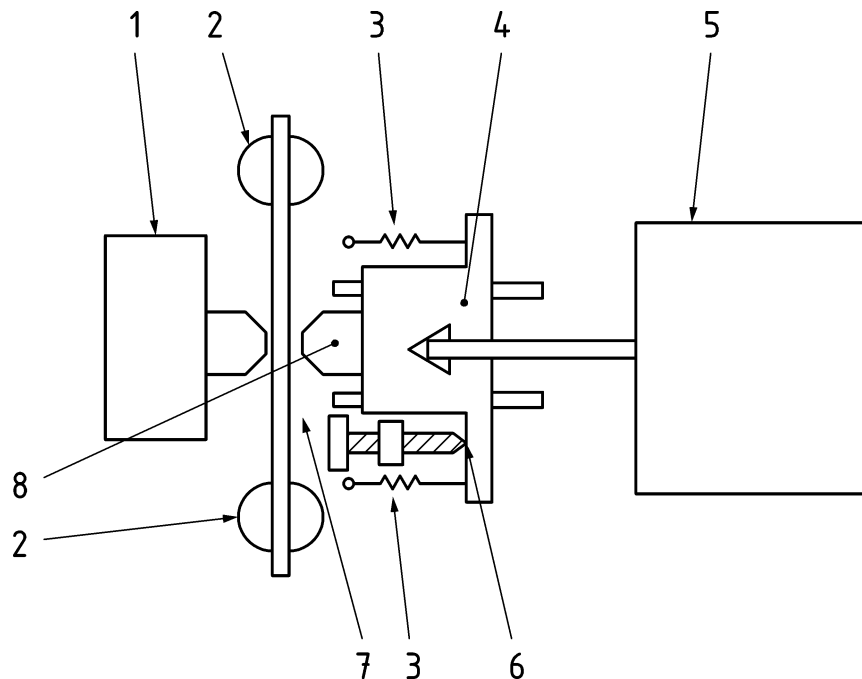
Figure 2 — Test 202 Method A: Refracted near-field technique – Schematic diagram



Key

- 1 laser
- 2 50 μm pinhole
- 3 lamp
- 4 lens
- 5 electronic micrometre
- 6 motor
- 7 optical fibre
- 8 recorder
- 9 electrical amplifier
- 10 photodiode
- 11 disc
- 12 liquid cell
- 13 quarter wave plate

Figure 3 — Test 202 Method A: Typical arrangement of the refracted near-field test set



Key

- 1 fixed anvil
- 2 specimen support
- 3 spring
- 4 retro reflector
- 5 electronic micrometre
- 6 micrometre screw
- 7 specimen
- 8 anvil on precision stage

Figure 4 — Test 202 Method D: Top view of electronic micrometre system

6.4 Test 203: Cable dimensions

6.4.1 General

This clause specifies a method of measuring the dimensions of fibre optic cables.

6.4.2 Test 203: Preparation of specimens

6.4.2.1 Test 203: Dimensions

6.4.2.1.1 Test 203: Tube and jacket

Each sample shall consist of a cross-sectional slice of insulation from the cable. The sample should be cut and then be placed under the measuring equipment with the plane of cut perpendicular to the optical axis.

6.4.2.1.2 Test 203: Tight buffer

Prepare a sample of a minimum of 3 m in length.

6.4.2.2 Test 203: Mass

Prepare a sample of a minimum of 1 m in length.

6.4.3 Test 203: Apparatus

6.4.3.1 Test 203: Buffer and jacket dimensions

The measurements shall be carried out either with a profile projector, or measuring microscope or equivalent apparatus having at least 10 × magnification. Readings shall be taken to 2 decimal places and an estimated 3 decimal places with a specified thickness less than 0,5 mm.

6.4.3.2 Test 203: Mass

The mass and length of the specimen shall be determined with an apparatus having an accuracy of at least $\pm 1\%$.

6.4.4 Test 203: Method A

6.4.4.1 Test 203: Method A: Buffer and external diameter

Measure the outside diameter (OD) of the specimen in at least three locations approximately one meter apart. Each measurement shall consist of two micrometer readings taken at 90° from each other.

6.4.4.2 Test 203: Method A: Buffer tube and jacket thickness and concentricity

6.4.4.2.1 The sample shall be placed under the measuring equipment with the plane of cut perpendicular to the optical axis. The radial thickness shall be measured and recorded at the thinnest and thickest points.

6.4.4.2.2 The concentricity shall be expressed as 100 times the ratio of the minimum radial thickness to the maximum radial thickness.

6.4.4.3 Test 203: Method A: Mass

The measurement shall be made on a specimen whose length shall be given in the technical specification.

6.4.5 Test 203: Method A: Final measurements and requirements

6.4.5.1 Test 203: Method A: Buffer dimensions

6.4.5.1.1 Test 203: Method A: Tight buffer

The characteristics shall conform to requirements given in the technical specification or the product standard.

6.4.5.1.2 Test 203: Method A: Loose tube

The characteristics shall conform to the requirements given in the technical specification or the product standard.

The minimum value of the concentricity shall conform to the requirements given in the technical specification or the product standard.

6.4.5.2 Test 203: Method A: External diameter

The external diameter, minimum radial thickness, maximum radial thickness and concentricity shall conform to that stated in the product standard.

None of the individual readings shall exceed the maximum specified value defined in product standard.

6.4.5.3 Test 203: Method A: Mass

The mass of the cable, expressed in kg/km, shall conform to the value given in the product standard.

6.5 Test 205: Cable longitudinal dimensional stability

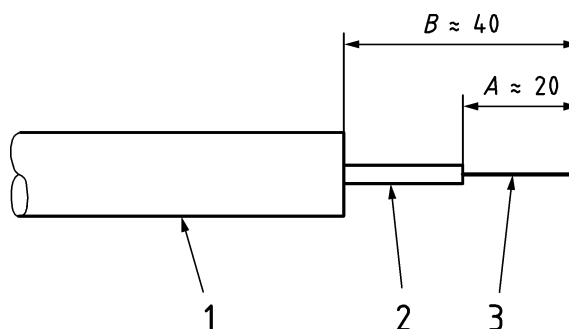
6.5.1 General

This clause specifies a method to determine the longitudinal dimensional stability of the outer sheath/jacket (if present) and secondary coating or buffer of a fibre optic cable or fibre.

6.5.2 Test 205: Preparation of specimens

6.5.2.1 Specimen lengths to be tested shall be $(5 \pm 0,1)$ m. Unless otherwise specified in the product standard, the outer sheath (and strength members if present) shall be removed using a specific tool to expose approximately 40 mm of clad (or clad and coated/buffered) fibre at both ends. Any coatings shall then be removed to reveal approximately 20 mm of bare fibre as follows:

Dimensions in millimetres



Key

- 1 overall cable jacket
- 2 coated/buffered fibre
- 3 bare fibre

Figure 5 — Test 205: Preparation of specimens

Measurements shall be taken to determine the length of exposed fibre (dimension A) and the distance of the jacket from the fibre end (dimension B). These lengths shall be measured to an accuracy of $\pm 0,1$ mm at both ends. The points of measurement on the circumference of the jackets (and/or buffers) shall be marked using any suitable method. These measurements shall be repeated 15 min after the stripping procedure, and the difference between these measurements and those taken previously, shall be recorded.

6.5.2.2 The following details shall be specified if not already included in the product standard:

- number of samples to be tested;
- type of stripping tool(s) used;
- maximum permitted change in length for dimensions A and B;
- see 8.2, temperature cycling.

6.5.3 Test 205: Apparatus

Suitable length measuring apparatus.

See 8.2, temperature cycling.

6.5.4 Test 205: Method A

6.5.4.1 Test 205: Method A: Procedure

Unless otherwise specified in the technical specification the specimen(s) shall be subjected to temperature cycling test as defined in 8.2, temperature cycling.

Multiple cycles may be specified. At the end of the cycles, the sample shall be removed and the exposed fibre lengths A and B measured as before.

6.5.4.2 Test 205: Method A: Final measurements and requirements

The change in dimensions A and B shall not exceed the maximum values specified.

7 Serie 3xx: Optical tests

7.1 General

Test series –30x corresponds to test methods allowing to measure optical fibre and cable characteristics.

7.2 Test 301: Attenuation

7.2.1 General

This clause specifies procedures for the practical measurement of the attenuation and variation in attenuation of optical fibre or optical cable (both hereafter referred to as fibre). Methods A and B are intended for fibre acceptance testing and shall be performed on fibre lengths greater than 1 km. Method C is intended for attenuation measurement required during environmental and mechanical testing and shall be performed on fibre lengths less than 100 m. If no method is mentioned, method A applies.

7.2.2 Test 301: Preparation of specimens

7.2.2.1 The fibre ends shall conform to the fibre end preparation criteria specified in EN 2591-100.

7.2.2.2 The length of fibre to be tested shall be in accordance with the product specification.

7.2.2.3 All other aspects of specimen preparation shall be in accordance with EN IEC 60793-2 or method 302, or EN 2591-602:2001 method A, or EN IEC 60793-1-40:2019 depending on the test being performed.

7.2.3 Test 301: Apparatus

7.2.3.1 The light launch system for methods A and B shall conform to the criteria specified in EN IEC 60793-2. The light launch system for method C shall conform to the criteria specified in EN 2591-100:2024. The light launch system for method D shall conform to the criteria specified in EN IEC 60793-1-40:2019.

7.2.3.2 The light detection system shall be compatible with the light launch system as discussed in EN 2591-100.

7.2.3.3 All other aspects of the apparatus shall be in accordance with EN IEC 60793-2, EN 2591-601:2001 method 1 or 4, or EN 2591-602:2001 method A, or EN IEC 60793-1-40:2019 Annex C depending on the method being performed.

7.2.3.4 Test conditions for attenuation or attenuation variation measurement shall be as specified in Clause 4 (Test conditions) unless stated otherwise in the product specifications.

7.2.4 Test 301: Methods

7.2.4.1 Test 301: Method A (Cut-back technique)

Procedure: the test method shall conform to EN IEC 60793-2.

7.2.4.2 Test 301: Method B (Insertion loss)

Procedure: the test method shall conform to EN IEC 60793-2.

7.2.4.3 Test 301: Method C (Attenuation variation)

Procedure: the test method shall conform to EN 2591-602:2001 method A.

7.2.4.4 Test 301: Method D (Backscattering)

Procedure: the test method shall conform to EN IEC 60793-1-40:2019, Annex C.

7.3 Test 302: Numerical aperture

7.3.1 General

This clause specifies a method of determining the effective numerical aperture of an optical cable or fibre used in aerospace applications. If no method is mentioned, method A applies.

7.3.2 Test 302: Preparation of specimens

7.3.2.1 The specimens shall be prepared in accordance with EN 2591-100, unless otherwise specified in the product standard.

If not yet at standard test conditions, the specimens shall be subjected to standard test conditions and stabilized at these conditions for 24 h as defined in Clause 4 (Test conditions).

7.3.2.2 Unless specified in the technical specification, the following details shall be stated:

- type of cable or fibre and length if different from 2 m;
- acceptable radius of curvature during measurement.

7.3.3 Test 302: Apparatus

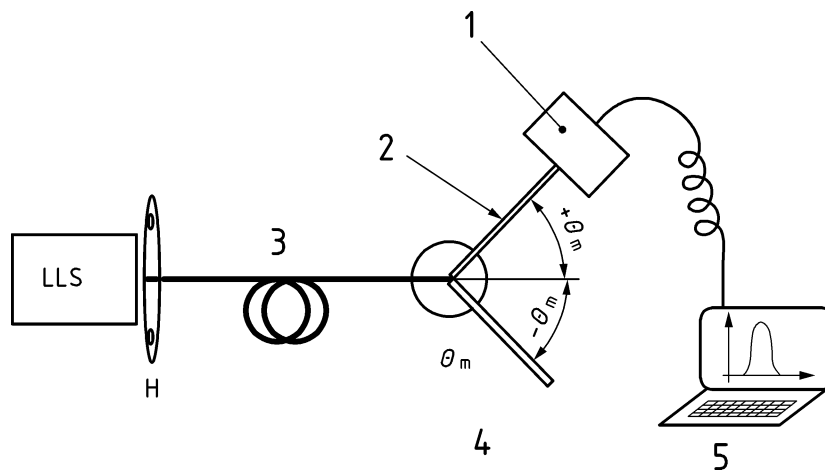
7.3.3.1 General

The apparatus shall comprise:

- a Light Launch System (LLS) as defined in EN 2591-100;
- a mechanical chopper H;
- detection systems depending on the selected method.

7.3.3.2 Test 302: Apparatus for method A (see Figure 6)

- for the “far field rotating arm method”, the specimen is fixed, the detector is attached to a rotating arm; distance between detector and fibre $> 2\varnothing_{CR}^2 / \lambda$;
- a goniometer;
- a classical detector with a small aperture.



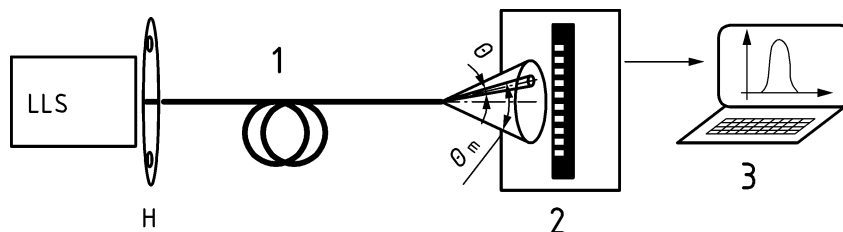
Key

- 1 detector
- 2 rotating arm
- 3 specimen
- 4 goniometer
- 5 processing

Figure 6 — Test 302 Method A: Far field rotating arm method

7.3.3.3 Test 302: Apparatus for method B (see Figure 7)

- for the “Charge Coupled Device (CCD) camera method”, everything is fixed (specimen and detector), required apparatus is only a CCD camera, placed at a distance from the optical fibre $> 2\varnothing_{CR}^2 / \lambda$.



Key

- 1 specimen
- 2 CCD camera
- 3 processing

Figure 7 — Test 302 Method B: Charge Coupled Device camera method

7.3.4 Test 302: Method

7.3.4.1 Test 302: Method description

Adjust the launch condition parameters to the following values:

— $NA = 110 \% NA_{nom}$;

— $\varnothing_{CR} = 100 \% \varnothing_{CR nom}$.

Connect the specimen to LLS and to the required detector following selected method.

7.3.4.2 Test 302: Method A (see Figure 6)

The principle consists in measuring the variation in the radiant intensity emitted by the fibre versus the angular position of the detector that is: $i = f(\theta)$ (θ being the emission angle with respect to a line normal to the source).

Install the arm supporting the detector on a goniometer driven by a step motor connected to a computer.

Rotate the rotating arm at regular rotation angle intervals e.g. $\alpha \leq 1^\circ$. If the optical axis of the fibre is taken as being the origin, the arm will describe sector: $-60^\circ, 0^\circ, 60^\circ$.

Process the modulated optical signal received by the detector at each measurement step (synchronous detector amplifier).

Average this signal over the measurement intervals, store it and then plot the radiation intensity diagram.

NOTE The resolution tg corresponds to the following ratio:

$$tg = \frac{\text{detector aperture diameter}}{\text{fibre detector distance}}$$

7.3.4.3 Test 302: Method B (see Figure 7)

The principle consists in analysing the output light of the fibre by means of a CCD camera. The intensity profile is given by the processing of the intensity delivered by each pixel of the CCD output.

Adjust the CCD camera illumination level and acquire the output signal emerging from the optical fibre. A corrective factor ($\cos \theta$) shall be applied to the received signal to take into account the angle between CCD plane and unit output beam.

Store it and then plot the radiation intensity diagram.

For each numerical aperture determination, three curves will be plotted allowing an average of the calculated value to be determined with a related standard deviation.

NOTE An angle measurement determined at $\theta \pm 0,5^\circ$, corresponds typically to a numerical aperture accuracy of $\pm 0,01$.

7.3.4.4 Test 302: Final measurements and requirements

Following the radiation diagram $i = f(\theta)$, the numerical aperture corresponds to:

$NA = \sin \theta_m$ at 5 % of I_{max} . (see Figure 8).

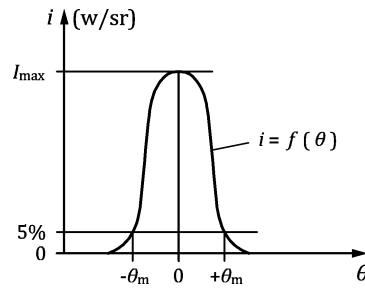


Figure 8 — Test 302: Radiation diagram

7.3.4.5 Test 302: Special precautions

Care will be taken not to modify curvature bend radius of specimen during the various measurement steps.

7.4 Test 303: Bandwidth

7.4.1 General

This clause specifies methods of measuring the bandwidth of optical cable. If no method is mentioned, method A applies.

7.4.2 Test 303: Test procedures

The procedure defined in EN IEC 60793-1-41 shall be referred to.

7.4.3 Test 303: Apparatus

The apparatus defined in EN IEC 60793-1-41 test shall be referred to.

7.4.4 Test 303: Methods

7.4.4.1 Test 303: Method A

The method A defined in EN IEC 60793-1-41 shall be referred to.

7.4.4.2 Test 303: Method B

The method B defined in EN IEC 60793-1-41 shall be referred to.

7.4.5 Test 303: Requirements

Defined in the product standard.

7.5 Test 305: Immunity to ambient light coupling

7.5.1 General

This clause specifies a method of measuring the immunity of optical fibre or cable to the coupling of power coming from an external light source.

7.5.2 Test 305: Preparation of specimens

7.5.2.1 The specimens shall be prepared according to the product standard.

If not yet at standard test conditions, the specimens shall be subjected to standard test conditions and stabilized at these conditions for 24 h as defined in Clause 4 (Test conditions).