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INTERNATIONAL STANDARD

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**Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-35: Examinations and measurements –
Visual inspection of fibre optic connectors and fibre-stub transceivers**

**Dispositifs d'interconnexion et composants passifs à fibres optiques –
Procédures fondamentales d’essais et de mesures –
Partie 3-35: Examens et mesures – Examen visuel des connecteurs à fibres optiques et des émetteurs-récepteurs à embase fibrée**

IEC 61300-3-35:2015-06(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers

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International Standard IEC 61300-3-35 has been prepared by subcommittee SC86B: 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 2009 and constitutes a technical revision.

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

a) modification to the title;
b) addition of some terms and definitions;

c) reconsideration of the specific values of Tables 1 to 4 to reflect the current market situation;

d) addition of visual requirements for single-mode transceivers using a fibre-stub interface in Table 3;

e) addition of a sentence in 4.1 concerning the susceptibilty of the methods to system variability.

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

FDIS	Report on voting
86B/3886/FDIS	86B/3912/RVD

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

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

A list of all parts 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 publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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

Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers

1 Scope

This part of IEC 61300 describes methods for quantitatively assessing the end face quality of a polished fibre optic connector or of a fibre optic transceiver using a fibre-stub type interface. Sub-surface cracks and fractures are not considered in this standard. In general, the methods described in this standard apply to 125 μm cladding fibres contained within a ferrule and intended for use with sources of ≤ 2 W of input power. However, portions are applicable to non-ferruled connectors and other fibre types. Those portions are identified where appropriate. It is not the intention of this standard that the size of scratches should be measured, the dimensions and requirements are selected such that they can be estimated. There is no need to measure for example if a scratch is 2,3 μm wide.

2 Normative references

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

Void.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
defect
non-linear surface feature detectable on the end face of ferrule including particulates, other debris, fluid contamination, pits, chips, edge chipping, etc.

Note 1 to entry: Some fibre types have structural features potentially visible on the fibre end face. Fibres that use microstructures to contain the light signal, such as photonic band-gap and hole-assisted fibres, can have an engineered or random pattern of structures surrounding the core. These features are not defects.

3.1.2
defect size
smallest circle that can encompass the entire defect

3.1.3
loose debris
particulate and debris that can be removed by cleaning

Note 1 to entry: Loose debris are classified as defects.

3.1.4
scratch
a permanent linear surface feature where the fiber or ferrule end face has been damaged or removed, and where the width of the damaged area is small compared to its length

3.1.5
reliably detectable
sufficiently clear and visible so that a typical technician of average training would recognize the feature at least 98 % of the time.

3.2 Abbreviations

Term	Description
DUT	Device under test
FOV	Field of view

4 Measurement

4.1 General

The objective of this standard is to prescribe methods for quantitatively inspecting fibre optic end faces to determine if they are suitable for use. Three methods are described:

A. direct view optical microscopy as described in 5.1;

B. video microscopy as described in 5.2;

C. automated analysis microscopy as described in 5.3.

Within each method, there are hardware requirements and procedures for both low resolution and high resolution systems. Low resolution systems should be used for examination of single-mode and multi-mode connectors prior to mating and after polishing. High resolution systems may be used for end face inspection in the factory after polishing of single-mode connectors. High resolution systems are not required for inspection in the field nor for inspection of multi-mode connectors nor for field polished connectors.

For Methods A and B, it is recommended that visual gauge tools be developed to facilitate the measurement procedure. For Method A, an eyepiece reticule is recommended. For Method B, an overlay is recommended.

All methods are susceptible to system variability: Methods A and B are operator dependent; Method C is operator independent.

4.2 Measurement conditions

No restrictions are placed on the range of atmospheric conditions under which the test can be conducted. It may be performed in controlled or uncontrolled environments provided that the end faces are carefully cleaned before the test.

4.3 Pre-conditioning

No pre-conditioning time is required.

4.4 Recovery

No minimum recovery time is required.

5 Apparatus

5.1 Method A: Direct view optical microscopy

This method utilizes an optical microscope in which a primary objective lens forms a first image that is then magnified by an eyepiece that projects the image directly to the user's eye. It shall have the following features and capabilities:

- a suitable ferrule or connector adapter;
- a light source and focusing mechanism;
- a built-in laser safety filter.

Laser safety is of particular concern when using direct view microscopes, as any energy in the optical path is directed into the eye of the observer. If Method A is used the user shall ensure there is no laser active on the link prior to inspection. See IEC 60825-2 for laser safety of optical fibre communication systems.

5.2 Method B: Video microscopy

This method utilizes an optical microscope in which a lens system forms an image on a sensor that, in turn, transfers the image to a display. The user views the image on the display. It shall have the following features and capabilities:

- a suitable ferrule or connector adapter;
- a light source and focusing mechanism;
- a means to measure surface anomalies observed in the image.

5.3 Method C: Automated analysis microscopy

This method utilizes an optical microscope in which a digital image is acquired or created and subsequently analysed via an algorithmic process. The purpose of such a system is to reduce the effects of human subjectivity in the analysis process. It shall have the following features and capabilities:

- a suitable ferrule or connector adapter;
- a means for acquiring or creating a digital image;
- algorithmic analysis of the digital image;
- a means to compare the analysed image to programmable acceptance criteria in such a manner that a result of "pass" or "fail" is provided.

5.4 Certification requirements for low and high resolution systems

5.4.1 General

Microscope systems for Methods A, B and C shall be certified for use in either low or high resolution applications. This certification shall be conducted with a purpose-built certification artefact that can serve to validate a system's ability to detect surface anomalies of relevant size. Such an artefact shall be provided with instructions on its use and shall be manufactured in a method such that it can be measured in a traceable manner. Details of the manufacture of such artefacts can be found in Annex B.

5.4.2 Requirement for low resolution microscope systems

This requirement is a minimum total magnification offering a field of view (FOV) of at least 250 μm (for Methods B and C, this dimension shall be measured in the vertical, or most constrained, axis) capable of detecting defects of 2 μm in diameter.

5.4.3 Requirements for high resolution microscope systems

These requirements are a minimum total magnification offering a field of view of at least 120 μm (for Methods B and C, this dimension shall be measured in the vertical, or most constrained, axis) capable of detecting scratches 1 μm in width. A system with FOV less than 250 μm will require scrolling/panning of the end face or subsequent inspection with a larger FOV system to meet the full requirements of this standard.

6 Procedure

6.1 Certification procedure

On commissioning, and periodically during its life, the microscope system shall be certified.

Fix the artefact(s) on the microscope system and focus the image.

Follow the manufacturer's instructions on how to certify the system using the artefact.

Generally, this should entail viewing the artefact and verifying that the small features and contrast targets are "reliably detectable"; and that the region of interest can be fully viewed or scanned.

For automated systems, software utilities to perform this certification shall be provided. In any event, these systems shall be able to perform the same certification so as to validate the fact that they can reliably detect the features of the artefact.

6.2 Inspection procedure

It is recommended that the complete ferrule end face be inspected for cleanliness and absence of loose debris. This is especially important for rectangular ferrules such as MT ferrules. Use of inspection equipment with large FOV of and oblique illumination eases the detection of loose particles. This inspection for cleanliness should take place prior the inspection of the polished end faces.

Figure 1 shows a flowchart which describes the following procedure which shall be employed.

- Focus the microscope so that a crisp image can be seen.
- Align the inspection zones prescribed within the inspection criteria with the outer edge of the optical fibre.
- Locate all defects and scratches within the zones as specified in the relevant Tables of 6.3. Count and measure defects and count scratches within each zone. Exclude from analysis all defects contained within the zone covering the interface between fibre and ferrule (Zone C: adhesive). In the context of this standard, "none" means no scratch or defect detectible by the qualified inspection system.
- Once all defects and scratches have been quantified, the results should be totalled by zone and compared with the appropriate acceptance criteria (see Tables 1 to 4). If a defect is found to be in more than one zone, apply the scratch/defect to the most stringent zone and exclude from further analysis.
- Any end face with quantified defects or scratches in excess of the values shown in any given zone on the table is determined to have failed. Scratches that are extremely wide may be judged to be too large, per the acceptance criteria and result in immediate failure of the device under test (DUT).
- If the end face fails inspection for defects, the user shall clean the end face and repeat the inspection process. Several attempts at cleaning may be required. Consult IEC TR 62627-01 for recommendations on cleaning methods.

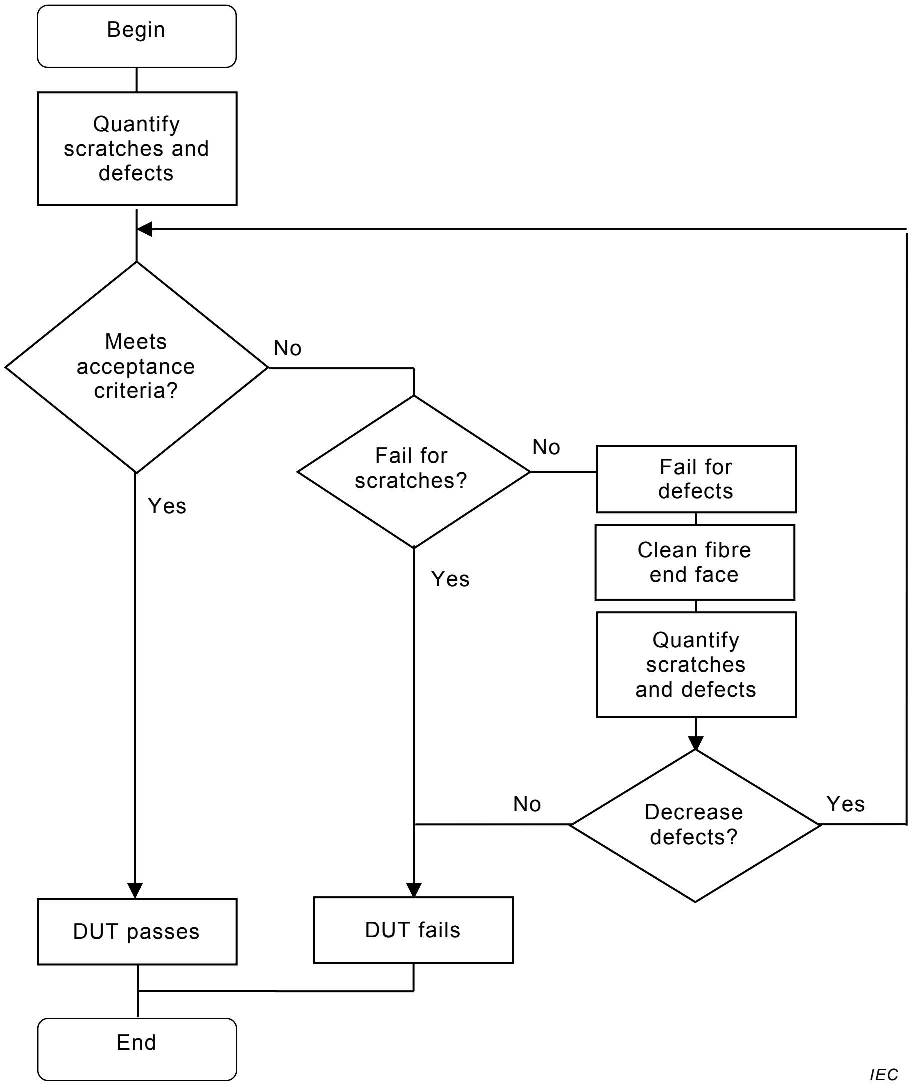

Figure 1 – Inspection procedure flow

6.3 Visual requirements

It is not the intention of this standard that the size of scratches shall be measured, the dimensions and requirements are selected such that they can be estimated. There is no need to measure for example if a scratch is 2,3 µm wide.

Visual requirements for single-mode and multi-mode connectors are shown in Table 1 to Table 4.

Table 1 – Visual requirements for single-mode PC polished connectors, RL ≥ 45 dB

Zone[a]	**Scratches** (maximum number of a given dimension)	**Defects** (maximum number of a given dimension)
A: core 0 µm to 25 µm	None	None
B: cladding 25 µm to 115 µm	No limit ≤ 3 µm None > 3 µm	No limit < 2 µm 5 from 2 µm to 5 µm None > 5 µm
C: adhesive 115 µm to 135 µm	No limit	No limit
D: contact 135 µm to 250 µm	No limit	None > 10 µm

NOTE 1 There are no requirements for the area outside the contact zone. Cleaning loose debris beyond this region is recommended good practice. This is of particular concern for multiple-fibre rectangular-ferrule connectors.

NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array.

[a] For multiple-fibre rectangular-ferrule connectors only the requirements of Zone A and Zone B apply.

Table 2 – Visual requirements for single-mode angle polished (APC) connectors

Zone[a]	**Scratches** (maximum number of a given dimension)	**Defects** (maximum number of a given dimension)
A: core 0 µm to 25 µm	4 ≤ 3 µm	None
B: cladding 25 µm to 115 µm	No limit	No limit < 2 µm 5 from 2 µm to 5 µm None > 5 µm
C: adhesive 115 µm to 135 µm	No limit	No limit
D: contact 135 µm to 250 µm	No limit	None > 10 µm

NOTE 1 There are no requirements for the area outside the contact zone. Cleaning loose debris beyond this region is recommended good practice. This is of particular concern for multiple-fibre rectangular-ferrule connectors.

NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array.

[a] For multiple-fibre rectangular-ferrule connectors, only the requirements of Zone A and Zone B apply.

Table 3 – Visual requirements for single-mode PC polished connectors, RL ≥ 26 dB and single-mode transceivers using a fibre-stub interface

Zone[a]	Scratches (maximum number of a given dimension)	Defects (maximum number of a given dimension)
A: core 0 μm to 15 μm	2 ≤ 3 μm None > 3 μm	None
B: cladding 15 μm to 115 μm	No limit ≤ 3 μm 3 > 3 μm	No limit < 5 μm 5 from 5 μm to 10 μm None > 10 μm
C: adhesive 115 μm to 135 μm	No limit	No limit
D: contact 135 μm to 250 μm	No limit	No limit < 20 μm 5 from 20 μm to 30 μm None > 30 μm
NOTE 1 There are no requirements for the area outside the contact zone. Cleaning loose debris beyond this region is recommended good practice. This is of particular concern for multiple-fibre rectangular-ferrule connectors. NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array.		
[a] For multiple-fibre rectangular-ferrule connectors, only the requirements of Zone A and Zone B apply.		

Table 4 – Visual requirements for multi-mode PC polished connectors

Zone[a]	Scratches (maximum number of a given dimension)	Defects (maximum number of a given dimension)
A: core 0 μm to 65 μm	No limit ≤ 3 μm None > 3 μm	4 ≤ 5 μm None > 5 μm
B: cladding 65 μm to 115 μm	No limit ≤ 5 μm None > 5 μm	No limit < 5μm 5 from 5 μm to 10 μm None > 10 μm
C: adhesive 115 μm to 135 μm	No limit	No limit
D: contact 135 μm to 250 μm	No limit	No limit < 20 μm 5 from 20 μm to 30 μm None > 30 μm
NOTE 1 There are no requirements for the area outside the contact. Cleaning loose debris beyond this region is recommended good practice. This is of particular concern for multiple-fibre rectangular-ferrule connectors. NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array. NOTE 3 The zone size for multi-mode fibres has been set at 65 μm to accommodate both 50 μm and 62,5 μm core size fibres. This is done to simplify the grading process.		
[a] For multiple-fibre rectangular-ferrule connectors only, the requirements of Zone A and Zone B apply.		

Annex A
(informative)

Examples of inspected end faces with surface anomalies

In Figures A.1 to A.10, the images on the left are with a computer overlay highlighting where the scratch or defect was found, and the images on the right are without the overlay.

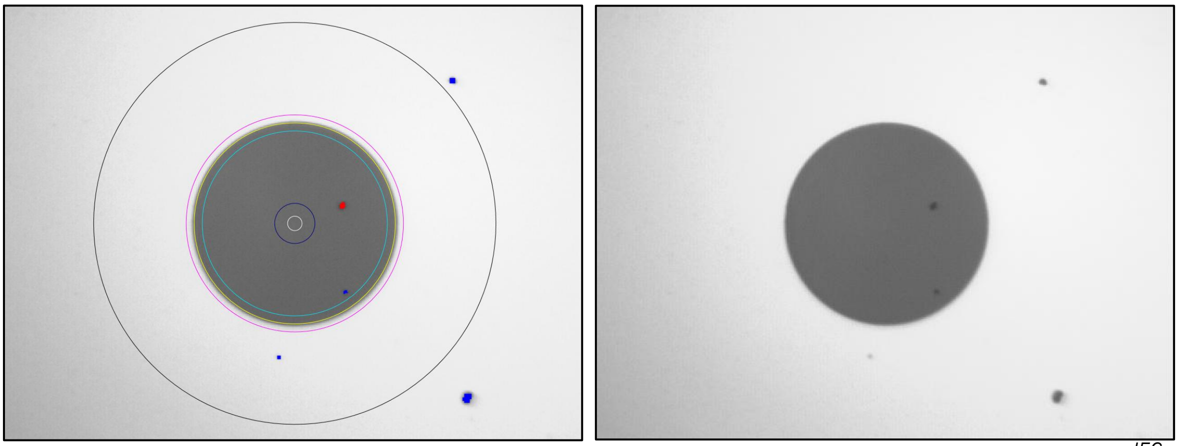

Figure A.1 – Example 1 (low resolution system)

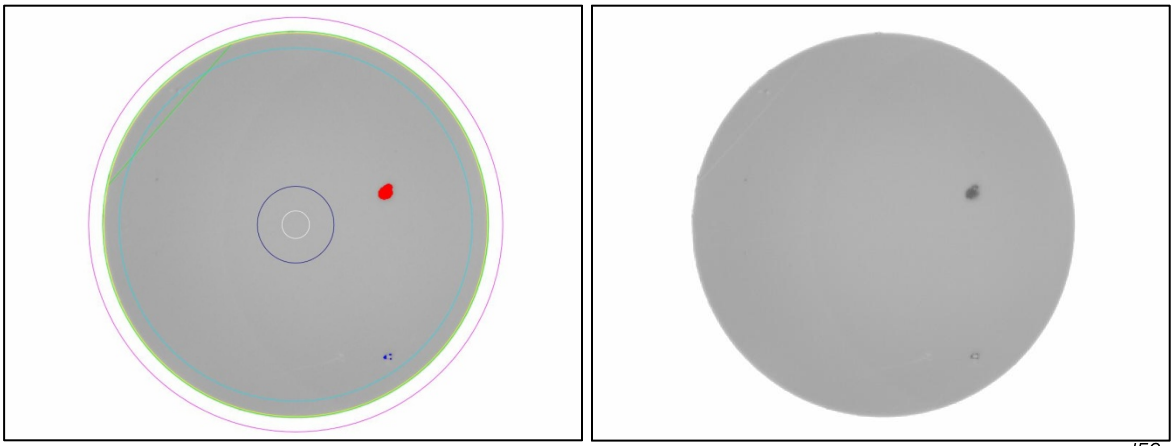

Figure A.2 – Example 1 (high resolution system)

Test requirements:	Single-mode PC polished connectors, RL ≥ 45 dB (see Table 1).
Result:	Rejected.
Reason:	1 defect (highlighted in red) in Zone B (cladding). This defect is larger than 5 μm, which is a failure condition as per Table 1.

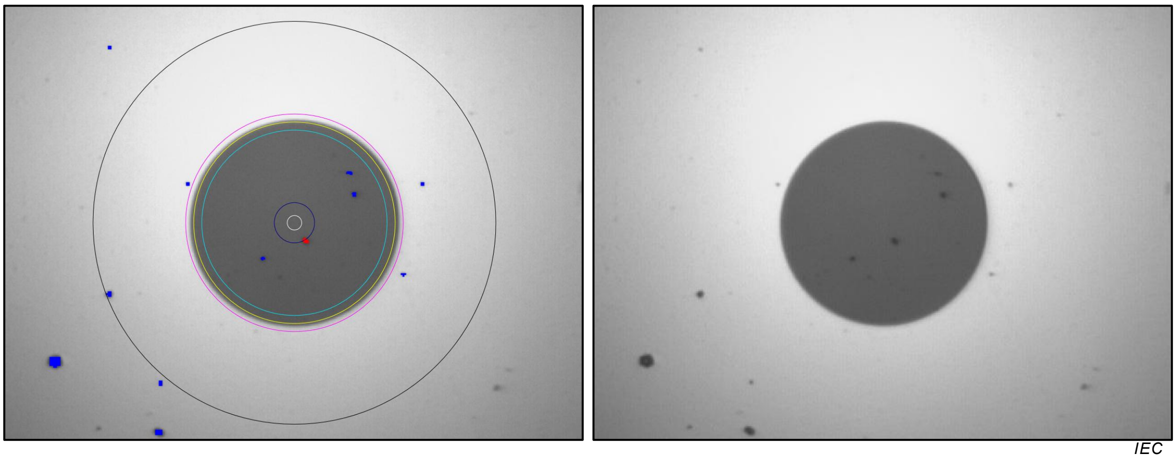

Figure A.3 – Example 2 (low resolution system)

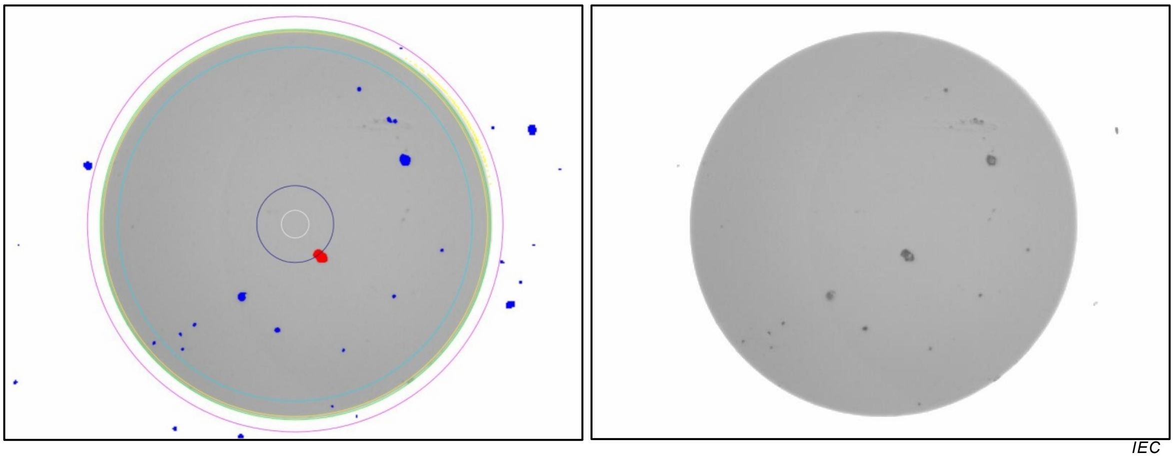

Figure A.4 – Example 2 (high resolution system)

Test requirements:	Single-mode angle polished (APC) connectors (see Table 2).
Result:	Rejected.
Reason:	1 defect (highlighted in red) touching Zone A (core). As per Table 2, since it touches Zone A, it is judged to exist entirely in Zone A. Per Table 2, no defects are allowed in Zone A.

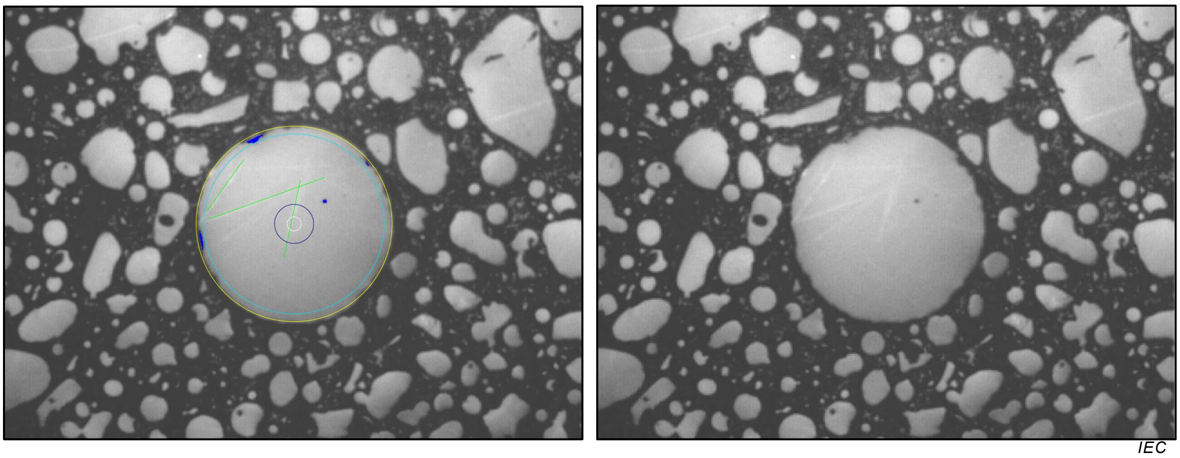

Figure A.5 – Example 3 (low resolution system)

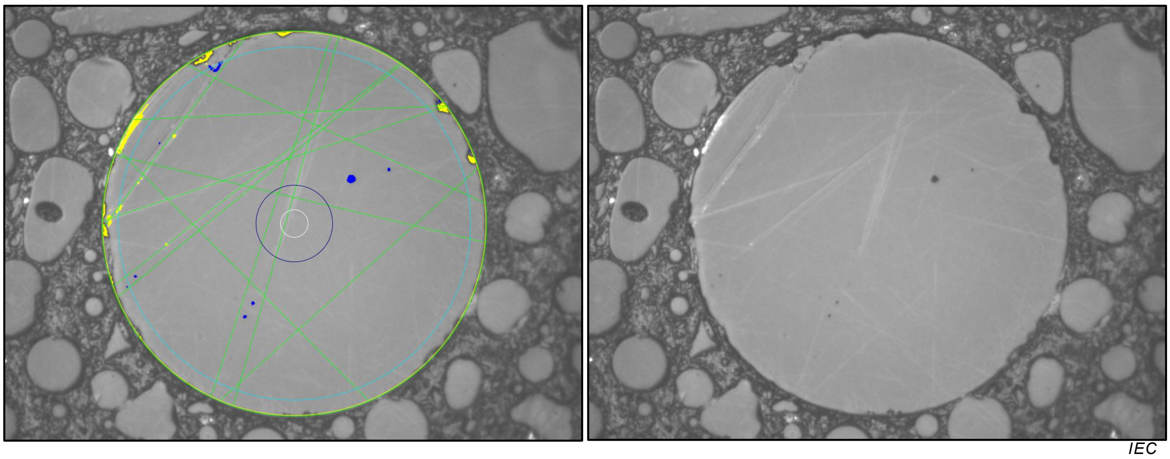

Figure A.6 – Example 3 (high resolution system)

Test requirements: Single-mode angle polished (APC) connectors (see Table 2), multiple-fibre rectangular-ferrule connectors.

Result: Accepted.

Reason: Defects observed in Zone B, but are acceptable according to Table 2 requirements. One defect observed between 2 μm to 5 μm in Zone 2 (Table 2 allows up to 5) A few defects that are < 2 μm appear on the high resolution system (Table 2 allows no limit). Scratches observed are within the acceptance parameters of Table 2.

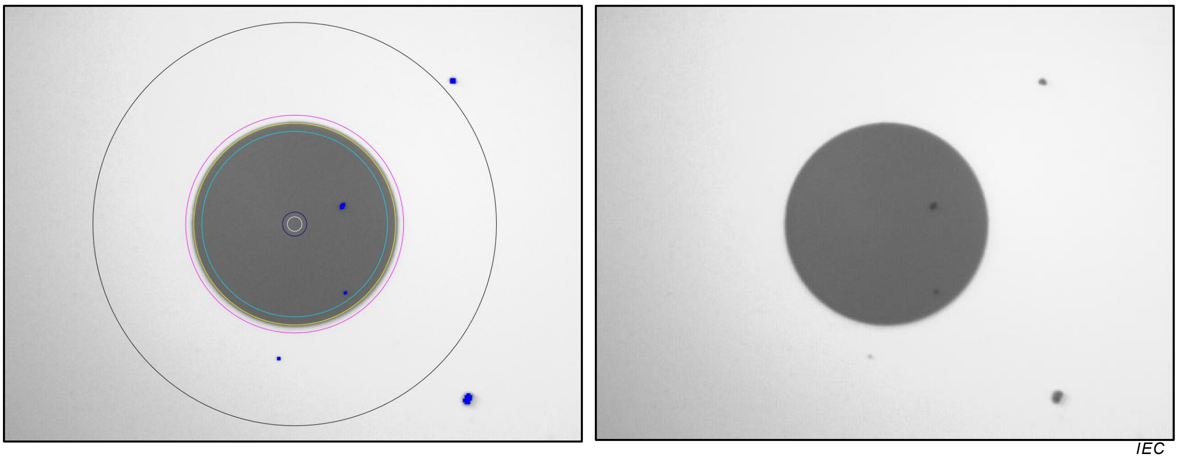

Figure A.7 – Example 4 (low resolution system)

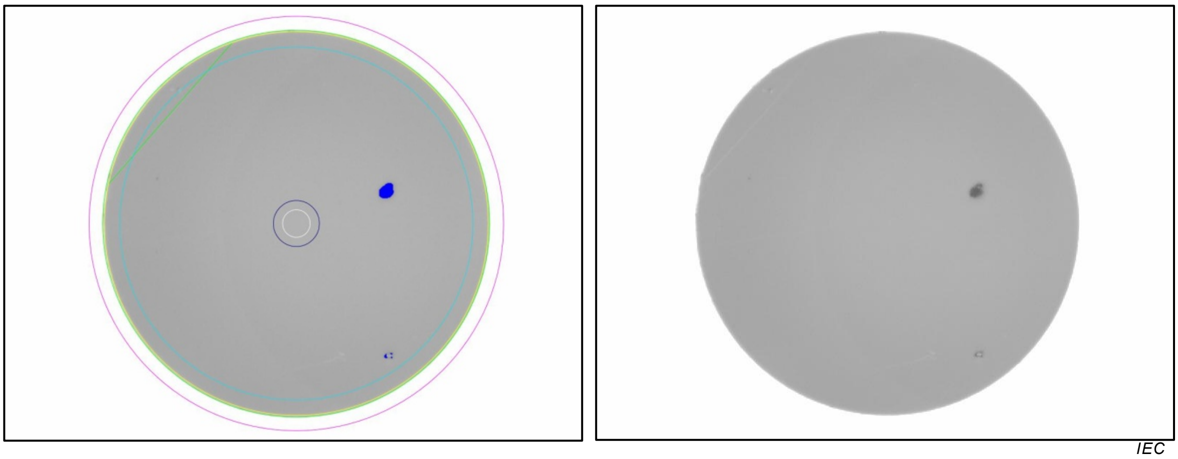

Figure A.8 – Example 4 (high resolution system)

Test requirements: Single-mode PC polished connectors, RL ≥ 26 dB (see Table 3).

Result: Accepted.

Reason: Observed defects in Zone B (the large particle in Zone B is 6 μm), however these are acceptable as per the requirements in Table 3.

Note: This is the same fibre as shown in Example 1. This fibre failed as per the requirements of Table 1, but passes when the requirements of Table 3 are applied. This is because Zone B in Table 3 allows up to 5 particles between 5 μm to 10 μm, but Table 1 does not allow any particles larger than 5 μm.

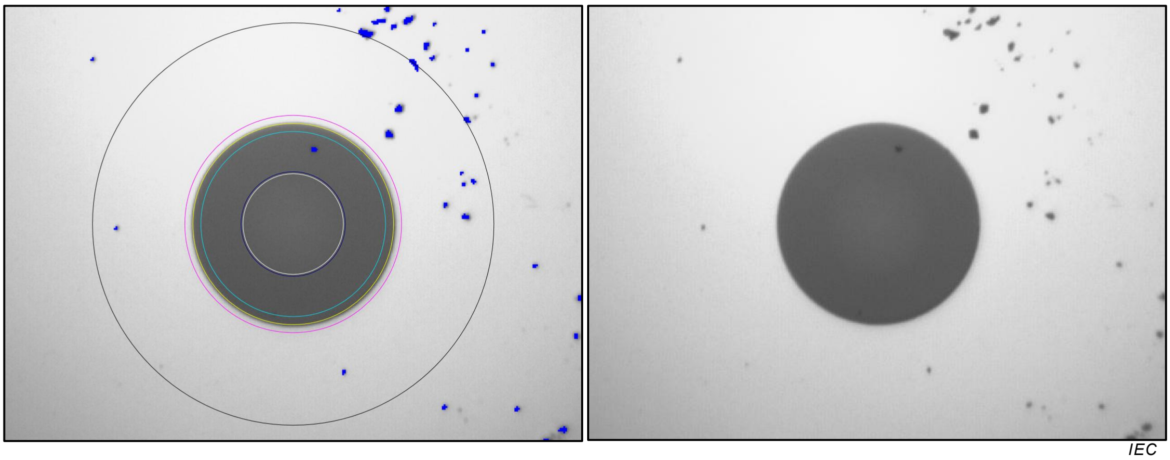

Figure A.9 – Example 5 (low resolution system)

Test requirements: Multi-mode PC polished connectors (see Table 4).

Result: Accepted.

Reason: Observed defects in Zones B and C; however, these are acceptable as per the requirements in Table 4.

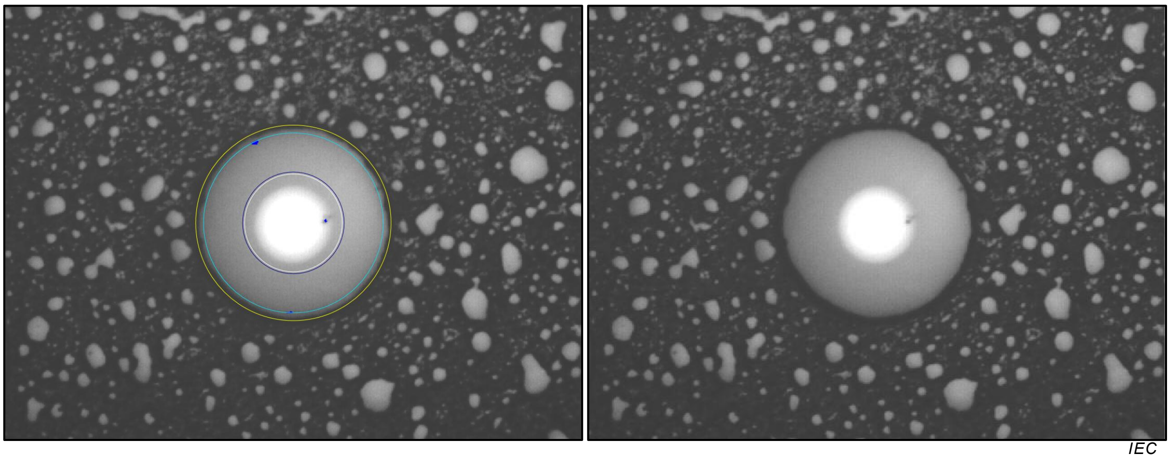

Figure A.10 – Example 6 (low resolution system)

Test requirements: Multi-mode PC polished connectors (see Table 4), multiple-fibre rectangular-ferrule connectors.

Result: Accepted.

Reason: Observed defects in Zones B and C; however, these are acceptable as per the requirements in Table 4.

Annex B
(normative)

Diagram of qualification artefact and method of manufacture

B.1 High resolution artefact

The artefact is constructed by inducing a series of scratches into an otherwise pristine end face. The scratches should be cut into a simple, but recognizable pattern to ensure the user can differentiate them from scratches that may be created through normal use and cleaning during the artefact's life. This is done using a device commonly referred to as a nano-indentation test system. An example is shown in Figure B.1.

A nano-indenter is similar to a hardness tester, but uses much smaller indentation tips with less force. The operating principle of a nano-indenter is quite simple. A tip is brought into contact with the sample, a small force is applied and the tip compresses the sample and indents itself into the material. Based on the depth to which the tip indents, one can determine the hardness of the sample.

To create the high resolution artefact, the device is used in a slightly different manner. The sample is a pristine fibre end face. For practical purposes, a common 1,25 mm or 2,5 mm PC polished ferrule with RL $\geq$ 45 dB is recommended. The tip shall be a 90° cone type with 1,0 μm radius. The tip is brought into contact with the cladding and a force of 450 μN is applied. The tip is then passed across the surface of the cladding so that it scratches the glass. The result will be a scratch that is approximately 200 nm to 400 nm wide. Of key importance is that the scratch is created with a means that does not produce a square "trench" type of scratch that will be high contrast. This is the purpose of the radius shaped tip.

Each artefact shall be measured using a method traceable to a national standards body. Two suitable means are the scanning electron microscope or the atomic force microscope. The width of the scratch shall be within 200 nm to 400 nm and the depth of the scratch shall be within 3 nm to 8 nm.

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Figure B.1 – Example of nano-indentation test system

Samples of pattern cut into a 125 μm cladding on the end of a polished SC connector are shown in Figure B.2.

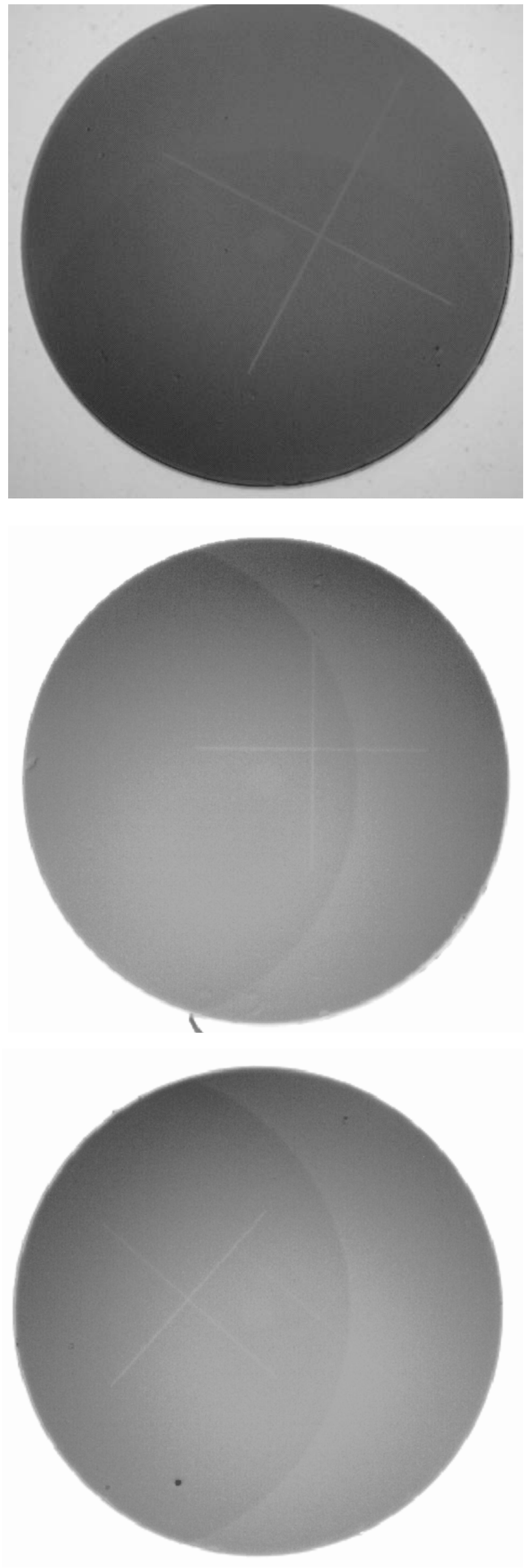

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Figure B.2 – Example of high resolution artefacts

B.2 Low resolution artefact

This artefact can be constructed as either deposited chrome on glass, or by some other means. The contrast level for this is less critical. Recommended construction is as follows:

– flat glass substrate with deposited chrome (< 15 % transmittance);

– five detection targets (solid circles) near the centre arranged in a star pattern as shown in Figure B.3;

– each target measuring 2,0 μm in diameter;

– the outer 4 targets shall be 50 μm apart from one another;

– a large field-of-view circle measuring 250 μm in diameter and 5 μm in line width (unfilled circle);

– field of view circle labelled with “FOV 250 μm”.

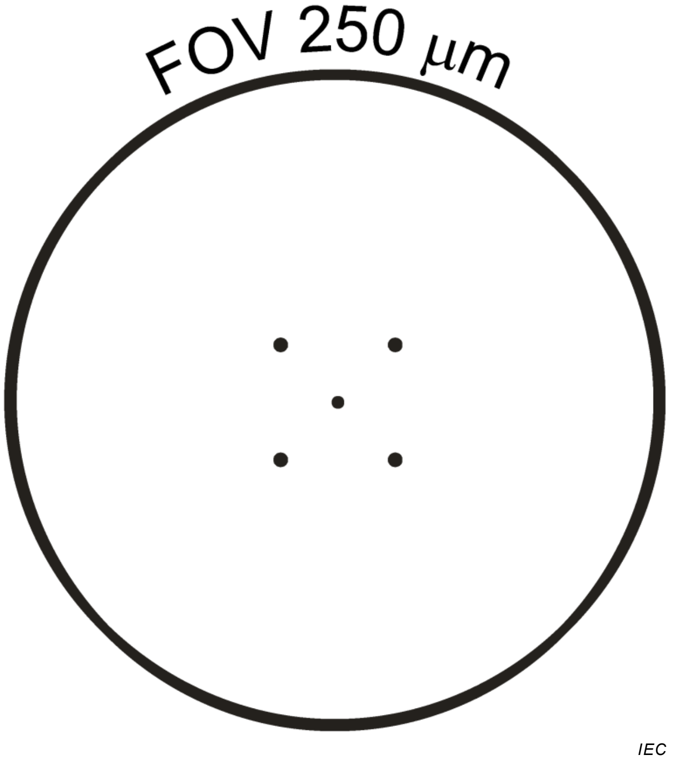

Figure B.3 – Example of low resolution artefact pattern

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IEC TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*

ISO 5807, *Information processing – Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resource charts*