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INTERNATIONAL STANDARD

colour inside

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

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- withdrawn,
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- 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 ~~endface visual and automated inspection~~ 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. ~~The information is intended for use with other standards which set requirements for allowable surface defects such as scratches, pits and debris which may affect optical performance.~~ 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.

~~None~~ 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. High resolution systems are to be utilized for critical examination of the glass fibre after polishing and upon incoming quality assurance. High resolution systems are typically not used during field polishing or in conjunction with multimode connectors. Low resolution systems are to be utilized prior to mating connectors for any purpose. All methods require a means for measuring and quantifying defects. 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.

There are many types of defects. Commonly used terminology would include: particles, pits, chips, scratches, embedded debris, loose debris, cracks, etc. For practical purposes, all defects will be categorized in one of two groups. They are defined as follows:

scratches: permanent linear surface features;

defects: all non-linear features detectable on the fibre. This includes particulates, other debris, pits, chips, edge chipping, etc.

All defects and scratches are surface anomalies. Sub-surface cracks and fractures are not reliably detectable with a light microscope in all situations and are therefore not covered within this standard. Cracks and fractures to the fibre may be detected with a light microscope and are generally considered a catastrophic failure.

Differentiating between a scratch and all other defects is generally intuitive to a human being. However, to provide clarity, and for automated systems, scratches are defined as being less than 4 µm wide, linear in nature, and with a length that is at least 30 times their width. As the width dimension is not practical to visually measure below 3 µm, these figures can be grossly estimated.

Defects size is defined for methods A and B as the diameter of the smallest circle that can encompass the entire defect. Defect size for method C can be either the actual measured surface area or the diameter of the smallest circle than can encompass the entire defect.

Some fibre types have structural features potentially visible on the fibre endface. 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.

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 minimum pre-conditioning time is required.

4.4 Recovery

Since measurements are to be made at standard test conditions, No minimum recovery time is required.

5 Apparatus

5.1 Method A: Direct view optical microscopy

This method utilizes a light 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 means to measure defects observed in the image 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 ~~a light~~ 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 ~~defects~~ surface anomalies observed in the image.

5.3 Method C: Automated analysis microscopy

This method utilizes ~~a light~~ 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 ~~and, in some cases, to improve cycle times~~. 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 ~~Calibration~~ Certification requirements for low and high resolution systems

5.4.1 General

Microscope systems for Methods A, B and C shall be ~~calibrated~~ certified for use in either low or high resolution applications. ~~It is suggested that this calibration~~ This certification shall be conducted with a purpose-built ~~calibration~~ certification artefact that can serve to validate a system’s ability to detect ~~defects~~ 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.

~~For reference, a system’s optical resolution may be calculated using the formula below. Optical resolution is not equivalent to the system’s detection capability. In most cases, the system will be able to detect defects smaller than its optical resolution.~~

~~Optical resolution = (0,61 × wavelength of illumination source) / system’s numerical aperture~~

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 ~~is to~~ shall be measured in the vertical, or most constrained, axis) capable of detecting ~~low-contrast~~ defects of 2 μm in diameter ~~or width~~.

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 ~~low contrast scratches of 0,2 μm in width and 0,003 μm in depth~~ 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 Measurement regions~~

~~For the purposes of setting requirements on endface quality, the polished endface of a connector is divided into measurement regions defined as follows (see Table 1 and Table 2).~~

~~Table 1 – Measurement regions for single fibre connectors~~

~~Zone~~	~~Diameter for single mode~~	~~Diameter for multimode~~
~~A: core~~	~~0 µm to 25 µm~~	~~0 µm to 65 µm~~
~~B: cladding~~	~~25 µm to 120 µm~~	~~65 µm to 120 µm~~
~~C: adhesive~~	~~120 µm to 130 µm~~	~~120 µm to 130 µm~~
~~D: contact~~	~~130 µm to 250 µm~~	~~130 µm to 250 µm~~
~~NOTE 1 All data above assumes a 125 µm cladding diameter.~~ ~~NOTE 2 Multimode core zone diameter is set at 65 µm to accommodate all common core sizes in a practical manner.~~ ~~NOTE 3 A defect is defined as existing entirely within the inner-most zone which it touches.~~		

~~Table 2 – Measurement regions for multiple fibre rectangular ferruled connectors~~

~~Zone~~	~~Diameter for single mode~~	~~Diameter for multimode~~
~~A: Core~~	~~0 µm to 25 µm~~	~~0 µm to 65 µm~~
~~B: Cladding~~	~~25 µm to 115 µm~~	~~65 µm to 115 µm~~
~~NOTE 1 All data above assumes a 125 µm cladding diameter.~~ ~~NOTE 2 Multimode core zone diameter is set at 65 µm to accommodate all common core sizes in a practical manner.~~ ~~NOTE 3 A defect is defined as existing entirely within the inner-most zone which it touches.~~ ~~NOTE 4 Criteria should be applied to all fibres in the array for functionality of any fibres in the array.~~		

6.1 ~~Calibration~~ Certification procedure

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

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

Follow the manufacturer's instructions on how to ~~calibrate~~ 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. ~~Reliably detectable is defined as sufficient clear and visible so that a typical technician of average training would recognize the feature at least 98 % of the time.~~

For automated systems, software utilities to perform this ~~calibration~~ certification shall be provided. In any event, these systems shall be able to perform the same ~~calibration~~ 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 ~~prescribed in the acceptance criteria~~ 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). ~~Such criteria can be found in 5.4.~~ 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 ~~fibre~~ end face fails inspection for defects, the user shall clean the ~~fibre~~ end face and repeat the inspection process. Several attempts at cleaning may be required. Consult IEC TR 62627-01 for recommendations on cleaning methods.

~~In this way, loose debris can be removed and the fibre may be able to pass a subsequent inspection without rework or scrap. Cleaning shall be repeated a number of times consistent with the cleaning procedure being used.~~

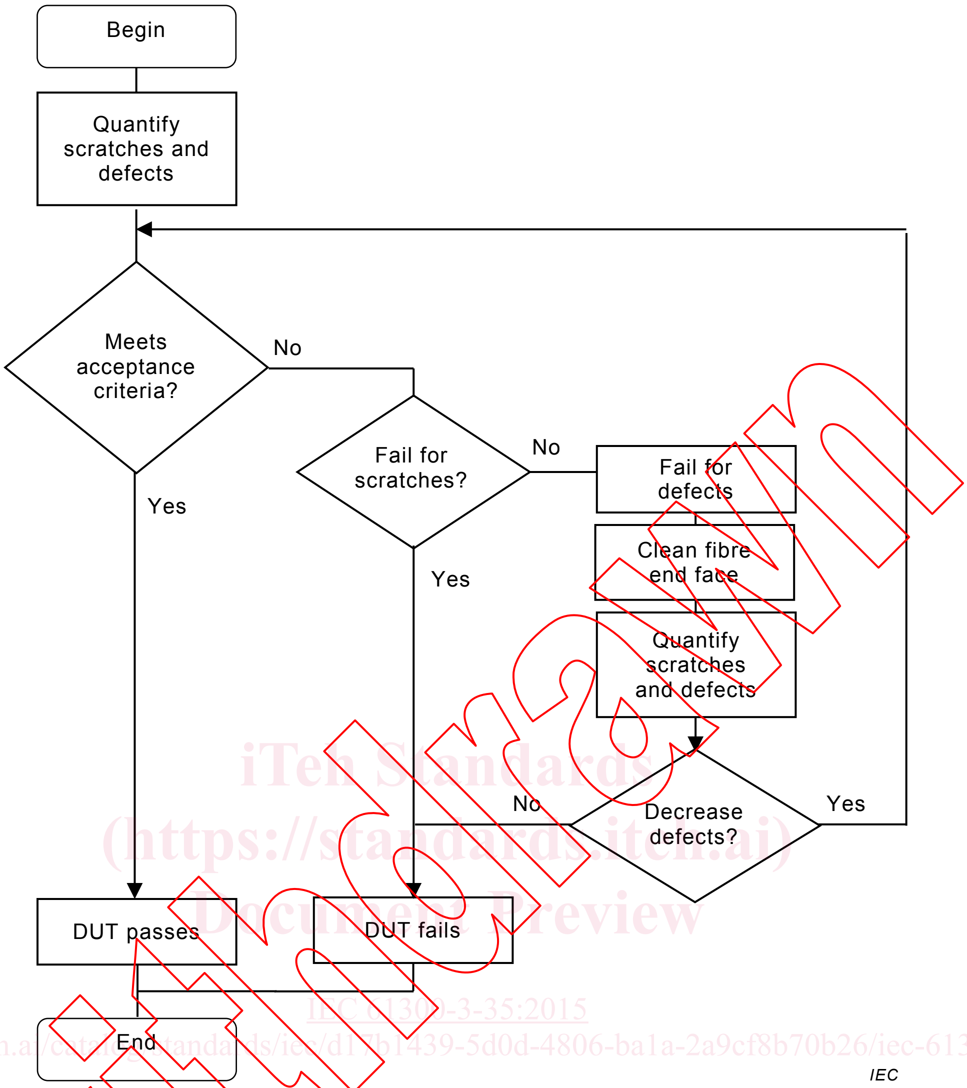

Figure 1 – Inspection procedure flow

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 ~~each~~ single-mode and multi-mode connectors are shown in ~~Table 3, Table 4, Table 5 and Table 6~~ Table 1 to Table 4.