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Edition 3.0 2022-09

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 fibroniques – Procédures fondamentales d'essais et de mesures – Partie 3-35: Examens et mesures – Examen visuel des connecteurs fibroniques et des émetteurs-récepteurs à embase fibrée

IEC 61300-3-35:2022-09(en-fr)

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IEC 61300-3-35 has been prepared by subcommittee SC 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

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

a) adding of a statement that visual inspection is not a substitute for optical qualification such as attenuation and return loss measurement;
b) adding of some terms and definitions;
c) adding requirements for SM 35 dB connectors;

d) adding of a sentence in Clause 5 concerning the susceptibility of the methods to system variability and variability within systems from same supplier;

e) removal of inspection requirements for zones C and D;

f) insertion of a generic cleanliness specification for whole rectangular ferrule and 250 µm area around every fibre;

g) adding a cleaning recommendation for rectangular and cylindrical ferrules;

h) outer edge of inspection zone B has changed from 115 µm to 110 µm to meet manufacturing tolerances of fixture for microscopes;

i) change that defects that are partly in core are only to be judged for the part they are in the core. The remainder of the defect is considered to be located in the cladding.

j) adding a statement that a connector cannot be rejected by just failing visual inspection. Meeting the specified optical performance determines the use of this connector.

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

Draft	Report on voting
86B/4643/FDIS	86B/4665/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61300 series, published under the general title *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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

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

1 Scope

This part of IEC 61300 is concerned with the observation and classification of debris, scratches and defects. The inspection requirements are based on IEC TR 62627-05. Advice for cleaning of contamination from fibres/ferrule is found in IEC TR 62627-01 and a recommendation is given in Annex D. IEC TR 62572-4 provides the cleaning method for a stub for optical transceivers. Visual inspection is in addition to, and does not replace measurement of performance parameters such as attenuation and return loss, or end face parameters. The dimensions specified are chosen such that they can be easily estimated. Not only the zones A and B on the fibre are inspected for defects and scratches but the whole contact area (where the two fibres/ferrules meet when mated) needs to be inspected for contamination (this is up to 250 µm diameter for cylindrical ferrules and the whole ferrule surface for rectangular ferrules).

The objectives of this document are the following:

- specify the minimum criteria for a microscope to be compliant to this document;
- specify the procedure and criteria for inspecting fibre-optic end faces for cleanliness to determine if the end faces are fit for use. All connector optical interfaces (IEC 61755 series and IEC 63267 series) are based on physical contact between fibre cores;
- provide quantitative criteria for the analysis of end face images.

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.

IEC 60825-2, *Safety of laser products – Part 2 Safety of optical fibre communication systems (OFCSs)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

3.1.1
defect
permanent non-linear surface feature on the fibre or ferrule end face within the regions of interest, which includes, but it not limited to, pits, chips, edge chipping, and/or non removable foreign material

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.

Note 2 to entry: Scratches are excluded from this definition.

3.1.2
defect size
diameter of the smallest circle that can encompass the entire defect

3.1.3
debris
unwanted material or particulates of any kind on the surface of fibre or ferrule end face within the regions of interest that is removeable using standard cleaning methods

Note 1 to entry: Multiple cleaning methods are described in IEC TR 62627-01.

3.1.4
scratch
permanent surface feature on the fibre end face where the width of the damaged area is smaller than or equal to one fifth of its length

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

3.2 Abbreviated terms

APC angled physical contact
DUT device under test
FOV field of view
LFOV large field of view
MM multimode
PC physical contact
RL return loss
SFOV standard field of view
SM single-mode

4 Apparatus

4.1 General

One of the objectives of this document is to specify the minimum criteria (see 4.5 and 4.6) a microscope shall meet to be compliant to this document.

Three types of microscopes are described:

a) method A microscope: direct view optical microscope as described in 4.2;
b) method B microscope: video microscope as described in 4.3;
c) method C microscope: automated analysis microscope as described in 4.4.

For each type, there are optical/hardware requirements to be met and procedures to be followed. As these processes are in support of the inspection criteria defined in Clause 5, all three are expected to result in a "pass" or "fail".

The minimum optical requirements for all types of microscopes to be compliant with this document are given in 4.5 and 4.6.

The microscopes described in this document, with the exception of large field of view (LFOV), are capable of being used for inspection for contamination (cleanliness) prior mating in the field and factory and after polishing SM and MM, single-fibre and multifibre connectors in the factory.

LFOV microscopes can be used for inspection of contamination of the entire ferrule surface of multifibre connectors in the field and in the factory.

For methods A and B, visual gauge tools should be used to facilitate the estimation procedure. For method A, an eyepiece reticule should be used. For method B, a transparent overlay should be used.

WARNING – All methods are susceptible to system variability: methods A and B are operator and equipment hardware dependent. Method C is less operator dependent but exhibits from software irregularities and variations in hardware and, in case of field use, operator handling differences can cause a variation in results that might appear even when equipment from the same brand is compared. Method C has an inherent uncertainty when defects or scratches are located near test limits, as described in Annex A tables.

4.2 Method A: Direct view optical microscopy

This method uses 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 focussing mechanism;
- a built-in laser safety filter;
- a means to compare dimension of defects or scratches observed in the image with a sufficient reliability (i.e. eyepiece reticule with certified dimension according the magnification).

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. When method A is used, the user shall ensure there is no laser active on the link prior to inspection. IEC 60825-2 shall be used for laser safety of optical fibre communication systems.

4.3 Method B: Video microscopy

This method uses 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 focussing mechanism;
- a means for creating an image (display);
- a means to estimate surface dimensions defects and/or scratches observed in the image (e.g. overlay with certified dimension according the image on the screen).

4.4 Method C: Automated analysis microscopy

This method uses an optical microscope in which a digital image is acquired or created and is 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 light source and focussing mechanism;
- a means for acquiring and creating a digital image;
- algorithmic analysis of the digital image;
- a means to compare the analysed image to programmable acceptance criteria.

4.5 Requirements of validation

Microscope systems for methods A, B and C shall be validated for use as compliant with this document. This validation shall be conducted with a purpose-built validation artefact that can serve to validate a system's ability to detect surface defects or scratches of relevant size and/or the required system response. Such (an) artefact(s) 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. The related validation procedure is found in Annex C.

4.6 Minimum requirements for standard field of view microscope

This requirement for the standard field of view microscope (SFOV) is a minimum total magnification offering a field of view 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 and scratches of 3 µm wide in the whole field of view.

The minimum requirements for systems for methods A, B and C are as follows:

- particle size detection: 2 µm diameter;
- scratch detection: 3 µm wide.

4.7 Minimum requirements for large field of view microscope

Microscopes with large field of view are only capable of being used for cleanliness inspection of the complete ferrule of single-mode (SM) and multimode (MM) array type connectors like MPO. This requirement is a minimum total magnification offering a LFOV of at least 6,4 mm × 2,5 mm and capable of detecting debris of 10 µm in diameter in the whole field of view.

The minimum requirement for very large field of view systems for methods A,B and C is 10 µm diameter for particle size detection.

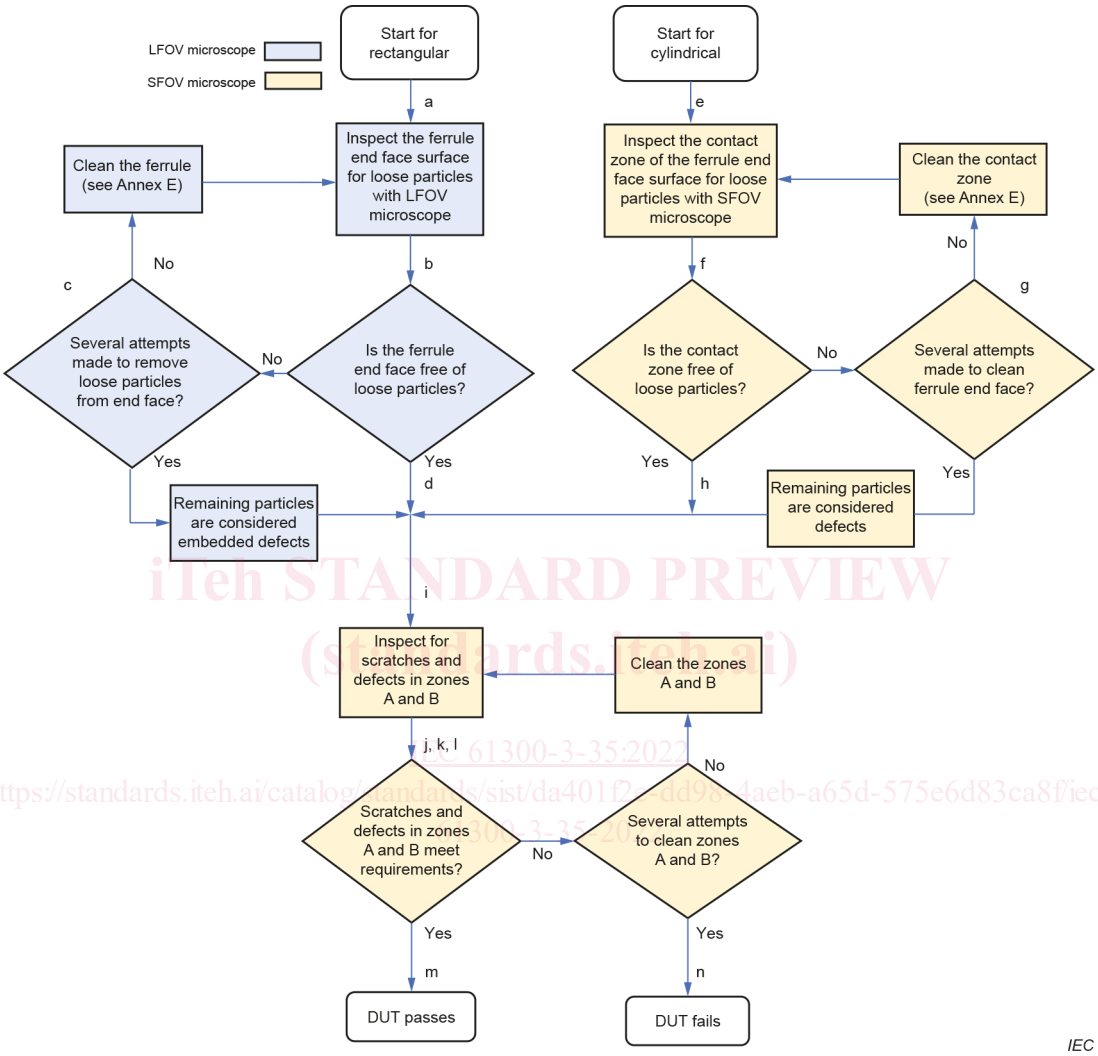
5 Inspection procedure

The inspection for cleanliness of ferrules shall take place prior to any other inspection of the polished parts of the end faces. For cylindrical ferrules, at least an area of 250 µm diameter shall be inspected and cleaned when necessary. Cylindrical ferrules should be inspected and cleaned beyond the 250 µm area.

For rectangular ferrules, the entire ferrule surface (6,4 mm × 2,5 mm) shall be inspected for cleanliness and cleaned when necessary. Use of inspection equipment with LFOV and oblique illumination eases the detection of contamination on the rectangular ferrules.

SFOV may also be used for cleanliness inspection of the entire rectangular ferrule surface. It requires scrolling over the entire 6.4 × 2.5 mm ferrule surface. During the scrolling action, care should be taken not to miss any part of ferrule surface and maintain ferrule surface in focus.

The flowchart in Figure 1 shows the procedure to be employed.



NOTE Letters a, b, … to n correspond to procedure in Clause 5.

Figure 1 – Flowchart of inspection procedure

The following cleanliness for rectangular ferrules shall apply.

a) Using a LFOV microscope as defined in 4.7, focus the microscope so that a crisp image of the ferrule end face of rectangular ferrules can be seen.

b) Inspect the entire end face for contamination. For APC ferrules, only the angled area needs to be inspected; the small flat non-angled area, if present, does not require inspection.

   A maximum of 10 particles between 10 µm and 25 µm are the recommended limit. There is no limit for particles below 10 µm, and no particles larger than 25 µm should appear. The defect size is the diameter of the smallest circle that can encompass the entire defect.

c) All loose particles should be removed; several attempts at cleaning may be required. Debris remaining after cleaning shall be considered as a defect(s). Consult IEC TR 62627-01:2016, Annex E of this document, and IEC TR 62572-4 for recommendations on cleaning methods for connectors and transceivers.

d) If the rectangular ferrule end face meets the limits for cleanliness, the inspections of zones A and B of all fibres of the rectangular ferrule against the requirements of the relevant table in Annex A can start.

The following cleanliness for cylindrical ferrules shall apply.

e) Using a microscope as defined in 4.6, focus the microscope so that a crisp image of the cylindrical ferrule end face can be seen.

f) Inspect the 250 µm diameter central zone of the end face for contamination. A maximum of 10 particles between 5 µm and 10 µm are the recommended limit in the ring between 135 µm to 250 µm diameter. There is no limit for particles smaller than 5 µm, and no particles larger than 10 µm should appear.

g) All loose particles shall have been removed, and any remaining particles shall be considered as defects. Debris remaining after cleaning shall be considered as defects. Consult IEC TR 62627-01:2016, Annex E of this document, and IEC TR 62572-4 for recommendations on cleaning methods for connectors and transceivers.

h) If the cylindrical ferrule end face meets the limits for cleanliness, the inspection of zones A and B of the fibre against the requirements in the relevant table in Annex A can start.

The visual inspection of zones A and B for cylindrical and rectangular ferrules is as follows.

i) Focus the microscope so that a crisp image of the fibres can be seen.

j) Locate all defects and scratches (see Annex B for examples of defects and scratches) within the zones specified in the relevant table in Annex A. Classify and count defects and scratches within zones A and B.

k) If a defect or scratch is found in both the zones A and B, classify the part of the scratch or defect only for zone A that falls in zone A and only for zone B that falls in zone B.

l) Once all defects and scratches have been classified and counted, the results shall be totalled and compared with the appropriate acceptance criteria (Table A.1 to Table A.5).

m) If the scratches and defects are less than or equal to the criteria, then the DUT passes.

n) If the scratches and defects are greater than the criteria and several attempts at cleaning have been made, the DUT fails.

If a connector fails after executing the inspection procedure and no loose debris is present, the connector shall be tested against its optical performance specification (typically attenuation and/or return loss). If the connector meets the specified optical performance, the connector is suitable for use.

Consult IEC TR 62627-01:2016, Annex E of this document, and IEC TR 62572-4 for recommendations on cleaning methods for connectors and transceivers.

NOTE It is possible than an optical assembly that has not been verified to be clean pass an optical performance test but have reduced performance in the future due to debris migration towards the fibre core. It is possible an optical assembly with debris on the end face become damaged and potentially damage the mating connector.

Annex A
(normative)

Visual requirements for connector end faces

A.1 Requirements

The normative inspection requirements for various connector end face types and performance grades are specified in Clauses A.2 to A.6. These define the allowable defects and scratches for single-mode and multimode connectors, with PC and APC polished interfaces.

NOTE The IEC 63267 series and IEC 61755 series optical connector interfaces are under development. After publication of both interfaces, the inspection requirements will be normatively placed in the IEC 63267 series and IEC 61755 series, while the content of this Annex A will become informative by means of revision or amendment.

A.2 Visual inspection requirements for multimode PC and APC polished connectors

Measurements of scratch width using inspection methods A and B are subject to significant variability due to the subjectivity and human-dependence inherent to these methods. When method A or B is used, the specified dimensions of defects and scratches may be estimated in order to be classified and counted. Additionally, when method C is used, as described in IEC TR 63367, machine imaging and processing systems have intrinsic limitations that also result in variability in scratch width measurement. As a result, it is commonplace to obtain different values for defect diameter and scratch width and pass/fail conditions when connector end face features are measured across different equipment or repeatedly on the same equipment and when using methods A, B, and C.

The zone size for multimode fibres has been set at 65 µm to accommodate both 50 µm and 62,5 µm diameter core fibres. This has been done to simplify the grading process. Table A.1 shows the requirements for allowed defects and scratches for MM connectors.

Table A.1 – Visual requirements for multimode PC and APC polished connectors

Zone (diameter)	**Defects** (diameter)	**Scratches** (width)
A: core zone 65 µm	< 2 µm: no limit ≥ 2 µm and ≤ 5 µm: maximum 4 > 5 µm: none	< 3 µm: no limit ≥ 3 µm and ≤ 4 µm: maximum 4 > 4 µm: none
B: cladding zone 65 µm to 110 µm	≤ 25 µm: no limit > 25 µm: none	No limit
NOTE 1 See Figure B.1 and Figure B.2 as examples. NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array.		

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

Measurements of scratch width using inspection methods A and B are subject to significant variability due to the subjectivity and human-dependence inherent to these methods. When method A or B is used, the specified dimensions of defects and scratches may be estimated in order to be classified and counted. Additionally, when method C is used, as described in IEC TR 63367, machine imaging and processing systems have intrinsic limitations that also result in variability in scratch width measurement. As a result, it is commonplace to obtain different values for defect diameter and scratch width and pass/fail conditions when connector end face features are measured across different equipment or repeatedly on the same equipment and when using methods A, B, and C.

Table A.2 shows the requirements for allowed defects and scratches for SM connectors with 26 dB return loss.

Table A.2 – Visual requirements for single-mode PC polished connectors, RL ≥ 26 dB, and single-mode transceivers using a fibre-stub interface

Zone (diameter)	Defects (diameter)	Scratches (width)
A: core zone 25 µm	< 2 µm no limit ≥ 2 µm and ≤ 3 µm maximum 1 > 3 µm none	< 3 µm no limit ≥ 3 µm and ≤ 4 µm maximum 2 > 4 µm none
B: cladding zone 25 µm to 110 µm	≤ 25 µm no limit > 25 µm none	No limit

A.4 Visual requirements for single-mode PC polished connectors, RL ≥ 35 dB

Measurements of scratch width using inspection methods A and B are subject to significant variability due to the subjectivity and human-dependence inherent to these methods. When method A or B is used, the specified dimensions of defects and scratches may be estimated in order to be classified and counted. Additionally, when method C is used, as described in IEC TR 63367, machine imaging and processing systems have intrinsic limitations that also result in variability in scratch width measurement. As a result, it is commonplace to obtain different values for defect diameter and scratch width and pass/fail conditions when connector end face features are measured across different equipment or repeatedly on the same equipment and when using methods A, B, and C.

Table A.3 shows the requirements for allowed defects and scratches of SM connectors for 35 dB return loss.

Table A.3 – Visual requirements for single-mode PC polished connectors, RL ≥ 35 dB

Zone (diameter)	Defects (diameter)	Scratches (width)
A: core zone 25 µm	< 2 µm no limit ≥ 2 µm and ≤ 3 µm maximum 1 > 3 µm none	< 3 µm no limit Maximum 1 ≥ 3 µm and ≤ 4 µm None > 4 µm
B: cladding zone 25 µm to 110 µm	≤ 25 µm no limit > 25 µm none	No limit