# IEC TR 62627-01

Edition 2.0 2016-01

# TECHNICAL REPORT

colour inside

## Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods



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## Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods

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# FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS –

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IEC TR 62627-01, which is a Technical Report, has been prepared by subcommittee 86B: 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 2010. This edition constitutes a technical revision.

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

a) restructure of clauses;
b) addition of some terms and definitions;
c) addition of information on cleaning tools and machines;
d) addition of information on dust caps;
e) addition of applicable cleaning tools and machines for optical connectors.

The text of this Technical Report is based on the following documents:

| Enquiry draft | Report on voting |
|---|---|
| 86B/3926/DTR | 86B/3943A/RVC |

Full information on the voting for the approval of this Technical Report 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 62627 series, published under the general title *Fibre optic interconnecting devices and passive components*, 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 website 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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# FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS –

# Part 01: Fibre optic connector cleaning methods

## 1 Scope

This part of IEC 62627, which is a Technical Report, details cleaning methods for fibre optic connectors. It includes typical cleaning tools and machines, and cleaning procedures. Other cleaning methods may exist. The impact of contamination and the reasons for connector visual inspection and cleaning are described in Annex B. This Technical Report does not address the visual inspection criteria, which are covered in IEC 61300-3-35: 2015.

Optical fibre patch cords are handled by the operators and maintenance staff of optical network systems. This Technical Report may be used as a guideline to prepare instruction manuals for those involved in optical system maintenance and operation.

This Technical Report covers fibre optic connector plugs, optical adaptors, optical receptacles (excluding optical transceivers) and dust caps. Guidelines for optical connector end-face cleaning methods for receptacle style optical transceivers are covered in IEC TR 62572-4.

## 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.

There are no normative references in this document.

## 3 Terms and definitions

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

### 3.1 Cleaners

**3.1.1**
**adhesive backed stick type cleaner**
cleaning tool for optical connector end-faces, receptacles and optical connector adaptors using a soft adhesive backing at the end of a stick

**3.1.2**
**air duster**
canned air
cleaning tool where compressed air is blown from a nozzle of a can

**3.1.3**
**gas and vacuum type cleaning machine**
optical connector end-face cleaning machine in which volatile liquid solvent (gas) is injected and extracted from a nozzle

**3.1.4**
**pen type cleaner**
probe type cleaner
cleaning tool for optical connector end-faces, receptacles and optical connector adaptors where a tape cleaning cloth at the top of the tool moves and cleans

**3.1.5**
**reel type cleaner**
cassette type cleaner
optical connector plug end-face cleaning tool, in which a cleaning cloth roll is packed in a cassette box, with a small window for cleaning

**3.1.6**
**stick type cleaner**
swab type cleaner
optical connector receptacle and optical connector adaptor end-face cleaning tool in which a cleaning cloth is attached to the top of a stick

### 3.2 Optical connector parts

**3.2.1**
**bulkhead adaptor**
component in which two or more plugs may be mated

Note 1 to entry: A bulkhead adaptor has one or more alignment sleeves in which two or more ferrules are aligned.

**3.2.2**
**dust cap**
cover or cap which is attached to an optical connector plug, an optical connector adaptor or an optical receptacle when the optical connector is not connected to protect it from contamination

**3.2.3**
**exposed plug end-face**
**EPE**
fibre optic plug without any fixed optical end-face protection, that may be held in the hand

EXAMPLE *End of a patch cord.*

Note 1 to entry: The ferrule is exposed to the air and is not confined within an alignment sleeve of a bulkhead adaptor or device port. The end-face of the plug is easy to access and may be brought into contact with cleaning material.

**3.2.4**
**port**
open fibre optic alignment sleeve which contains a fibre optic plug end-face to which a fibre optic plug may be mated

Note 1 to entry: In the case of a bulkhead adaptor, it is the open side of the adaptor after a fibre optic plug has been inserted into one side. In the case of an optical device, it is the opening into which a user of the device will plug a patch cord. The mating side of a port can only be accessed through the alignment sleeve. Therefore the cleaning material shall be brought to the end-face through the alignment sleeve.

**3.2.5**
**power blocking shuttered adaptor**
optical adaptor that has a shutter to block optical power emitted from an optical connector plug

Note 1 to entry: An optical adaptor with shutter should have a structure that, when two optical connector plugs are interfaced and the optical connector plug is removed at the shuttered side, the shutter automatically moves to block emitted optical power. There are two types of optical adaptors with shutter that have already been commercialized: one focuses on blocking the optical power and the other focuses on dust-proofness. Generally, power blocking shuttered adaptors that focus on blocking power often have a metal shutter within the optical adaptor.

# 4 Application of optical connectors

## 4.1 General

Optical connectors consist of several parts: connector plugs, receptacles, adaptors, dust caps, etc.

Optical communication network equipment generally has optical adaptors on the front panel or the back-plane to interface with other equipment or transmission lines. An optical patch cord, which has optical connector plugs on both ends of an optical fibre cord, is generally used for optical connection between equipment.

## 4.2 Influence of contamination of optical connector end-faces

Optical network equipment is located in the central offices, data centres, computer rooms, etc. The environment of these locations is not necessarily clean, and it is possible that dust or condensation is introduced onto the optical connector end-faces which may affect their optical performances (see Annex B).

# 5 Care in handling optical connectors

## 5.1 General

Clause 5 describes general care in handling optical connectors.

## 5.2 Storage of optical connectors

Unused ports on optical network equipment, and unused optical connector plugs on optical patch cords should be covered or capped by clean dust caps. A dust cap should not enter into contact with a fibre end-face when fitted. Optical patch cords are recommended to be stored in clean boxes or bags. Used dust caps should be cleaned before storage. Dust caps should be stored in clean boxes or bags. It is recommended that storage boxes or bags are ESD (electric static discharged) processed.

## 5.3 Connection of optical connector plugs to ports on optical network equipment

For safety reasons, before connection, optical power should be off. Dust caps should be removed just before the optical connection is made. Before the optical connection, both the optical connector end-faces to be mated should be inspected, and cleaned if necessary unless otherwise recommended by the manufacturer. Annex C shows an example of optical connector end-face visual inspection equipment. The applicable cleaning tools and machines should be appropriate for optical connector plugs and optical adaptors.

After inspection of optical connector end-faces, the clean optical connector plugs should be inserted in ports and mated securely.

## 5.4 Disconnection of optical connector plugs to ports

Before disconnection, optical power should be off.

Immediately after the disconnection, clean dust caps should be fitted to optical connector plugs and ports.

# 6 Dust caps

Many shapes and materials of dust caps are available in the market. Appropriate dust caps should be fitted. For optical connector plugs, there are typically two types of dust caps: covering the top of the ferrule, or covering part of the plug housing. Dust caps should have a

structure so that their inner surfaces do not come into contact with the ferrule end-face when dust caps are fitted. Dust caps are recommended to be processed to prevent the creation of a static electric charge. It is recommended that dust caps should be cleaned using an air duster.

## 7 Cleaning tools and machines

### 7.1 General

Clause 7 describes cleaning tools machines for optical connectors.

Optical connector cleaning tools or machines should be used.

Optical connector plugs are easier to clean than optical receptacles or optical adaptors. A typical cleaning method for optical connector plugs is to wipe the ferrule end-face with a cloth. As rubbing may produce a static electric charge, which may attract contamination, it is recommended to use an optical connector cleaner with cloth that has been processed so that it will not create a static electric charge. Lint-free cloths are also recommended.

NOTE An ionizer can be useful to neutralize the electrostatic charge which can develop from the cleaning process.

Typical cleaning tools and machines are described in the following clauses. This list is not exhaustive.

### 7.2 Reel type cleaner

A reel type cleaner is used for cleaning optical connector plug end-faces, but is not suited for cleaning optical receptacles. The cleaning cloth in the reel type cleaner is rolled and packed in a cassette which has a small window into which the plug end-face is inserted for cleaning. Figure 1 shows an example of a reel type cleaner. The cleaning process of connector end-faces with reel type cleaner may result in an electrostatic charge (ESC) effect. Therefore it is recommended that the cleaning cloth has been processed to prevent the creation of a static electric charge. The optical connector plug end-face to be cleaned is pressed into then wiped along the cleaning cloth. The cleaning cloth should be advanced before every cleaning to prevent contamination.

For IEC 61754-7, type MPO connector plugs with guide-pins, dedicated reel type cleaners are available in the market.

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NOTE Reproduced from OPTIPOP TM, Optical Connector Cleaner, NTT Advanced Technology Corporation website http://www.ntt-at.com/product/optipop/

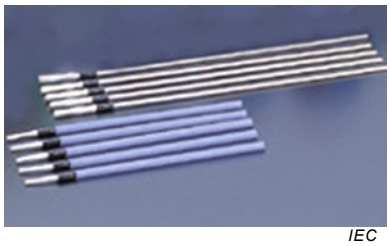
**Figure 1 –Example of a reel type cleaner**

### 7.3 Stick type cleaner

A stick type cleaner has cleaning cloth on the top of a stick. It is sometimes called a swab type cleaner. This cleaner is suitable for optical receptacles and optical adaptors. Figure 2 shows an example of stick type cleaners.

Lint-free cloths are recommended. Cleaning material should be processed to prevent the creation of a static electric charge on the end-face. This type of cleaner should be used once only.

There are several thicknesses of stick type cleaners available, depending on the ferrule diameter.



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NOTE Reproduced from CLETOP TM, Optical Connector Cleaner, NTT Advanced Technology Corporation website http://www.ntt-at.com/product/cletop/.

**Figure 2 –Example of stick type cleaners**

### 7.4 Pen type cleaner

Pen type cleaners have a cleaning cloth on the top of the cleaner. The cleaning cloth rotates when the top of the cleaner is pressed on the end-face of an optical receptacle, and cleans the end-face. For some cleaners, as the width of the cleaning cloth limits the area of cleaning, only the centre of end-faces may be cleaned. It is recommended that the cleaning cloth has been processed to prevent the creation of a static electric charge. The cleaning cloth should be lint-free. It is sometimes called a probe type cleaner. Figure 3 shows an example of a pen type cleaner.

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NOTE Reproduced from NEOCLEAN R, Optical Connector Cleaner, NEOCLEAN R-E Pen Type, NTT Advanced Technology Corporation website http://www.ntt-at.com/product/neoclean/.

**Figure 3 –Example of a pen type cleaner**

### 7.5 Adhesive backed stick type cleaner

Adhesive backed stick cleaners have a soft adhesive backing at the top of the cleaner. The adhesive backed stick cleaner is briefly pressed into and removed from the end-face of an optical connector, receptacle or optical connector adaptor whereby the soft adhesive backing removes dust and other particulates. Figure 4 shows an example of an adhesive backed stick type cleaner.

IEC

NOTE Reproduced from Optres TM, Optical Plug Assembly Cleaner, OPTO LEAF, TOMOEGAWA website http://opt.tomoegawa.co.jp/english/tech/mochi.html.

**Figure 4 – Example of an adhesive backed stick type cleaner**

### 7.6 Gas and vacuum cleaning machine

A volatile liquid solvent is injected and extracted from a nozzle. Contamination is removed by the solvent. Liquid should not enter the cable elements or other parts of a connector where it cannot be removed. Figure 5 shows an example of a gas and vacuum cleaning machine.

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NOTE Reproduced from CLEAN BLAST TM, JDS Uniphase Corporation website http://www.jdsu.com/en-us/Test-and-Measurement/Products/a-z-productlist/Pages/cleanblast-portable.aspx.

**Figure 5 – Example of a gas and vacuum cleaning machine**

### 7.7 Air duster

An air duster is widely used for cleaning electronic and electric equipment. Compressed air is blown from the nozzle of a can. It is sometimes called canned air. Examples of materials are difluoroethane (HFC-152a), trifluoroethane (HFC-143a) or tetrafluoroethane (HFC-134a). HFC-152a has a lower global warming potentials (GWP) index than HFC-143a, which is better for the environment. Care should be taken as some air dusters may leave a stain on the ferrule end-face. Figure 6 shows an example of an air duster.

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NOTE Reproduced from http://www.microcareelectronics.com/products/product/voc-free-flux-remover-ultraclean/.

**Figure 6 – Example of an air duster**

### 7.8 Tissue and solvent, wet cleaning

The wet cleaning method uses a solvent, such as isopropyl alcohol, with cleaning tissues for optical elements to clean the optical connector end-face. No residue from the solvent should remain after cleaning. Using a solvent prevents the creation of a static electric charge on the end-face and is sometimes effective for removing sticky contamination. After wet cleaning, dry cleaning is recommended to remove solvent residue. It is recommended that the cleaning tissues are lint-free.

## 8 Optical connectors and their applicable cleaning tools and machines

Table 1 shows typical optical connectors and their applicable cleaning tools and machines. For power blocking shuttered adaptors, stick type tools cannot be used as the cleaning cloth on top of the stick may be caught by the shutter plate.

**Table 1 – Applicable cleaning tools and machines for typical optical connector parts**

| Tools and machines | Plugs | Adaptors/ receptacles with connected plugs on back side | Power blocking shuttered adaptors with connected plugs on back side | Dust caps |
|---|---|---|---|---|
| Reel (cassette) type | recommended | n/a | n/a | n/a |
| Stick type | n/a | recommended | n/a | n/a |
| Pen type | applicable | recommended | recommended | n/a |
| Adhesive backed stick type | applicable | recommended | recommended | n/a |
| Gas and vacuum | applicable | applicable | n/a | n/a |
| Air duster | n/a | n/a | n/a | applicable |
| Paper and solvent | applicable | n/a | n/a | n/a |

If dust caps are dirty, clean the caps using an ultrasonic cleaner filled with a suitable solvent. Attention is drawn to the fact that liquid cleaning can leave a residue.

## 9 Procedures

### 9.1 General

As described in 5.3, it may be necessary to inspect and clean both sides and the inside of the sleeve of a connection before they are mated unless otherwise recommended by the manufacturer.

### 9.2 Basic procedure of cleaning

The basic procedure of cleaning is as follows.

a) Inspect the optical connector end-face for contamination or damage before cleaning.

b) Dry clean the optical connector end-face if contamination, scratches or defects are found.

c) Inspect the optical connector end-face after every cleaning to determine if contamination has been removed.

d) Repeat b) and c) several times. If contamination still remains, it may be due to contamination of the cleaning tools.

e) If contamination remains after dry cleaning several times, try wet cleaning using a solvent.

f) After wet cleaning, dry clean again.

g) Inspect the optical connector end-face after every cleaning, and judge according to the pass/fail criteria.

h) Repeat f) to g) several more times, if needed.

### 9.3 Procedure to clean exposed plug end-faces with a reel type cleaner

The procedure to clean exposed plug end-faces with a reel type cleaner is as follows.

a) Before cleaning, inspect the plug. If it is clean, do not clean it.

b) First, try a dry cleaning method, as shown in Figure 7:

1) use a designed-for-optics cleaner;
2) clean as per the manufacturer's instructions;
3) inspect after every cleaning attempt;
4) repeat 2 or 3 times, if needed;
5) if the debris remains it is bonded to the surface or mated-in (not removable).

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**Figure 7 – Cleaning with a reel type cleaner**

c) Next, try a wet-to-dry cleaning method:

1) use a designed-for-optics solvent;
2) do not saturate the cloth or tape: damp is effective, soaking wet is not;
3) clean as per the plug manufacturer's instructions;
4) wet cleaning shall be followed immediately by dry cleaning. Wet-dry can be one step (moving from damp to dry on a wipe) or two steps (damp wipe followed by dry wipe);
5) inspect after every cleaning attempt;
6) repeat 2 or 3 times if needed;
7) if the debris remains, it is mated-in (not removable).

d) Compare the plug end-face with the pass/fail criteria to decide to either use of replace the plug.

It is recommended to follow the plug manufacturer's instructions for cleaning fibre optic plugs. Do not clean against a hard surface. When using a wipe or reel type cleaner, typically one or two 25 mm strokes of the cleaning material is sufficient. Enough pressure shall be applied so that the resilient/conforming material allows the wipe to conform to the end-face geometry of the plug ensuring the entire plug end-face has been cleaned.

### 9.4 Procedure for port cleaning using a stick type or a pen type cleaner

Plugs that can be removed from an optical adaptor for cleaning should be removed and cleaned.

a) Before cleaning, inspect the plug.

- If it is clean, do not clean it.

b) First, try a dry cleaning method, as shown in Figure 8 and Figure 9:
   1) select the designed-for-optics cleaner that corresponds to the plug type/ferrule size;
   2) clean as per the plug manufacturer's instructions;
   3) inspect after every cleaning attempt;
   4) repeat 2 or 3 times, if needed;
   5) if the debris remains, it is bonded to the surface or mated-in (not removable).

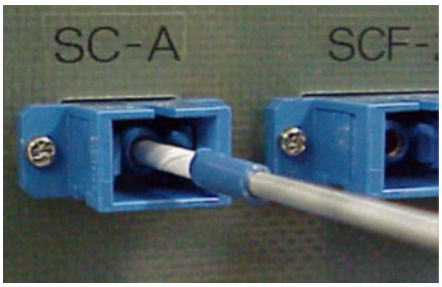


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**Figure 8 – Cleaning ports using a stick type cleaner**

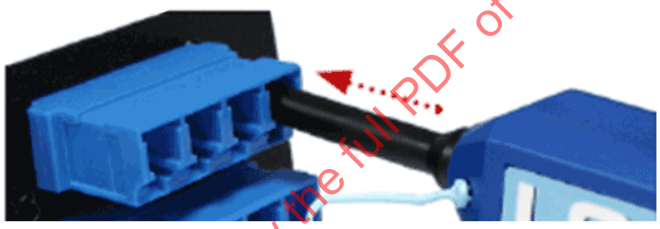

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**Figure 9 – Cleaning ports using a pen type cleaner**

c) Next, try a wet -to-dry cleaning method:
   1) apply a designed-for-optics solvent to a clean designed-for-optics cleaning wipe;
   2) moisten the tip of the cleaning tool by touching it to the solvent spot on the cleaning wipe;
   3) clean as per the plug manufacturer's instructions;
   4) wet cleaning shall be followed immediately by dry cleaning. Wet-dry can be one step (moving from damp to dry on a wipe) or two steps (damp wipe followed by dry wipe);
   5) inspect after every attempt;
   6) repeat 2 or 3 times, if needed;
   7) if the debris remains, it is mated-in (not removable);

d) Compare the plug end-face with the pass/fail criteria to decide to either use or replace the plug.

Select a swab or port cleaning device that is manufactured for the size and type of plug being cleaned. Do not touch or contaminate the cleaning end of the swab or the port cleaning device. It is recommended that the user follow the manufacturer's instructions for use with all fibre optic cleaning devices.

Stick type cleaning detail: place the cleaning end of the swab into the port and rotate the swab while applying appropriate pressure to the plug end-face. Usually, pushing so that the compression spring in the plug is slightly activated is ideal for 2,5 mm plugs. Rotating the swab several times is sufficient. The swab should only be used once and then discarded. If the user is cleaning angled polished plugs – APC (green plug housing or bulkhead adaptor) –

then using a 1/4 turn back and forth rotation may help the swab end-face conform to the 8° angle.

Pen type cleaning detail: insert the device into the alignment sleeve and activate the cleaner to perform the mechanical clean either by pushing the device or by pressing on a button on the device. For wet-to-dry cleaning, an additional activation of the device assures that any excess solvent has been removed.

### 9.5 Procedure for port cleaning using an adhesive backed stick type cleaner

Adhesive backed stick type cleaning detail: insert the cleaning end of the stick into the port of the optical connector, receptacle or optical connector adaptor and apply some pressure briefly, then remove.

Depending on manufacturer guidelines repeat the process of inserting the stick into the port, pressing briefly and removing a number of times. Typically this process can be repeated about 3 times.

Depending on the manufacturer's guidelines the same adhesive backed stick cleaner can be used on multiple ports before being discarded.

### 9.6 Cleaning procedure using a gas and vacuum type cleaning machine

Insert the nozzle into the receptacle of an optical adaptor to clean the optical end-face. The cleaning machine injects a volatile solvent into the transceiver to dislodge contamination and then extracts the solvent to remove the contamination. For operating details, the instruction manual provided with the machine by the supplier should be thoroughly reviewed before use.

# Annex A
(informative)

# Precautions for the cleaning process

## A.1 Material to be cleaned

### A.1.1 Plug connector

Plug end-faces should be inspected first, cleaned if necessary, then mated. This applies to plugs with a single fibre cylindrical ferrule and a multi-fibre rectangular ferrule.

### A.1.2 Plug connector inside adaptors

Ferrule end-faces inside of connector plugs inside ports and receptacles should also be inspected first, cleaned if necessary, then inserted into the plugs. The receptacle connectors are widely used as interface in communication equipment, measuring instruments, transceivers, etc.

### A.1.3 Adaptor for a cylindrical ferrule plug

An adaptor for a cylindrical ferrule plug usually contains an alignment sleeve. Although there is no end-face in the adaptor, the inside of the sleeve should be cleaned. Contamination inside the sleeve may spread onto the plug end-face during mating. Therefore the cleaning of the inside of the sleeve is important to maintain the cleanliness of plug end-faces.

### A.1.4 Timing of the cleaning

There is a possibility that contamination adheres to the end-face at any time. Therefore before every connection, inspection and if necessary cleaning of the plug end-face should be performed. After every cleaning, an inspection of the plug end-face should follow to ensure a clean end-face.

If installing a fibre optic patch cord in a network, even a brand new one (right out of the package), the plug end-faces on both ends of the patch cord should be cleaned before mating if no inspection has been carried out. It is probable that it was clean when tested at the manufacturing plant but it could become contaminated before the package is opened to install the fibre optic cord.

## A.2 Additional information

a) Isopropyl alcohol (IPA) and some liquid cleaners will absorb moisture from its surroundings, including air. Therefore, a container of IPA left open to the air can easily become diluted and contaminated. Contaminated IPA can leave a residue on the end-face of the plug contributing to the reduced performance of the fibre optic link. IPA with a volume fraction of 95% or higher should be used.

b) Not all materials are suitable for cleaning optical plugs. Materials not specifically designed for optical cleaning (e.g. cotton swabs, some types of tissue paper, some types of foam) may contain contaminants that will remain on the fibre surface, or break down and leave material remnants on the plug.

c) Repackaging of wipes or swabs into one's own containers may contaminate the cleaning products. Cleaning wipes or swabs removed from packaging and left “out” before use can pick-up contaminates from the air or handling.

d) If in doubt about the cleanliness/effectiveness of the fibre optic cleaning products, try the “do no harm” test.

e) Take a clean plug (verified clean by inspection with a microscope).

1) Clean it with the appropriate cleaning materials.
2) Re-inspect the end-face with a microscope. Has the process damaged or added any contamination to the plug end-face?
3) The process may be repeated several times.
4) It is not unusual for cleaning products to occasionally leave some contamination on the end-face.

f) Use of canned air to directly clean the end-face of a fibre optic plug or port is not recommended. Canned air can contain some oils, which are out-gassed by the main seal in the valve of the can. This is particularly true during the first few seconds of spraying after the can has not been used. The high velocity air could force some hard contaminates onto the plug surface potentially damaging it. Canned air is under pressure and cools as it leaves the confines of the container. Therefore, it can chill the optical component causing moisture in the air to condense on the surface, likely depositing contaminants.

g) All cleaning materials shall be packaged in a way that does not adversely affect the cleaning properties of the cleaning material.
1) Lint free wipes shall be packaged so that the wipe does not become contaminated in transport, storage or use.
2) Liquid cleaners shall be packaged so that they cannot be contaminated.
- Hermetically sealed containers that dispense solvents only when being used are best.
- Propellants in aerosols should not contribute to the contamination problem.

h) Opened containers of IPA will absorb moisture from the air along with any airborne contaminates dissolved in that moisture in the air and leave a residue on the end-face.

i) Inspect both plugs before making the connection. This is the only way to ensure the devices are clean and safe to connect.

# Annex B
(informative)

# General information on contamination

## B.1 Impact of contamination

### B.1.1 General

Contamination is the most common source of problems in optical networks. A single particle located on the core of a single mode fibre can cause significant back reflection, attenuation and fibre damage. IEC TR 62627-05 contains an investigation on the impact of contamination on the optical performance of optical connectors.

With increased data rates, it has become increasingly important to ensure that all plugs and adaptors are inspected and if necessary cleaned before mating. This means that both sides of a connection and the inside of the adaptor sleeve should be inspected and if necessary cleaned before making the connection. This applies to test equipment and test cords as well as network components. New plugs shall be inspected and if necessary cleaned. Inspecting and cleaning every connection every time is the best assurance of a reliable optical network.

### B.1.2 High power levels

High power levels may be experienced in transmission fibres, particularly where Raman amplifiers are used – pump power levels of one watt (+30 dBm) or more may be present in the core of the fibre giving an energy density equivalent to 12,5 GW/m$^2$ for a single mode core with an effective area of 80 $\mu$m$^2$. High power levels may also be used for information transmission in dense wavelength division multiplexing (DWDM) systems, where high power systems may have 100 mW to 1 W total signal power. When optical power of this magnitude is transmitted within a single mode fibre, any contamination on the end-face of a fibre optic plug will be heated to extremely high temperatures resulting in possible vaporization of the contaminate and melting of the glass, thereby destroying the integrity of the connection and requiring a complete replacement of the connection components.

### B.1.3 High data rates

With the onset of high data rate systems at 1 Gbit/s and above, cleaning multimode fibre optic plugs has become much more important. In the past, at slower data rates (10 Mbit/s and 100 Mbit/s), the use of LEDs as the light source and the larger size of the multimode core allowed for “some” contamination without noticeable network performance degradation. Equipment power budgets were typically in the range of 10 dB to 15 dB. Now with data rates at 1 Gbit/s, 10 Gbit/s and higher data rates, the allowable channel insertion loss may be as low as 2,35 dB for example. Also, the use of VCSELs means that plug cleanliness is necessary to ensure minimal back reflection thereby ensuring system performance.

## B.2 Source of contamination

### B.2.1 Mishandling

Mishandling of a plug end-face is the most common source of contamination. Accidentally touching the end-face will spread skin oil or hand lotion across the end-face. Accidentally brushing the plug end-face on clothing can leave skin oil or other oil previously absorbed by the fabric, lint generated from the material, particles held in the fabric or surfactants from previous cleaning of the garment. Leaving a fibre optic port or plug end-face unprotected from the environment subjects the end-face to environmental sources of contamination as discussed below.

Typical examples of contamination are shown in Figure B.1.


a) Clean plug wiped on a T-shirt


b) Clean plug wiped on jeans

**Figure B.1 – Typical examples of contamination**

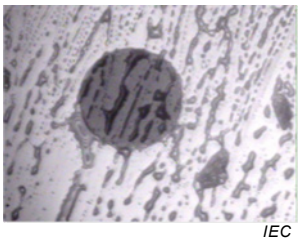
### B.2.2 Environmental sources

Environmental sources of contamination are too numerous to catalogue completely. Building materials are a common contributor to fibre optic plug contamination; sawdust, sheet plaster dust and paint fumes are all potential contributors. Pollutants in the air can find their way onto plug end-faces. In dry climates airborne dust particles will find their way onto plug end-faces. In very damp humid areas, airborne contaminates can condense on the plug end-face. Considering fibre optic applications exist in military, medical, oil and gas and manufacturing industries, the variety of potential contaminants becomes very large.

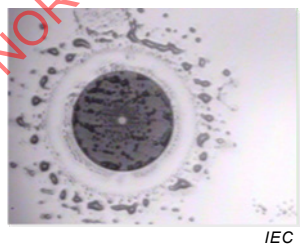
### B.2.3 Contamination travels

Contamination travels between plugs, as illustrated in the images in Figure B.2. The insertion of a contaminated plug into a port will spread that contamination to the mated end-face, which in turn will spread the contamination to the next plug that is plugged into the port. Below are pictures of the results of mating a clean plug with a contaminated plug.

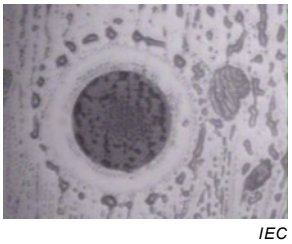

a) Plug A before mating




b) Plug B before mating




c) Plug A after mating

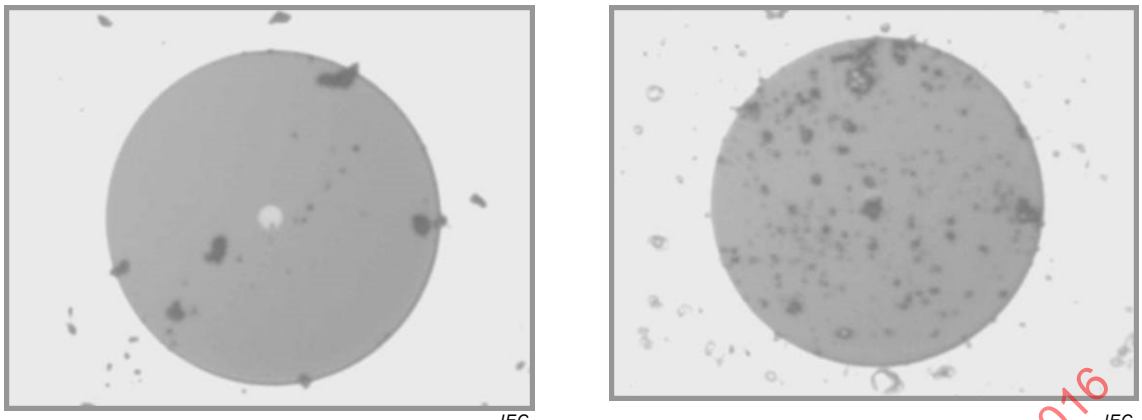



d) Plug B after mating

**Figure B.2 – Results of mating**

### B.2.4 Contamination migration

Contamination can migrate toward the core, as shown in Figure B.3. Initial contamination outside the core zone can be broken up by mating and travel toward or onto the fibre core.



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a) Initial contamination

b) After 4th mating

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**Figure B.3 – Contamination migration**

## B.3 Problems due to end-face contamination

### B.3.1 Signal degradation

An example of signal degradation (increased attenuation and back reflection) is shown in Figure B.4.

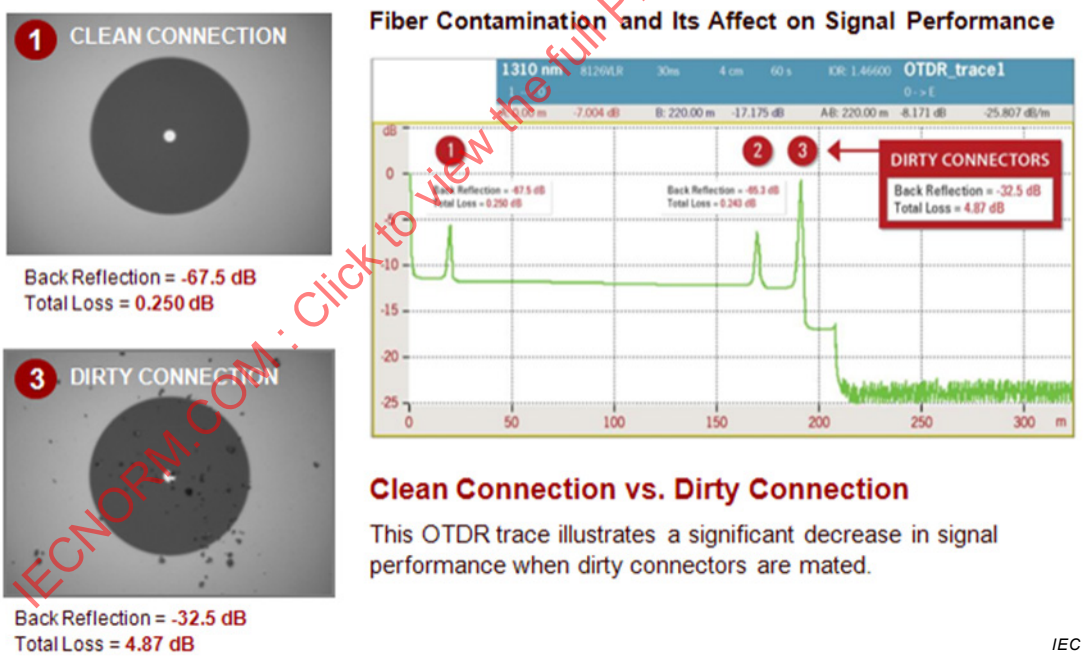


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**Figure B.4 – Signal degradation due to contamination**