

Inspection And Cleaning Of Optical Connectors

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1 About This Document

Warning!

To reduce the risk of bodily injury and damage to equipment, observe all safety precautions, procedures, and details contained in Reference [1] and Reference [2].





2 Introduction

Any attempt at mating optical connectors without first cleaning them can lead to data transport failure. The presence of any dirt or particles on the connector will be transferred to the patch cord and to any connectors that are subsequently brought into contact with it. This can cause irreparable damage to both faces of the inter-connection

Optical connectors are vulnerable every time they are separated or when the dust cap is removed. Connectors should be separated and dust caps removed only when absolutely necessary and if so, they should be cleaned.





3 General Handling of Fiber for Inspection

When handling optical devices it is essential that all Electrostatic Discharge (ESD) precautions are observed at all times.

Unless previously agreed with Process Quality Assurance, the cleaning and inspecting as specified within this document must be carried out immediately prior to any optical connector mating.

3.1 Fiber Bend Radius

When handling any fiber optic cables for inspection, care should be taken not to stress the fiber. In particular a bend radius of less than 30mm should not be broken. This will prevent fractures from being introduced to the fiber due to mishandling.

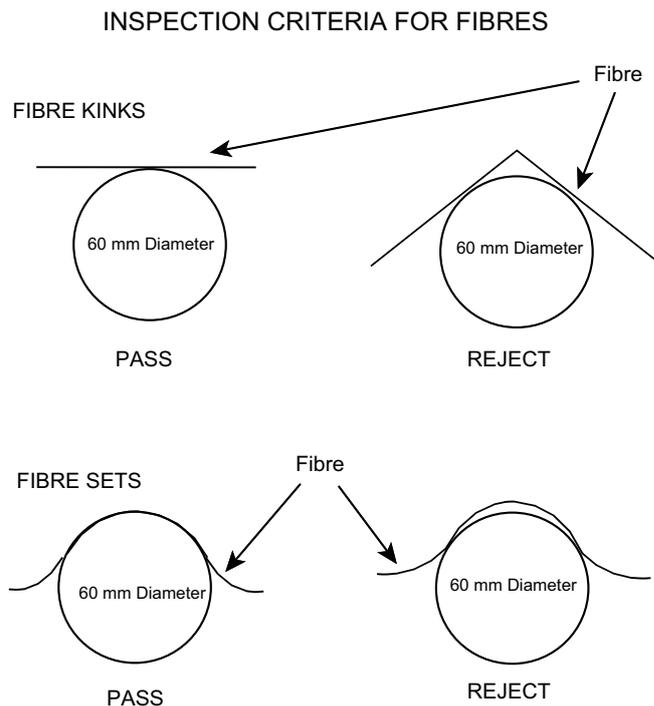


Figure 1 Inspection Criteria for Fiber Optic Cables

3.2 Insertion of Fiber to Bulkhead Adapter

Care should be taken during insertion to avoid contact with any sharp edges such as the keyway. This is particularly relevant where the keyway has been subjected to multiple insertions such as on captive units.



3.2.1 SC, LC, and Mu

Offer the connector squarely up to the bulkhead adapter as shown in Figure 2. Push all the way in until a positive click is felt.

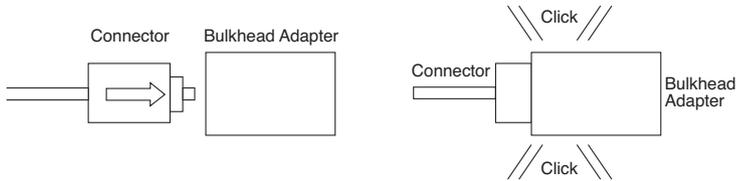


Figure 2 Insertion of Fiber to Bulkhead Adapter

3.2.2 FC-PC Type Connectors

The connector should be presented to the bulkhead adapter at an acute angle such that the connector face is just inside the bulkhead adapter; see Figure 3. At this point the connector should be rotated until the connector and bulkhead adapter are correctly aligned at which point the insertion can be completed.

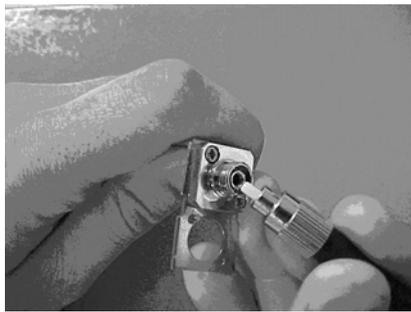


Figure 3 FC-PC Type Connectors

3.2.3 HDMT Type Connectors

Prior to insertion ensure that the epoxy window is in the correct attitude; see Figure 4. Carefully align the connector and ensure that the attached ribbon is not kinked or put under stress.

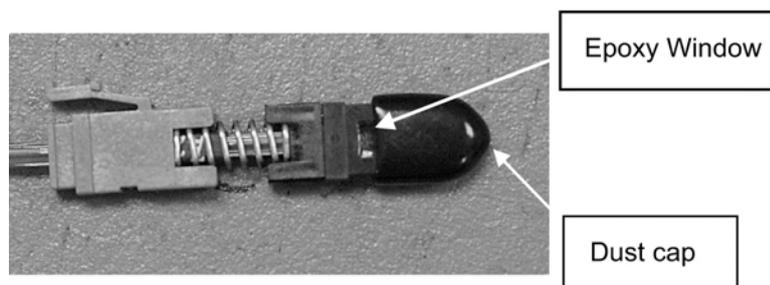


Figure 4 HDMT Type connectors



3.3 Dust Caps and Bulkhead Adapters

Any dust caps or bulkhead adapters that are not in use should be contained within a sealed bag in order to stop any contamination while not in use. It is essential that this is followed in order to minimize cross contamination when a dust cap is fitted to a disconnected optical fiber. Dust caps and bulkhead adapters should not be left in an open-air environment at any time, as this will allow dust or contamination to settle in them over a period of time will cause cross contamination of these components.

Dust caps are to be fitted at all times when optical fibers or bulkhead adapters are disconnected. Immediately after the connector is disconnected, the free ends of the optical fiber and the bulkhead adapter must be protected with appropriate dust caps. The dust caps should be obtained from a sealed bag; not ones that are lying in and around the vicinity of the equipment. This is essential to the overall serviceability of the optical fiber as any dust or contamination ingress can cause upstream problems, such as scratching or pitting even during the cleaning process. It is therefore essential to limit any contamination to a minimum at all times.

Care must be exercised when removing or replacing dust caps to avoid stress being introduced to the optical fiber; see Section 3.1 on page 5.





4 Inspection

Warning!

To inspect optical connectors on a fiber trail, the power should not be restored until the field engineer at the distant end has received instruction from the person carrying out the connector examination. To inspect the optical connectors on equipment, remove the optical unit from the shelf and place it on a convenient work surface.

Warning!

The use of laser components in Ericsson equipment has been classified in Reference [1] and Reference [2] according to the way the equipment design control-measures have been implemented to comply with the laser standards.

Warning!

The lasers used in this equipment have the potential to cause harm. Do not use the equipment in any way not specified by Ericsson, and do not adjust or tamper with any laser or its control circuitry as this may result in laser emissions in excess of safe limits.

4.1 Inspection Equipment

The two acceptable methods of inspection are optical and charge-coupled device (CCD) camera with monitor fiberscopes.

The following criteria should be met with the both optical and CCD.

- View should be capable of viewing contamination as small as $1.0\mu\text{m}$.
- The field of view should be a minimum of $300\mu\text{m}$.

4.1.1 Optical

Apparatus for the this method includes:

- A suitable ferrule or connector holder
- Microscope with a minimum 200x magnification
- Resolution capable of viewing $1.0\mu\text{m}$
- Non-polarized direct axial illumination light source

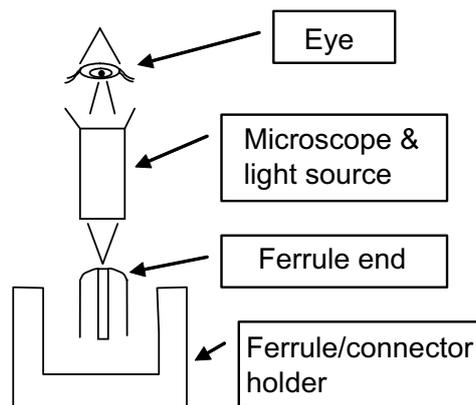


Figure 5 Optical

4.1.2 CCD Camera With Monitor

Apparatus for this method includes:

- Microscope with minimum magnification of 200x
- CCD camera with a pixel array capable of defining $1.0\mu\text{m}$
- Monitor large enough to view $1.0\mu\text{m}$ as picked up by camera CCD
- Light source
- Ferrule or connector holder

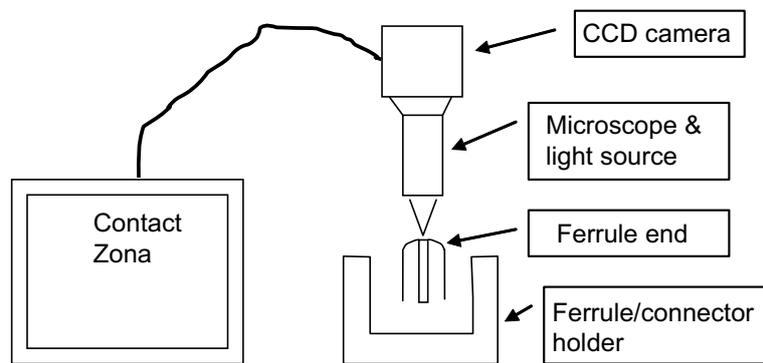


Figure 6 CCD Camera

4.2 Ferrule Inspection

All optical fiber connectors must be inspected immediately before a connection or reconnection is made and carefully cleaned. The inspection criteria is supported in the appendices of this document; see Section 5.1.1 on page 13. Some of the defects shown in the Appendix (Page 25) may not be visible until the connector is cleaned.

The sides as well as the end of the ferrule should be inspected for serious scores or scratches (visible to the naked eye). The side can be cleaned with a specified wipe as per the cleaning equipment list. The ferrule end should then be inspected using a suitable microscope as mentioned in document.

4.3 Connector End-Face Inspection

Inspect the connector end-face using the methods outlined in Section 4.1 on page 9 this document. Particular attention should be given to the core area of the fiber. If the fiber end is generally smooth and free from cracks, scratches, chips and dirt (see Appendix on Page 25) the ferrule is acceptable. Slight chipping in the ferrule region is permissible, but no obvious cracks or damage, that extends into the fiber area, are permitted.

There will always be some score marks present on the ferrule end-face since most of these connectors are polished epoxy. Some connectors employ a compressed metal alloy which when viewed through a microscope will appear to have small black inclusions. However, obvious deep score marks are usually evidence of damage by foreign bodies. If these marks are pronounced or extend near to or into the fiber then the connector should be rejected to enable the fiber to be reterminated.



4.4 Bulkhead Adapter Inspection

Inspect the bulkhead adapter to ensure that there is no evidence of dust, dirt, grease or metal particles. If any of the above are present then the bulkhead adapter must be cleaned reinspected and if necessary recleaned.



5 Defect Definition and Criteria

Contamination - Defect on the surface face of the ferrule, Cladding or core attributable to dust, grease or moisture. Removable by cleaning method.

Pits - Permanent features caused by polishing or mishandling of fiber. Non removable with cleaning method.

Scratches - Permanent lines caused by polishing or mishandling of fiber. Non removable with cleaning.

5.1 Criteria

5.1.1 Fiber Measurement Table

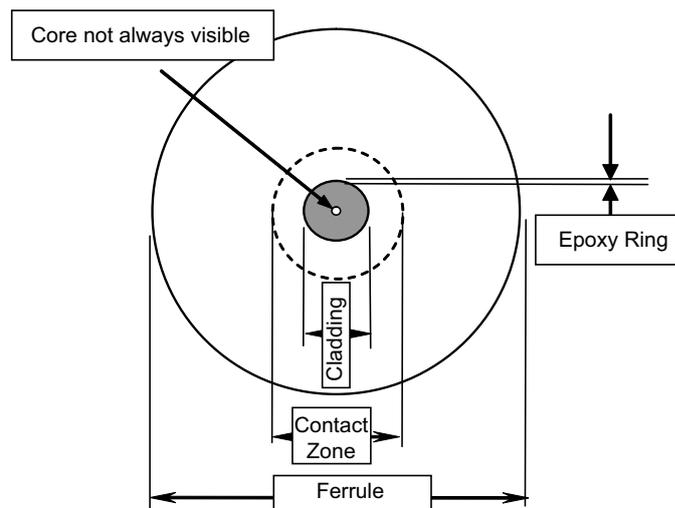


Figure 7 Fiber Measurement



Table 1 *Fiber Measurement Table*

Fiber Measurement Table				
Description	Multimode	Single Mode FC-PC, SC	Single mode LC, Mu	Comment
Unit of measure Y	µm	µm	µm	
Core	50 /62.5	9	9	Signal Carrier. Not always visible
Cladding	250	125	125	Maintains the signal within the core.
Epoxy	2	2	2	Thin layer between Cladding & Ferrule
Contact Zone	200	200	200	Area that actually contacts when connectors are mated
Ferrule	2.5mm	2.5mm	1.5mm	



5.1.2 Fiber Inspection Zones

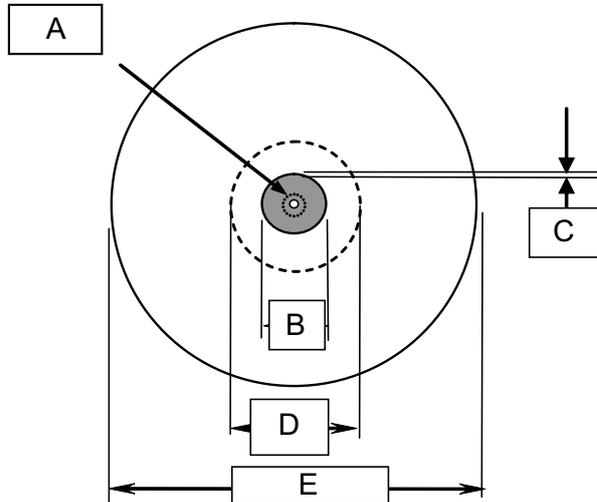


Figure 8 Fiber Inspection Zones

Table 2 Fiber Inspection Zones Table

Fiber Inspection Zone Table				
	Description	Multimode	Single Mode FC-PC, SC	Single mode LC, Mu
	Unit of measure Y	µm	µm	µm
A	Core	70	25	25
B	Cladding	240	115	115
C	Epoxy	255	130	130
D	Contact Zone	300	250	250
E	Ferrule	400	400	400



5.1.3 Visual Criteria for Connectors Primary Incoming

Table 3 Visual Criteria for Connectors Primary Incoming Table

Zone	Requirement				Reference	Westover camera zone
	Cracks	Scratches (No Length Limits)	Pits	Contamination		
A	None	Individual None Width ³ 0.7mm Occurrences < x 1 Discount any under Ø 0.7mm	Individual None ³ Ø 1mm Occurrences < x 1 Sum < 1mm Discount any under Ø 0.7mm	Individual None ³ Ø 1mm Occurrences < x 1 Sum < 1mm Discount any under Ø 0.7mm	Figure 15	A (0-25mm)
B	None	Individual None Width ³ 1mm Occurrences < x 2 Discount any under Ø 0.7mm	Individual None ³ Ø 2mm Occurrences < x 3 Sum < Ø 6mm Discount any under Ø 0.7mm	Individual None ³ Ø 2mm Occurrences < x 3 Sum < Ø 6mm Discount any under Ø 0.7mm	Figure 15	B(15-115mm)
C	None	Individual None Width ³ 2mm Occurrences < x 6 Epoxy ring width < 2mm Discount any under Ø 0.7mm	Individual None ³ Ø 2mm Occurrences < x 6 Sum < Ø 10mm Epoxy ring width < 2mm Discount any under Ø 1mm	Individual None ³ Ø 2mm Occurrences < x 6 Sum < Ø 10mm Epoxy ring width < 2mm Discount any under Ø 1mm	Figure 15	C(115-130)
D	None	Individual None Width ³ 5mm Occurrences < x 6 Discount any under Ø 0.7mm	Individual None ³ Ø 5mm Occurrences < x 6 Sum < Ø 20mm Discount any under Ø 2mm	Individual None ³ Ø 5mm Occurrences < x 6 Sum < Ø 20mm Discount any under Ø 2mm	Figure 15	D(130-250mm)
E	None	Individual None Width ³ Ø 5mm Occurrences < x 6 Sum width < 20mm Discount any under Ø 2mm	Individual None ³ Ø 10mm Occurrences < x 10 Sum < Ø 50mm Discount any under Ø 2mm	Individual None ³ Ø 10mm Occurrences < x 10 Sum < Ø 50mm Discount any under Ø 2mm		E(250-400mm)



5.1.4 Visual Criteria for Connectors Secondary Outgoing

Table 4 Visual Criteria for Connectors Secondary Outgoing

Zone	Requirement				Reference	Westover camera zone
	Cracks	Scratches (No Length Limits)	Pits	Contamination		
A	None	Individual None Width ³ 0.7mm Occurrences < x 1 Discount any under Ø 0.7mm	Individual None ³ Ø 1mm Occurrences < x 1 Sum < 1mm Discount any under Ø 0.7mm	Individual None ³ Ø 1mm Occurrences < x 1 Sum < 1mm Discount any under Ø 0.7mm	Figure 15	A (0-25mm)
B	None	Individual None Width ³ 1mm Occurrences < x 2 Discount any under Ø 0.7mm	Individual None ³ Ø 5mm Occurrences < x 3 Sum < Ø 15mm Discount any under Ø 0.7mm	Individual None ³ Ø 5mm Occurrences < x 3 Sum < Ø 15mm Discount any under Ø 0.7mm	Figure 15	B(15-115mm)
C	None	Individual None Width ³ 4mm Occurrences < x 6 Epoxy ring width < 2mm Discount any under Ø 0.7mm	Individual None ³ Ø 5mm Occurrences < x 6 Sum < Ø 15mm Epoxy ring width < 2mm Discount any under Ø 11.8mm	Individual None ³ Ø 5mm Occurrences < x 6 Sum < Ø 15mm Epoxy ring width < 2mm Discount any under Ø 11.8mm	Figure 15	C(115-130)
D	None	Individual None Width ³ 5mm Occurrences < x 6 Discount any under Ø 0.7mm	Individual None ³ Ø 20mm Occurrences < x 10 Sum < Ø 100mm Discount any under Ø 2mm	Individual None ³ Ø 20mm Occurrences < x 10 Sum < Ø 100mm Discount any under Ø 2mm	Figure 15	D(130-250mm)
E	None	Individual None Width ³ Ø 5mm Occurrences < x 6 Sum width < 20mm Discount any under Ø 2mm	Individual None ³ Ø 25mm Occurrences < x 15 Sum < Ø 100mm Discount any under Ø 2mm	Individual None ³ Ø 25mm Occurrences < x 15 Sum < Ø 100mm Discount any under Ø 2mm		E(250-400mm)



5.1.5 Example of Defect Calculation for Above Primary Criteria

The above example fails on three points for section D contamination. (Sum $< 20\mu\text{m}$ or None $\geq 5\mu\text{m}$ or occurrences < 6)

The sum of contamination in D is calculated by adding all the contamination.

For example 1: $V+W+X+Y+Z+U=21.5\mu\text{m}$ sum contamination. (This should be less than $20\mu\text{m}$)

For example 2: $U=6\mu\text{m}$ (This should be Not greater or equal to $5\mu\text{m}$)

For example 3: $V+W+X+Y+Z+U = 6$ Occurrences (This should be < 6 Occurrences)

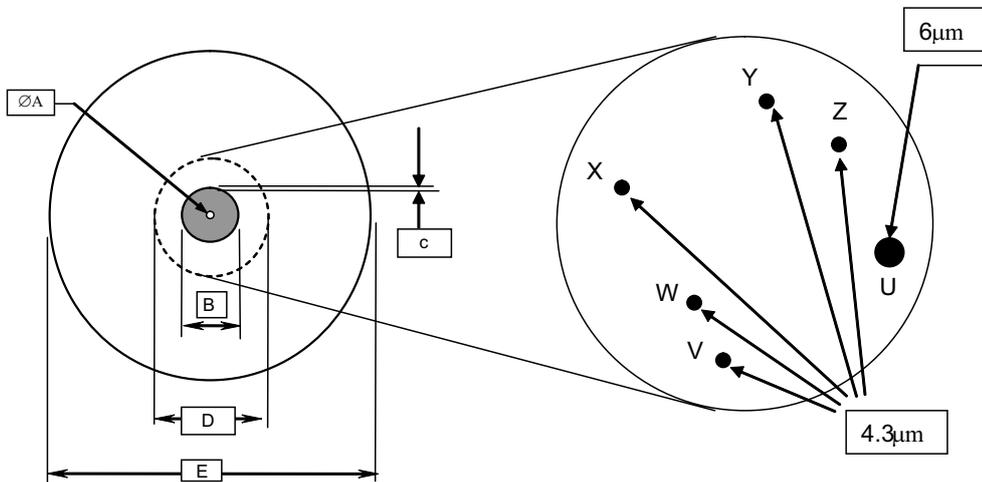


Figure 9 Example of Defect Calculation for Above Primary Criteria



6 Cleaning Optical Fiber Connectors

The following procedure combines the procedures intended for safety, cleaning and examination of optical connectors (pigtails) utilizing an optical microscope.

It is essential, for the correct operation of any optical system, that all of the optical interfaces and bulkhead adapters are clean and free from contamination and damage.

Note: It is equally important that all instruments, Optical Microscopes, Power meters, and Optical Time-Domain Reflectometer (OTDR) interfaces that is are maintained and cleaned to reduce the risk of cross contamination occurring from this source.

This procedure shall be applied immediately before pigtails are connected to any equipment (card or optical aid) and on each and every occasion an optical dis-connect is undertaken where this occurs as the result of a fault finding activity.

Disconnection of optical pigtails shall be kept to a minimum. Where necessary, such pigtails shall be protected from mechanical damage and contamination. Where a 'dust cap' is employed for such purpose the cap shall itself be clean and suitable for the purpose' and shall at all times of storage be held in a clean plastic bag to protect from contamination.

Note: Pigtails shall not be left in rack bases or in any place that may result in contamination or damage to the ferrule of the pigtail.

6.1 Cleaning Fiber Tails

Note: All dust caps should be removed and discarded. They may in themselves be the most common source of contamination to the face of pigtails. If caps are left in the open, contamination may settle inside the cap and may be subsequently transferred to the pigtail when used. Spare dust caps, where held by the engineer for future use, shall be stored in a clean plastic bag at all times.



6.2 Optical Cleaning Equipment

To be used when cleaning connector ferrules of Physical Contact (PC) and Angled Physical Contact (APC) type and connector of Mechanical Transfer (MT) and Multiple-Fibre Push-On/Pull-off (MP-) type before termination.

Table 5 Optical Cleaning Equipment

Description	Part Number	Part Number for Refill	Notes
CLEANING CASSETTE FOR PC AND APC TYPE (Cletop-S)	LTT 179 001 (including 1 cleaning tape/refill)	1/LTT 179 001 (6 pcs/set)	Preferably for connectors with ferrule Ø 2.5mm
Anti-Static CLEANING CASSETTE FOR PC and APC Ø 1.25 and 2.5mm.	LTT 179 001/1 (including 1 cleaning tape/refill)	1/LTT 179 001/1 (6 pcs/set)	And MP and MT TYPE without pins (Optipop)

6.3 Cleaning Process

There are two approved methods of cleaning.

- Cletop - Applicable to Ferrule Connector/Physical Contact (FC-PC), Subscriber Connector (SC), Lucent Connector (LC), Deutsches Institut für Normung (DIN) and Miniature unit (Mu) connectors
- Wet Process - Applicable to all connectors

Both the methods listed below must be proceeded with a wipe around the side surfaces of the ferrule, using a lint free cloth. The first and main cleaning method is with the use of a Cletop cleaner. This is a dry method and will clean adequately for the vast majority of applications. If however upon inspection the fiber will not clean to the inspection criteria then the second wet method can be used followed by the Cletop method.



6.3.1 Initial Cletop Cleaning Process

Using a Cletop cartridge cleaner, the end face of the ferrule can be polished which results in uniform results.

Note: Care should be exercised when cleaning the angled end faces of the ferrules to follow the connector profiles as shown below.

Do not use the Cletop cartridge for mechanical transfer pull off (MTP) fibers as the end-face locating pins prevent contact of the tape with the fiber ferrules.

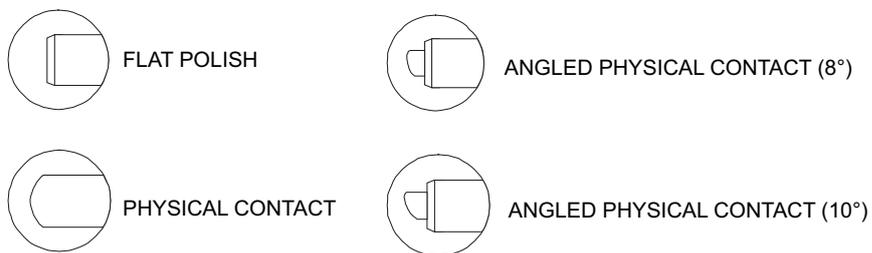


Figure 10 Cleaning Process

1. Hold the cassette in the palm of the hand and depress/rotate the lever with the thumb. This action winds the cleaning cloth tape inside the cassette case and simultaneously opens the shutter as shown in Figure 11.

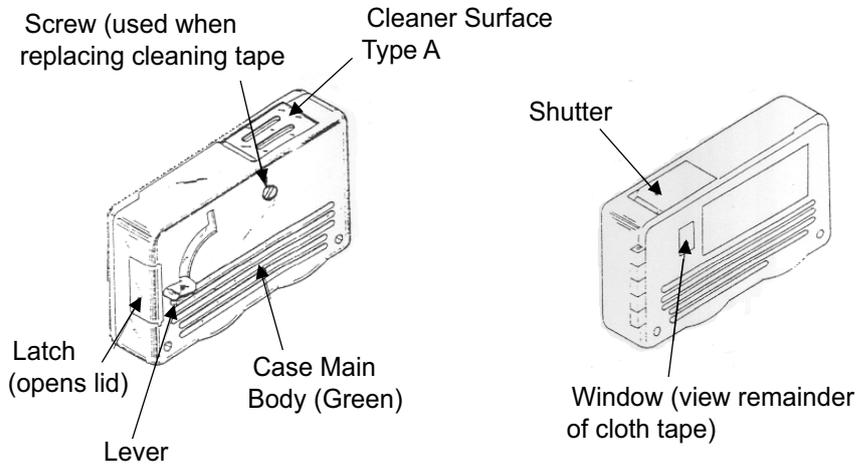


Figure 11 Cletop Cartridge Cleaning Cassette

Note: Each depression of the lever facilitates the exposure of a new cleaning cloth face. Exercise caution not to double click the lever as such an action will waste one of the available cleaning faces and reduce the life of the cassette.

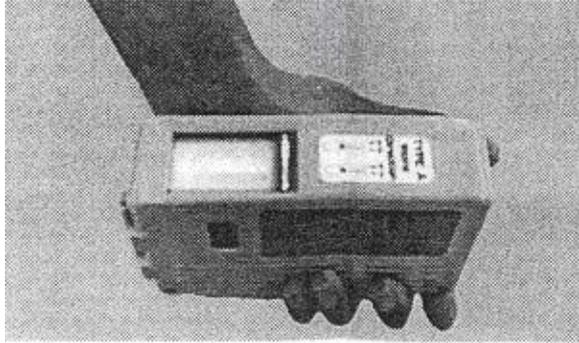


Figure 12 Cartridge Cleaning Cassette

2. Rotate the lever with the thumb. Ensure that the lever is kept depressed during the cleaning operation; see Figure 12.
3. Press the optical ferrule end face of the connector to be cleaned against the cleaning cloth and drag the connector in the direction shown in Figure 13 below.

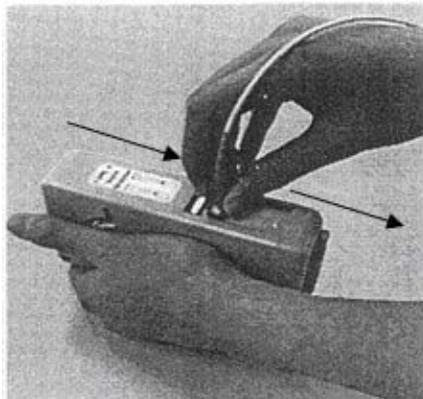


Figure 13 Cartridge Cleaning Cassette (optical ferrule)

Note: Ensure that the optical end face is pressed snug against the cleaning tape surface while dragging the connector (cleaning may not be complete if the connector end face is insufficiently pressed).

4. When the cleaning procedure is complete, release the shutter lever allowing it to return to its initial position.

Note: When the cleaning cloth is completely used, The user shall return the cassette to the supervisor and request a replacement.

5. Re-examine the connector using the microscope. (If the connector does not come clean after 3 attempts then carry out a clean with the wet process followed by the Cletop process.
6. Fit the connector when fiber is clean.



6.3.2 Secondary Wet Cleaning Process

- 1 Wipe the end face and surrounding area (The sides of the ferrule) at the front of the connector with an impregnated wipe to remove any greasy contamination.
- 2 Fit the connector, using the appropriate adapter, into the hand held microscope.
- 3 Examine the ferrule end, check that it is free from dust, grease or particles of grit:
 - a Dust will manifest itself as lumps, flakes and fibers.
 - b Grease, commonly introduced during handling, will appear as a blob or smear
 - c Particular attention must be paid to the core area of the ferrule area. It should be generally smooth and free from cracks. Slight chipping in the cladding area is permissible but not obvious cracks, scratches or other damage across the core area.
- 4 As the connector is of epoxy/polish type, score marks will always be present on the surface of the ferrule end face. Obvious deep score marks, particularly where they appear circular in shape, are normally evidence of damage by foreign bodies. If such score marks are pronounced, or extend into the core region, the connector should be rejected and replaced.
- 5 To remove any grease, soak a lint free wipe with a small amount of the approved solution (IPA/De-Ionised water). Carefully stroke it across the ferrule end face several times in the same direction before repeating the stroking with a clean and dry wipe. For safe disposal of the wipes, Section 3.2 refers.
- 6 Follow with the Cletop procedure for FC-PC, SC, LC Din and Mu connectors.

6.3.3 Cleaning Process for the HDMT TYPE

After ensuring that the guide pins, where present, are below the surface, use a moistened, approved, cleaning tissue to lightly clean the surface to remove any large particles. This cleaning should be performed using a circular motion.

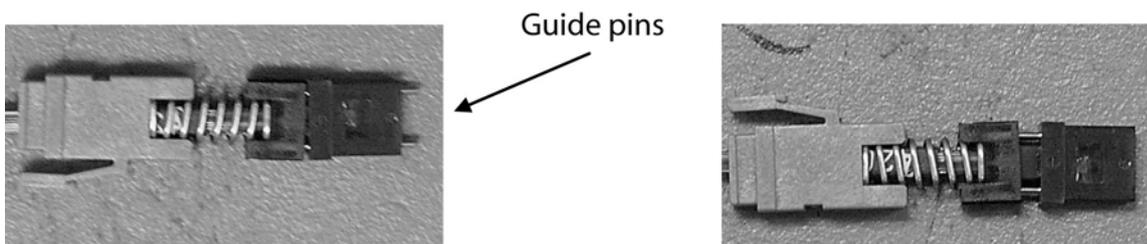


Figure 14 Cleaning for the High Density MT (HDMT) TYPE



6.3.3.1 Cleaning the Connector End Face

Inspect connector, as above. Remove dust from the connector end face by carefully wiping the connector surface using a circular motion. Do this with a Cletop purple stick as per cleaning equipment list moistened with approved solvent from the dispenser, or alternatively dip the tip of the connector (not HDMT Type) into the solvent. Either of the above should then be followed by cleaning using a clean dry Cletop stick using circular motions throughout.

Reinspect the connector and repeat the cleaning if necessary.

If the connector is still dirty after the recleaning then it should be considered unsatisfactory for use.

Caution!

Do not shake the aerosol can prior to use.

Blow any dust from the bulkhead adapter using an approved aerosol dust remover.

Reinspect the bulkhead adapter, as above. Any remaining dirt, dust or metallic particles should be removed with a portion of dry tissue rolled to create a cylinder, which should be pulled through the bulkhead adapter. Alternatively use an approved cleaning bud (not cotton).



Appendix

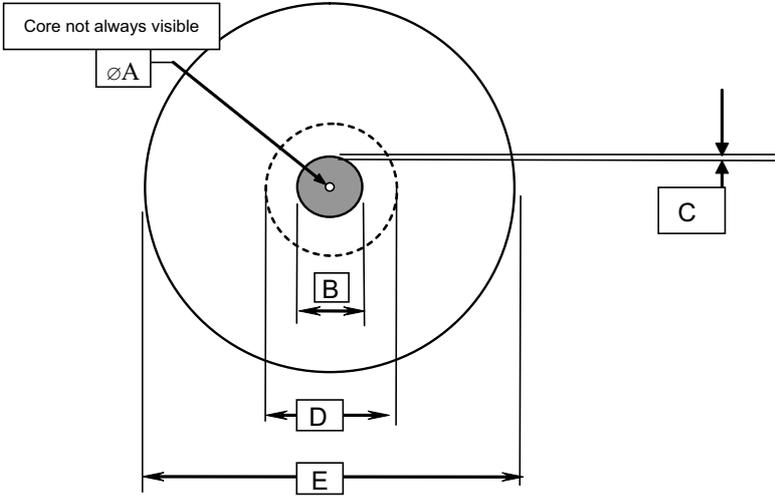


Figure 15 General View of End Face

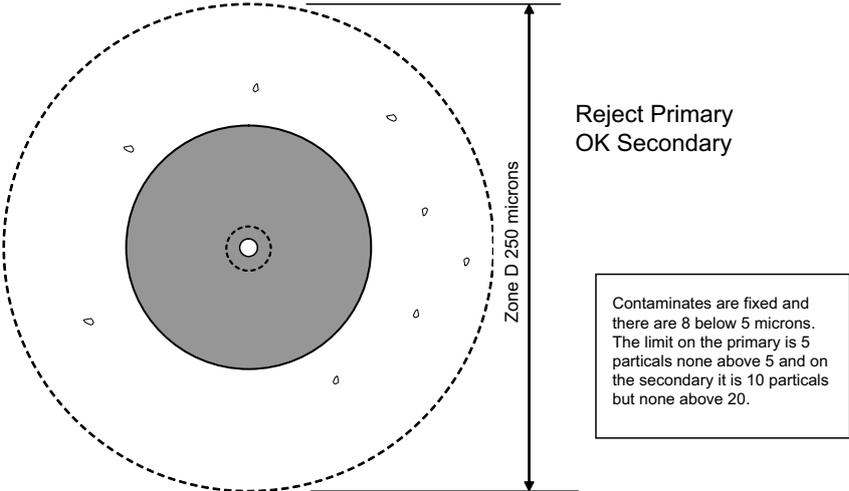


Figure 16 Examples of pitting

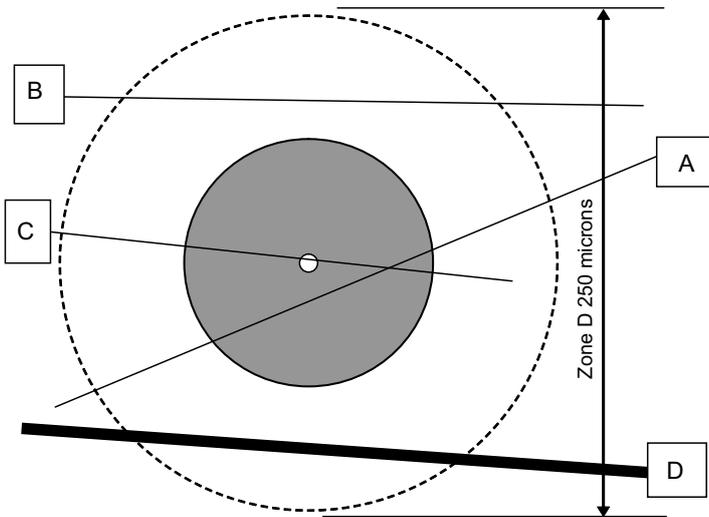


Figure 17 Scratches

Table 6 Scratches Table

Scratch	Reject or OK	Comment
A	OK	Scratch is just outside of Fiber Core Zone. However if there were more than 1 through the fiber cladding this would amount to a fail. Also if this scratch was greater than 1 micron it would also fail.
B	OK	Scratch is through ferrule area and below 5 microns in width and hence is acceptable
C	Reject	Scratch is through core. Any scratch through the core is a failure.
D	Reject	Scratch is through ferrule area but is Above 5 microns in the Contact Zone D. This amounts to a failure.



Diamond Metallic Ferrule Connector

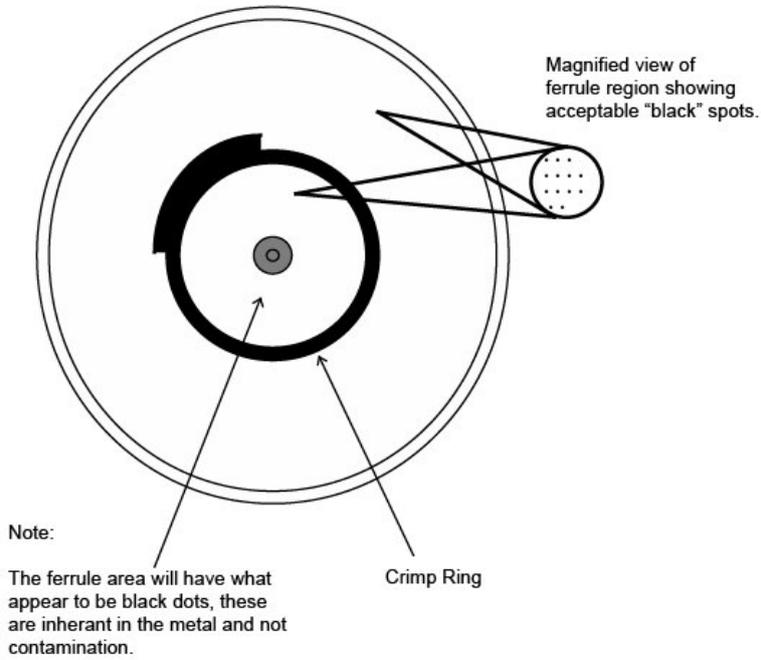


Figure 18 Diamond Metallic Ferrule Connector



CERAMIC FERRULE

Cords and Pigtails.

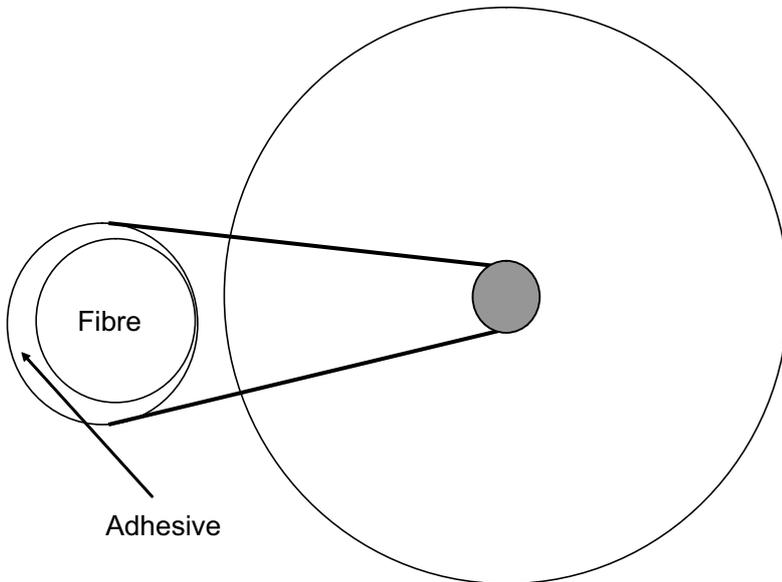


Figure 19 Cords and Pigtails

Reject if:

1. Cracks which do not start and finish at the cladding edge.
2. If adhesive forms a crescent on one side of fiber.



Glossary

APC

Angled Physical Contact

CCD

Charge-Coupled Device

DIN

Deutsches Institut für Normung

ESD

Electrostatic Discharge

FC/PC

Ferrule Connector/Physical Contact

HDMT

High Density MT

LC

Lucent Connector

LLSR

Local Laser Safety Representative

LSO

Laser Safety Officer

MP-

Multiple-Fibre Push-On/Pull-off

MT

Mechanical Transfer

MTP

Mechanical Transfer Pull Off

OTDR

Optical Time-Domain Reflectometer

PC

Physical Contact

SC

Subscriber Connector





Reference List

- [1] *Safety Guide*, 1/124 46-CSA 113 62/5 Uen
- [2] *SFP/XFP Optical Safety Rules*, 3/124 46-CSA 113 62/5 Uen
- [3] *System Safety Information*, 124 46-2886 Uen
- [4] *Personal Health and Safety Information*, 124 46-2885 Uen