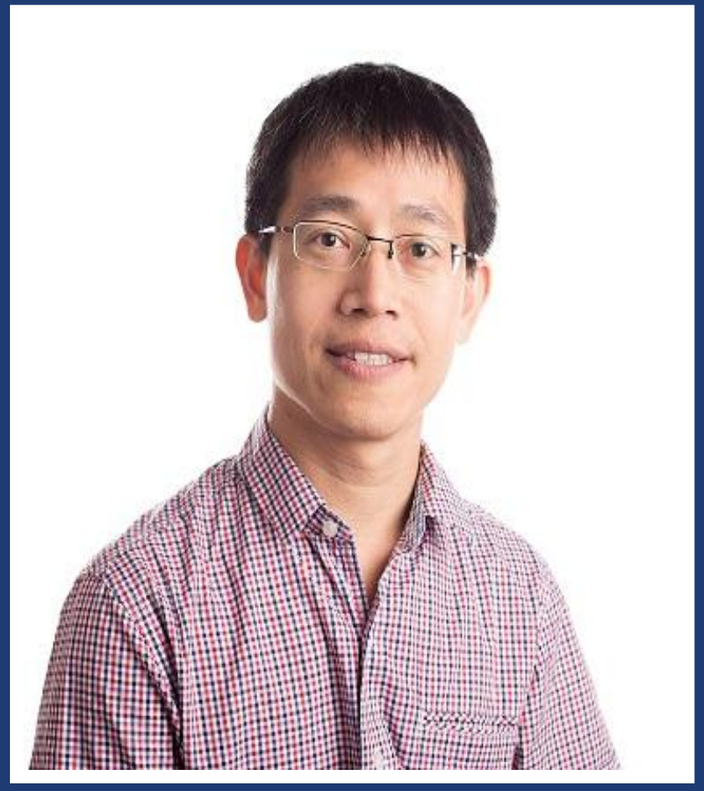
How to become a Fiber Testing Expert



Ng Chin Keong

Applications Engineer

EXFO Southeast Asia

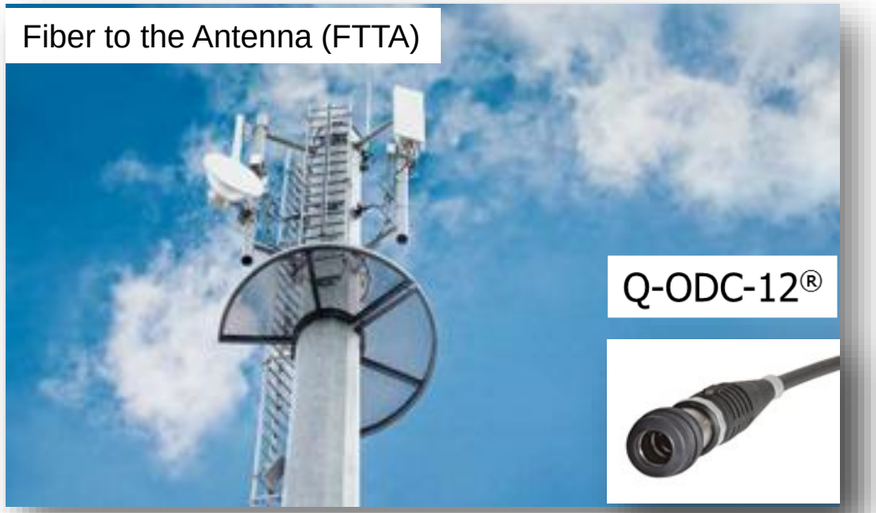
How to become a Fiber Testing Expert

Ng Chin Keong

Applications Engineer

EXFO

Fiber to the Antenna (FTTA)

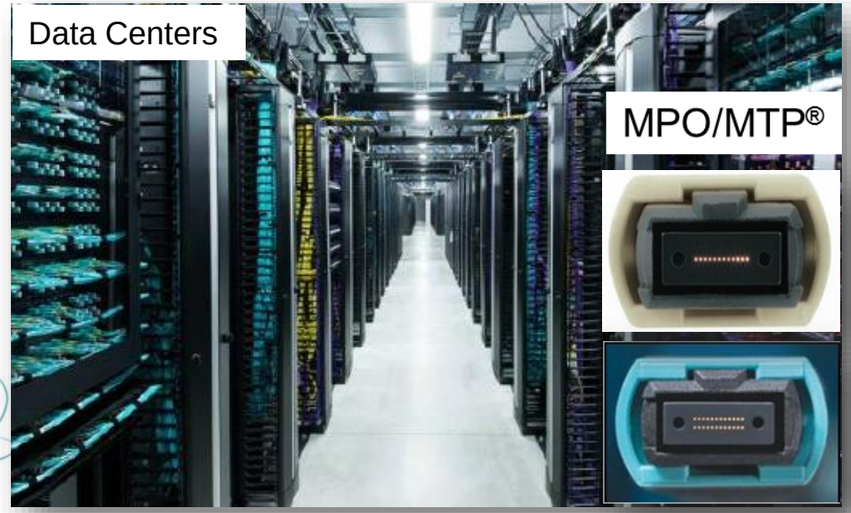


Q-ODC-12®

Fiber to the home (FTTH)

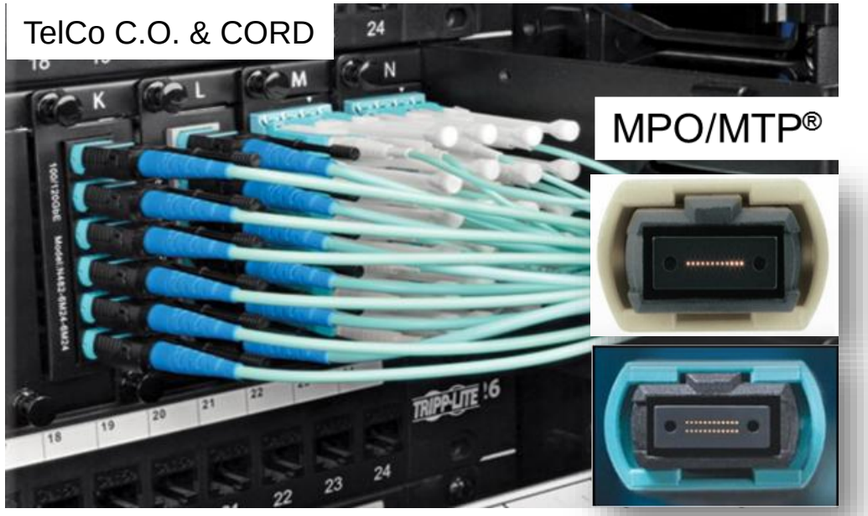
OptiTip®

Data Centers



MPO/MTP®

TelCo C.O. & CORD



MPO/MTP®

Understanding Multifiber Connectors


Optitip socket


Optitip plug

Optitip ®

- APC
- 12 Fiber Rows
- Single Row


Q-ODC plug and socket

Q-ODC-12 ®

- UPC or APC
- 12 Fiber Rows
- Single Row


MPO-12/MTP-12 ®

- **MPO/MTP®**
- MTP® is a brand of USConec
- APC or UPC
- 12 Fiber Rows or 16 Fiber Rows
- Single Row (12/16 Fibers) or Dual Row (24/32 fibers)

Best Practices for Optical Fiber Cabling Installation

No. 1 | Ensure connector endfaces are clean with no damage

No. 2 | Ensure the Loss through the Link is within the allowable limits

No. 3 | Submit Clear Documentation

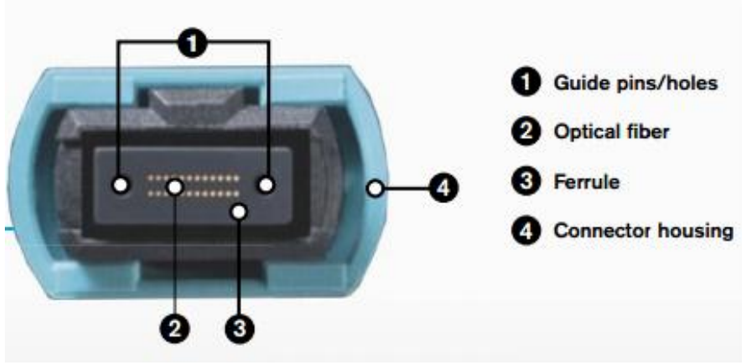
No. 1

Ensure the Connector end faces are not damaged or Dirty.

Fixes 80% of Faults

BEST PRACTICES

1. Connector Inspection is essential in any optical fiber installation



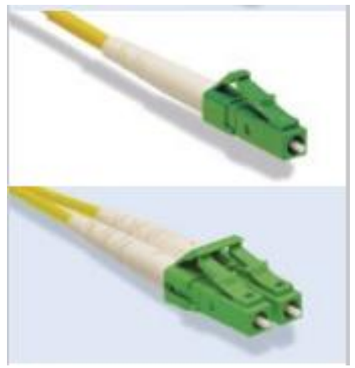
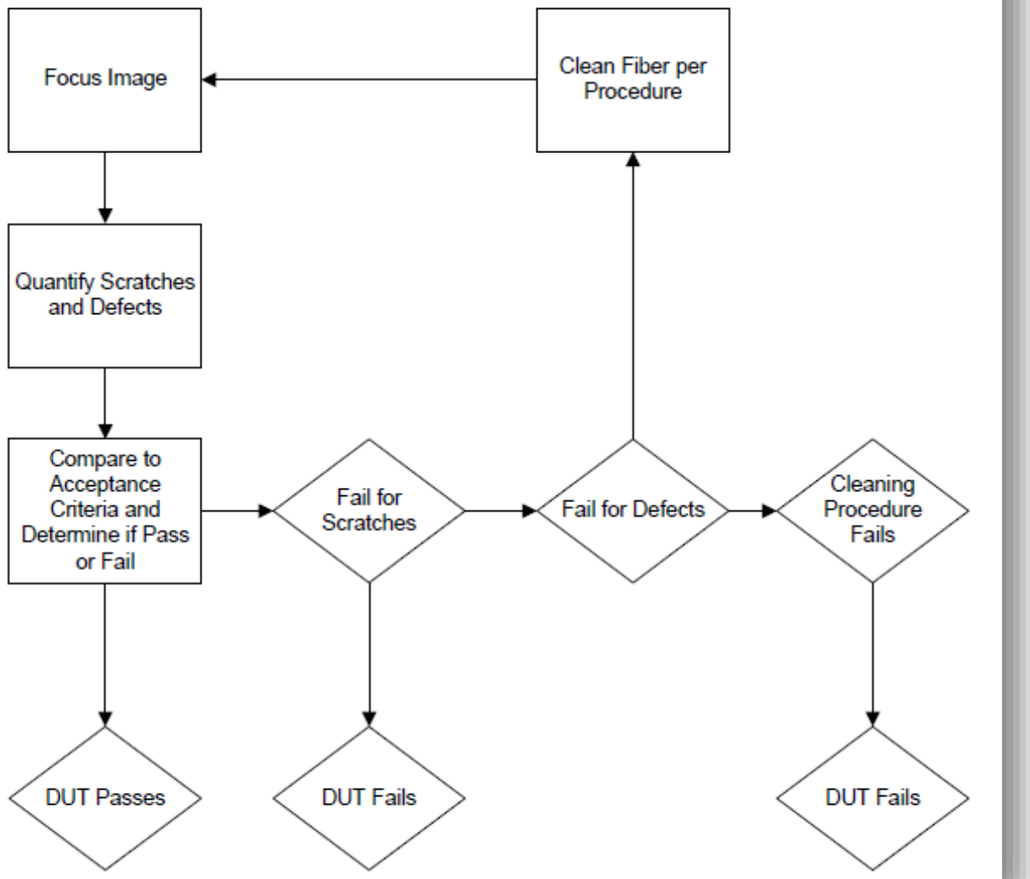
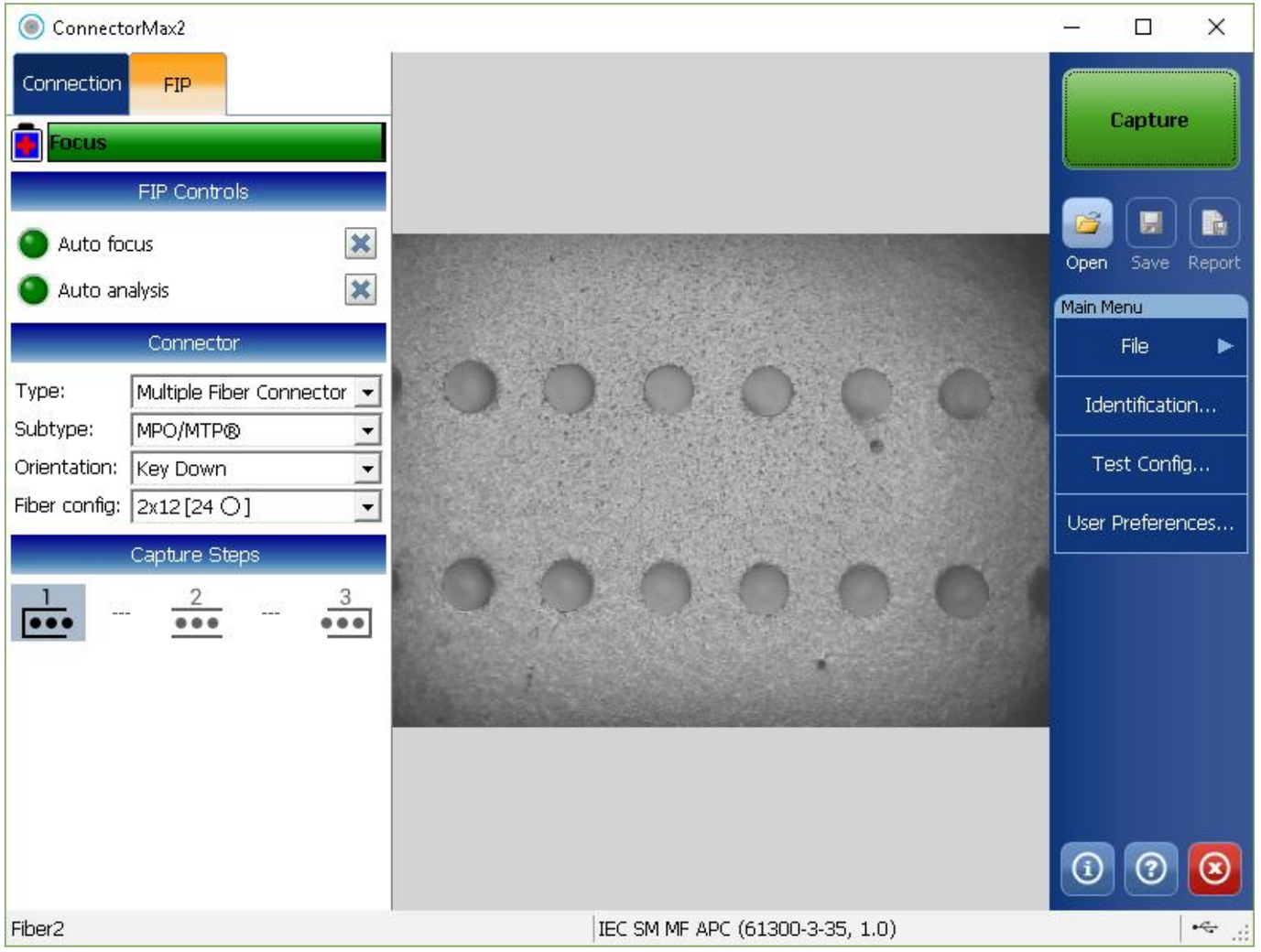


Figure 1: Inspection Procedure Flow



Source: IEC standard 61300-3-35

Fiber Inspection



Cleaning Method

- If the fiber fails inspection, the user shall clean the connector and repeat the inspection process
  - Dry Cleaning

Single-fiber mechanical cleaner (male/female)

Multifiber mechanical cleaner (MTP/MPO) (male/female)

Patch-cord mechanical cleaner (female only)

  - Hybrid Cleaning

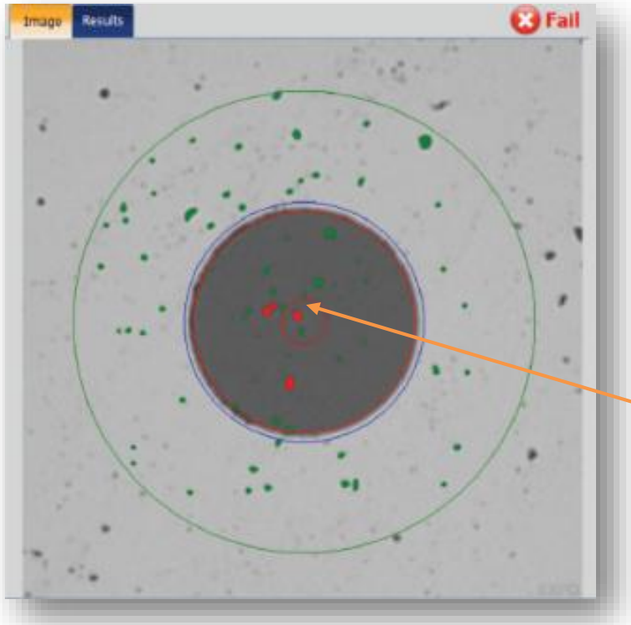
Cleaning pen
Used to dispense optical grade solvent to clean optical connectors

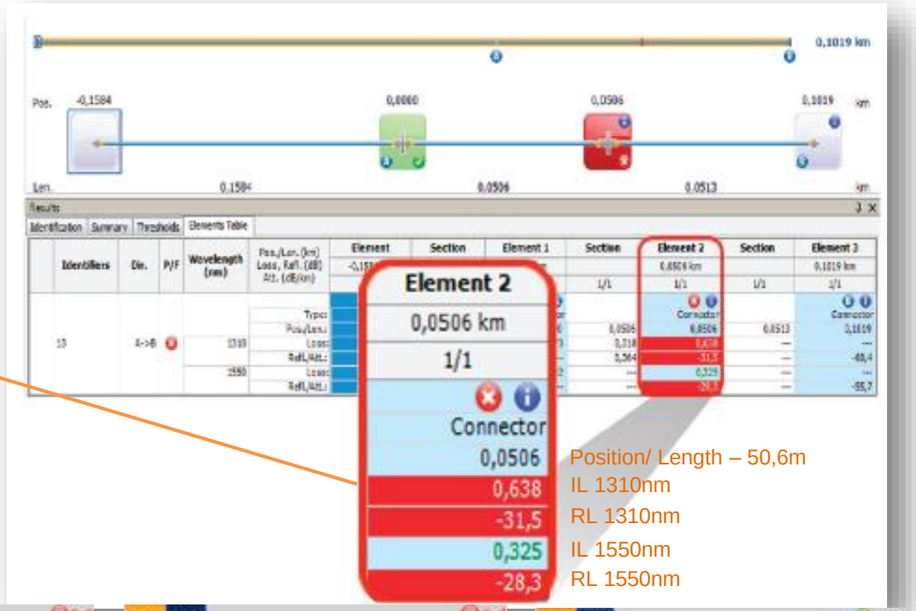
Cleaning swabs
Used to clean the inside of female connectors and adaptors

Lint-free wipes
Used in dry cleaning procedures and also used to dry off any solvent

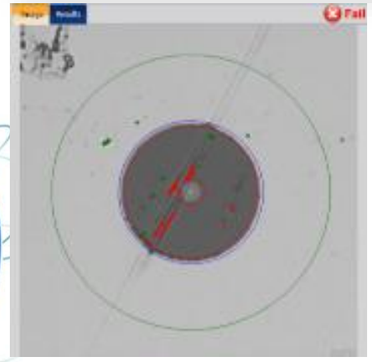
DIFFERENT CONTAMINATION SOURCES

Contaminations creates high Insertion Loss (IL) and/or Return Loss (RL) and degrades network performances

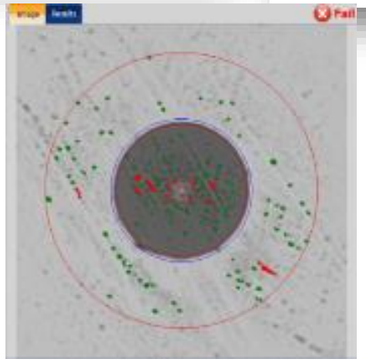




Position/ Length – 50,6m
IL 1310nm
RL 1310nm
IL 1550nm
RL 1550nm

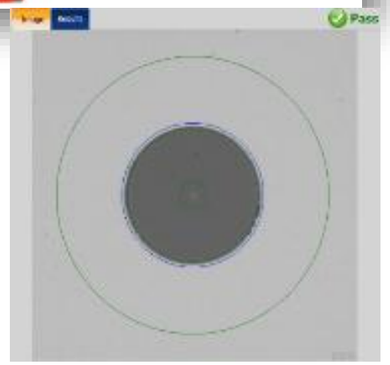


Damaged = Replace



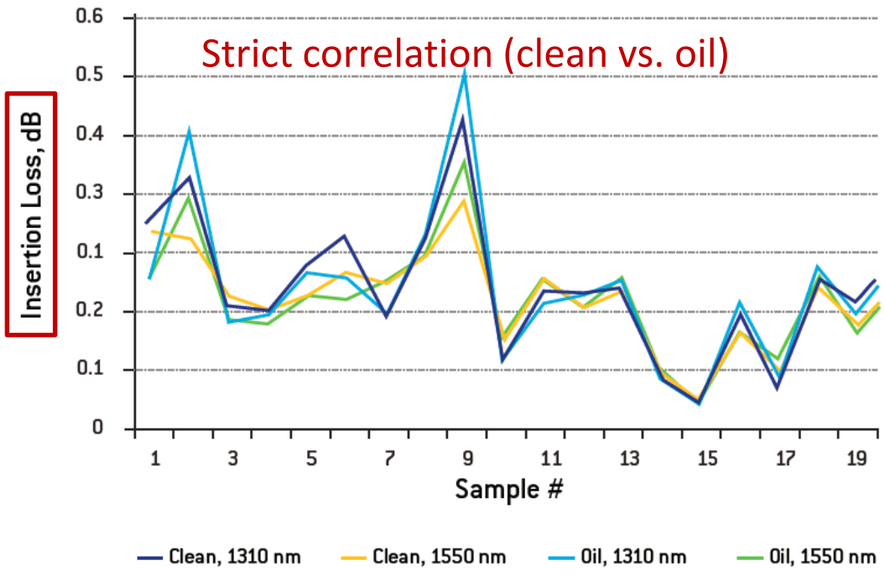
Dirty = Clean

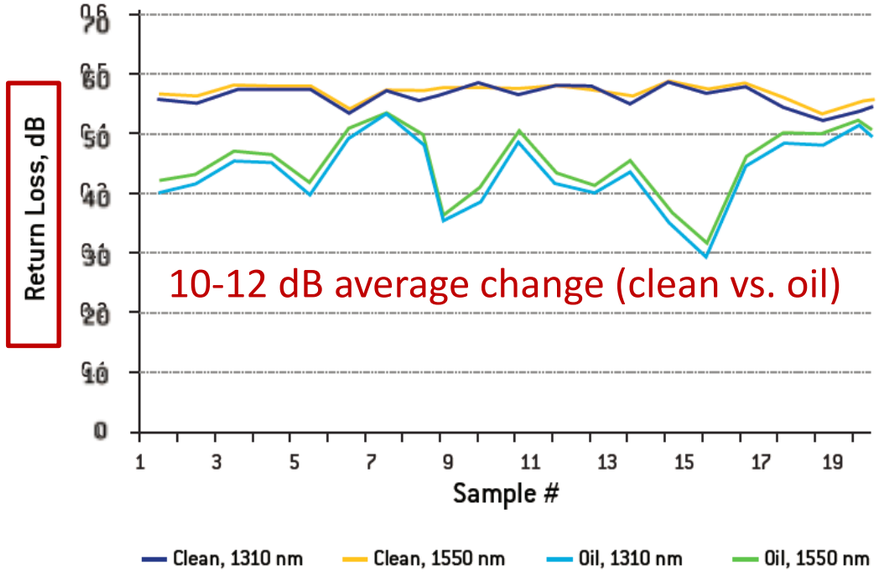
Dusty cap (out of the bag) = Clean



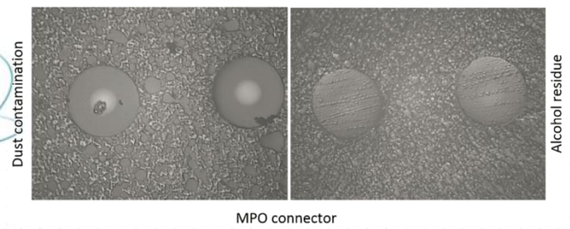
Clean = Connect

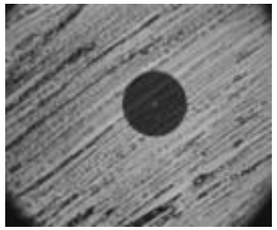
Source of Fiber link failure





Source: EXFO Application Note 327 – Touching on Failure: Sources of Fiber Optic Issues in the Data Center, *December 2015*





Finger oil

Connector to Connector

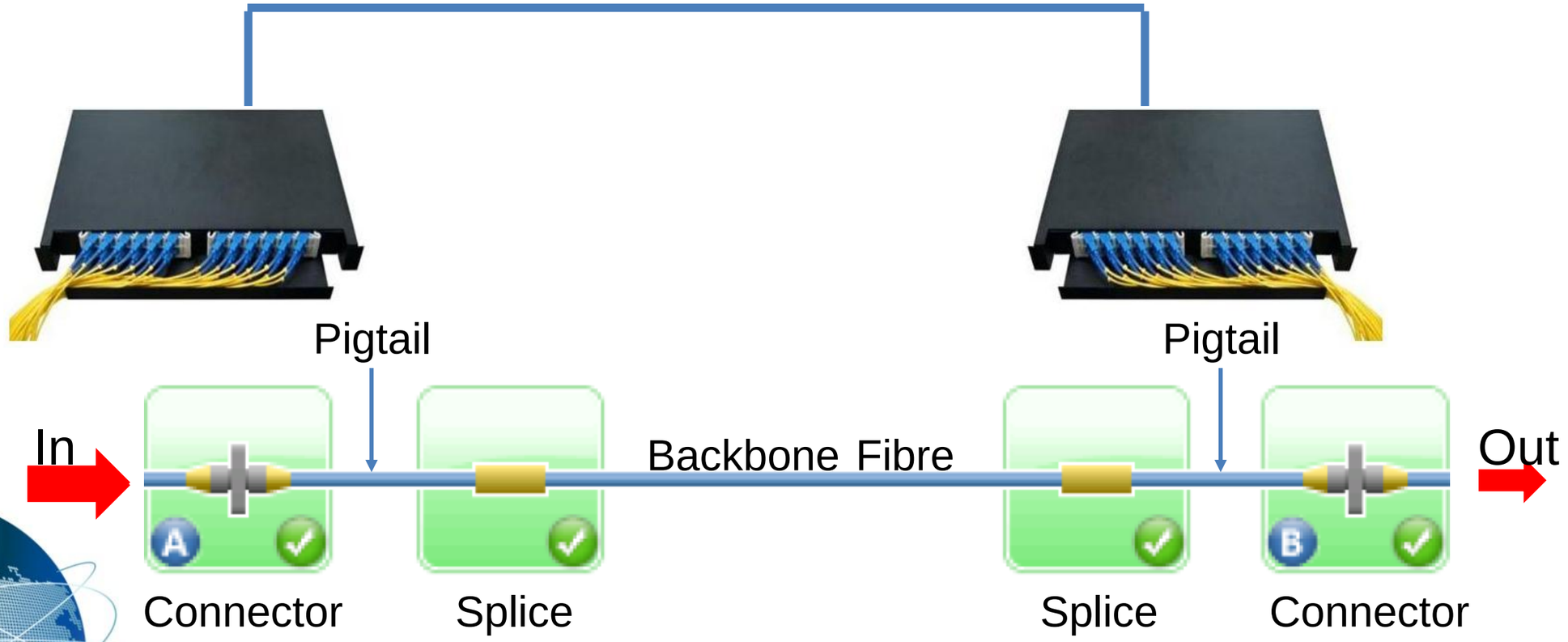
ORL	AS/NZS 3080 ISO/IEC 11801	TIA 568.C-3
MMF	-20 dB	-20 dB
SMF	-35 dB	-26 dB
	Real life requirement for 25G+ line rate?	
SMF + Video	Not Specified	-55 dB

Source: Bhatt, Dama, Nicholl – Cisco Systems (2012)

No. 2

Ensure the Loss through the Link is within the allowable limits?

What is a Permanent Fibre Link



Allowable Limit - Which standard do we test to ?

ISO/IEC 11801

Information technology – Generic Cabling for customer premises

ISO/IEC 14763-2

Information technology – Implementation and operation of customer premise cabling Part 2: Planning and installation

ISO/IEC 24702

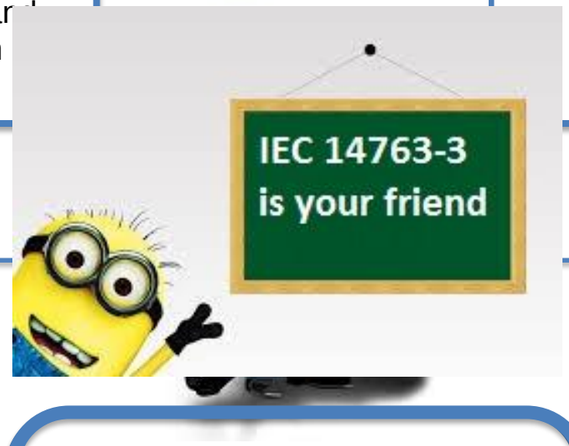
Information technology – Generic Cabling – Industrial

ISO/IEC 24764

Information technology – Generic Cabling systems for Data Centres

ISO/IEC 15018

Information technology – Generic Cabling for homes



ISO/IEC 61935-1

Generic specification for the testing of elements of generic cabling in accordance with ISO/IEC 11801
Part 1: Test methods

ISO/IEC 14763-3

Information technology – Implementation and operation of customer premise cabling
Part 3: Testing of optical fibre cabling

ISO/IEC 61935-3

Testing of balanced and coaxial information technology cabling
Part 3:Installed cabling as specified in ISO/IEC 15018 and related standards

IEC 14763-3 2014 Allowable Test Values

Allowable Attenuation Values

Component and Wavelength	**ISO/IEC 14763-3 Ed2: 2014** **Attenuation (Loss)** Maximum
Mated Ref to Ref Connection	
at 850 & 1300 nm	MMF 0.10 dB
at 1310 & 1550 nm	SMF 0.20 dB
Mated Ref to Non-Ref Connection	
at 850 & 1300 nm	MMF 0.50 dB (new value)
at 1310 & 1550 nm	SMF 0.75 dB (new value)
Non-Ref to Non-Ref at all wavelengths	MMF & SMF 0.75 dB
Splice at 850 & 1300 nm	
at 1310 & 1550 nm	0.30 dB
MMF All multimode fibres	
at 850 nm	3.50 dB/km
at 1300 nm	1.50 dB/km
SMF at 1310 & 1550 nm OS1	1.0 dB/km
OS2	0.4 dB/km

Ref = Reference Connector Non-Ref = Non-reference (embedded) Connector

IEC 14763-3 – Testing of Optical Fibre Cabling

Reference and Testing Methods

New Version – IEC 14763-3 2014 – Three Methods

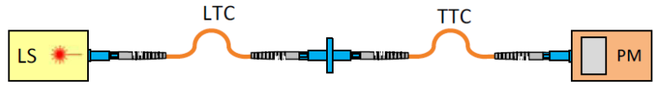
1

- Permanent Link – One Cord Reference Method B (Preferred)

IEC & TIA

2

- Permanent Link – Two Cord Reference Method A



TIA

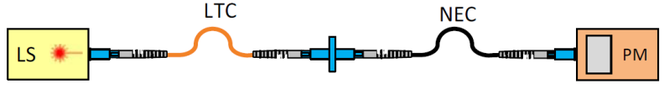
3

- Permanent Link – Enhanced 3 Cord Reference Method C

IEC

4

- Channel Test – Enhanced 3 Cord Reference Method



IEC

One Cord Reference Method

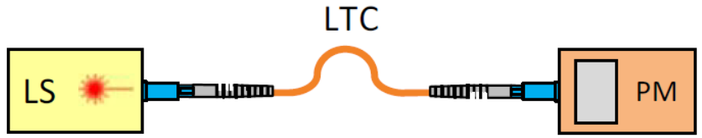
Step 1 Set Reference

One-Test-Cord Reference Method for Optical Fibre Links

Clause 9.1.1.3 of ISO/IEC 14763.3 [1] sets out the following method:-

1. Allow the light source to warm up following the tester manufacturer's recommendations. This could take up to 15 minutes.

2. Connect the LTC to the light source at one end and to the power meter at the other end. Ensure EF compliance of the LTC for multimode fibre.



3. Set the reference to 0.0 dB or record the reference power in dBm or watts.

Test Cords

Both multimode and singlemode fibre reference settings use the following test cords

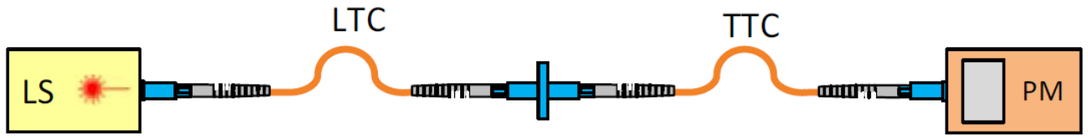
- LTC Launch Test Cord (2 – 10 m with reference connector at link interface end)
- TTC Tail Test Cord (2 – 10 m with reference connector at link interface end)

The LTC for multimode fibres *shall meet the launch modal distribution* at the output of the launch test cord. For multimode, this is also known as meeting **Encircled Flux** requirements.

One Cord Reference Method

Step 2 Verification Stage

The attenuation of the connectors on the launch test cord and tail test cord should be verified by connecting these cords together and verifying the attenuation of this connection is no more than the expected attenuation between two reference grade connectors.



Disconnect the LTC from the power meter and connect it to the TTC using a Reference Adaptor. Connect the other end of the TTC to the power meter.

The attenuation of the reference-to-reference connection must be no greater than;

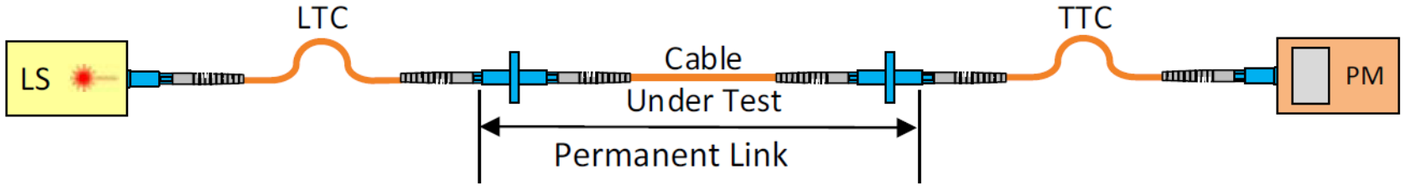
- MMF 0.1 dB, SMF 0.2 dB.

Note: If the attenuation is more than the allowable value, clean all end faces, inspect then reconnect and re-test. Re-set the reference if necessary. Use alternate test cords if necessary.

One Cord Reference Method

Step 3 Test Link

4. Connect the LTC to the cleaned fibre connector at the Near End of the link.
   At the far end, connect the TTC to the cleaned connector of the link.



5. Measure the attenuation of the link, which includes the two end connectors.

The Calculation Limit of Testing link attenuation is:

- For MMF: Limit = (2 x 0.5dB) + ∑ (Cable attenuation) + ∑ (embedded connection attenuation)
- For SMF: Limit = (2 x 0.75dB) + ∑ (Cable attenuation) + ∑ (embedded connection attenuation)

These formulae are from Corrigenda 1 to ISO/IEC 14763-3 Ed2 dated 17.03.2015.

Examples of Calculations of Link Limits

Component and Wavelength	**ISO/IEC 14763-3 Ed2: 2014** **Attenuation (Loss)** Maximum
Mated Ref to Ref Connection at 850 & 1300 nm at 1310 & 1550 nm	 MMF 0.10 dB SMF 0.20 dB
Mated Ref to Non-Ref Connection at 850 & 1300 nm at 1310 & 1550 nm Non-Ref to Non-Ref at all wavelengths	 MMF 0.50 dB (new value) SMF 0.75 dB (new value) MMF & SMF 0.75 dB
Splice at 850 & 1300 nm at 1310 & 1550 nm	 0.30 dB
MMF All multimode fibres at 850 nm at 1300 nm	 3.50 dB/km 1.50 dB/km
SMF at 1310 & 1550 nm OS1 OS2	1.0 dB/km 0.4 dB/km

Ref = Reference Connector Non-Ref = Non-reference (embedded) Connector

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Splice at 850 & 1300 nm at 1310 & 1550 nm	 0.30 dB
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SMF at 1310 & 1550 nm OS1 OS2	1.0 dB/km 0.4 dB/km

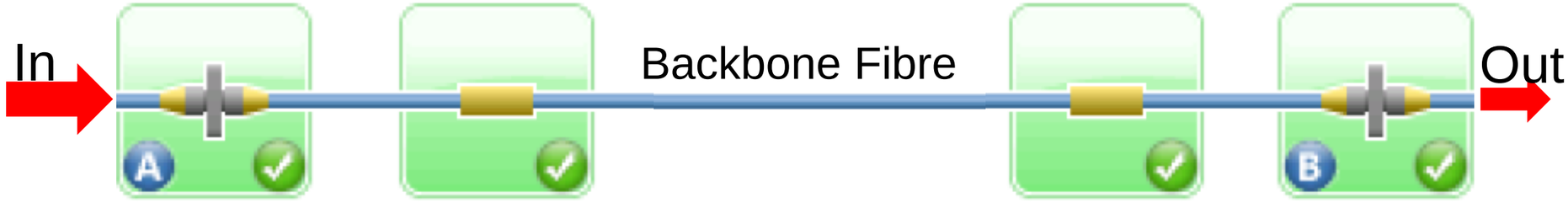
Ref = Reference Connector Non-Ref = Non-reference (embedded) Connector

Cabling Standards vs Application standards

- Thank you for testing my link.
- Does that mean it's now guaranteed to run at 100Gbps?
  - That depends on which Transmission Standard you are using!

Standard	Cable Type	Adapter Loss dB	Adapter Loss First & Last dB	Splice Loss dB	850 nm Loss dB dB	1300 nm Loss dB dB	1310 nm Loss dB dB	1550 nm Loss dB dB	850 nm Loss/km dB	1300 nm Loss/km dB	1310 nm Loss/km dB	1550 nm Loss/km dB	Length m
ISO/IEC 14763-3	OM1, OM1_160, OM2, OM2_400, OM3, OM4	0.75	0.5	0.3					3.5	1.5			2000
ISO/IEC 14763-3	OS1	0.75	0.75	0.3							1	1	5000
ISO/IEC 14763-3	OS2	0.75	0.75	0.3							0.4	0.4	5000
ANSI/TIA-568-C	OM1, OM1_160, OM2, OM2_400, OM3, OM4	0.75		0.3									2000
ANSI/TIA-568-C	OS1, OS2	0.75		0.3									40000
10BASE-FL	OM1, OM1_160				12.5								2000
10BASE-FL	OM2, OM2_400, OM3, OM4				7.8								2000
100BASE-FX	OM2, OM2_400, OM3, OM4					6.3							2000
1000BASE-LX	OS1, OS2						4.7						5000
1000BASE-SX	OM2, OM3, OM4				3.56								550
10GBASE-E	OS1, OS2							11					40000
10GBASE-SR	OM3				2.6								300
10GBASE-SR	OM4				2.9								400
40GBASE-LR4	OS1, OS2						6.7						10000
40GBASE-SR4	OM3				1.9								100
40GBASE-SR4	OM4				1.5								150
100GBASE-LR4	OS1, OS2						6.3						10000
100GBASE-SR10	OM3				1.9								100
100GBASE-SR10	OM4				1.5								150

Examples of Calculations of Link Limits



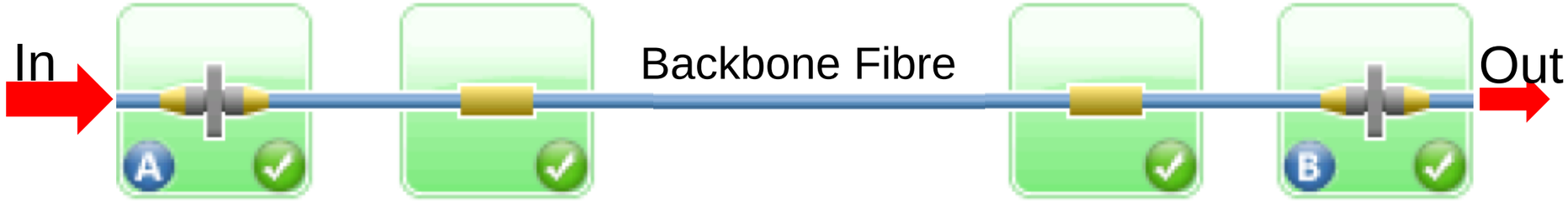
Example 1

Consider a permanent link comprising

- Cabled optical fibre conforming to OM4 of ISO/IEC 11801
- A total length of 100m
- Two panel connections in accordance with ISO/IEC 11801
- Two optical fibre splices in accordance with ISO/IEC 11801

Loss Budget = ∑ (Connector Loss) + ∑ (Cable attenuation) + ∑ (Splice loss)

Examples of Calculations of Link Limits



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- Cabled optical fibre conforming to OM4 of ISO/IEC 11801
- A total length of 100m
- Two panel connections in accordance with ISO/IEC 11801
- Two optical fibre splices in accordance with ISO/IEC 11801

Loss Budget = ∑ (Connector Loss) + ∑ (Cable attenuation) + ∑ (Splice loss)

Loss Budget @ 850nm = (2 x 0.3dB) + (0.1 x 3.5dB) + (2 x 0.3dB) = 1.55dB

Loss Budget @ 1300nm = (2 x 0.3dB) + (0.1 x 1.5dB) + (2 x 0.3dB) = 1.35dB

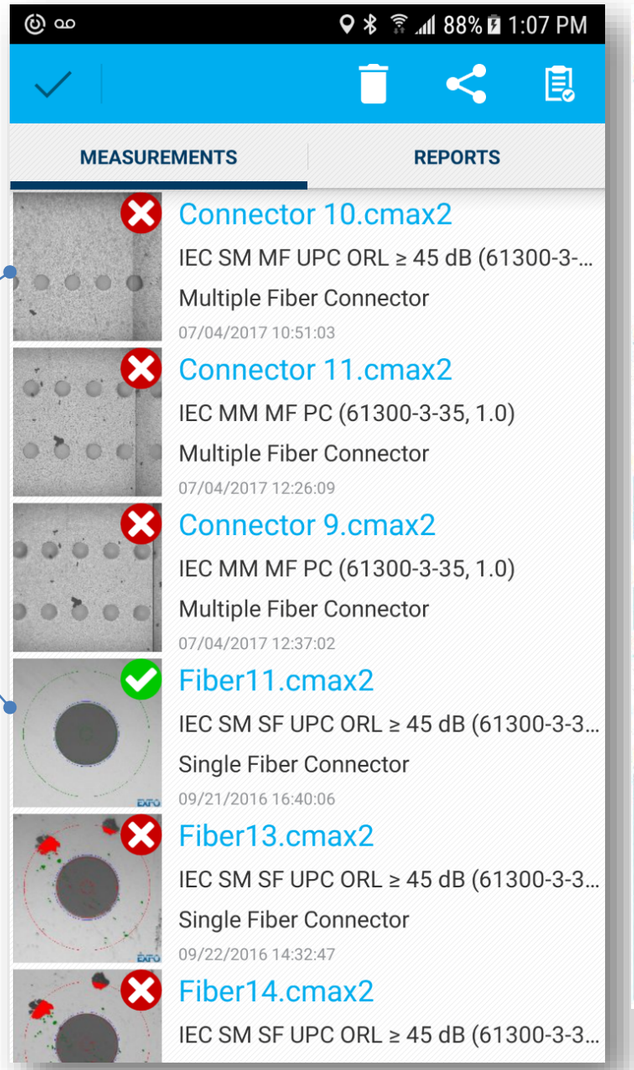
No. 3

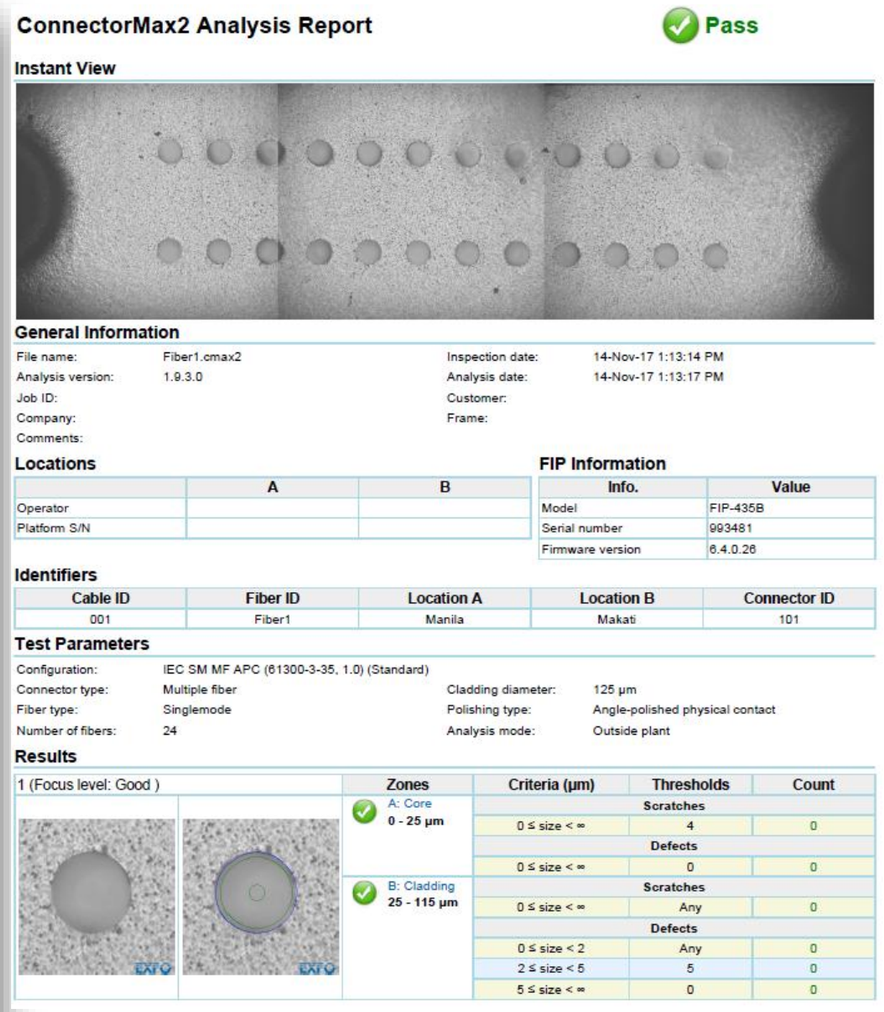
Submit Clear Test Result Documentation.

Measurements & Reports

File preview Multi-fiber

File preview Single-fiber





ConnectorMax2 Analysis Report — Pass

Instant View

General Information

File name:	Fiber1.cmax2	Inspection date:	14-Nov-17 1:13:14 PM
Analysis version:	1.9.3.0	Analysis date:	14-Nov-17 1:13:17 PM
Job ID:		Customer:	
Company:		Frame:	
Comments:			

Locations

	A	B
Operator		
Platform S/N		

FIP Information

Info.	Value
Model	FIP-435B
Serial number	993481
Firmware version	6.4.0.26

Identifiers

Cable ID	Fiber ID	Location A	Location B	Connector ID
001	Fiber1	Manila	Makati	101

Test Parameters

Configuration:	IEC SM MF APC (61300-3-35, 1.0) (Standard)		
Connector type:	Multiple fiber	Cladding diameter:	125 µm
Fiber type:	Singlemode	Polishing type:	Angle-polished physical contact
Number of fibers:	24	Analysis mode:	Outside plant

Results

1 (Focus level: Good)

Zones	Criteria (µm)	Thresholds	Count
A: Core 0 - 25 µm	Scratches		
	0 ≤ size < ∞	4	0
	Defects		
	0 ≤ size < ∞	0	0
B: Cladding 25 - 115 µm	Scratches		
	0 ≤ size < ∞	Any	0
	Defects		
	0 ≤ size < 2	Any	0
	2 ≤ size < 5	5	0
	5 ≤ size < ∞	0	0

Software Analysis

Reporting

Standards & Custom Pass/Fail Status	
ISO/IEC 14763-3:2012	

Identification Information	
Filename:	Cable1_Fiber00_Simplex.olts
Test date:	13/04/2016
Job ID:	
Company:	EXFO
Customer:	BICSI Sydney 2016
Operator A:	Alan McReynolds
Operator B:	Alan McReynolds
Comments:	

Locations		
	Location A	
Model	MAX-940-ICERT-Q1-EI-EI	MAX-940-IC
Serial number	858990	858950
Calibration date	1/10/2015	1/10/2015

Link Definition		
Fiber Type	Connections	Splices
OS2 singlemode	2	

Bidirectional Resul					
Identifiers	Wavelength (nm)	Loss Average (dB)	Loss Margin (dB)	Length (m)	Loss A->B (dB)
Cable 1; Fiber1	1310	0.52	1.14	149.3	0.5
Cable 1; Fiber1	1550	0.43	1.23	149.3	0.4

Standards & Custom Pass/Fail Status	
40GBASE-FR	ISO/IEC 14763-3:2012
100GBASE-LR4	

Pass

Identification Information	
Filename:	MAX-940 demo_Cable 1_Fiber1_AB.cmax2; MAX-940 demo_Cal
Test date:	1/09/2010; 17/07/2015
Job ID:	MAX-940 demo
Company:	EXFO
Customer:	BICSI Sydney 2016
Operator A:	Alan McReynolds
Operator B:	Alan McReynolds
Comments:	Combine OLTS and FIP Report

Locations		
	Location A	Location B
Model	FIP-400; MAX-940-Q1	MAX-945-SM3
Serial number	SIMMAX025F	SIMMAX02B5
Calibration date	1/01/2015	1/01/2015

FIP AB

FIP BA

Pass/Fail Thresholds				Link Definition		
Standard	Wavelength (nm)	Max. Link Loss (dB)	Max. Link Length (m)	Fiber Type	Connectior	Splices
40GBASE-FR	1310	0.00	10000	OS2 singlemode	6	5
40GBASE-FR	1550	0.00	10000	OS2 singlemode	6	5
100GBASE-LR4	1310	0.00	10000	OS2 singlemode	6	5
100GBASE-LR4	1550	0.00	10000	OS2 singlemode	6	5

Duplex Results							
Identifiers	Wavelength (nm)	Loss (dB)	Loss Margin (dB)	Length (m)	Reference (dBm)	Test Cord Verification (dB)	Test Date/ Time
Cable 1; Fiber1	1310	1.40	4.14	103.5	-6.13	---	1/09/2010 3:25 AM
Cable 1; Fiber1	1550	1.40	2.60	103.5	-5.16	---	17/07/2015 9:46 PM

Voice of Customers…

- Complexity of configuring the unit.
- Referencing Issues
- Choosing the wrong standard
- Calibrating the units every year
- Speed of Testing
- Have to use a separate Fibre Inspection kit at far end
- Multi Mode Encircle Flux Compliant
- Fault diagnosis or assistance
- Report Generation