Deploying Optical Fiber? Do Not ‘Plug and Pray’!

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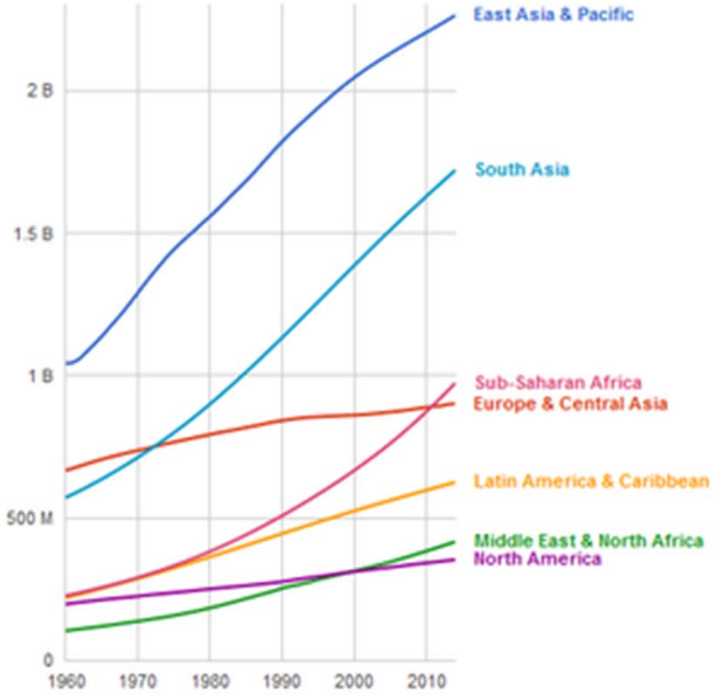
Introduction

85% of the issues in any optical fiber network are induced by bad/dirty connections. And as if we did not have enough troubles with single fiber connectors, we now have to deploy multi-fiber connectors like MTP/MPO to increase density. In this presentation, we will explain the impact of wrongdoing on an optical network and describe 5 best practices that will make your network safer and more reliable. We will dedicate a special chapter on MPO/MTP connectors.

And the world goes… ***more connected!***



- **7.4B peoples WW (2017)**

8 billion mobile-connected devices in 2017
12 billion mobile-connected devices by 2020
including IoT M2M modules
Cisco VNI 2017

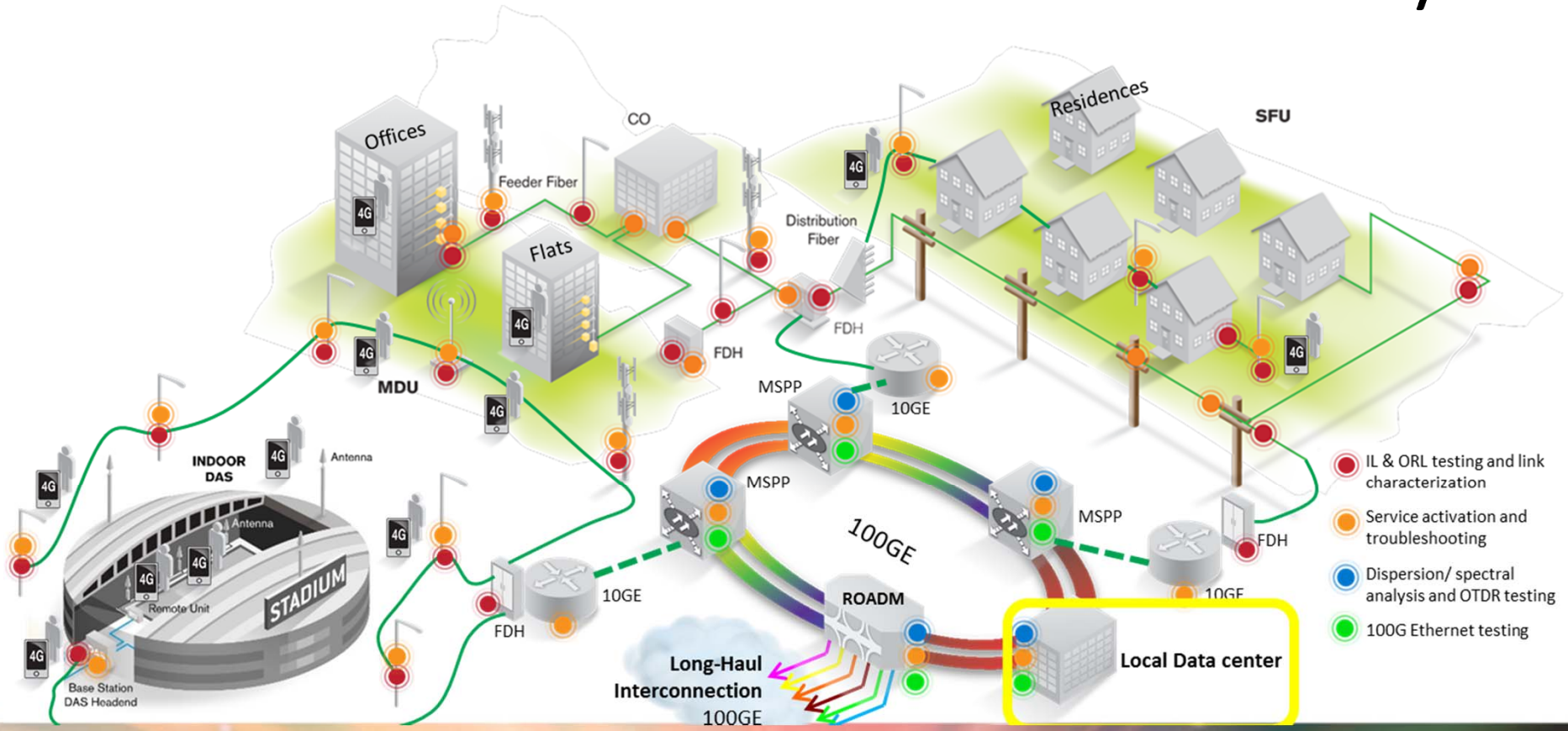
Spotify
FaceTime
NETFLIX
hulu
YouTube

3.5B
Internet users (2017)

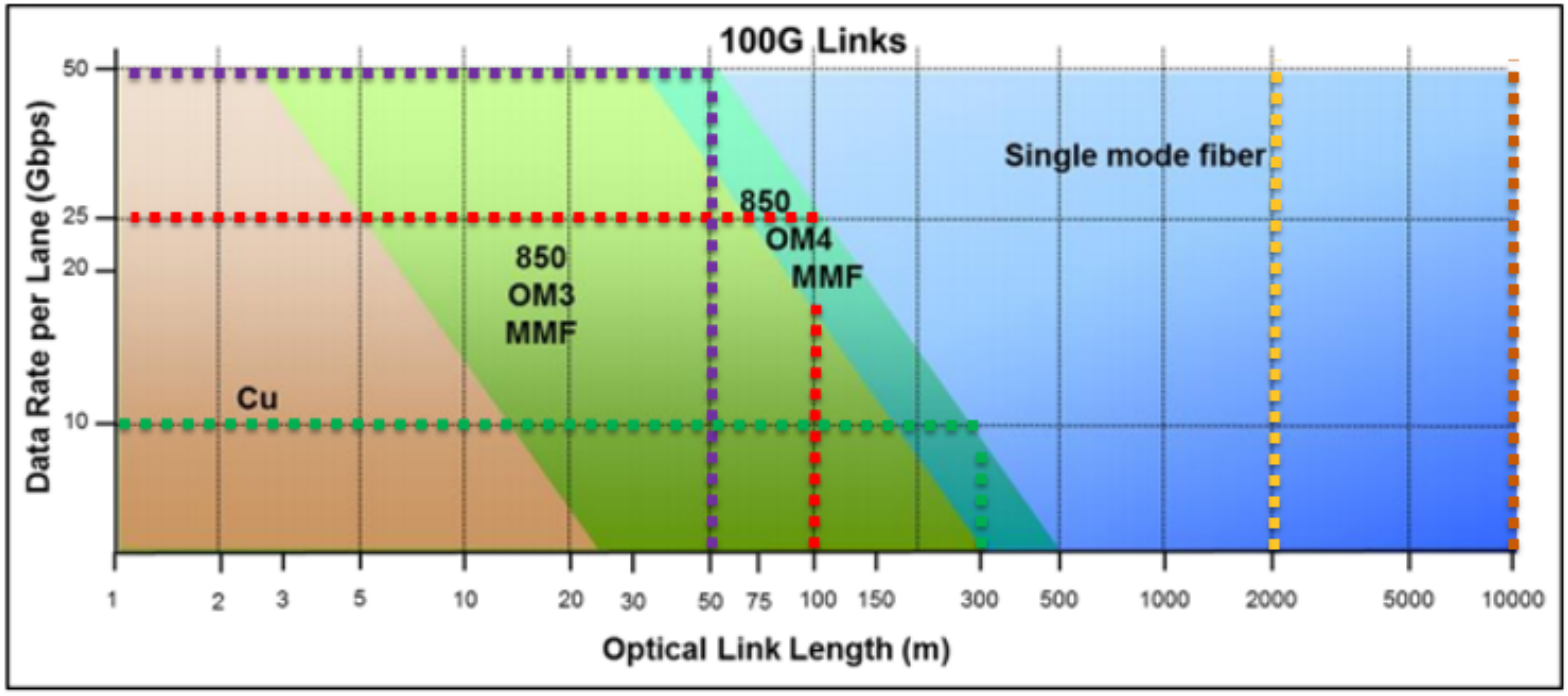
+6.5B cumulative users

Applications	Users
Facebook	2B
WhatsApp	1B
Instagram	1B
YouTube	1B
QQ	1B
Snapchat	250M
Pokemon GO	200M
Netflix (10$/m)	100M
Skype	100M
Spotify	100M
Uber	1B rides

Fiber +DAS Networks Build for Mobility

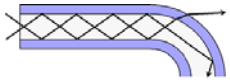


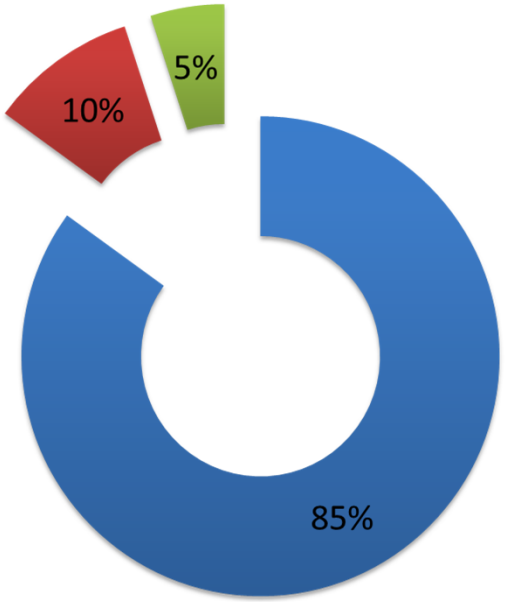
Fiber Deployment

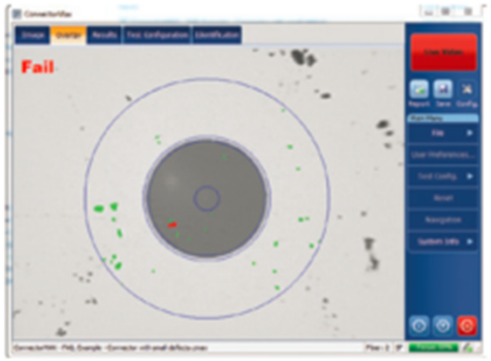


Where are the troubles coming from?

- Connector cleanliness and macrobending

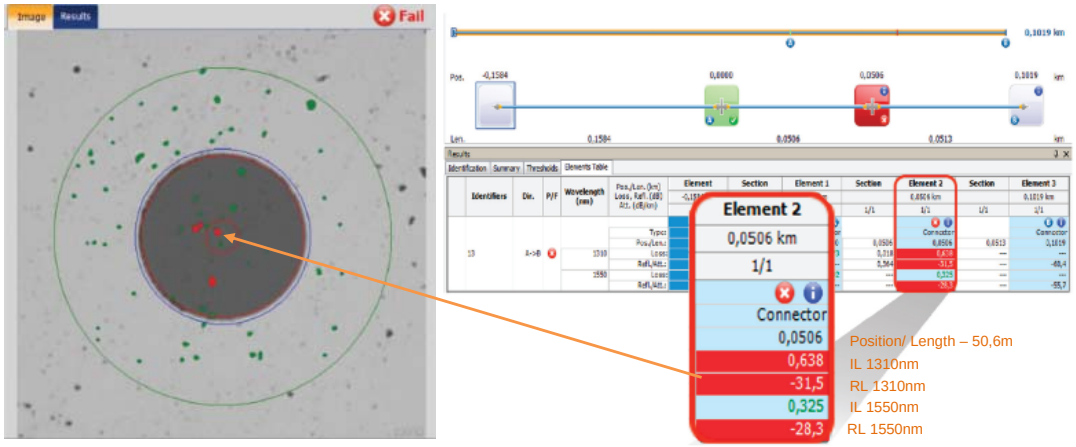






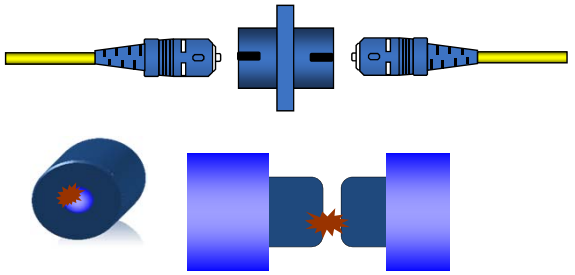
Defective connector failing acceptance criteria.

Impact of Bad Connections

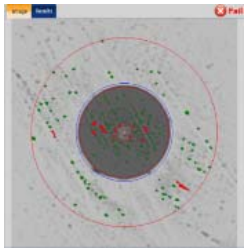


Contamination creates high insertion loss (IL) and/or return loss (RL).

Contamination degrades network performances.

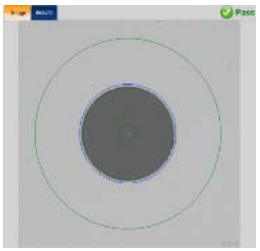


Damaged = Replace



Dirty = Clean

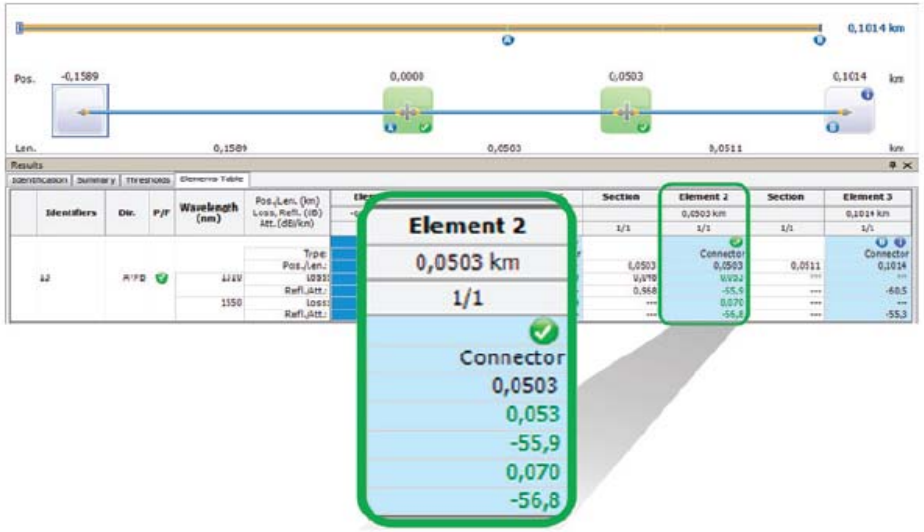
Dusty cap (out of the bag) = Clean



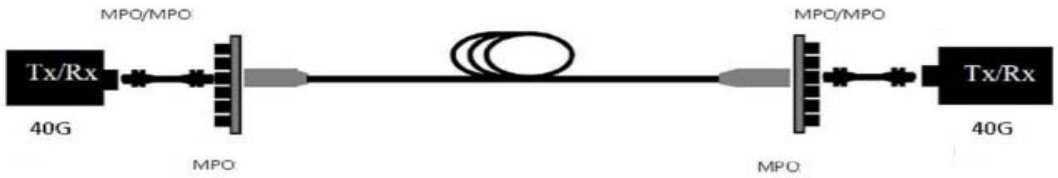
Clean = Connect

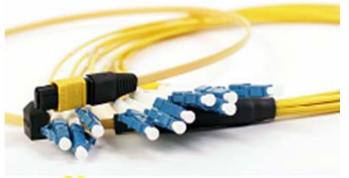
Impact of Bad Connection

- Acceptable values for loss at 1310/1550nm are:
  - Less than 0.35dB / connection (industry average standard)
  - Less than -50dB reflectance if UPC, less than -65dB if APC



Parallel (MTP) or WDM (LC) Optics





MTP (Parallel)

2015

100GBASE PSM4 (SMF)
(4x26@1310) 2km QSFP

2014

100GBASE-SR4 (MMF)
(4x25@850) 100m QSFP28

2010

40GBASE-LR4 (SMF)
(4x10@1310) 10 km QSFP

2005

40GBASE-SR4 (MMF)
(4x10@850) 100m QSFP


100GBASE-SR10 (MMF)
(10x10@850) 100m CFP

LC Duplex (WDM)

~2017
400GE
(4x100G)
coherent

2015

100GBASE-LR4 (SMF)
(4x25@1310) 10km CFP4

2014

100GBASE-CLR4 (SMF) CWDM4
(4x25@1310) 2km QSFP28

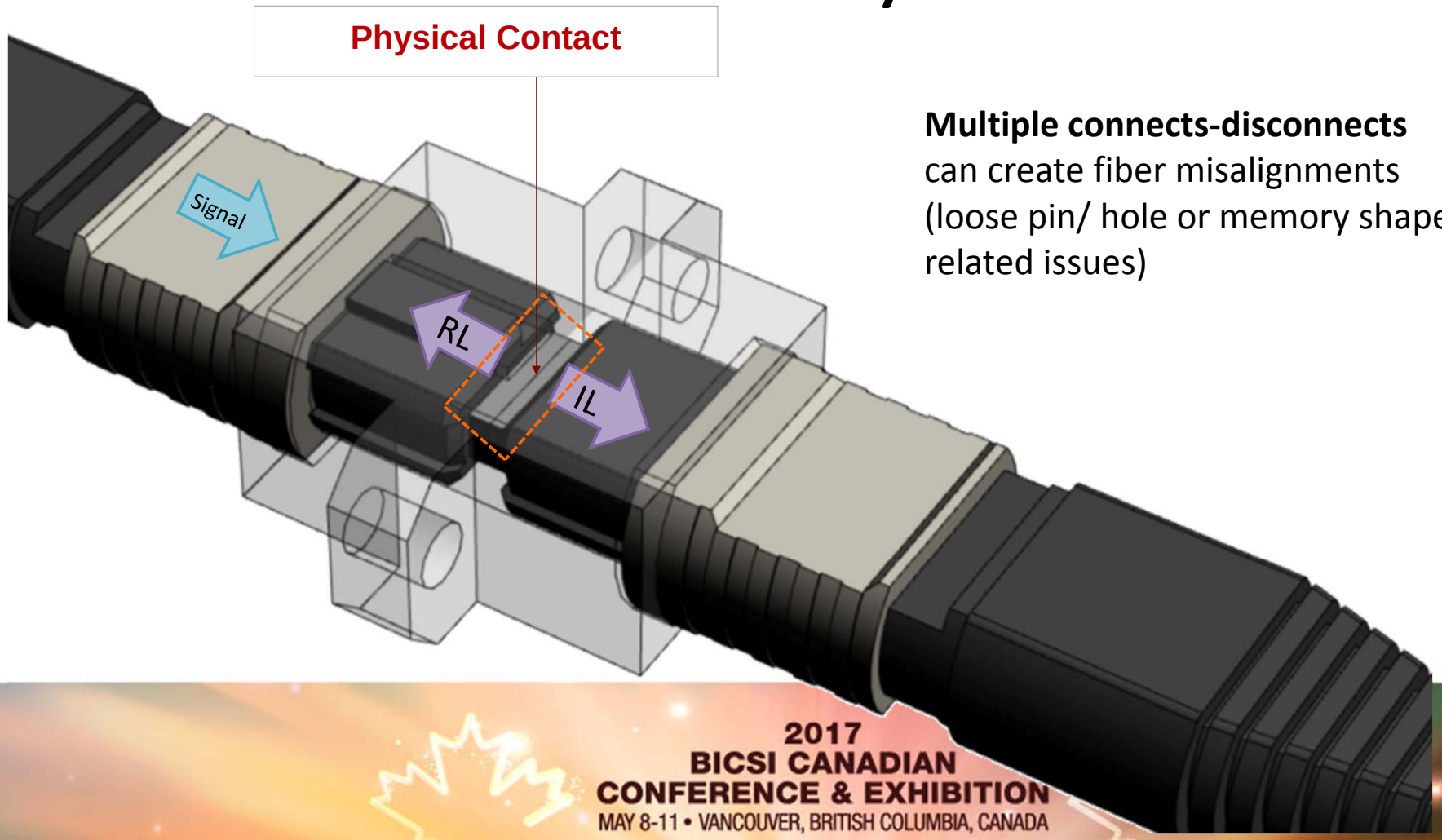
2013

100GBASE-LR4 (SMF)
(4x25@1310) 10km CFP2

2010

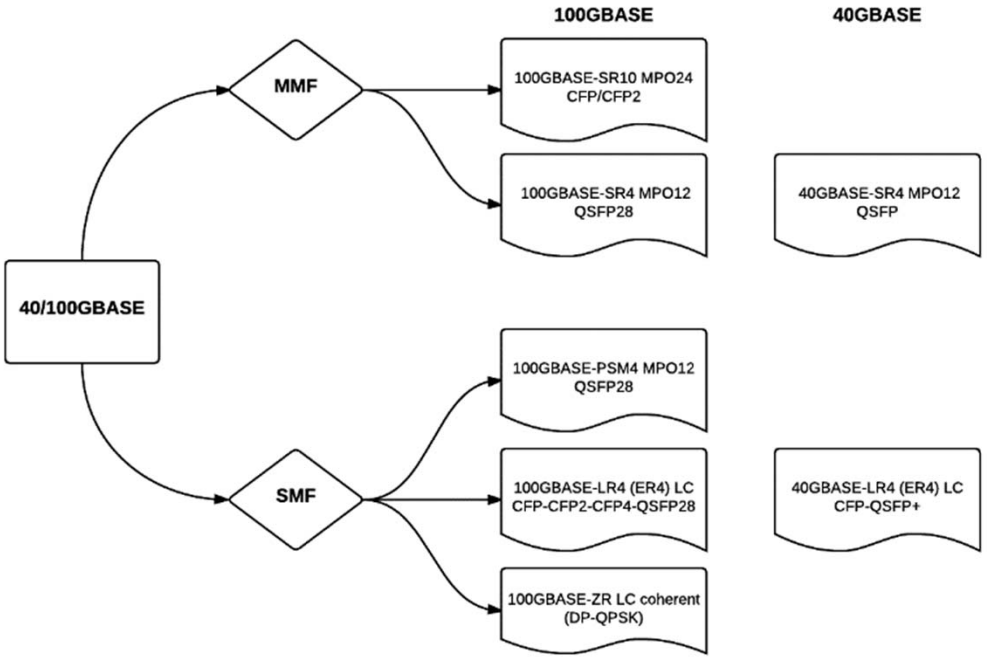
100GBASE-LR4 (SMF)
(10x10@1310) 2km CFP

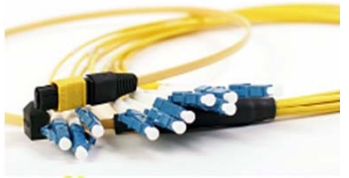
MPO-MTP®: Physical Contact



Multiple connects-disconnects can create fiber misalignments (loose pin/ hole or memory shape related issues)

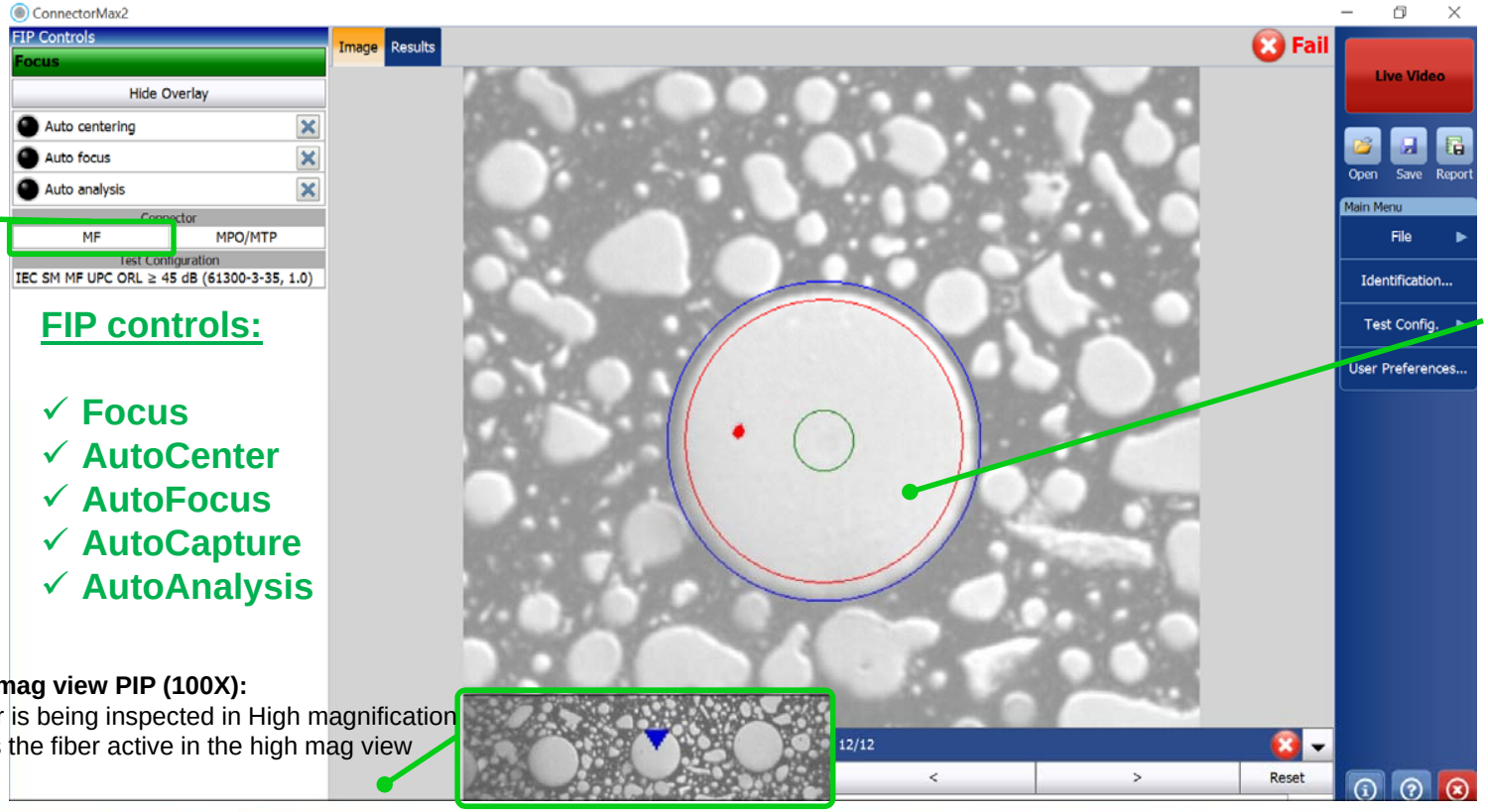
Transceivers Options





FIP Inspection: IEC Analysis 61300-3-35

MultiFiber mode



FIP controls:

- ✓ Focus
- ✓ AutoCenter
- ✓ AutoFocus
- ✓ AutoCapture
- ✓ AutoAnalysis

Low mag view PIP (100X):
Allows to see which fiber is being inspected in High magnification
Blue Arrow indicates the fiber active in the high mag view

High mag view (400X):
Highest Magnification on the market
Auto-center + Auto Focus

ConnectorMax2 ANALYSIS SOFTWARE

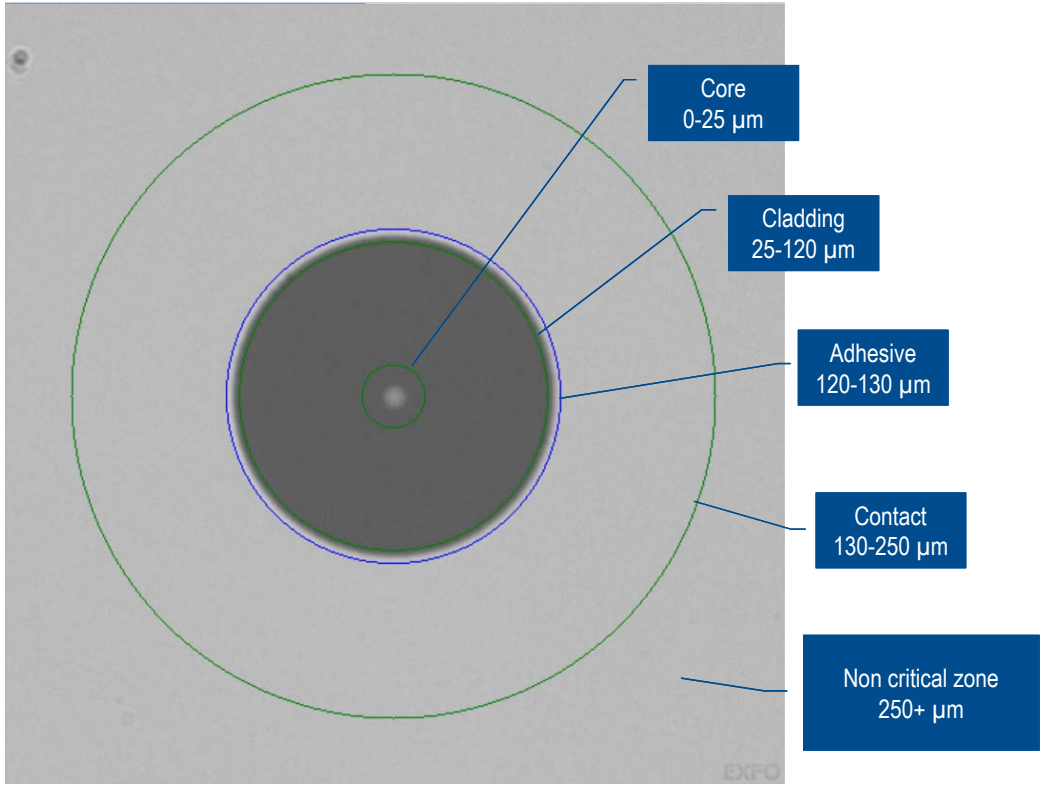
MPO-MTP® Automated Inspection FIPT-400-MF

1. **Automated and fumble-free inspection of multifiber connector in a snap!**
2. **Right the first time. No repeats, no missed fibers, no confusion.**
3. **Find dirty connectors – fast. Tool designed for dense, recessed panels.**
4. **One MF-ready probe, cover all single-fiber and multifiber inspection needs.**

Available first for Android smart devices

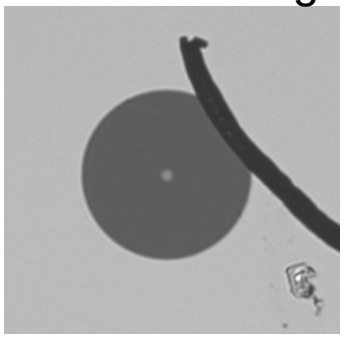
Connector Endface Analysis

Zones	Scratches	Defects
A: Core	None	None
B: Cladding	No limit ≤3 µm None >3 µm	No limit <2 µm 5 from 2 – 5 µm None >5 µm
C: Adhesive	No limit	No limit
D: Contact	No limit	None ≥10 µm

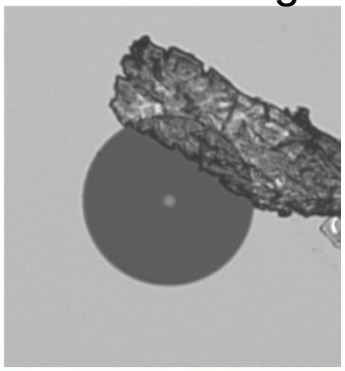


Dust, Spider Legs…..

Before mating



After mating



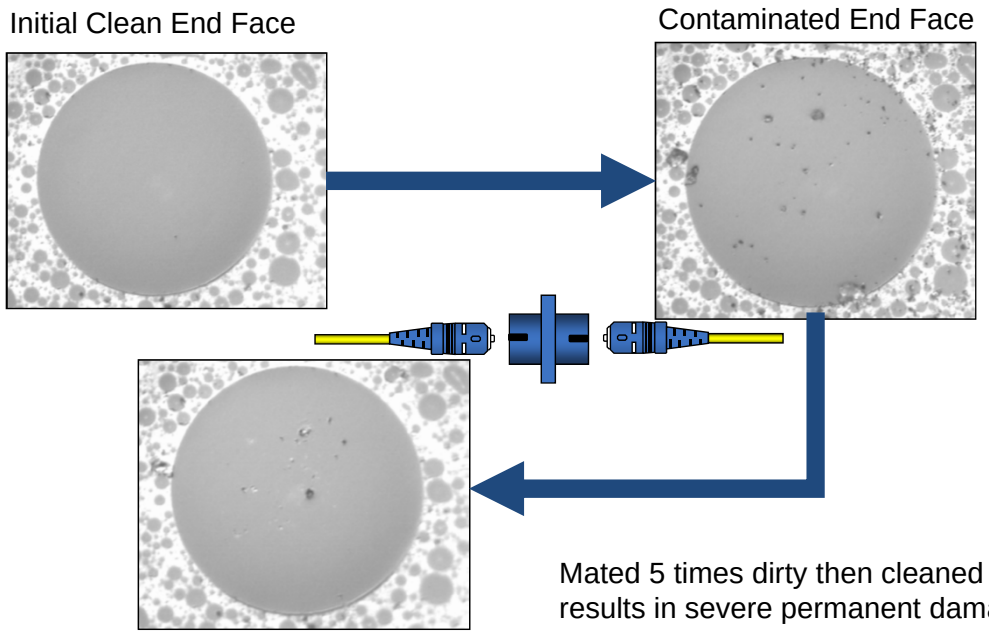
- Not the most common one but surely the most damageable to the connectors…
- Drywall, concrete, skin particles and sand are hard and solid contaminants that will:
  - Limit the quality of mating resulting in misalignment and bad contact
  - Permanently damage the connectors resulting in high reflectance and high loss
- Proper cleaning will remove the residue

Tight Budget Examples

Datacenters and high speed interfaces

	IEEE	Designa-tion	Mbit/s	Fiber Type	Number of fibers	Maximum link length (m)	Maximum channel insertion loss (dB)
10-Gbit Ethernet	802.3ae	10GBase-SR	10,000	OM3	2	300	2.6
40-Gbit Ethernet	P802.3ba	40GBase-SR4	40,000	OM3	8	100	1.9
40-Gbit Ethernet	P802.3ba	40GBase-SR4	40,000	OM4	8	150	1.5
100-Gbit Ethernet	P802.3ba	100GBase-SR10	100,000	OM3	20	100	1.9
100-Gbit Ethernet	P802.3ba	100GBase-SR10	100,000	OM4	20	150	1.5

Lasting Effects of Dust Contamination



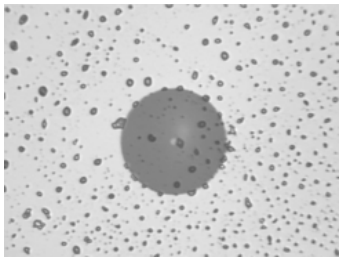
Mated 5 times dirty then cleaned
results in severe permanent damage

Residue Cross Contamination

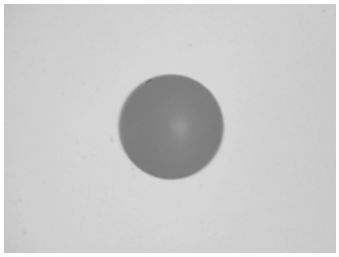
Dust/dirt residues transfer:

› If not cleaned properly residues will transfer when mating

Before mating:

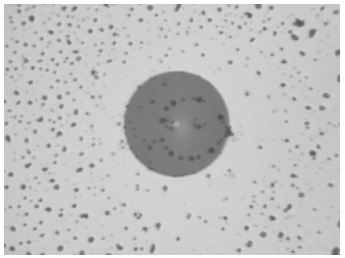


Connector A

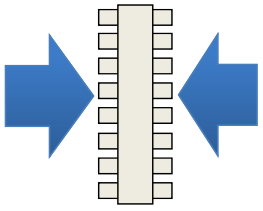


Connector B

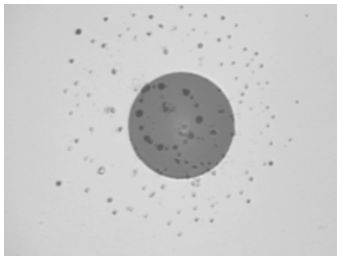
After mating:



Connector A

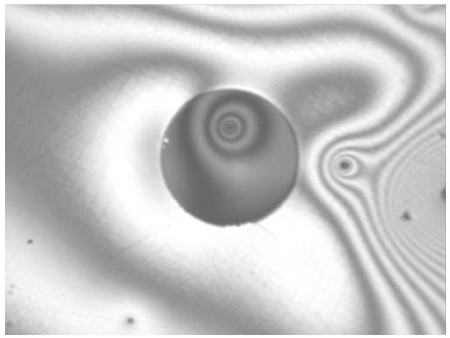


Patch Panel

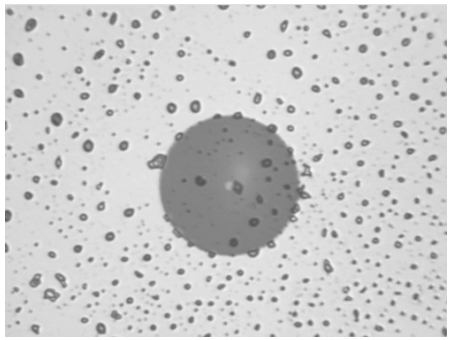


Connector B

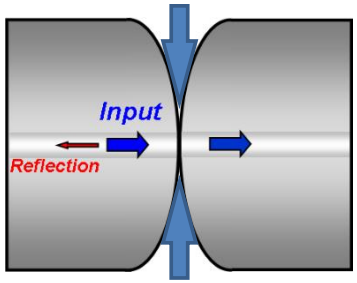
WET Residue



After drying

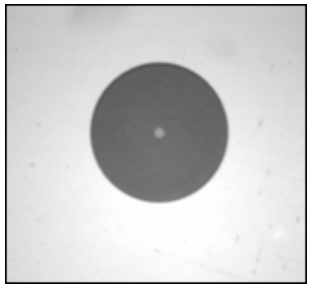


- Most often caused by an improper cleaning technique—fibers must be dried after a wet cleaning
- When drying, remaining dust particles will migrate toward the core

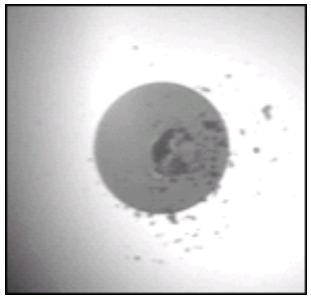


- Proper cleaning will remove the residue
- Liquid residues have different refractive indices than the fiber which can create problems during physical contact.
- Residue contamination commonly interferes with back reflectance.

High Power and Dirty Connectors

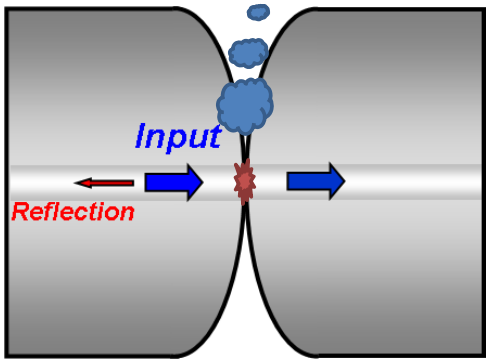


Clean



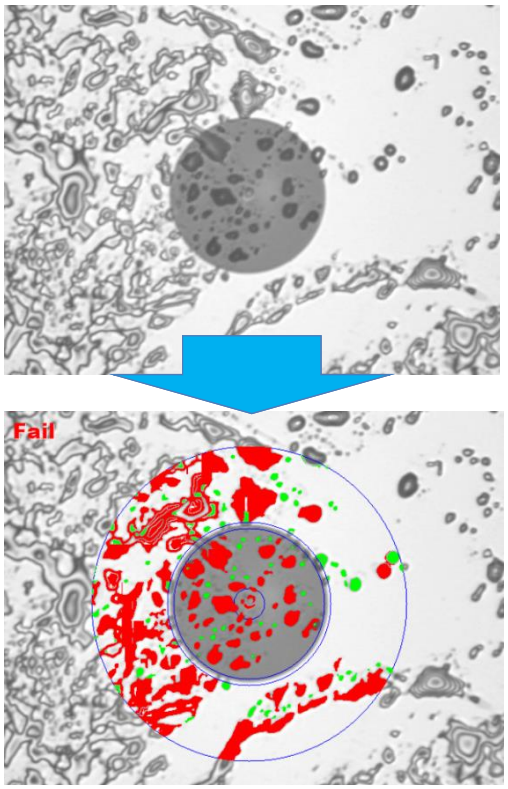
Permanently burnt –
combined high power and dirt

- When connecting a dirty connector into a Raman or CATV system, the density of power per surface is so high that the connector end face will burn



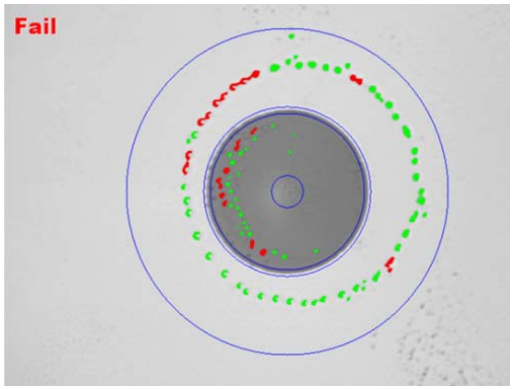
+15dBm is consider high power.

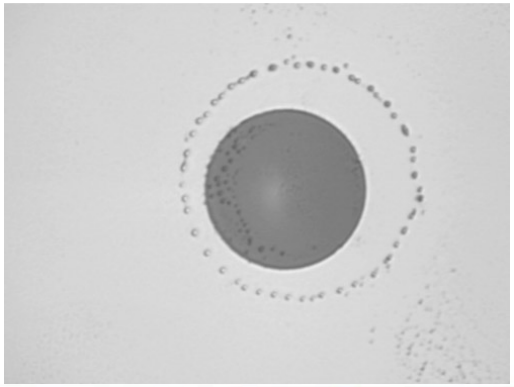
Oil Residue



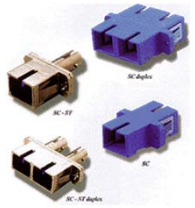
- Most often caused by touching the fiber end—users must never touch fiber ends
- An oil residue may act as a matching gel:
  - May not affect IL and RL short term
  - May trap dust and increase IL and RL with time
  - Additional truck rolls: $$$
- Proper cleaning will remove residue

Circular Residue



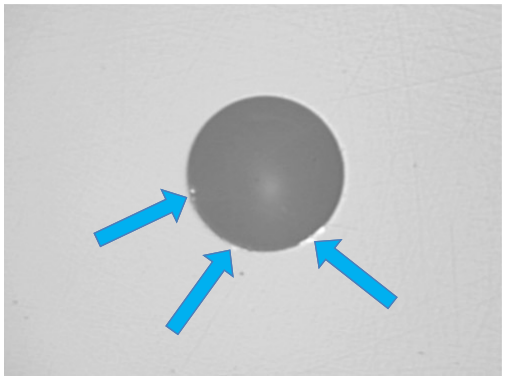


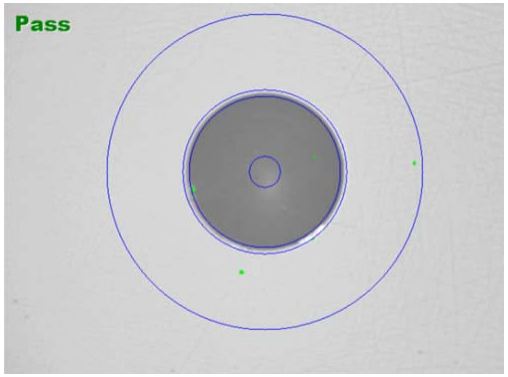
- Most often caused by improper cleaning technique
- Shows when fiber is mated while still wet



- Typically happens within the contact area
- Contamination will migrate from male to female fiber ends
- Proper cleaning will remove the residue

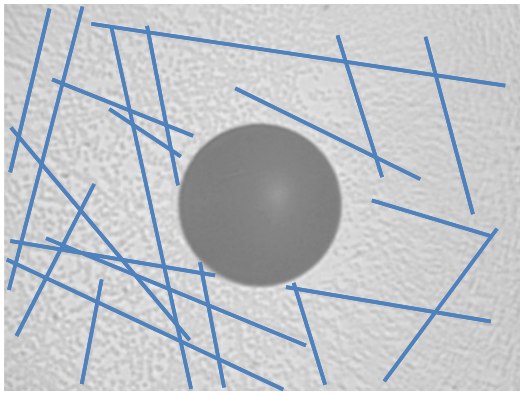
Adhesive Region Defects

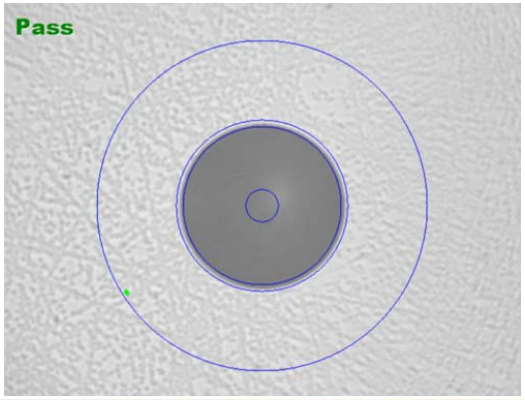




- May originate during the manufacturing process or a mishandling
- Epoxy and chips may show in this region
- Are most often permanent defects
- May show as dark or light defects
- Are normal if size does not exceed the IEC and IPC criteria

Scratches





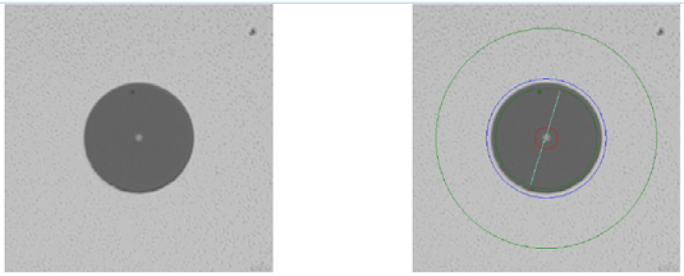
- Are linear defects in nature
- Are critical if appearing in the core area
- May originate from mishandling or improper cleaning technique
- Are permanent defects
- May be normal if they are on the ferule surface (contact zone) depending on manufacturing techniques and connector grade
- Cleaning connectors with shirts or trousers doesn't help…

Scratches

Test Parameters

Configuration:	IEC SM SF UPC ORL ≥ 45 dB ENLARGED C (Standard)		
Connector type:	Single fiber	Cladding diameter:	125 µm
Fiber type:	Singlemode	Polishing type:	Ultra-polished physical contact
Focus level:	Good	Analysis mode:	Outside plant

Image(s)



Image

Overlay

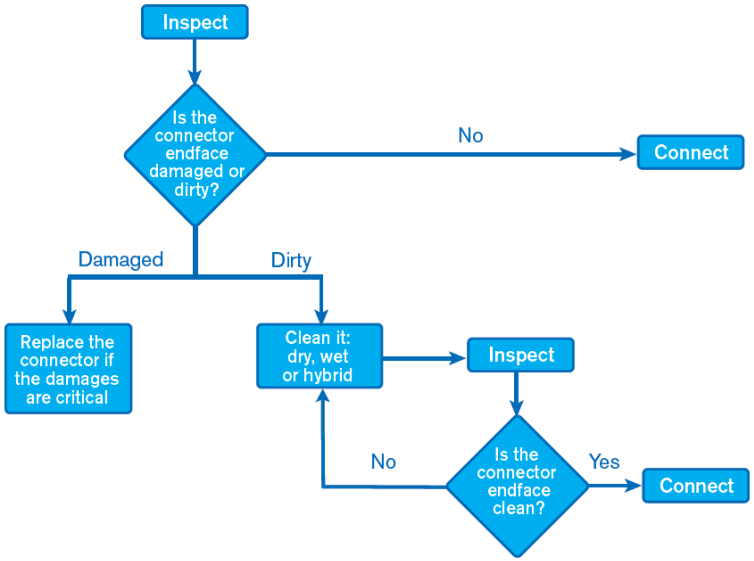
Results

Zones	Zones Diameter (µm)	Scratches			Defects		
		Criteria (µm)	Thresholds	Count	Criteria (µm)	Thresholds	Count
A: Core	0 - 25	0 ≤ size < ∞	0	1	0 ≤ size < ∞	0	0
B: Cladding	25 - 115	0 ≤ size < 3	Any	1	0 ≤ size < 2	Any	0
		3 ≤ size < ∞	0	0	2 ≤ size < 5	5	1
					5 ≤ size < ∞	0	0
C: Adhesive	115 - 135	---	---	---	---	---	---
D: Contact	135 - 250	0 ≤ size < ∞	Any	0	0 ≤ size < 10	Any	0
					10 ≤ size < ∞	0	0

- May appear as light or dark defects
- May be hard to see with the naked eye
- Are critical if appearing in the core area of SM fibers

Scratches

- What is the first step to any fiber testing?
  - ~~Cleaning~~
  - Connector inspection



Cleaning: Dry Method

- An efficient technique for removing light contaminants
- Often considered the technique of choice in a controlled manufacturing environment where speed and ease of use are important factors

Advantages	Disadvantages
Convenience of readily available tools	Can possibly create electrostatic charges
Fast and easy	Not effective in removing all contaminant types

- Example of dry cleaning supplies:
  - Specialized lint free wipes and swabs
  - Mechanical cleaning devices

Cleaning: Wet Method

- The main purpose of using the wet-solvent approach is to raise dust and contaminants from the connector's endface to avoid scratching the connector
- The most widely-known solvent in the industry is the 99.9% isopropyl alcohol (IPA), which removes most contaminants

Advantages	Disadvantages
Can dissolve complex soils and contaminants	Can leave residue on the ferrule when too much solvent is used and not properly dried
Eliminates the accumulation of electrostatic discharge on the ferrule	Solvent choice can be confusing with issues of performance and EH&S

- Example of wet cleaning supplies:
  - Pre-saturated swabs

Combination Method (Hybrid)

- Combination cleaning is a mix of the wet and dry cleaning methods
- The first step in hybrid cleaning is to clean the connector end-face with a solvent and to dry any remaining residue with either a wipe or a swab

Advantages	Disadvantages
Cleans all soil types	Requires multiple products
Reduces potential static field soil accumulation	
Automatically dries moisture and solvent used in the cleaning process	
Captures soil in wiping material as an integrated aspect of cleaning procedure	
Not expensive	

Example of combination cleaning supplies:

- Specialized wipes and solvents