Best Practices for Ensuring Fiber Optic System Performance

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JDSU

Bicsi®

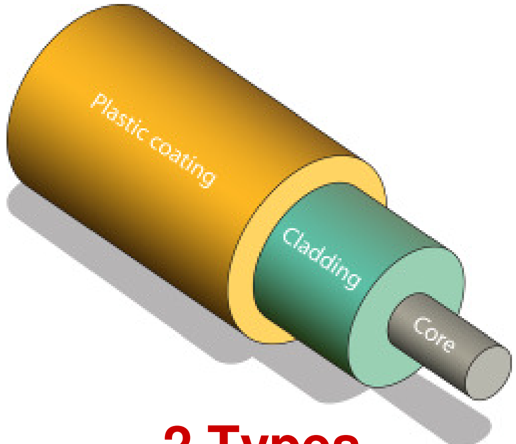
Inspect Before You Connect

- Optical Connectors in our Networks
- Contamination and Signal Performance
- Sources of Contamination
- Process for Cleaning and Inspection
- Standards update
- Summary & Backup slides

Fibre Optic Connectors

Understanding Fibre Optic Connectors

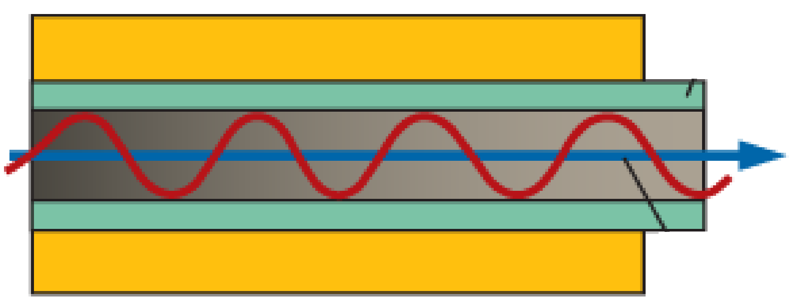
Optical Fiber Types



2 Types

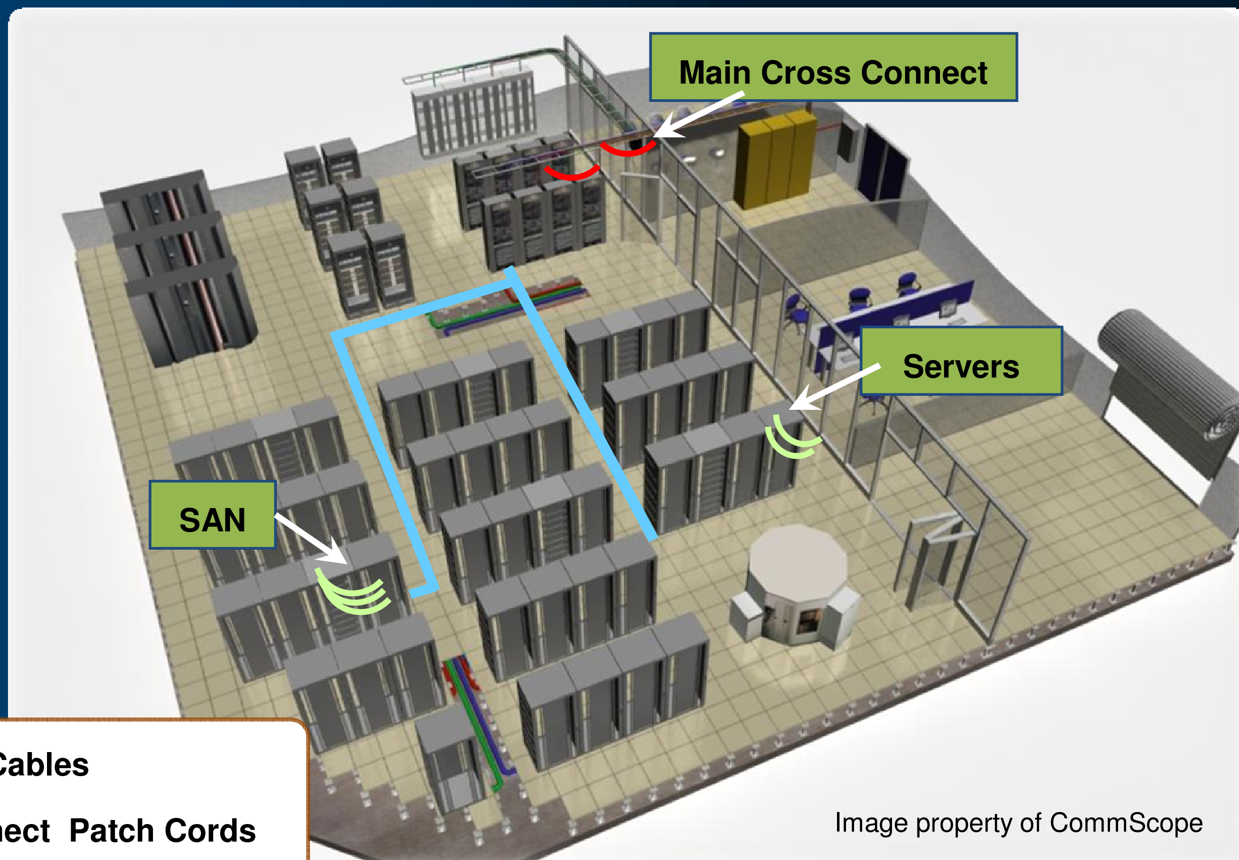
Multimode

Single-mode



Connectors Enable Network Adaptability

Connectors play an important role in Enterprise network architecture.
They give you the power to add, drop, move, and change the network.



Backbone Cables
Cross Connect Patch Cords
Interconnect Patch Cords

Exponential Impact

If a critical connection is affected, the impact can be exponential.

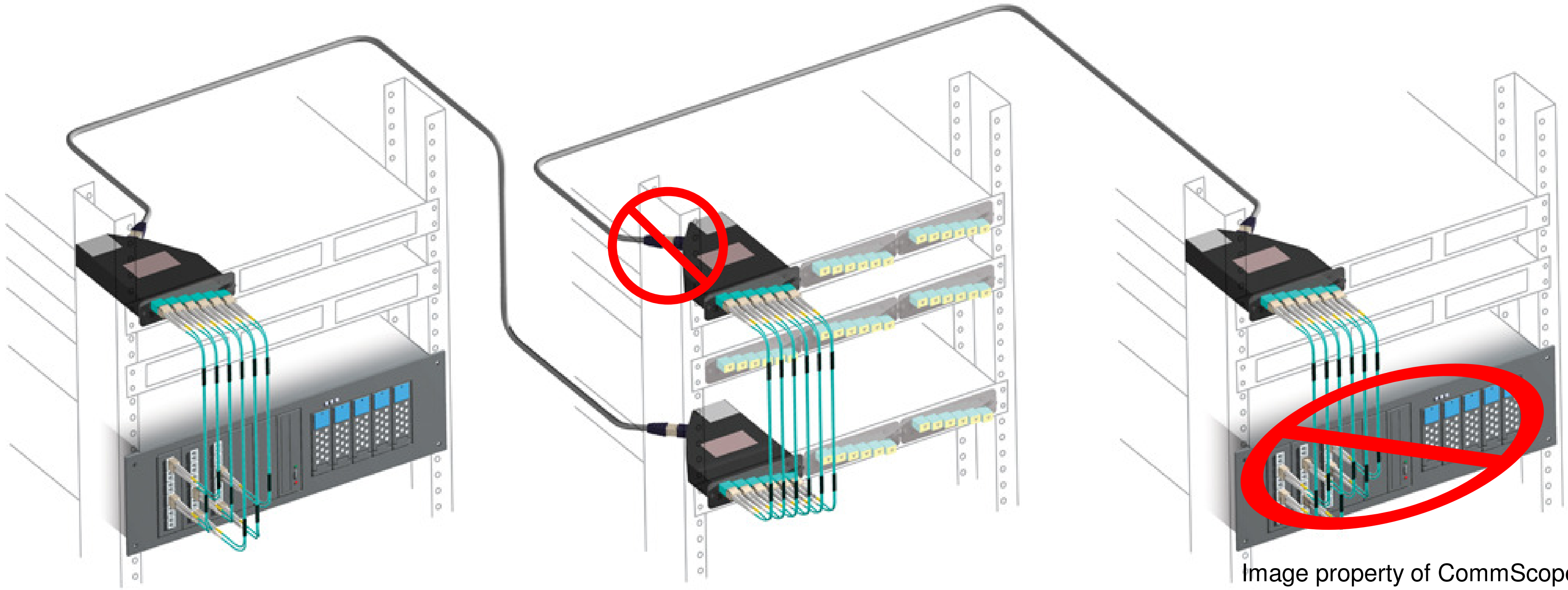
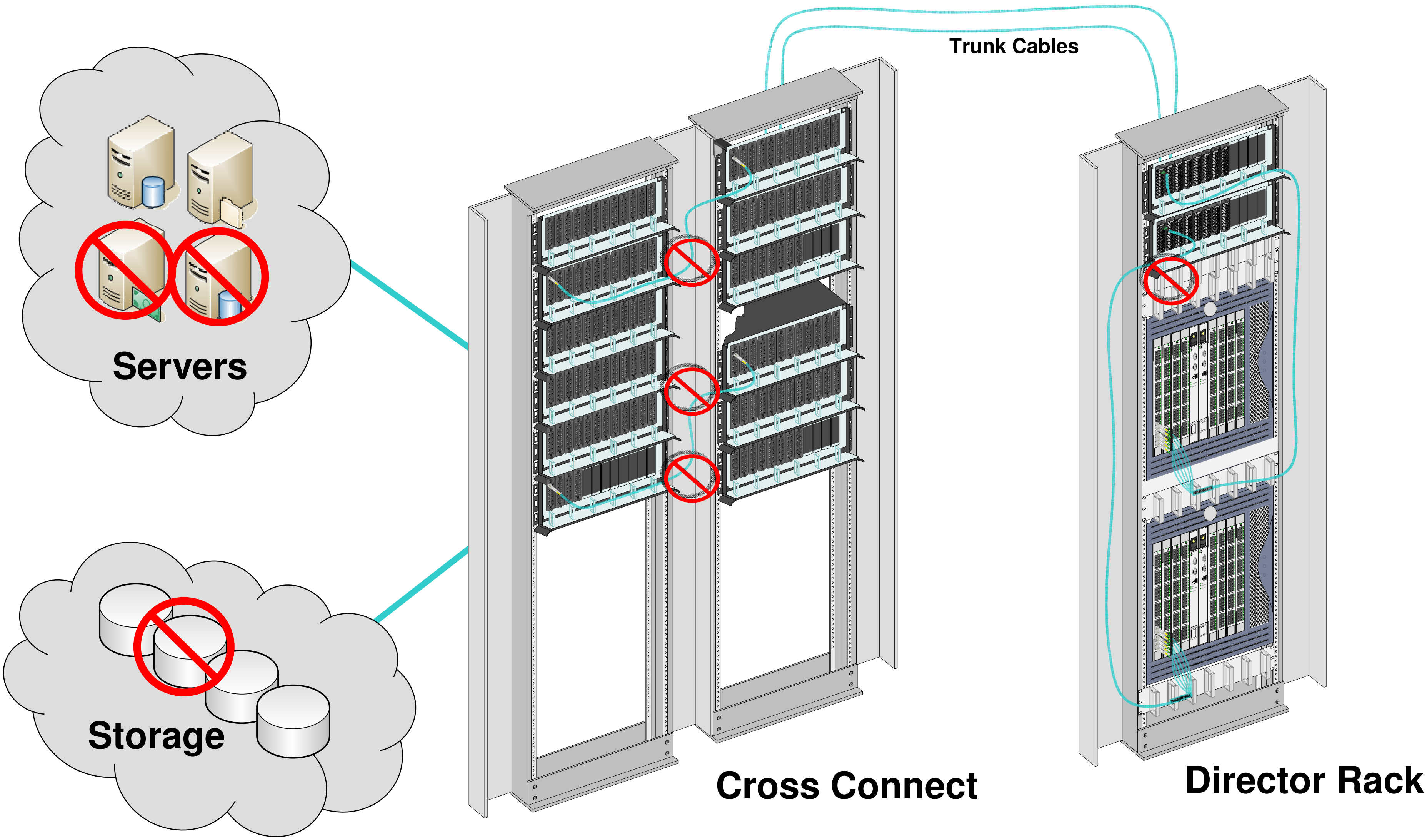
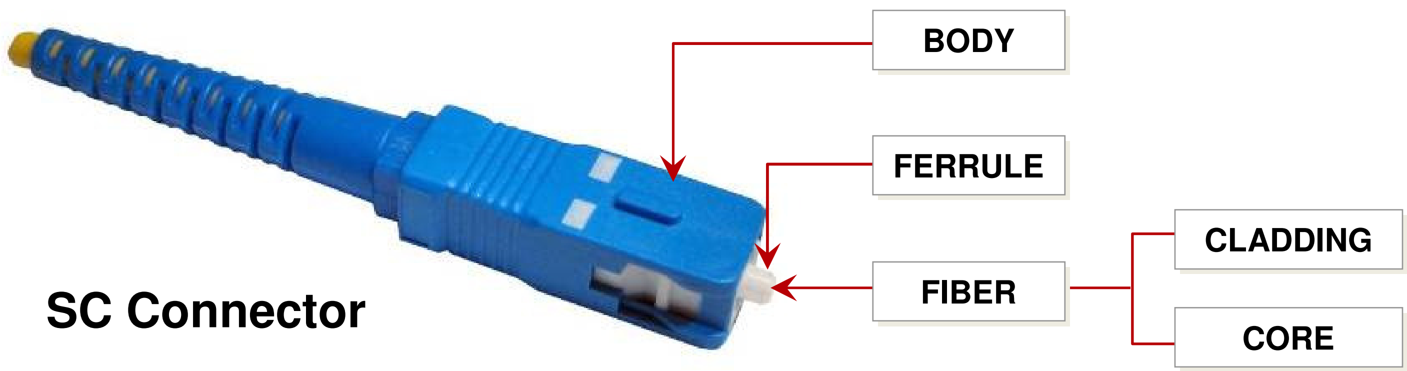


Image property of CommScope

Exponential Impact



Fiber Optic Connector

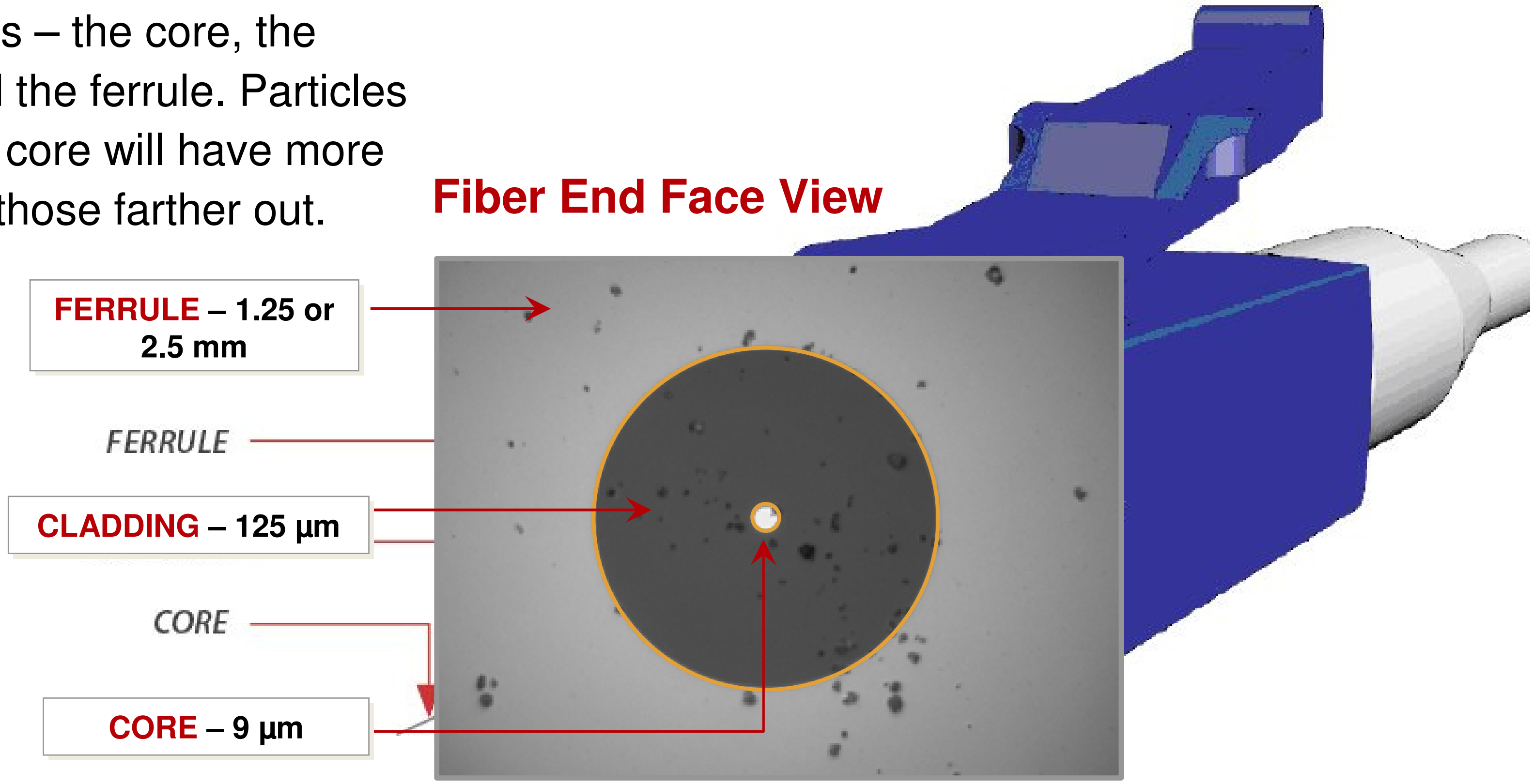


- The **BODY** houses the ferrule to secure the fiber in place.
- The **FERRULE** is a small cylinder used to mount the fiber and acts as the alignment mechanism. The end of the fiber is located at the end of the ferrule.
- The **FIBER** comprises 2 layers: the **CLADDING** and the **CORE**.
  - The **CLADDING** is a glass layer surrounding the core, which prevents the signal in the core from escaping.
  - The **CORE** is the critical center layer of the fiber and the conduit that light passes through.
- Fiber connectors have extremely tight tolerances with the potential to make a low-loss connection. To achieve this potential, they must be handled and mated properly.

Anatomy of Fiber Connectors

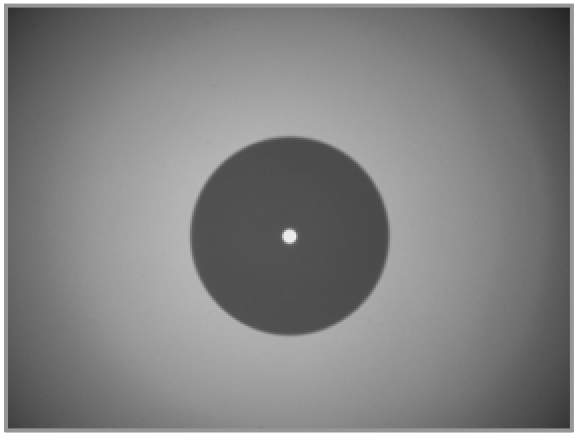
Light is transmitted and retained in the **CORE** of the optical fiber by *total internal reflection*.

The fiber connector endface has 3 major areas – the core, the cladding and the ferrule. Particles closer to the core will have more impact than those farther out.



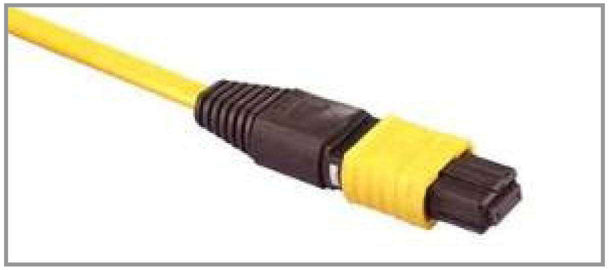
Single Fiber vs. Multi-Fiber Connectors

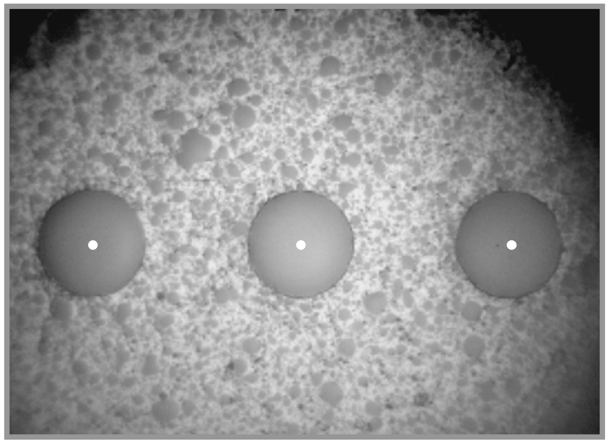
SINGLE FIBER CONNECTOR



- White ceramic ferrule
- One fiber per connector
- Common types include SC, LC, FC, and ST

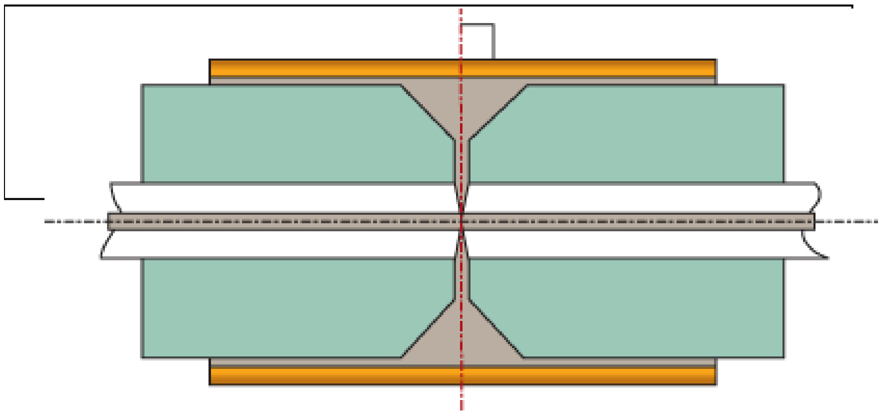
MULTI-FIBER CONNECTOR

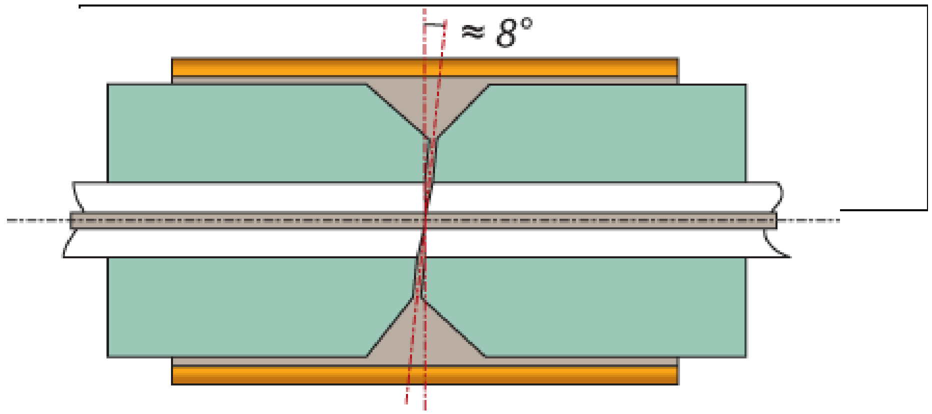




- Polymer ferrule
- Multiple fibers in linear array (12, 24, more) in single, high-density connector
- Common type is MPO or MTP®

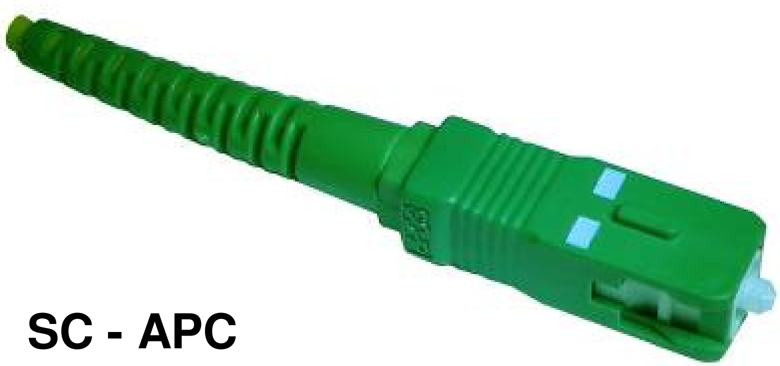
Types of End Faces





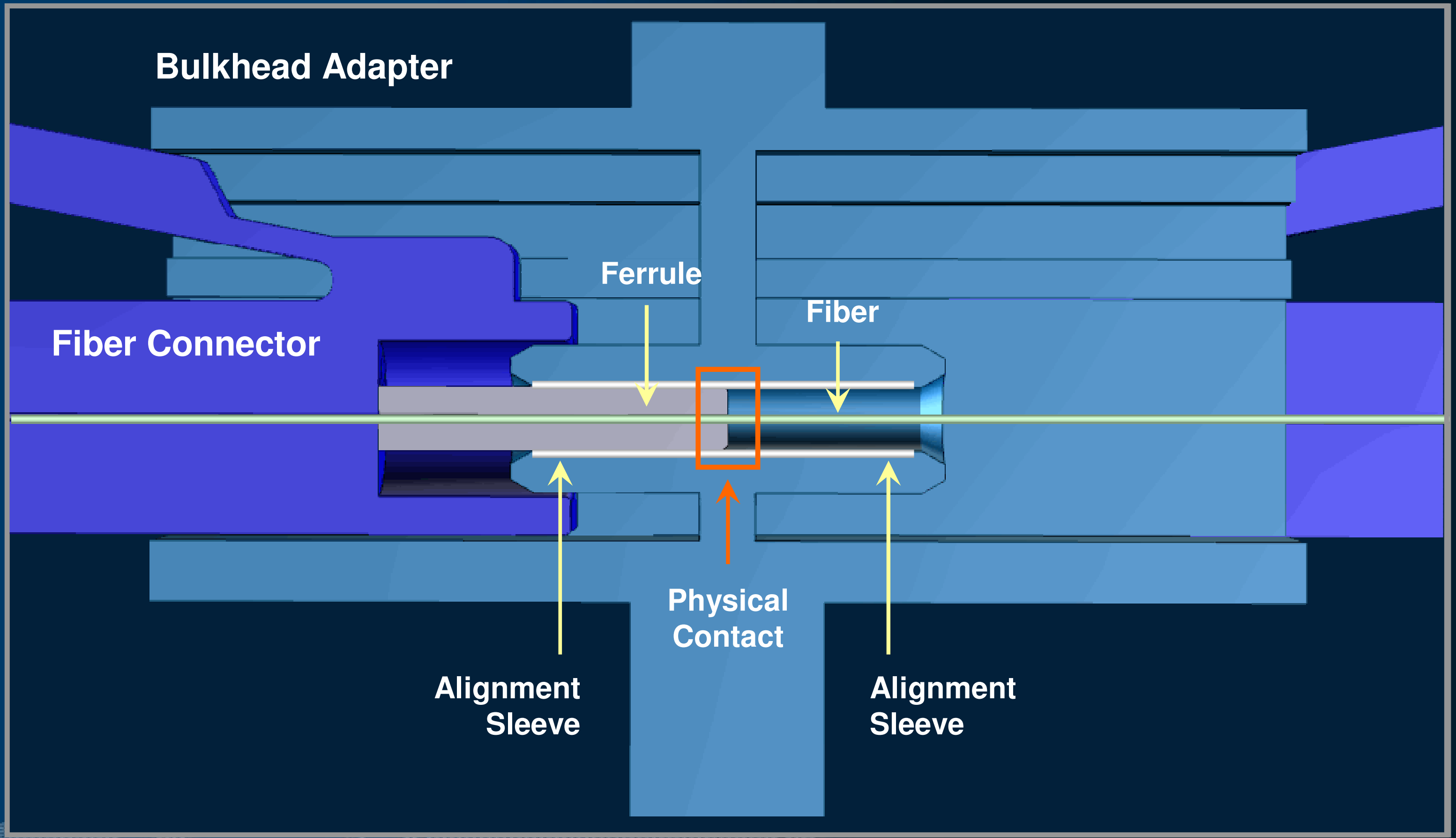
- The angle reduces the back-reflection of the connection.

SC - PC



SC - APC

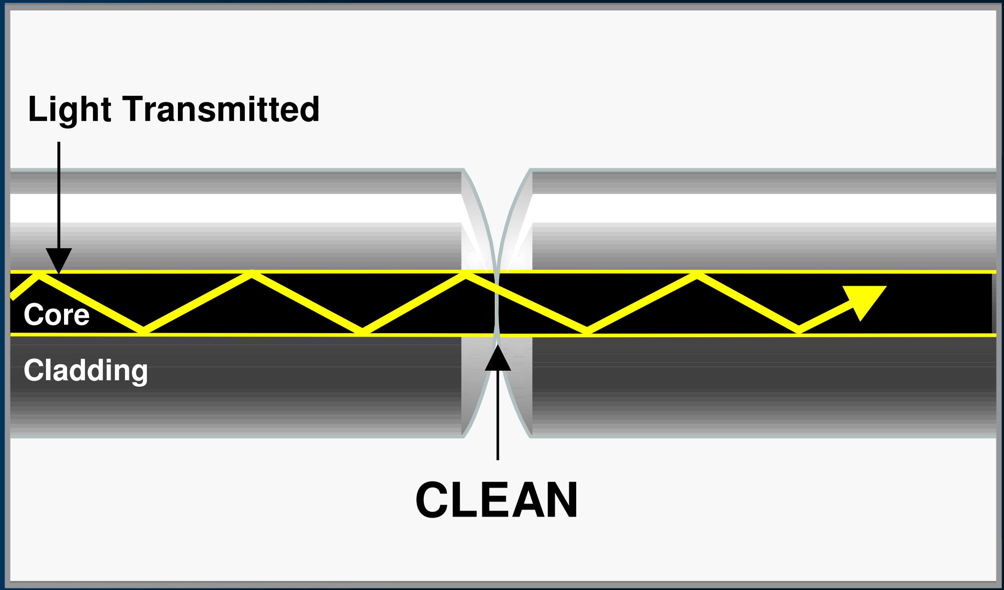
Focus on the Connection



What Makes a GOOD Fiber Connection?

The 3 basic principles that are critical to achieving an efficient fiber optic connection are "The 3 Ps":

- **Perfect Core Alignment**
- **Physical Contact**
- **Pristine Connector Interface**



Today's connector design and production techniques have eliminated most of the challenges to achieving core alignment and physical contact.

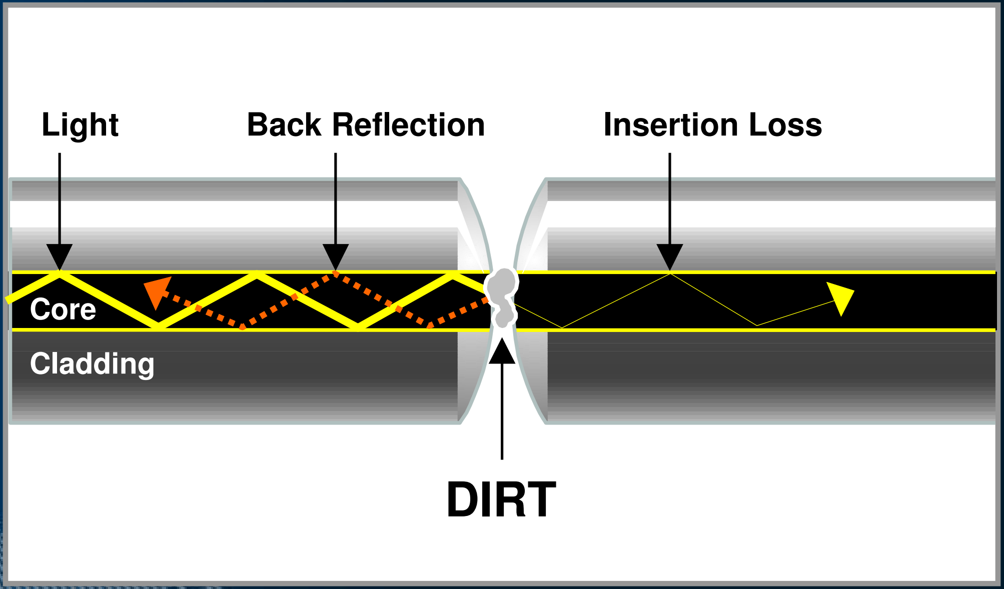
BICSI

What Makes a BAD Fiber Connection?

Today's connector design and production techniques have eliminated most of the challenges to achieving Core Alignment and Physical Contact.

What remains challenging is maintaining a **Pristine End-face.** As a result, **CONTAMINATION is the #1 source of troubleshooting in optical networks.**

- A single particle mated into the core of a fiber can cause significant **back reflection, insertion loss** and even **equipment damage.**



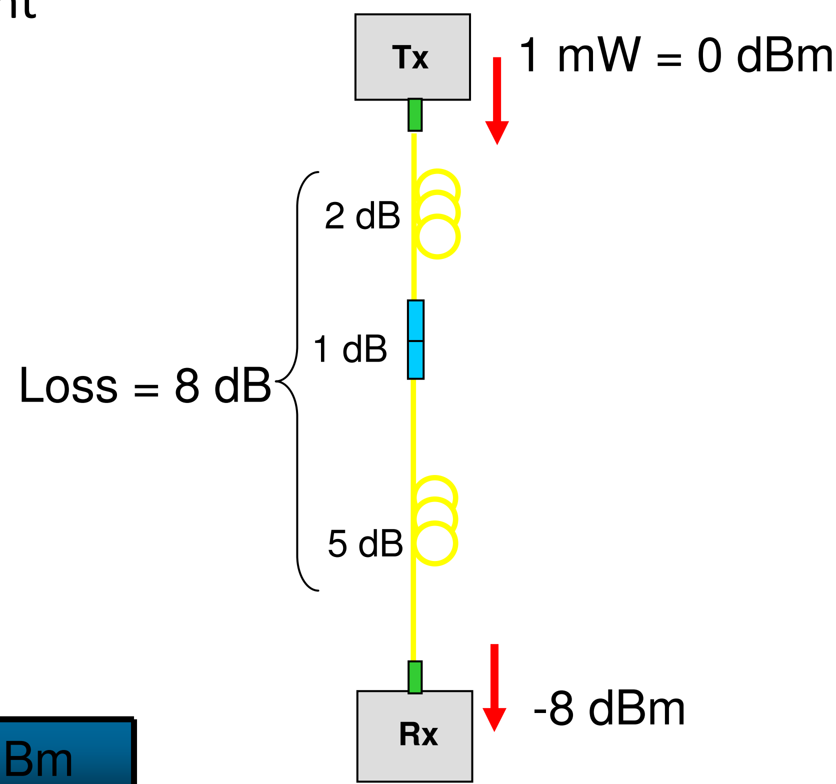
Impact on Network Performance

Measurement Units

- dBm unit is decibels relative to 1 mW of power
- dBm is an ABSOLUTE measurement
- dB is a RELATIVE measurement

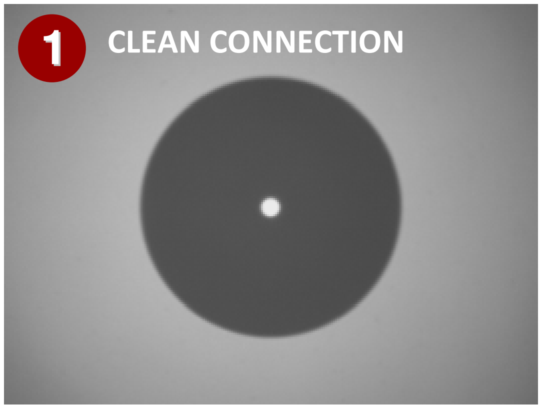
$$\textbf{Relative Power (dB)} = 10 * \text{Log} \frac{Pi\,(mW)}{Pt\,(mW)}$$

$$\textbf{Absolute Power (dBm)} = 10 * \text{Log} \frac{Pi(mW)}{1mW}$$



0 dBm	-3 dBm	-10dBm	-20 dBm	-40 dBm
1 mW	0.5 mW	0.1 mW	0.01 mW	0.0001 mW

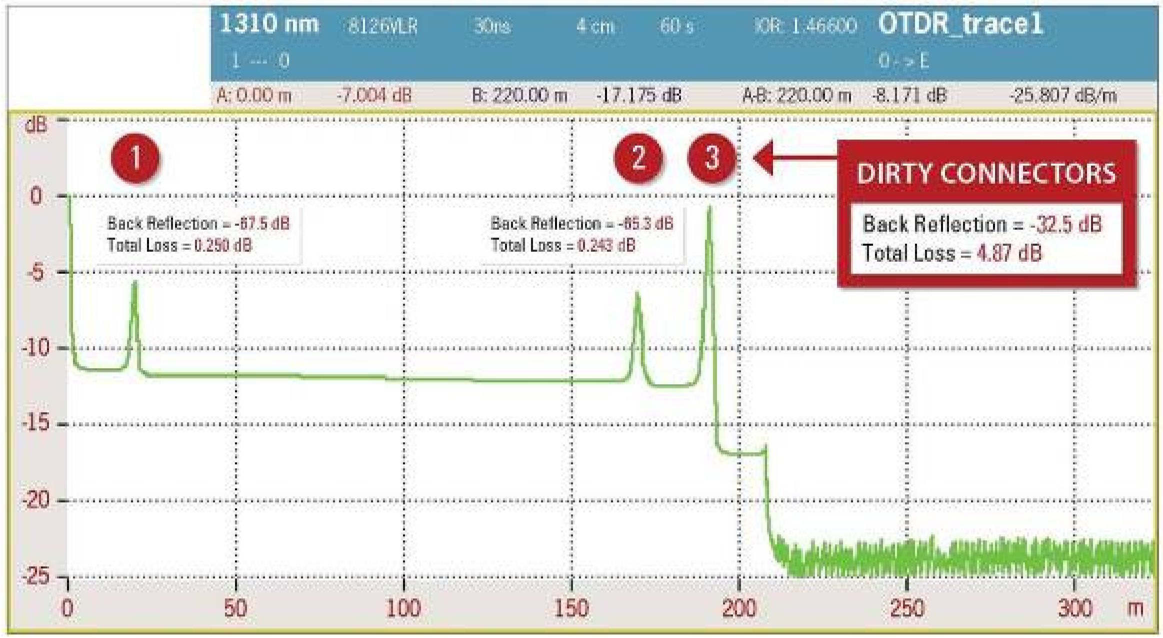
Contamination and Signal Performance



Back Reflection = **-67.5 dB**
Total Loss = **0.250 dB**

Back Reflection = **-32.5 dB**
Total Loss = **4.87 dB**

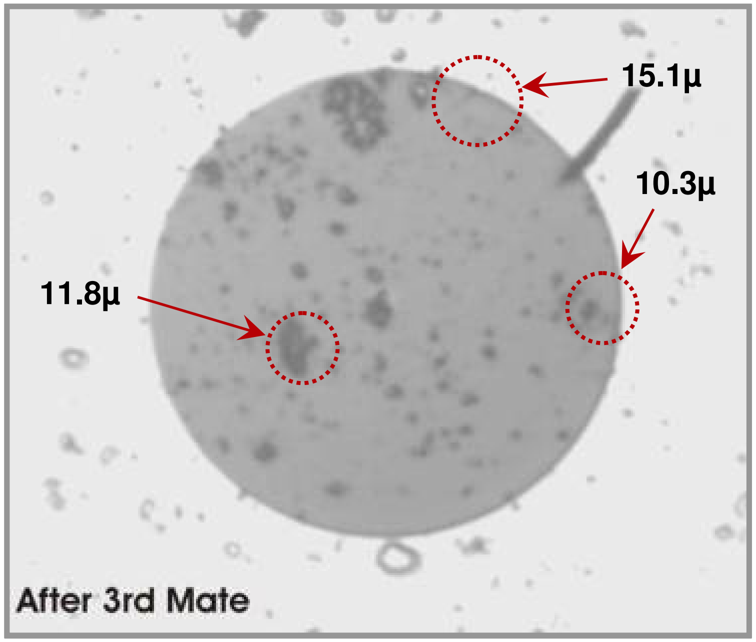
Fiber Contamination and Its Effect on Signal Performance

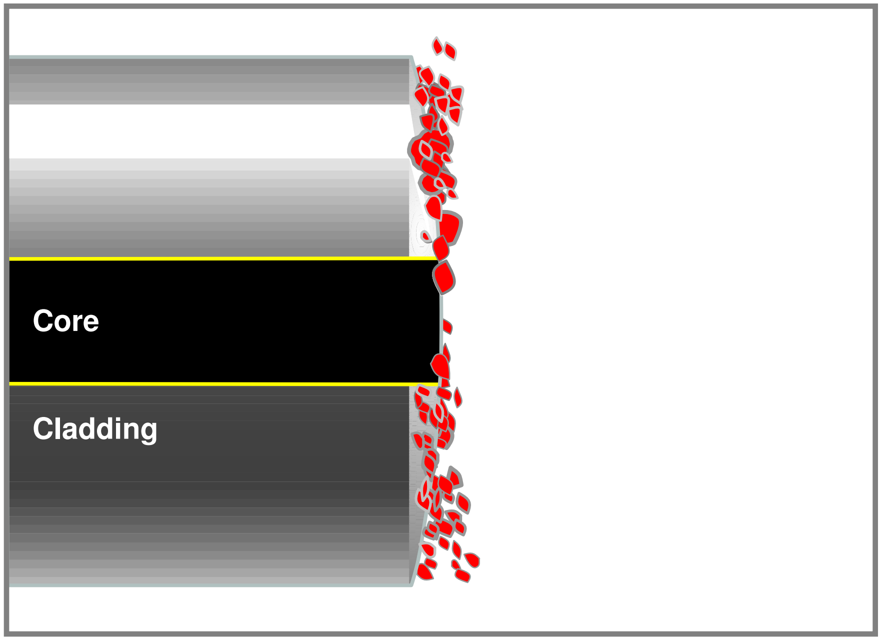


Clean Connection vs. Dirty Connection

OTDR trace illustration of the significant decrease in signal performance after mating dirty connectors

Illustration of Particle Migration





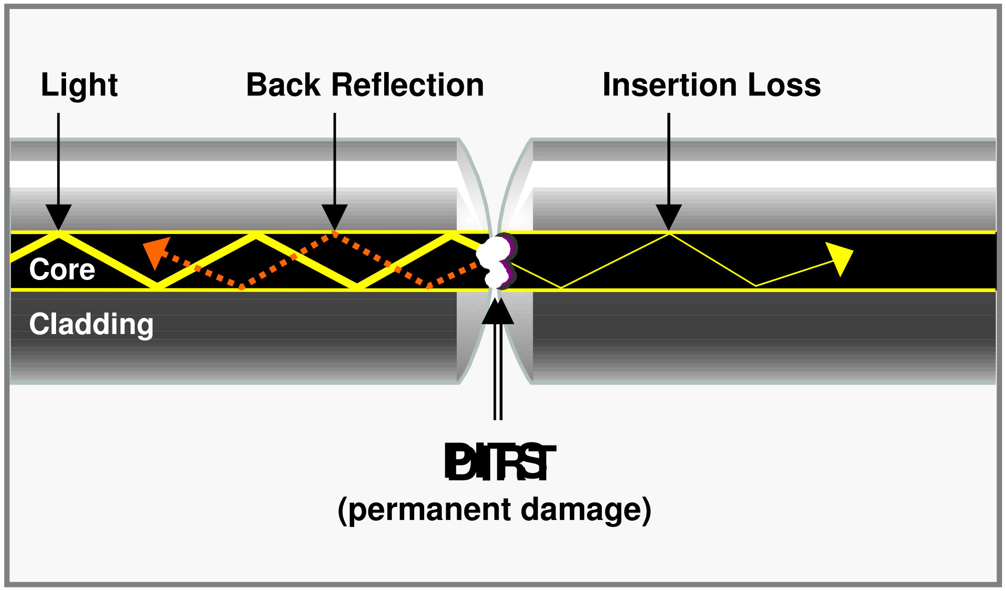
Actual fiber end face images of particle migration

- Each time the connectors are mated, particles around the core are displaced, causing them to migrate and spread across the fiber surface.
- Particles larger than 5µm usually explode and multiply upon mating.
- Large particles can create barriers ("air gaps") that prevent physical contact.
- Particles less than 5µm tend to embed into the fiber surface, creating pits and chips.

Dirt Damages Fibre!

Mating dirty connectors embeds the debris into the fiber.

Mating force of 1kg (2.2lb) over 200µm diameter gives 45,000 psi.



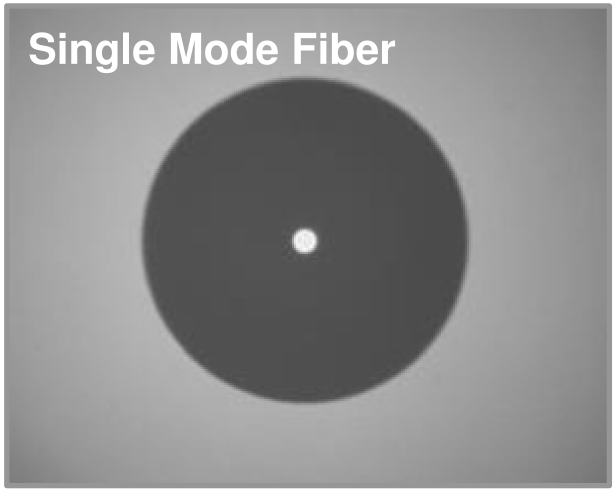
- Once embedded debris is removed, **pits and chips remain in the fibre.**
- These pits can also prevent transmission of light, causing **back reflection, insertion loss and damage** to other network components.

Most connectors are not inspected until the problem is detected… AFTER permanent damage has already occurred.

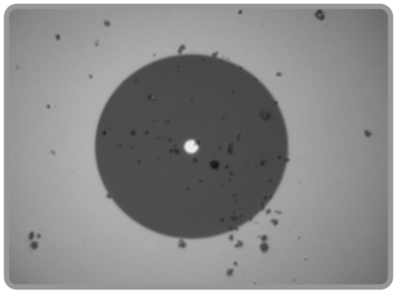
Contamination

Types of Contamination

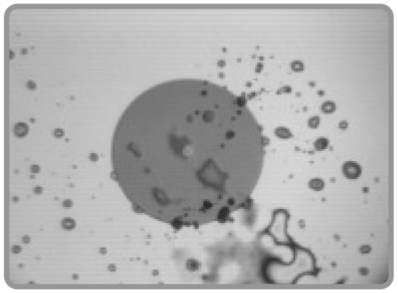
Fiber end faces **should be free of any contamination or defects,** as shown below:



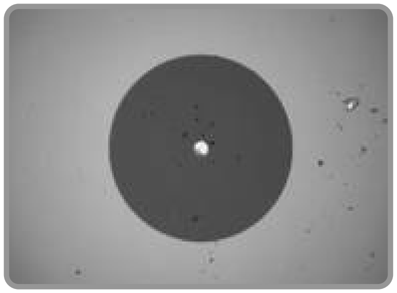
Common types of contamination and defects include the following:



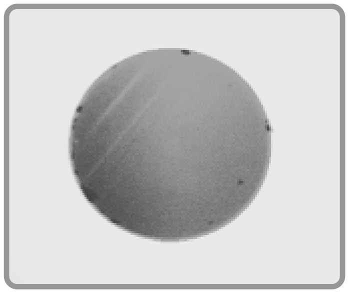
Dirt



Oil



Pits & Chips



Scratches

Where Is It? – Everywhere!

Your biggest problem is right in front of you… you just can't see it!

DIRT IS EVERYWHERE!

- Airborne, hands, clothing, bulkhead adapter, dust caps, test equipment, etc.
- **The average dust particle is 2–5µ, which is not visible to the human eye.**
- A single spec of dust can be a major problem when embedded on or near the fiber core.
- **Even a brand new connector can be dirty.** Dust caps protect the fiber end-face, but can also be a source of contamination.
- Fiber inspection microscopes give you a clear picture of the problems you are facing.

How is it getting on the fiber?

There are a number of different sources where dirt and other particles can contaminate the fiber.

- **Test Equipment**
- **Dust Caps**
- **Bulkheads**
- **People**
- **Environment**

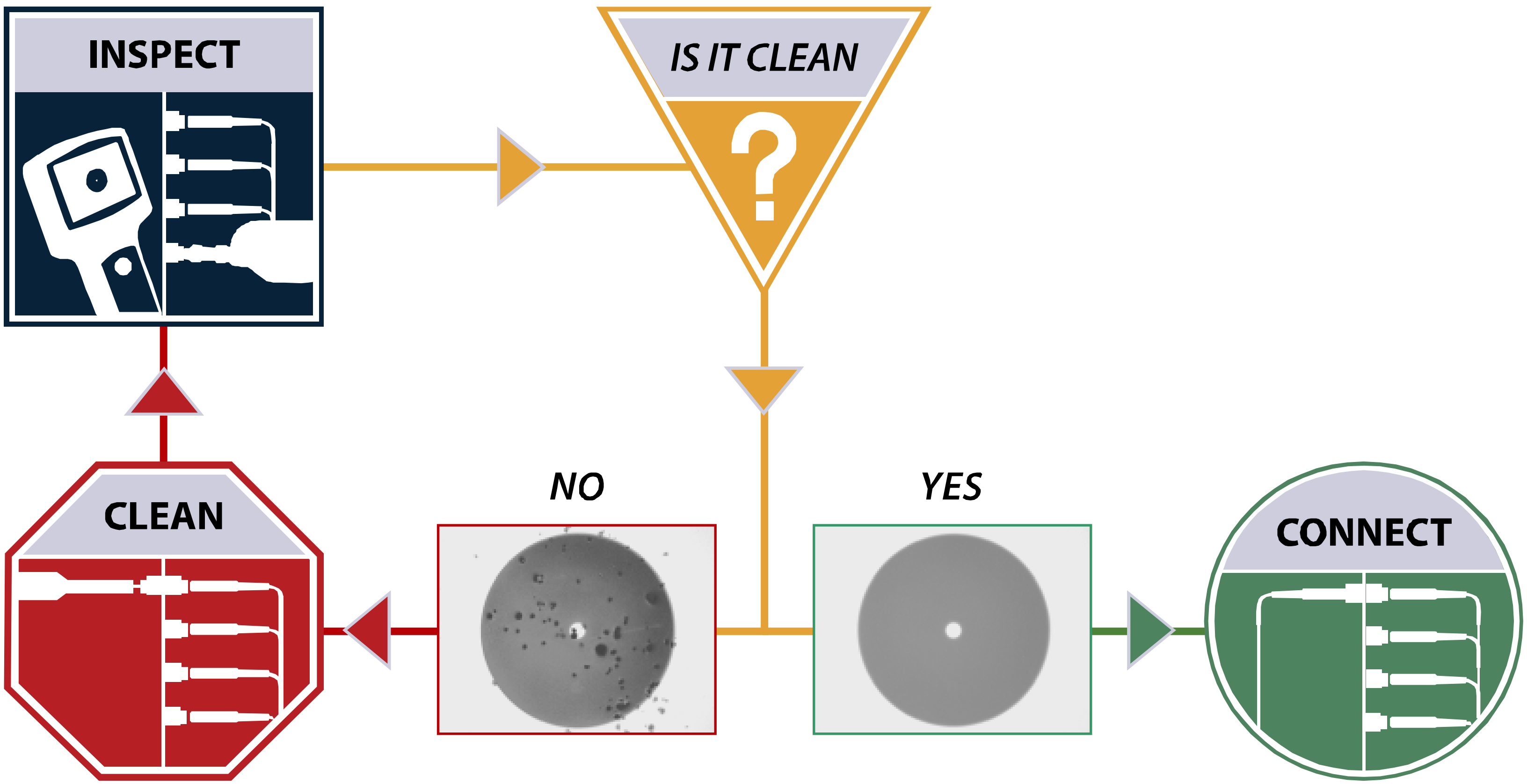
Connectors and ports on test equipment are mated frequently and are highly likely to become contaminated. Once contaminated, this equipment will often cross-contaminate the network connectors and ports being tested.

Inspecting and cleaning test ports and leads before testing network connectors prevents cross-contamination.

Inspection and Cleaning

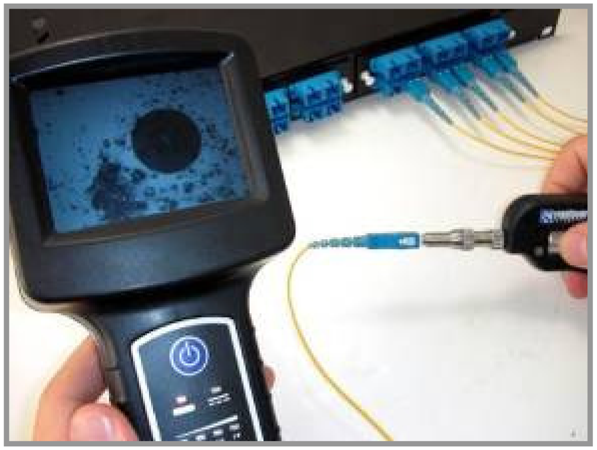
Inspect Before You Connect℠

Follow the simple **"INSPECT BEFORE YOU CONNECT"** process to ensure fiber end faces are clean prior to mating connectors.



Inspect and Clean Both Connectors in Pairs!

Inspecting BOTH sides of the connection is the **ONLY WAY** to ensure the connector will be free of contamination and defects.



Patch Cord (Male) Inspection

Bulkhead (Female) Inspection

Patch cords are easy to access and view compared to the fiber inside the bulkhead (or test equipment or network equipment) which are frequently overlooked. The bulkhead side may only be half of the connection, but it is far more likely to be dirty and problematic.

Inspect, Clean, Inspect, and Go!

Fiber inspection and cleaning are SIMPLE steps with immense benefits.

1 Inspect

- **Use a probe microscope to INSPECT the fiber.**

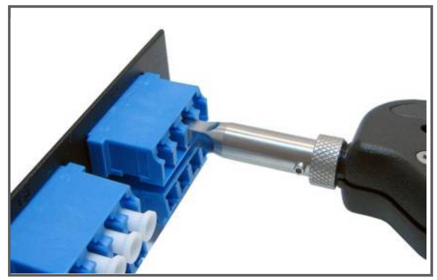
– ***If the fiber is dirty,*** go to Step 2, Clean.

– ***If the fiber is clean,*** go to Step 4, Connect.

2 Clean

- **If the fiber is dirty, use a simple cleaning tool to CLEAN the fiber surface.**

3 Re-inspect



- **Use a probe microscope to RE-INSPECT** *(confirm fiber is clean).*

– ***If the fiber is still dirty,*** repeat Step 2, Clean.

– ***If the fiber is clean,*** go to Step 4, Connect.

4 Connect

- **If the fiber is clean, CONNECT the connector.**

NOTE: *Be sure to* ***inspect both sides*** *(patch cord "male" and bulkhead "female") of the fiber interconnect.*

Proactive vs. Reactive Inspection

REACTIVE INSPECTION:

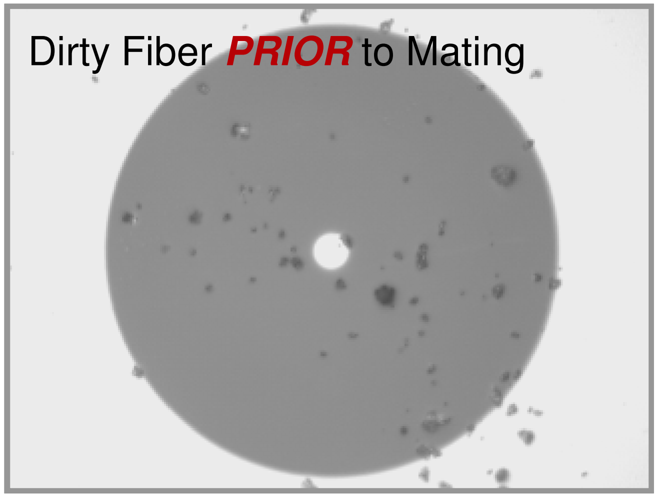
Visually inspecting fiber connectors ***AFTER*** a problem is discovered, typically during troubleshooting.

By this time, connectors and other equipment may have suffered permanent damage.

PROACTIVE INSPECTION:

Visually inspecting fiber connectors at every stage of handling ***BEFORE*** mating them.

Connectors are much easier to clean prior to mating, before embedding debris into the fiber.



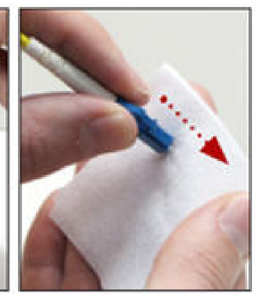
Benefits of Proactive Inspection

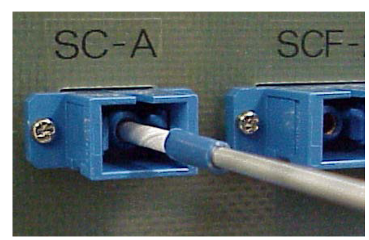
PROACTIVE INSPECTION is quick and easy, **with indisputable benefits**

- **Reduce Network Downtime**
  Active network = satisfied customers
- **Reduce Troubleshooting**
  Prevent costly truck rolls and service calls
- **Optimize Signal Performance**
  Network components operate at highest level of performance
- **Prevent Network Damage**
  Ensure longevity of costly network equipment

Cleaning Best Practices

- Many tools exist to clean fiber
- Many companies have their own “best practices”
- Dry clean first, then try wet cleaning.
- Always finish with a dry cleaning process.





Standards Update

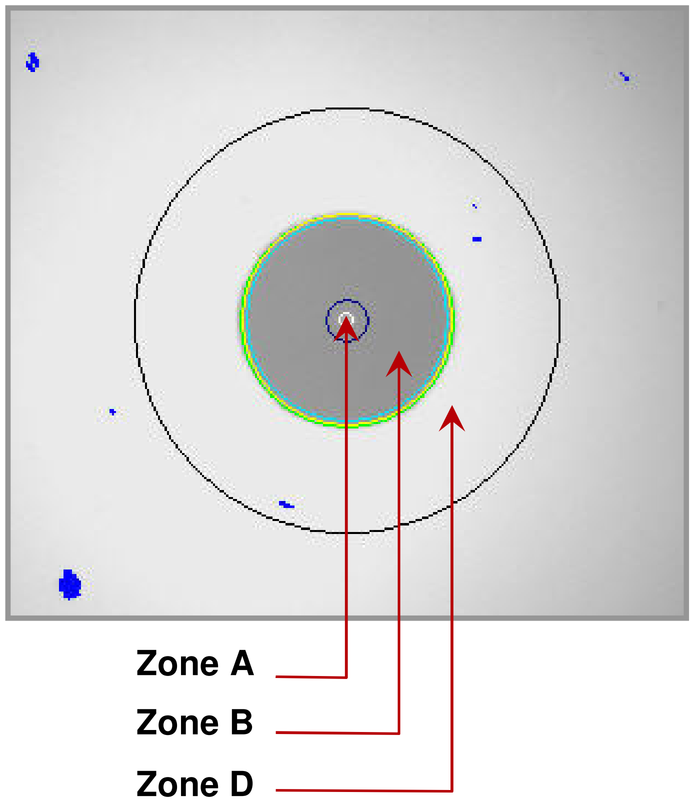
Standards and Zones

IEC 61300-3-35 – "Fibre Optic Connector Endface Visual and Automated Inspection" has recently been published as an interoperability standard for connector manufacturers and users.

- **ZONES are used to prioritize evaluation criteria.**

  Zone A: Core Zone
  Zone B: Cladding Zone
  Zone C: Adhesive Zone
  Zone D: Contact Zone

- **Different *failure criteria* for defects and scratches are specified for each zone:**
  - **Quantity** and **Size**
  - **Location** relative to core

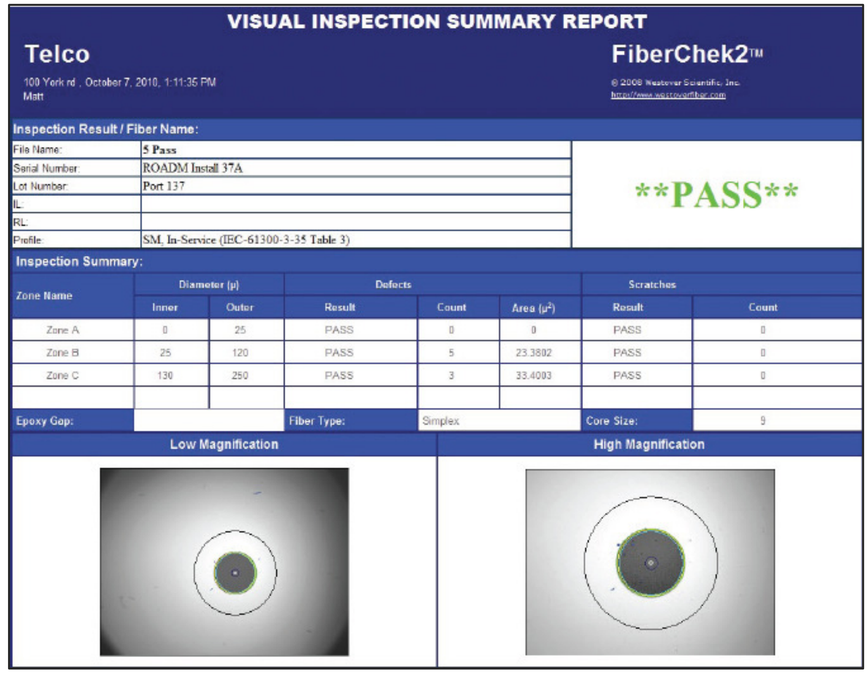


Recommended Acceptance Criteria for SM-UPC Connectors (IEC 61300-3-35)

Zone Name (diameter)	**Scratches**	**Defects**
A, Core Zone (0-25µm)	none	none
B, Cladding Zone (25-120µm)	none > 3µm width	no limit < 2µm 5 from 2 - 5µm none > 5µm
C, Adhesive Zone (120-130µm)	no limit	no limit
D, Contact Zone (130-250µm)	no limit	none > 10µm

Standard status

- IEC 61300-3-35 **recently approved!**
- **Criterias defined for**
  - **SM-UPC**
  - **SM-APC**
  - **MM-PC**
  - **SM-UPC (Ribbon)**
  - **MM-PC (Ribbon)**



VISUAL INSPECTION SUMMARY REPORT

Telco

100 York rd , October 7, 2010, 1:11:35 PM
Matt

FiberChek2™

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Inspection Result / Fiber Name:

File Name:	5 Pass
Serial Number:	ROADM Install 37A
Lot Number:	Port 137
IL:	
RL:	
Profile:	SM, In-Service (IEC-61300-3-35 Table 3)

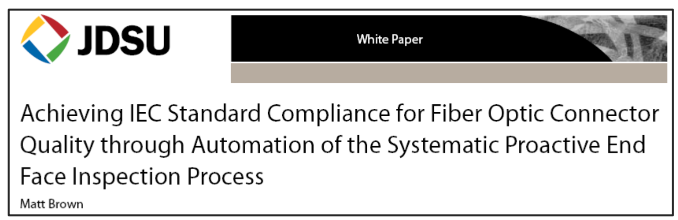
****PASS****

Inspection Summary:

Zone Name	Diameter (µ)		Defects			Scratches	
	Inner	Outer	Result	Count	Area (µ²)	Result	Count
Zone A	0	25	PASS	0	0	PASS	0
Zone B	25	120	PASS	5	23.3802	PASS	0
Zone C	130	250	PASS	3	33.4003	PASS	0
Epoxy Gap:			Fiber Type:	Simplex		Core Size:	9

Low Magnification | High Magnification

Please visit www.jdsu.com/inspect to learn more...
Paper on IEC Compliance available for download



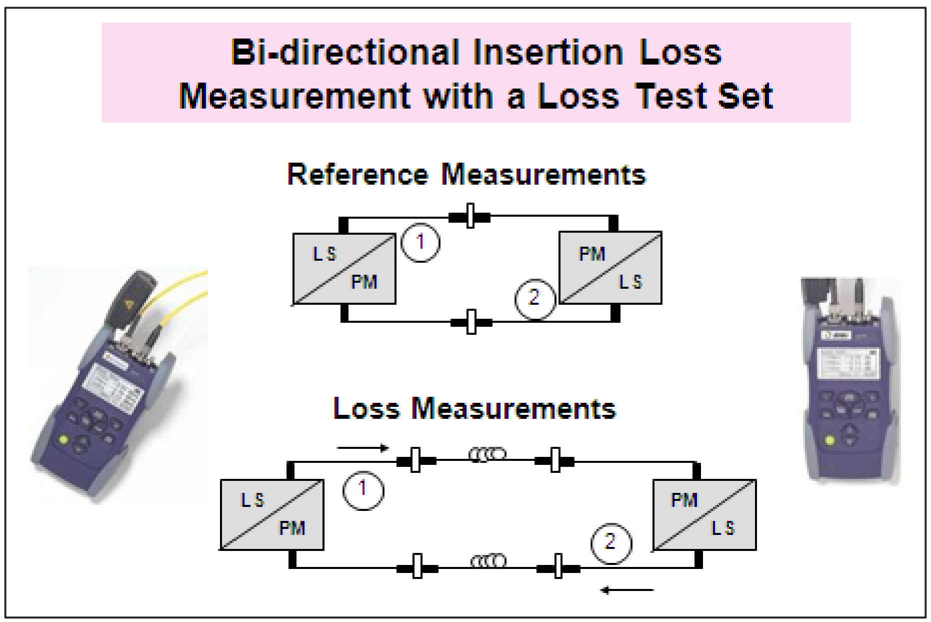
Key Takeaways

- Connectors are valuable and essential, but they must be handled properly.
- **CONTAMINATION** is the #1 source of troubleshooting in optical networks.
- This challenge is easily overcome with proactive inspection and cleaning.
- Visual inspection of fiber optic connectors with a microscope is the only way to determine if connectors are clean before they are mated.
- Proactive inspection is easy, and the benefits are:
  - Reduced Network Downtime
  - Reduced Troubleshooting
  - Optimized Signal Performance
  - Prevention of Network Damage
- Always ***"INSPECT BEFORE YOU CONNECT"***

Backup slides: LAN Fiber Testing Essentials

Fiber Certification Tier 1

- **Polarity and LTS Tests,** end-face inspection test strongly recommended
- The cabling infrastructure should respect maximum channel attenuation to ensure a reliable signal transmission over distance. This attenuation value should consider end-to-end channel losses
- Maximum channel attenuation is specified in the ANSI/TIA-568-B.1 standard



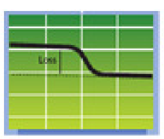
10 Gig Eth	Wavelength (nm)	Max. Channel Attenuation (dB) according to ANSI/TIA-568-B.1			
		62.5 µm MM	50 µm MM	850nm Laser-optimized 50µm MM	9µm SM
10GBASE-SX	850	2.5	2.3	2.6	--
10GBASE-LX4	1300	2.5	2.0	2.0	6.6

Fiber cable length must be either calculated or measured

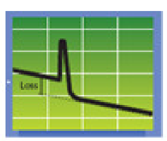
Fiber Certification Tier 2

- **Adds Fiber Plant Characterization with OTDR tests,** end-face inspection tests strongly recommended
- An OTDR is the most powerful tool for certifying and troubleshooting Fiber Optic networks
  - It provides the whole picture of the fiber link
  - Detects, locates and measures events at any location of the fiber link

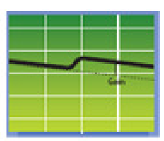
- Some requirements are needed
  - SM/MM capabilities (850/1300/1310/1550nm)
  - Minimum ADZ/EDZ (Attenuation/Event Dead Zone) ➔ Short fiber patchcords
  - EF Compliance (IEC 61280-4-1) and end-face inspection (IEC 61300-3-35)



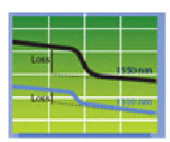
Fusion Splice



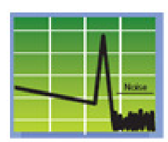
Connector or mechanical Splice



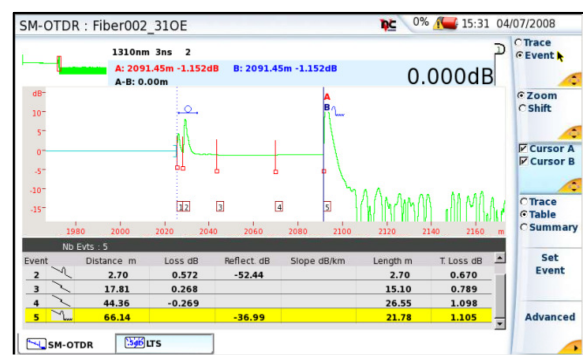
Gainer



Bend



Fiber end or break



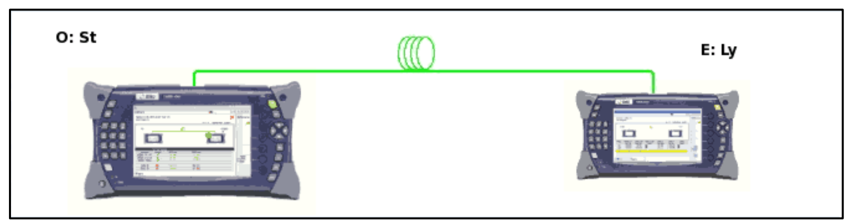
The trend: Fiber Tests Automation

- Fiber Tests Automation reduces operational expenses (OPEX) and minimizes training time with a simple, automated measurement process:
  - Minimize the number of connections
  - Guide the technician through the process
  - Generate the report on the fly
  - Allow uni-directional or bi-directional testing

Reduces testing time during deployment of fiber optic networks by up to 75%!

- <u>Fiber Test Automation examples</u>:
  - Connector Inspection Pass/Fail Analysis
  - Bi-directional IL/ORL
  - Bi-directional OTDR
  - Full Fiber Characterization (IL/ORL/OTDR/Dispersion)

Automated bi-directional Insertion Loss / Return Loss and OTDR testing through a single fiber connection



IL/ORL Results

Wavelength	Pass/Fail	1310 nm	1550 nm	1625 nm
Loss B->A	✘	9.33	5.58	6.64
Loss A->B	✘	10.49	6.66	6.47
Avg Loss	✘	9.95	6.15	6.56
ORL A	✘	27.95	27.60	26.92
ORL B	✘	31.82	31.88	32.03

Any questions?

Thank you!