



Fibre Connector Inspection & Cleaning

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Inspect Before You ConnectSM

- Inspection Overview
- Fiber Optic Connectors
- Contamination
- Simple Solution
- Standards Update
- Extras – MTP/MPO connector inspection



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Inspection Overview – Microscopes

DIRECT-VIEW SCOPE



BENCH SCOPE



PROBE SCOPE & DISPLAYS



DIGITAL PROBE



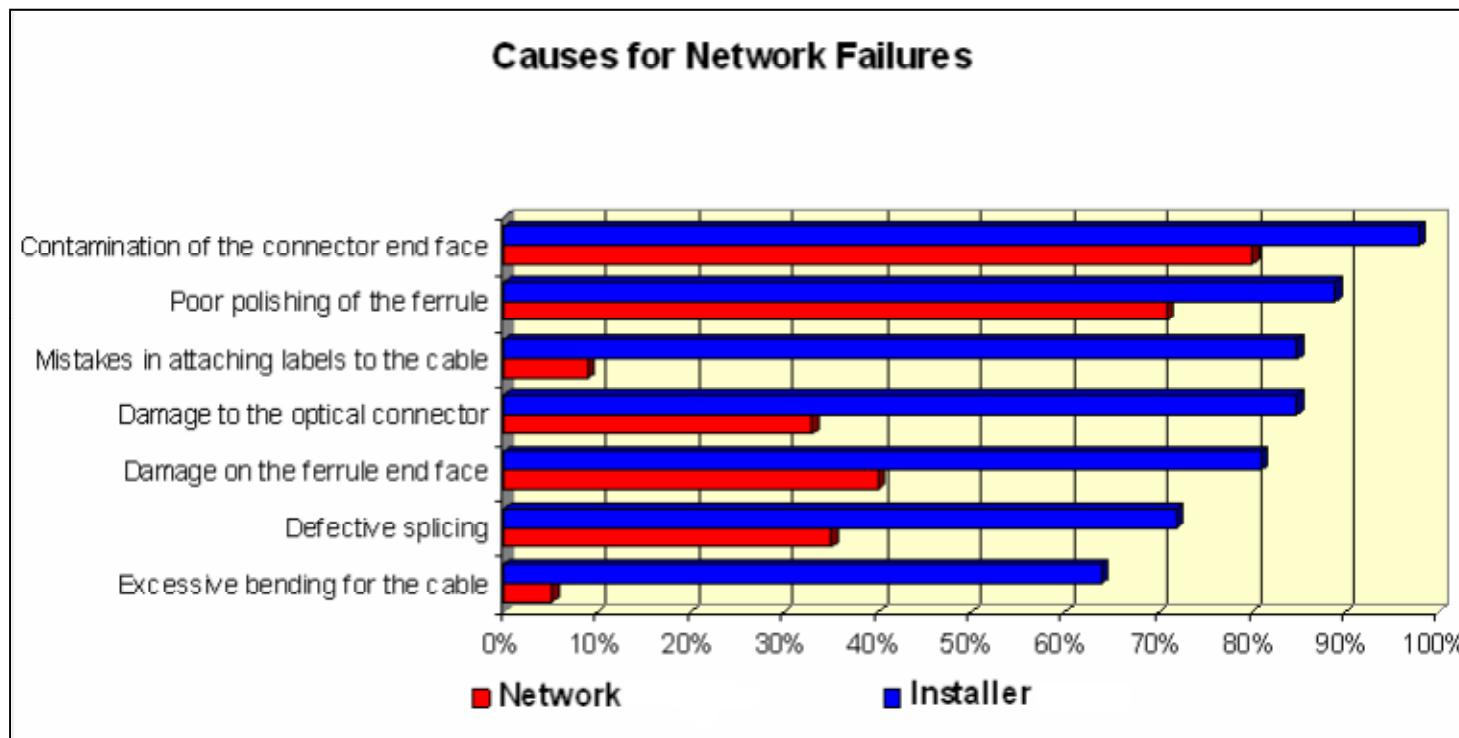
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Part I: Fibre Optic Connectors



Causes of Network Failure

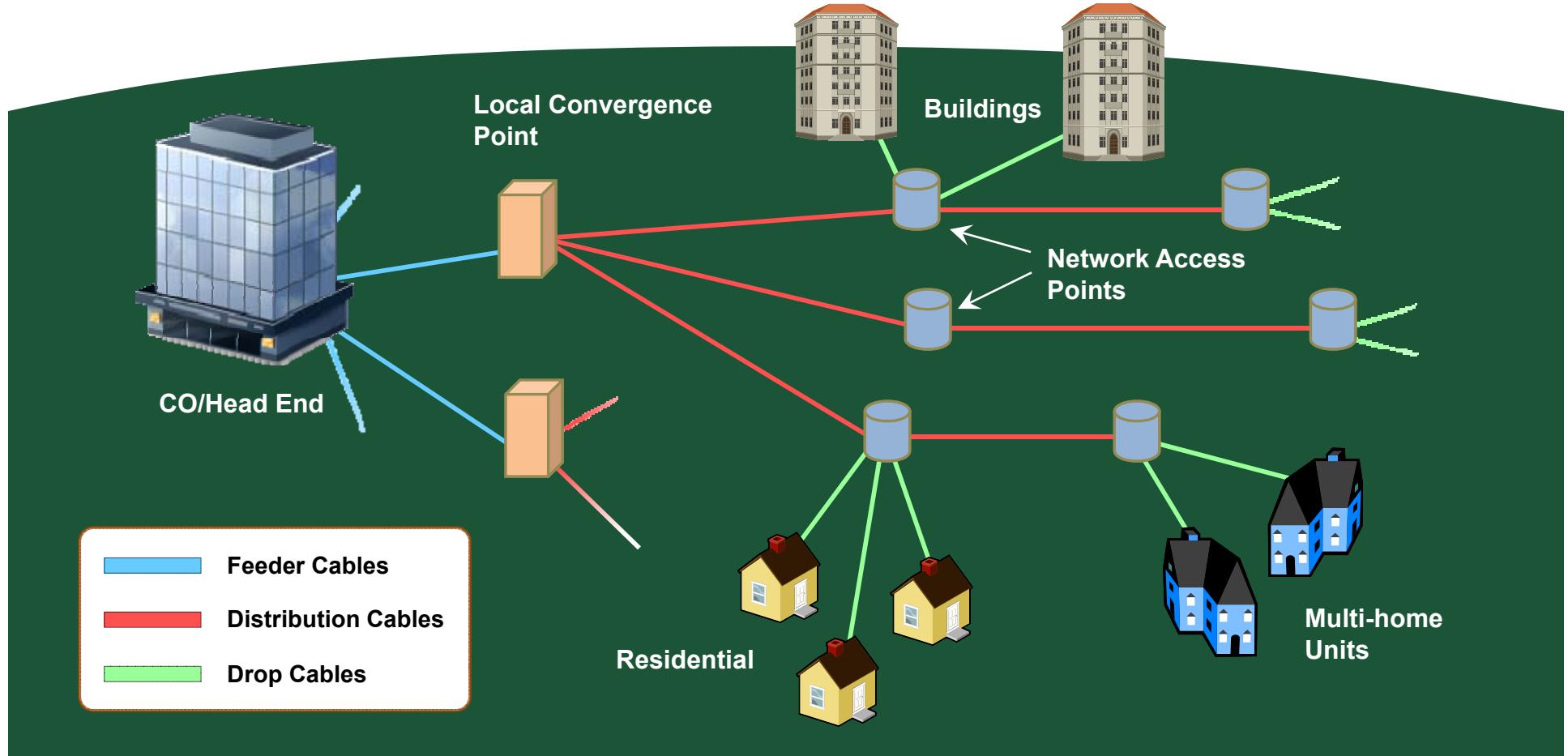


In a recent study by NTT-Advanced Technology, 98% of installers (blue) and 80% of network owners (red) reported that issues with connector contamination was the greatest cause of network failure.



Fiber Connectors Are Everywhere

Fiber optic connectors are common throughout the network, and they give you the power to add, drop, move and change the network.



Anatomy of Fiber Connector

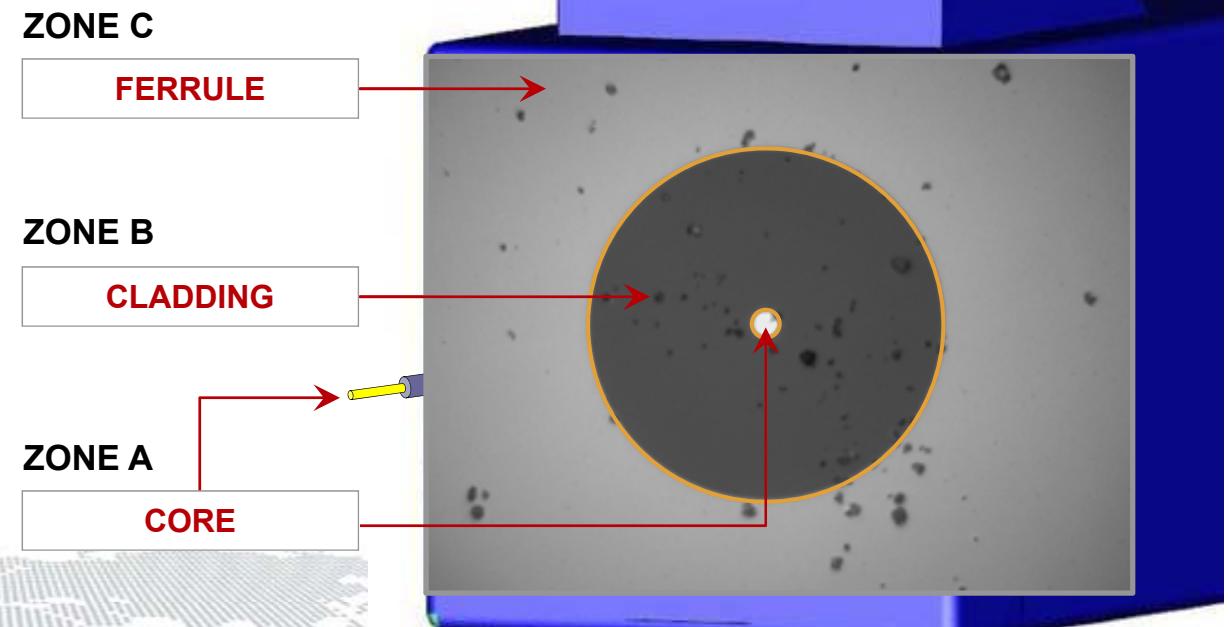
Light is transmitted and retained in the “**CORE**” of the optical fiber by *total internal reflection*.

Singlemode fibers carry a single ray of light, making them better in retaining the fidelity of light over long distances.

There are **3 major ZONES** on the end face that are used to define the level of impact contamination may have on signal performance. Particles closer to Zone A (Core) will have more impact than those farther out.

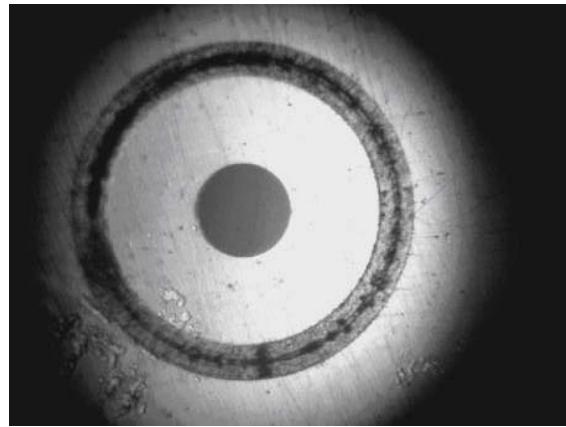
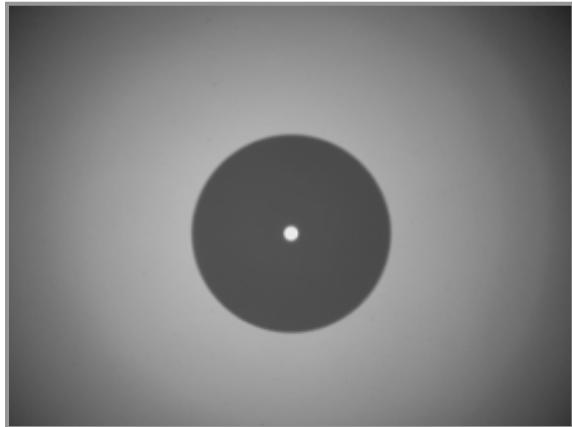
Singlemode Fiber Structure

Fiber End Face View

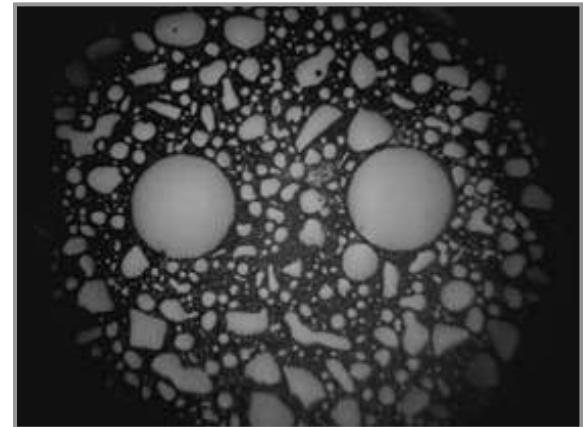
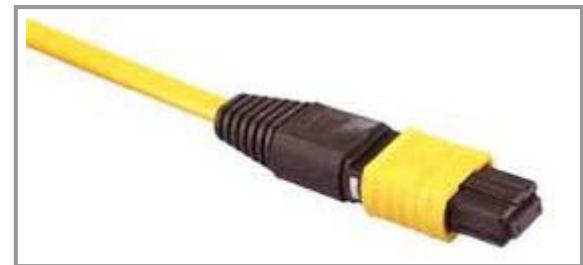


Simplex vs. Multi-fiber Connectors

SIMPLEX CONNECTOR



RIBBON CONNECTOR

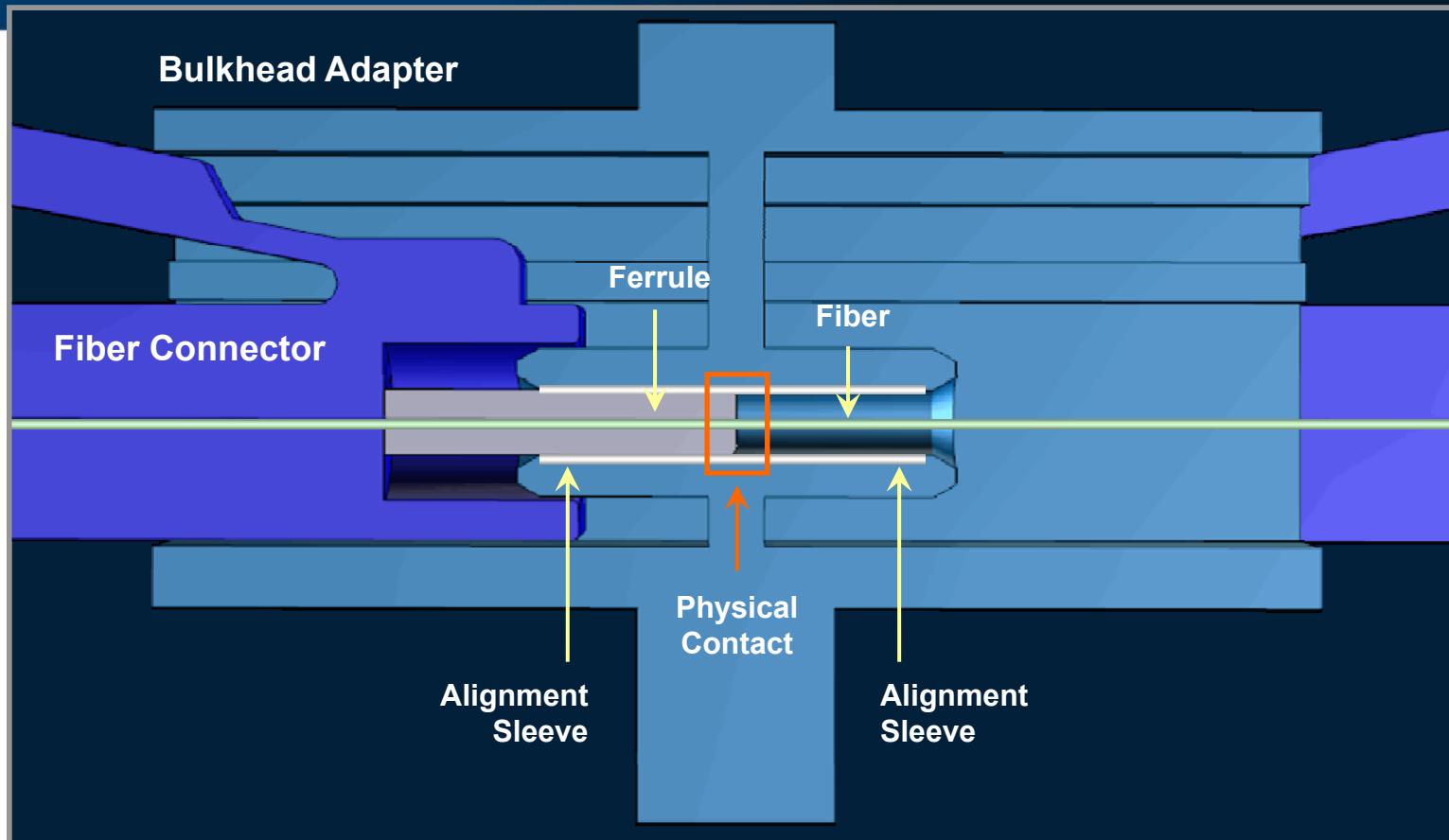


- White ceramic or metallic ferrule
- One fiber per connector
- Common types include SC, LC, FC, E2000 and ST

- Multiple fibers in linear array (8, 12, 24, 48, 72, etc.) in single connector providing high-density connectivity
- Includes MPO or MTP®

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Focused On the Connection



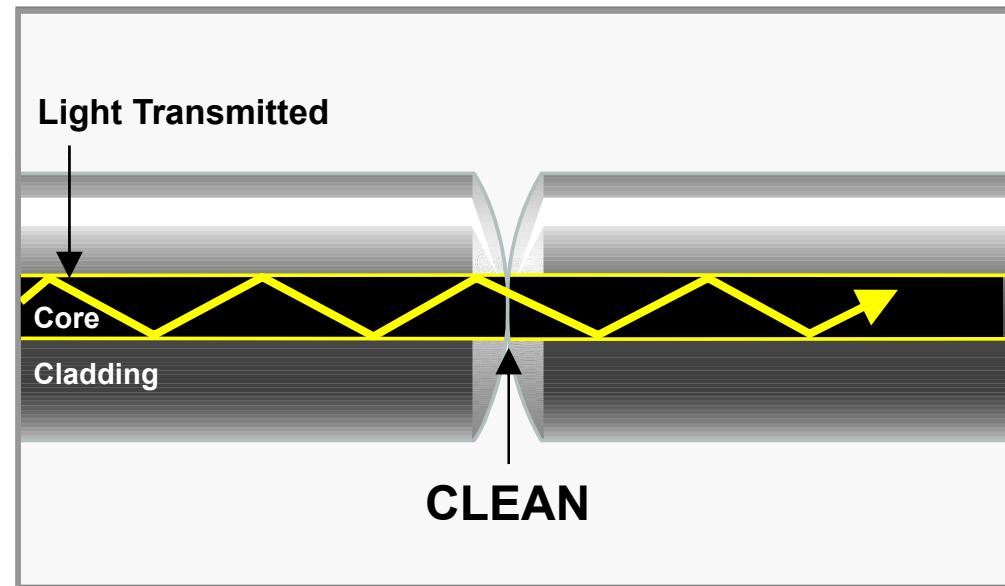
Fiber connectors are widely known as the **WEAKEST AND MOST PROBLEMATIC** points in the fiber network.



What Makes a GOOD Fiber Connection?

The **3 basic principles** that are critical to achieving an efficient fiber optic connection are “The 3 P’s”:

- 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.



Part II: Contamination

Understanding the effect on signal performance

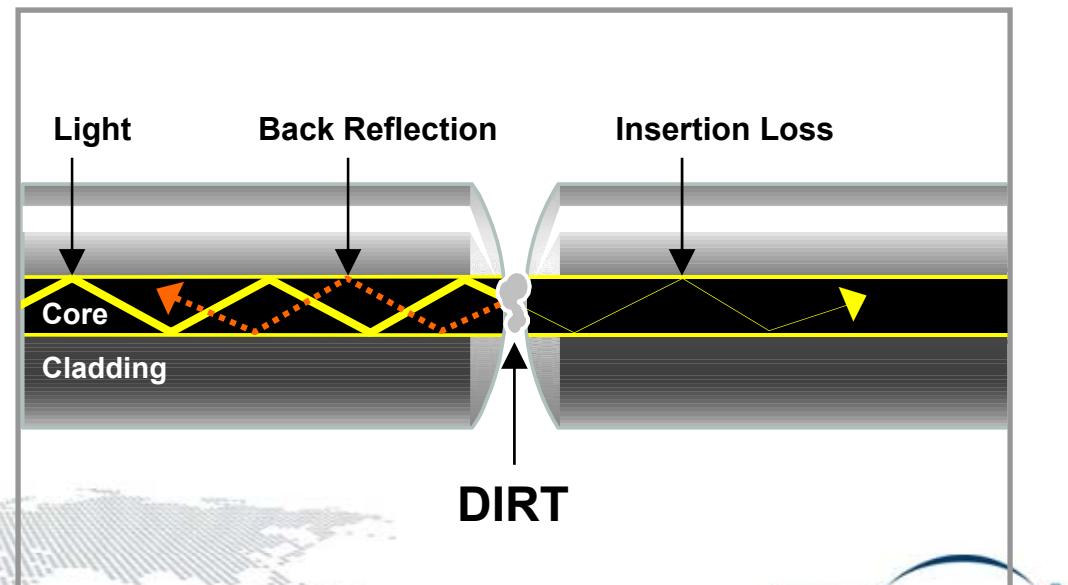


What Makes a BAD Fiber Connection?

Today's connector design and production techniques have eliminated most of the challenges to achieving **CORE ALIGNMENT** and **PHYSICAL CONTACT**.

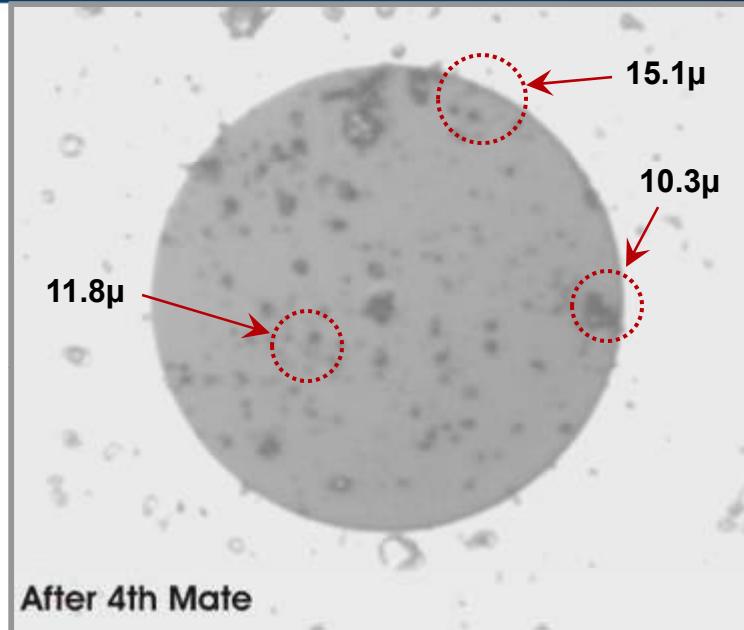
What remains challenging is maintaining a **PRISTINE END FACE**. As a result, **CONTAMINATION** is the #1 source of troubleshooting in optical networks.

- A single particle mated into the core of a fiber can cause significant **back reflection**, **insertion loss** and even **equipment damage**.
- Pressure is approx 50kpsi
 - similar to water jet cutters



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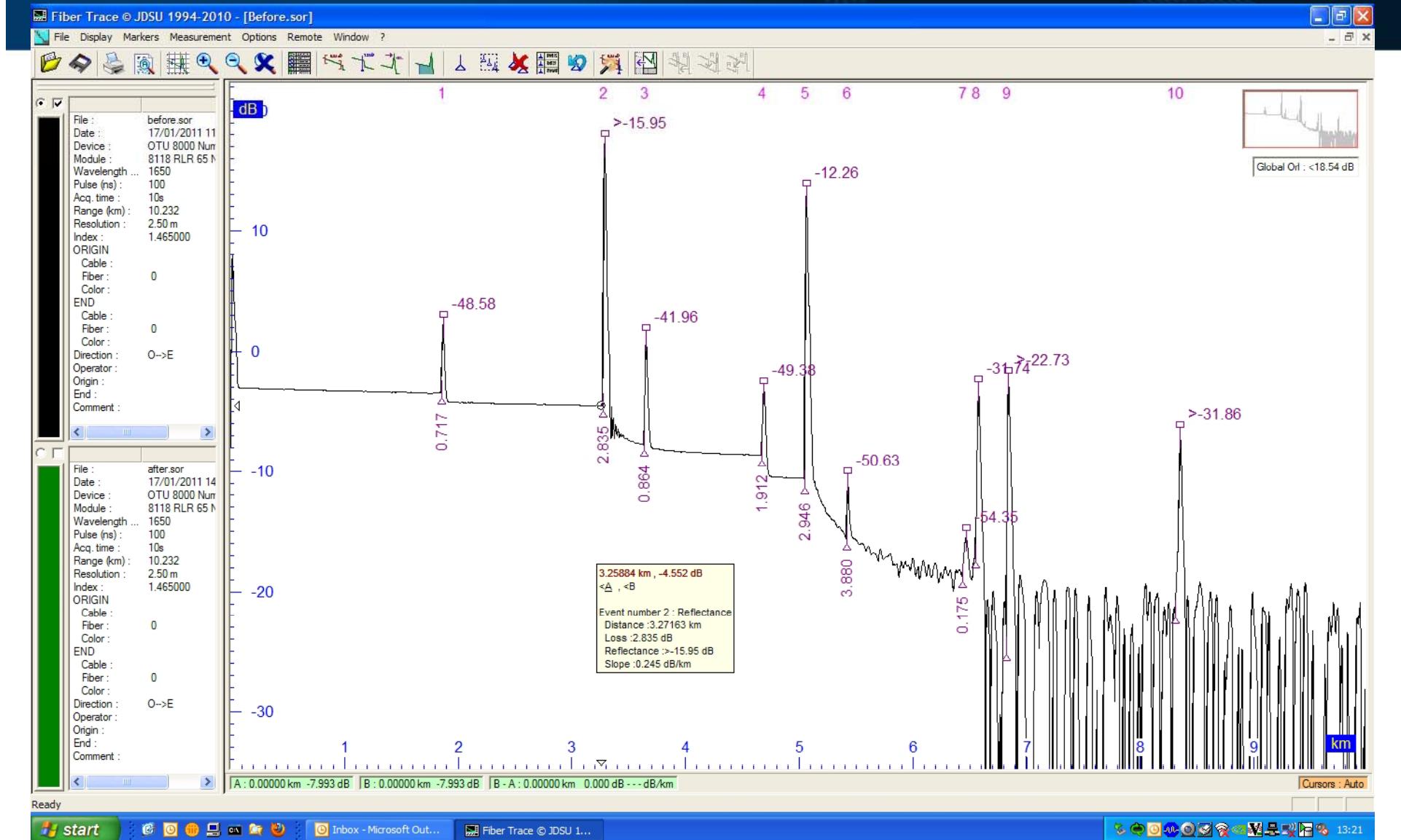
Illustration of Particle Migration



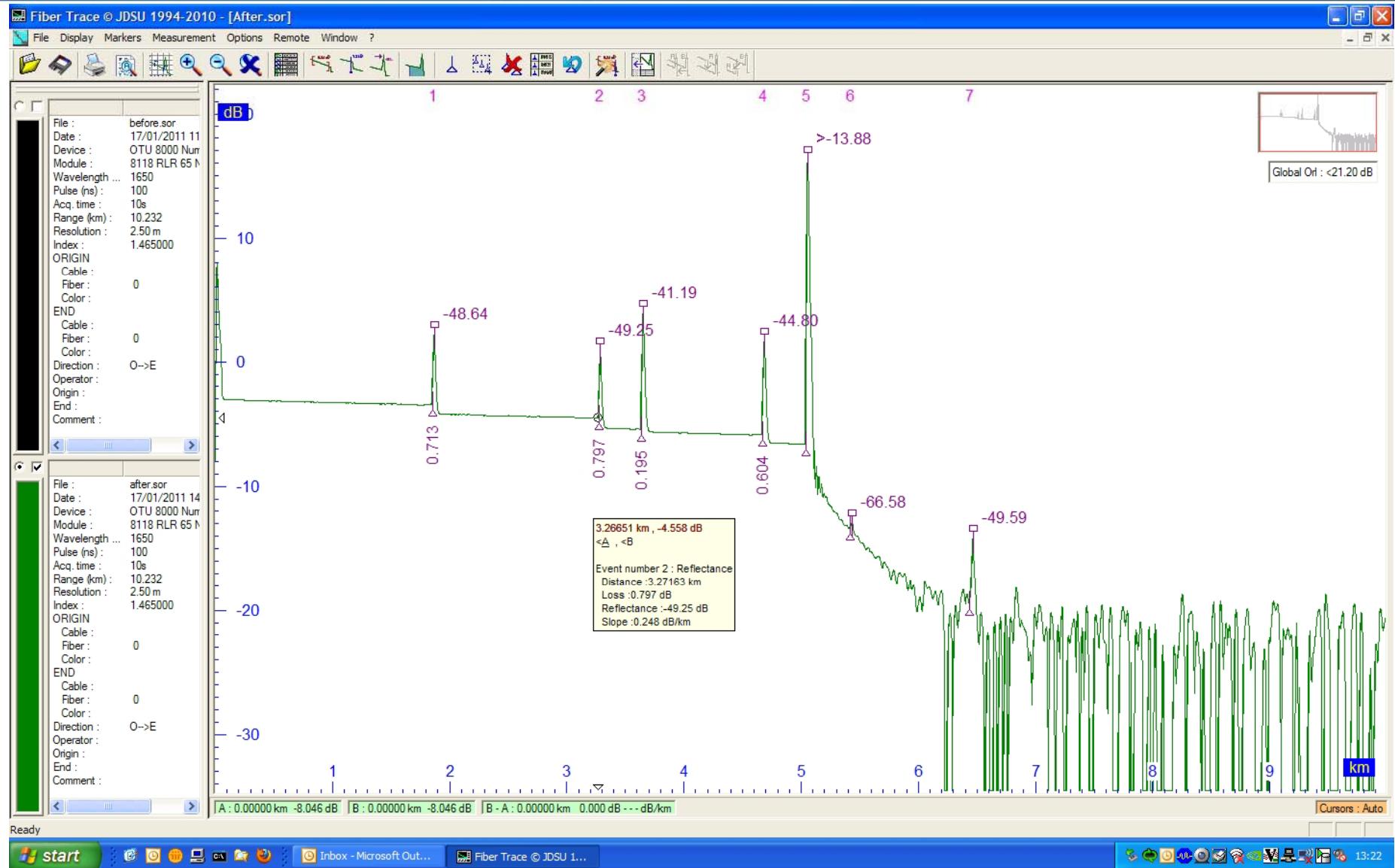
Actual fiber end face images of particle migration

- 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 5 μ m usually explode and multiply upon mating.
- Large particles can create barriers ("air gaps") that prevent physical contact.
- Particles less than 5 μ m tend to embed into the fiber surface, creating pits and chips.

Original OTDR Trace



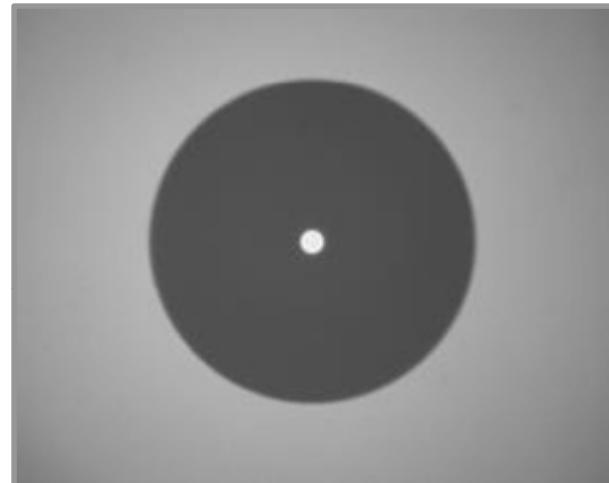
OTDR Trace after cleaning connector at event 2



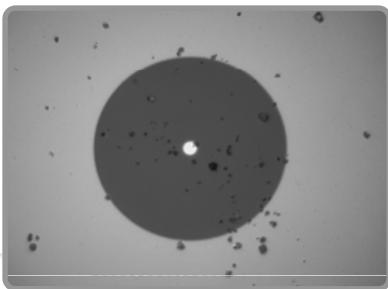
Types of Contamination

A fiber end face **should be free of any contamination or defects**, as shown below:

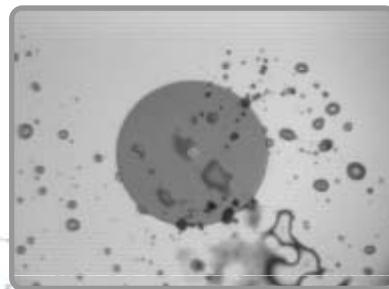
SINGLEMODE
FIBER



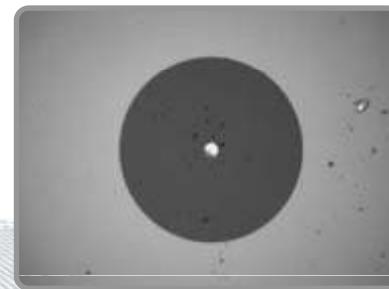
Common types of contamination and defects include the following:



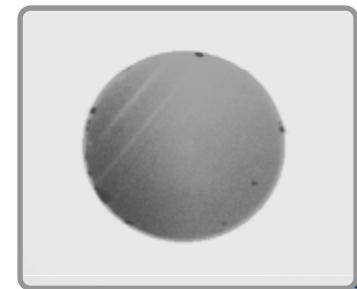
Dirt



Oil



Pits & Chips



Scratches

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Where is it? – Proliferation of Dirt

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.



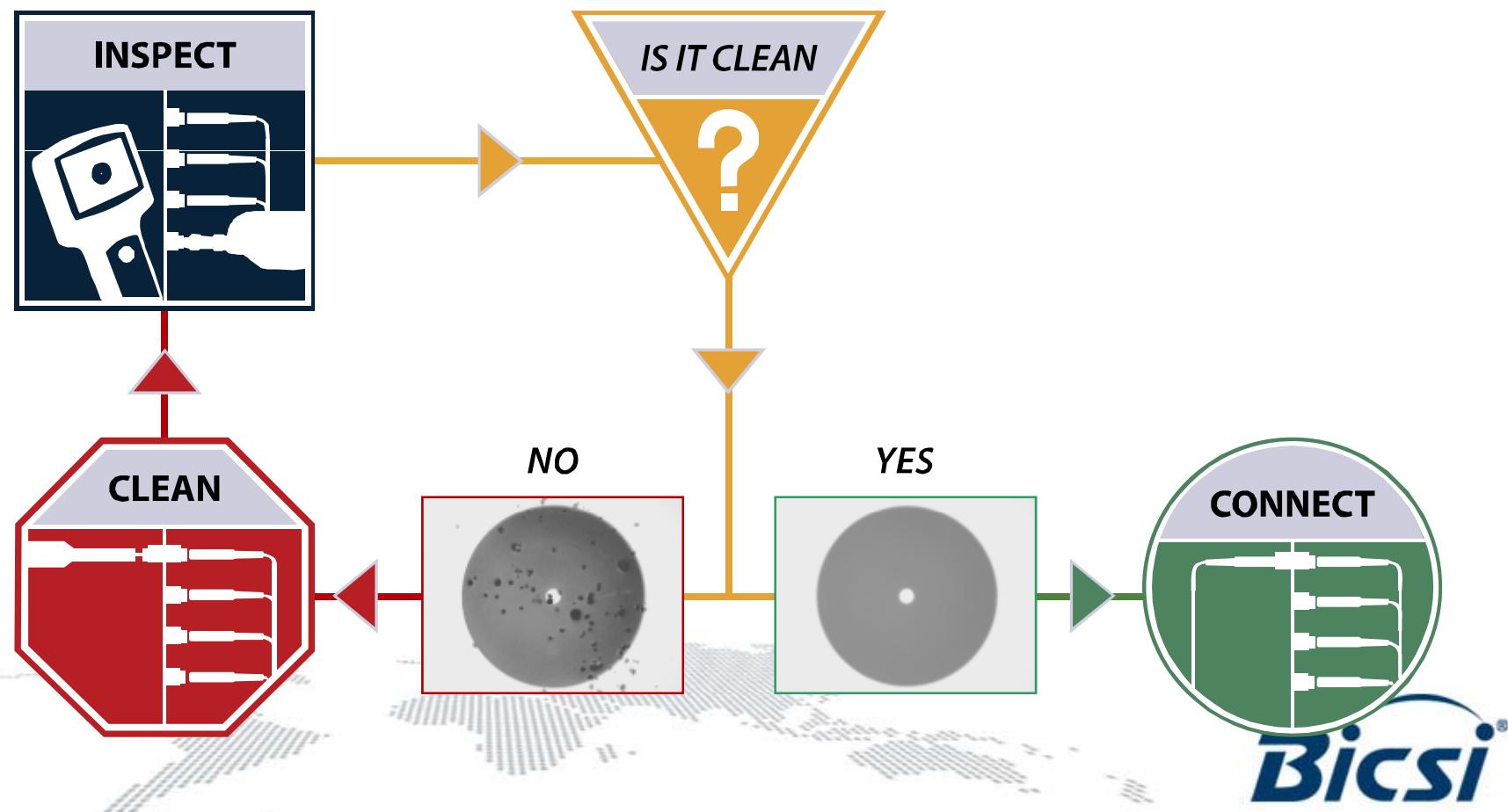
Part III: Simple Solution

Inspect Before You Connect



Inspect Before You Connectsm

Follow this simple “**INSPECT BEFORE YOU CONNECT**” process to ensure fiber end faces are clean prior to mating connectors.



Inspect, Clean, Inspect, and Go!

Fiber inspection and cleaning are SIMPLE steps with immense benefits.

1 Inspect



2 Clean



3 Inspect



4 Connect



- Use a probe microscope to **INSPECT** the fiber.
 - **If the fiber is dirty**, go to step 2, cleaning.
 - **If the fiber is clean**, go to step 4, connect.

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

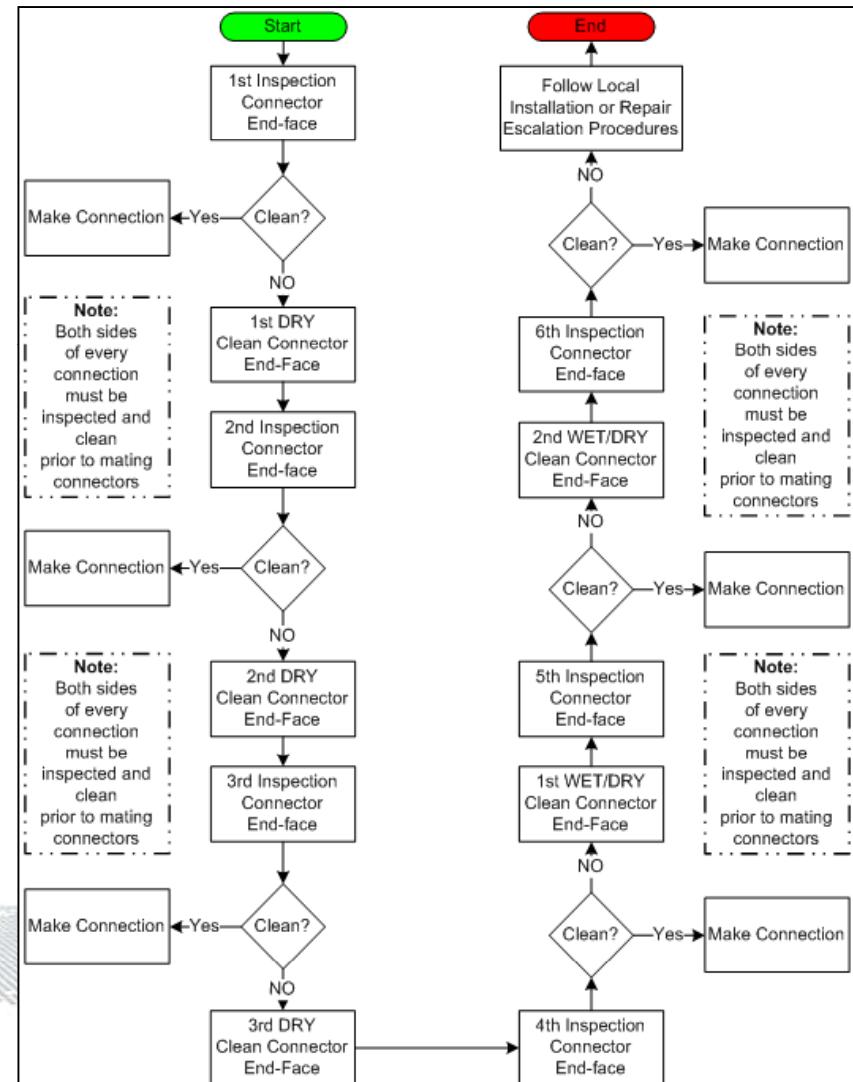
- Use a probe microscope to **RE-INSPECT** (confirm fiber is clean).
 - **If the fiber is still dirty**, go back to step 2, cleaning.
 - **If the fiber is clean**, go to step 4, connect.

- 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.



Procedure Example – AT&T

- This workflow chart comes from AT&T Document ATT-TP-76461 titled “AT&T Fiber Optic Connector and Adapter Inspection and Cleaning Standards” - in the public domain.
- AT&T’s procedures call for continual inspection and cleaning.
- AT&T procedures starts with dry cleaning connectors for the first three cleanings.



Inspect and Clean Both Connectors in Pairs!

Inspecting BOTH sides of the connection is the **ONLY WAY** to ensure that it 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, which is frequently overlooked. The bulkhead side may only be half of the connection, but it is far more likely to be dirty and problematic.



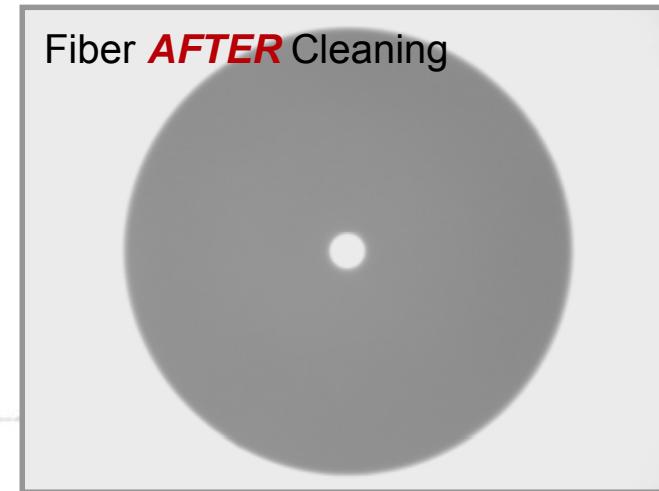
Proactive vs. Reactive Inspection

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.

Fiber **AFTER** Cleaning



REACTIVE INSPECTION:

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

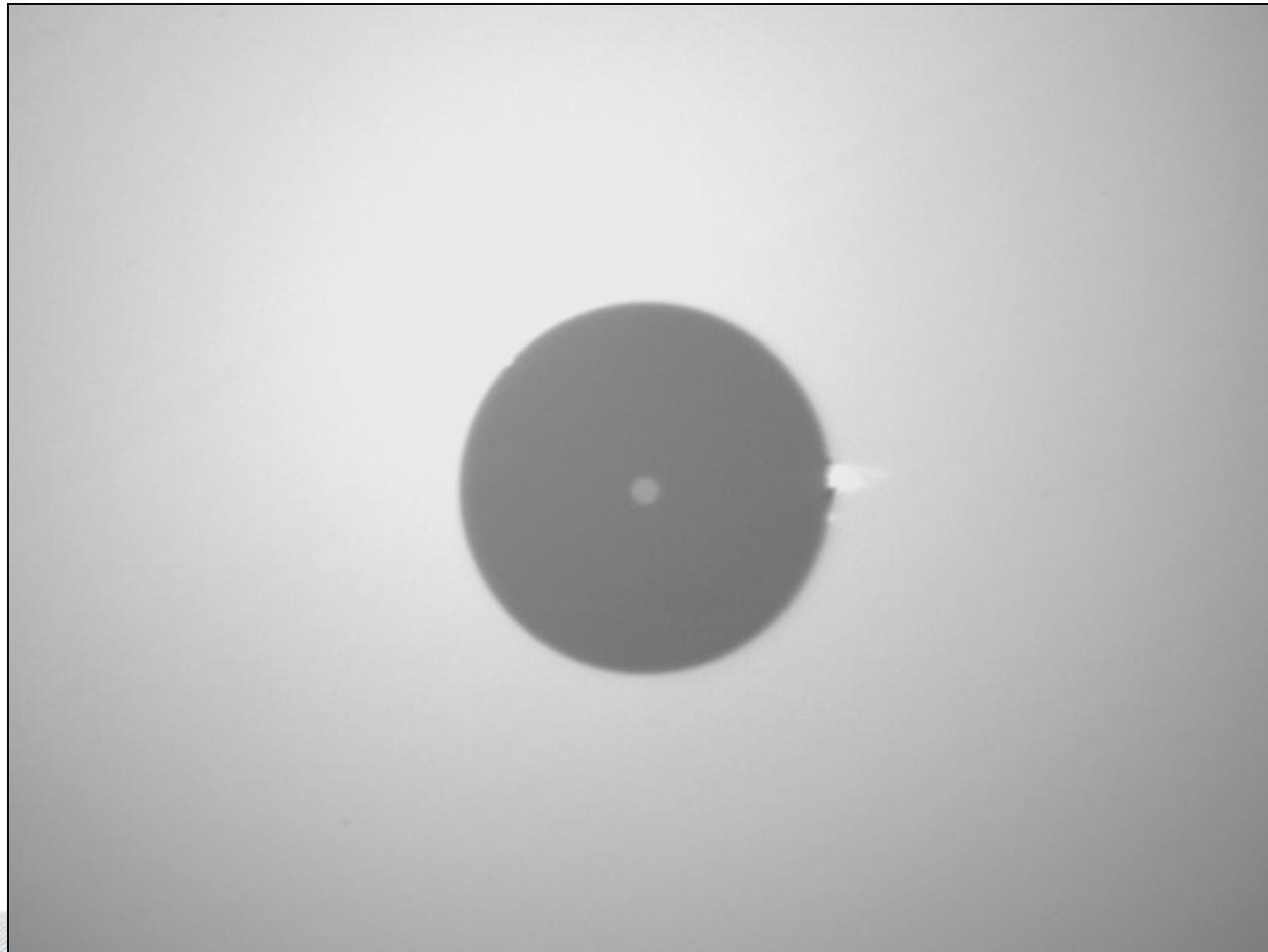
By this time, connectors and other equipment may have suffered permanent damage.

Fiber **AFTER** Mating and Numerous Cleanings



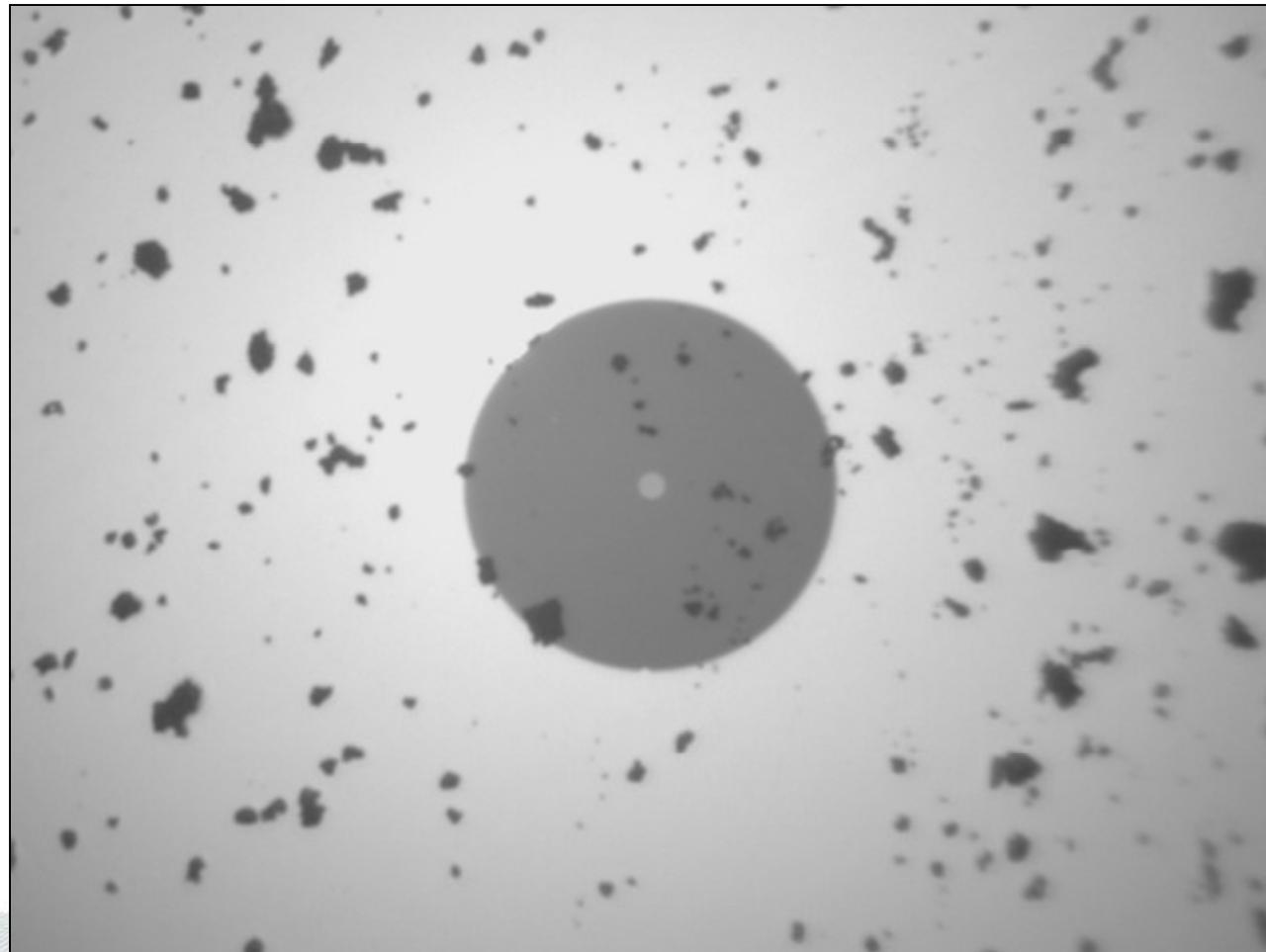
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Connector #1 - Clean



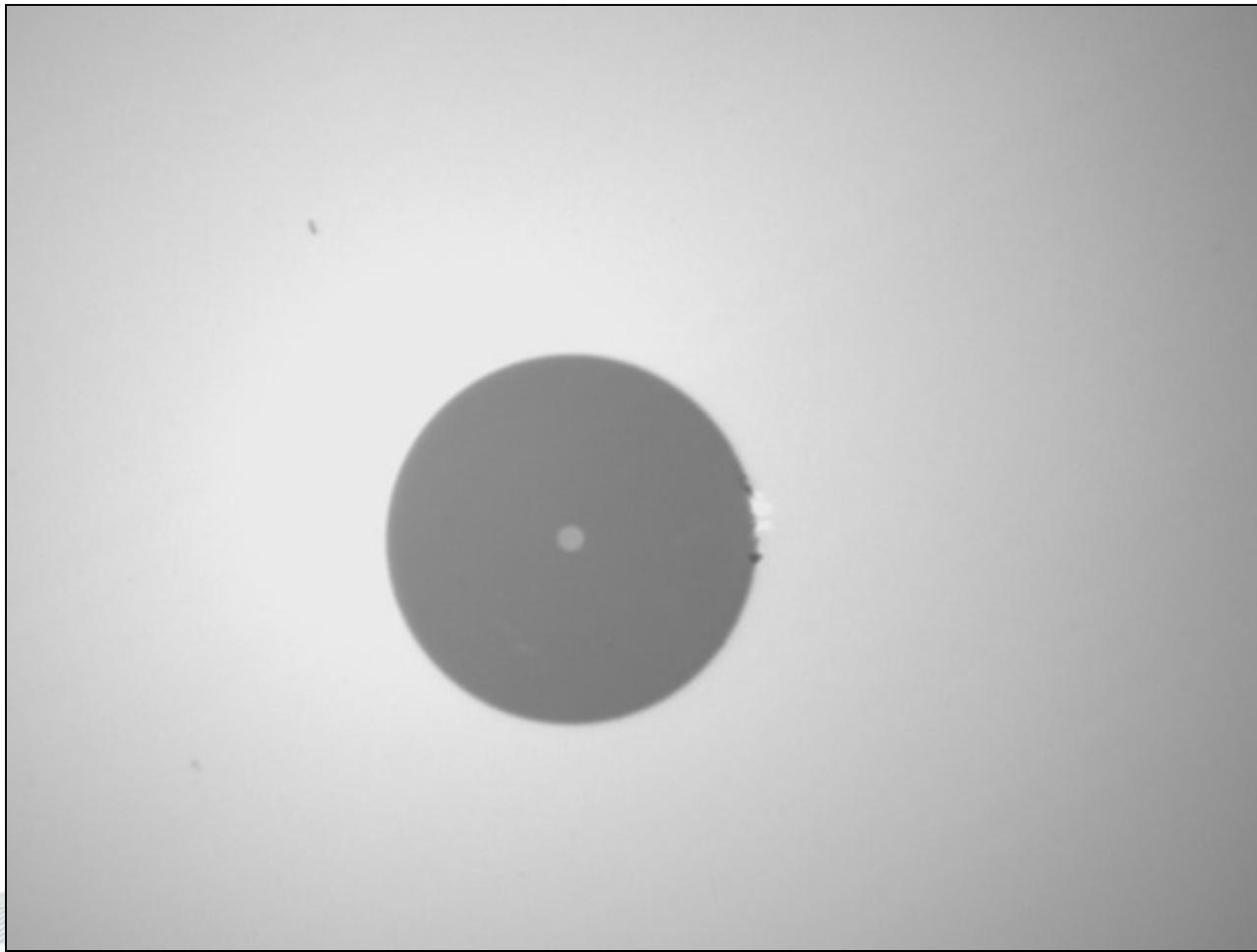
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Connector #1 – Loose Contamination



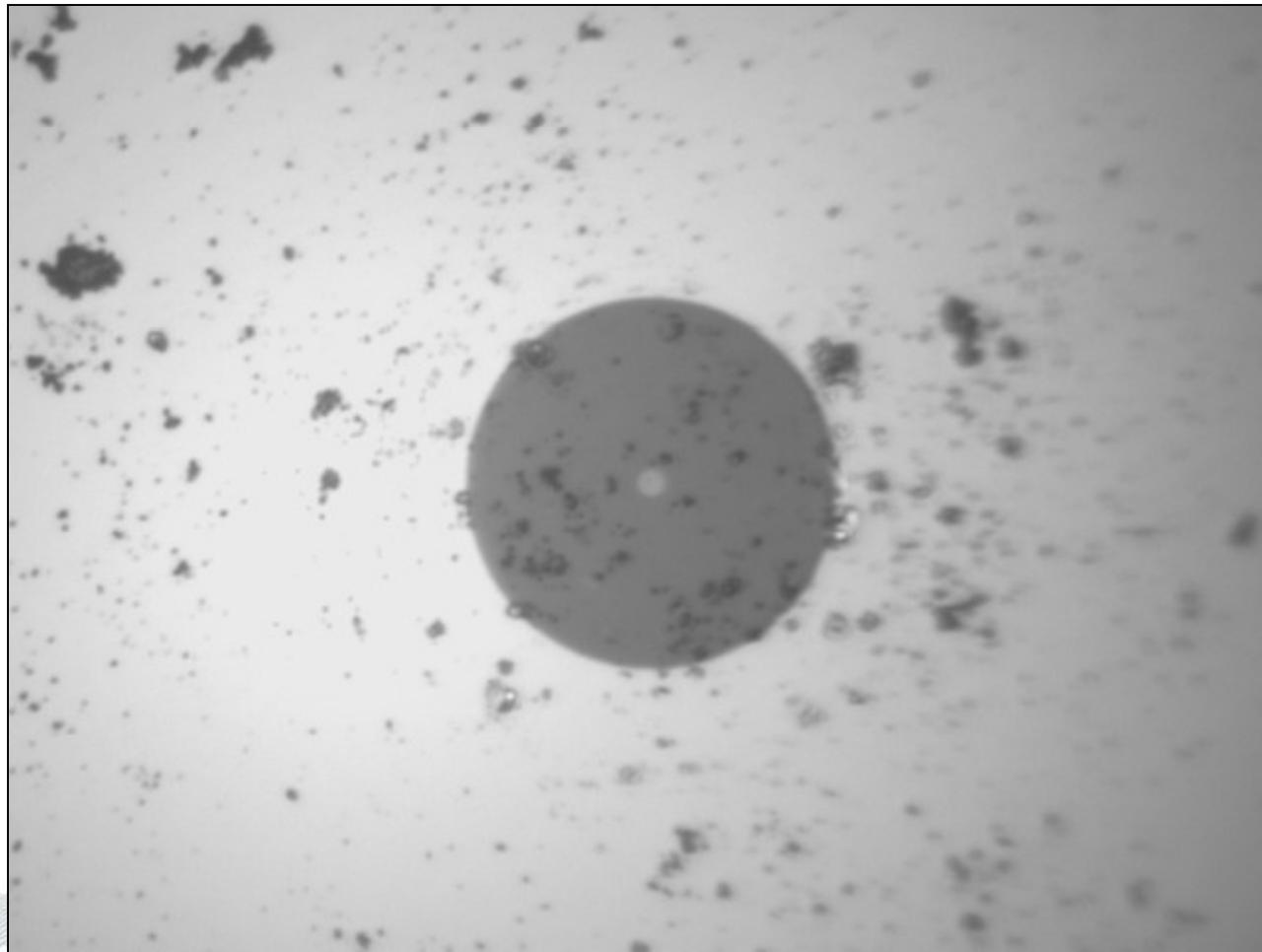
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Connector #2 - Clean



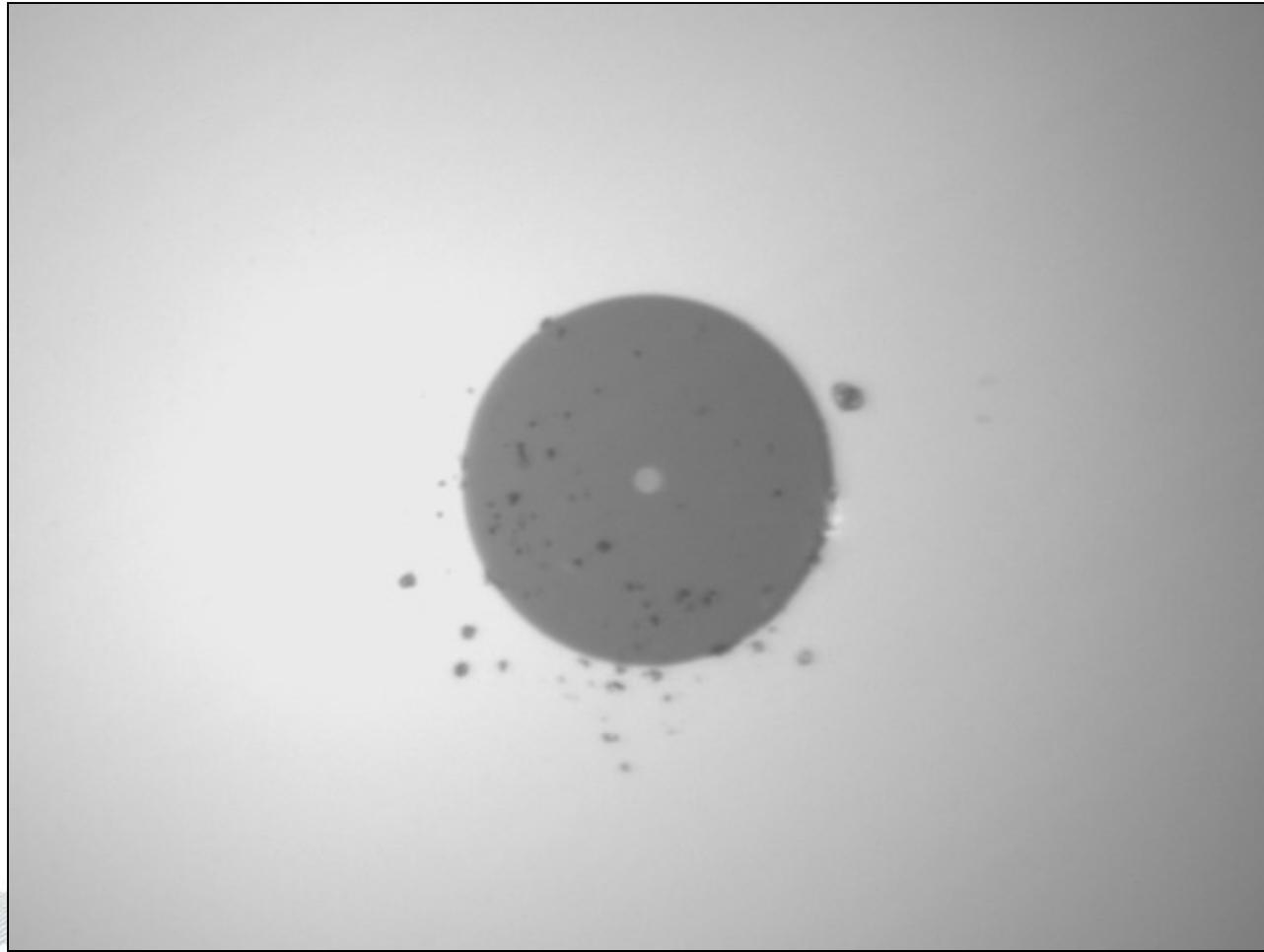
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Connector #2 – After One Connection



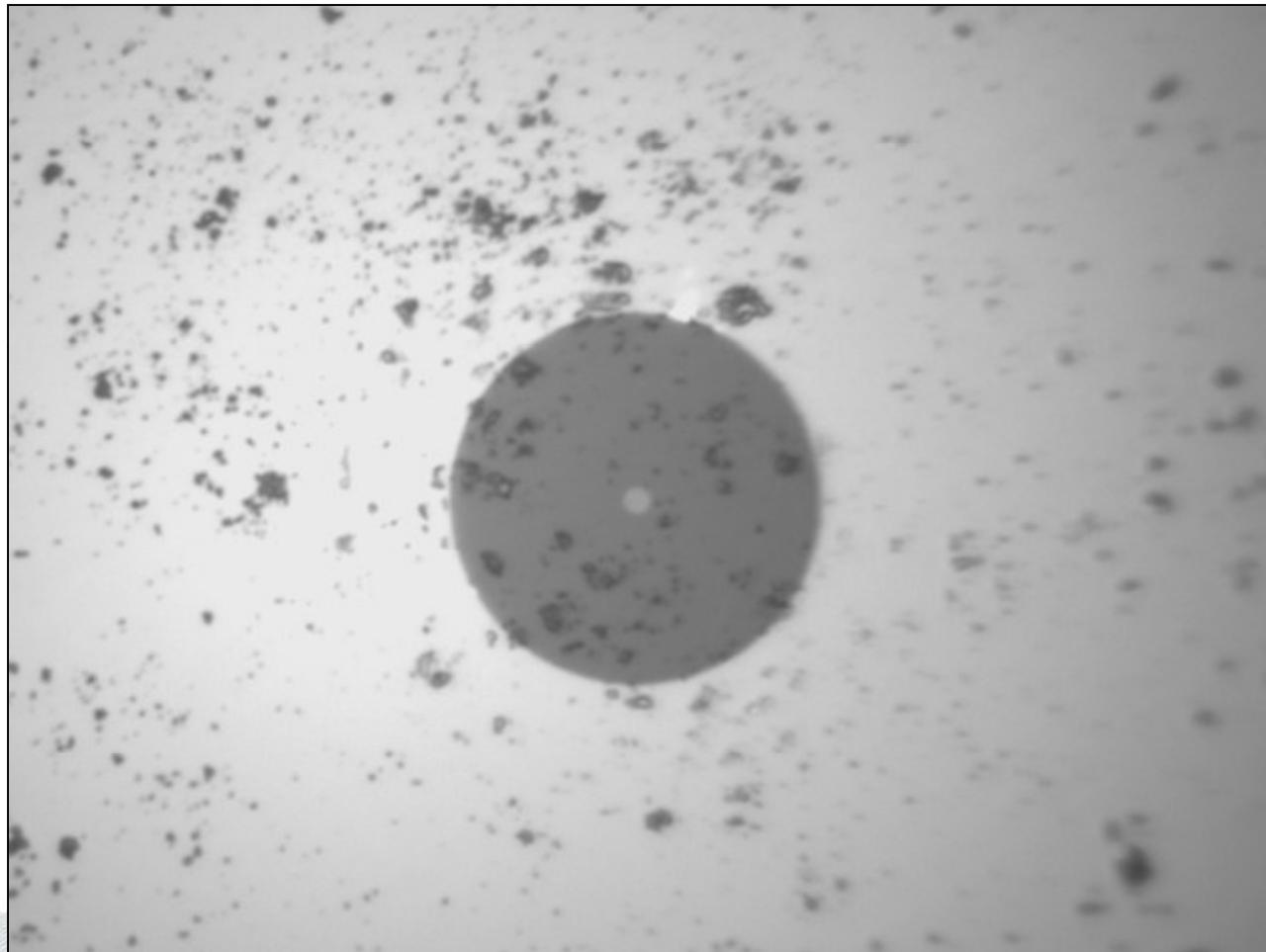
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Connector #2 – After Repeated Cleaning

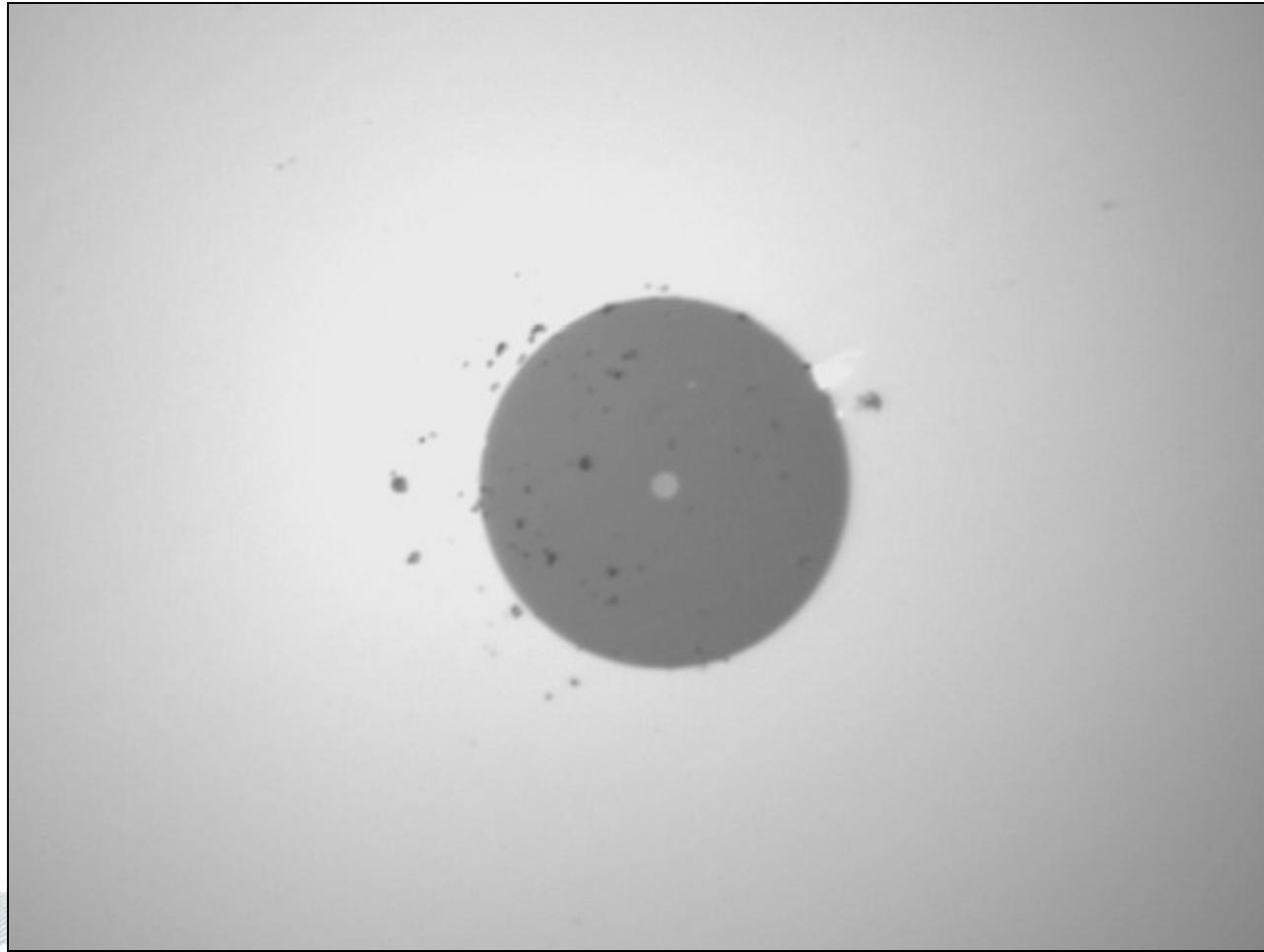


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Connector #1 – After One Connection



Connector #1 – After Repeated Cleaning



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Part IV: 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

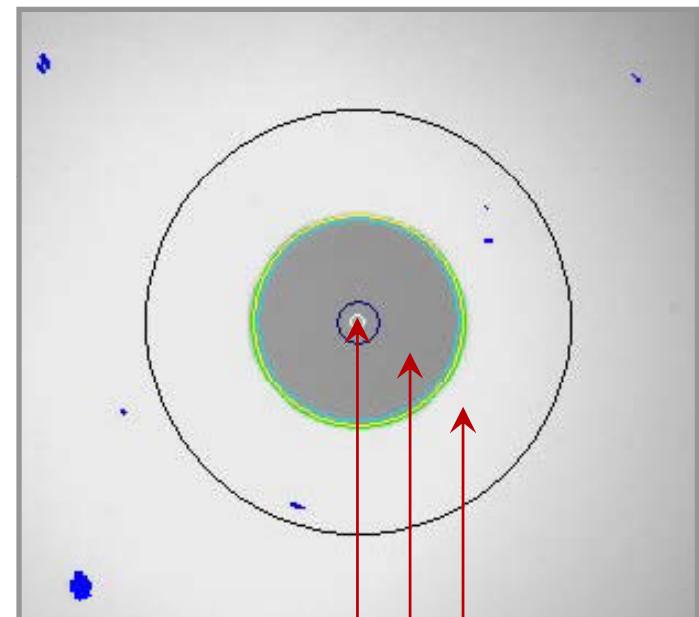
Zone C: Adhesive Zone

Zone D: Contact Zone

- Different **failure criteria** for defects and scratches are specified for each zone:

- **Quantity** and **Size**

- **Location** relative to core



Zone A

Zone B

Zone D

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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

The BICSI logo is located in the bottom right corner of the slide. It consists of the word "BICSI" in a bold, blue, sans-serif font, with a stylized blue swoosh graphic extending from the letter "i".

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

Zone Name (diameter)	Scratches	Defects
A, Core Zone (0-25µm)	< 4 scratches	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

Recommended Acceptance Criteria for MM-PC Connectors (IEC 61300-3-35)

Zone Name (diameter)	Scratches	Defects
A, Core Zone (0-65µm)	none > 3µm width	$4 \leq 5\mu\text{m}$ none > 5µm
B, Cladding Zone (65-120µm)	none > 5µm 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

The BICSI logo is located in the bottom right corner of the slide. It consists of the word "BICSI" in a bold, blue, sans-serif font, with a registered trademark symbol (®) to the top right of the letter "i". Below the text, there is a stylized graphic element consisting of several curved, greyish-blue lines of varying lengths that converge towards the right side of the logo.

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

Zone Name (diameter)	Scratches	Defects
A, Core Zone (0-25µm)	none	none
B, Cladding Zone (25-115µm)	none > 3µm width	no limit < 2µm 5 from 2 - 5µm none > 5µm

Criteria must be applied to all fibres in the array for functionality of any fibres in the array



Recommended Acceptance Criteria for MM-PC Ribbon Fiber Connectors (IEC 61300-3-35)

Zone Name (diameter)	Scratches	Defects
A, Core Zone (0-65µm)	none > 3µm width	$4 \leq 5\mu\text{m}$ none > 5µm
B, Cladding Zone (65-115µm)	none > 5µm width	no limit < 2µm 5 from 2 - 5µm none > 5µm

Criteria must be applied to all fibres in the array for functionality of any fibres in the array



Where is IEC-61300-3-35 Referenced?

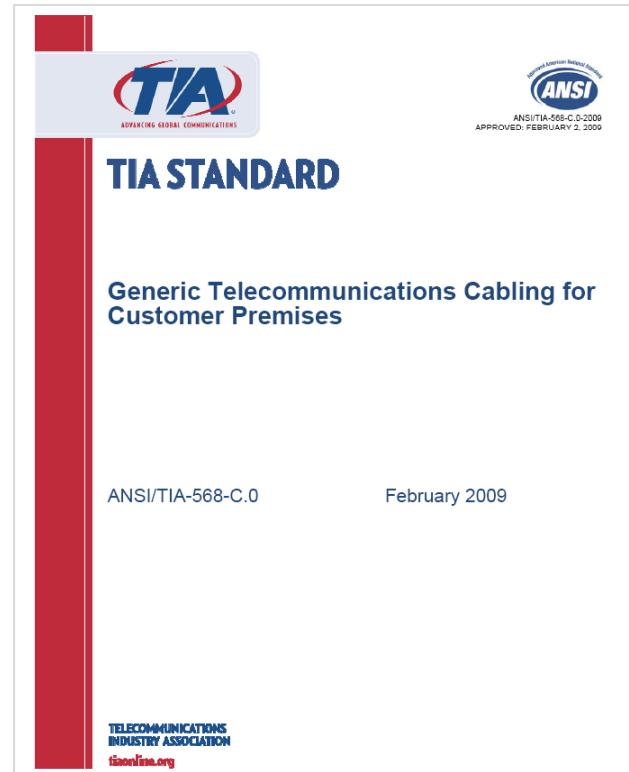
- **TIA-568-C.0**
 - **Referenced in test procedures**
- TIA-526-7 / IEC 61280-4-1
 - Insertion loss testing of multimode fiber optic cabling
- TIA-526-14B / IEC 61280-4-2
 - Insertion and return loss testing of singlemode fiber optic cabling
- ISO/IEC 11801
 - References ISO/IEC 14763-3 for all fiber testing
- ISO/IEC 14763-3
 - Testing fiber optic cabling in premises networks
- IEC 61280-4-4 Ed.2
 - PMD testing of installed fiber optic cabling
- IEC 61757-1
 - International Standard for fiber optic sensors
- ITU-T G.650.3
 - ITU Recommendation for fiber characterization
- Purchasing specifications & work instructions



Fibre Test Standards for the Premise

Overview: TIA-568-C.0

- “*The foundation for premises telecommunications cabling infrastructure*”
- Includes cabling **transmission performance** and **test requirements** for BOTH twisted-pair and Optical Fibre
- Includes test guidelines that are described in an informative annex
 - Tier 1 Certification
 - Extended Testing (Tier 2)
- Next release is scheduled for release later this year



568-C and Connector Quality

The test procedures specified by 568-C require tools and procedures for ensuring connector quality



- End faces on test cords shall be accordance to IEC 61300-3-35
- Use a microscope that is compatible with IEC 61300-3-35
- The microscope must use adapters that are compatible with connectors

5.7 Connector end-face cleaning and inspection equipment

Cleaning equipment (including apparatus, materials, and substances) and the methods to be used shall be suitable for the connectors to be cleaned. Connector suppliers' instructions shall be consulted where doubt exists as to the suitability of particular equipment and cleaning methods.

A microscope compatible with IEC 61300-3-35, low resolution method, is required to verify that the fibre and connector end faces of the test cords are clean and free of damage. Microscopes with adaptors that are compatible with the connectors used are required.

The next update of 568-C will include explicit details about the inspection requirements in Annex E (testing)



Summary

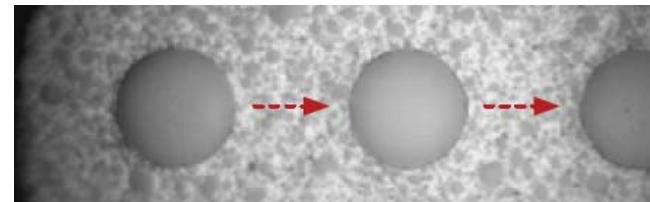
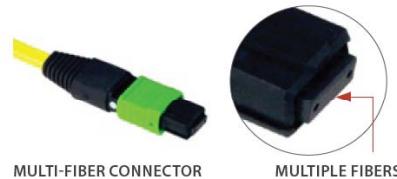
- Connectors are valuable and essential, but they must be handled properly.
- **CONTAMINATION** is the #1 source of troubleshooting in optical networks.
- This challenge is easily overcome with proactive inspection and cleaning.
- Visual inspection of fiber optic connectors with a microscope is the only 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**”



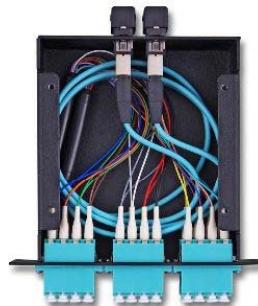
Backup slide

Multi-Fiber Push-on/Pull-off (MPO)

- Multiple fibres in linear array (more fibres in same space!)
 - 8,12,24,48, etc.
 - MTP is an enhanced MPO connector



- Often used in breakout cassette



- Or used direct
 - 12 fibres (40G - 4 lanes, 8 active fibres)
 - 24 fibres (100G - 10 lanes, 20 active fibres)



Backup slide

Application Specific Performance Requirements

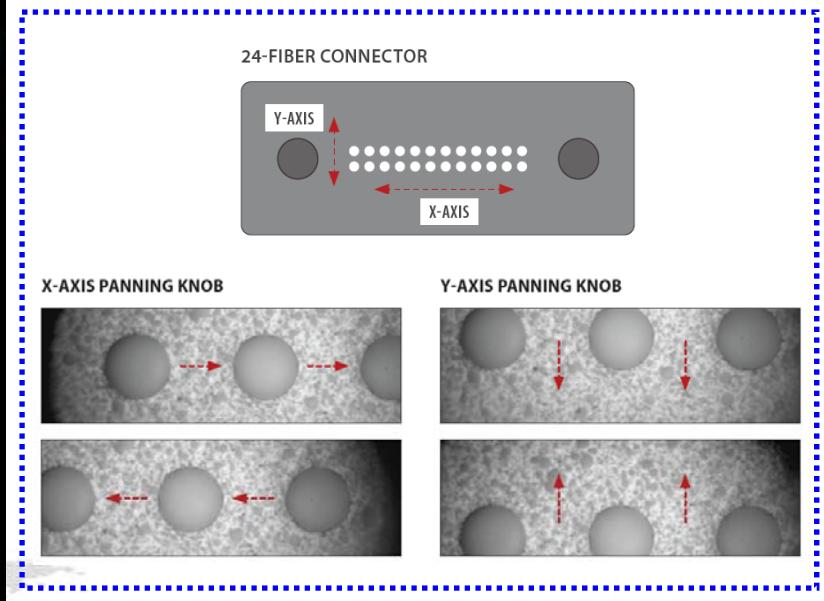
Cable Type	Wavelength	1GBE		10GBE		40 /100GBE	
		Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)
OM1	850	2.6	275	2.4	33	n/a	n/a
	1300	2.3	550	2.5	300	n/a	n/a
OM2	850	3.6	550	2.3	82	n/a	n/a
	1300	2.3	550	2.0	300	n/a	n/a
OM3	850	4.5	1000	2.6	300	1.9	100
	1300	2.3	550	2.0	300	n/a	n/a
OM4	850	4.8	1100	3.1	1100	1.5	150
	1300	2.3	550	2.0	300	n/a	n/a

Note: Ethernet standards limit 1GBE to 550 m and 10GBE to 300m. Some vendors allow greater distances



Backup slide: Ribbon connector inspection

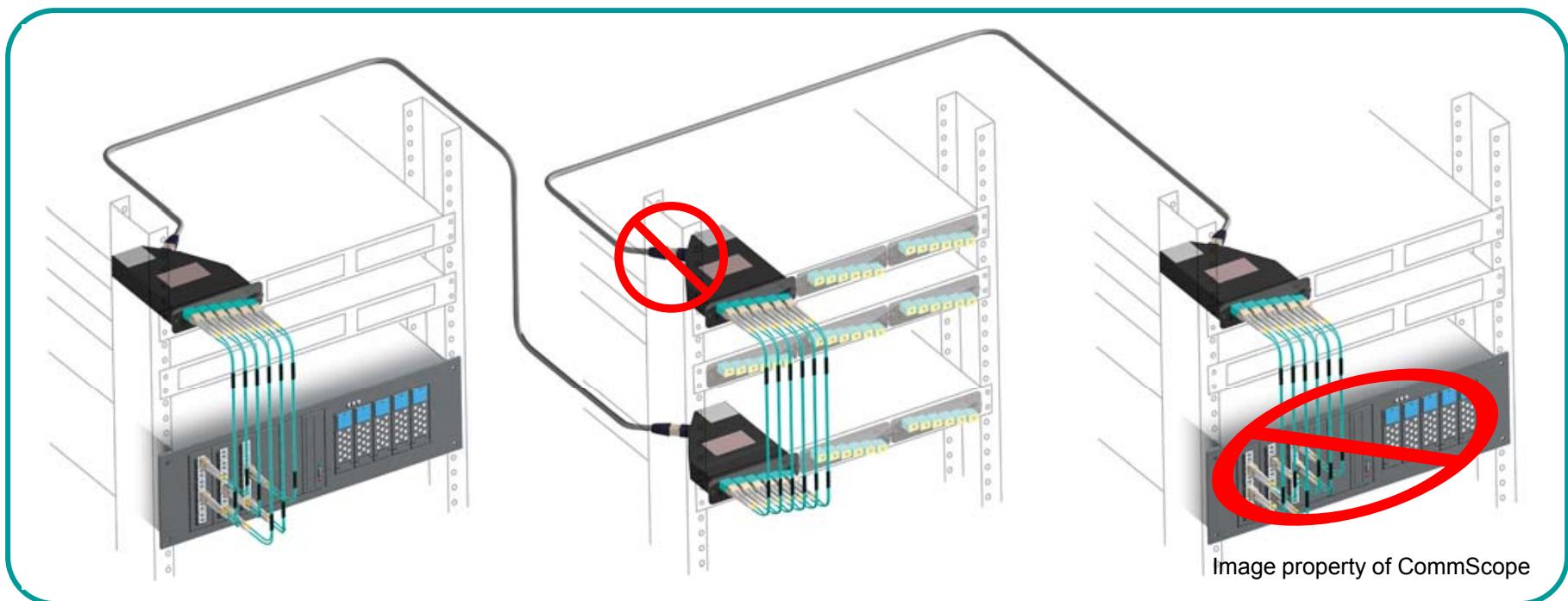
- MPO cassettes add connections and associated loss
 - One connector, multiple fiber end-faces – troubleshooting nightmare in live network



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Backup slide: Exponential Impact

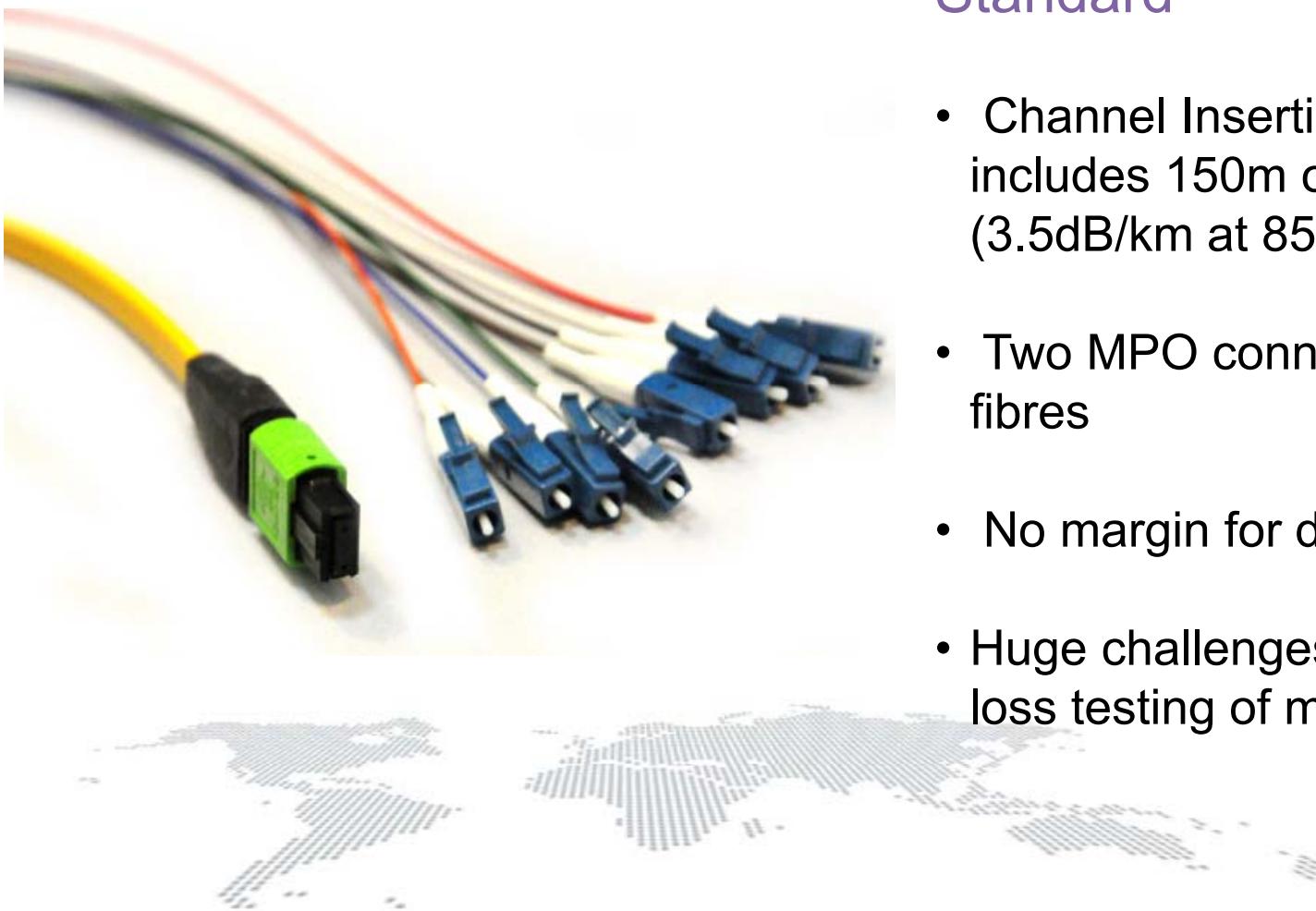
CONTAMINATION is the #1 source of troubleshooting in optical networks



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

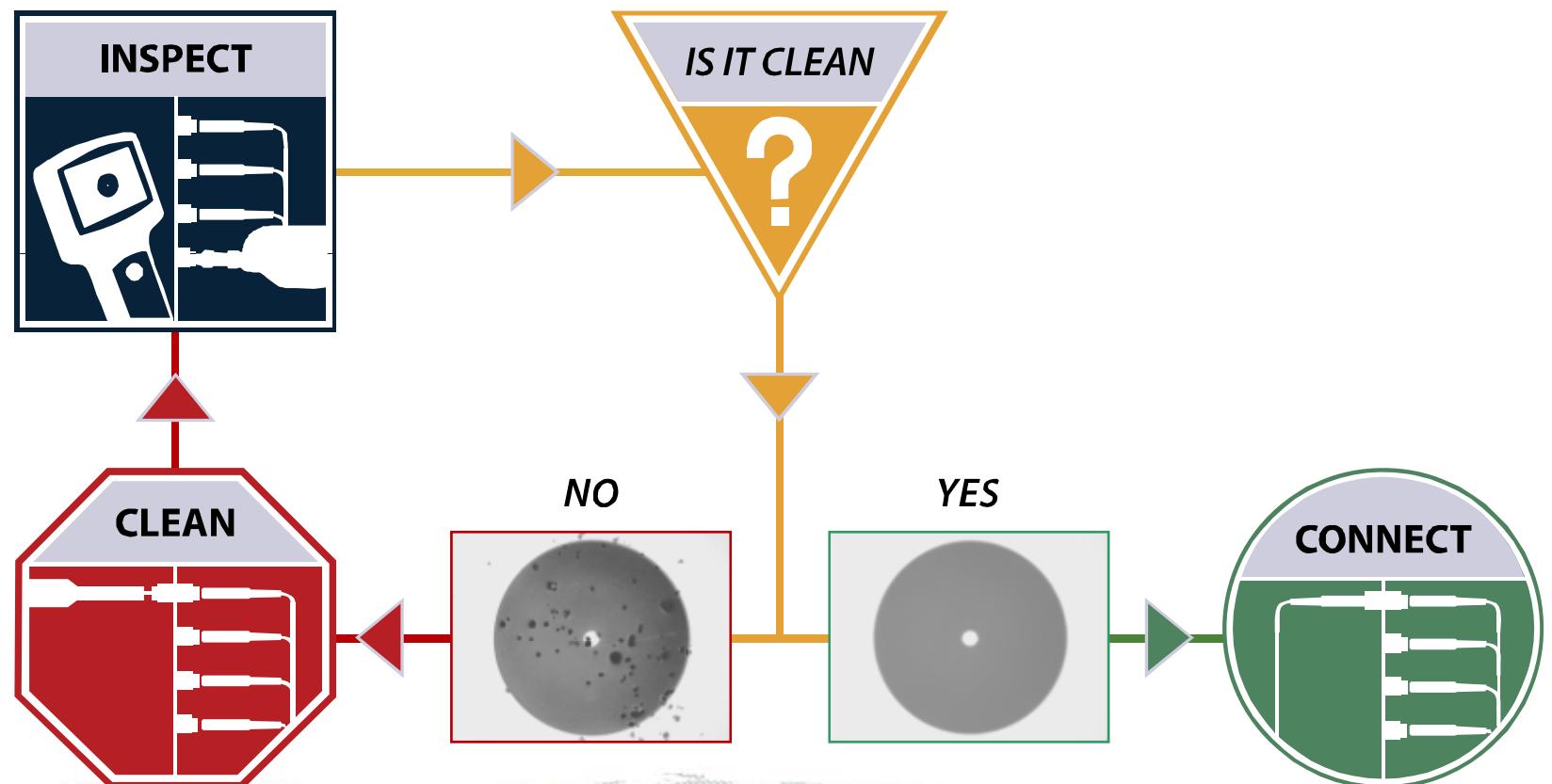
Backup slide: Data Centre – 40 or 100GBASE-SR10

From the IEEE802.3ba
Standard



- Channel Insertion Loss 1.5dB, includes 150m of OM4 fibre (3.5dB/km at 850nm)
- Two MPO connectors – 8 or 20 fibres
- No margin for dirty connectors
- Huge challenges exist with insertion loss testing of multi fibre cables

Inspect Before You Connectsm

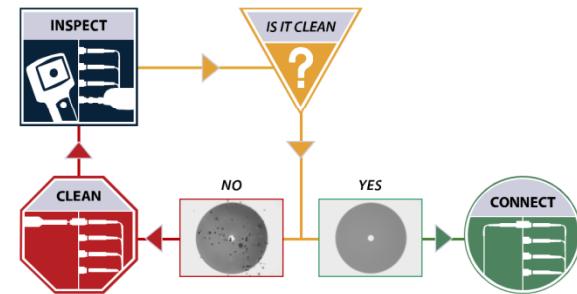


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Backup slide

Fibre Optic Cleaning

- Apply **IBYC** always!
 - Even with brand new patchords
- Cleaning process
 - Start with dry cleaning
 - If particles are stubborn, use a wet cleaning process
 - IPA not an ideal solvent
 - Always finish up with dry cleaning!
- Don't reuse your cleaning tools (i.e. wipes)
- Use the right tool for the job





*Any questions?
Thank you!*

