



Inspect Before You Connectsm

Layer 0 “Pre-Troubleshooting”

NANOG49

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San Francisco, CA

Inspect Before You Connectsm

- **Inspection Overview**
- **Fiber Optic Connectors**
- **Contamination**
- **Sources of Contamination**
- **Simple Solution**
- **Summary**



Inspection Overview – Microscopes

DIRECT-VIEW SCOPE



BENCH SCOPE



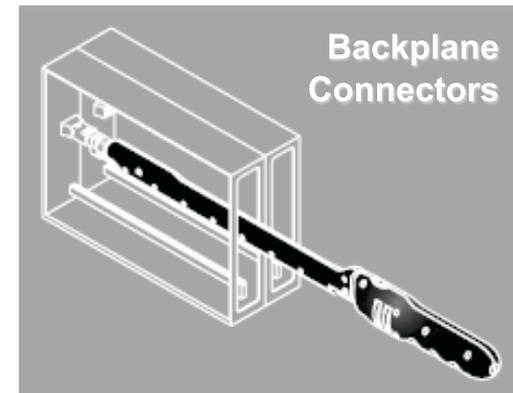
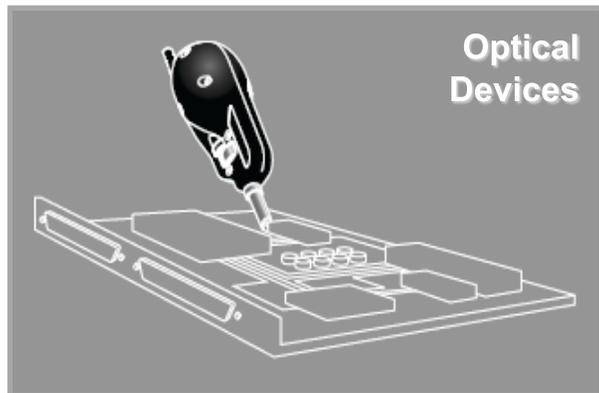
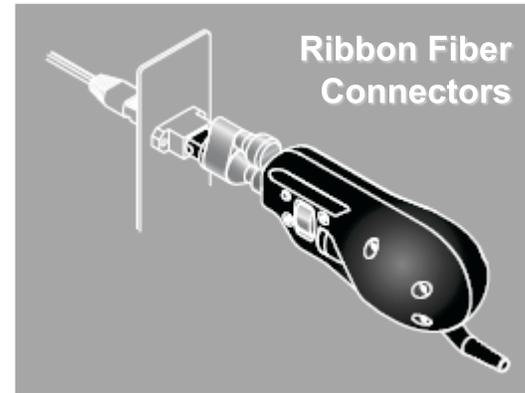
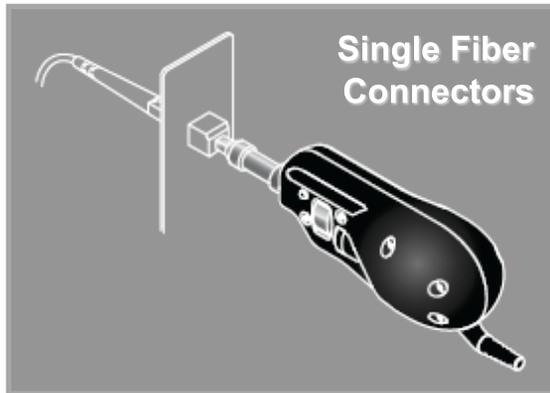
PROBE SCOPE & DISPLAYS



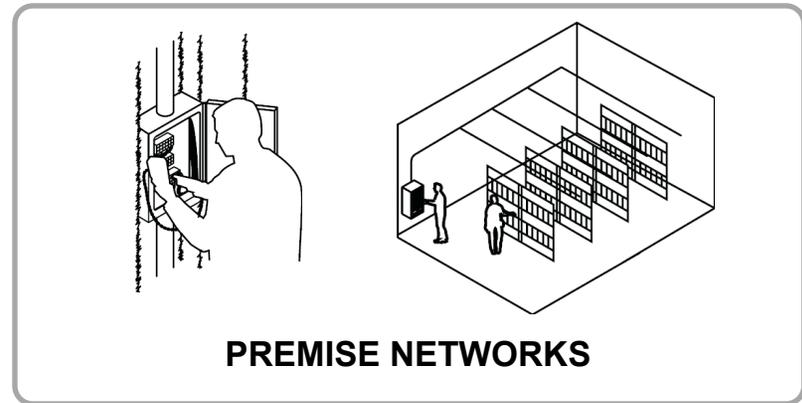
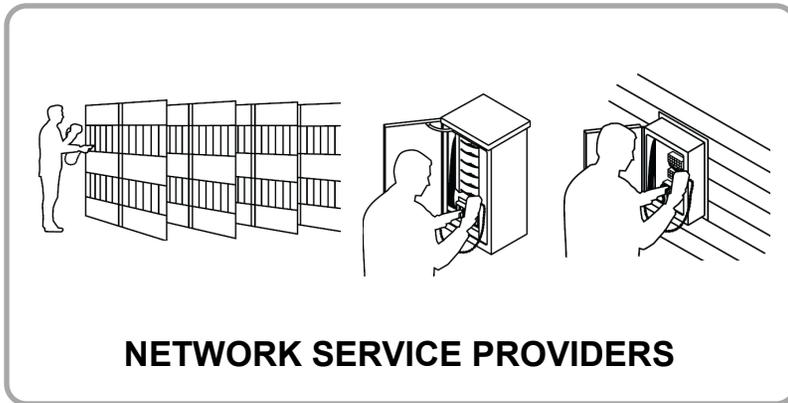
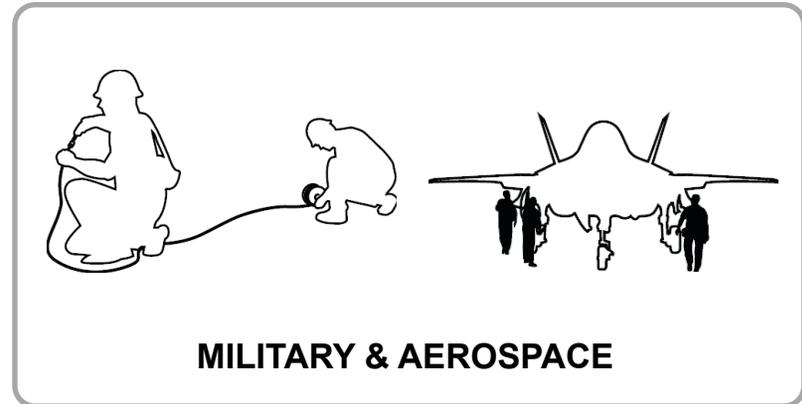
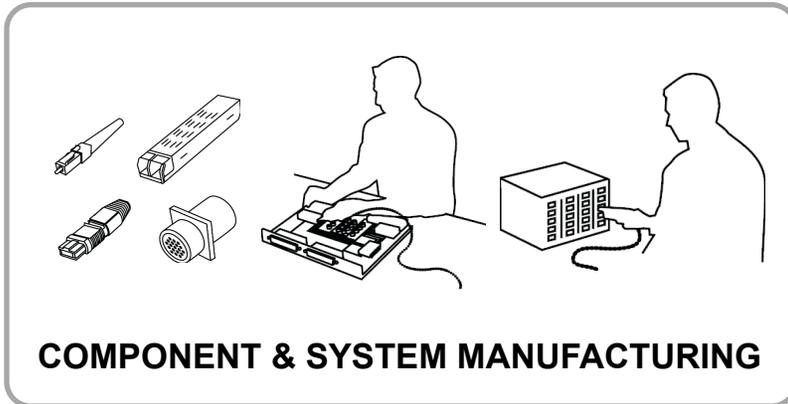
AUTOMATED ANALYSIS



Inspection Overview – Applications



Inspection Overview – Industries



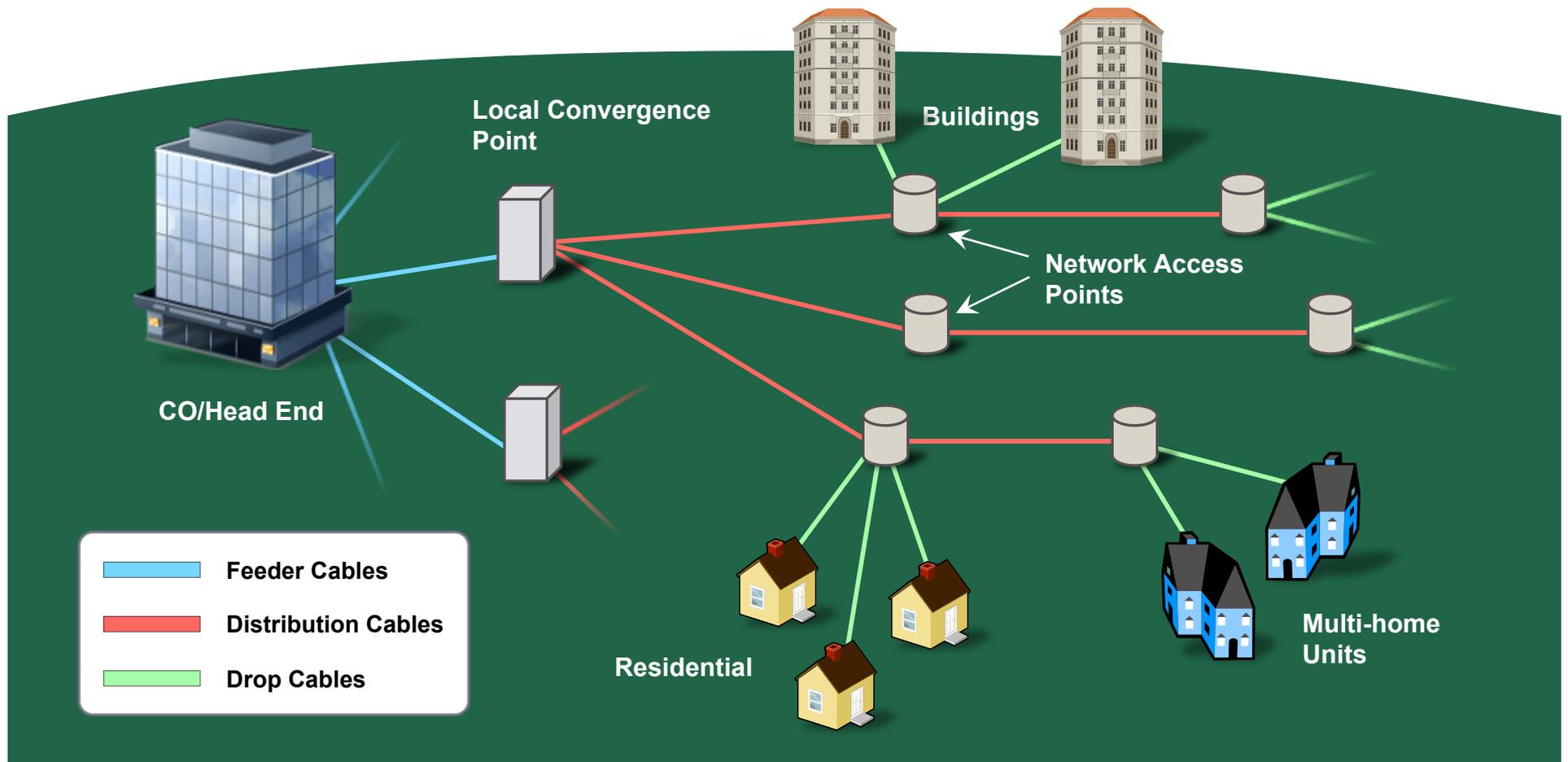


Part I: Fiber Optic Connectors

Understanding Fiber Optic Connectors

Fiber Connectors Are Everywhere

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



Recent Market Drivers

- Fiber penetration & popularity
 - FTTn/c/h/d, COs, Data Centers
- Increasing PHY demands
 - Higher speeds, tighter IL/RL/Disp budgets
- New technologies
 - ROADM, PON, 40/100G, Fibre Channel, 40/100GE
- More technicians are being required to implement these more demanding optical links.
 - New techs → limited fiber experience
 - Experienced techs → developed bad habits

Fiber Optic Connector



SC Connector

- The **BODY** houses the ferrule that secures the fiber in place.
- The **FERRULE** is a small cylinder where the fiber is mounted and acts as the fiber alignment mechanism. The end of the fiber is located at the end of the ferrule.
- The **FIBER** is comprised of 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.***

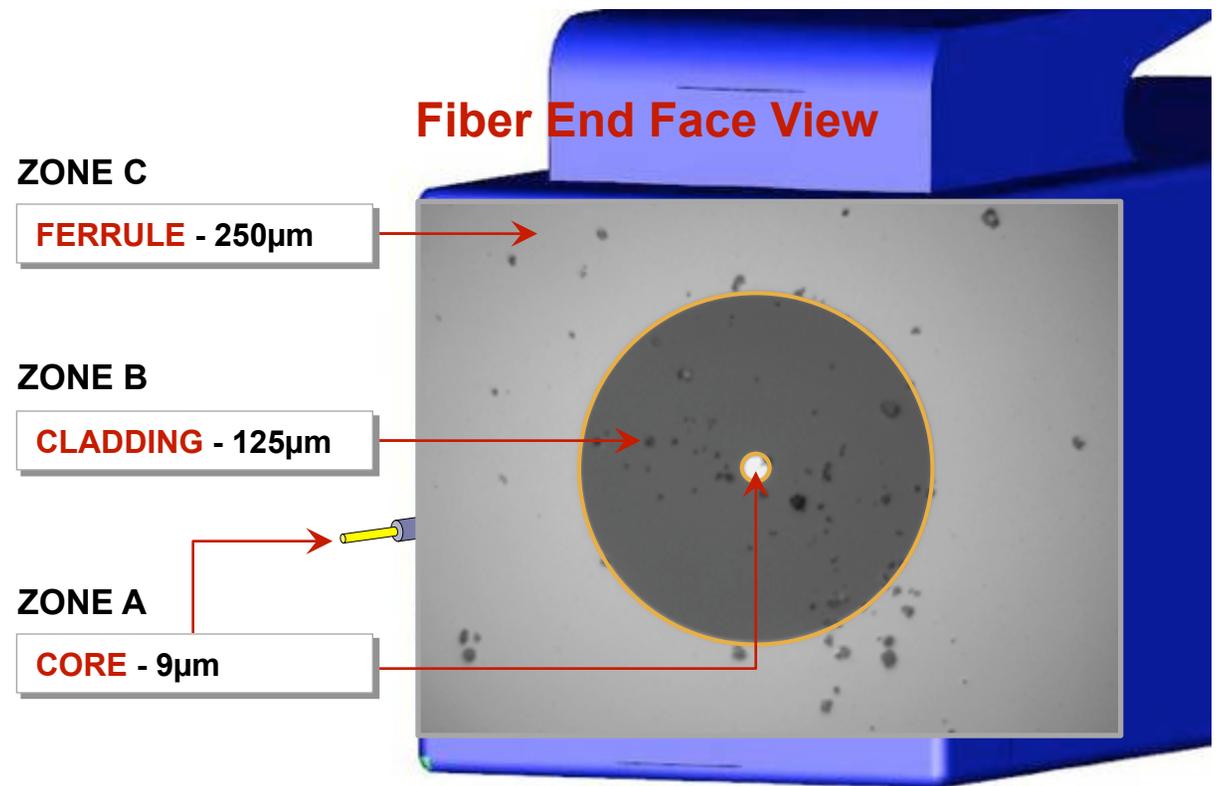
Anatomy of Fiber Connector

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.

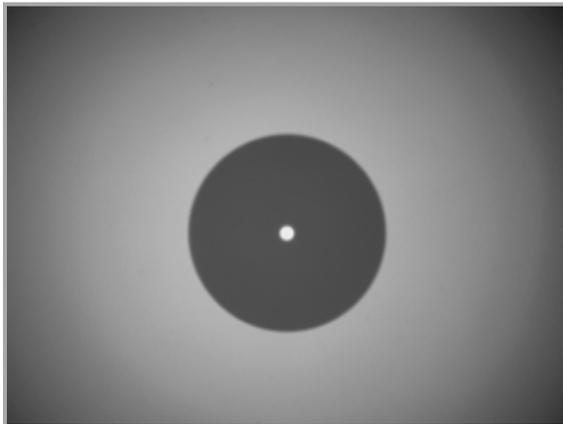
There are **3 major ZONES** on the end face that are used to define the level of impact contamination may have on signal performance. Particles closer to Zone A (Core) will have more impact than those farther out.

Singlemode Fiber Structure



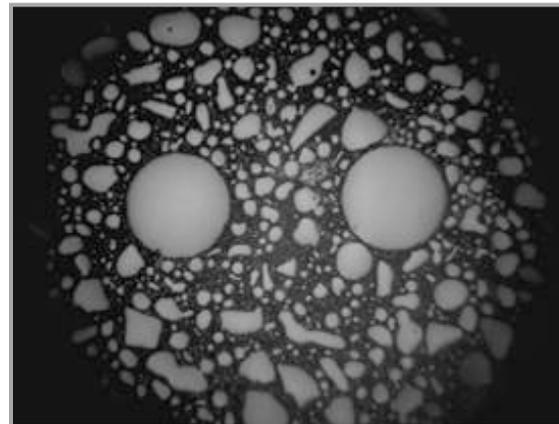
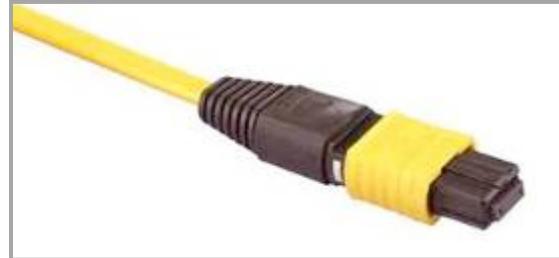
Simplex vs. Multi-fiber Connectors

SIMPLEX CONNECTOR



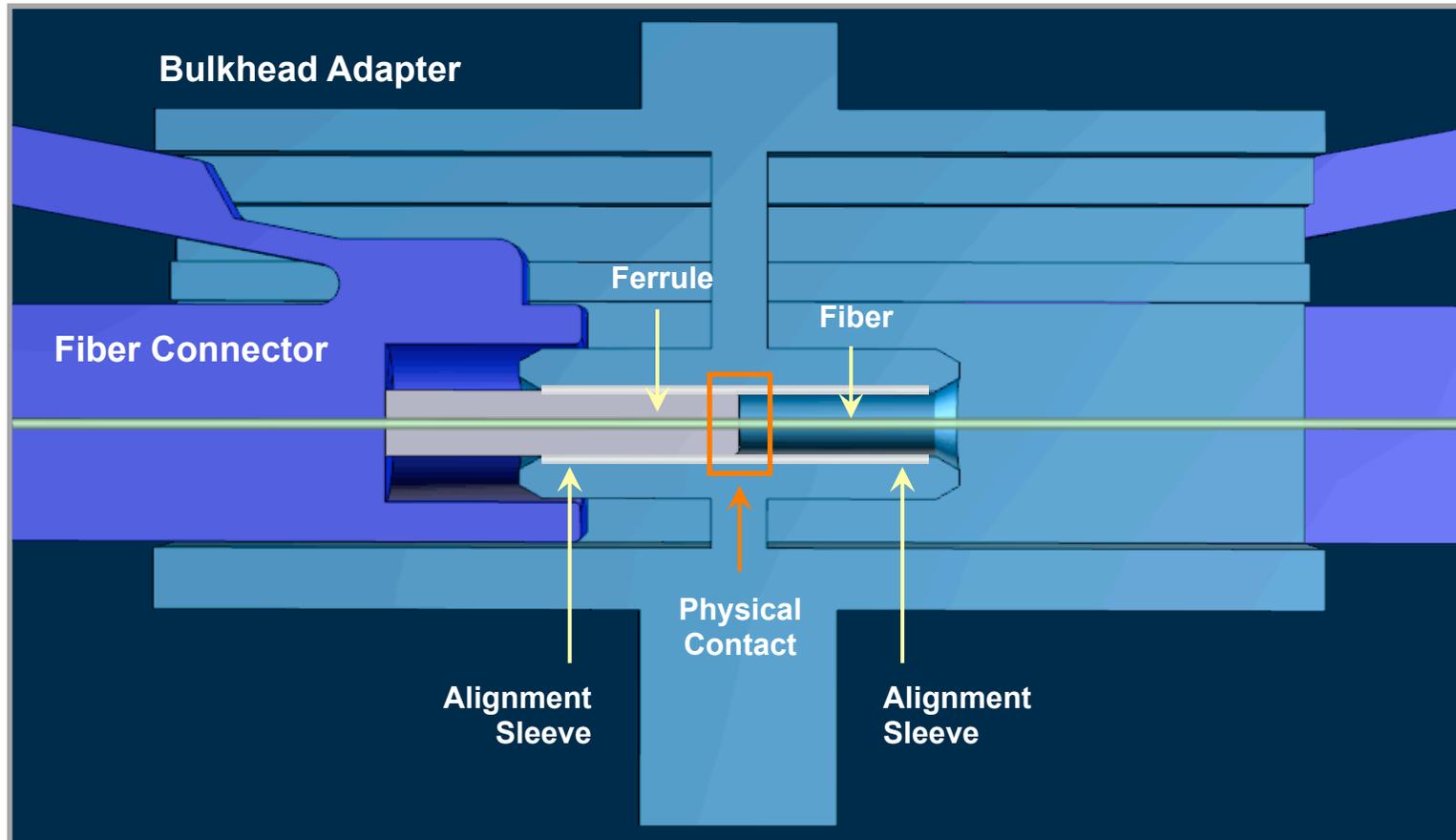
- White ceramic ferrule
- One fiber per connector
- Common types include SC, LC, FC and ST

RIBBON CONNECTOR



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

Focused On the Connection

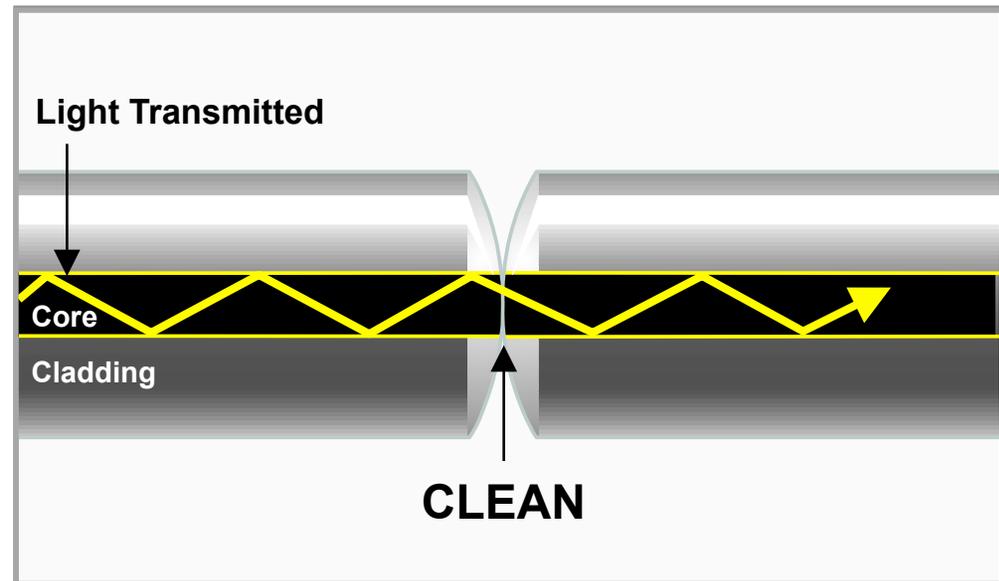


Fiber connectors are widely known as the **WEAKEST AND MOST PROBLEMATIC** points in the fiber network.

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

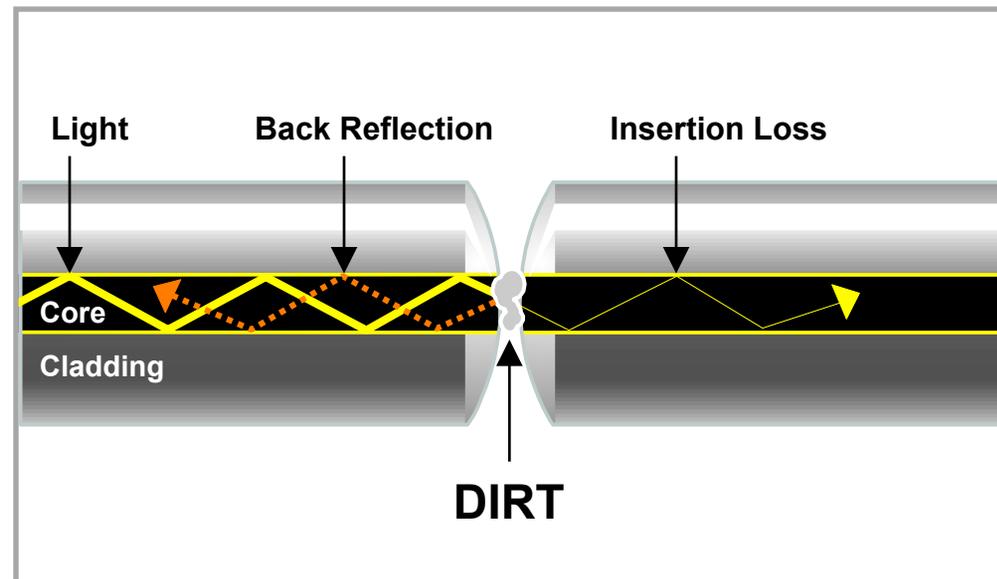
Understanding Contamination on Fiber Optic Connectors
and Its Effect on Signal Performance

What Makes a BAD Fiber Connection?

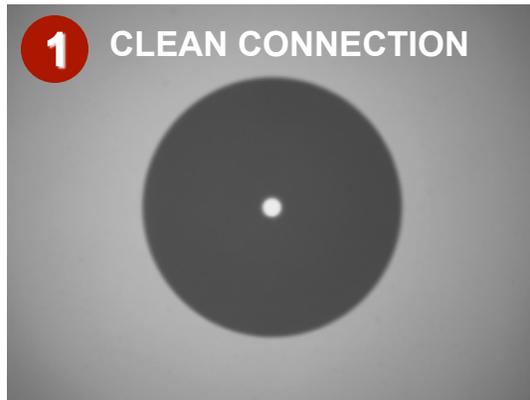
Today's connector design and production techniques have eliminated most of the challenges to achieving **CORE ALIGNMENT** and **PHYSICAL CONTACT**.

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**.



Contamination and Signal Performance



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



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

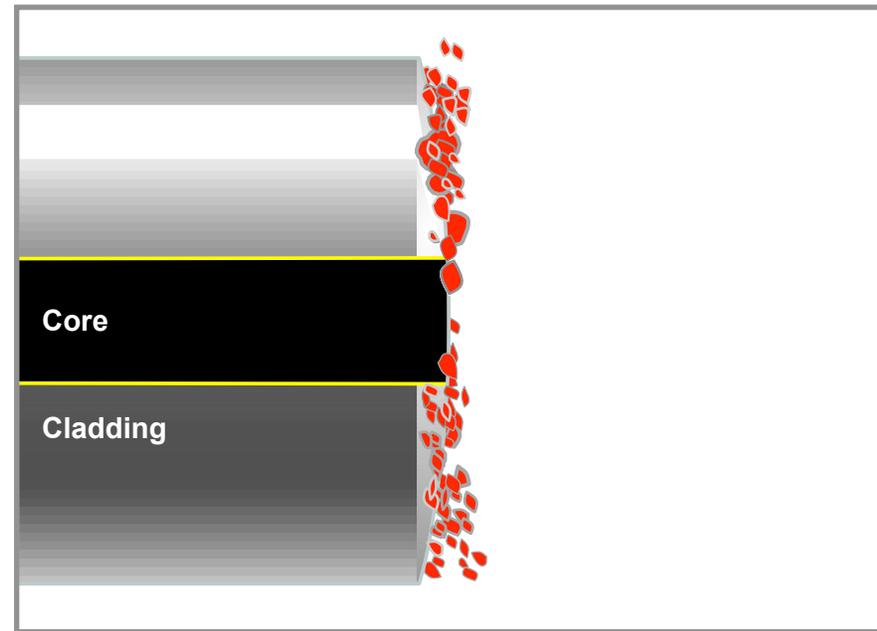
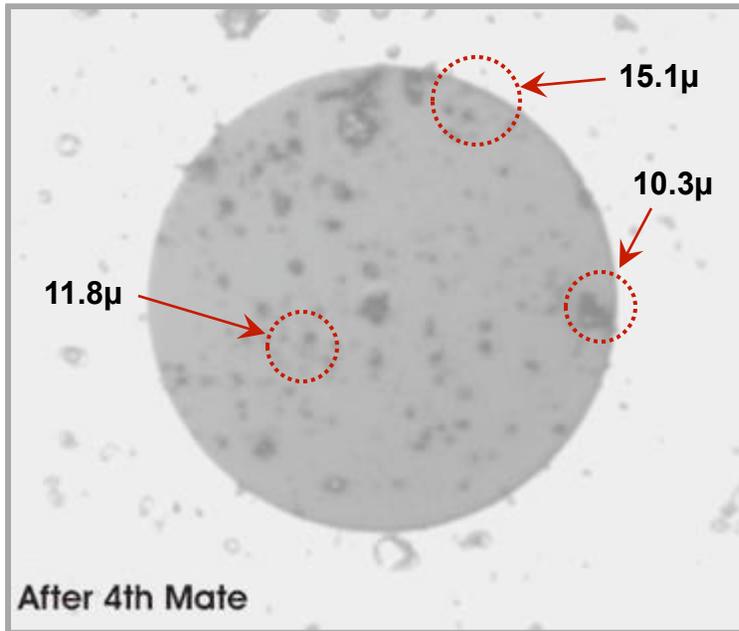
Fiber Contamination and Its Effect on Signal Performance



Clean Connection vs. Dirty Connection

This OTDR trace illustrates a significant decrease in signal performance when dirty connectors are mated.

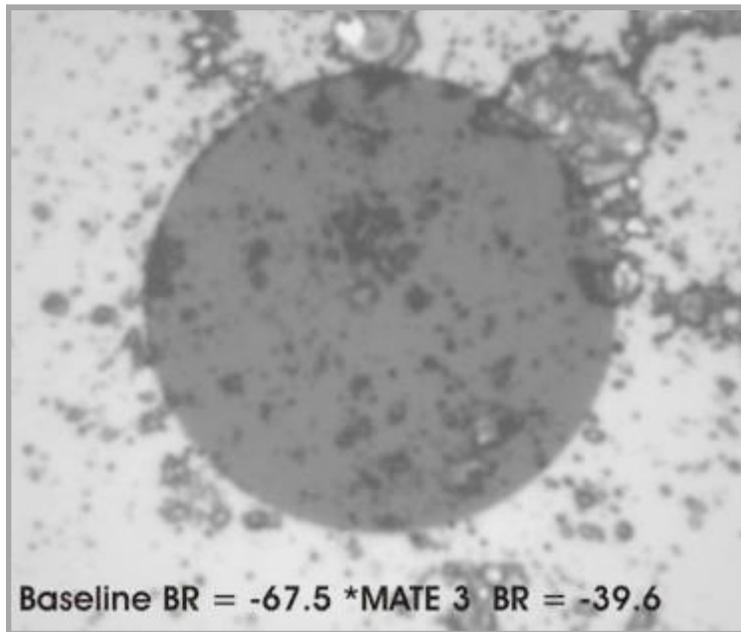
Illustration of Particle Migration



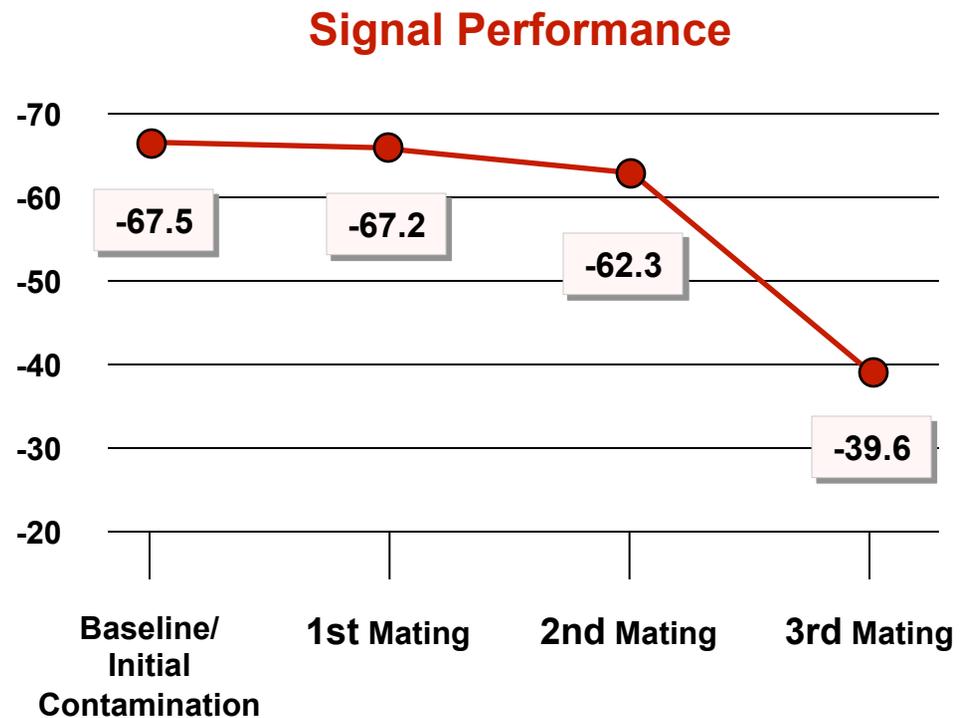
Actual fiber end face images of particle migration

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

Particle Migration & Signal Performance



Actual fiber end face images of particle migration

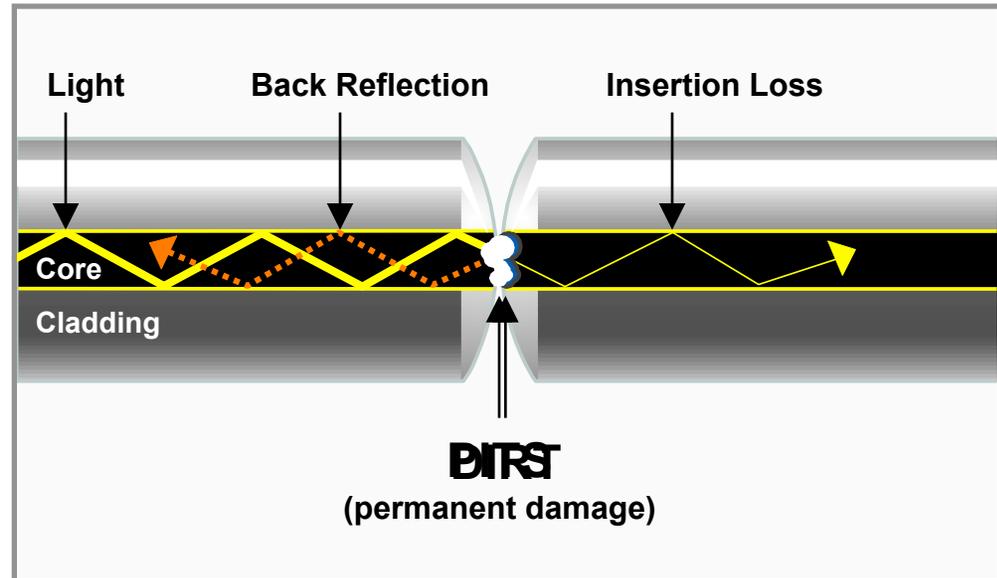


- For every successive mating, notice the increase in actual dB values and decrease in signal performance.
- Dirt particles near or on the fiber core will significantly affect signal performance.

Dirt Damages Fiber!



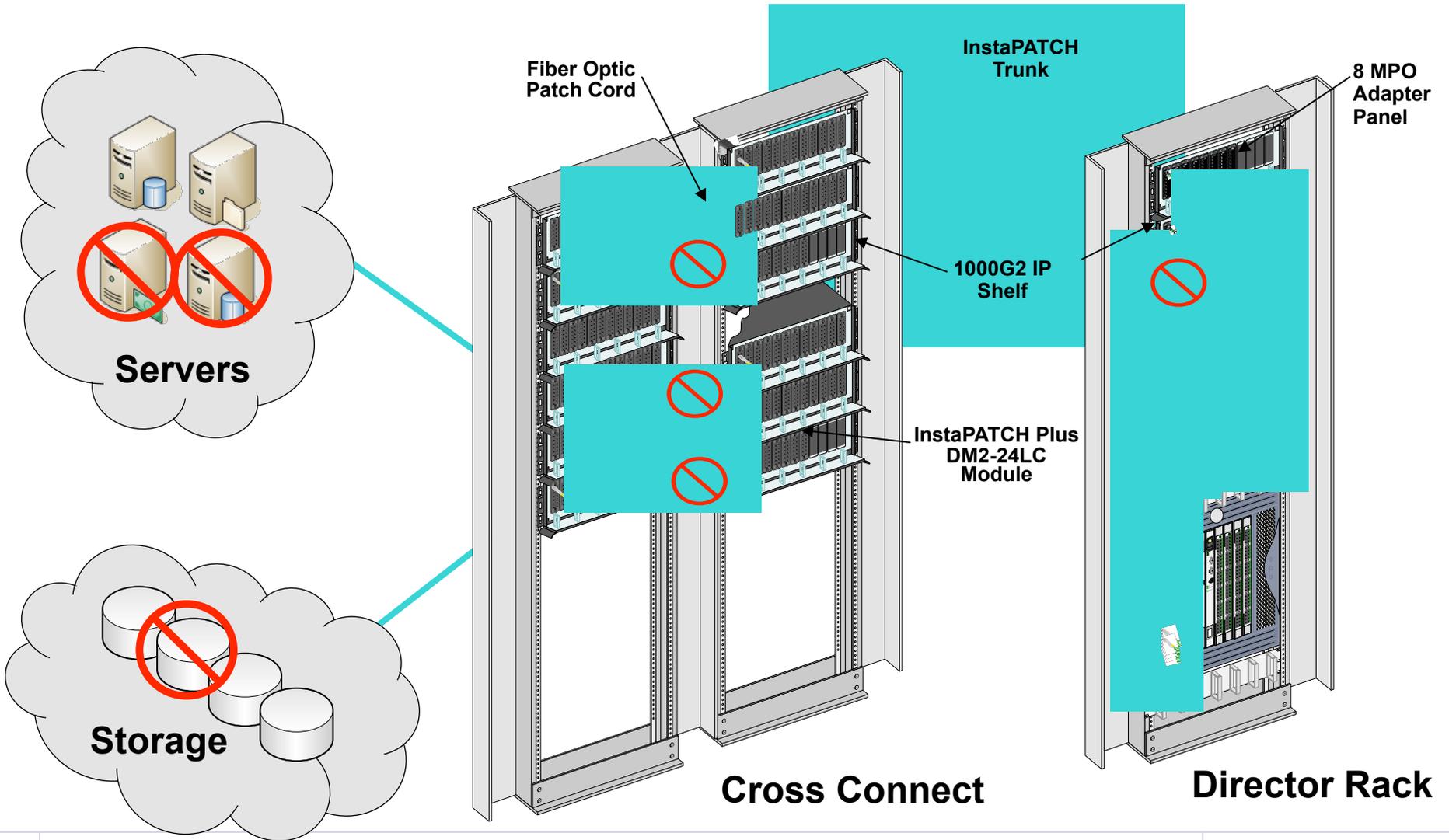
Mating dirty connectors embeds the debris into the fiber.



- Once embedded debris is removed, **pits and chips remain in the fiber.**
- 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.

Exponential Impact





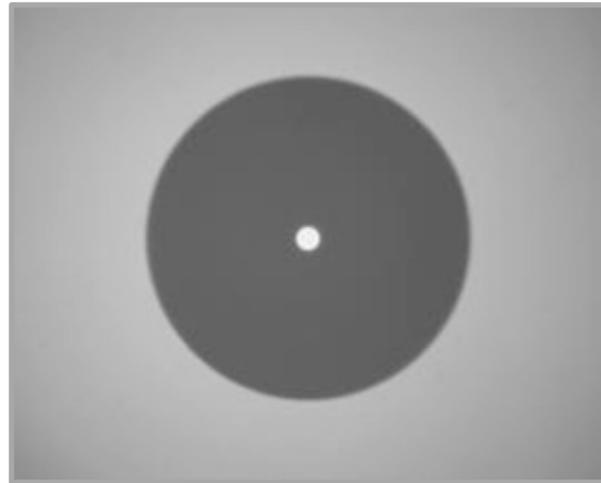
Part III: Sources of Contamination

Where Contamination Exists

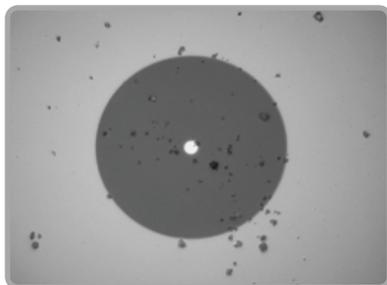
Types of Contamination

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

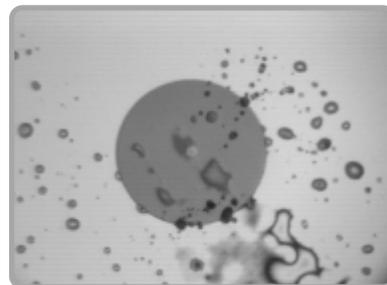
**SINGLEMODE
FIBER**



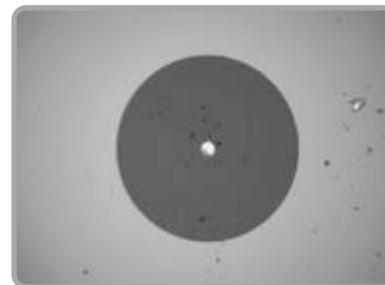
Common types of contamination and defects include the following:



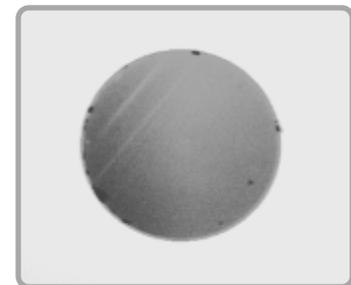
Dirt



Oil



Pits & Chips



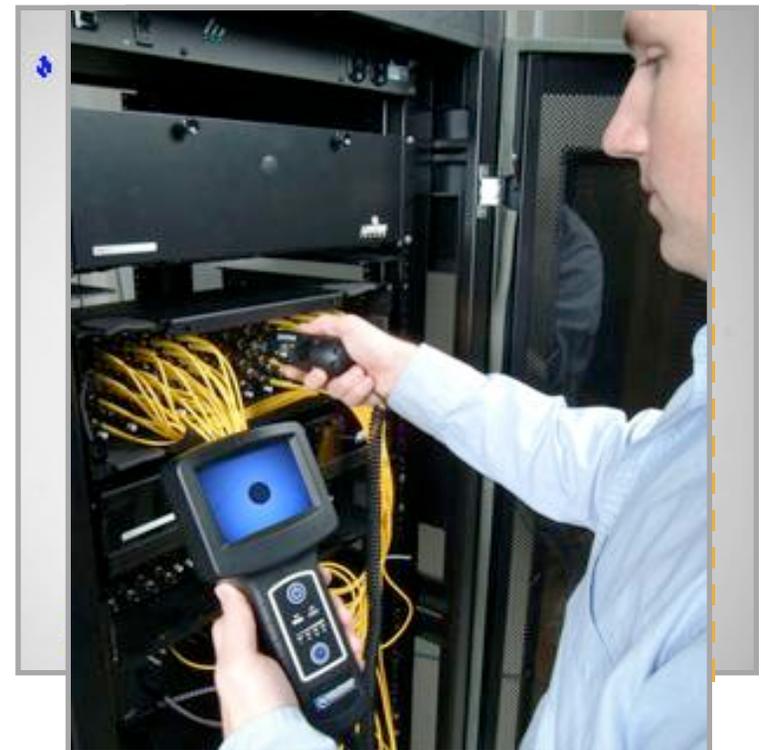
Scratches

Where is it? – Everywhere

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

DIRT IS EVERYWHERE!

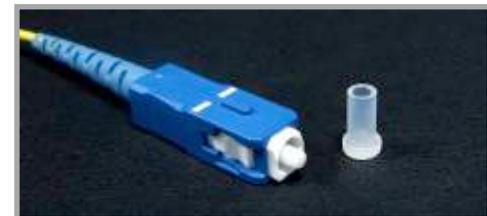
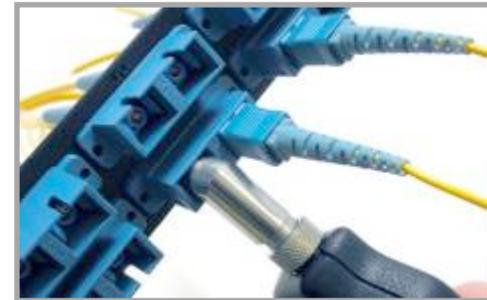
- Airborne, hands, clothing, bulkhead adapter, dust caps, test equipment, etc.
- **The average dust particle is 2–5 μ , which is not visible to the human eye.**
- A single spec of dust can be a major problem when embedded on or near the fiber core.
- **Even a brand new connector can be dirty.** Dust 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.



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.

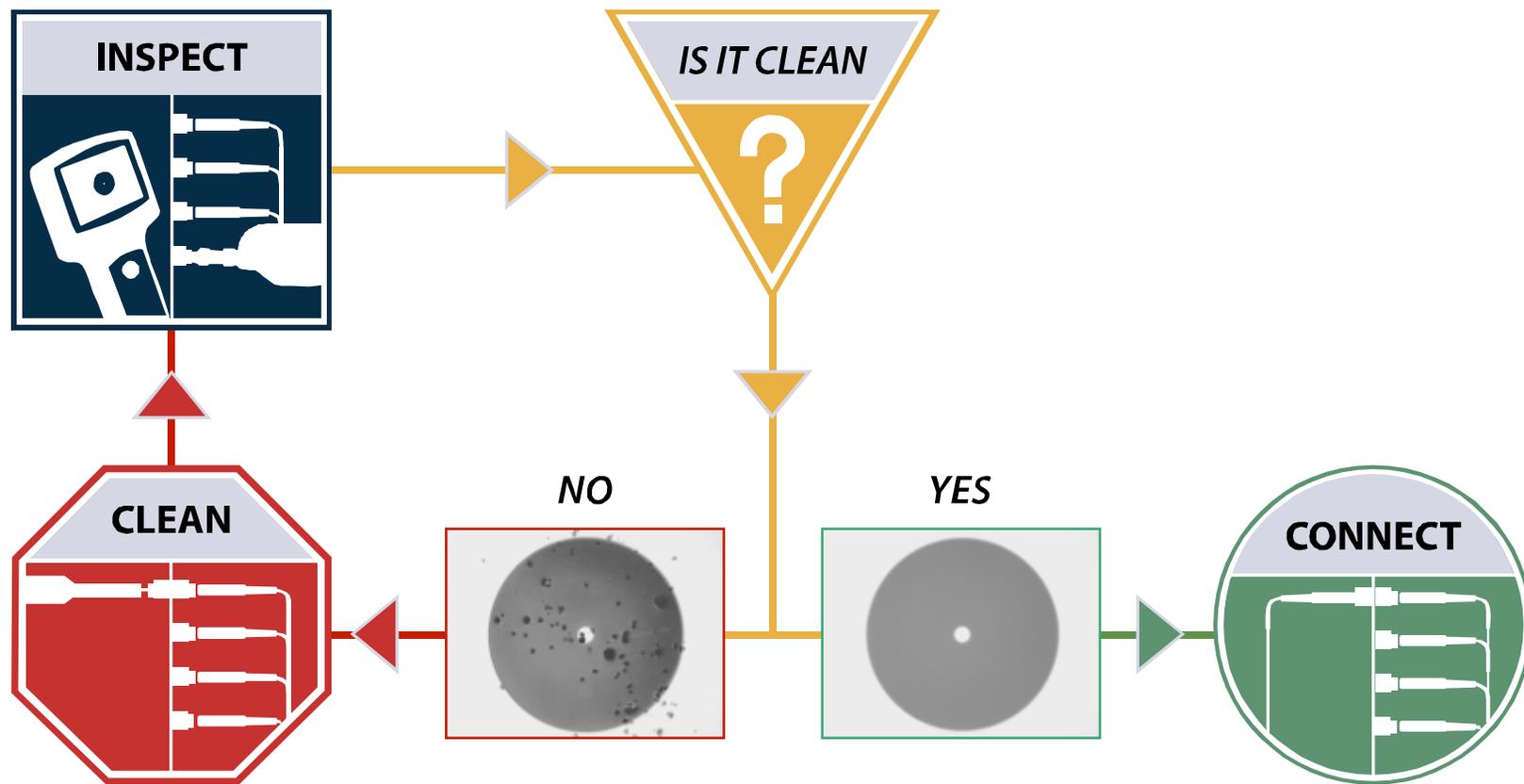


Part IV: Simple Solution

Inspect Before You Connect

Inspect Before You Connectsm

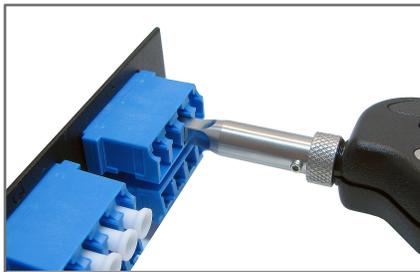
Follow this simple **“INSPECT BEFORE YOU CONNECT”** process to ensure fiber end faces are clean prior to mating connectors.



Inspect, Clean, Inspect, and Go!

Fiber inspection and cleaning are **SIMPLE** steps with immense benefits.

1 Inspect



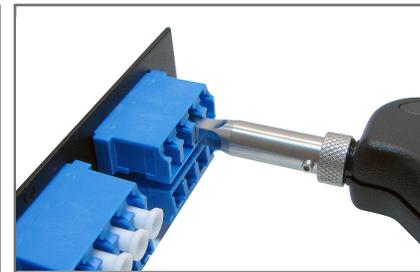
- Use a probe microscope to **INSPECT** the fiber.
- *If the fiber is dirty*, go to step 2, cleaning.
- *If the fiber is clean*, go to step 4, connect.

2 Clean



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

3 Inspect



- 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.

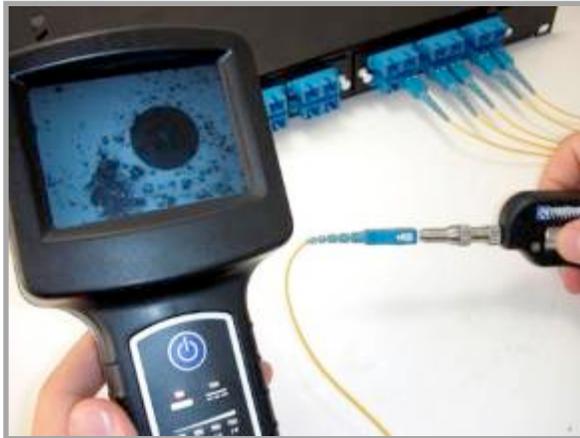
4 Connect



- 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.

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

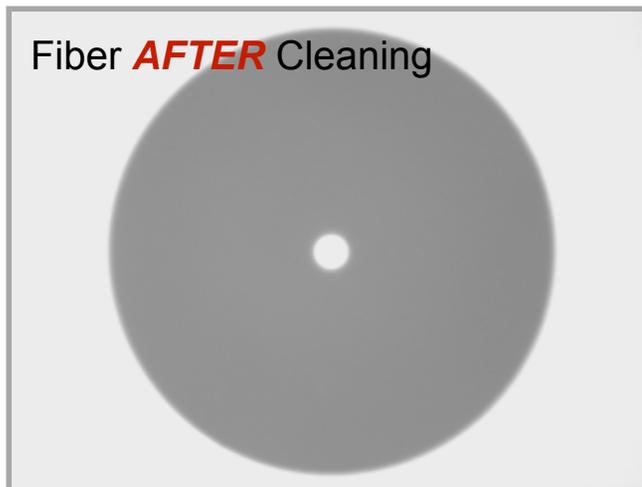
Patch cords are easy to access and view compared to the fiber inside the bulkhead, which is frequently overlooked. The bulkhead side may only be half of the connection, but it is far more likely to be dirty and problematic.

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.



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.



Benefits of Proactive Inspection

PROACTIVE INSPECTION is quick and easy, and the benefits are indisputable.

- **Reduce Network Downtime**

Active network = satisfied customers

- **Reduce Troubleshooting**

Prevent costly truck rolls and service calls

- **Optimize Signal Performance**

Network components operating at highest level of performance

- **Prevent Network Damage**

Ensure longevity of costly network equipment



Choosing the Right Tools Will Impact Performance

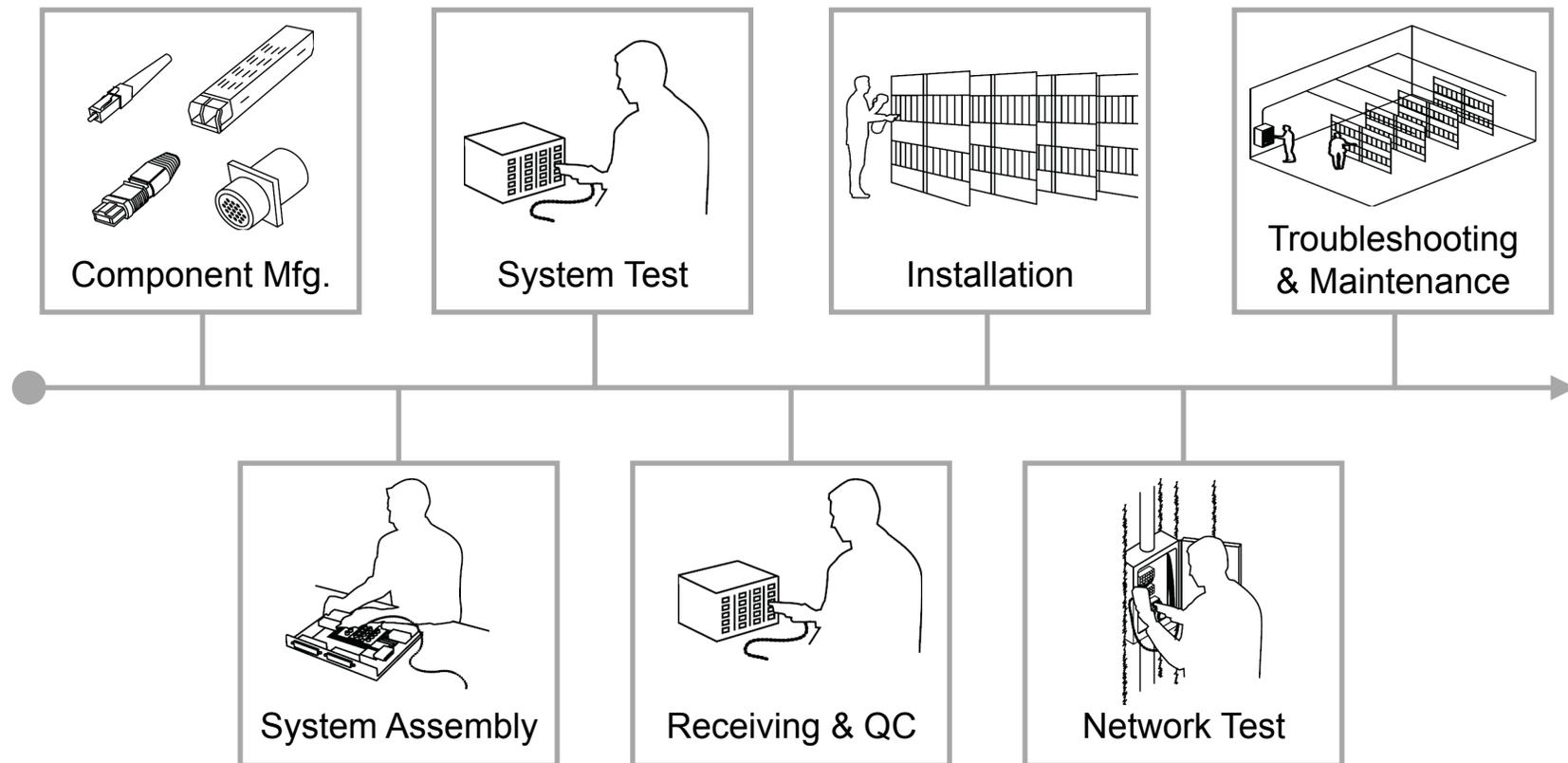
- **Improve technician performance with tools designed for workflow**
 - Equip technicians to follow best practices from Day 1
 - **Efficiency:** Do more in less time
 - **Reliability:** Drives techs to follow correct procedures & prevents forming of bad habits
 - **Repeatability:** Easy, repeatable process

- **Achieve better network performance**
 - Save money with Smarter & Faster Technicians
 - Better Practices = Better Performance
 - Prevents costly mistakes by “doing it right the first time”
 - Protects your network investment



Where Inspection Should Occur

Inspection of fiber end faces is critical at **EVERY STAGE** of handling fiber!



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.
- A Probe Microscope and hand-held video display most practical inspection tool for Datacenters
- 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”***