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FIBER TROUBLESHOOTING

- **Jeremy Davis –VIAVI**
- **Chris Bailey – Wesco**
- **Sean Guinan - VeEX**

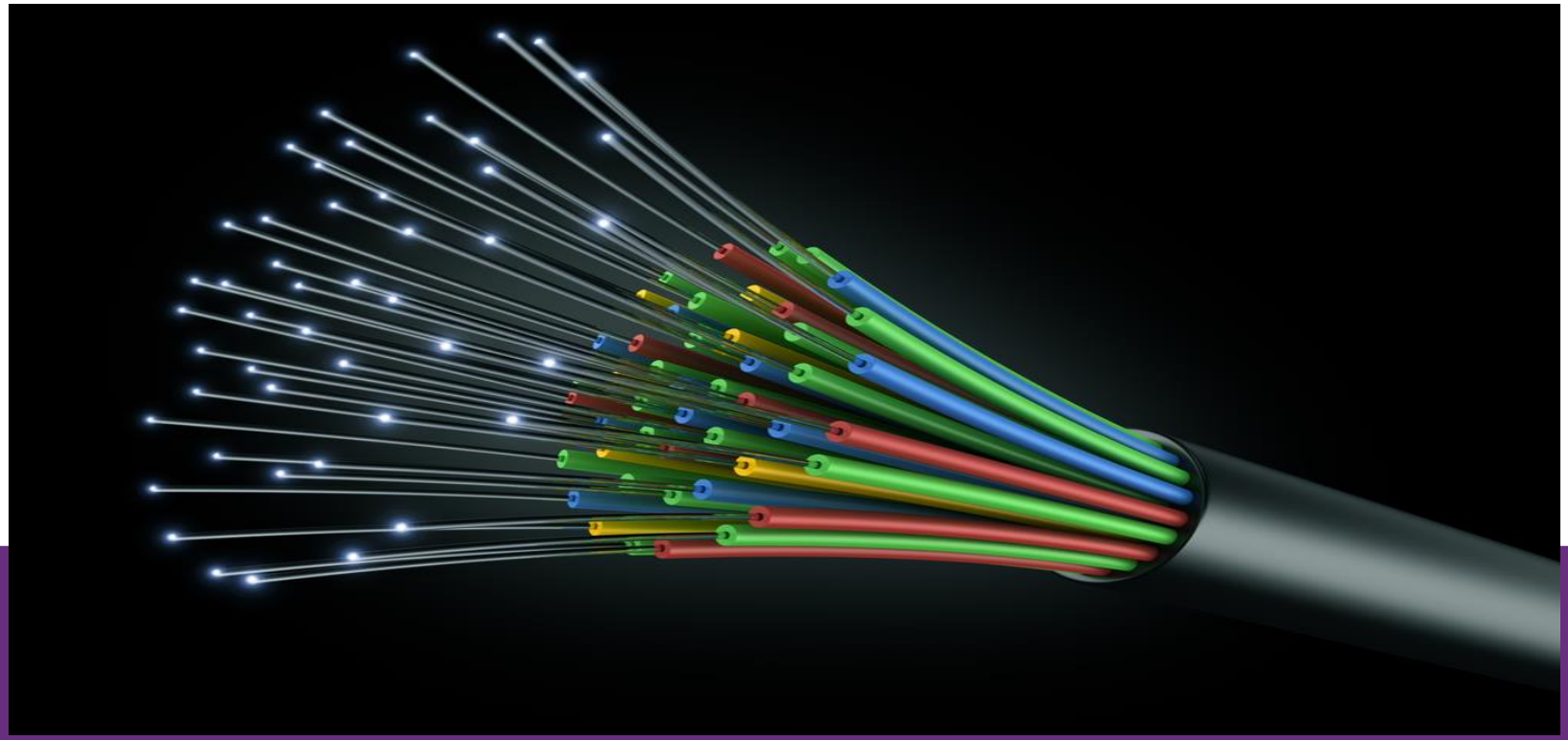
AGENDA

You will learn how to trouble shoot fiber issues with these tools.:

1. **Fiber 101 – quick background**
2. **Fiber Inspection – IBYC**
3. **PON Testing**
4. **Advanced OTDR/Dispersion**
5. **Remote Monitoring**

FIBER 101

- Why use fiber ?
- Applications
- Fiber glass types and construction
- Fiber cable types and constructions
- Loose Tube vs Tight Buffer
- Deployments in Public Power
- Construction
- TANGLE



ADVANTAGES OF FIBER

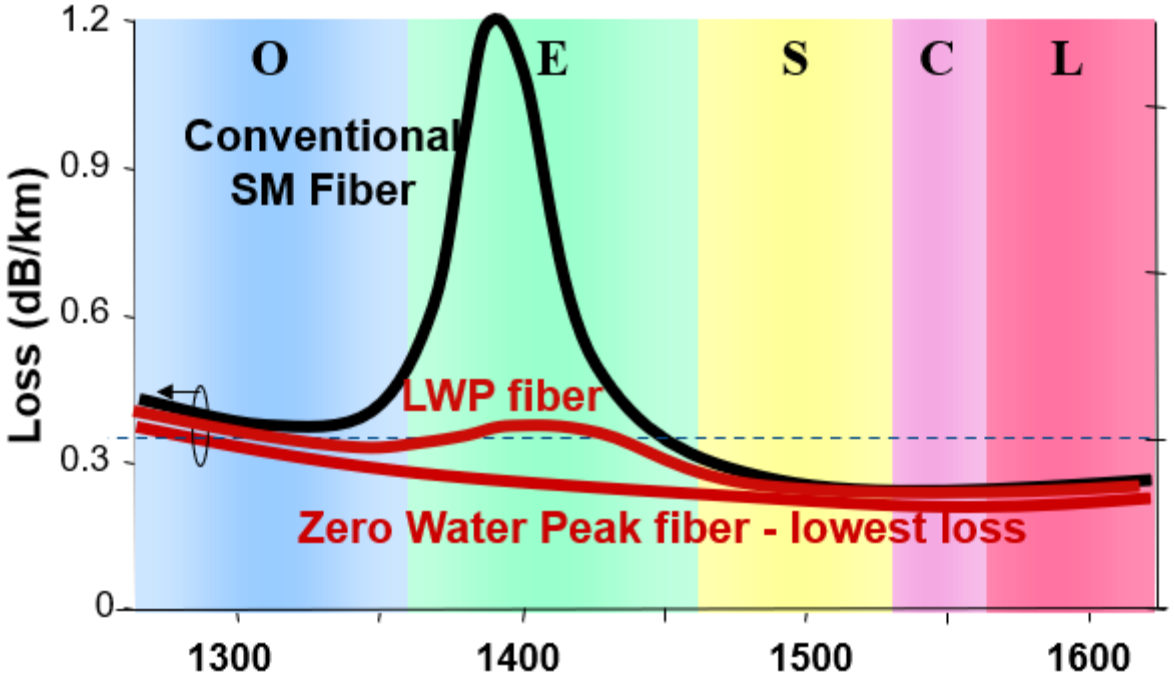
- Fiber optics has many advantages over copper wire including: *f*

Increased Bandwidth	The high signal bandwidth of optical fibers provides significantly greater information carrying capacity. Typical bandwidths for multimode (MM) fibers are between 200 and 600MHz-km and >10GHz-km for single mode (SM) fibers. Typical values for electrical conductors are 10 to 25MHz-km.
Electromagnetic/Radio Frequency Interference Immunity	Optical fibers are immune to electromagnetic interference and emit no radiation.
Lower loss	Optical fiber has lower attenuation (loss of signal intensity) than copper conductors, allowing longer cable runs and fewer repeaters.
Safety (No sparks or shorts)	Fiber optics do not emit sparks or cause short circuits, which is important in explosive gas or flammable environments.
Security	Since fiber optic systems do not emit RF signals, they are difficult to tap into without being detected.
Electrical Isolation	Fiber optics allow transmission between two points without regard to the electrical potential between them.
Decreased cost, size and weight:	Compared to copper conductors of equivalent signal carrying capacity, fiber optic cables are easier to install, require less duct space, weigh 10 to 15 times less and cost less than copper.

APPLICATIONS

- **Outside Plant Network**
  - – Very long distances
  - – High data rates
  - – Singlemode
- **Single building Riser**
  - – Medium distances (<300 m)
  - – Mostly multimode
- **Multiple buildings (Campus)**
  - – Multimode and singlemode
- **Internal Communications**
  - – Short distances
  - - Substation Communications
  - – Very high data rate

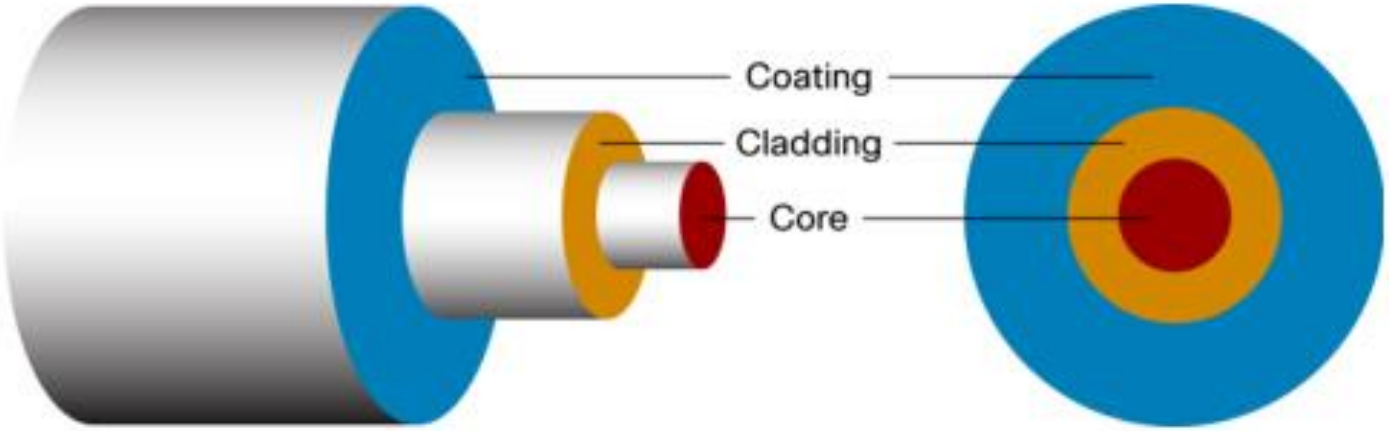
Glass Specification



CONSTRUCTION OF OPTICAL FIBERS

An optical fiber is made of 3 concentric layers: *f*

1. **Core**: This central section, made of silica or doped silica, is the light transmitting region of the fiber. *f*
2. **Cladding:** This is the first layer around the core. It is also made of silica, but not the same composition as the core. This creates an optical waveguide which confines the light in the core by total internal reflection at the core-cladding interface. *f*
3. **Coating:** The coating is the first non-optical layer around the cladding. The coating typically consists of one or more layers of polymer that protect the silica structure against physical or environmental damage. The coating (250μm) is stripped off when the fiber is connectorized or fusion spliced.



BASIC FIBER CABLE DESIGN: LOOSE TUBE VS TIGHT BUFFERED

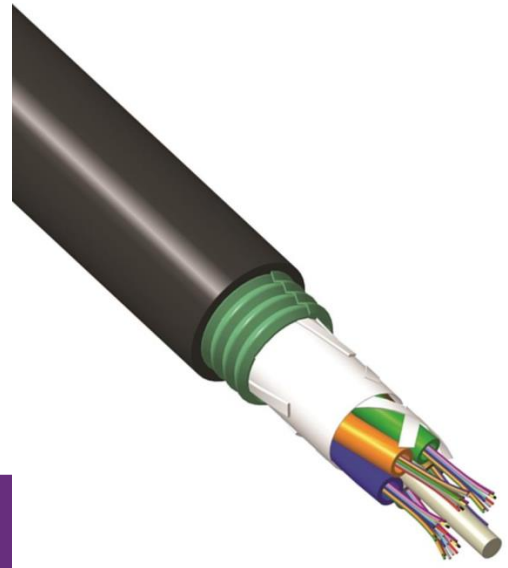
Outdoor (OSP) Loose Tube

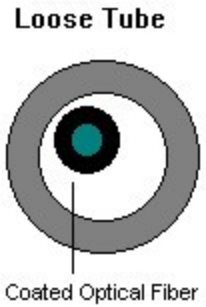
- 250 µm buffer diameter
- Too small for connectors – requires breakout kit
- Typically for outdoor use (uncontrolled temperatures and/or harsh environment)
- Delicate thinly-coated individual fibers are enclosed in a buffer tube for protection
- Fibers move freely inside tube when ten

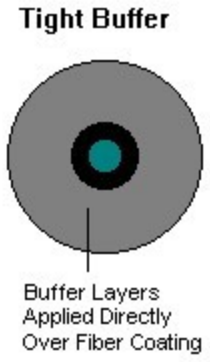
Indoor (ISP) Tight Buffered Design

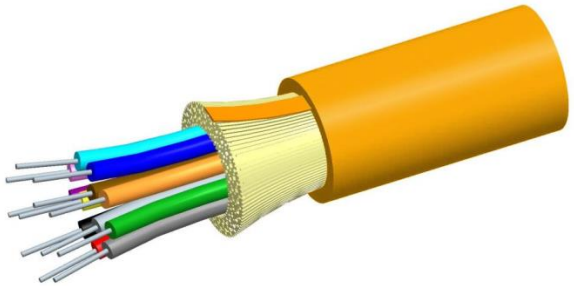
- 900 µm buffer diameter
- Fits most connectors
- Typically for indoor use (controlled temps, stable environment)
- Each fiber's thick plastic buffer layer gives maximum protection and ease of handling

ly bound in cable, minimal/no movement



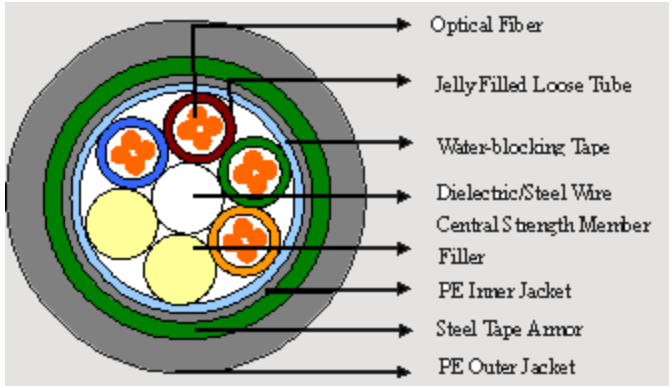


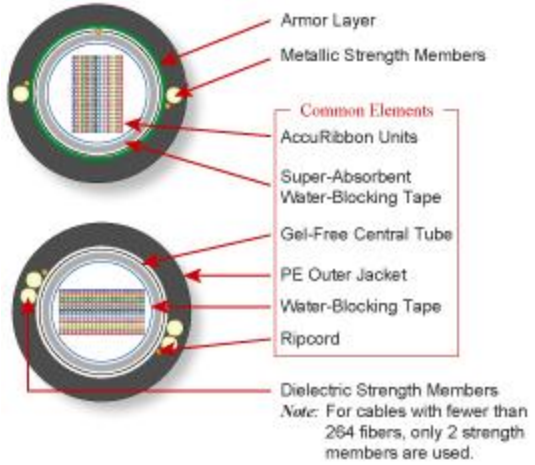




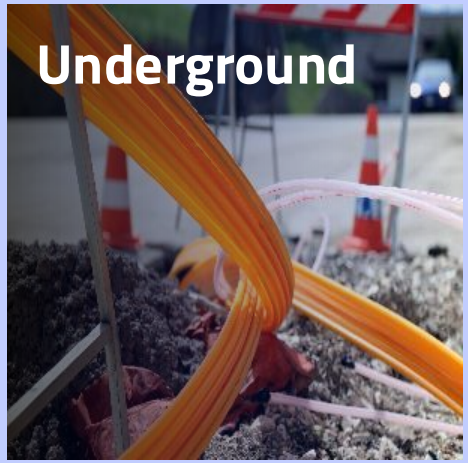
VARIOUS STYLES OF FIBER OPTIC CABLES

- **Single jacket, All Dielectric Cable**
- **Double Jacket, heavy-duty Cable**
- **Single/Double jacket, Armored Cable**
- **Interlocked Armor Distribution Cable** ***(Eliminates Need for Innerduct)***
- **Riser/Plenum Indoor Outdoor** ***(For entrance to building)***
- **ADSS (All Dielectric Self-Supporting) and Messengered**

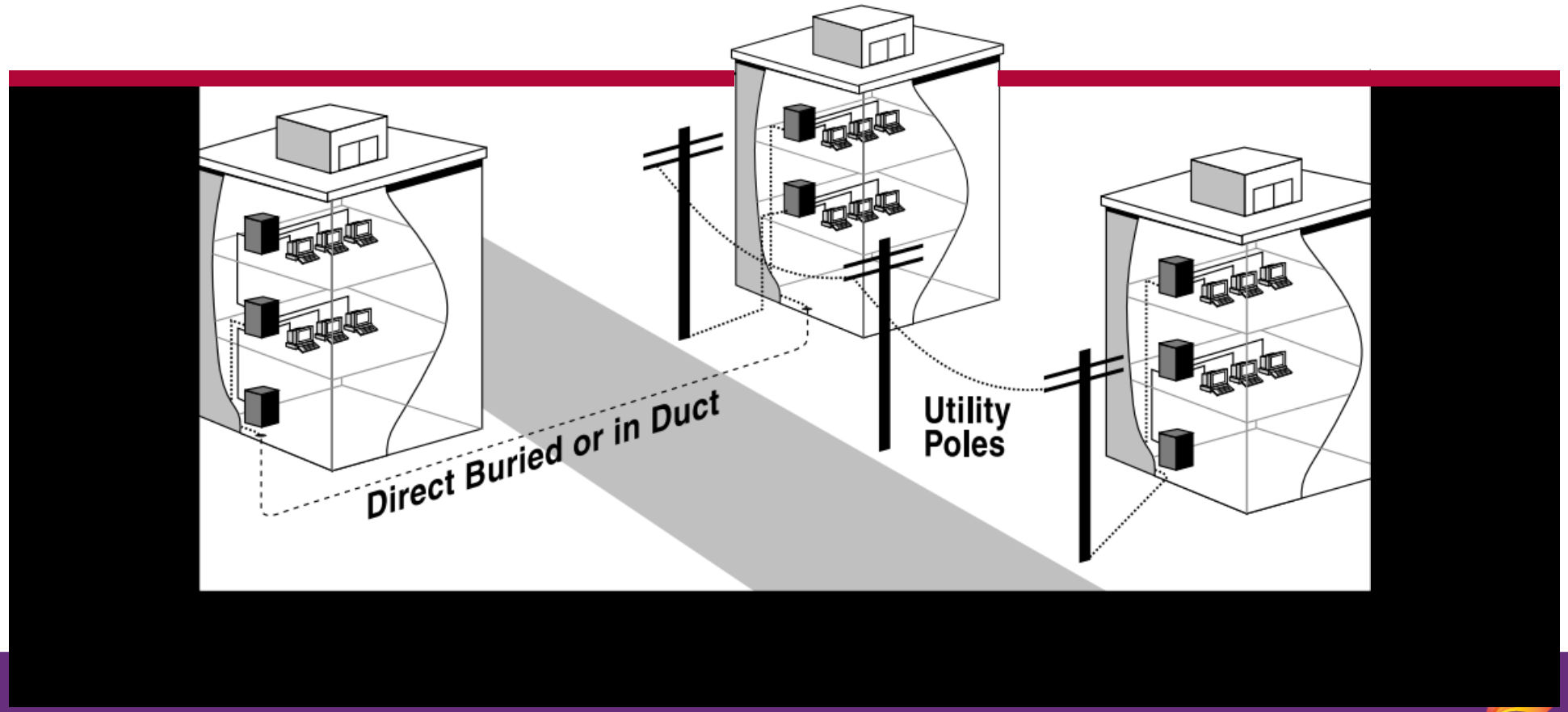




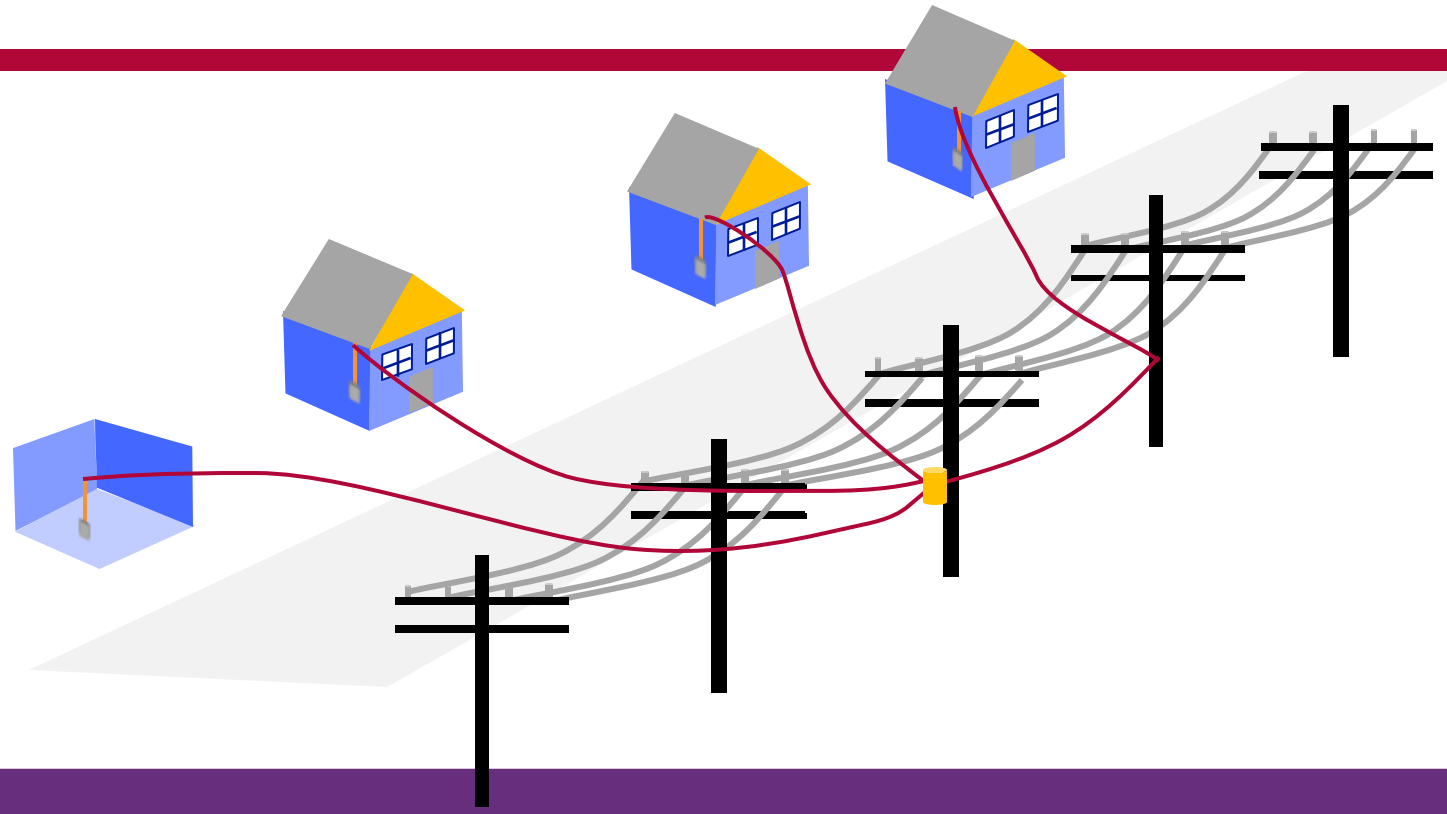
STARTING WITH FIBER



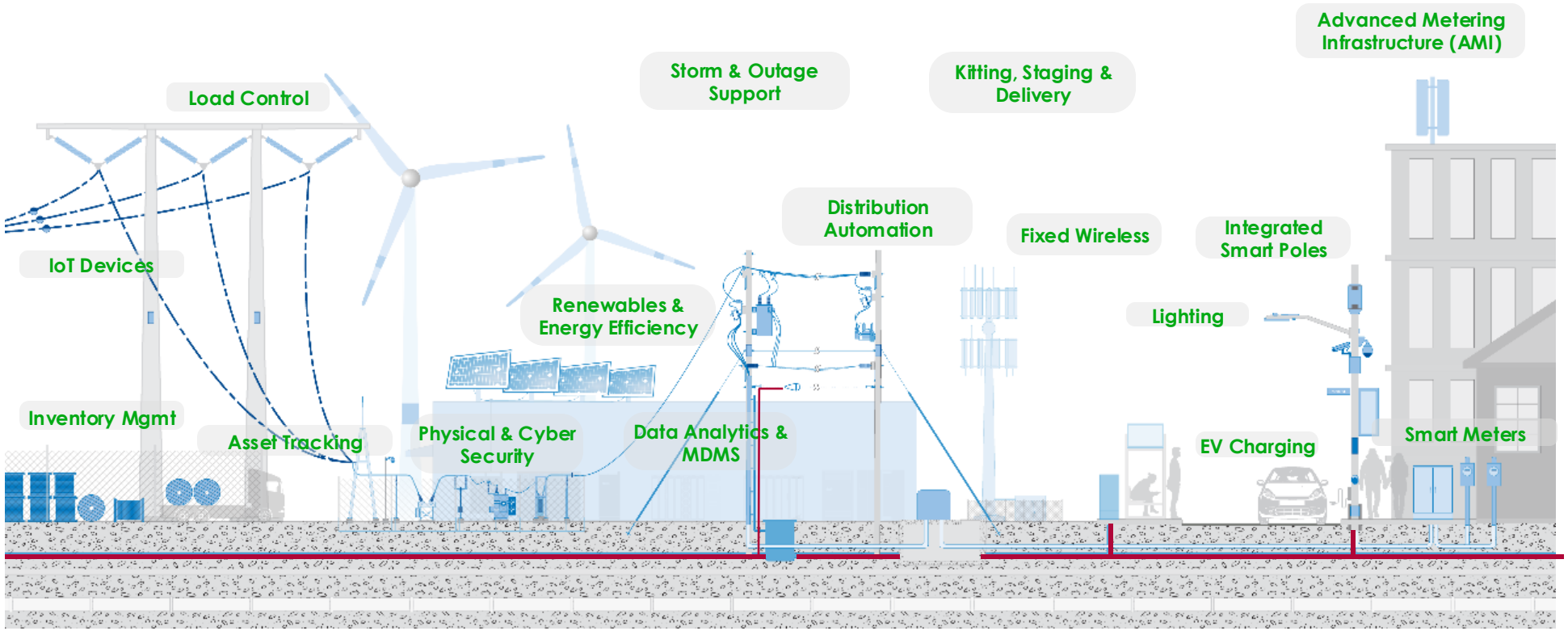
UNDERGROUND DEPLOYMENTS



AERIAL DEPLOYMENTS



A UNIFIED APPROACH



CHALLENGES WITHIN FIBER

- Permits
- Lack of Standardization
- Internal Alignment
- Marketing the Product

Thinking Beyond the Technology

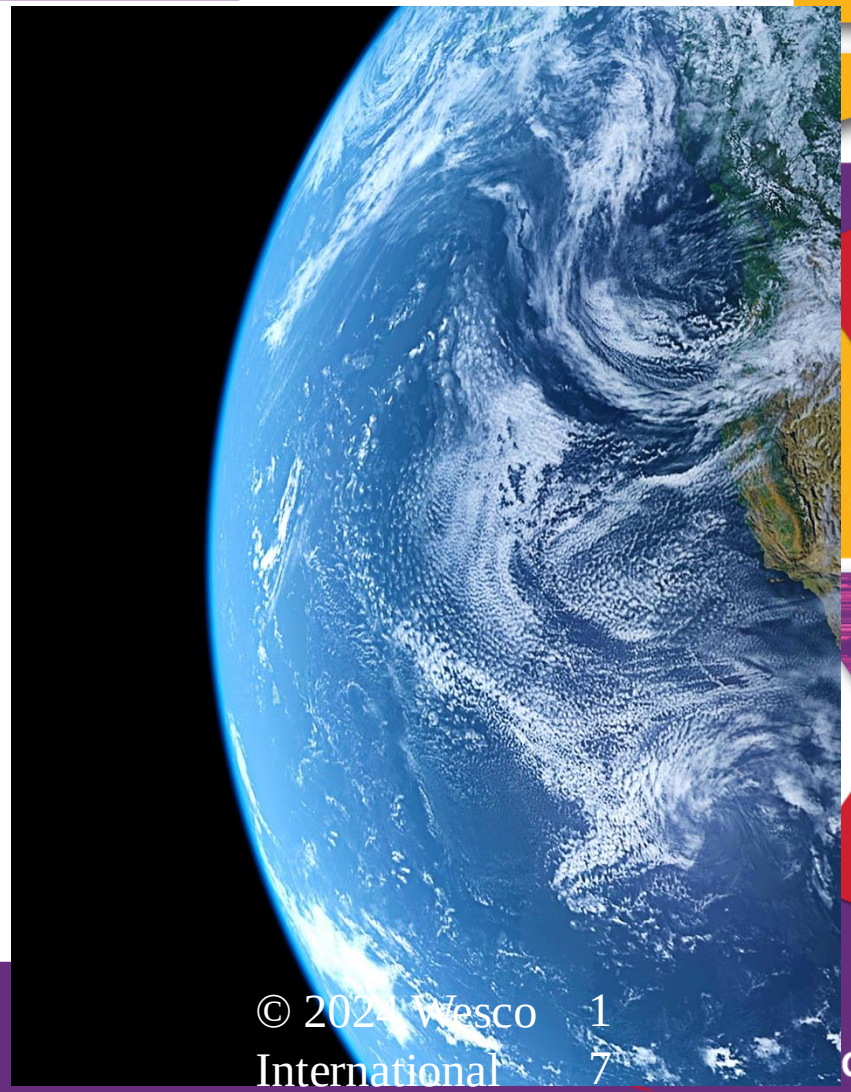
Sustainability

Longevity

Adoption

CURRENT & FUTURE CHALLENGES

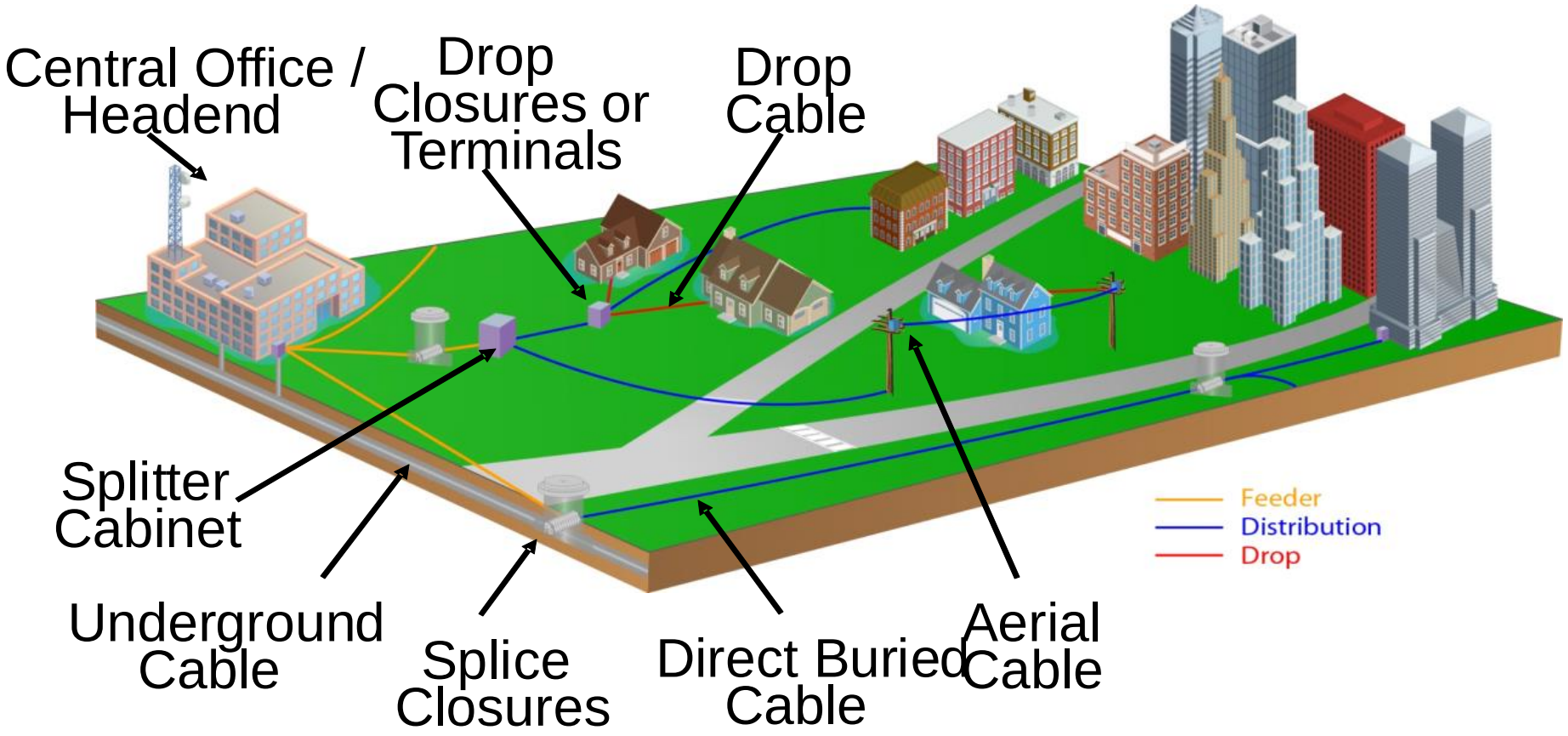
- Lead-Times
- Fiber
- Pedestals
- Vaults
- HDPE
- Raw Material
- Facility Capacity
- Transportation
- Limited Drivers
- Limited Conex Trailers
- Surcharges



WHY BROADBAND

- Reason for deploying Broadband to your community
- Compliment you services you are already offering
- Keeping the business local
- Economic development
- Telemedicine
- Creation of Jobs
- Future Proofing your network – 5G, Smart poles
- Fiber is the start of everything

FTTx Network

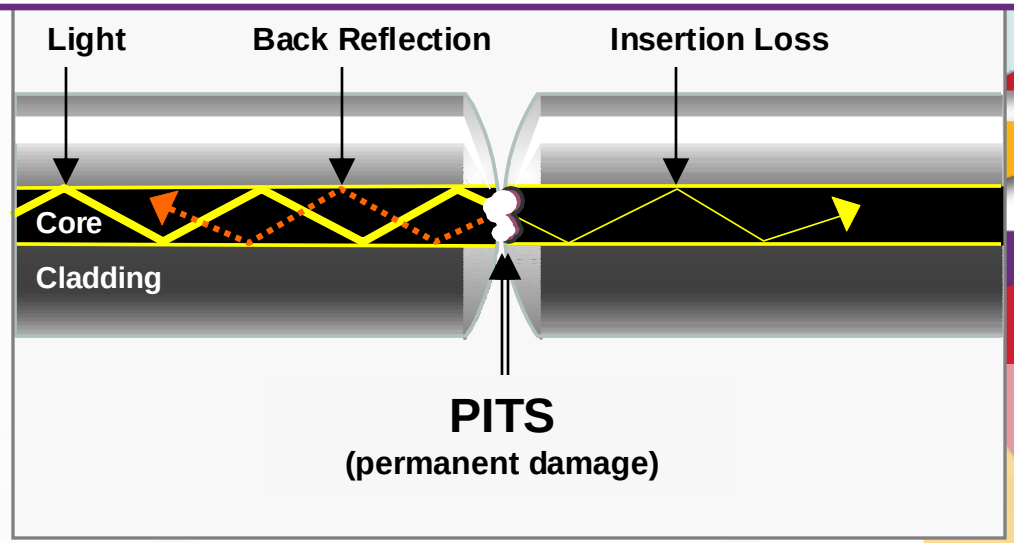


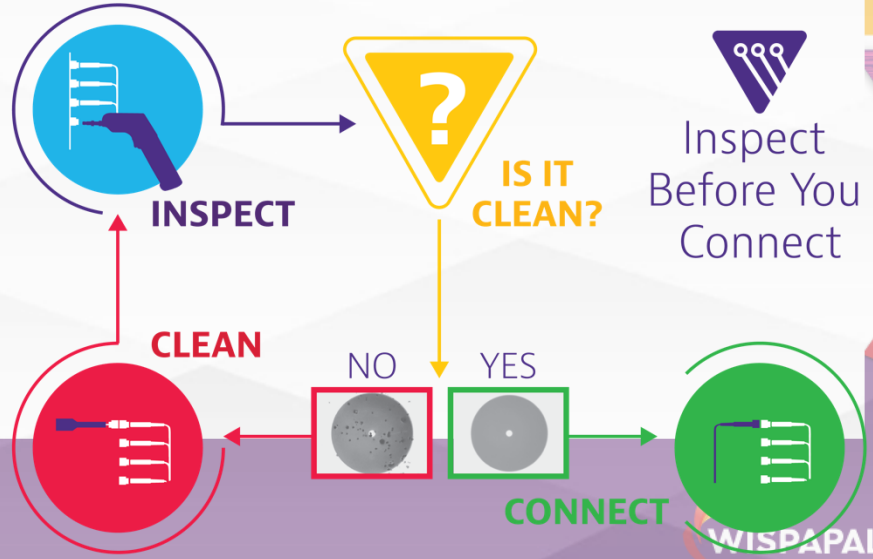
FIBER INSPECTION

- FIBER INSPECTION

INSPECT BEFORE YOU CONNECT

- Dirty connectors cause 80% of field test failures
- Microscopic debris significantly degrades signal performance and can cause permanent damage to connectors and the equipment they are plugged into Mating dirty connectors can break apart debris, spreading it across the fiber end face. Mating force of 2.2 lbs. over 200um diameter gives **45,000 psi**
- Typical debris on a fiber connector can only be seen with a fiber optic probe microscope
- Following the Inspect Before You Connect process ensures fiber end faces are clean prior to mating connectors

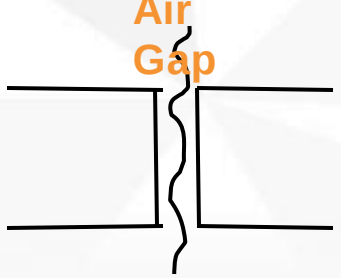




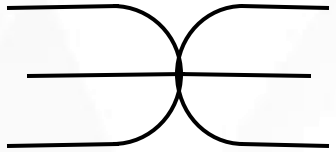
REFLECTANCE

The most important attribute of the connector is its reflectance level. When you look out a window you see outside but will also see your reflection.

In an optical network, light that is reflected into the LASER from the glass can be re-modulated creating errors.



Standard Connector ≤ -14 dB reflectance

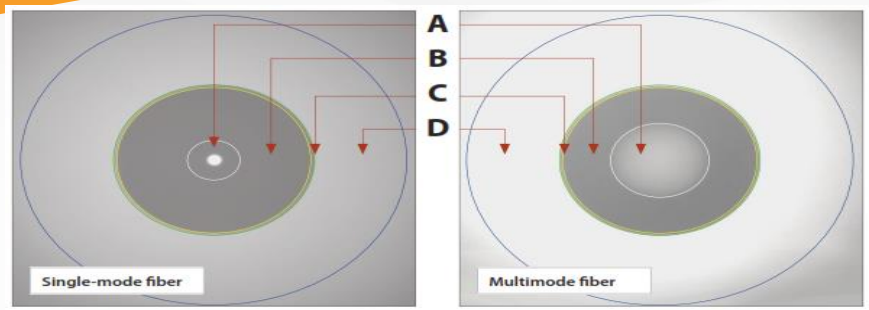


Ultra Polished Connector ≤ -55 dB reflectance Blue

Angled Polished Connector ≤ -65 dB reflectance Green

- The connector manufacturers provided Standard Connectors, Ultra Polished Connectors (UPC) and Angle Polished Connectors (APC)
- Older standard connectors have a reflectance of -14dB, which is unacceptable for high bandwidth circuits
- Newer UPC has a reflection closer to –55dB and APC connectors are even better at a reflectance of –70dB
- Both the UPC and APC connectors meet the current industry standards for reflectance. The diagram below shows the different types of connectors and their characteristics

DIRTY CONNECTORS-UNDERSTANDING THE ZONES OF FIBER CLEANING



ZONE NAME	SCRATCHES	DEFECTS
A. CORE (0–25µm)	None	None
B. CLADDING (25–120µm)	No limit <= 3µm None > 3µm	No limit < 2µm 5 from 2–5 µm None > 5µm
C. ADHESIVE (120–130µm)	No limit	No limit
D. CONTACT (130–250µm)	No limit	None => 10µm

The Grading Process

1. Count/measure the particles/contamination that are on the fiber surface
2. Estimate or use a grading overlay to grade the fiber by determining the number and size of each particle
   - Present in each of the four fiber zones
   - In most cases, there are no limits to the number/size of
   - Contaminations present on zone C (adhesive/epoxy)

A. Core zone
B. Cladding zone
C. Adhesive/epoxy zone
D. Contact/ferrule zone

SIMPLEX FIBER INSPECTION TESTING

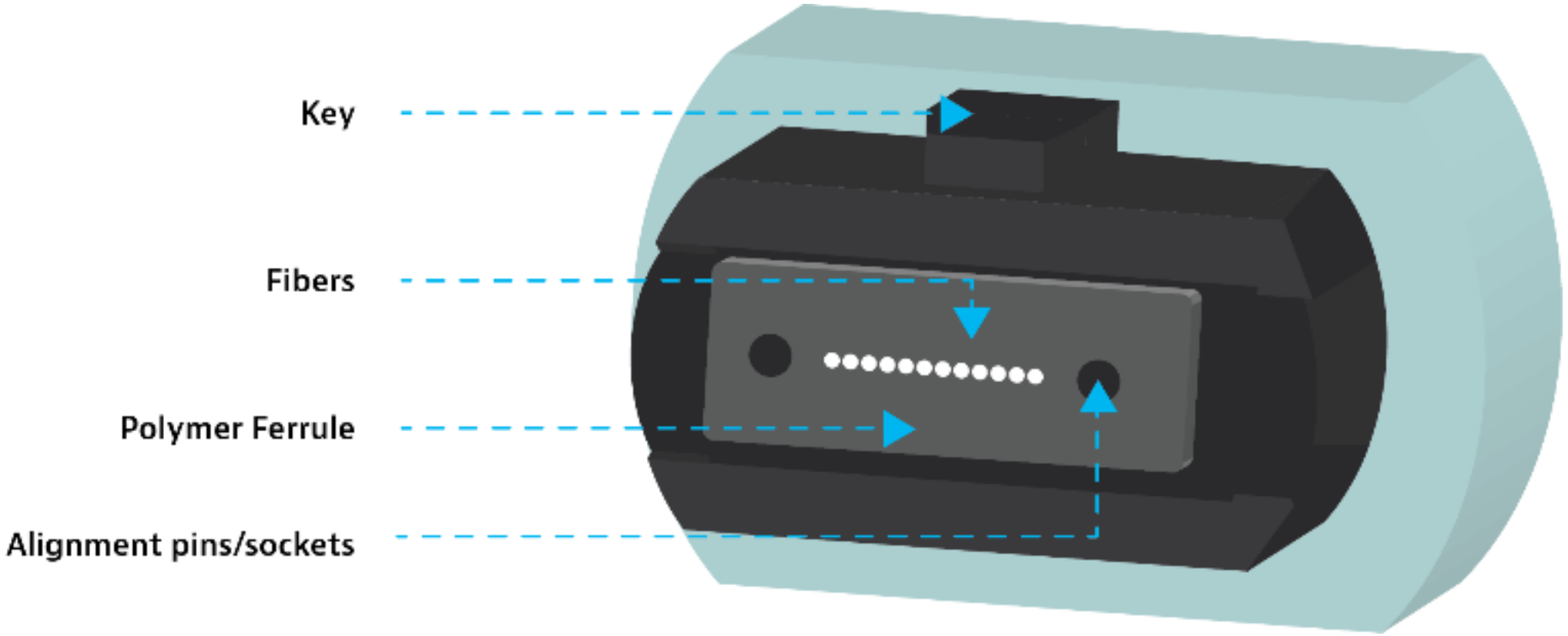
FiberChek Probe

The FiberChek probe is an “all-in-one” handheld solution with built-in capabilities for image viewing, auto-focus, PASS/FAIL analysis, and storing/recalling results.

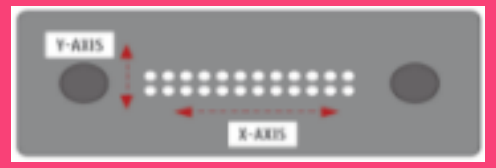
1.5” Touchscreen Display

- Wireless (WiFi and BT – No USB Cord!)
- FiberChek Mobile App – iOS and Android
- Auto Focus
- Auto Pass / Fail Analysis
- Simplex Fiber Inspection – LC, SC
- MPO Fiber Inspection – SM and MM
- MPO Fiber Cleaning Tools

ANATOMY OF A 12-FIBER MULTI-FIBER CONNECTOR



Note: Ribbon connectors with higher fiber counts (e.g. 24) will have multiple rows of fiber on the ferrule



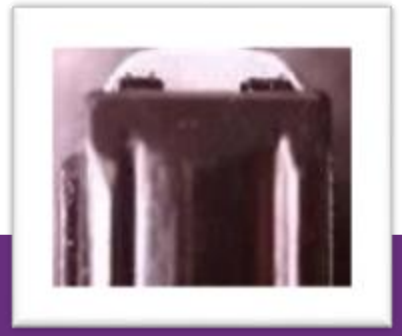
CLEANING MPO/MTP PORTS/CONNECTORS

- Clickers are good for cleaning end faces during network installations
- Cleans both ports and patch cords
- Uses micro woven ultrasonically cut cleaning ribbon

If after several attempts with the click cleaner, you still can't get the end face clean, perform a wet to dry method of cleaning

Best Practice: Wet-to-Dry

- Apply small amount of cleaning fluid to an optical grade wipe
- Touch the cleaning tip of the clicker on the wet spot on the wipe
- Do NOT apply the cleaning fluid directly to the cleaning ribbon



Images courtesy of Sticklers

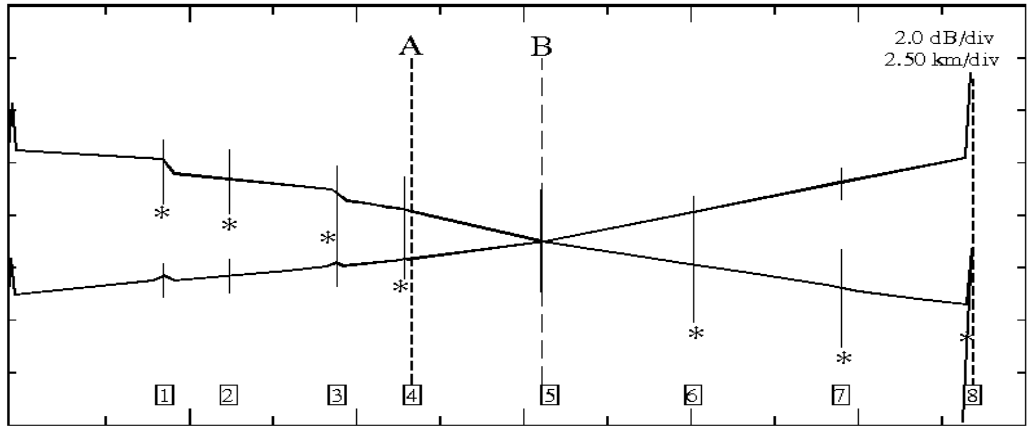
FIBER CHARACTERIZATION

- Bidirectional OTDR
- Dispersion
  - CD
  - PMD

BI –DIRECTIONAL OTDR MEASUREMENTS

End-to-end Bi-directional OTDR Testing

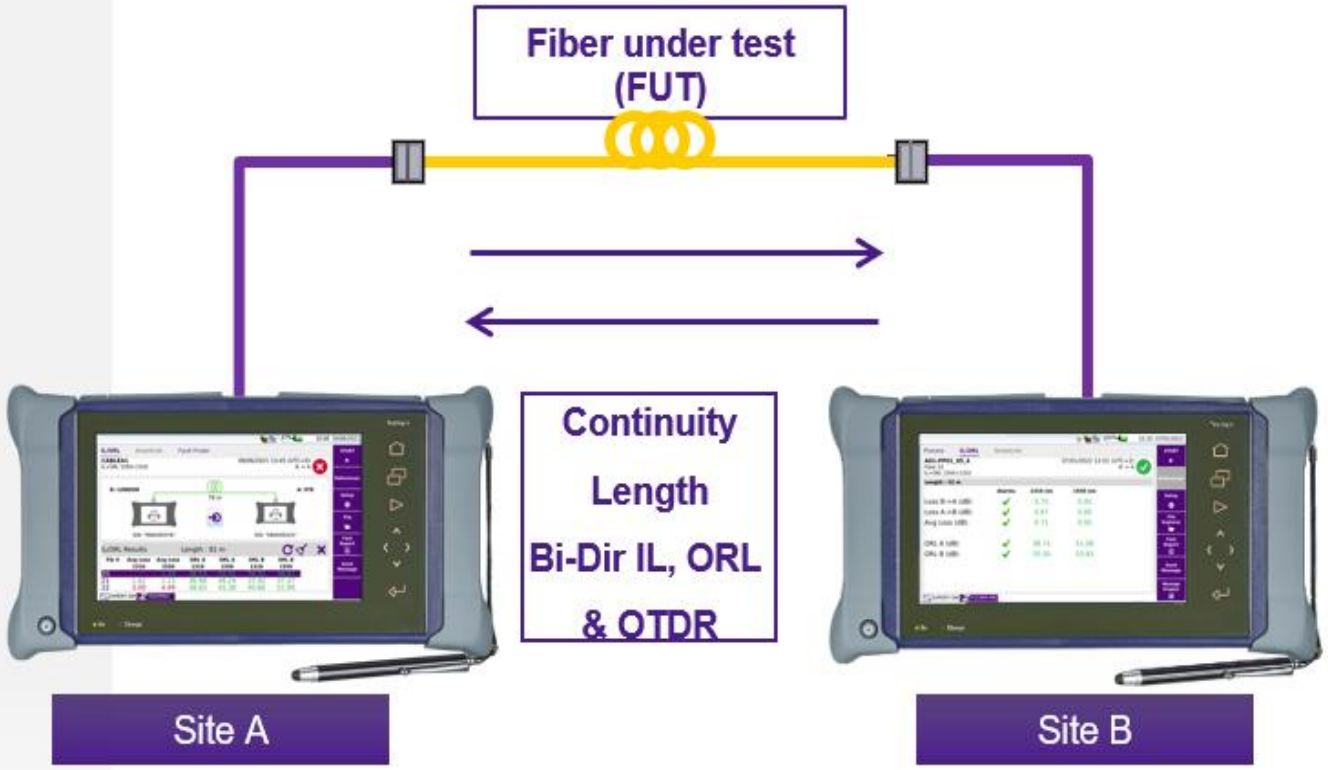
All bi-directionally measured fibers shall be measured first in one direction and then in the opposite direction. This is necessary because the amount of light loss can be different in each direction. This is due to the fibers having slightly different core sizes. Most OTDR's will allow you to measure the fiber in both directions then perform an overlay in order to compare the traces.



Dual OTDR Trace

Ideal Technician Setup

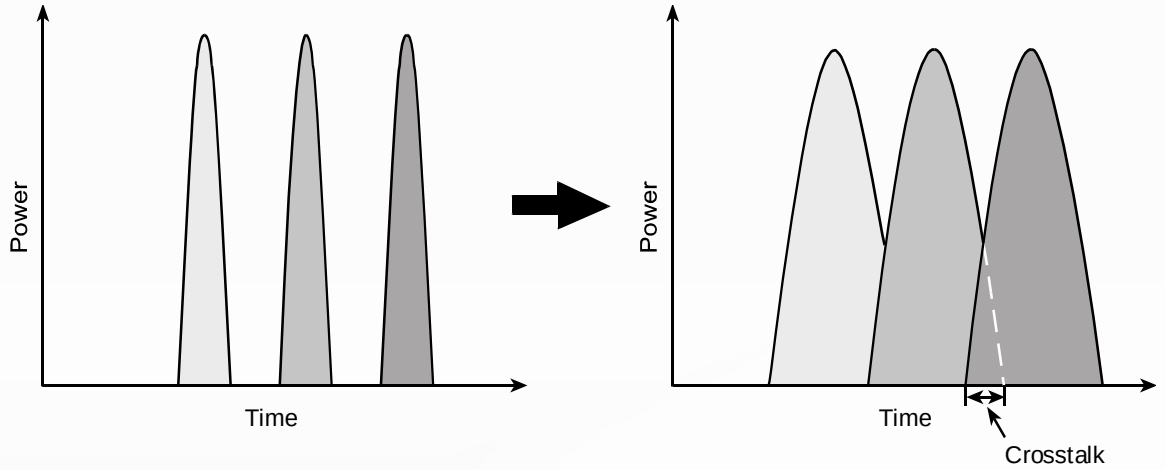
- Two technicians on each side
- Complete bi-directional certification – IL and ORL & OTDR, as well as CD/PMD
- Auto test setup and configuration
- Data link via Fiber Under Test (FUT) for auto test config/setup and results exchange
  - No need for cloud/internet connection
- Instant bi-directional OTDR event loss analysis “TrueBIDIR”
  - Eliminates post processing work*
- Auto file naming, storage and on-board (.pdf) report generation



DISPERSION

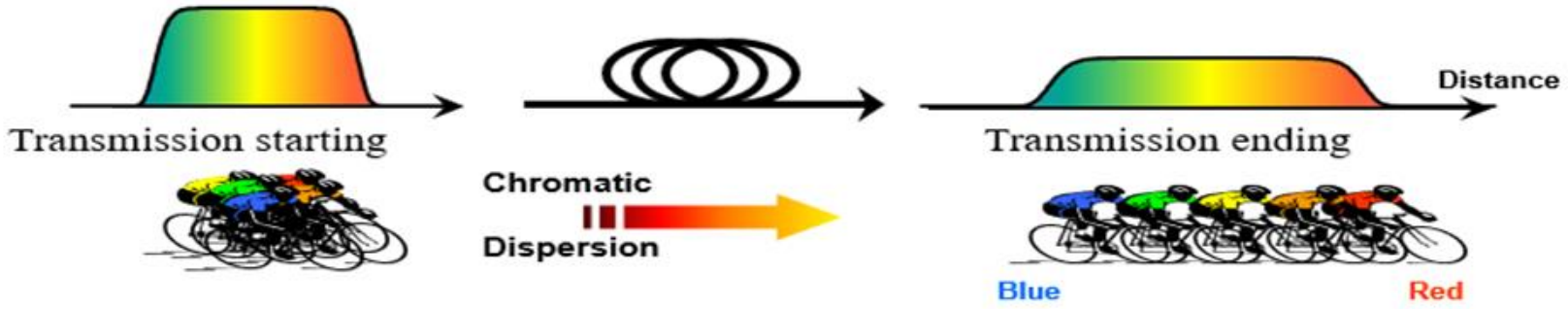
Dispersion

Dispersion is a spreading of the optical signal. There are three types of dispersion that affect fiber services: Modal Dispersion in multimode fiber, Polarization Mode Dispersion and Chromatic Dispersion, which affect single mode in different ways. They all have the same impact on the network, although the mechanism for pulse spreading is a little different. The signal broadening that is caused by dispersion results in crosstalk. The spreading of the pulse can result in bit errors. Dispersion has more impact on higher rate signals due to the shorter pulse period. Dispersion is expressed in picoseconds (nm*Km).



CHROMATIC DISPERSION

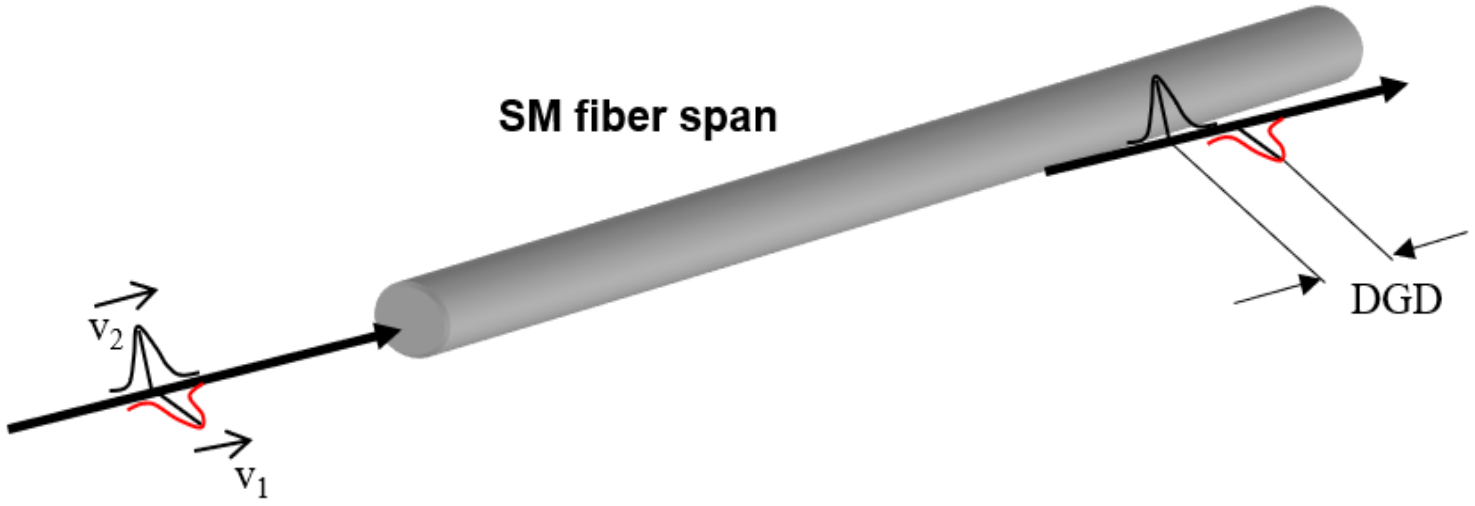
- Chromatic Dispersion: the propagation delay time due to the variation of index according to the wavelength (ps/(nm.km))
- CD caused by different wavelengths travelling at different speed. (No perfect laser - never 100% monochromatic)



- CD limits the transmission speed and distance of the networks.
- CD is critical in bit rate of 10 Gbit/s per channel or higher.

What is Polarization Mode Dispersion (PMD)?

- **Polarization Mode Dispersion (PMD) -** is a form of modal dispersion where two different polarizations of light in a fiber travel at different speeds due to the glass not being perfectly circular.



- NOT PREDICTABLE
- Can vary over time

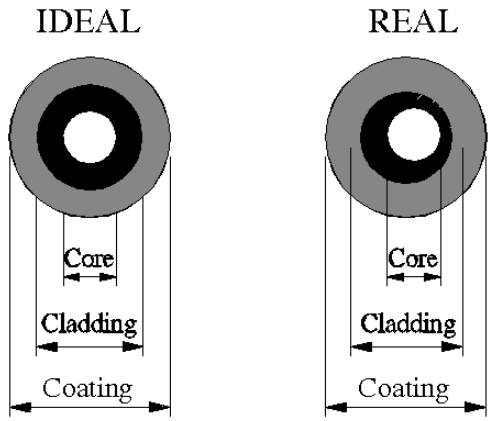
POLARIZATION MODAL DISPERSION

Polarization Modal Dispersion (PMD)

PMD is an issue for transmission rates of 10G and higher. PMD is one of several effects that can cause light signals to become unreadable when they have traveled over long distances. It occurs when light travels faster in one polarization plane than another.

PMD is an issue because of the fiber manufacturing process, but it can also be exasperated during the installation if the cable is kinked, overstressed, or by micro bending. Environmental and climatic changes can effect the circular geometry and thus worsen the PMD characteristics.

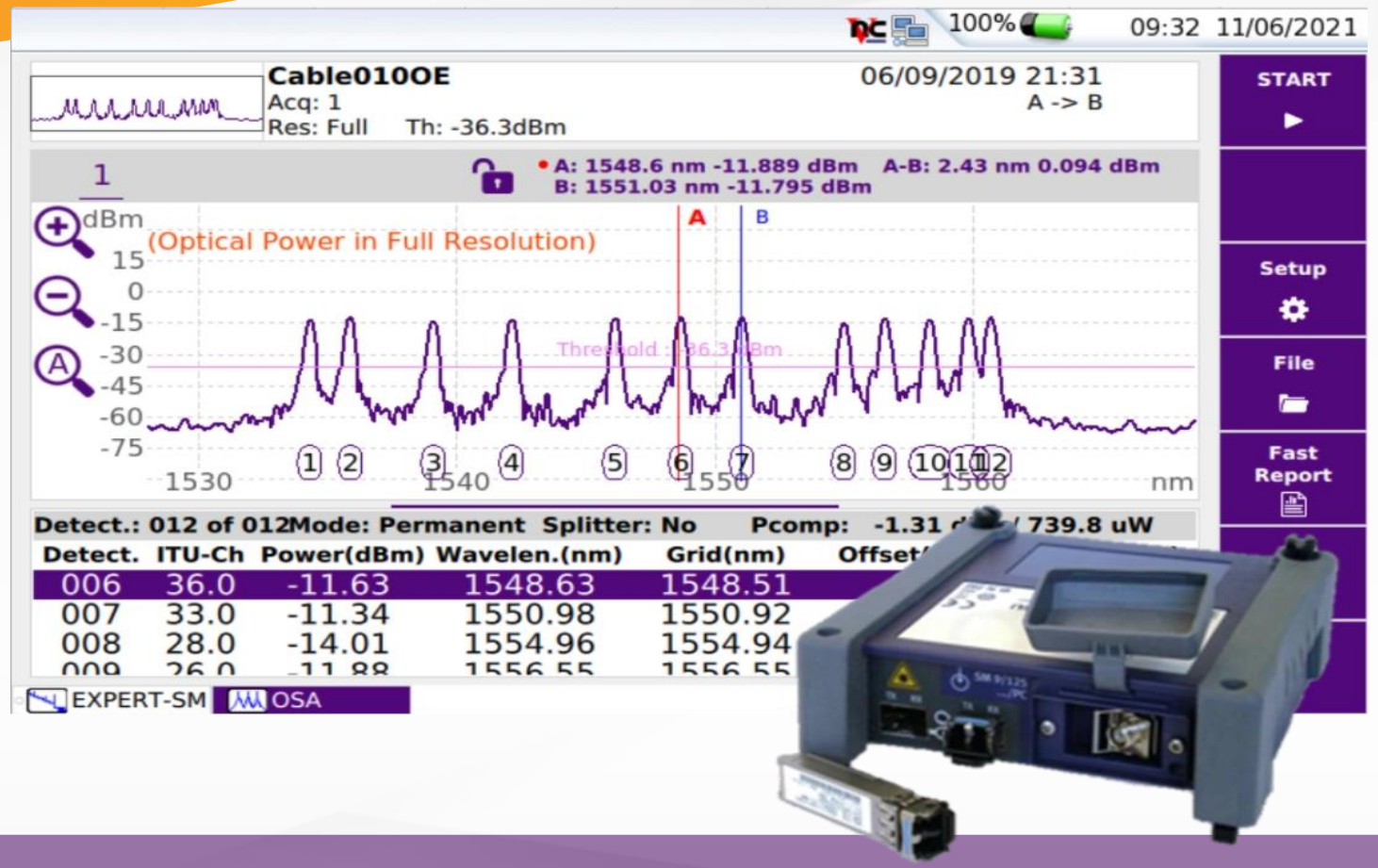
CROSS SECTION of a Typical Fiber



Pass/Fail Thresholds

Transmission Type	Transmission Rate	PMD Max	CD Max
OC-192/STM-64	10 Gb/s	10 ps	1176 ps/nm
Ethernet	10 Gb/s	5 ps	738 ps/nm
OC-768/STM-256	40 Gb/s	2.5 ps	64 ps/nm
100GigE	100Gb/s	25 ps	2400 ps/nm

OSA /CHANNEL CHECKERS



THANK YOU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