How do you troubleshoot a FTTH network?

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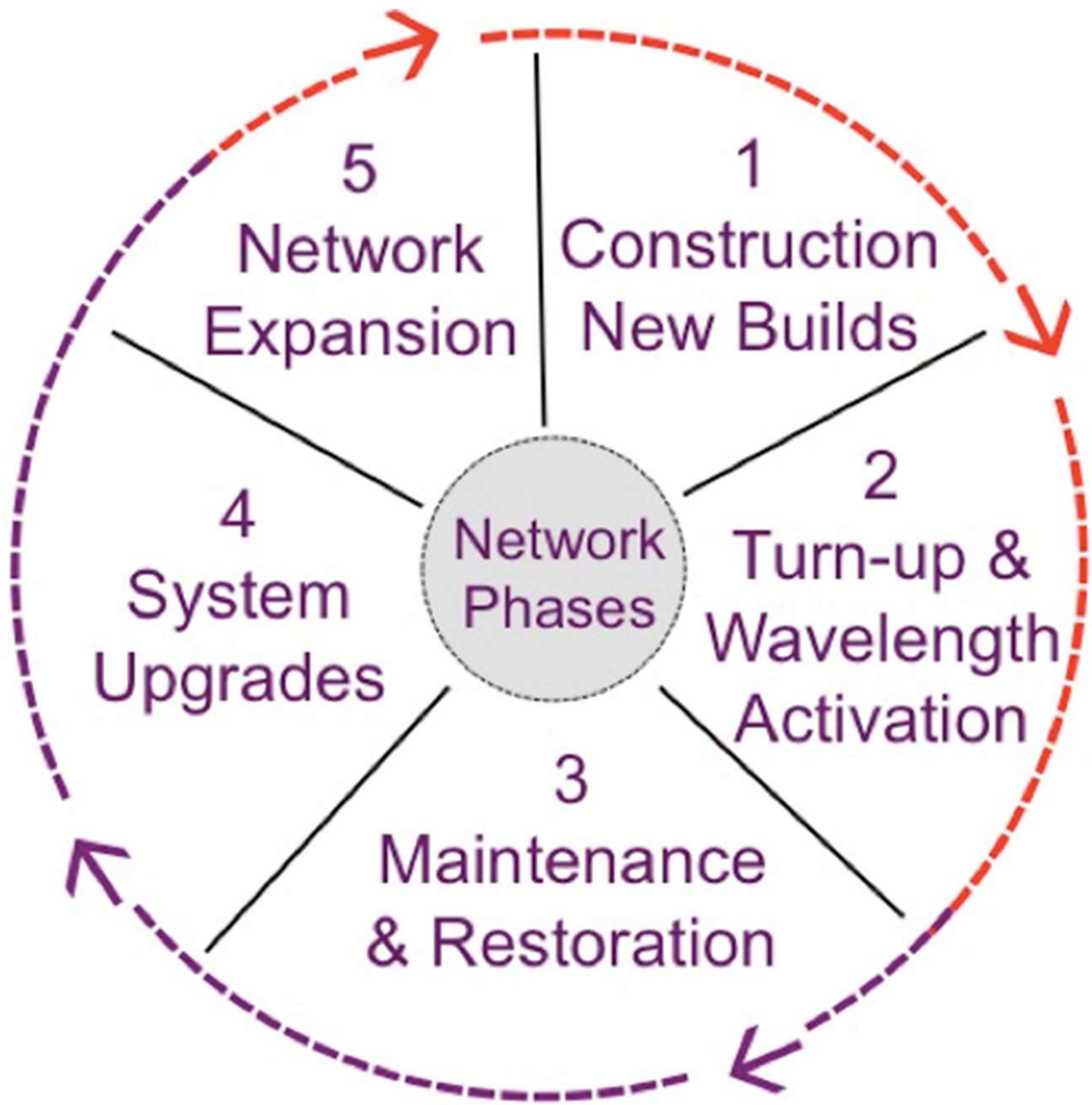
ACCELERATE THE DEPLOYMENT OF TECHNOLOGY
TO THE ADVANTAGE OF OUR INDUSTRY.

SCTE
Society of Cable Telecommunications Engineers
a subsidiary of CableLabs®

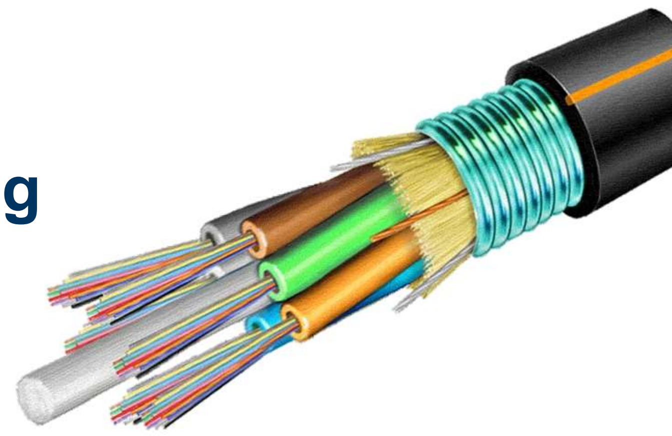
CCTA
CARIBBEAN CABLE & TELECOMMUNICATIONS ASSOCIATION

Troubleshooting Fiber

- Optimize a FTTH network by keeping connectors and ports clean
- Activity: Use a recommended practices for cleaning
- Activity: Use an optical scope to verify a connector is clean
- Recognize the value of an optical visual fault locator (VFL)
- Activity: Use an VFL
- Recognize the value passive optical network (PON) optical power meters
- Describe the testing options for Ethernet and Wi-Fi testing equipment
- Discover the fundamentals for an optical spectrum analyzer (OSA) and optical time domain reflectometer (OTDR)


1
Construction
New Builds
2
Turn-up &
Wavelength
Activation
3
Maintenance
& Restoration
4
System
Upgrades
5
Network
Expansion
Network
Phases

Optimize a fiber network by scoping and cleaning connectors



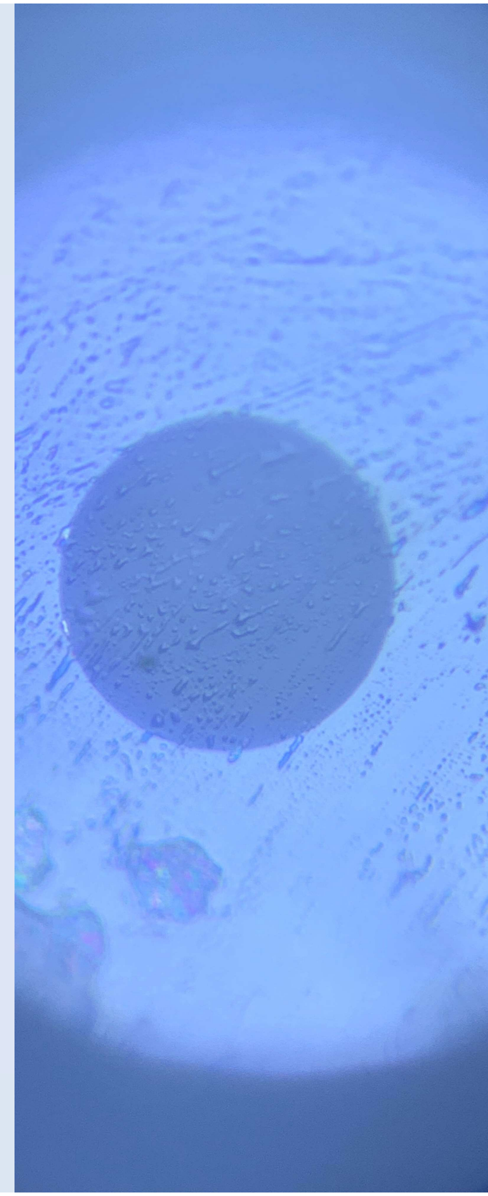
Raise Your Hands….

What is the biggest issue in fiber networks?

Fiber connectors!!

How does a technician verify connectors are optimized?

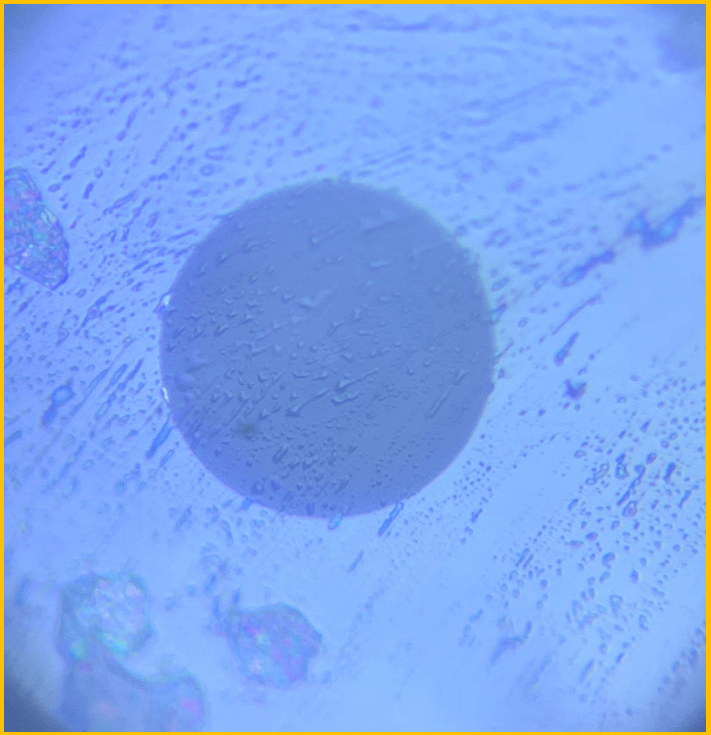
Use a fiber scope and a fiber cleaning process.



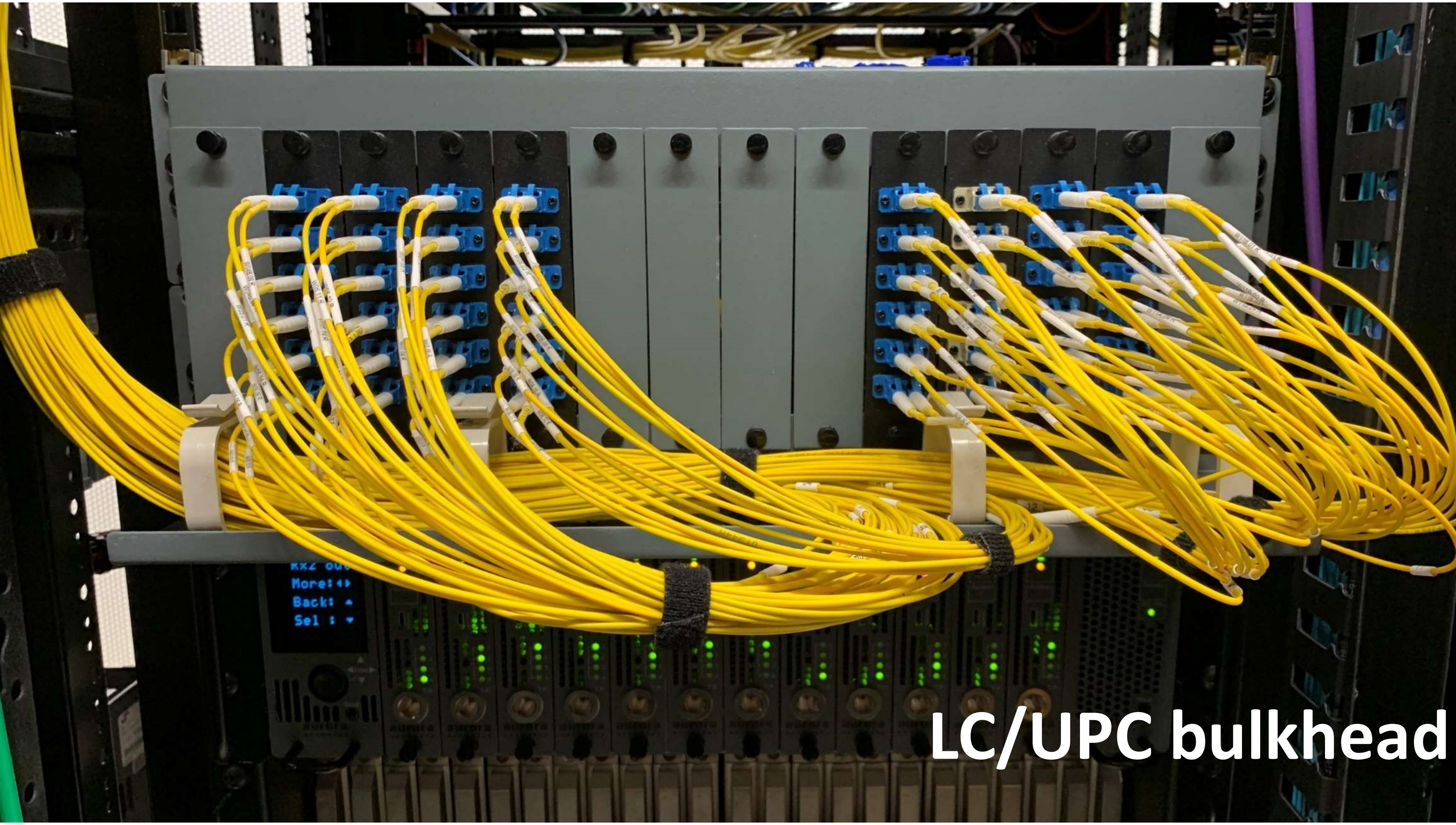
Fiber Cleaning

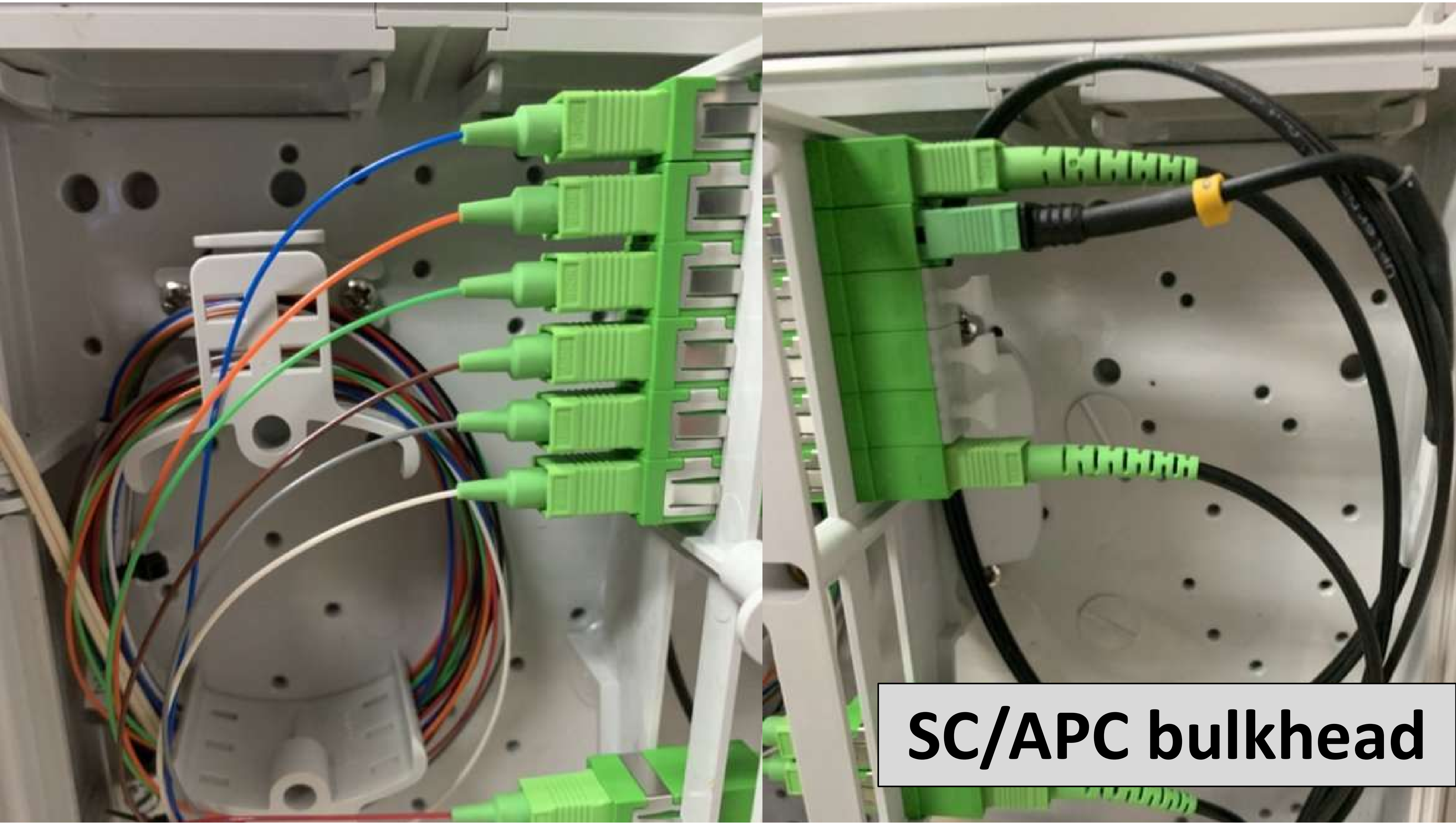
- Fiber inspection / cleaning of the patch cord and bulkhead sides are SIMPLE steps with immense benefits.

- Connectors behind the bulkhead are frequently dirty and problematic!

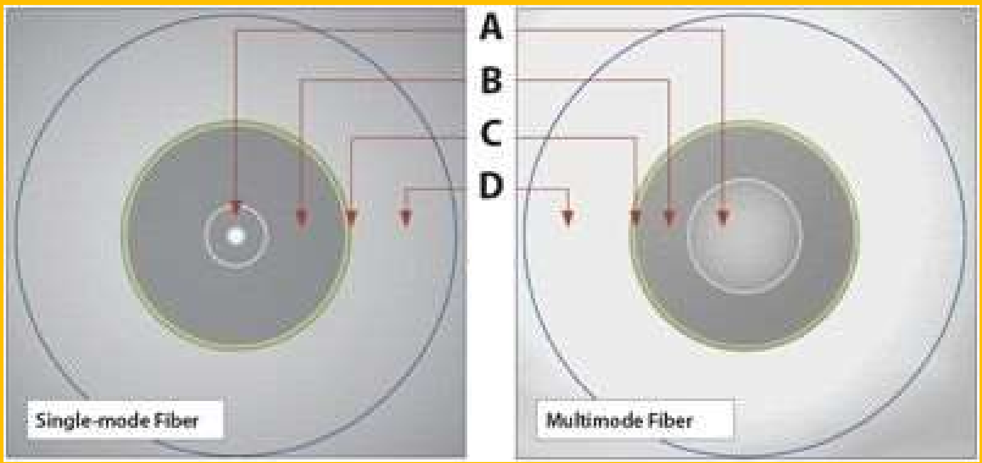


Types of Contamination: Dirt, oil, pits, scratches


More:
Back:
Sel :
LC/UPC bulkhead


SC/APC bulkhead

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 IEC 61300-3-35 sets the requirements for connector quality.**
- **The table shows four zones called A, B, C, and D.**
- **Each zone has a limit for scratches and a zone limit for defects.**

Fiber Cleaning

1. Inspect

2. Clean

3. Inspect Again

4. Connect

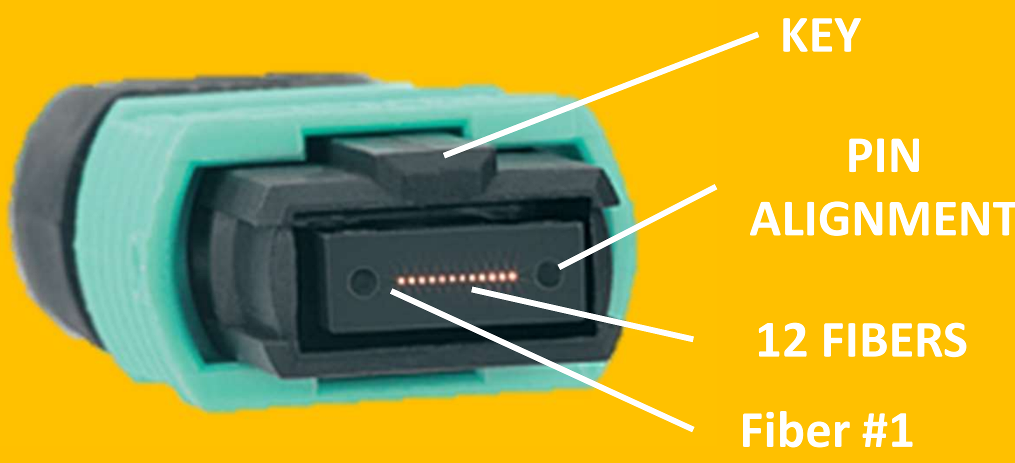
Ribbon Fiber Cleaning

1. Inspect

2. Clean

3. Inspect Again

4. Connect



Real Life Examples

Before Cleaning

- Level and MER okay
- Notice Bit Errors both pre and post
- Also shows errored seconds

After Cleaning

- MER and Level improvement
- Pre and Post Bit Error issue is corrected
- Errored Seconds corrected

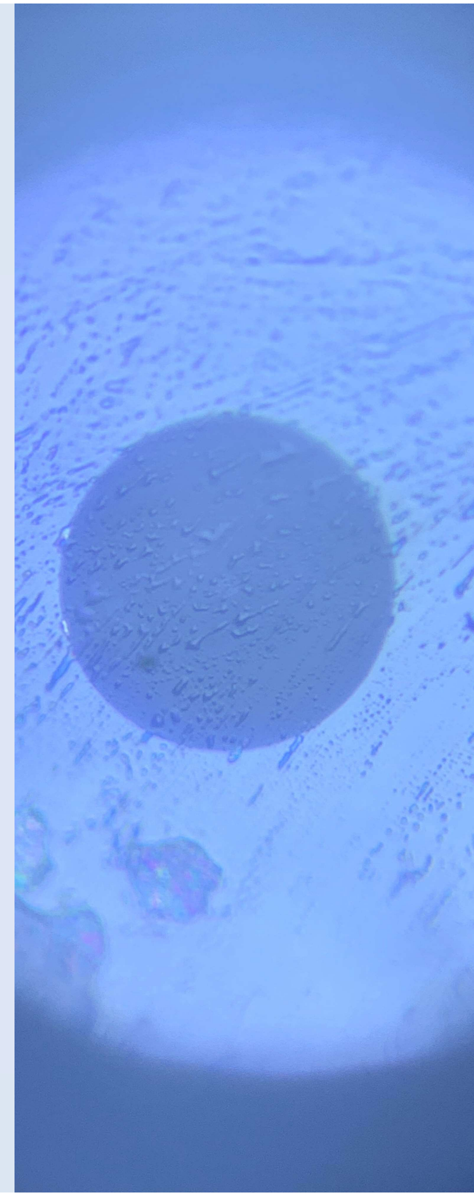
10Gb SFP Transmitter

Sent back for repair was *just* cleaned and shipped as defective

Raise Your Hands….

True or False: New Fiber Jumpers do not have to be cleaned if they are new in the plastic bag and have a dust cap from the manufacture.

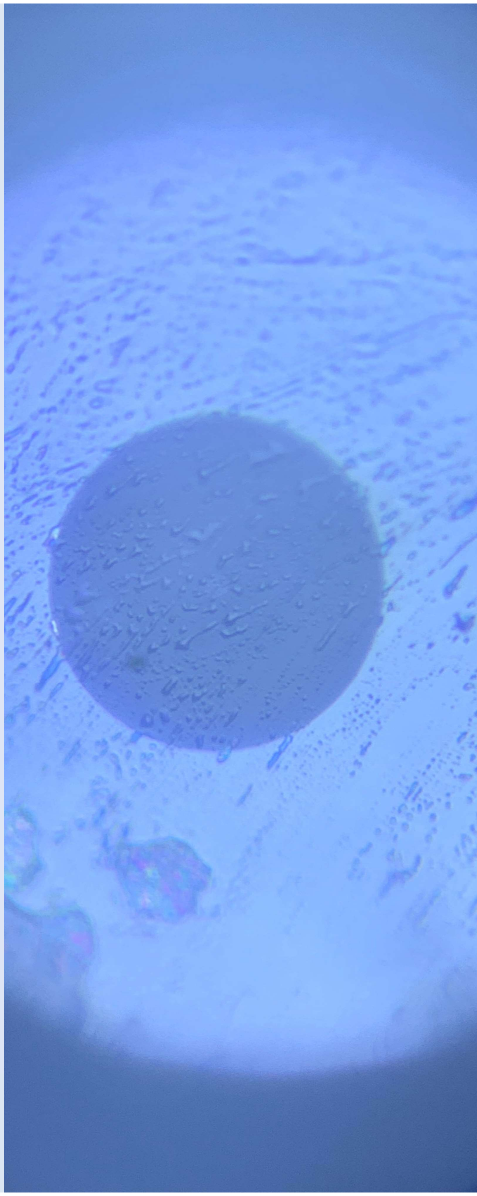
FALSE!!



Raise Your Hands....

When do you clean?

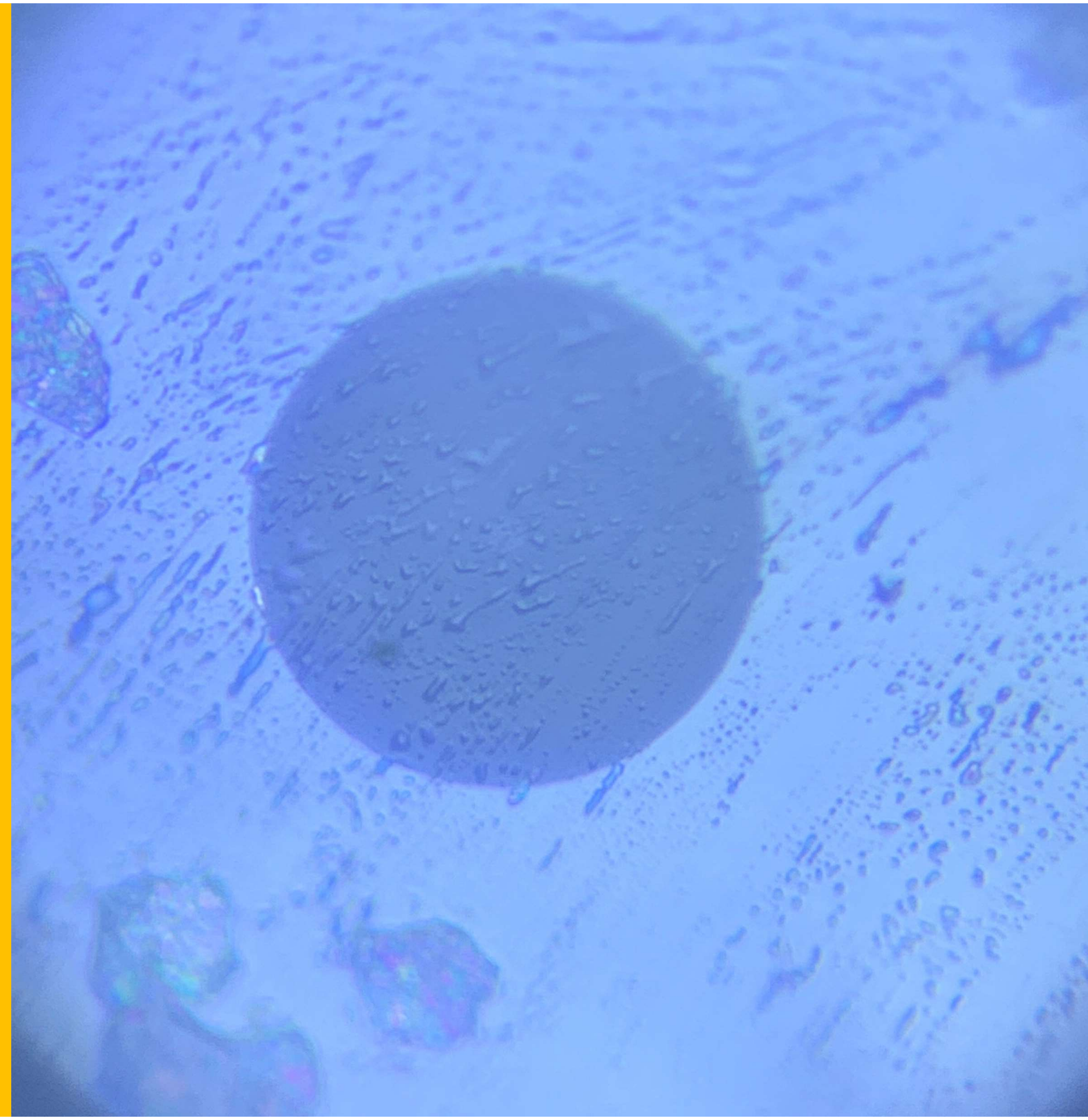
- *Installing new equipment and fiber connections*
- *Before using a new jumper*
- *When troubleshooting performance issues*
- *Anytime you touch an optical connector or port!!*

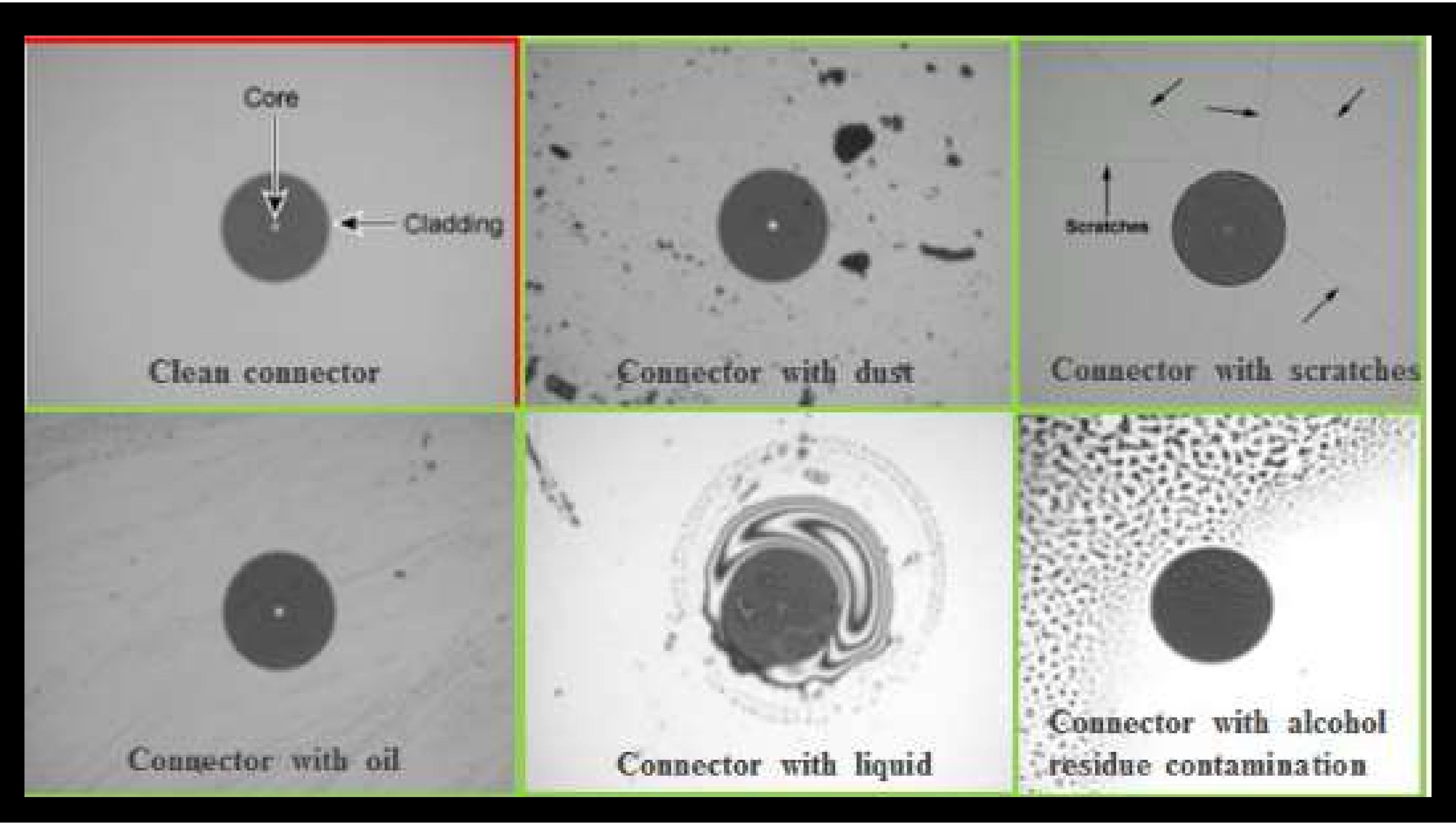


Inspection Tools

1. inspection microscope
2. 200x magnification
3. focus wheel
4. 2.5 mm (FC/SC/ST)
5. 1.25mm (LC)

Inspection Tools

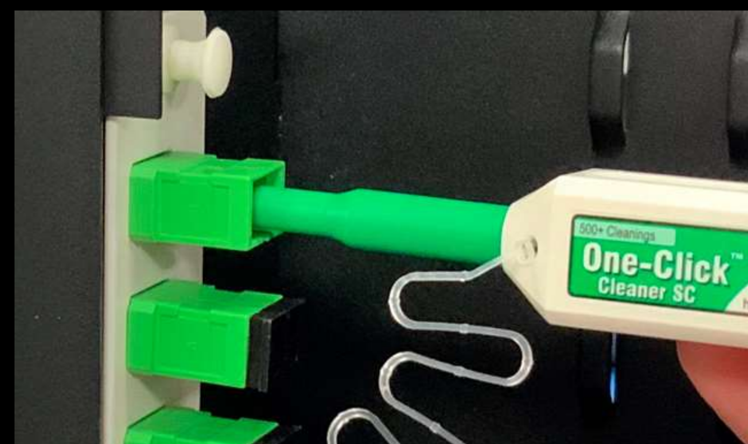




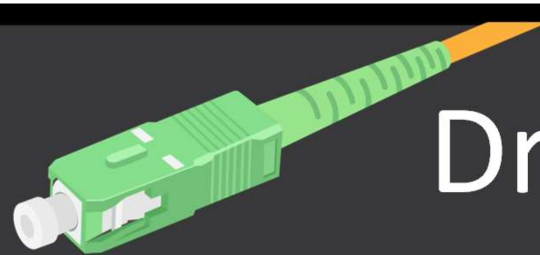
Core
Cladding
Clean connector
Connector with dust
Scratches
Connector with scratches
Connector with oil
Connector with liquid
Connector with alcohol residue contamination

Cleaning Tools

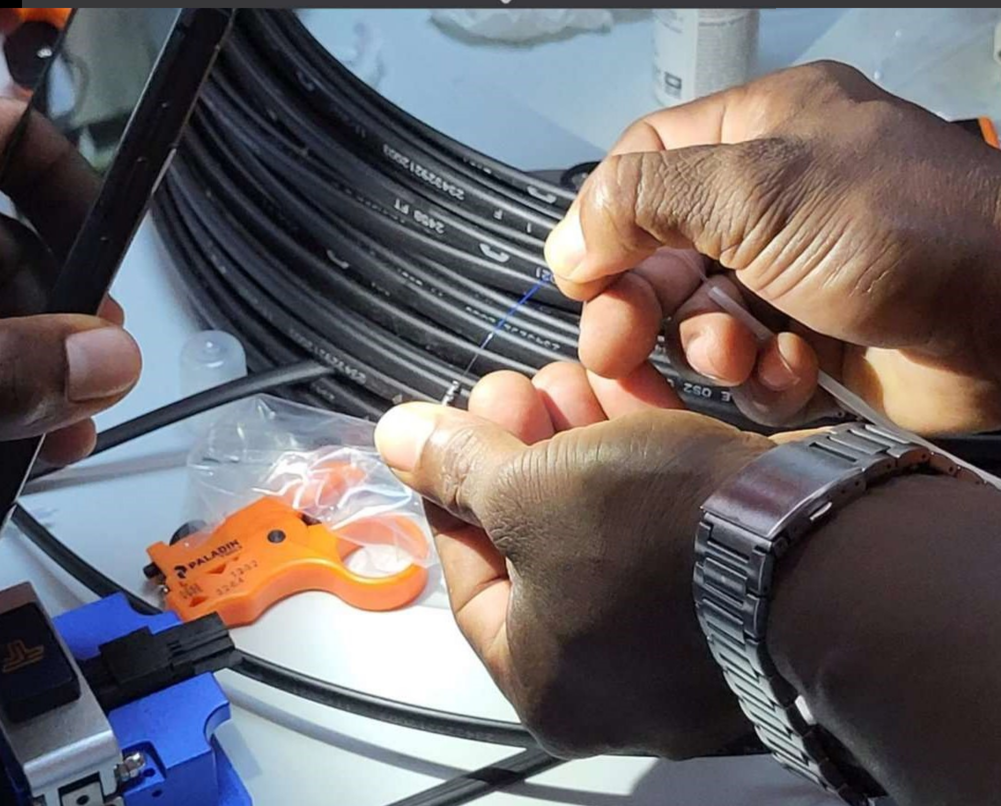
Cleaning the Fiber, Use the Proper One Click!



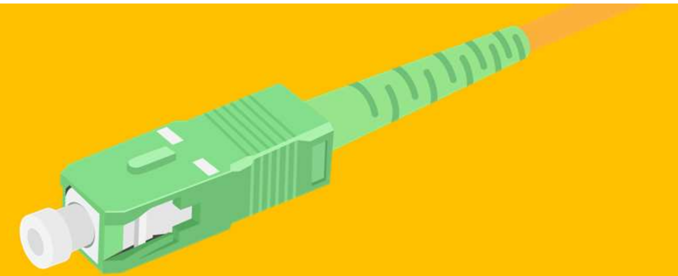
MST/NAP Cleaning



Drop Cleaning

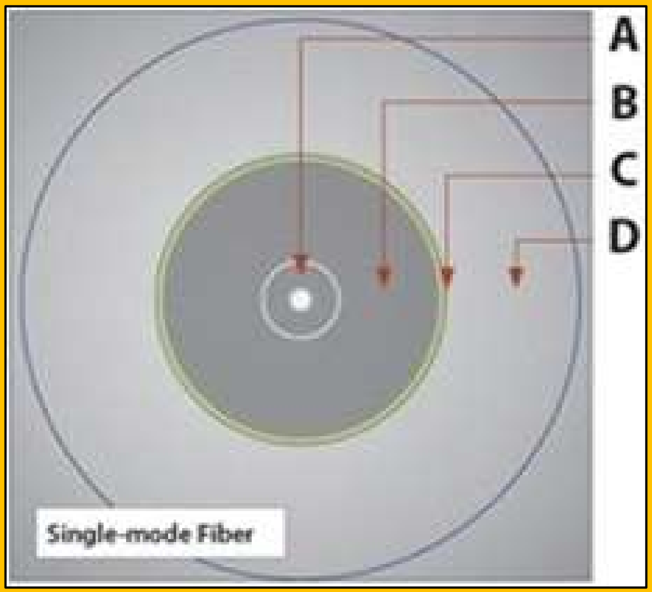


Cleaning Really Dirty Connectors
"Wet to Dry" Method



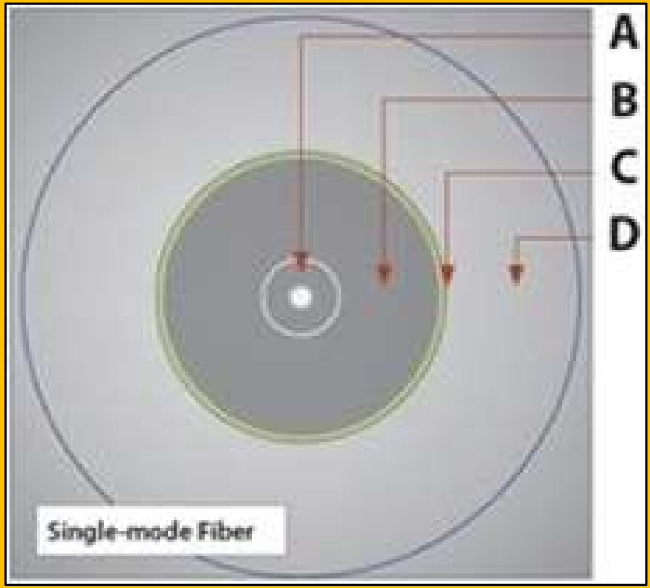
- Start by wetting a portion of the cleaning cube or cleaning tape.
- Place the connector in the wet part.
- Slide to the dry section.

Digital Scopes



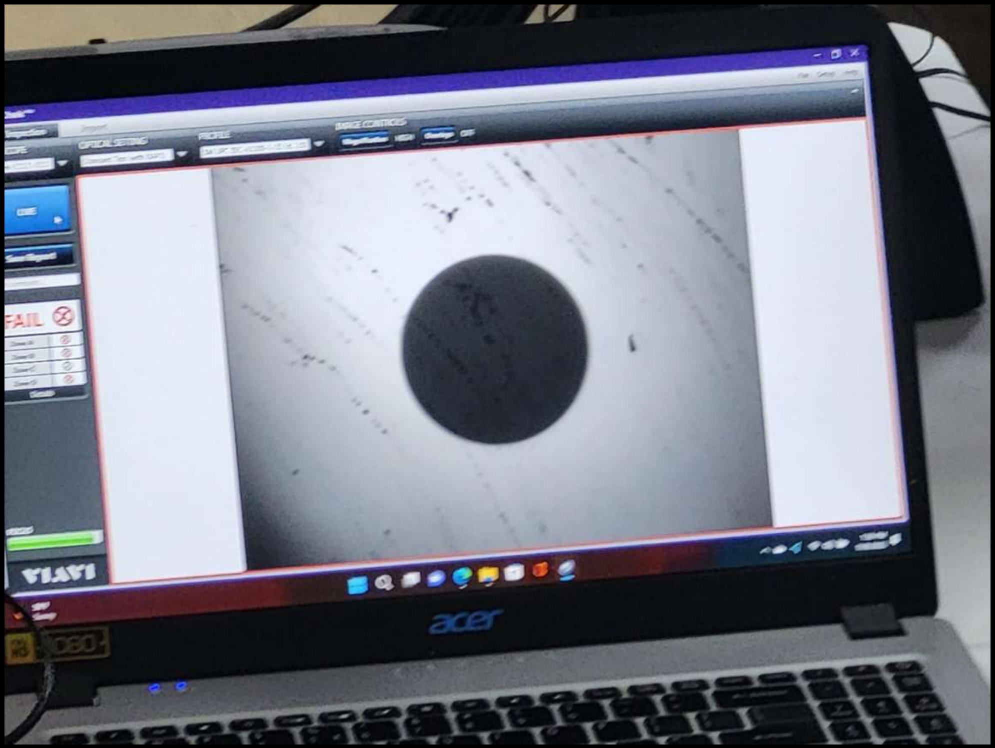
IEC 61300-3-35

Digital Scopes

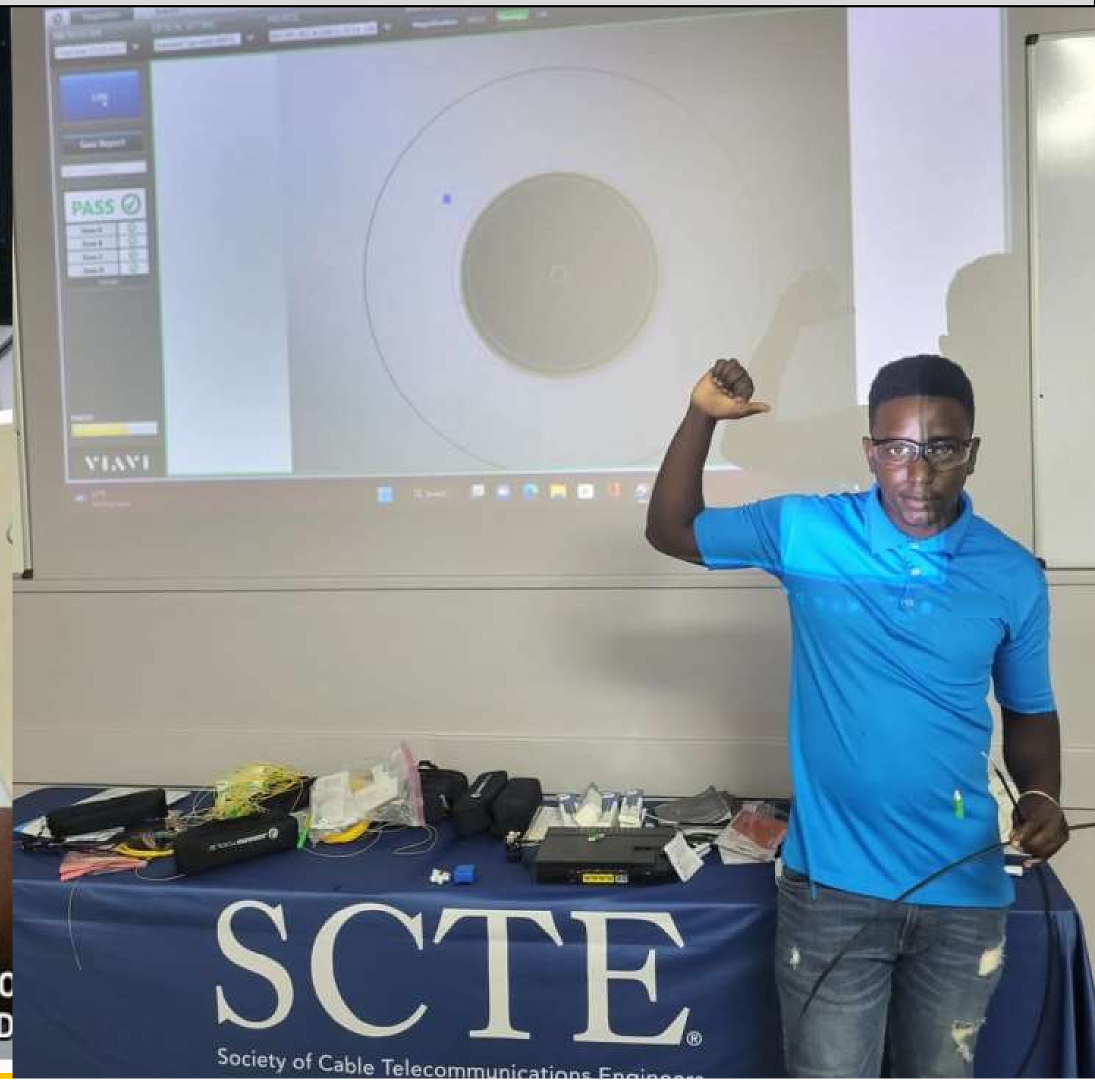


IEC 61300-3-35

Fiber Scoping, Here is the Fiber is Dirty!!



Digital Scopes



Bad One-Click

ACTIVITY: USE A SCOPE TO INSPECT

ACTIVITY: USE DRY CLEANING METHOD TO CLEAN FIBER

Cleaning Fiber

https://broadbandlibrary.com/

FIBER SOURCE

Cleaning Optics Is a Practice Not a Project

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Steve Harris is the senior director of advanced network technology and instruction at SCTE•ISBE. He is a respected international telecommunications subject matter expert, sought-after presenter and principal instructor. He is responsible for the tremendous growth of SCTE•ISBE training programs and certifications for over 100,000 telecommunications professionals. He is also responsible for the client partnership in the SCTE•ISBE Corporate Alliance Program for cable operators and vendors.

The trend in the cable industry going forward will be to deploy an increased number of fiber-rich networks that include sophisticated optic connections, equipment, and cabling. New architectures like distributed access, fiber deep (node + 0), and fiber to the x (FTTx) all take advantage of new fiber connectivity in the core, aggregation, access, and premises networks. Many of these fiber networks use single mode fiber (SMF) connections with an 8 micrometer or micron (µm) core, where a dust particle in an SMF core is like a clog in a premises water drain. These clogs may block a single optical wavelength or where operators are deploying wavelength division multiplexing (WDM), many wavelengths at once. Remember that the dust, scratches, and defects we are referring to here cannot be seen with the human eye. For example, in a fiber deep architecture a single dust particle may be able to take out a mother node (see my previous article on fiber deep) and all fiber deep nodes that are fed from the mother node. All of our new deployments in fiber optics will introduce new core competencies required by cable operators for their workforce to deploy, operate and troubleshoot fiber networks.

Whenever an optical connection occurs, there is a chance that contaminants may enter our networks. There is also vendor data to show that optical dust caps and/or new optical jumpers out of the box may also introduce contaminants. It is always important to inspect before you connect, never assume the optical connections, hub bulkheads, equipment ports, pluggable optics and test equipment ports are clean! Contaminants may be introduced by people that mishandle optical connections. Mishandling these connections introduces oils (e.g., from touching with fingers), dust, residue from poor wiping techniques, lint, condensation deposits, contaminated alcohol, not using connector caps, contaminated caps, etc.

It is also important that cable personnel visually inspect both sides of a connection, meaning the fiber optic connector and any other ports that will be utilized. Visually inspecting both sides of an optical connection with an appropriate instrument will lead to improved optical health and reduction in damaged connections in our networks. For example, visually inspecting and cleaning fiber connections improves many of our customer affecting metrics like optical power levels, end of line RF power levels, attenuation (e.g., reducing reflectance), modulation error ratio (MER), pre-forward error correction (FEC) bit error ratio (BER), and post-FEC BER.

In addition, proper cleaning of connectors will reduce connector to port mating damage, as hard contaminants may lead to scratches on the silica glass. With all cleaning mentioned, it is important to visually re-inspect to make sure proper cleaning was completed.

What is the recommended method that should be used by cable operators to maintain their optic connections? The answer is an International Electrotechnical Commission (IEC) standard known as 61300-3-35, which sets the requirements for connector quality. Another standard is known as IPC or referred to today as the Association Connecting Electronics Industries (ACEI), however our focus will be the IEC standard for this article as many of our cable vendors support the IEC method. The IEC standard was developed to guide the telecommunications industry in determining the types of issues that may occur in multiple diameter zones of an optical connection. In the figure below an optical end face is segmented into four zones for visual inspection known as the core (A), cladding (B), adhesive (C) and contact (D).

Figure 1 — Visual inspection of optical connector before cleaning, showing debris and poor metrics

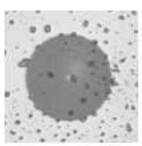


Figure 2 — Visual inspection of optical connector before cleaning, showing residue from poor wiping techniques

Figure 3 — Visual inspection of optical connector after cleaning, with debris removed and improved metrics

Figure 4 — Visual inspection of fiber: Zones A, B, C and D

The IEC standard defines multiple diameter zones with scratch and defect tolerances for SMF and multi-mode fiber (MMF). Below are the visual requirements for SMF scratches and defects for each zone.

Notice in Table 1 that scratches and defects in the core are not allowed, replacement will be needed for jumpers and other optical equipment when a zone requirement cannot be achieved. Also, note in Table 1 that the cladding should not have scratches greater than 3 µm nor defects greater than or equal to 5 µm. In practice, fiber inspection beyond the contact zone D is recommended, making sure to evaluate overall cleanliness beyond the contact zone to maintain good craftmanship.

The IEC standard also defines an MMF end face. Table 2 shows the visual requirements for MMF scratches and defects for each zone.

It is virtually impossible to qualify a connector against a standard such as IEC with a manual inspection process. Many optical vendors provide an automated visual inspection or microscope (scope) test instrument with analysis software. These instruments are used to grade the health of an optical connection, verifying that a connection has been properly cleaned or polished. Many of the vendors will also supply reporting options for record keeping, showing proof of compliance with IEC or IPC standards.

As operators deploy more optical connections in the network, it will be vital to handle these connections properly and with the utmost of care. Today's network must operate with the highest reliability possible, providing the best quality of experience (QoE) for our subscribers. Many of the vendors in the cable community have shared how contamination can be the number one source of issues in our optical networks. Be sure to proactively inspect the optical connections using an automated scope that is aligned to a standard like IEC. Since most of the contaminations are not visible to the human eye, this will be a crucial step to determine if a connection is clean. Finally, after cleaning always re-inspect the connection. To learn more about fiber optics or to pursue a career in this growing field, be sure to check out SCTE·ISBE's new certified broadband fiber installer, http://www.scte.org/BPI.

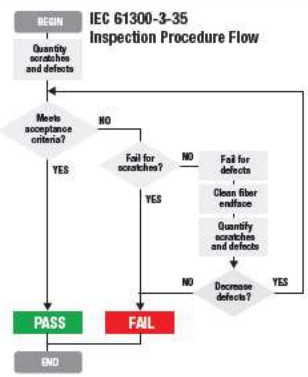


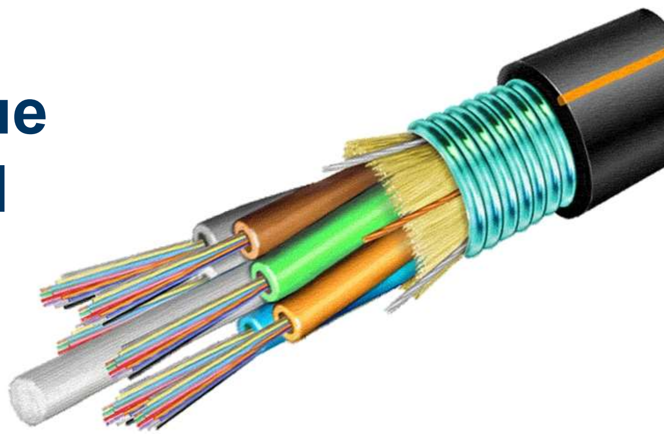
Table 1 — Single Mode Fiber Zones and Visual Requirements

ZONE	DIAMETER	ZONE NAME	SCRATCHES (Requirements refer to their width) (e.g., pits and chips)	DEFECTS (Requirements refer to their width) (e.g., pits and chips)
A	0 to 25 µm	Core	None is acceptable	None is acceptable
B	25 to 120 µm	Cladding	None > 3 µm No limit <= 3 µm	None > 5 µm 5 defects from 2 µm to 5 µm No limit < 2 µm
C	120 to 130 µm	Adhesive	No limit	No limit
D	130 to 250 µm	Contact	No limit	None >= 10 µm

Table 2 — Multi-mode Fiber Zones and Visual Requirements

ZONE	DIAMETER	ZONE NAME	SCRATCHES (Requirements refer to their width)	DEFECTS (Requirements refer to their width)
A	0 to 65 µm	Core	None > 5 µm No limit <= 5 µm	None > 5 µm 4 defects <= 5 µm
B	65 to 120 µm	Cladding	None > 5 µm No limit <= 5 µm	None > 5 µm 5 defects from 2 µm to 5 µm No limit < 2 um
C	120 to 130 µm	Adhesive	No limit	No limit
D	130 to 250 µm	Contact	No limit	None >= 10 µm

Recognize the value of an optical visual fault locator (VFL).

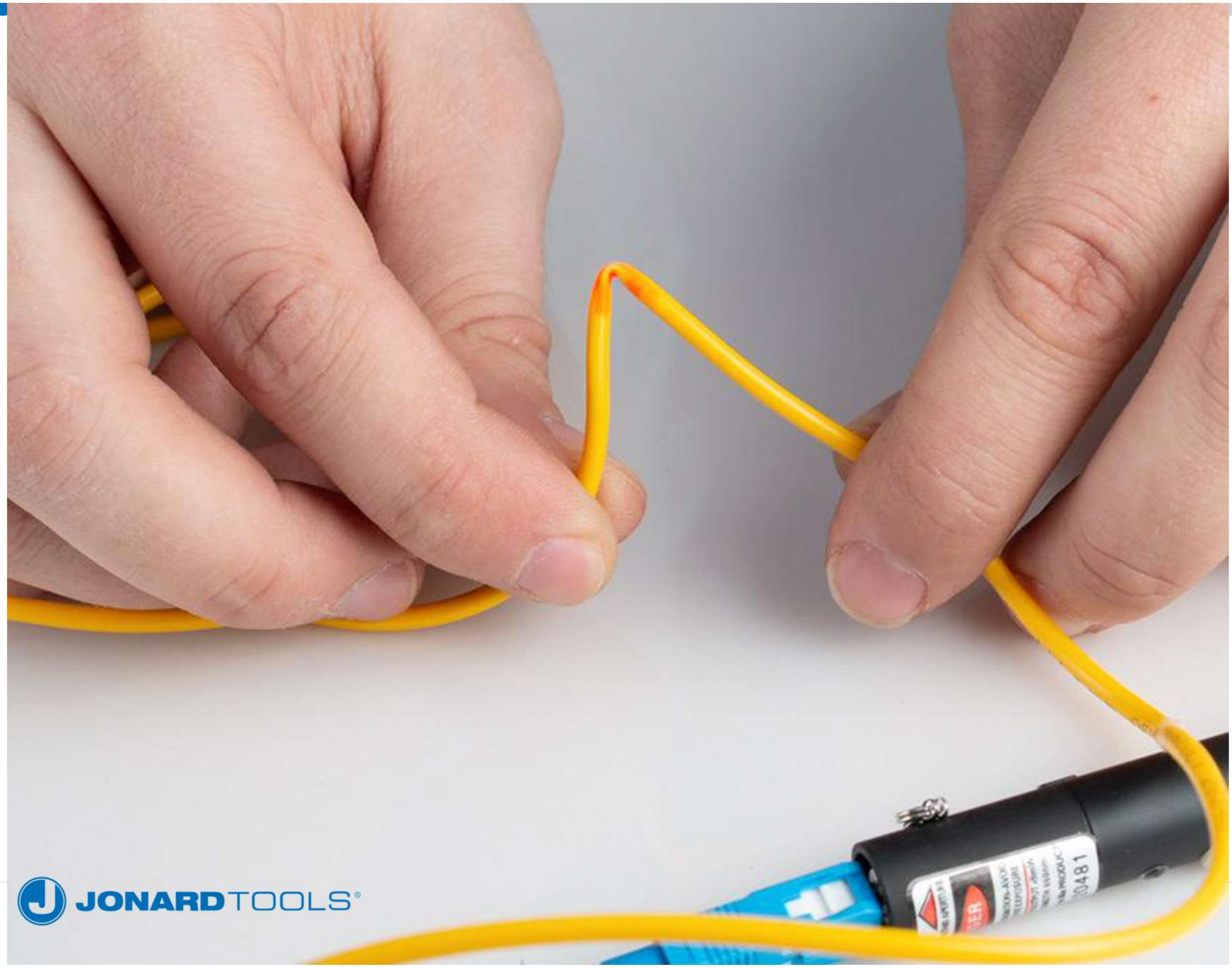


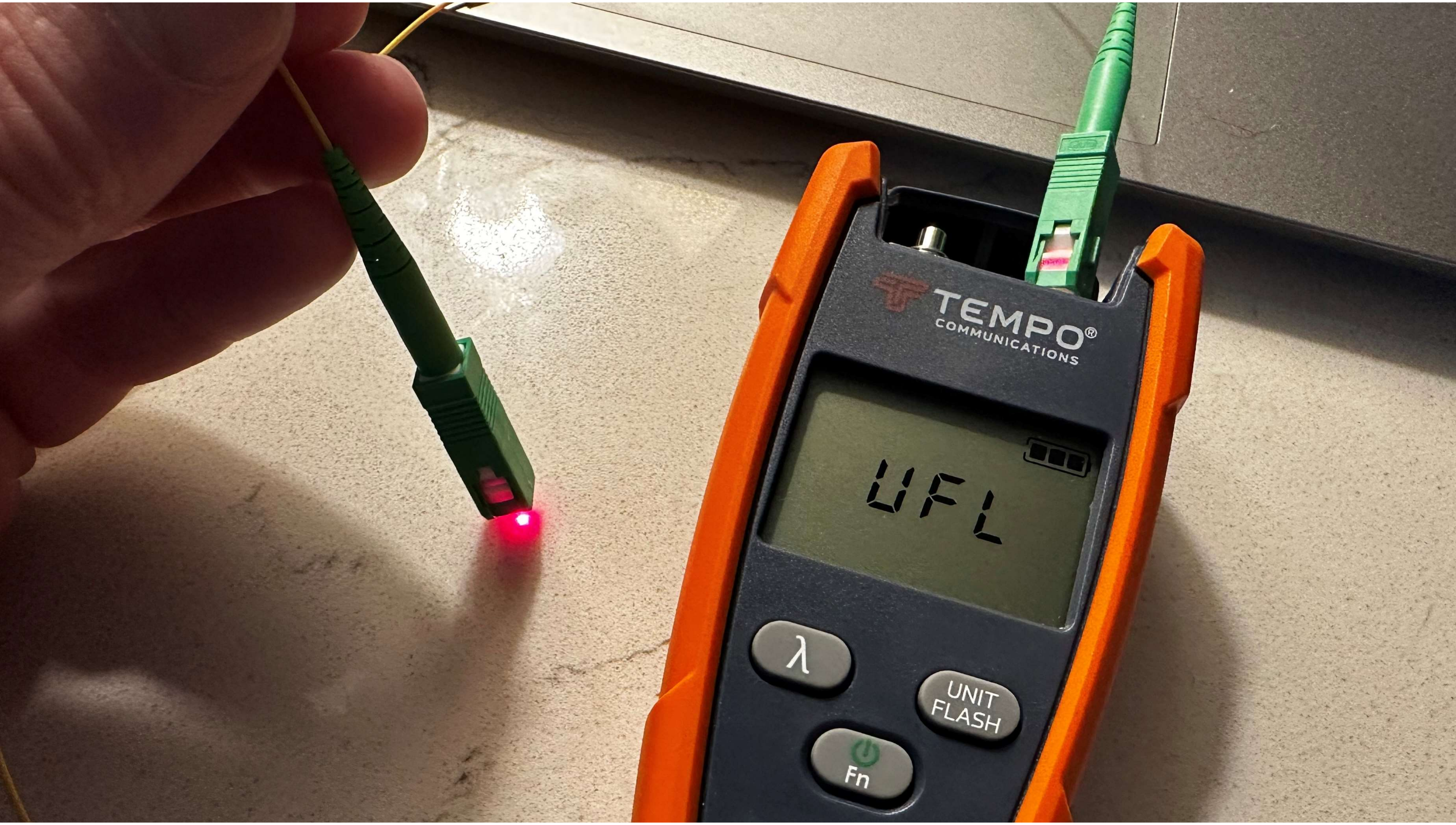
Macrobends

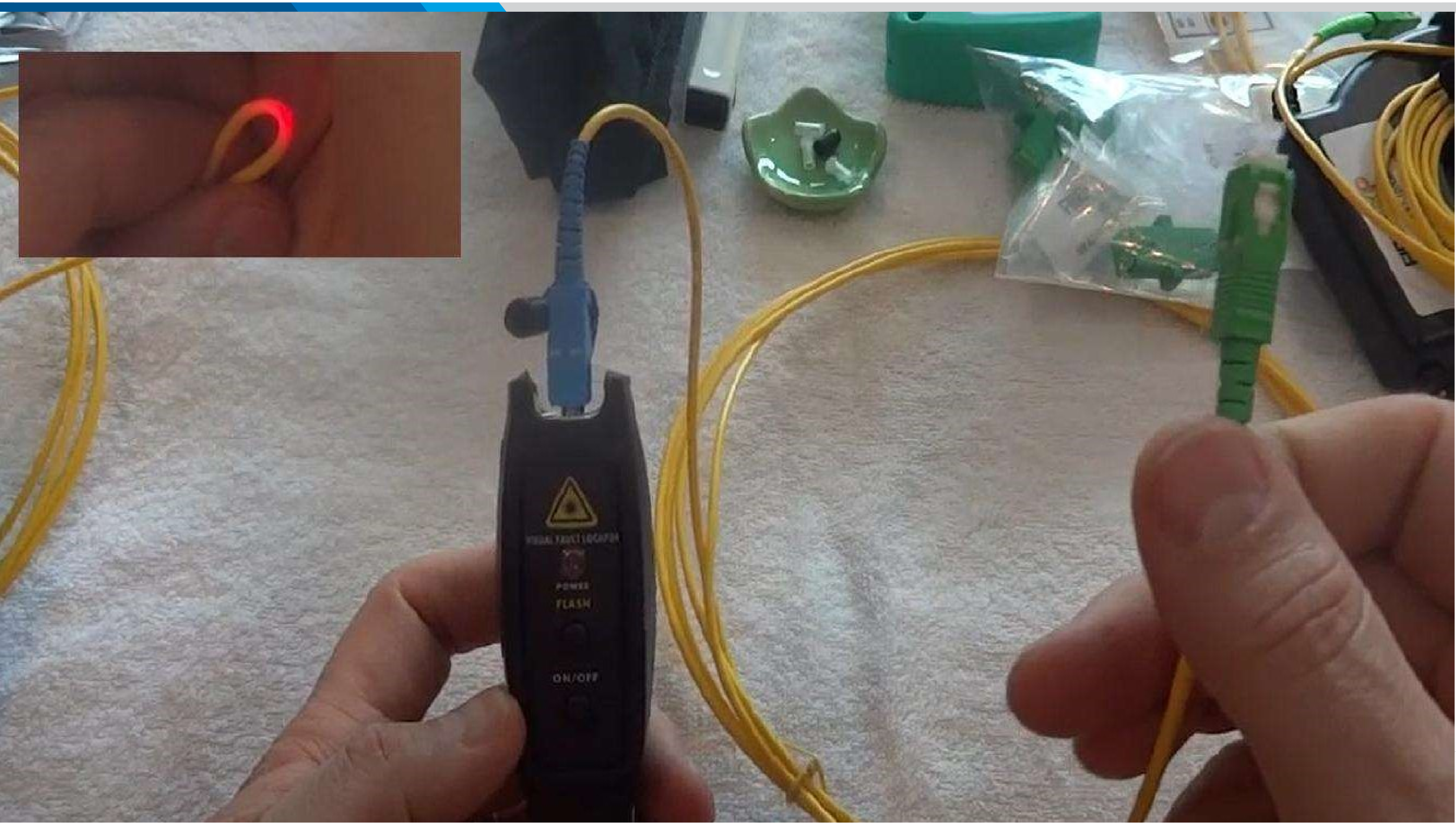
What is a VFL or visual fault locator?

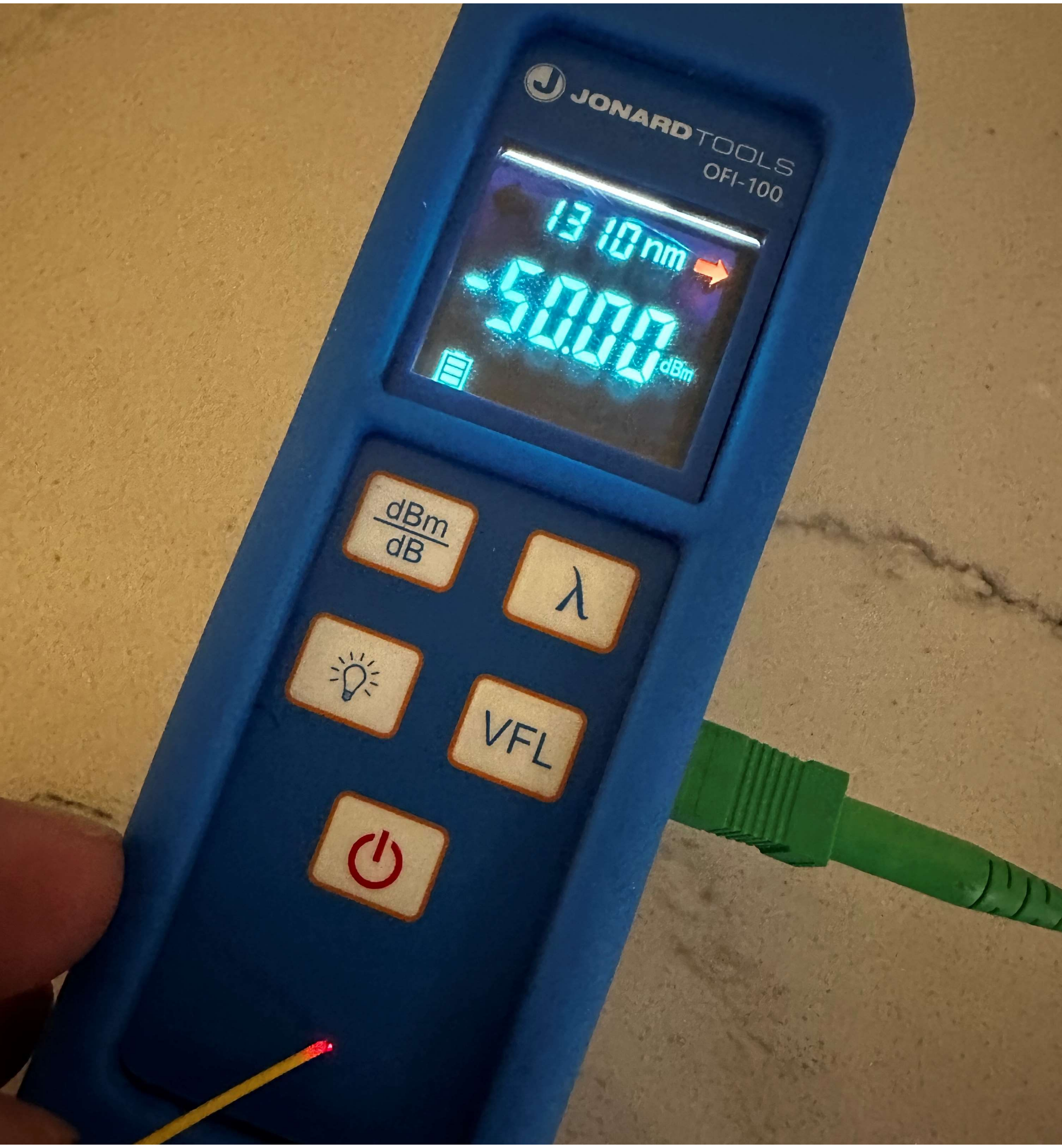
- Identify fiber breaks, macrobends / stress points, leaks, bad splices
- Identify a fiber.
- Uses 650 nanometers (nm) laser pulse
- Light that does not exit properly shows an issue.
- Weakened pulse or light exiting out the middle of the jumper (stress point).

Testing with a Visual Fault Locator (VFL)

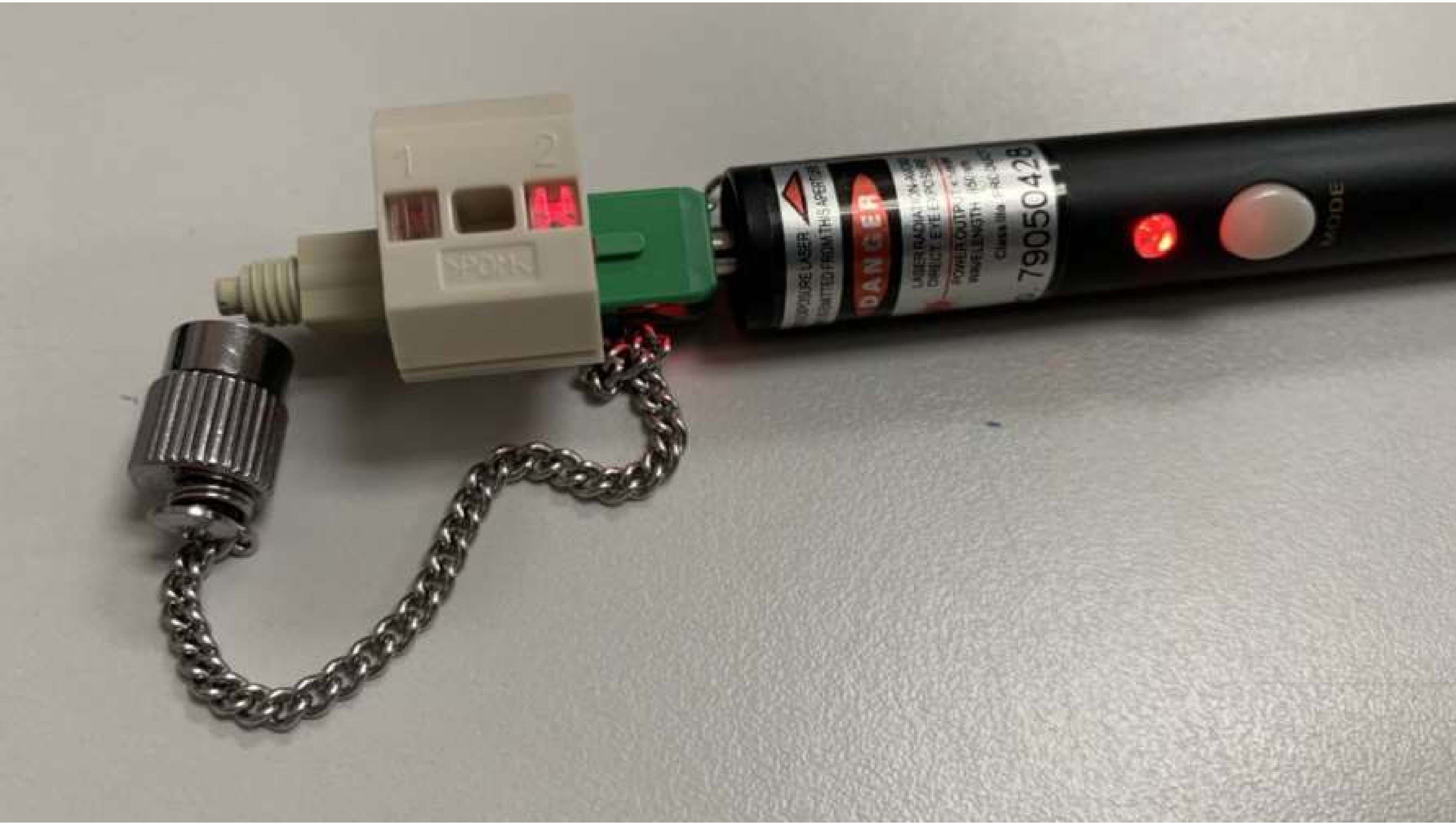



TEMPO
COMMUNICATIONS
UFL
λ
UNIT
FLASH
Fn


POWER
FLASH
ON/OFF

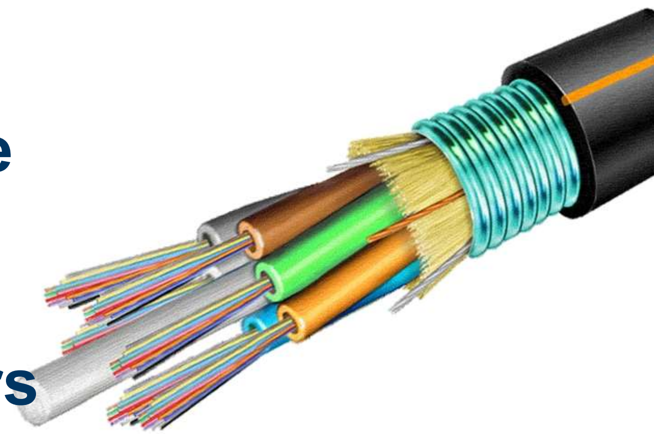

JONARD TOOLS
OFI-100
1310nm
-50.00
dBm
dBm
dB
λ
VFL


JONARD TOOLS
OFI-100
1310nm
-50.00
dBm
dBm
dB
λ
VFL


1
2
79050428
MODE

ACTIVITY: USE A VFL TO CHECK FOR MICROBENDS

Recognize the value passive optical network (PON) optical power meters



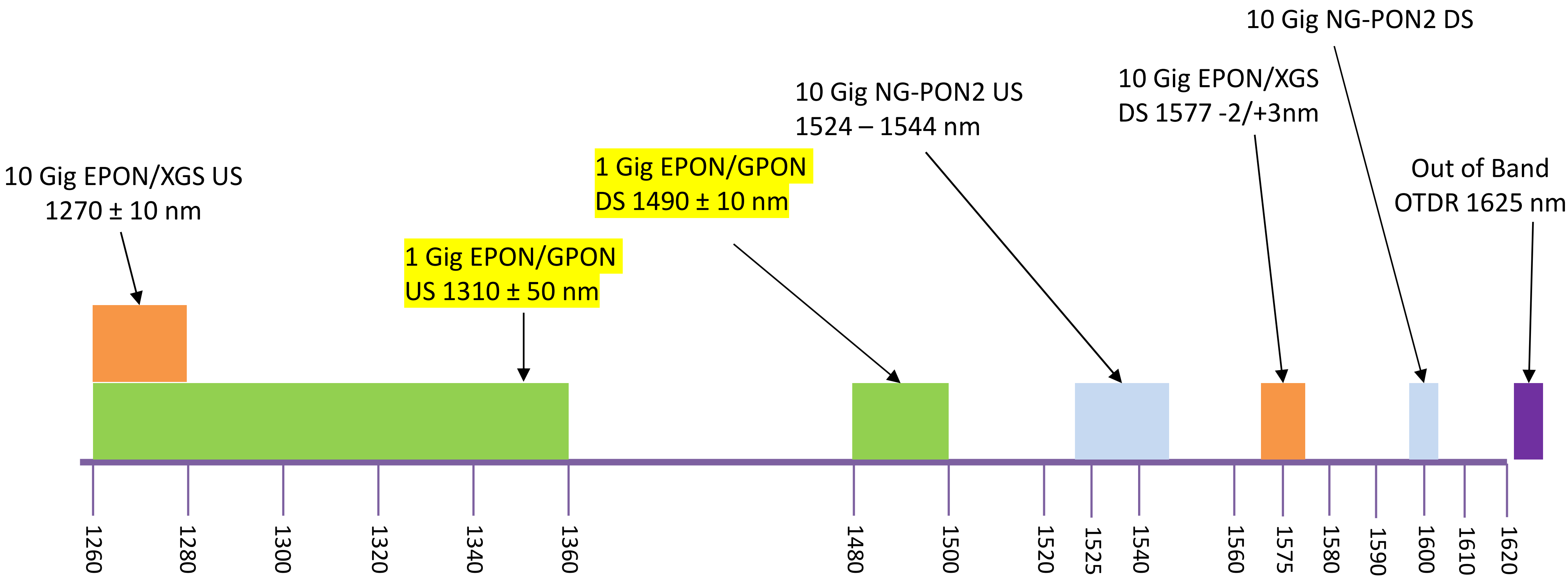
Raise Your Hands….

Why is optical power important?

What is a PPM or PON power meter?

- Quickly identify the decibel referenced to a milliwatt (dBm) or milliwatt (mW) optical power level
- Measurements at specific wavelengths (e.g., 1490 nm)
- Designed to test multiple wavelengths (e.g., 1577 nm, 1490 nm).
- Uses wave division multiplexing (WDM)
- Maintain optical power budgets
- New designs offer pass-through, allows ONx to transmit to OLT while measuring - out of band (OOB).
- "Attenuation by substitution" test, laser generates a signal instead of the fiber equipment.
    - Used before activating equipment in our networks.

PON Wavelength Chart




VIAVI
PASS
PON
G-PON
1490 nm
MODE
OLP-39
WPS
POWER
BROADBAND
SERVICE
WiFi 2.4 GHz
WiFi 5 GHz
ETHERNET 4
ETHERNET 3
ETHERNET 2
ETHERNET 1
PHONE 1
PHONE 2
USB

VIAVI
TruePON
G-PON
1490 nm
18:55
XGS-PON
1577 nm
-25.76 dBm
SIGNAL LOW
Dual
Config

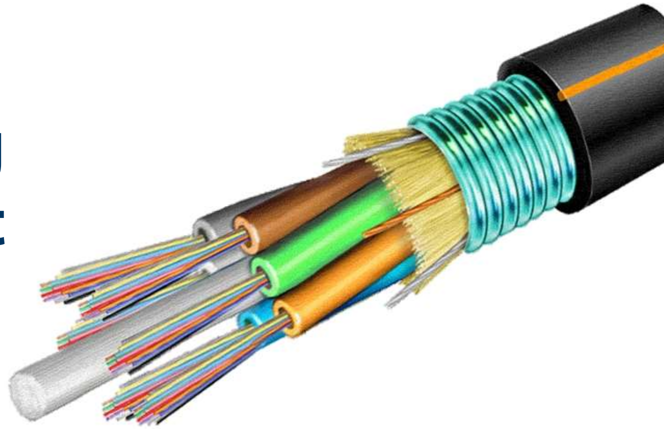

TEMPO
COMMUNICATIONS
1490nm
-24.15 dBm
λ
UNIT FLASH
Fn
OPM220


JONARD TOOLS
OFI-100
-22.22 dBm
1000 Hz
dBm/dB
λ
VFL

OLP-87

PON power meter with pass-through, allows ONx to transmit to OLT while measuring - out of band (OOB).

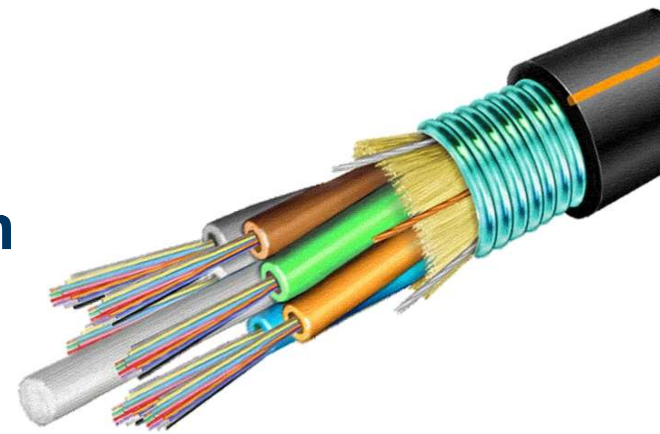
Describe the testing options for Ethernet and Wi-Fi testing equipment



Ethernet & Wi-Fi Testing

Combines active Ethernet and WiFi testing capabilities with PON Testing!

Discover the fundamentals for an optical spectrum analyzer (OSA) and optical time domain reflectometer (OTDR)



What is an OSA?

- Not common for technicians
- Used a facility or by field engineers
- Performs comprehensive measurements of the tests we discussed
- An OSA performs measurements of wavelengths (channels), optical signal power distribution, WDM and noise power characteristics of light waves.
- In addition, an OSA can perform the popular optical signal to noise ratio (OSNR) measurement.

What is an OSA?

Sample OSA Screen

OSNR > 18 dB

What is an OTDR?

- Provides time (or distance), as well as the physical layer transmission characteristics.
- Fresnel reflectance, attenuation (loss), scattering (Rayleigh) and distance measurements.
- Launch cable is used, often called a pulse width suppressor, to get accurate measurements (e.g., bulkhead).
    - Overcome blind spots in the testing called "deadzones".

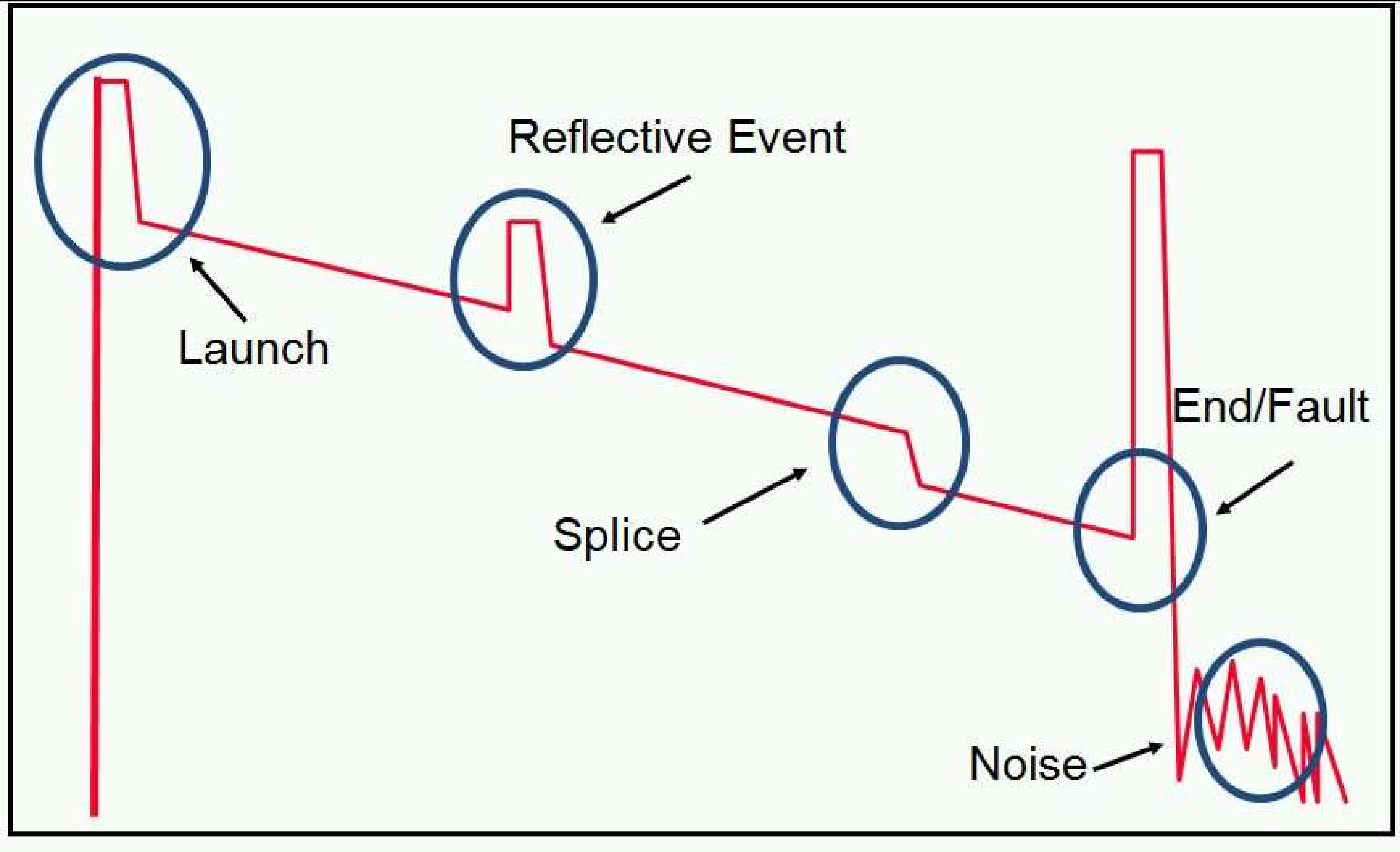
What is an OTDR?

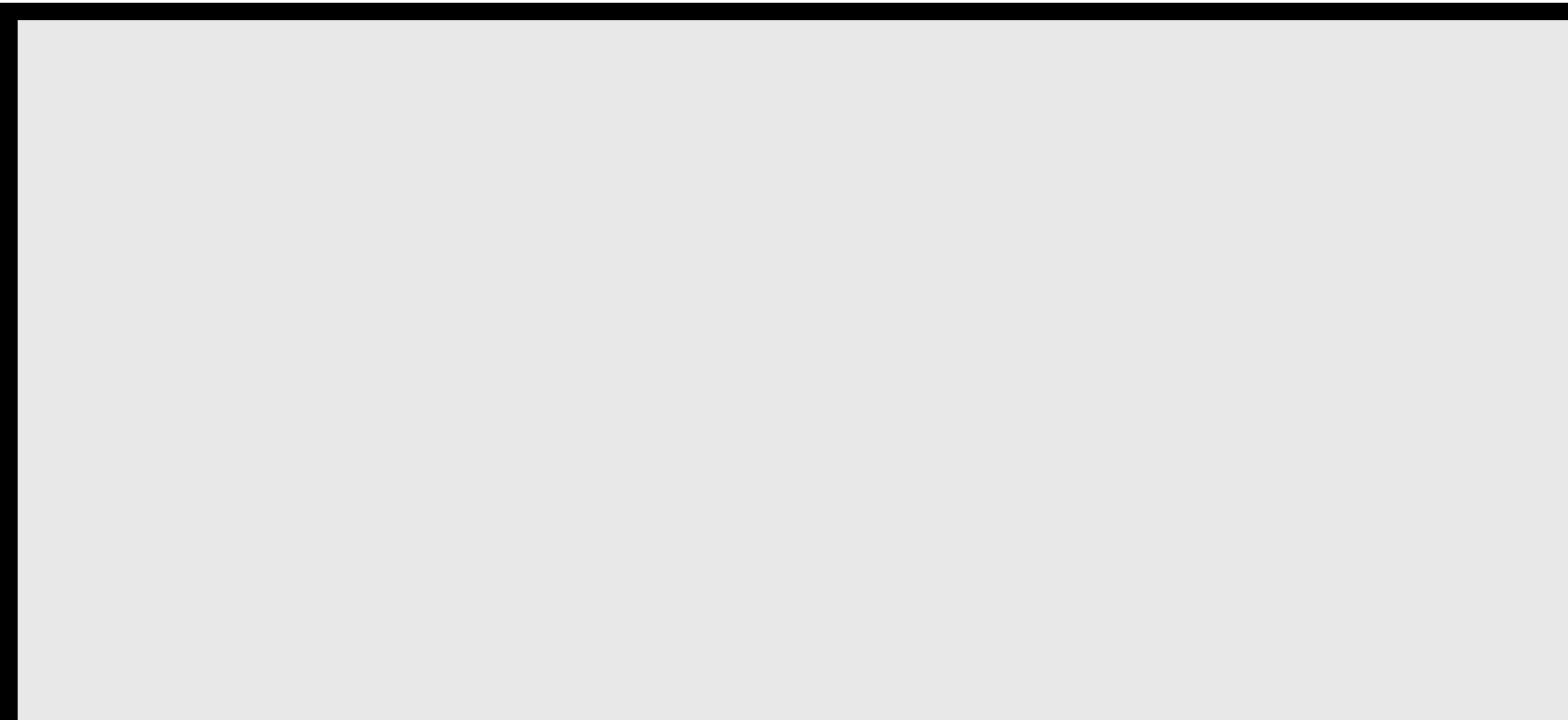
- OTDR’s software characterizes the anomalies in the fiber network as events.
- Set pulse of laser light at a specific wavelength from the premises or optical tap towards the facility.
- Decrease or increase the pulse width.
  - Directly correlated to the optical power of the pulse.
  - Large pulse better dynamic range (duration) of the test, but not able to detect smaller defects
  - Small pulse better spatial resolution and distinguishes close events

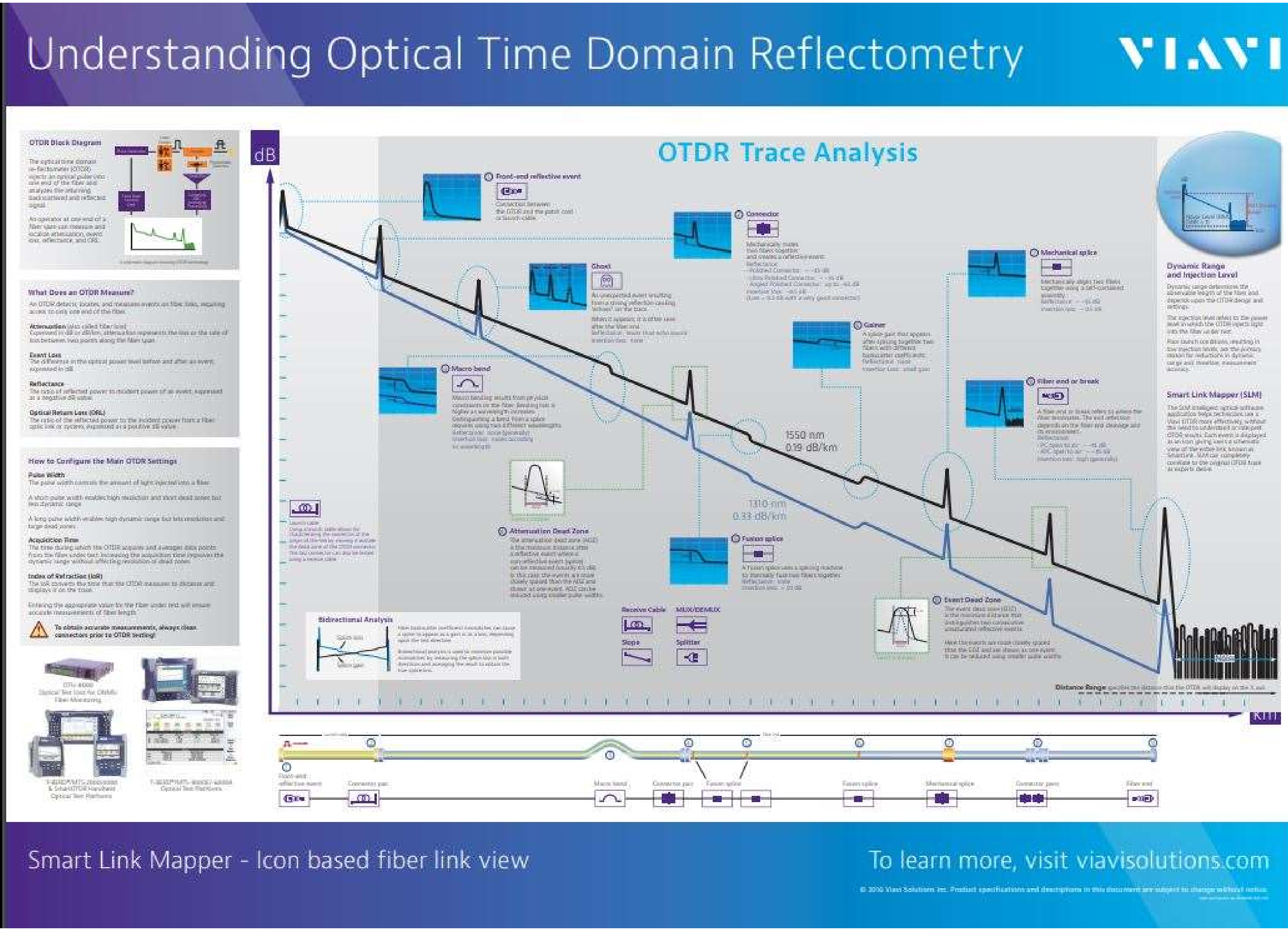
What is an OTDR?

- Results of the OTDR test depend on the optical distribution network (ODN) topology the technician is testing.
- Centralized split FTTH topology will result in a large attenuation event at the optical splitter.
- OTDR is well equipped to report types of splices, connectors and end reflections (breaks) in the optical cable.
- Final acceptance testing of fiber cable reels at the warehouse.
- CWDM and DWDM OTDR versions for validating wavelength continuity.
- Newer small form-factor pluggable (SFP) transceiver modules offer integrated micro OTDRs.

OTDR






Understanding Optical Time Domain Reflectometry
VIAVI
OTDR Block Diagram
What Does an OTDR Measure?
Attenuation
Event Loss
Reflectance
Optical Return Loss (ORL)
How to Configure the Main OTDR Settings
Pulse Width
Acquisition Time
Index of Refraction (IoR)
To obtain accurate measurements, always clean connectors prior to OTDR testing!
OTDR Trace Analysis
dB
Front-end reflective event
Connector
Ghost
Mechanical splice
Gainer
Macro bend
Fiber end or break
Attenuation Dead Zone
Fusion splice
Event Dead Zone
Bidirectional Analysis
Receive Cable
MUX/DEMUX
Slope
Splitter
1550 nm
0.19 dB/km
1310 nm
0.33 dB/km
Dynamic Range and Injection Level
Smart Link Mapper (SLM)
Distance Range
km
Smart Link Mapper - Icon based fiber link view
To learn more, visit viavisolutions.com

Conclusion

- Optimized a FTTH network by keeping connectors and ports clean
- Recognized the value of an optical VFL and PON optical power meter.
- Described the testing options for Ethernet and Wi-Fi testing.
- Discovered the fundamentals for an OSA and OTDR.

THANK YOU!

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10 Gbps Symmetrical with XGS-PON

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Many North American operators and other CableLabs members are working towards implementing a 10G initiative, a wired network for the future! Why is 10G essential? Video continues to apply pressure on the downstream and upstream spectrum of our access networks. Growth in shipments of next generation OLED and quantum dot displays will drive video bandwidth, subscriber streaming (i.e., OTT) and managed Internet protocol television (IPTV) requirements. Ultra HD (UHD) 4K shipments will continue to increase market penetration, while UHD 8K displays will ramp up next year. In addition, annual IP global traffic will reach zettabytes (ZB) in a few years, while global IP traffic will increase threefold over the next 5 years.[1] 10G is also essential to the future experiences our industry has not created yet!

To prepare future gigabit passive optical networks, or GPON, the family of standards is now featuring a new 10 Gbps symmetrical option for operators. Nowadays there are two symmetrical choices in the GPON roadmap for 10 Gbps: XGS-PON (ITU-T G.9807.1) and NG-PON2 (ITU-T G.989). In XGS-PON, the "X" refers to 10 Gbps while the "S" refers to symmetrical, however the "S" is not available in XG-PON (ITU-T G.987). In fact, there is a 10 Gbps symmetrical standard already, NG-PON2, though the technology uses a more costly optics known as time and wavelength division multiplexing (TWDM). Using TWDM with NG-PON2 allows operators to supply a 40 Gbps symmetrical service with other added benefits like mobile backhaul/fronthaul. The focus here is on the features and benefits of XGS-PON in a residential, business, enterprise or a greenfield network. The reason is that XGS-PON addresses the cost issue of NG-PON2 optics by utilizing less expensive fixed optics for connectivity, lowering cost of ownership for an operator. In addition, the symmetrical optics found in XGS-PON extends the life and profitability of a PON while allowing for mass market adoption over a GPON infrastructure. Below is a table that compares the data rates of the GPON family of technologies and standards.

Since the physical (PHY) layer of XGS-PON is based on existing specifications, it operates within the same optical transmission windows, assuming wide operating optical splitters exist from 1260 nanometers (nm) to 1650 nm. The PHY compatible transmission convergence (TC) layer allows for co-existence of XGS-PON with the earlier XG-PON and NG-PON2 that uses TWDM. XGS-PON operates over a downstream wavelength of 1577 nm and an upstream wavelength of 1270 nm, allowing further compatibility over the optical distribution network (ODN) with existing GPON that uses different wavelengths. This allows operators to maintain existing GPON deployments as they progress to faster Internet deployments with PON. Furthermore, XGS-PON also has the ability to operate on GPON wavelengths, 1490 nm in the downstream and 1310 nm in the upstream. The XGS-PON PHY also leverages time division multiplexing (TDM) and time division multiple access (TDMA) methods to accommodate XG-PON compatibility. Using TDMA allows coexistence of XGS-PON and XG-PON. XGS-PON supports up to a 1:128 split ratio in the ODN, as well as 1:64, 1:32 and 1:16 split ratios.

Standard	G-PON ITU-T G.984	XG-PON ITU-T G.987	XGS-PON ITU-T G.9807	NG-PON2 ITU-T G.989
Number of wavelengths per direction	1	1	1	4 to 8
Data rate(s) per wavelength downstream (Gbps)	2.5	10	10	10, 2.5
Data rate(s) per wavelength upstream (Gbps)	1.25	2.5	10	10, 2.5
Total data rate in the downstream and upstream (Gbps)	2.5/1.25	10/2.5	10/10	40/40 80/80

Table 1. Data rates of PON technologies

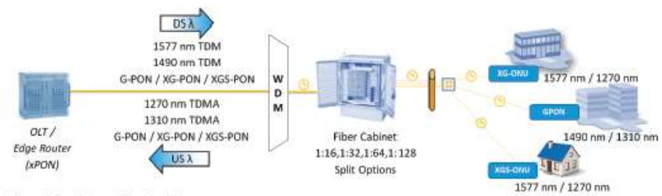

Figure 1. Co-existence of wavelengths

The new XGS-PON standard is available today for production deployment. It is being piloted by a few cable operators in North America already, with a European operator (Orange Polska) piloting at 5 Gbps down and 2 Gbps up. XGS-PON allows operators like these to skip the non-symmetrical versions of PON. An optical line terminal (OLT) can be equipped with XGS-PON capabilities allowing simultaneous PON technologies to operate over an ODN. For example, a recommended primary optical power budget of 29 dB allows for both XGS-PON and NG-PON2 to co-exist for maximum flexibility in the future, as operators see themselves using more NG-PON2 in the next few years. In addition, the split ratio flexibility permits a single XGS-PON OLT interface to operate multiple PONs over an ODN. For example, XGS-PON may be deployed on a 1:64 split basis that is overlaid on an ODN with older GPON operating at a 1:32 split ratio, allowing XGS-PON to serving 2 Gbps, 5 Gbps or 10 Gbps subscribers. XGS-PON maintains flexibility for a future overlay of an additional fixed optics 10 Gbps/10 Gbps business PON and/or multiple TDWM NG-PON2 wavlengths using higher capability tunable optics.

In addition, as operators increase their fiber deep (FD) architecture deployments, XGS-PON is also a possibility for reaching the last mile using new hardware like remote OLTs (R-OLTs). Finally, DOCSIS provisioning of GPON, or DPoG, is a scalable operational support system interface (OSSI) used by operators to provision GPON, XG-PON and XGS-PON. DPoG additionally leverages the foundation of a well proven DOCSIS back office system while promoting multivendor interoperability, lowering the cost of ownership, leveraging the workforce knowledgebase, and supporting 10 Gbps services.

The ODN, or fiber optic access network, now has 10 Gbps fixed optic architectures for both XGS-PON and EPON. 10 Gbps reliable wired networks will be the platform for the next generation consumer services and future service possibilities. Believe it or not, work has begun on emerging 25 Gbps and 50 Gbps PON technology as well!

As a Society member keep current with SCTE·ISBE and the many resources designed to keep you in the know! Did you know SCTE·ISBE offers a PON certification? The certification is known as broadband fiber installer (SCTE.org/BFI), which is a comprehensive exam on RFoG, GPON and EPON FTTx architectures.

1. Cisco Visual Networking Index

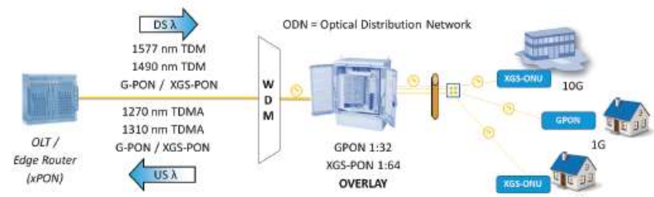

Figure 1. Co-existence GPON and XGS-PON

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