Single-Mode Fiber

The Perfect Fit for Your Evolving Enterprise

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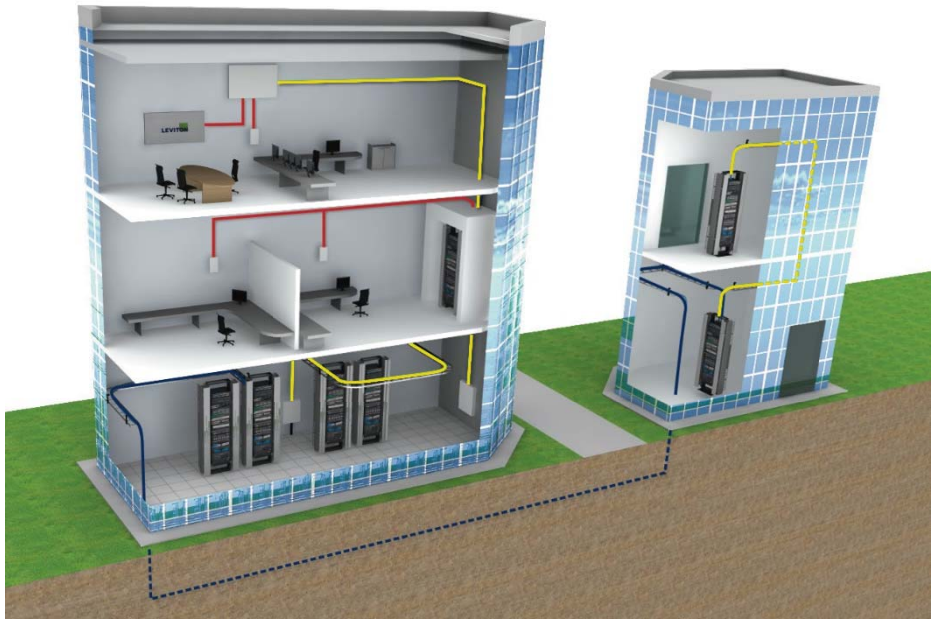
Optical Fiber in the Enterprise Network

- Used in telecom rooms or campus buildings
  - Less frequently used for fiber to the desk or Passive Optical LAN
- Bandwidth needs were supported with multimode
  - Lower cost transceivers made multimode optimal
  - LED or VCSEL light source vs. laser light source



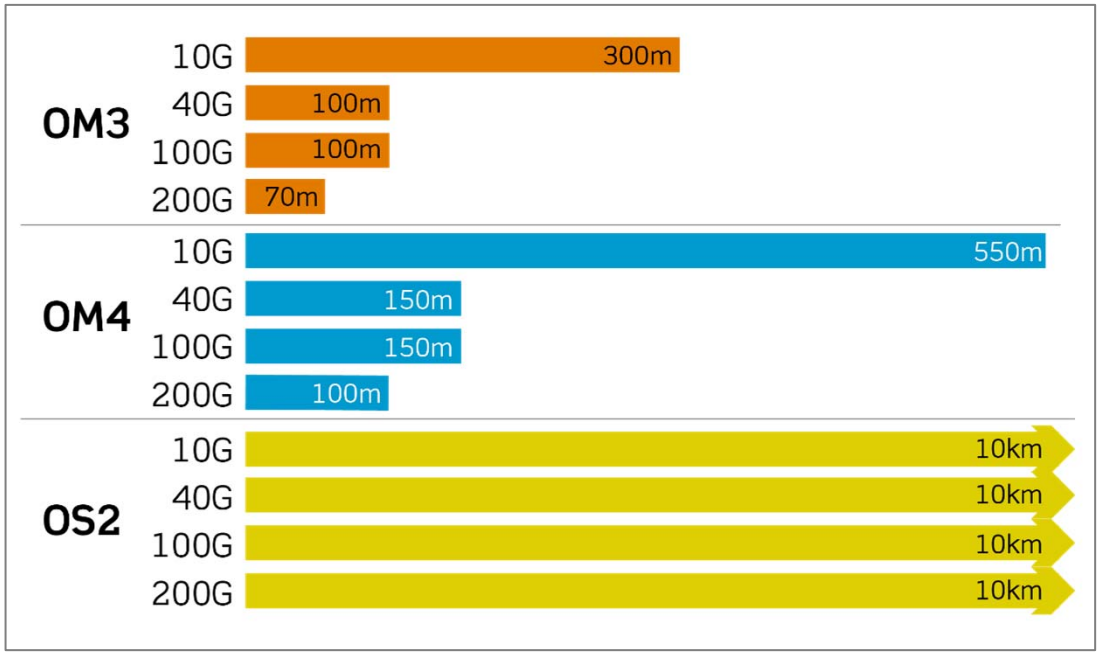
Network Bandwidth Needs Increasing

- HDBASE-T and video over Ethernet for digital signage
- More Wi-Fi WAPs generating more data
- Backbone bandwidth will need to increase to support more high-speed ports

Wi-Fi Generation	802.11g	802.11n	802.11ac		802.11ax
			Wave 1	Wave 2	
Backhaul Bandwidth	54 Mb/s	450 Mb/s	1.3 Gb/s	6.9 Gb/s	14 Gb/s

Reach of Multimode vs. Single-Mode Fiber

- As backbone speeds increase, single-mode fiber provides an easy upgrade path
  - No re-cabling required
  - No extra strands required
  - No reach restrictions



Cost Differences Becoming Smaller

- At higher speeds, the price difference grows
- Pricing on the 40G SMF QSFP+ has come down substantially since it was first introduced

	1G SFP	10G SFP+	40G QSFP+	100G QSFP28
Multimode Fiber	$6	$16	$59	$99
Single-Mode Fiber	$7	$34	$279	$799

Retail price research – 10/2019

New Enterprise Applications for Single-Mode Fiber

- Indoor deployment of fifth generation (5G) mobile networks
  - Indoor 5G small cell systems use single-mode fiber to connect BBU to remote radio hubs/controllers
  - Some systems also use fiber to connect the remote radio antenna/small cell to the radio hubs/controllers
- PoE extension beyond 100m
  - Systems designed to use composite fiber/copper cable to transmit Ethernet signal and carry DC power to remote devices

OPTIONS AND BEST PRACTICES FOR SINGLE-MODE FIBER DEPLOYMENT

Choose the Right Cable Type
Armored Cable Grounding and Bonding
PoE Extension with Single-Mode Fiber

Choose the Right Cable Type

- **Riser applications** – between floors
  - Premises distribution cable
  - Ease of installation

- **Plenum applications** – horizontal cabling
  - Plenum interlocked armor cables
  - Protects fiber from crush and breakage

- **Campus applications** – between buildings
  - Indoor/outdoor dry loose tube plenum
  - Water blocked with no need to transition at entrance

Riser Applications – between floors

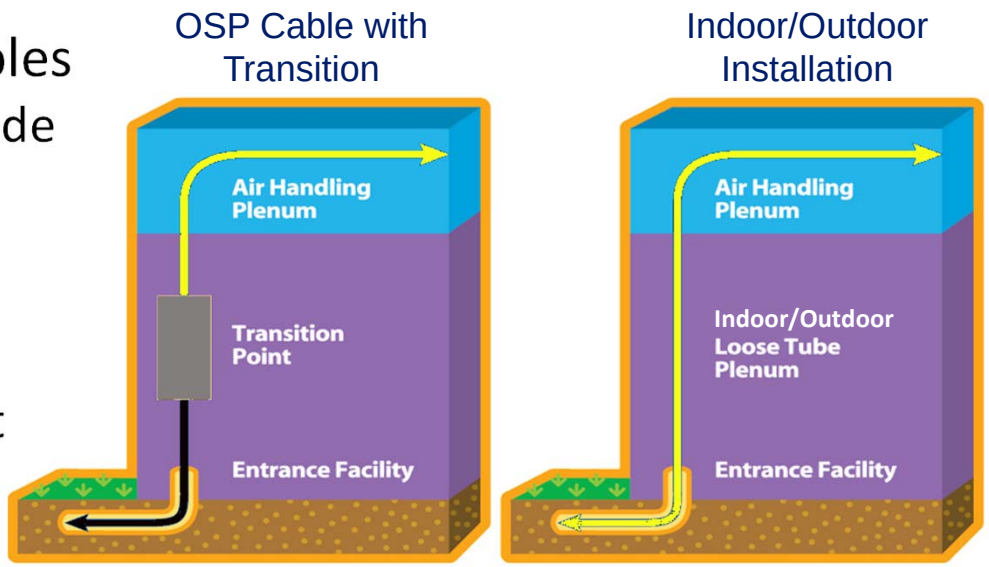
- OFNR 900 µm tight buffered fiber
  - Easily terminated with most connectors
- Easy to pull – high tensile strength
- Usually 6 - 144 fibers
- Indoor/Outdoor version reduce cost when running inter-building connections

Plenum Applications – horizontal cabling

- OFCP Tight buffer cables with interlocked armor
- Indoor/Outdoor versions simplify installation
- Significant cost savings over installation in conduit or plenum innerduct
  - Single pull vs. two pulls
  - Lower total material cost vs. plenum innerduct - up to 49%

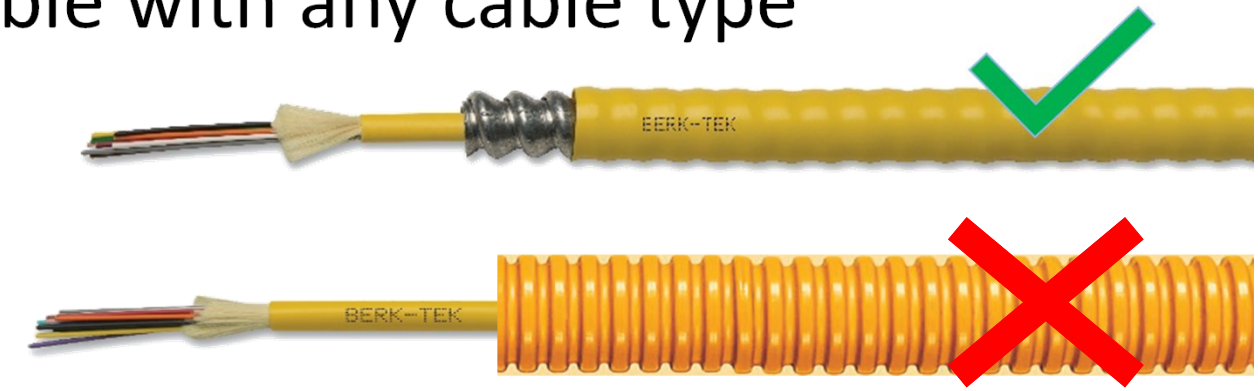
Campus Applications – between buildings

- Fire-rated Indoor/Outdoor cables
  - Loose tube design handles wide temperature range
  - Look for dry water-blocked design
  - Plenum or riser
  - No transition point needed at building entrance
  - Saves up to 26% total installed cost over OSP cable



Interlock Armored Cables

- Flexible spiral interlocking armor
- Aluminum or steel
- Usually Available with any cable type



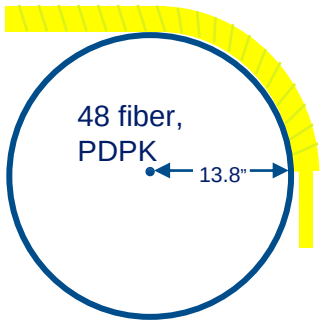
Optimal Armor Designs

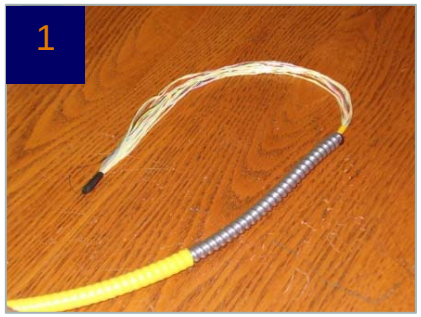
- Have been tested extensively to failure
- Best designs do not separate when subjected to small bend radius

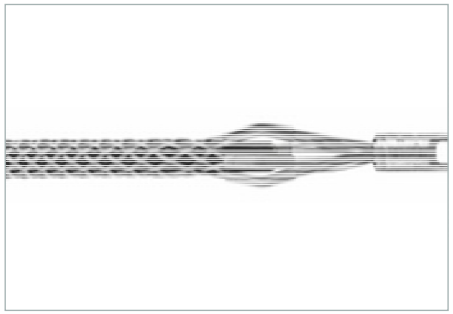
48 fiber Tight Buffer example	Best Design	Average
Installation bend radius	13.8 in	16.2 in
Long term bend radius	9.2 in	10.8 in

Proper Installation of Armored Cables

- Never pull cable by the armor
- Always use a pulling grip
- Always connect both armor and cable strength members to the pulling grip
- Always ensure proper bend radius while pulling the cable







PROPER CABLE ACCESS AND ARMOR GROUNDING

Armored Cable Access Best Practices

- Mark cable 2-3 feet from the end

Armored Cable Access Best Practices

- Make another mark 3" from the first mark

Armored Cable Access Best Practices

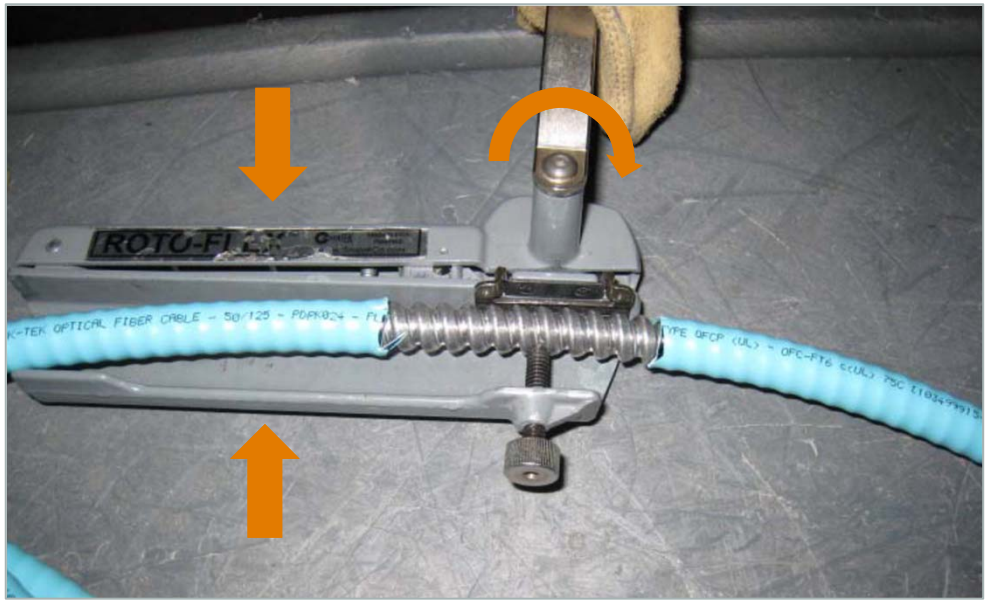
- Ring cut the jacket at each mark

Armored Cable Access Best Practices

- Using box cutter, remove cable jacket between marks

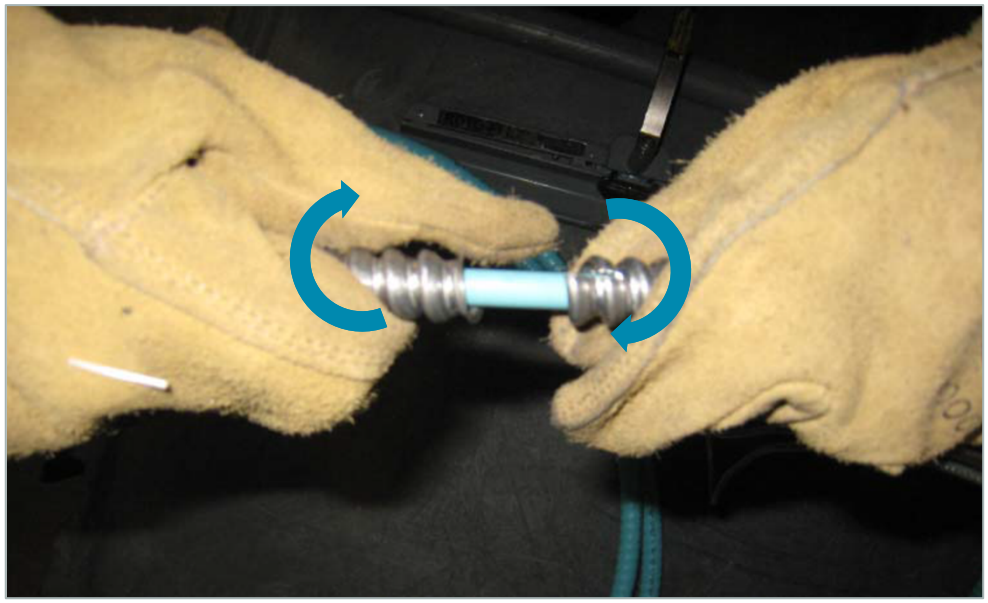
Armored Cable Access Best Practices

- Place cable in the armor cutting tool with the blade in the center of the area with exposed armor
- While compressing the cutter body, rotate the cutter wheel until armor is penetrated across one full winding



Armored Cable Access Best Practices

- Release the cable from the tool
- Grasp the cable on each side of the armor cut point and twist in opposite directions
- Remove the separated armor section and carefully discard



Armored Cable Grounding Best Practices

- Install the grounding clamp at the end of the armor by inserting the lower clamp jaw against the inner surface of the armor and placing the upper jaw over the threaded post
- Tighten the first nut onto the post, closing the jaws on the armor

Armored Cable Grounding Best Practices

- Attach one end of the grounding wire to the post
- Tighten second nut over ground wire eyelet

Armored Cable Grounding Best Practices

- Beginning at the ground clamp post, tightly wrap vinyl electrical tape around the end of the armor until wrap reaches one inch past the end exposed armor
- Connect ground wire to the grounding busbar

POE EXTENSION WITH SINGLE-MODE FIBER

PoE Extender System

- Enables remote PoE devices to be connected more than 100 m from the switch and powered from the closet
- Provides significant cost savings versus installation of a remote electrical outlet with hardened devices
- Should be capable of being installed in plenum, riser or outdoor pathways, with no transition point needed
- Streamlines network and device management through centralized IT infrastructure

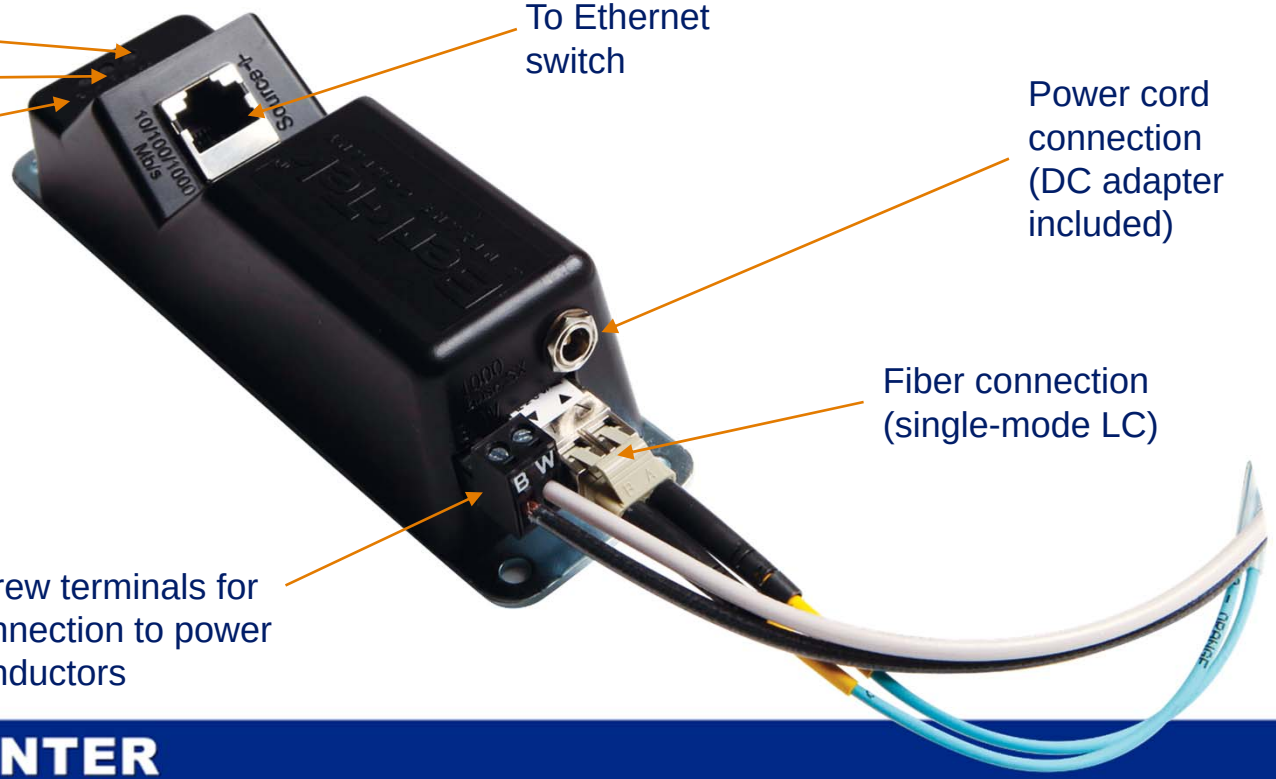
Three Components of PoE Extenders

Closet/Head End
(Power Injection)

Cabling

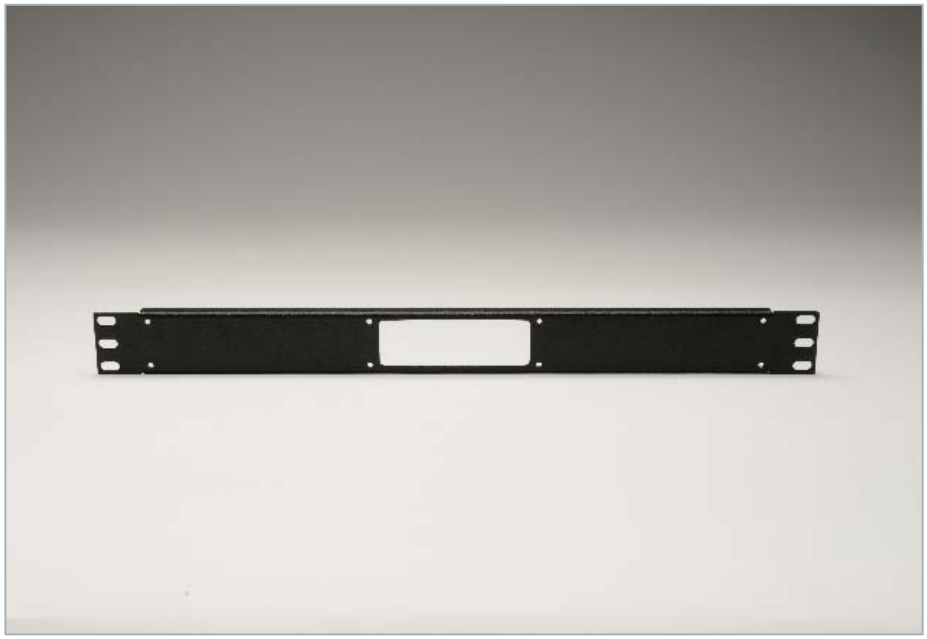
Remote End
(Remote PoE Port)

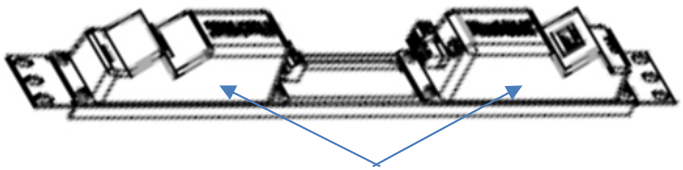
1-Port Power Module (Closet)



Rack Mount Bracket

- 19" rack compatible
- 1 rack unit
- Holds two one-port modules
- Center pass through opening for horizontal cable routing to appropriate ports





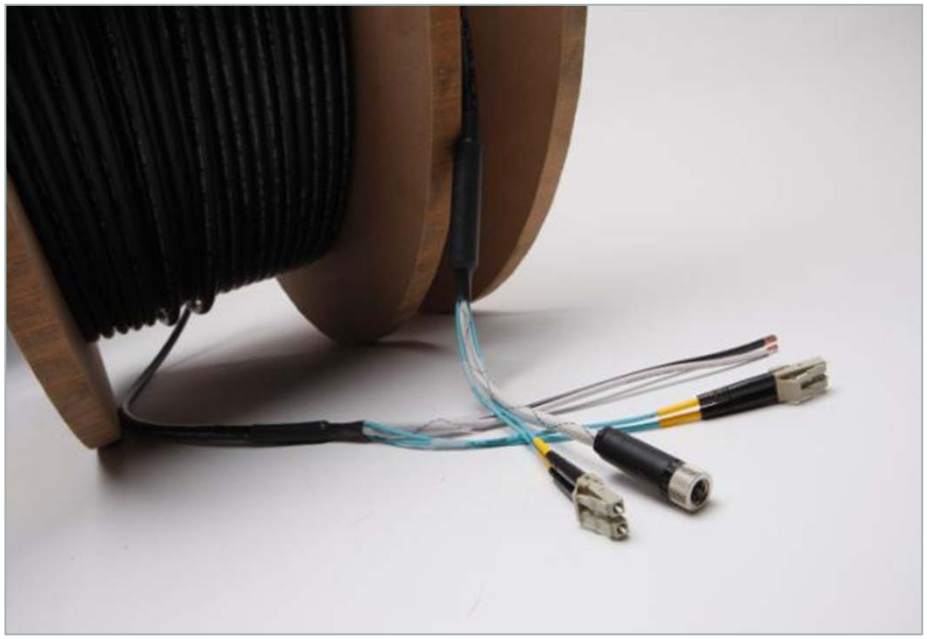
One port remotes

Composite Cables

- Two-fibers
  - Tight buffered or loose tube options
  - Indoor/outdoor versions available
- Two solid THWN or THHN conductors
  - 12 AWG allows for long reach
- CL3R-OF/CL3P depending on installation environment
  - Also look for OF/PLTC-OF

Pre-Terminated Composite Cables

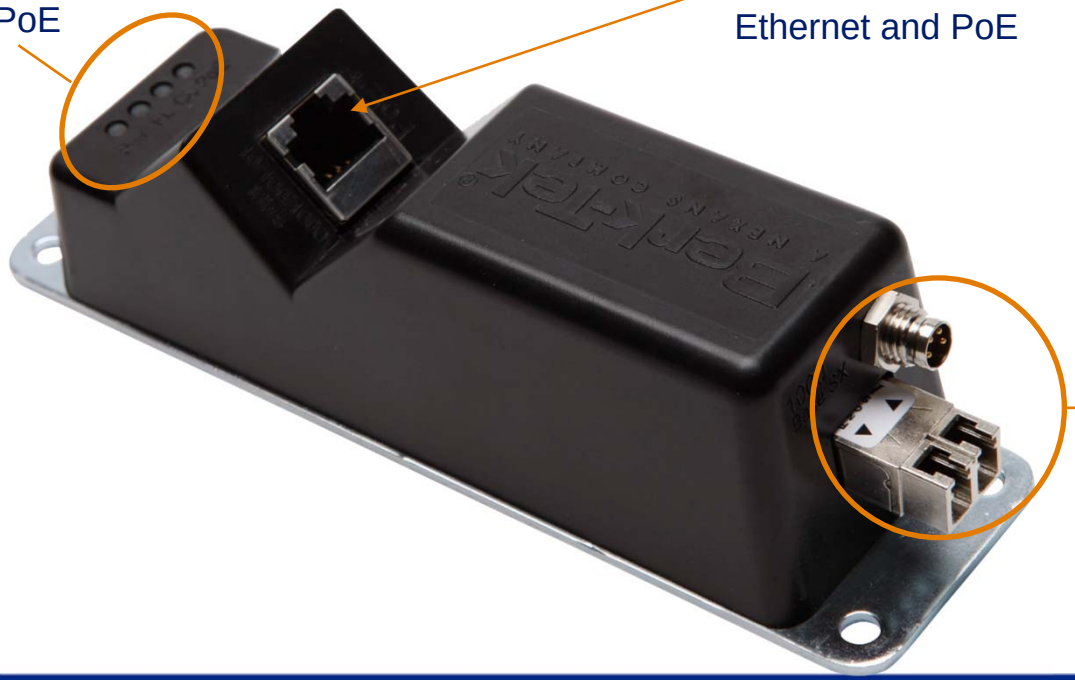
- Simplifies installation, especially at remote end
  - Look for three flange reels allowing for access to both ends
- Fiber terminated with LC connectors
  - At least at the remote end
- Copper conductors terminated in appropriate power connector at remote end (M8)



1-Port Remote Module

Indicator lights
power/fiber link/
copper link/PoE

To remote device –
Ethernet and PoE



Composite cable
connections
SMF LC, M8 DC power

Target Distance Capabilities

- Distances between source and remote modules
  - PoE (15W @ PSE) 8,200 ft (2499m)
  - PoE+ (30W @ PSE) 2,100 ft (640m)
  - HPoE (60W @ PSE) 1,000 ft (304m)
- Powered device can be up to 100m from remote module

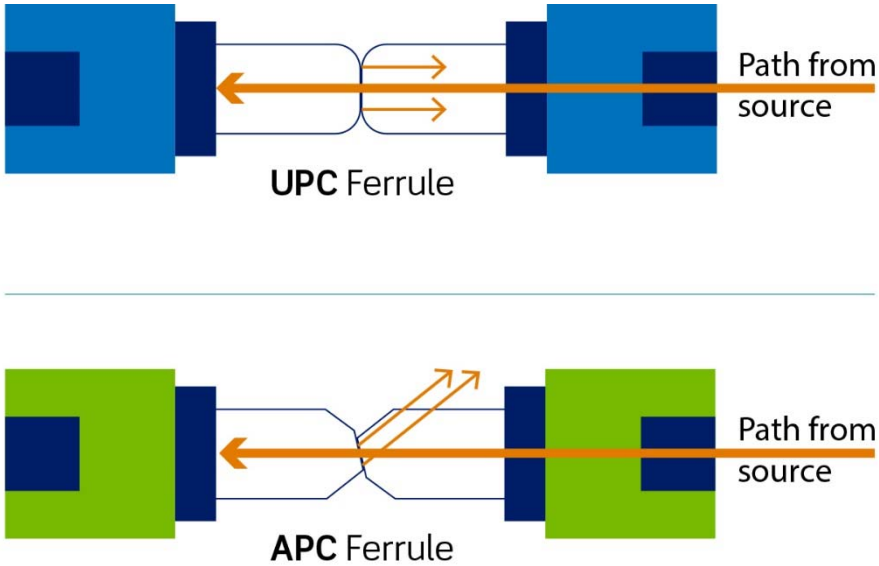
KEYS TO A SUCCESSFUL INSTALLATION

Connectivity options

Keys to single-mode success

Connectivity Options

- UPC vs. APC
  - **UPC** – Ultra Physical Contact
    - 0° ± 1.0°, RL ≥ -50 dB
  - **APC** – Angled Physical Contact
    - 8° ± 0.5°, RL ≥ -60 dB
- APC is rarely field polished
  - Factory polished connectors on pre-terminated assemblies, mechanical connectors, pigtails or splice-on connectors



Connectivity Options

- Factory polished mechanical connectors
  - Requires precision cleaving; minimal tools/training
- Pigtails
  - Available in splice module format; requires precision cleaving and fusion splicing; higher capital expense; better overall performance
- Splice-on connectors
  - Requires precision cleaving and fusion splicing; less termination real estate than pigtails; higher capital expense; better overall performance

FastCAM®

Pigtail Kits

Splice Trays

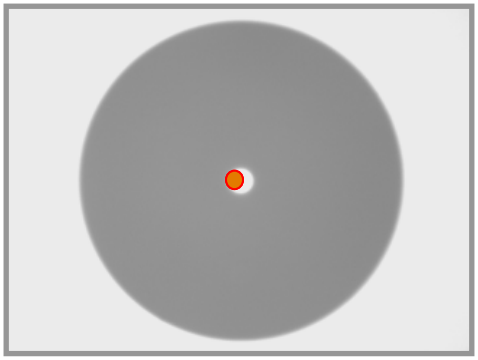
HDX Splice Module

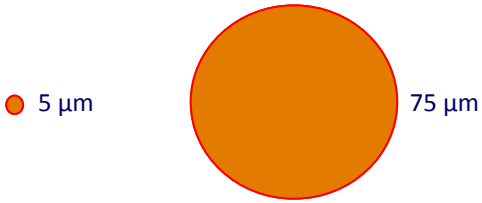
BEST PRACTICES FOR SUCCESS

Cleaning and Inspection

The Keys to Single-Mode Success

- The impact of cleanliness in single-mode applications
  - Core diameter vs. the contaminant
    - Core diameter of a single-mode fiber = 8-10 µm
    - Human red blood cell diameter = ~5 µm
    - Human hair diameter = ~75 µm





The Keys to Single-Mode Success

- Appropriately clean single-mode applications
  - Core diameter vs. the contaminant
  - Proactive vs. reactive practices
- Inspect cleaning
  - CL.I.C.
  - All end faces
  - Wet to dry cleaning
- Analogy – gorgeous paint job forever or just on day one?

Taking care of baby – 1968 Shelby GT 500

- Costs a whole lot of money
- Old but looks and performs like new
- Has a decreased value if not properly cared for
- Cost far more to maintain if we let it go

Taking care of baby – 1968 Shelby GT 500

- Which one would you trust to…
  - Get you down the road?
  - Win the car show trophy?
  - Get you the best return on your investment?

Proactive vs. Reactive Practices

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.

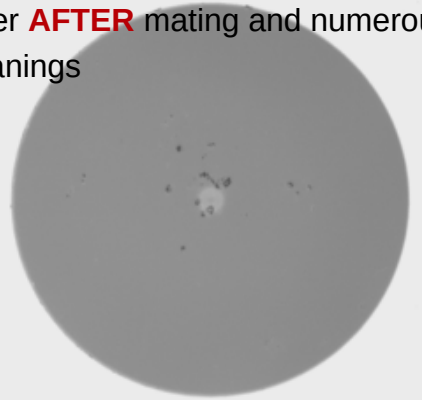
Fiber **AFTER** cleaning

REACTIVE INSPECTION:

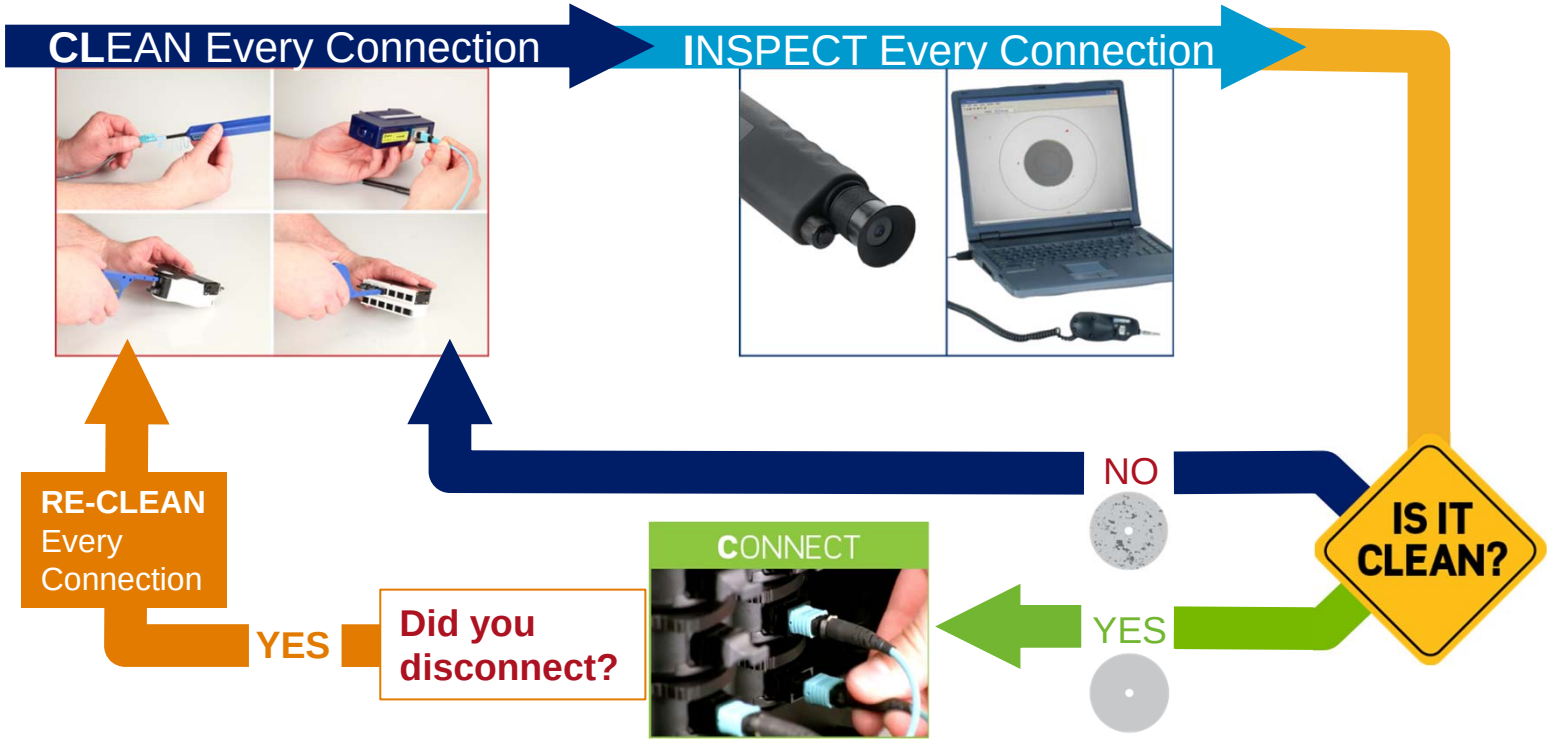
Visually inspecting fiber connectors ***AFTER*** a problem is discovered, typically during troubleshooting.

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

Fiber **AFTER** mating and numerous cleanings



CL.I.C – Clean, Inspect, Connect

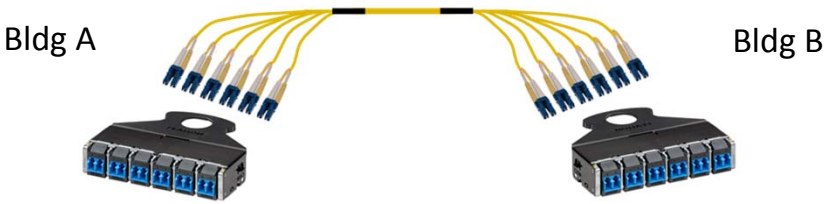


BEST PRACTICES FOR SUCCESS

Testing and Certification

Testing SM Channels

- Know what you need as an end user
  - All cabling segments tested?
  - All cabling channels tested?
  - Duplex Fiber Optical Loss (Tier 1) Testing Set recommended
    - Do I need OTDR (Tier 2) testing?
  - End face inspection – this ensures that connectors are clean and ready to use



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  - End face inspection – this ensures connectors are clean and ready to use

Testing SM Channels

- Know what you need as a contractor
  - Is testing defined in a specifications document?
  - Test equipment and “consumables”
    - Test reference cords and test cords
    - Mating lifecycle of a connector
  - End face inspection – this ensures that the best quality and accurate results will be achieved

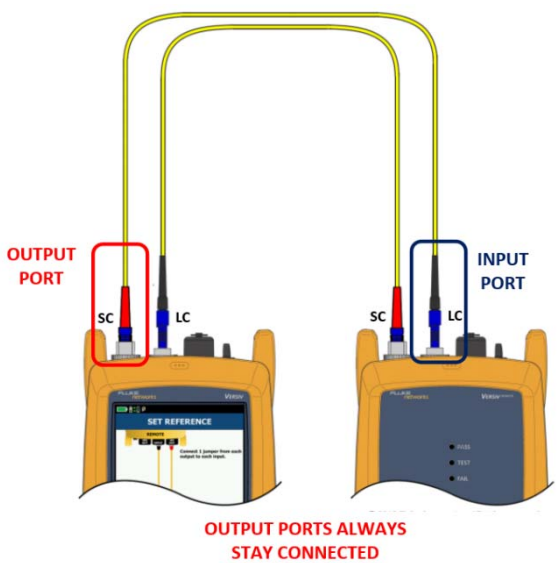
Testing SM Channels

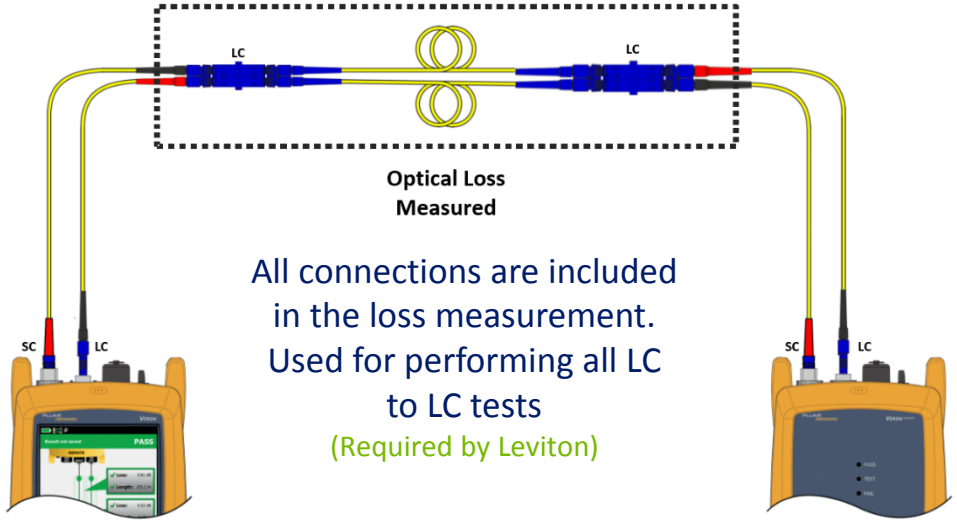
- ANSI/TIA (Tier 1) or ISO/IEC (Basic) compliant testing –
  - Tier 1 typically required
    - Length measurement is not always required but should be included
      - Ethernet applications compliance
      - Future troubleshooting aid
  - 1 jumper reference required in ANSI/TIA 568.3-D and ISO/IEC 14763-3
  - Test at 1310 and 1550 wavelengths
    - If results at 1550 are higher loss than 1310 indicates bends in fiber
  - End face inspection is required in the current standards – IEC 61300-3-35
  - Use known good test reference cords with a maximum verified loss of ≤ 0.20 dB

Testing Methods

Images courtesy of Fluke Networks

- Testing SM channels
  - 1 jumper reference required in ANSI/TIA 568.3-D and ISO/IEC 14763-3





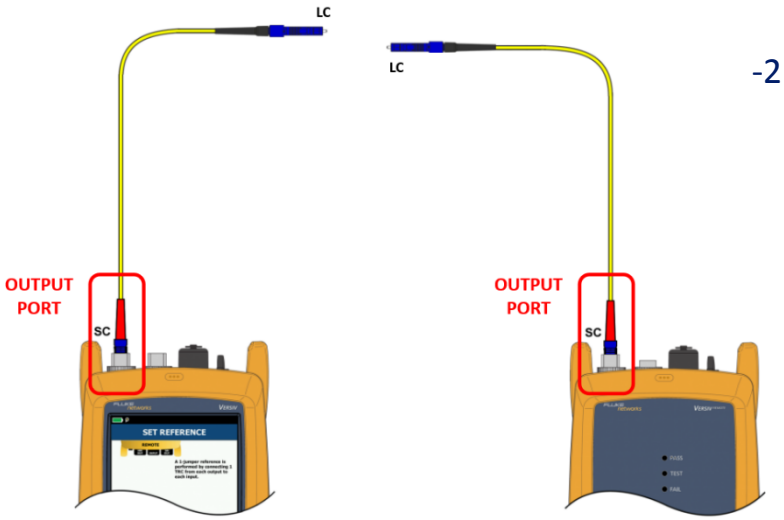
All connections are included in the loss measurement. Used for performing all LC to LC tests

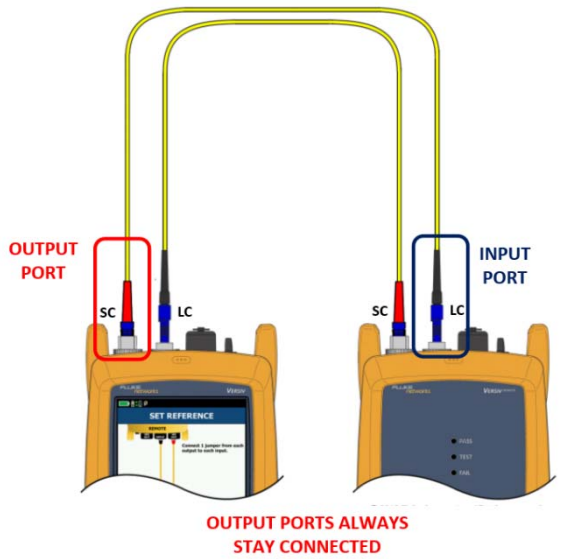
(Required by Leviton)

Testing Methods – Setting a 1 jumper reference

Images courtesy of Fluke Networks

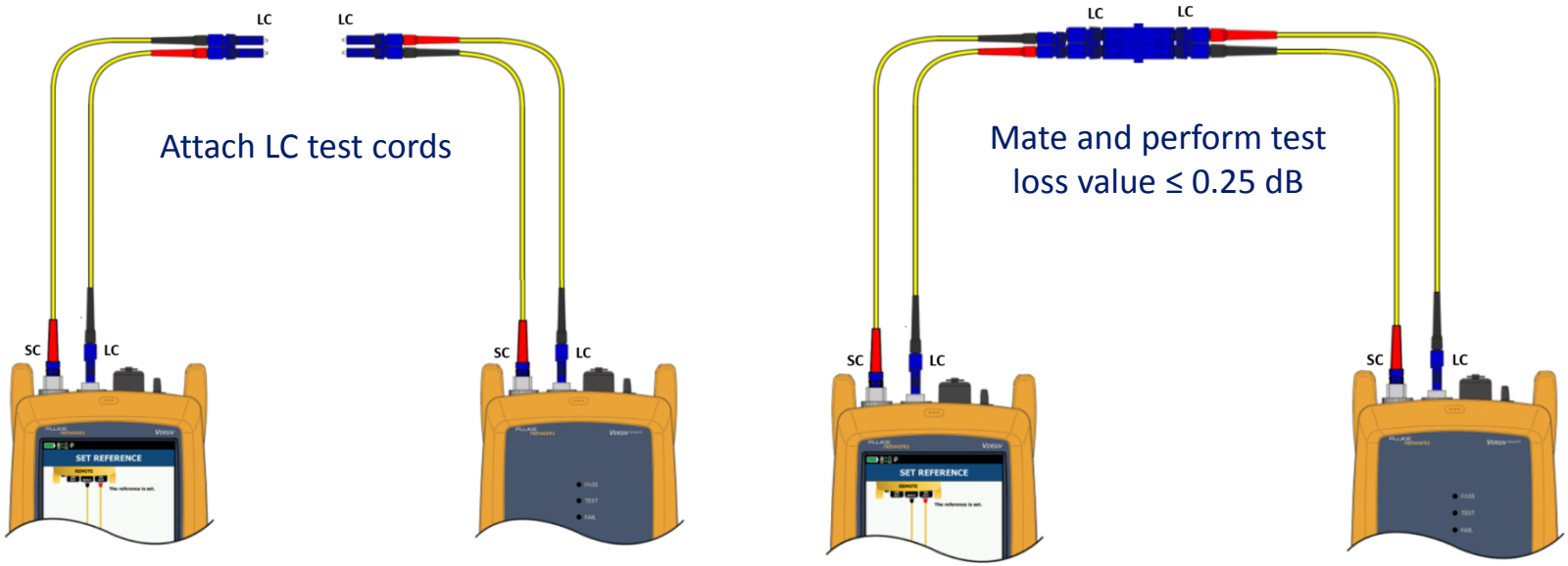
Reference range for SM 9/125 µm TRC's for wavelengths 1310/1550 nm is -2.50 dBm to -4.00 dBm





Testing Methods – Setting a 1 jumper reference

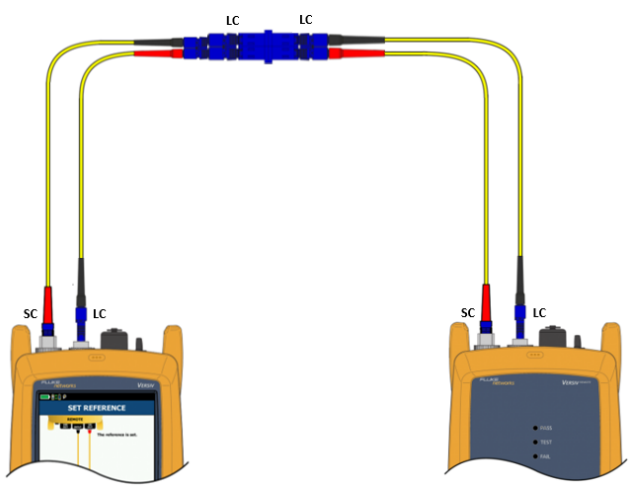
Images courtesy of Fluke Networks



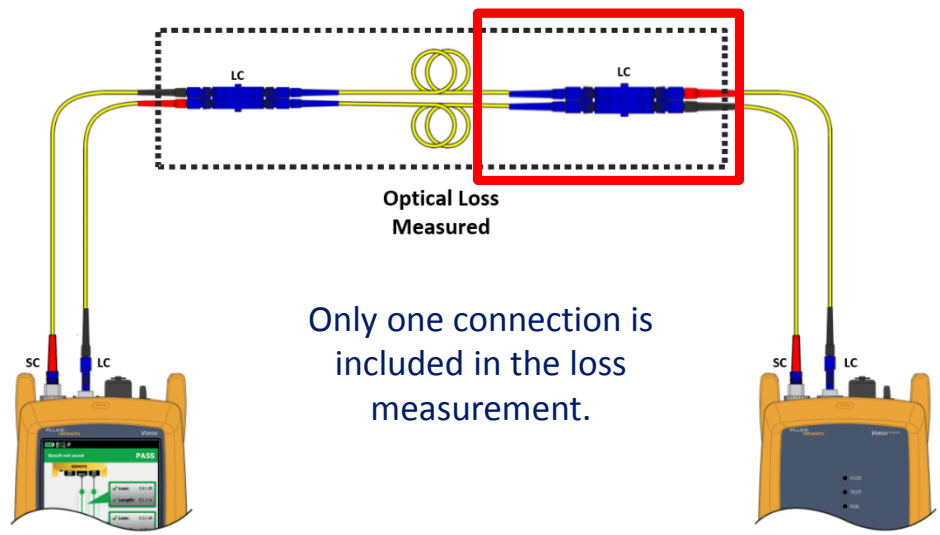
Testing Methods – 2 jumper

Images courtesy of Fluke Networks

- Testing SM channels
  - 2 Jumper reference is set by mating test cords through an adapter



OUTPUT PORTS SHOULD ALWAYS STAY CONNECTED



Only one connection is included in the loss measurement.

Testing Methods

Images courtesy of Fluke Networks

- Testing SM channels
  - 1 jumper reference required in ANSI/TIA 568.3-D and ISO/IEC 14763-3

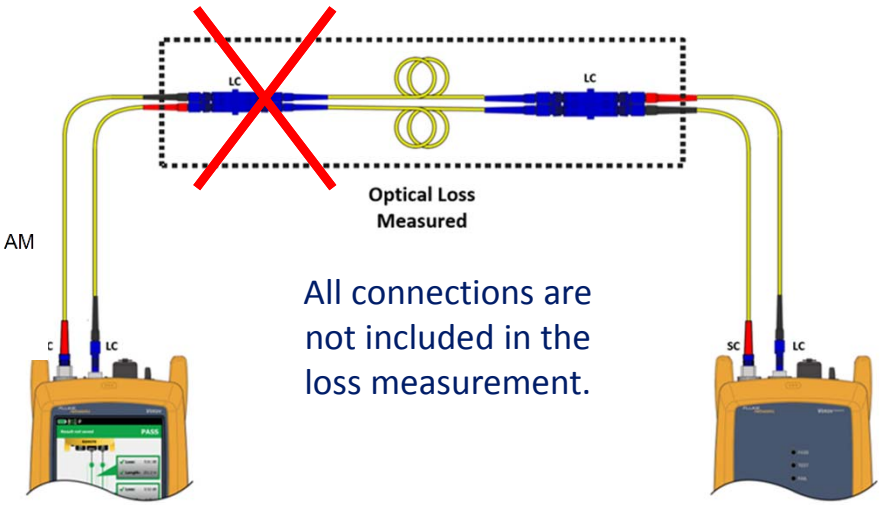
Propagation Delay (ns)	148	
Length ft	98	PASS
Limit 6562		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	-0.94	-1.30
Limit (dB)	2.15	2.15
Margin (dB)	3.13	3.45
Reference (dBm)	-27.48	-27.40

REJECTED

Negative loss
(a "gainer")

Number of Adapters: 2
Number of Splices: 2
Patch Type: OM3 Multimode 50
Patch Length1 (ft): 3
Patch Length2 (ft): 3
Reference Date: 12/14/2018 04:24:11 AM
2 Jumper

1 jumper
required



All connections are not included in the loss measurement.

In Summary

- Single-mode is the perfect fit for your evolving enterprise
- More bandwidth is being consumed, and backbone speeds need upgrading to provide more bandwidth to each TR
- As Ethernet speeds increase, multimode reach has decreased
- SMF transceiver prices are down
- New applications require single-mode, like 5G indoor DAS/small cell deployment and PoE extension

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