



Best Practices for Testing Fiber Optics in the Enterprise

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Agenda

- Quick review of some basics and standards
- End-face inspection and certification
- Polarity Check / Fiber map
- Loss, Length and Polarity testing
- OTDR testing
- Wrap up





Basics



Is MPO New?

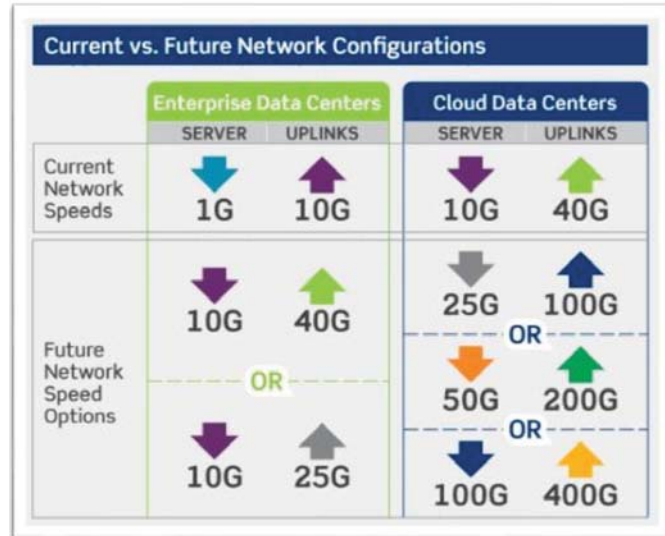


No – MPO connectors and ribbon fiber have been around for well over a decade



What's changed?

- Relentless need for speed
- MPO being extended to the equipment
 - Switches and Servers
 - QSFP ports



Courtesy of Leviton



40/100GE Client Interfaces available today

Interface/Application	Reach	Medium	Parallelism	Standard
100GBASE-ER4	40 km	SMF	4 λ / dir	IEEE 802.3ba
ER4-Lite	20-25km	SMF	4 λ / dir	Variation on 802.3ba
100GBASE-LR4	10 km	SMF	4 λ / dir	IEEE 802.3ba
CWDM4	2 km	SMF	4 λ / dir	CWDM4 MSA
CLR4	2 km	SMF	4 λ / dir	CLR4 Alliance
PSM4	500 m	SMF	4 fibers / dir	PSM4 MSA
SWDM4	100 m	OM5 MMF	4 λ / dir	SWDM Alliance
40GBASE-SR4	100 m	OM4 MMF	4 fibers / dir	IEEE 802.3bj
100GBASE-SR4	70 m	OM4 MMF	4 fibers / dir	IEEE 802.3bm

Newer Data Center Interfaces:

SWDM4/SR4 100m

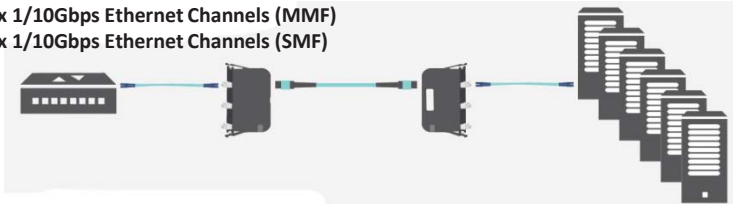
PSM4 500m

CWDM4 / CLR4 2km



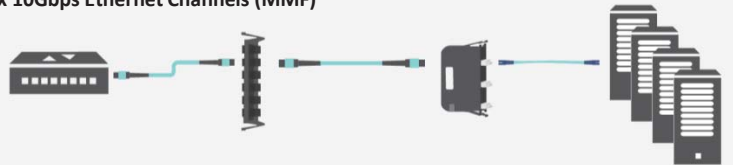
Data Center Examples of MPO/Ribbon Fiber

6 x 1/10Gbps Ethernet Channels (MMF)
6 x 1/10Gbps Ethernet Channels (SMF)



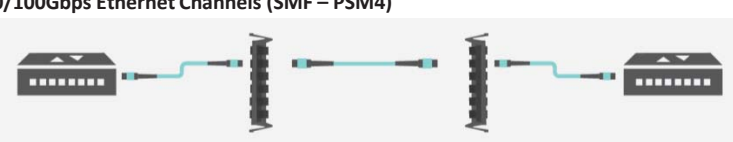
- 12 fiber MPO Link w/Cassettes at either end
- Fiber consolidation and migration path
- SFP/SFP+ at each end

4 x 10Gbps Ethernet Channels (MMF)



- 8 fiber MPO Link w/Cassette
- Fiber consolidation and migration path
- QSFP at switch SFP+ at server

40/100Gbps Ethernet Channels (MMF)
40/100Gbps Ethernet Channels (SMF – PSM4)

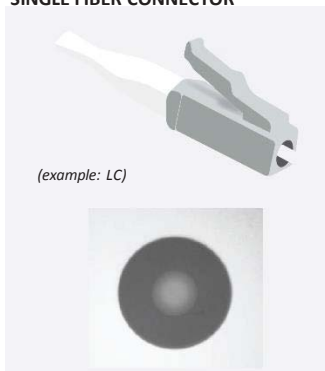


- 12 fiber MPO Link (8 fibers used)
- QSFP/CFP at both ends



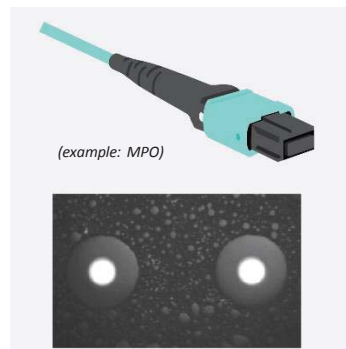
Single Fiber vs. Multi-Fiber Connectors

SINGLE FIBER CONNECTOR



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

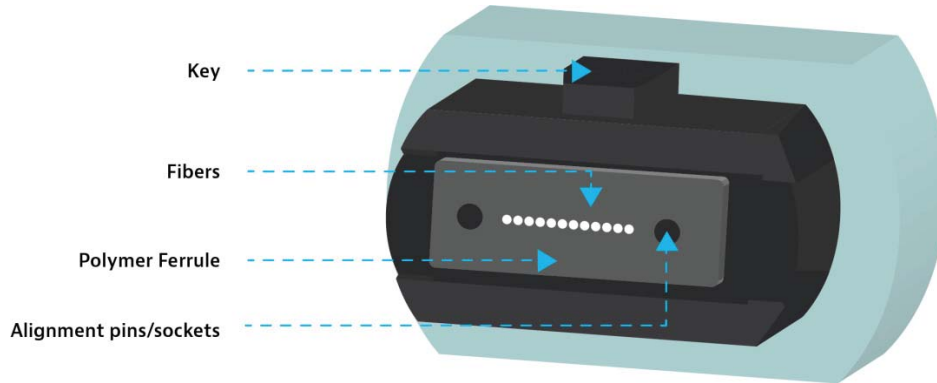
MULTI-FIBER CONNECTOR



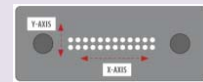
- Polymer ferrule
- Multiple fibers in linear array (for example, 8, 12, 24, 48, and 72) in single connector providing high-density connectivity
- Common type is MPO or MTP®



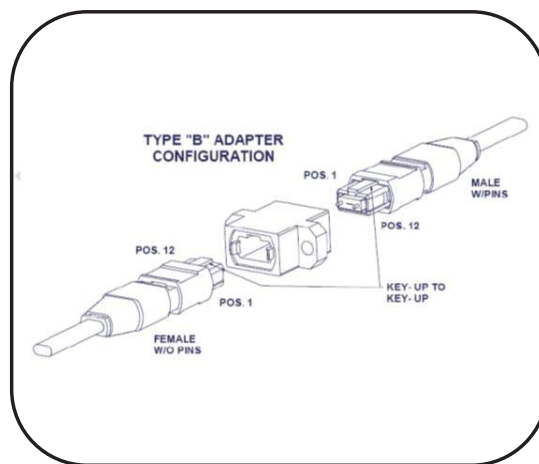
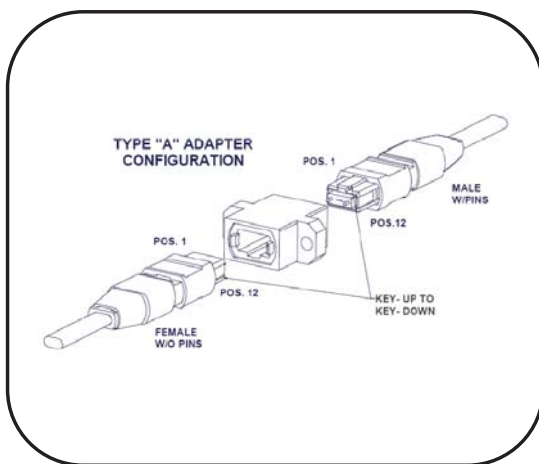
Anatomy of a 12-fiber Multi-Mode MPO Connector



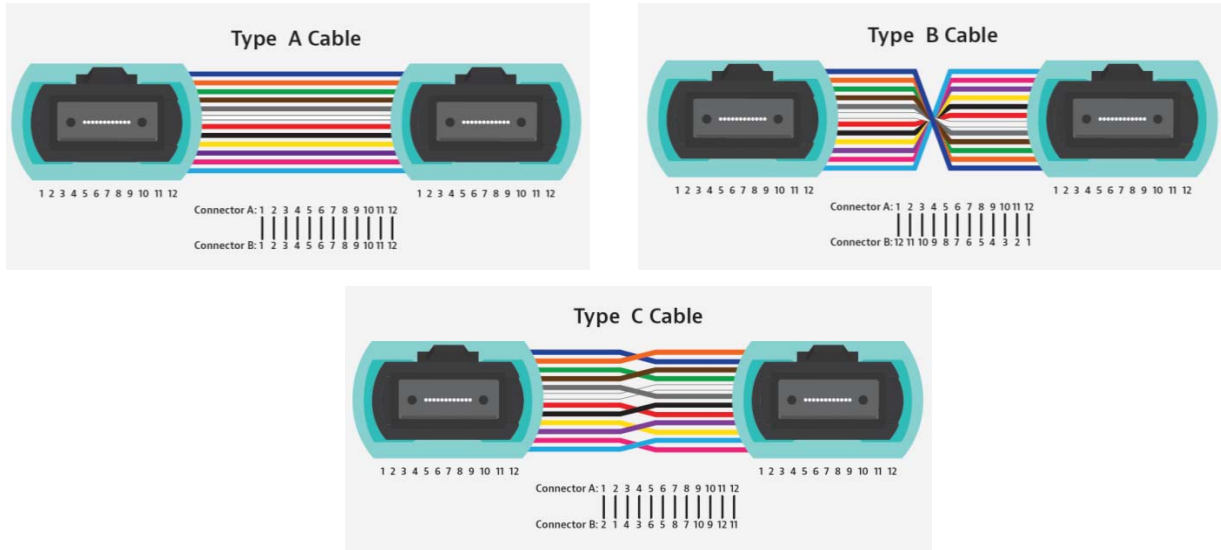
Note: MPO connectors with higher fiber counts (i.e.: 24) will have multiple rows of fiber on the ferrule



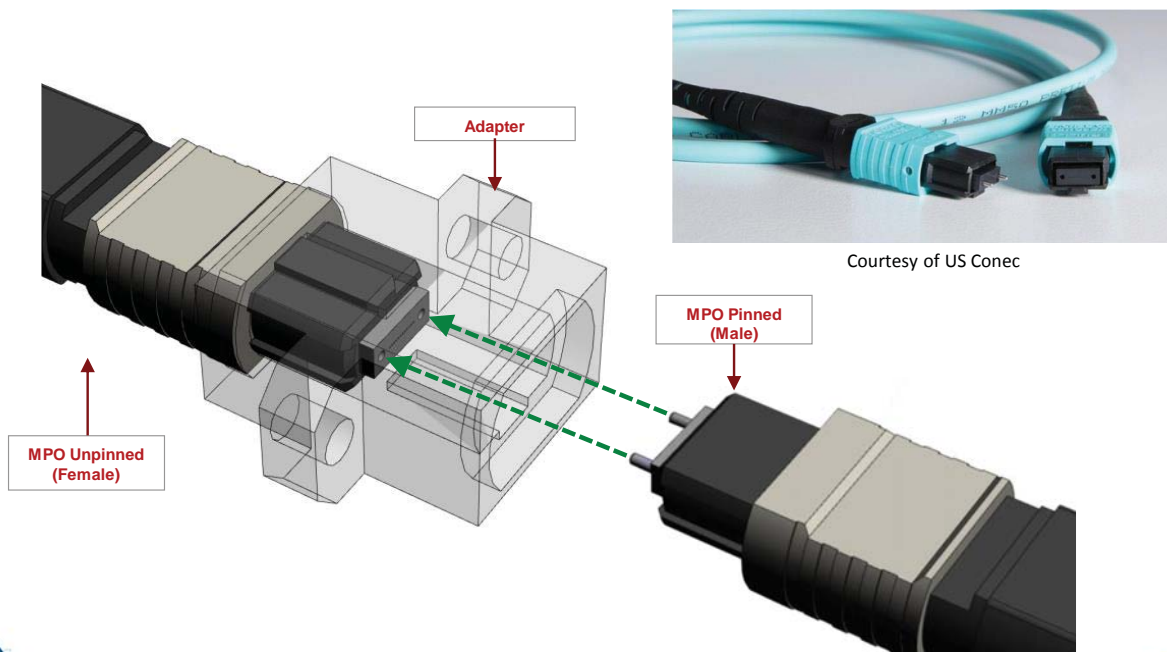
Polarity and Gender



MPO Patch Cord Configurations



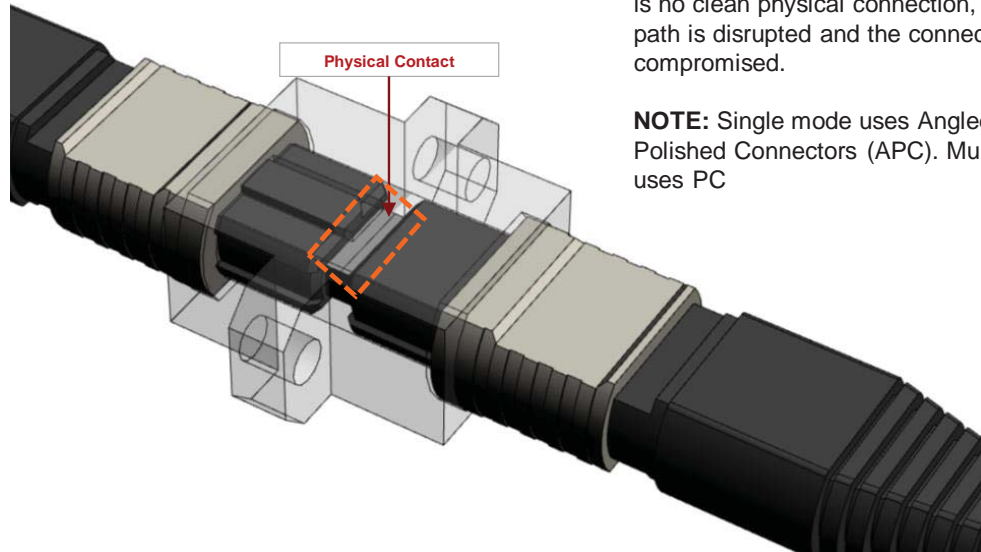
Focused on the Connection



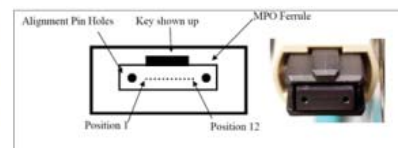
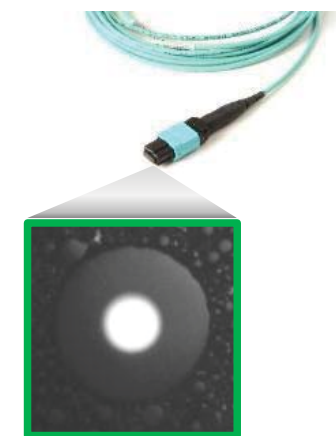
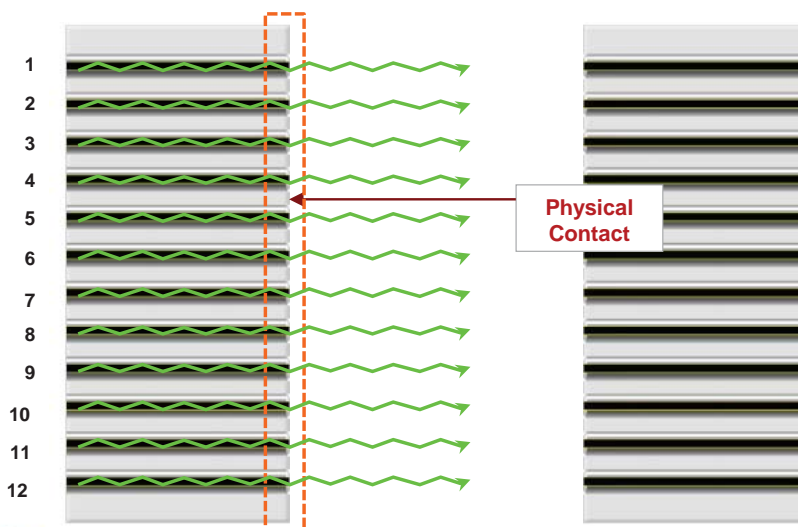
Focused on the Connection

The **Physical Contact** area is the critical joining point in the fiber network. If there is no clean physical connection, the light path is disrupted and the connection is compromised.

NOTE: Single mode uses Angled Polished Connectors (APC). Multimode uses PC



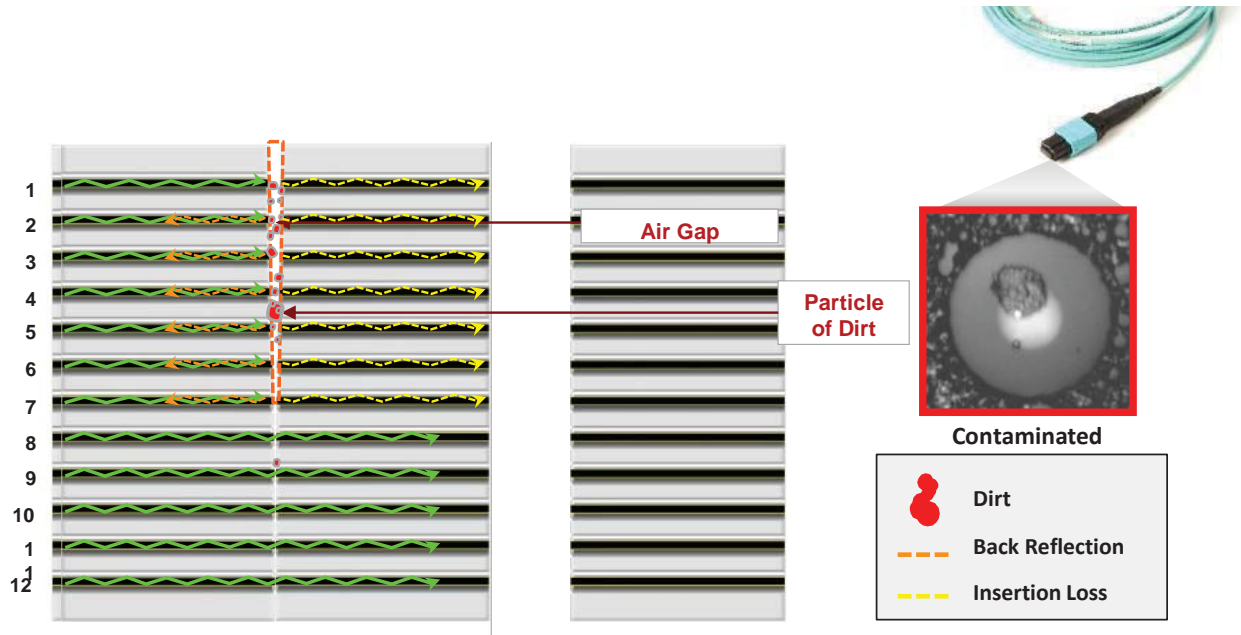
Top-View Cross Section of 12 Fiber MPO



MPO Front View



Top-View Cross Section of 12 Fiber MPO



Back Reflection! And Insertion Loss!



Impact of MPO contamination

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

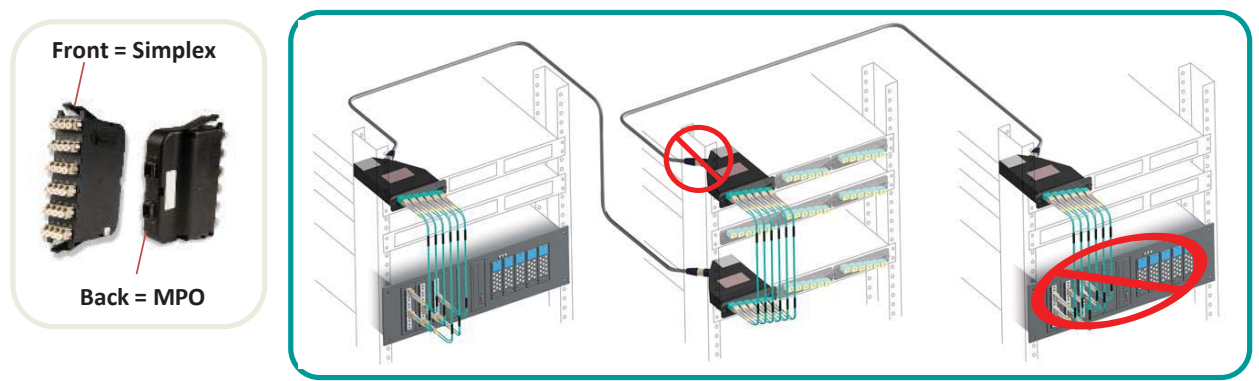
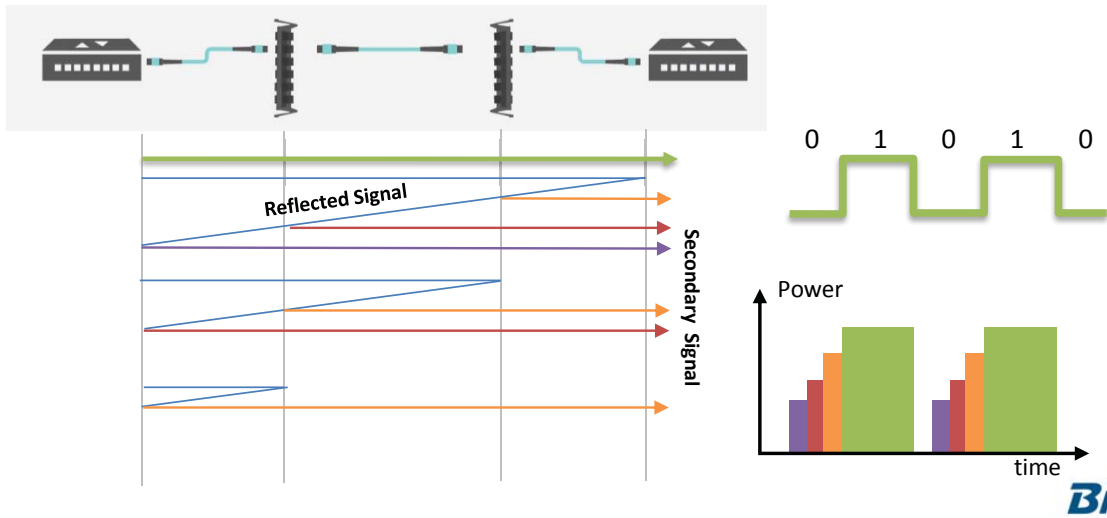


Image property of CommScope

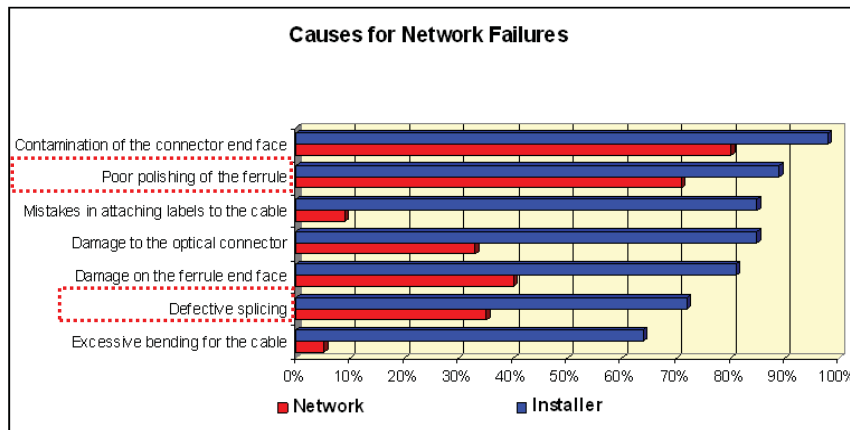


Reflection on the high bit-rate fiber network?

- Will be occurred multiple reflection(=Noise!)
- Multiple reflection generate signal dispersion effect
- It is impossible to identify by receive power measurement



Contaminated fiber end-face is the #1 cause of network failures



In a 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.





Test & Certification



IEC Standards Related to Fibre Testing

SC 25 WG 3

ISO 11801

Information technology -
Generic cabling for
customer premises

ISO 14763-3

Information technology -
Implementation and operation of
customer premises cabling - Part 3:
Testing of optical fiber cabling

SC 86C WG 1

Test Procedures

IEC 61280-4-1

Installed cable plant -
Multimode attenuation
measurement

IEC 61280-4-2

Installed cable plant -
Single-mode attenuation
and optical return loss
measurement

IEC 61280-1-4

General communication
subsystems - Light source
encircled flux
measurement method

IEC 61300-3-35

Visual inspection of
fiber optic connectors
and fiber-stub
transceivers



TIA Standards Related to Fiber Testing

- 568.3-D – Optical fiber cabling and component standard
 - Updated to revision “D” in October 2016
 - Transmission performance and test requirements in Clause 7
 - Annex E (informative) provided guidelines for field testing
- ANSI/TIA-526-14-C-2015
 - Test procedures for installed multimode fiber cable plant
 - Released in April 2015
 - Adaptation of IEC 61280-4-1 Ed. 2.0
 - Encircled Flux for 850nm/50 micron
- ANSI/TIA-526-7-A
 - Test procedure for installed single mode fiber cable plant
 - Released in July 2015
 - Adoption of IEC 61280-4-2 Ed 2.0



Tests Defined in Standards

- Both TIA and ISO/IEC standards specify two tiers of certification
 - Tier 1 (or basic): loss, length, and polarity
 - Tier 2 (or extended): Optical time domain reflectometer (OTDR): loss, length, Reflection, ORL and more.
- Tier 2 (extended) tests are an optional addition to tier 1 (basic) tests
- Fiber end-face inspection and certification is also a requirement to ensure pristine end-face condition PRIOR to mating



Simple/Duplex vs MPO testing

- Existing fiber test standards do not address MPO-specific concerns
- SC 86C WG 1 has published a Technical Report (TR) on testing MPO

IEC 61282-15/TR

Testing Multi-fiber optic
cable plant terminated
with MPO connectors

Cabling testing standards such as IEC 61280-4-1 for multimode attenuation measurements and IEC 61280-4-2 for single-mode attenuation and optical return loss measurement describe testing simplex or duplex fibre cabling terminated with single-fibre ferrule connectors. These IEC standards are difficult to apply to the testing of installed multi-fibre cabling terminated with multi-fibre connectors (MPO).



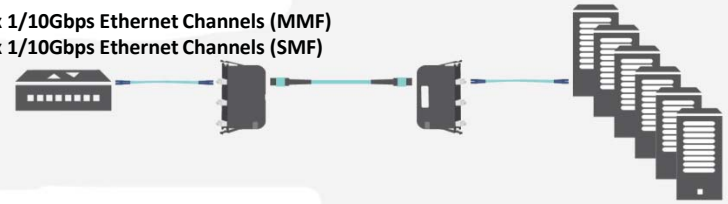
Challenges for testing MPO

- End-face condition at ALL connection points
- When to test MPO vs. duplex/simplex
- Fiber map (polarity)
- Gender (pinned/unpinned) and its impact on reference methods and types of cables
- QSFP to LC connections
- Loss test vs. OTDR test



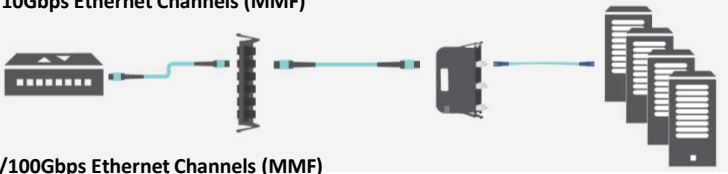
Data Center Examples of MPO/Ribbon Fiber Testing

6 x 1/10Gbps Ethernet Channels (MMF)
6 x 1/10Gbps Ethernet Channels (SMF)



- Inspect MPO connection to cassettes
- Test duplex drops

4 x 10Gbps Ethernet Channels (MMF)



- Inspect MPO connection to cassettes and patch panels
- Test from MPO to simplex

40/100Gbps Ethernet Channels (MMF)
40/100Gbps Ethernet Channels (SMF – PSM4)

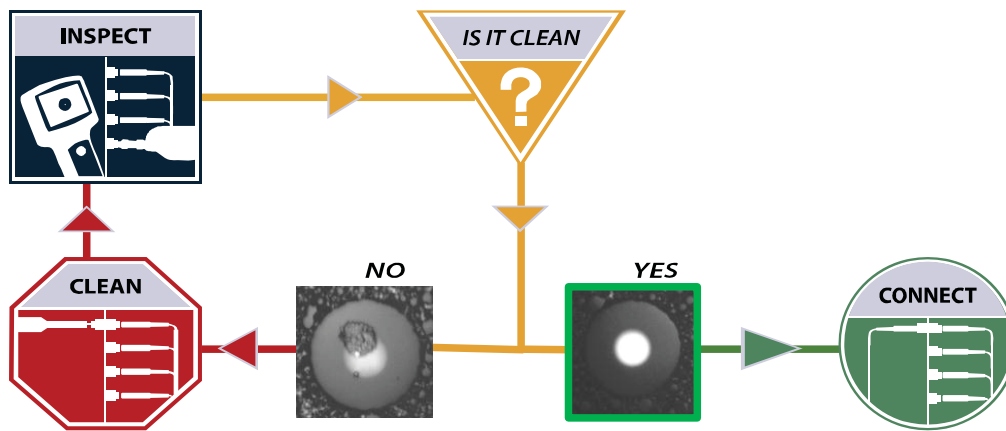


- Inspect MPO connection
- Test MPO Links/Channels



Inspect Before You Connect

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



Inspect and Clean Both Connectors in Pair

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.



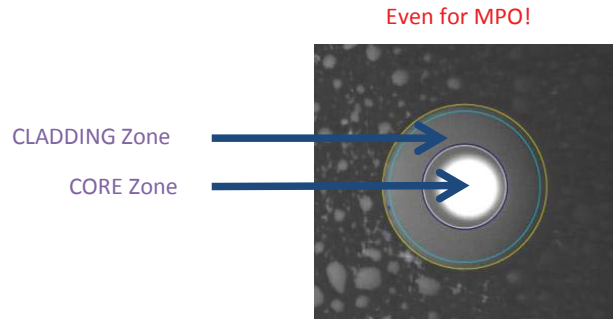
Inspect ALL fibers in a Multi-Fiber Connector



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.



IEC 61300-3-35 Sets Requirements for Connector Quality



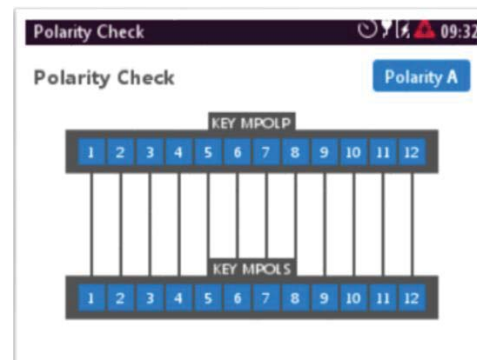
Multimode MPO Connectors

ZONE NAME (Diameter)	SCRATCHES	DEFECTS
A. CORE Zone (0-65µm)	no limit <= 5µm 0 > 5µm	4 <= 5µm none > 5µm
B. CLADDING Zone (65-115µm)	no limit <= 5µm 0 > 5µm	no limit < 2µm 5 from 2-5µm none > 5µm



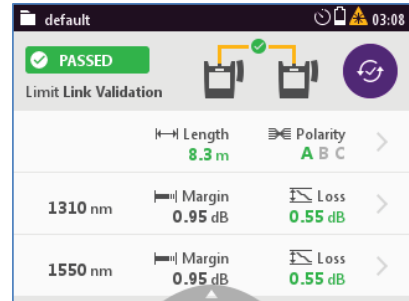
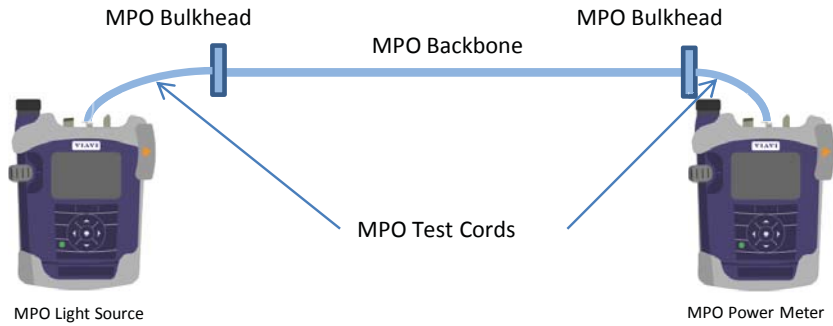
Polarity Check (Fiber Map)

- For existing installations, the end-to-end polarity is often not known
- Fiber Map shows the polarity of the system



Tier 1 (Basic) MPO to MPO Certification

- Test Links and Channels
- Loss, Length and Polarity



default 03:09

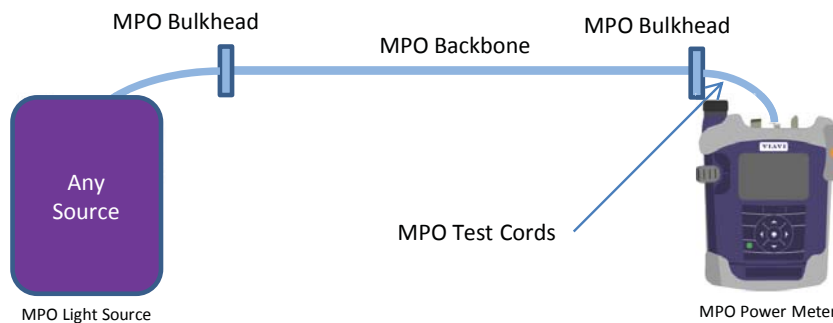
Loss Limit 1.5 dB

Pol.	Fib.	Margin	Loss	Fib.	Margin	Loss
1310	1	0.95	0.55	7	1.24	0.26
	2	1.03	0.47	8	1.22	0.28
	3	1.04	0.46	9	1.16	0.34
	4	0.99	0.51	10	1.16	0.34
1550	5	1.32	0.18	11	1.27	0.23
	6	1.28	0.22	12	1.22	0.28



MPO Power Meter

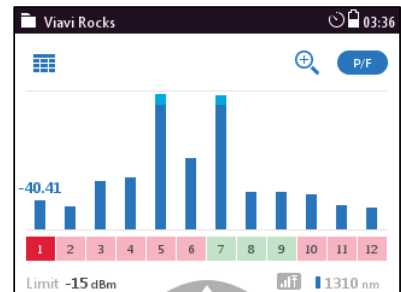
- MPO power meter – Using any MPO source
 - Fault Isolation
 - Testing output power from 40G optics



Viavi Rocks 03:35

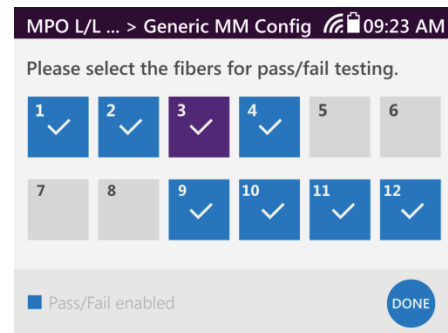
Fiber	Power	Fiber	Power
1	-44.18 dBm	7	-47.88 dBm
2	-37.65 dBm	8	-37.81 dBm
3	-3.26 dBm	9	-39.40 dBm
4	-1.64 dBm	10	-42.29 dBm
5	-0.78 dBm	11	-44.15 dBm
6	-0.79 dBm	12	-45.16 dBm

1310 nm



Selecting Channels

- Can apply to any of the above Test scenarios
- Helps in cases when 8 or fewer fibers are present in MPO links (e.g. 40GBASE-SR4)
- Allows selection of which of the 12 channels are active
 - At the Remote (TX) and at the Local (RX)
- Results reflect topology
- No unwanted “fails” due to nonexistent channels

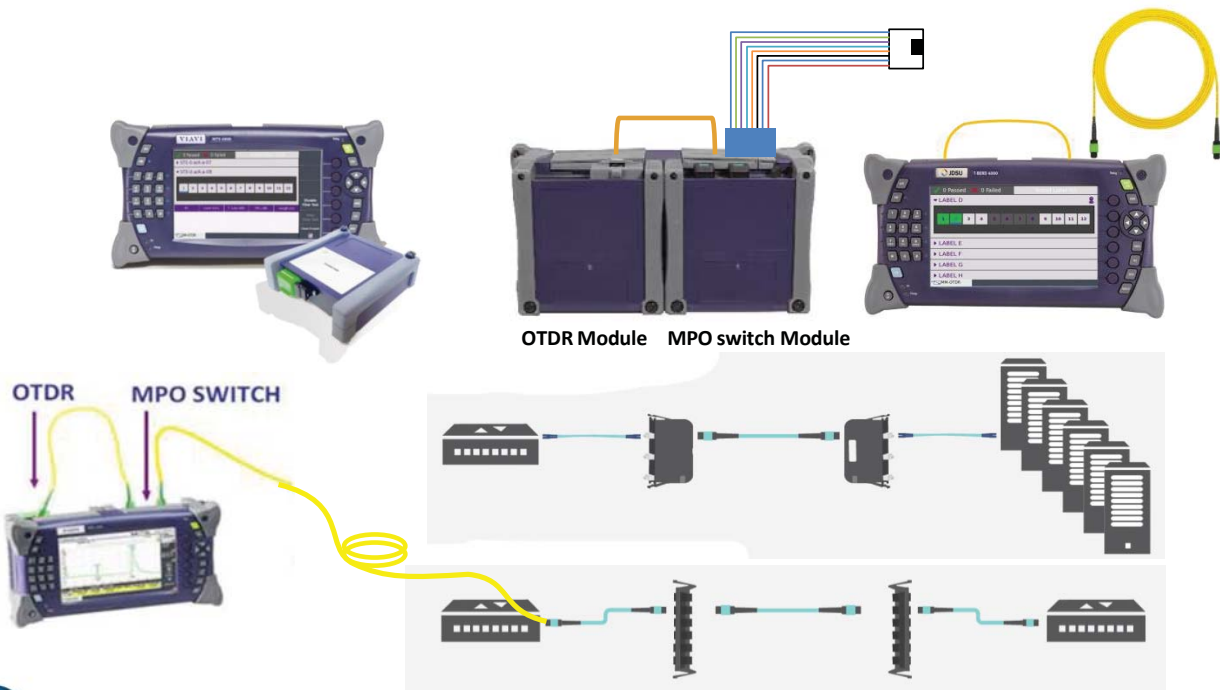


Tier 2 (Extended) Testing of MPO

- Tier 1 testing cannot ensure individual event (splices and connection) losses are within spec OR the cable attenuation is uniform
- Tier 2 (OTDR) testing adds the characterization of these events to the certification test
- Tier 2 testing is also the ideal fiber troubleshooting tool to find the cause AND location of excess loss (incl. breaks) and reflectance. if you fail in Tier 1
- Requires MPO switch
- Pinned/unpinned systems require different launch and receive cords



MPO OTDR Testing (via MPO Switch)



Multi-fibers/channel OTDR testing

The screenshot shows the OTDR software interface for a test labeled 'FiberCable001_RDZ 850_OE'. The interface includes a graph of the OTDR trace, a 'Link Table' with columns for Laser (855 (1ns)), Link Loss (1.102 dB), Link Ori (43.82 dB), and Fiber Length (19.02 m). Below the link table is an 'Alarms' table with columns for Distance (m) and Fault Detected. The fault at 2.17m is 'Bad or dirty connector'. A purple circle highlights the 'Event Diagnostic' button.

Distance m	Fault Detected
0.00	Bad Launch Cable End
1.03	Bad or dirty connector
1.62	Bad or dirty connector
2.17	Bad or dirty connector

Connector
 Reflectance and Loss too high
 Fail Threshold Reflectance : > -55 dB
 Fail Threshold Connector Loss : > 0.20 dB

Potential causes : dirty or damaged, loose connection, PC connector mated with APC, different fiber types, fiber core misalignment.

The screenshot shows the OTDR software interface for a test labeled 'ENTERPRISE_Modelo_MPO_12'. The summary indicates '0 Passed' and '2 Failed' tests. A list of labels is shown, with 'LABEL_01' and 'LABEL_07' marked as failed.

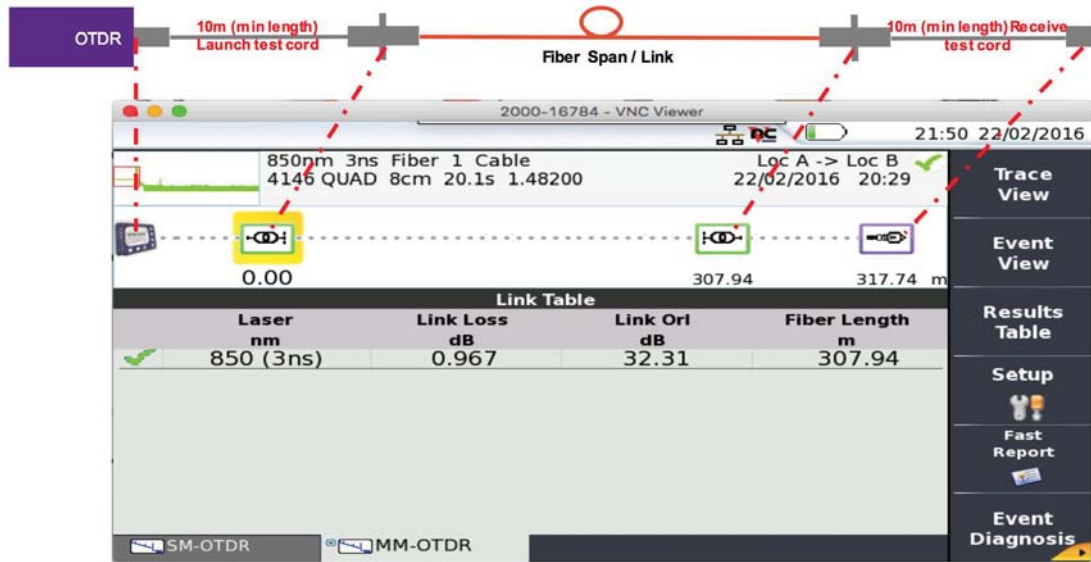
The screenshot shows the OTDR software interface for a test labeled 'ENTERPRISE_crTEST'. The summary indicates '0 Passed' and '0 Failed' tests. A list of labels is shown, all marked as passed.



Event diagnostic key suggests corrective actions for resolving fiber problems when a fault is detected.



Schematic test results (pass example)



Wrap-up

- MPO end-face condition is the most critical element in a channel with MPO connections
- Polarity can be a challenge – especially when adapting existing MPO backbones to new services
- Be aware of pinned/unpinned – presents challenges for testing (test cords must mate with system – challenges with test device and test cord gender)
- Loss testing is typically done on links
 - 1/10G MM, 1/10/40/100G SM link is duplex
 - 40/100G MM, PSM4 SM link is MPO
- Testing channels may make sense if hydra (fan cables) are used
- OTDR testing of MPO allows for:
 - Reflection is one of key to manage network performance in high bit-rate network
 - Characterization of the link or channel (uniformity of cable attenuation and connection loss)
 - Length measurements
 - Fault isolation to prevent unnecessary service interruptions





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