Testing Parallel Optics

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Agenda

- Quick review of some basics and standards
- End-face inspection and certification
- Fiber map
- Loss 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

100GE Client Interfaces – 2016 View

Interface	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
100GBASE-SR4	70 m 100 m	OM3 MMF OM4 MMF	4 fibers / dir	IEEE 802.3bj
100GBASE-SR10	100 m 125 m	OM3 MMF OM4 MMF	10 fibers / dir	802.3ba

Newer Data Center Interfaces:

IEC Standards Related to Fiber 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 fibre 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

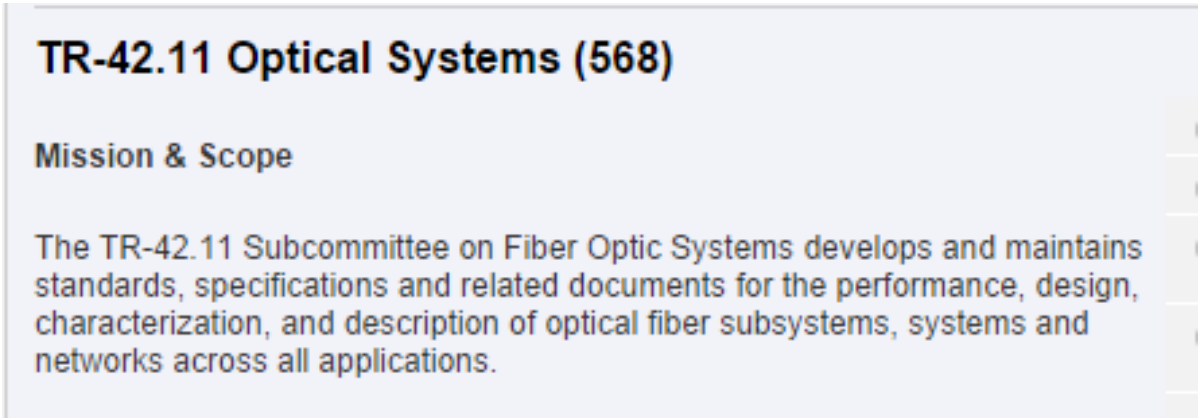
IEC 61280-1-4

General communication subsystems - Light source encircled flux measurement method

IEC 61300-3-35

Visual inspection of fibre optic connectors and fibre-stub transceivers

TIA Technical Subcommittee



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 to tiers of certification
  - Tier 1 (or basic): loss, length, and polarity
  - Tier 2 (or extended): Optical time domain reflectometer (OTDR)

- 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

The Problem

- Existing fiber test standards do not address MPO-specific concerns

> 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).

- SC 86C WG 1 is working on a Technical Report (TR) on testing

IEC 61282-15/TR

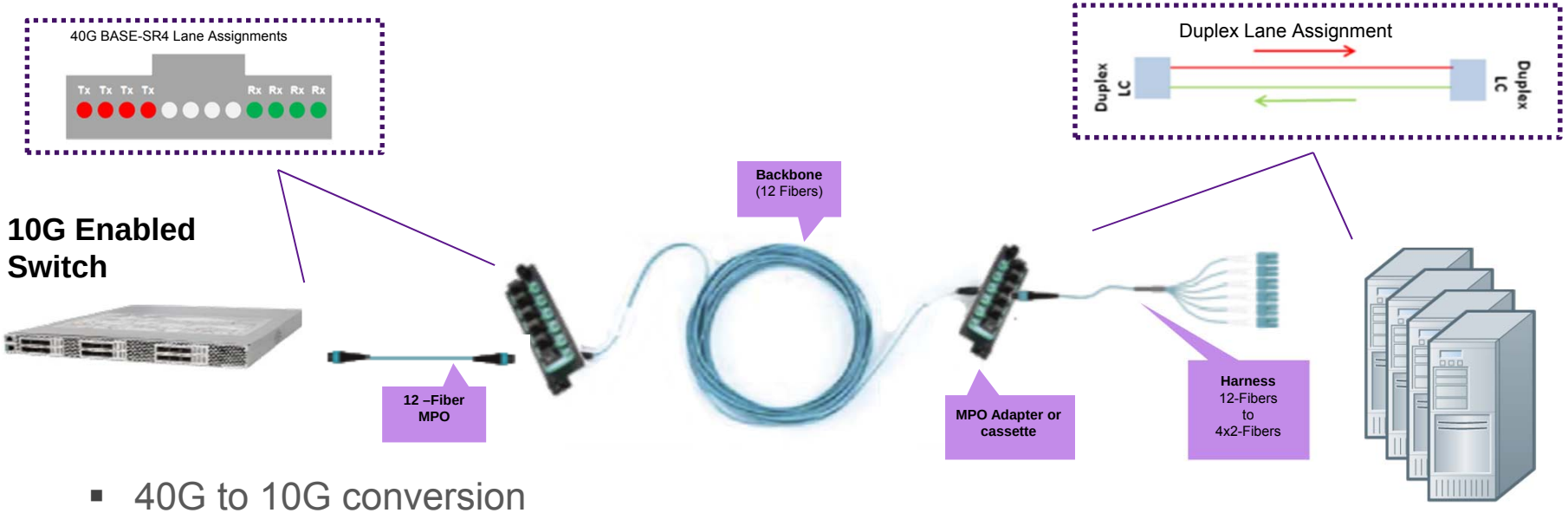
Testing Multi-fiber optic cable plant terminated with MPO connectors

Today’s 1G/10G Networks

1 Patch Cords & Cassettes

2 Harnesses & Adapter Panels

Today's 40G to 10G Network Integration

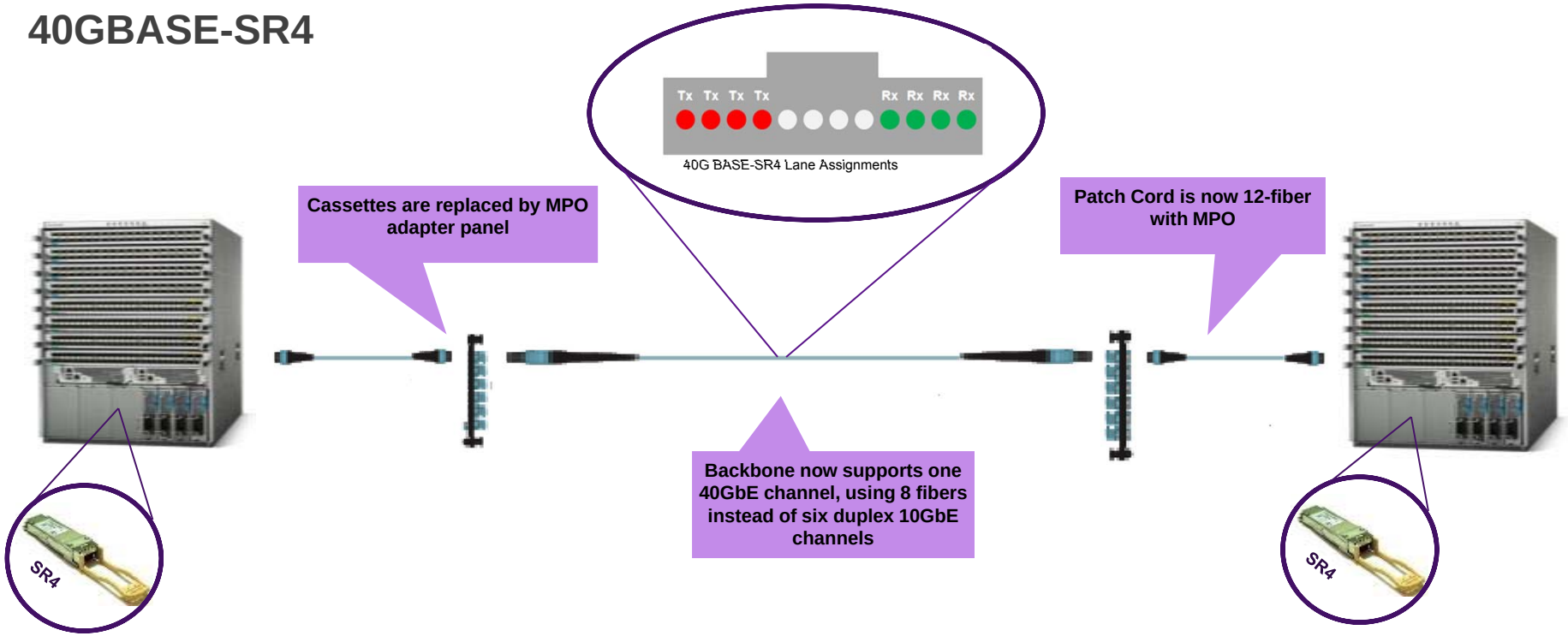


- 40G to 10G conversion
  - Polarity? Method A, Method B, Method C
  - Fiber position conversion from 40G Core to 10G Edge
  - MTP/MPO pinned or unpinned; Tab Up or Tab Down

4 servers – 10G to each server

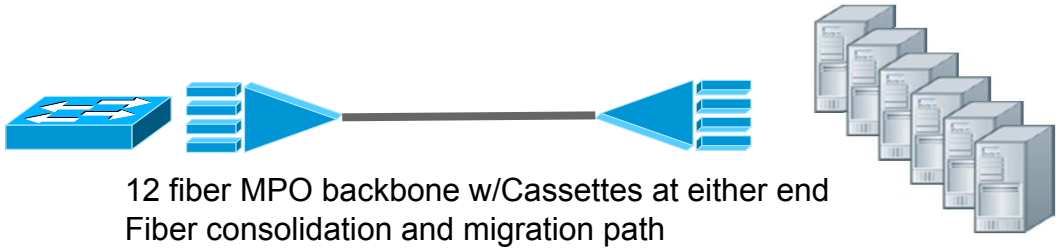
Migrating to 40G Network

40GBASE-SR4



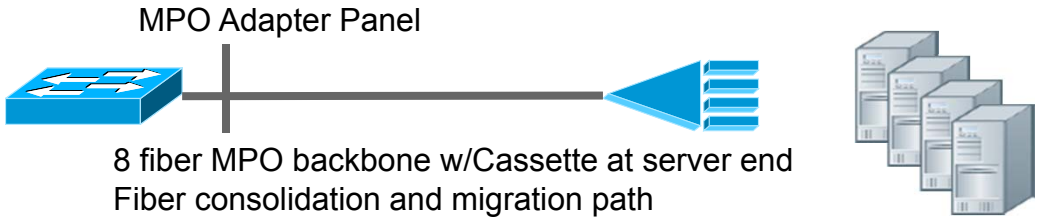
Data Center Examples of MPO/Ribbon Fiber

6 – 1/10Gbps Ethernet Links (MMF)
6 – 1/10/40/100Gbps Ethernet Links (SMF)



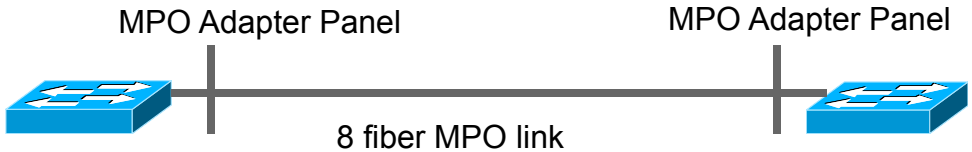
12 fiber MPO backbone w/Cassettes at either end
Fiber consolidation and migration path
SFP/SPF+ at each end

4 – 10Gbps Ethernet Links (MMF)



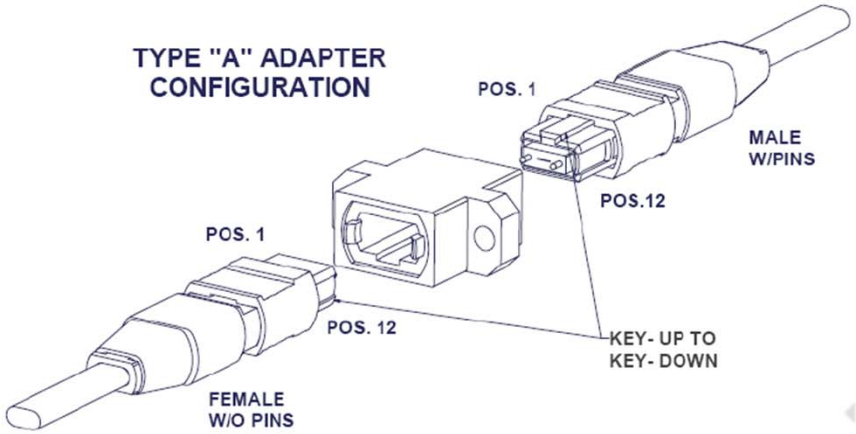
8 fiber MPO backbone w/Cassette at server end
Fiber consolidation and migration path
QSFP at switch SPF+ at server

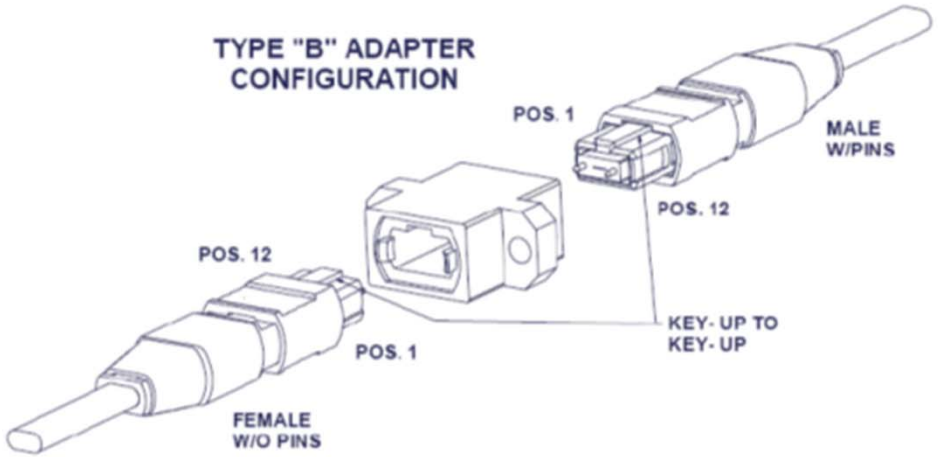
1 - 40Gbps Ethernet Link (MMF)
1 - 40Gbps Ethernet Link (SMF – PSM4)



8 fiber MPO link
QSFP at both ends

Polarity and Gender





MPO Patch Cord Configurations

Table 2 - Type-A:1-1 array patch cord and array cable fiber sequence

Near / Far End	Fiber sequence (viewing the array connector plug end-face with key up)											
Near	1	2	3	4	5	6	7	8	9	10	11	12
Far	1	2	3	4	5	6	7	8	9	10	11	12

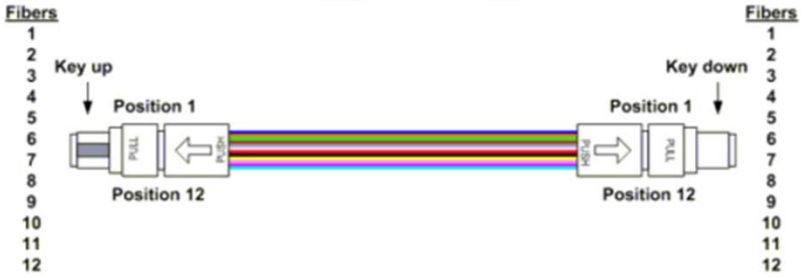


Figure 7 - Type-A:1-1 array patch cord and array cable (key-up to key-down)

Table 4 - Type-B:1-1 array patch cord and array cable fiber sequence

Near / Far End	Fiber sequence (viewing the array connector plug end face with key up)											
Near	1	2	3	4	5	6	7	8	9	10	11	12
Far	12	11	10	9	8	7	6	5	4	3	2	1

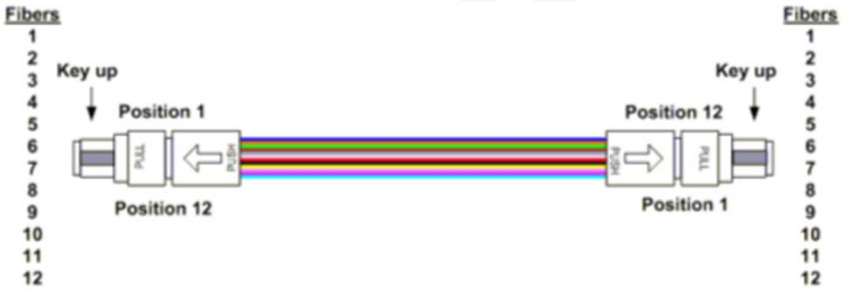
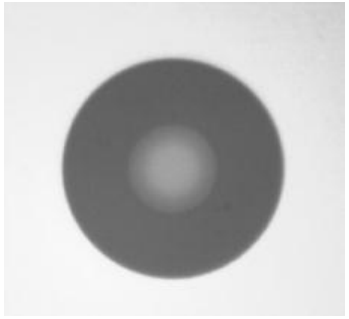


Figure 9 - Type-B:1-1 array patch cord and array cable (key-up to key-up)

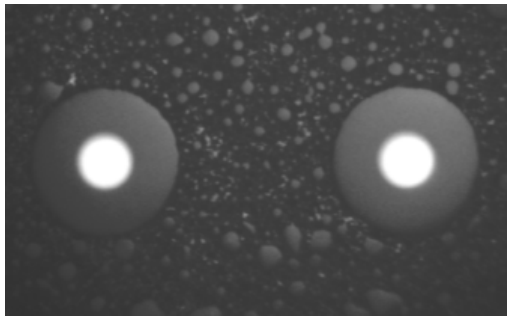
Single Fiber vs. Multi-Fiber Connectors

SINGLE FIBER CONNECTOR



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

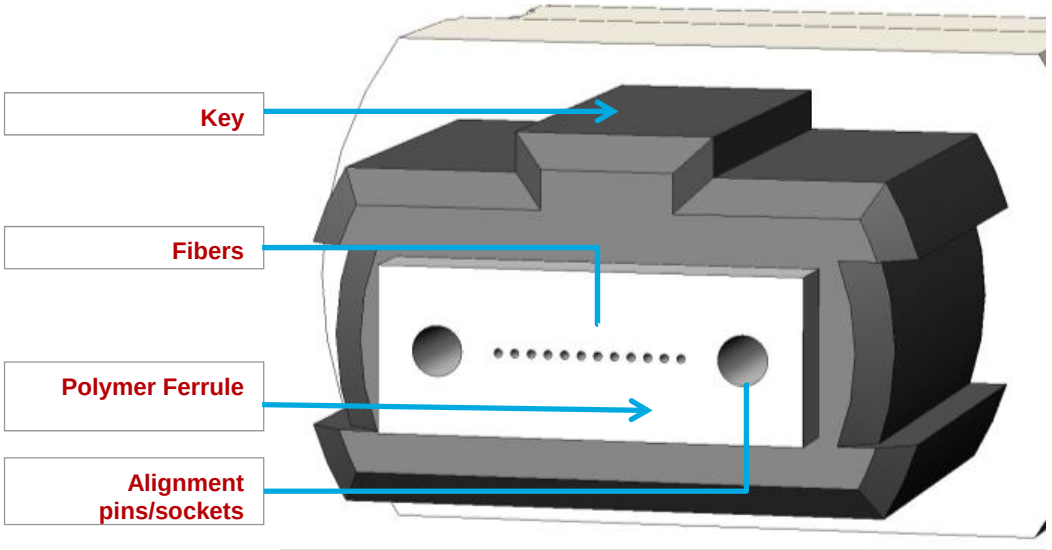
MULTI-FIBER CONNECTOR



- 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®

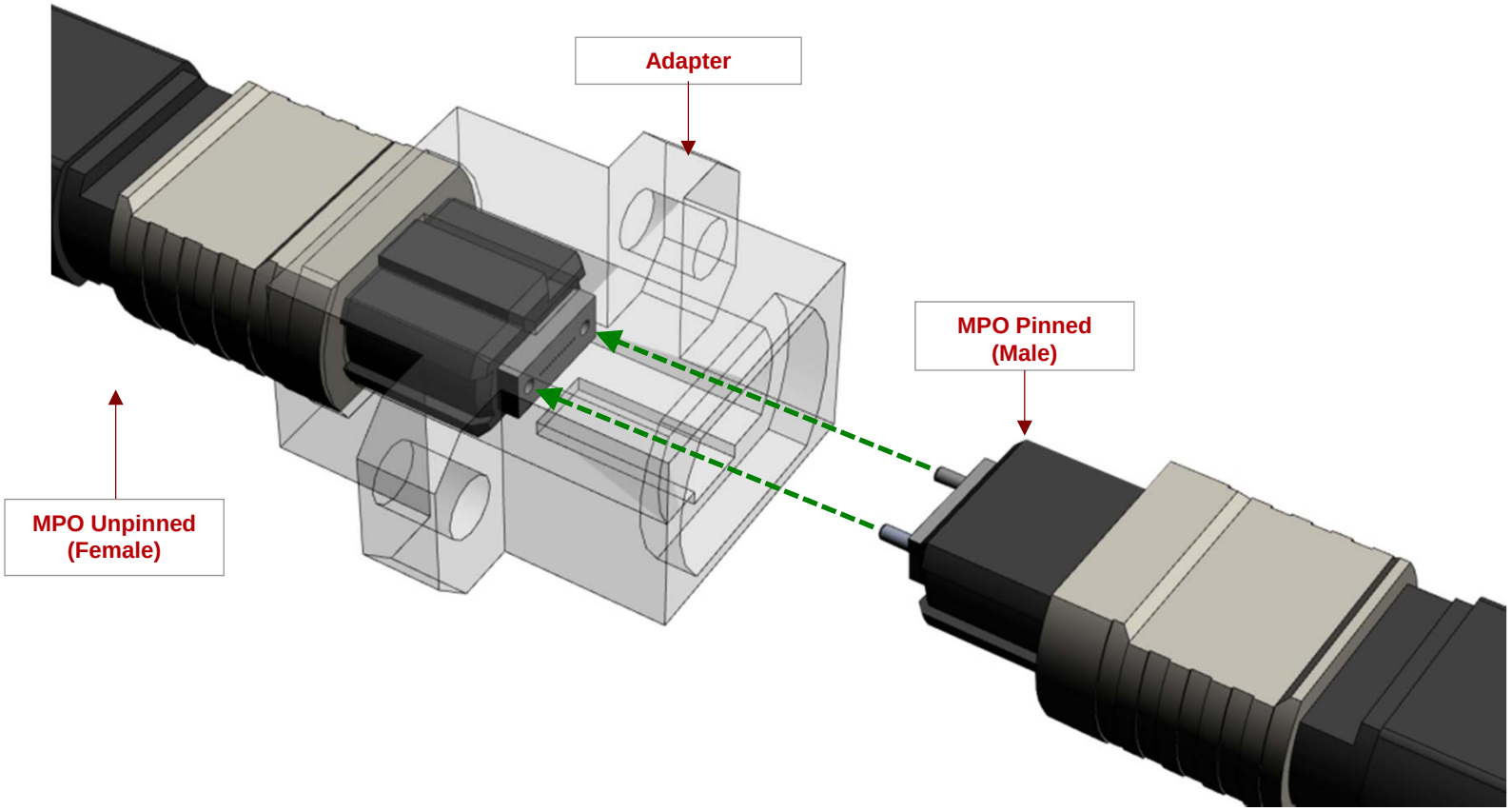
Anatomy of a 12-fiber Multi-Mode MPO Connector

- The MPO fiber connector has 4 **major areas:**
  - **Fiber**
  - **Ferrule**
  - **Alignment pins/sockets**
  - **Polarity key**

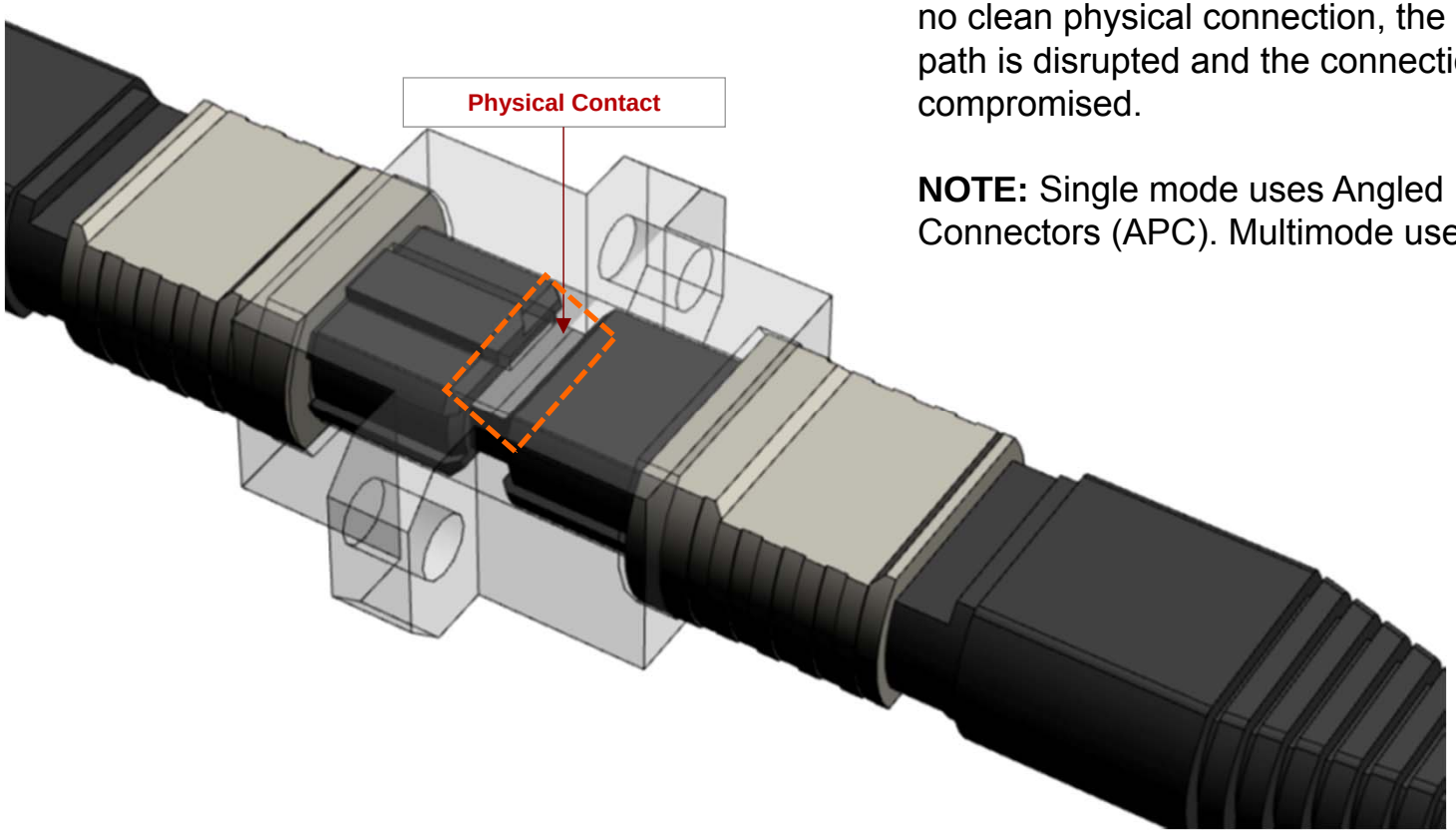


12 Fiber MultiMode Connector (Female)

Focused on the Connection



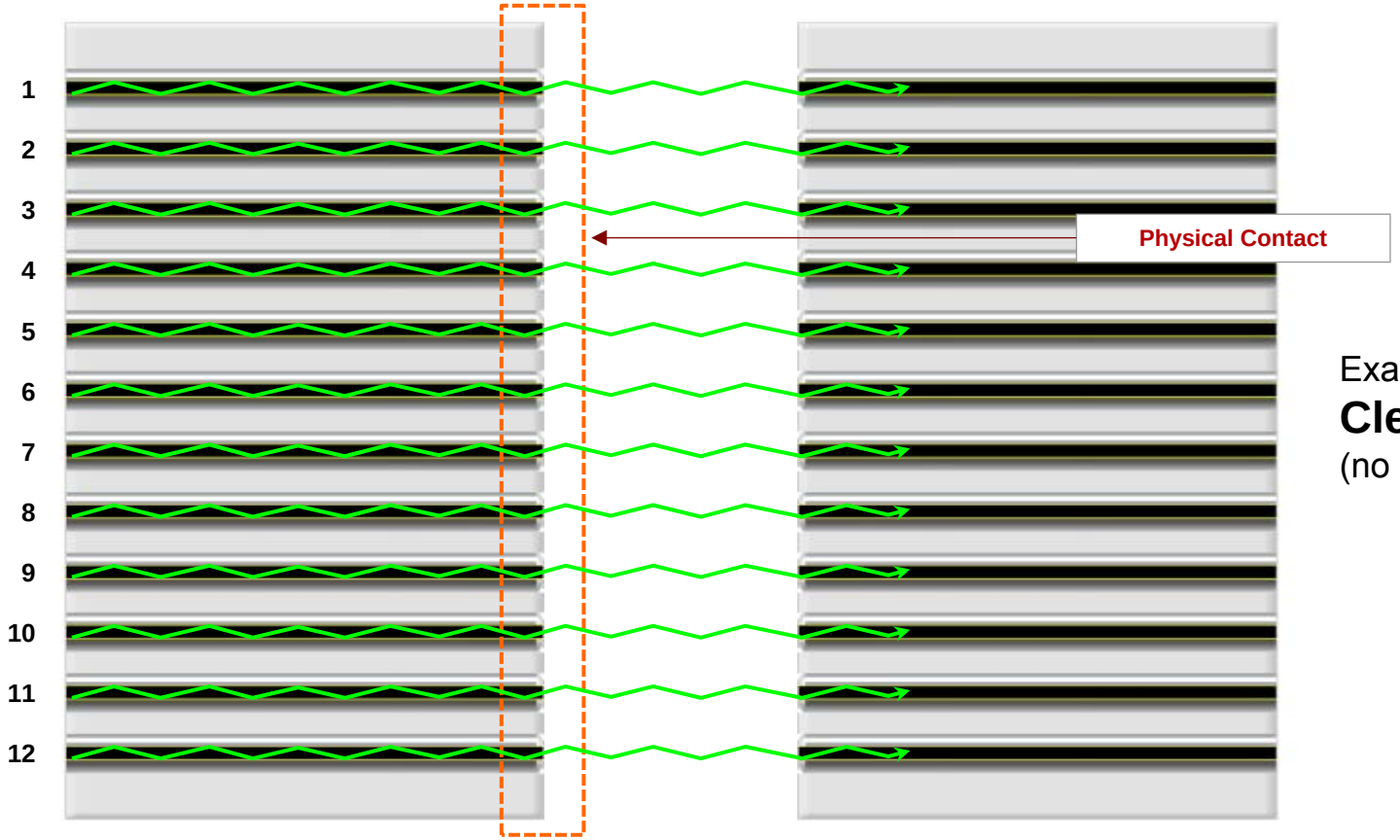
Focused on the Connection



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.

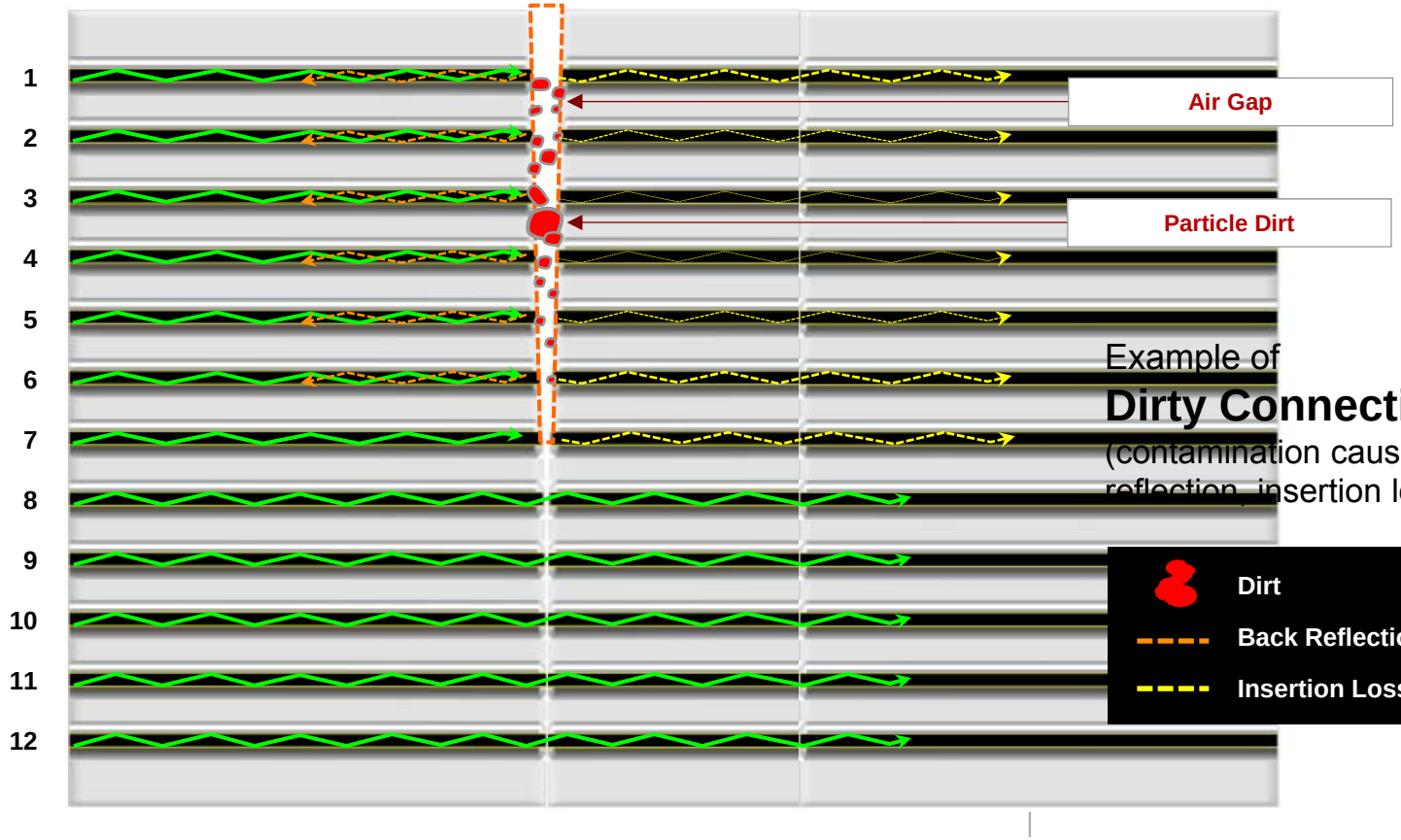
NOTE: Single mode uses Angled Polished Connectors (APC). Multimode uses PC

Top-view Cross Section 12 Fiber MPO - Clean



Example of
Clean Connection
(no contamination)

Top-view Cross Section (1–12 Fibers)



Example of

Dirty Connection

(contamination causing air gaps, back reflection, insertion loss)

Dirt

Back Reflection

Insertion Loss

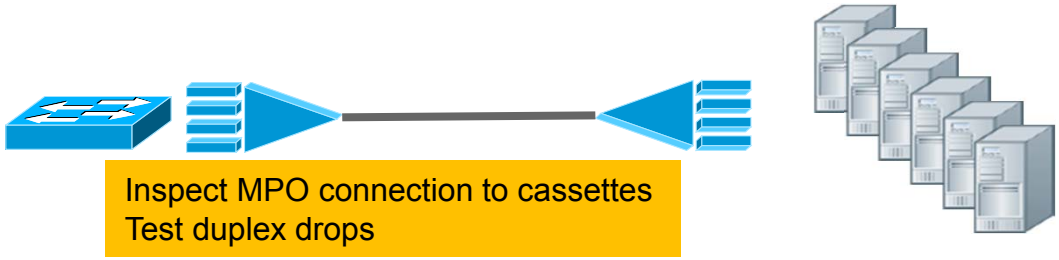
Testing

Test Challenges for MPO

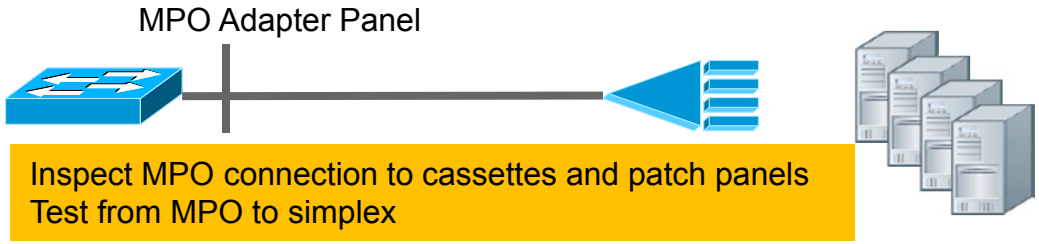
- End-face condition at ALL connection points
- When to test MPO vs. duplex/simplex
- Fiber map (polarity)
- Gender (pinned/unpinned) and its impact on reference methods and types of cables
- QSFP to LC connections
- Loss test vs. OTDR test

Data Center Examples of MPO/Ribbon Fiber

6 – 1/10Gbps Ethernet Channel (MMF)
6 – 1/10/40/100Gbps Ethernet Channel (SMF)



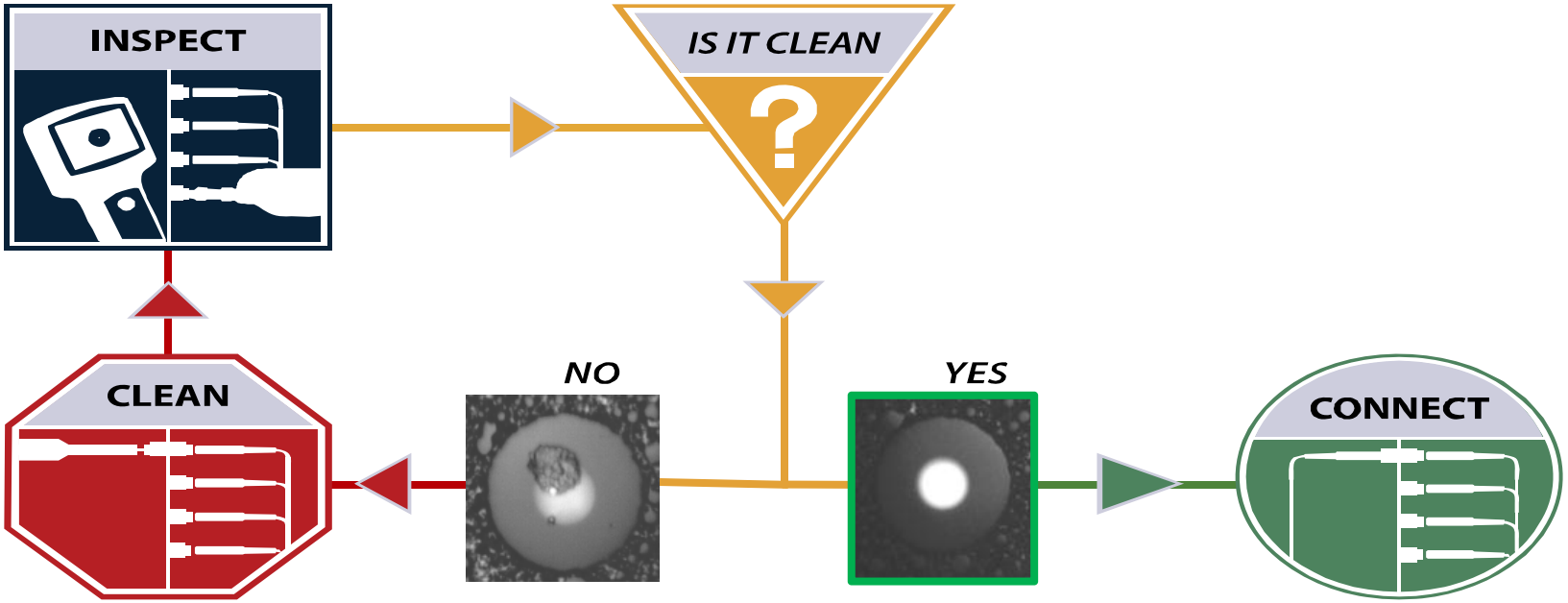
4 – 10Gbps Ethernet Channel (MMF)



1 - 40Gbps Ethernet Channel (MMF)
1 - 40Gbps Ethernet Channel (SMF – PSM4)

Inspect Before You Connect[sm]

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

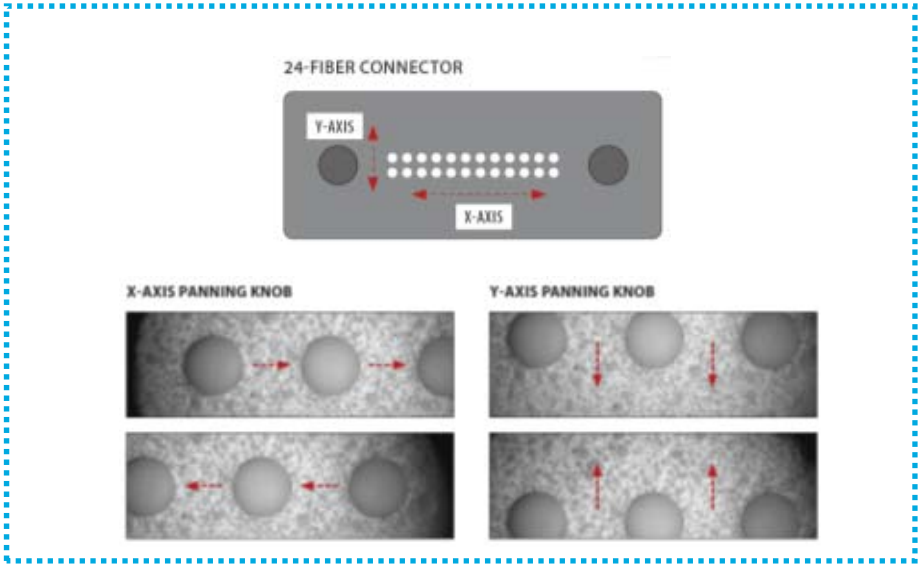
Inspecting BOTH sides of the connection is the **ONLY WAY** to ensure that it will be free of contamination and defects.

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

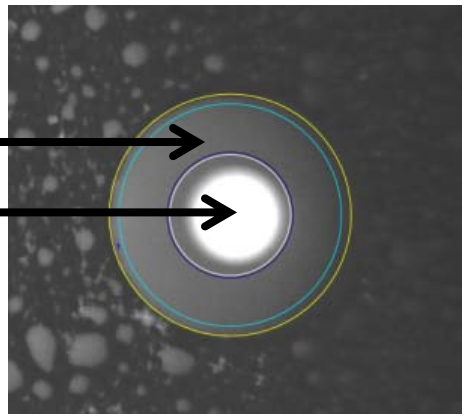


IEC 61300-3-35 Sets Requirements for Connector Quality

Even for MPO!

CLADDING Zone

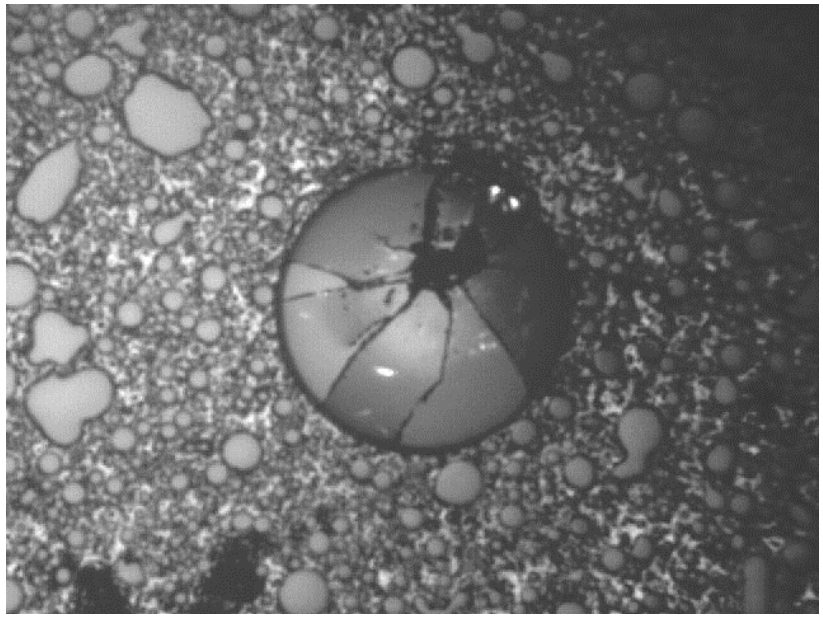
CORE Zone



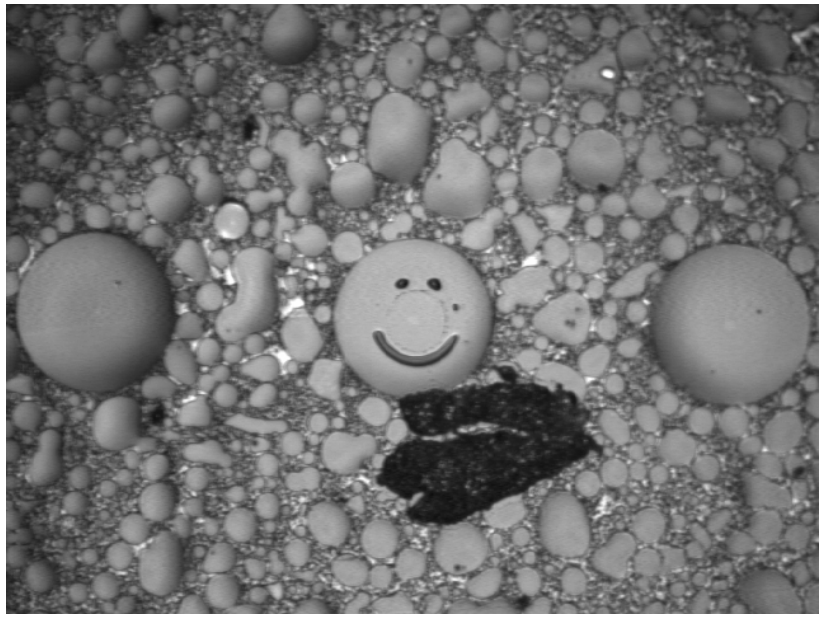
Multimode MPO Connectors

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

Bonus Slide! Real End-Face Examples



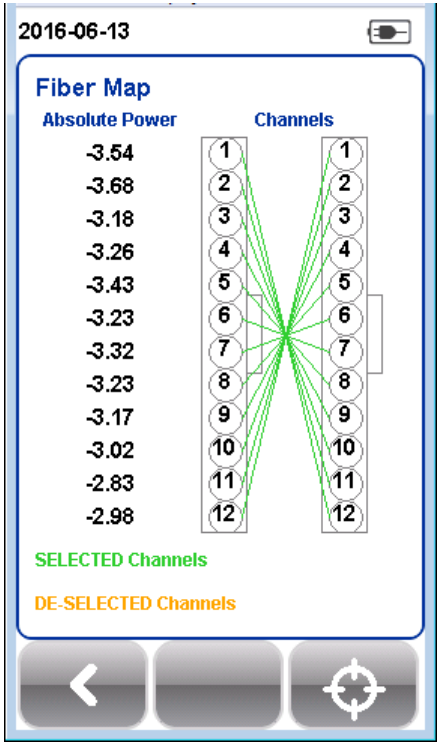
Cracked MPO



Happy MPO

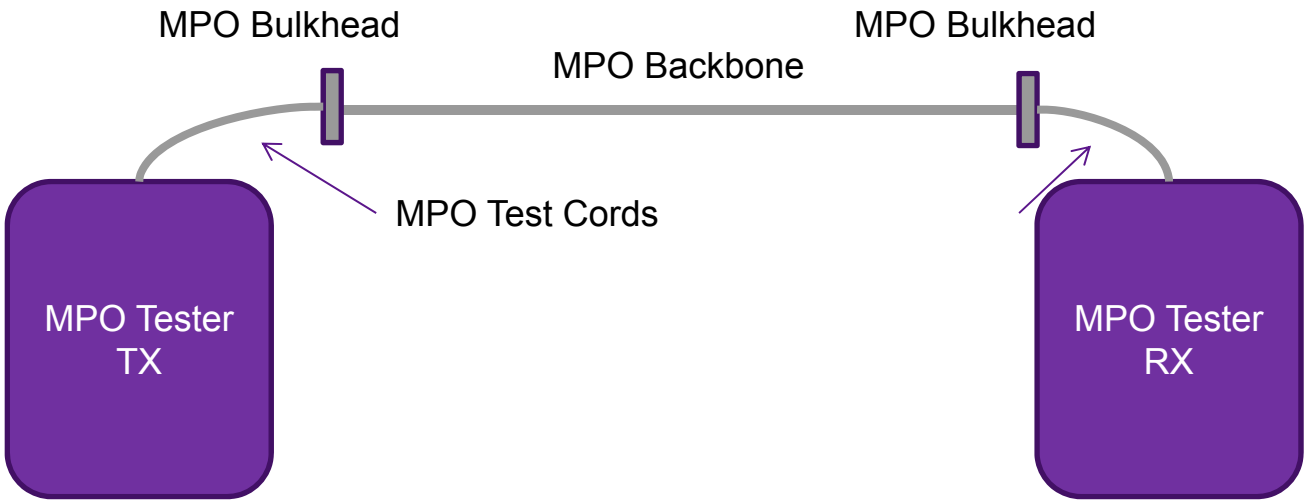
Fiber Map

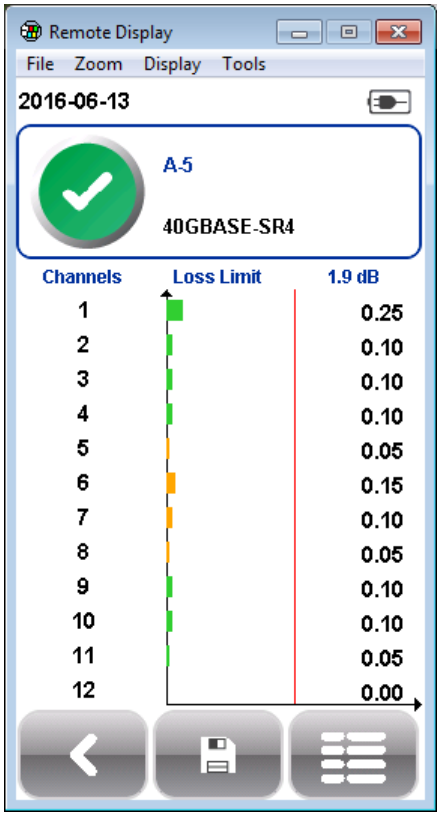
- For existing installations, the end-to-end polarity is often not known
- Fiber Map shows the polarity of the system



MPO to MPO Loss and Polarity Test

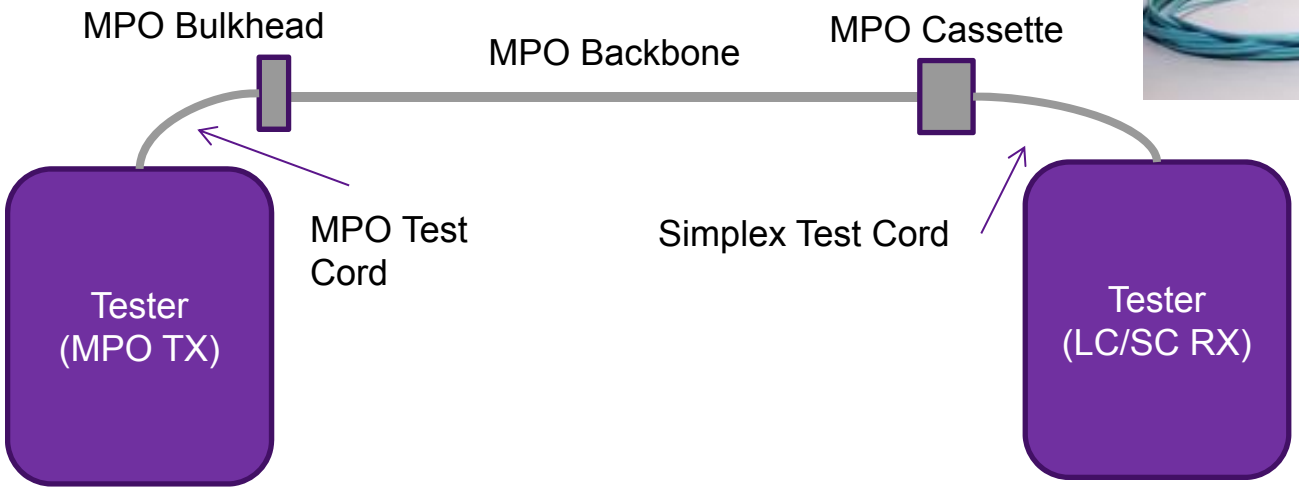
- Test 40G Links and Channels
- Ensure polarity and loss





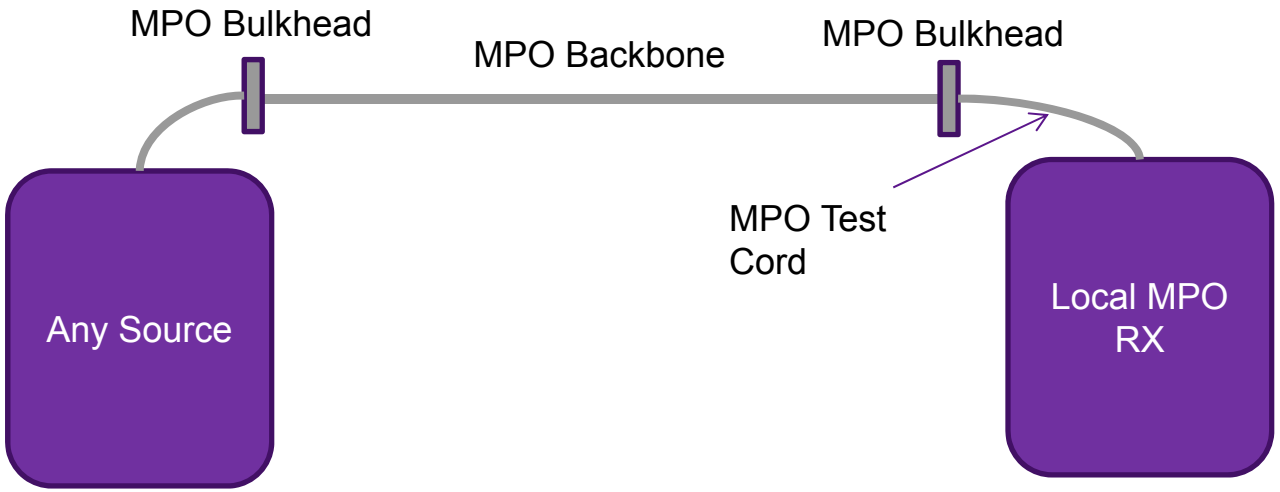
MPO to Single Fiber Loss and Polarity Test

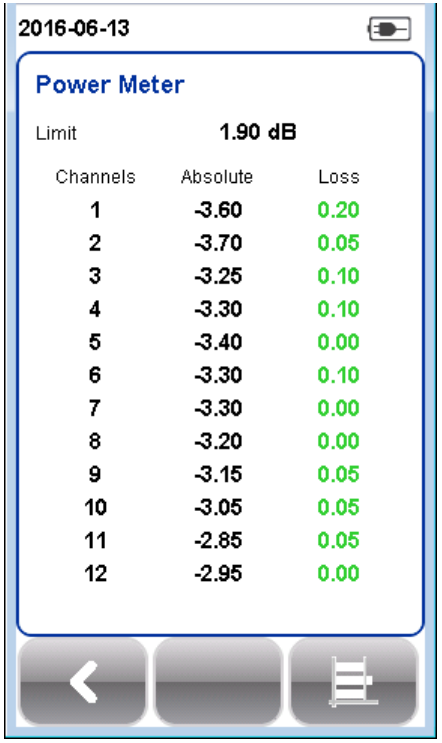
- One end MPO source – Other end simplex power meter
  - Testing from MPO to Fanouts or Cassettes
  - End-to-end channels for QSFP to 10G
  - Fiber Map from MPO to LC/SC (simplex)



MPO Power Meter

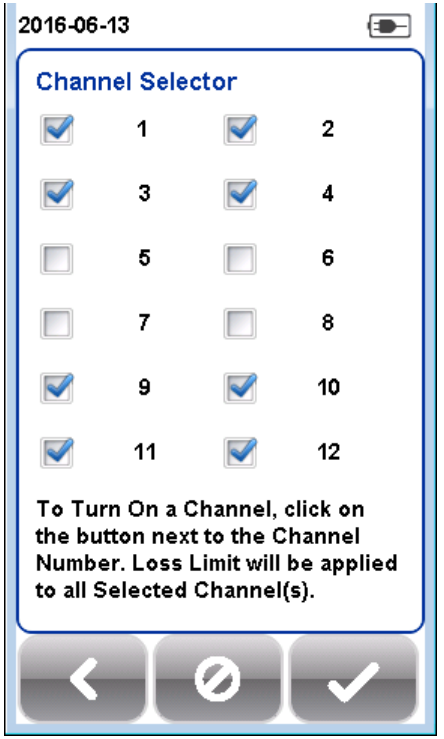
- MPO power meter – Using any MPO source
  - Fault Isolation
  - Testing output power from 40G optics





Selecting Channels

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



Multi-Fiber OTDR Testing

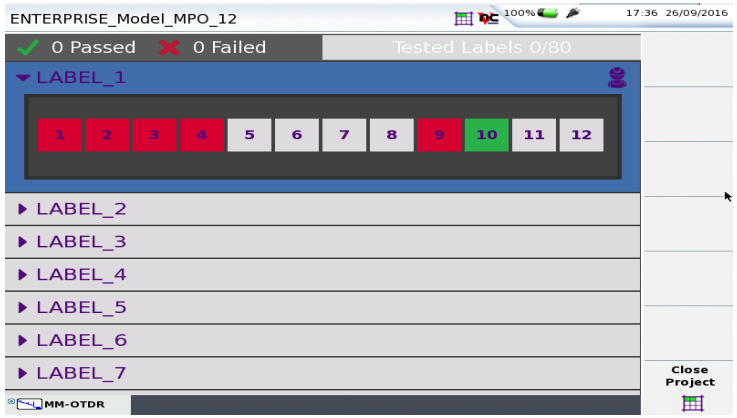
Configure
- Setup Enterprise-SLM using pre-defined SmartConfigs

Import Cable Id
- Import file (.csv) containing list of labels / cable IDs

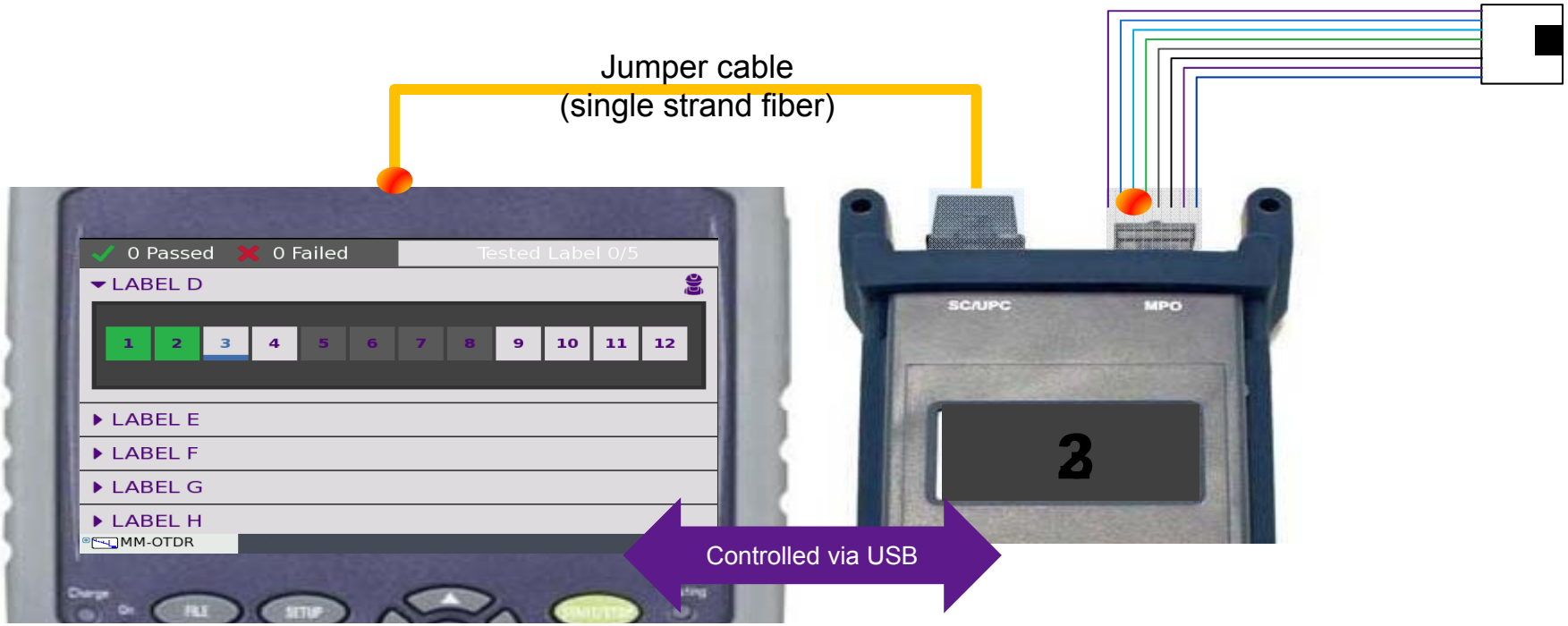
Measure
- Start OTDR acquisition, analyze and view SLM results

Control
- Visualize and control pass/fail status of all tested fibers and labels

Report
- Report OTDR fiber results (.sor & .pdf)
- At project closure generate a comprehensive summary report



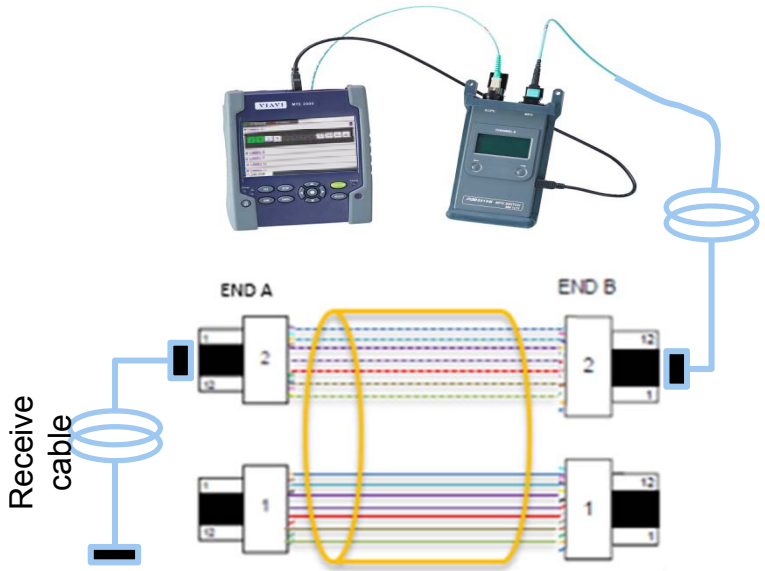
Automatic MPO Cable OTDR Testing (via MPO Switch)



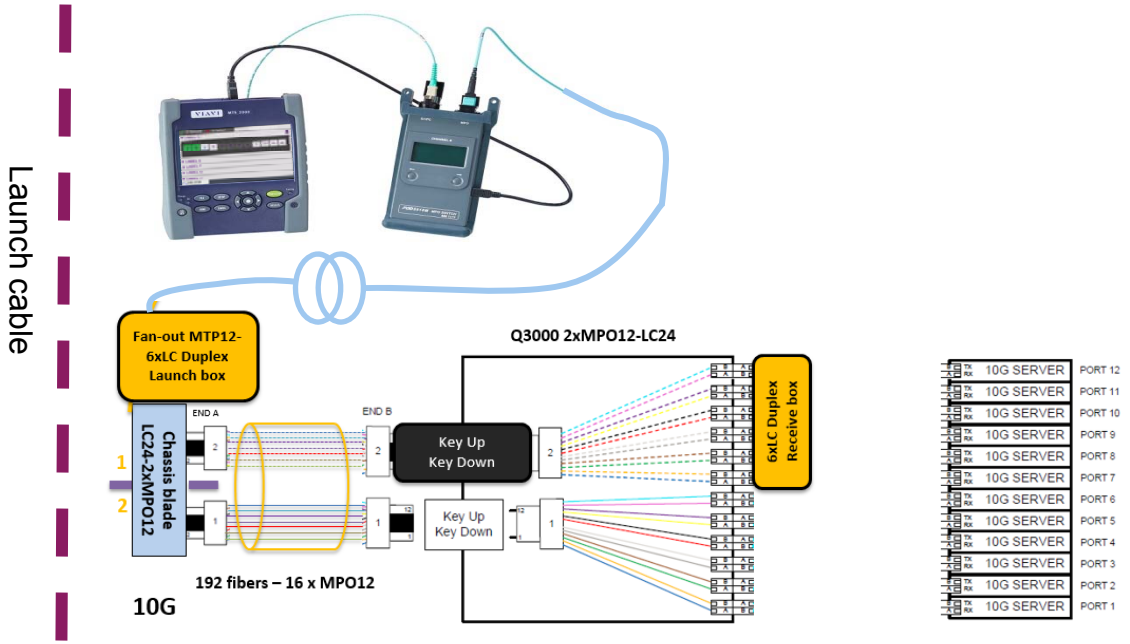
- **Test up to 12 fibers, sequentially, at a press of a single button.**
- **Reduce testing time by 50%**

10GbE LC-LC (MTP/MPO Backbone) Link Measurement

Step 1: Pre-installation quality test

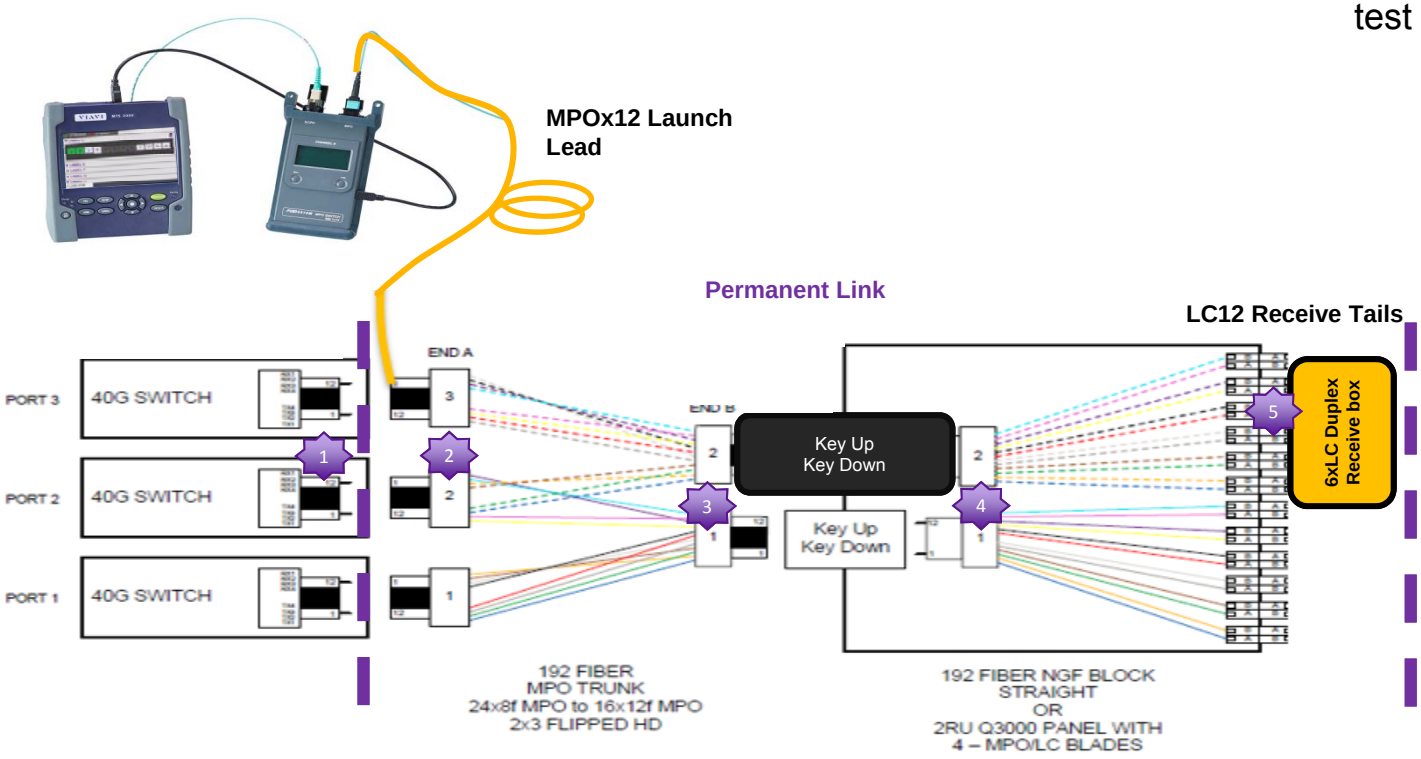


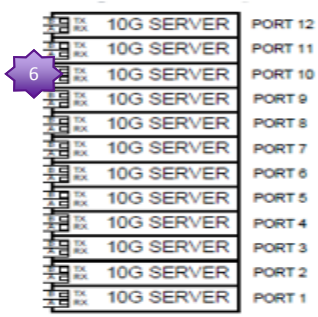
Step 2: End to end link test



MTP/MPO12-LC Link Measurement

Connecter endface inspection test points





MPO OTDR Testing Use Cases

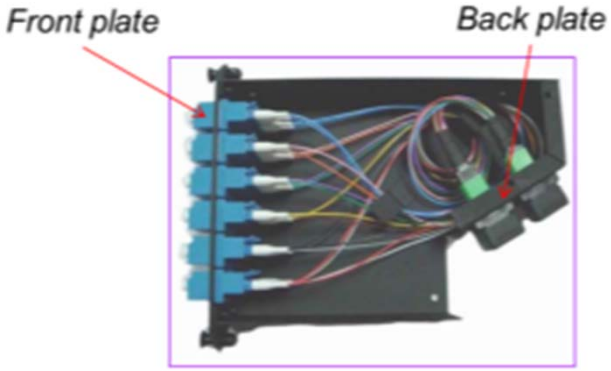
- Who
  - Fiber cable installers
  - IT / Network technicians
- When
  - At installation of native MPO network (Equipment supporting 10Gb/s + services) to ensure each passive elements (connectors/cassettes) are properly installed
  - At maintenance, to quickly find physical link issue on MPO cables and in cassettes
- Why
  - Certify the performance of the permanent links deployed in the network
  - Meet tight customer and industry specifications ➔ accurate and repeatable measurements
  - Identify the source of critical and costly problems

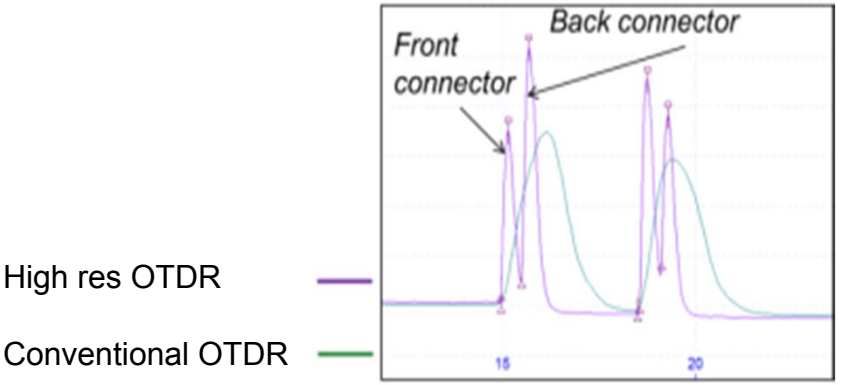
40GBASE-SR4 QSFP+ Optics

100GBASE-SR10 CFP Optics

Identify Front and Back Connectors

- Conventional OTDRs can't distinguish between front and back connectors of a cassette
  - If ribbon connector (back) is damaged/dirty, maintenance of the connector/replacement can affect multiple fibers/services (up to 10 other channels)
  - If front connector (single) is damaged/dirty, maintenance of the connector/ replacement will affect only one fiber/ channel.
- High resolution OTDR's
  - Quickly identify if the issues is at the front or back connector avoiding unnecessary service/traffic disruption





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:
  - Characterization of the link or channel (uniformity of cable attenuation and connection loss)
  - Length measurements
  - Fault isolation to prevent unnecessary service interruptions

Thank-you

Questions?

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