



# Testing Parallel Optics

David Kuan (MSc, PMP)

Regional Product Manager – APAC

Viavi Solutions



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# Agenda

- Basics
  - Why parallel optics with multi-fiber push-on/pull-off (MPO) connectors?
  - System architectures
  - Standards
  - Technology overview
- Test and Certification
  - End-face inspection and certification
  - Polarity check
  - Tier 1 (basic) certification
  - Tier 2 (enhanced) certification
  - Troubleshooting
- Wrap up

# Is MPO New?



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

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# What's Changed?

- Relentless need for speed
- MPO being extended to equipment

Current vs. Future Network Configurations				
	Enterprise Data Centers		Cloud Data Centers	
	SERVER	UPLINKS	SERVER	UPLINKS
Current Network Speeds	↓ 1G	↑ 10G	↓ 10G	↑ 40G
Future Network Speed Options	↓ 10G	↑ 40G	↓ 25G	↑ 100G
	OR		OR	↑ 200G
	↓ 10G	↑ 25G	OR	↑ 400G
			↓ 100G	↑ 400G

Courtesy of Leviton



# 40/100GE Client Interfaces Available

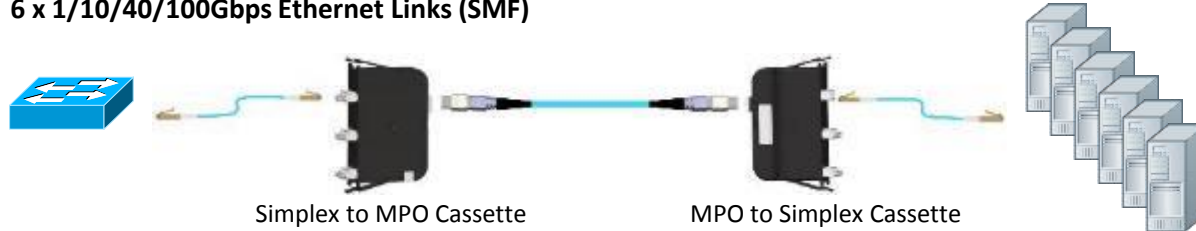
Interface/Application	Reach	Medium	Parallelism	Standard
100GBASE-ER4	40 km	SMF	4 $\lambda$ / dir	IEEE 802.3ba
ER4-Lite	20-25km	SMF	4 $\lambda$ / dir	Variation on 802.3ba
100GBASE-LR4	10 km	SMF	4 $\lambda$ / dir	IEEE 802.3ba
CWDM4	2 km	SMF	4 $\lambda$ / dir	CWDM4 MSA
CLR4	2 km	SMF	4 $\lambda$ / dir	CLR4 Alliance
PSM4	500 m	SMF	4 fibers / dir	PSM4 MSA
SWDM4	100 m	OM5 MMF	4 $\lambda$ / 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

# Tests Defined in Standards

- Both TIA(526-14-C-2015,568.3), and ISO/IEC (61280-4x) 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

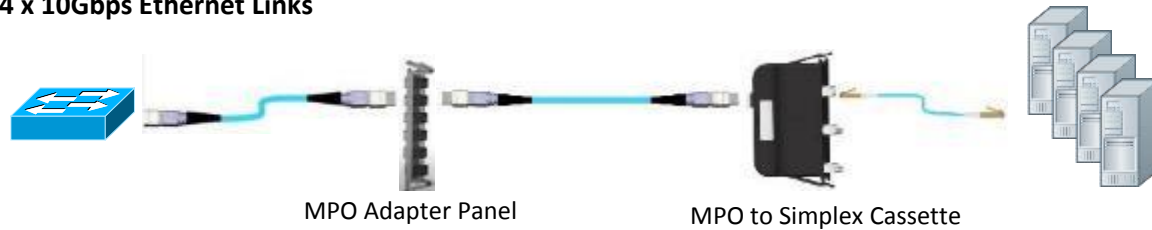
# Data Center **Examples** of MPO/Ribbon Fiber

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



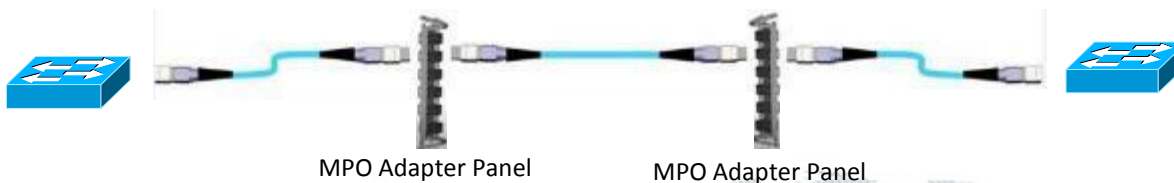
- 12 fiber MPO Link w/Cassettes at either end
- Fiber consolidation and migration path
- SFP/SPF+ at each end

4 x 10Gbps Ethernet Links



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

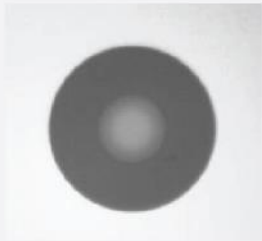
40/100Gbps Ethernet Link



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

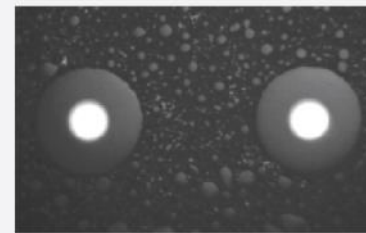
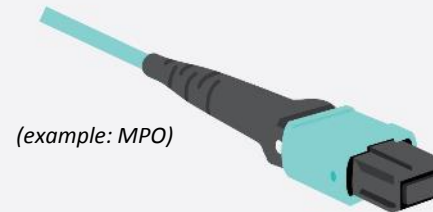
# Single Fiber vs. Multi-Fiber Connectors

## Single Fiber Connector



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

## Multi-Fiber Connector

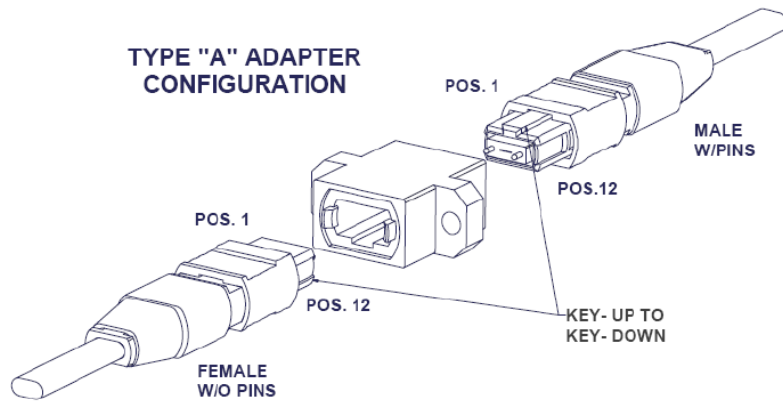


- Polymer ferrule
- Multiple fibers in linear array (for example, 8, 12, 24, 48, and 72) in single connector providing high-density connectivity
- Common type is MPO or MTP®

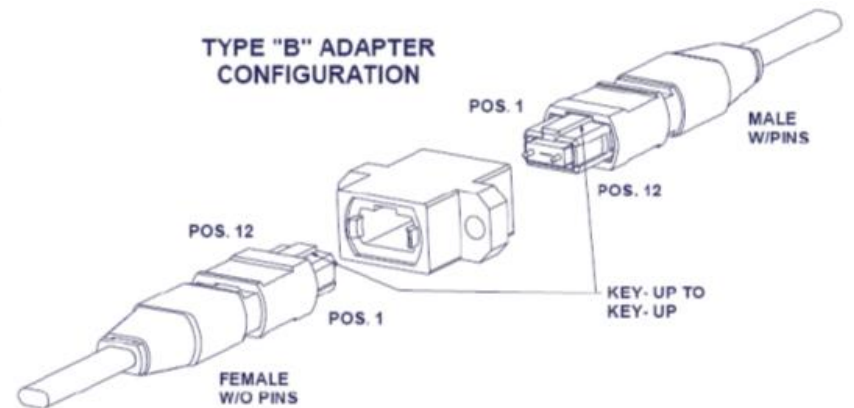


# Polarity and Gender

TYPE "A" ADAPTER CONFIGURATION



TYPE "B" ADAPTER CONFIGURATION



# 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

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

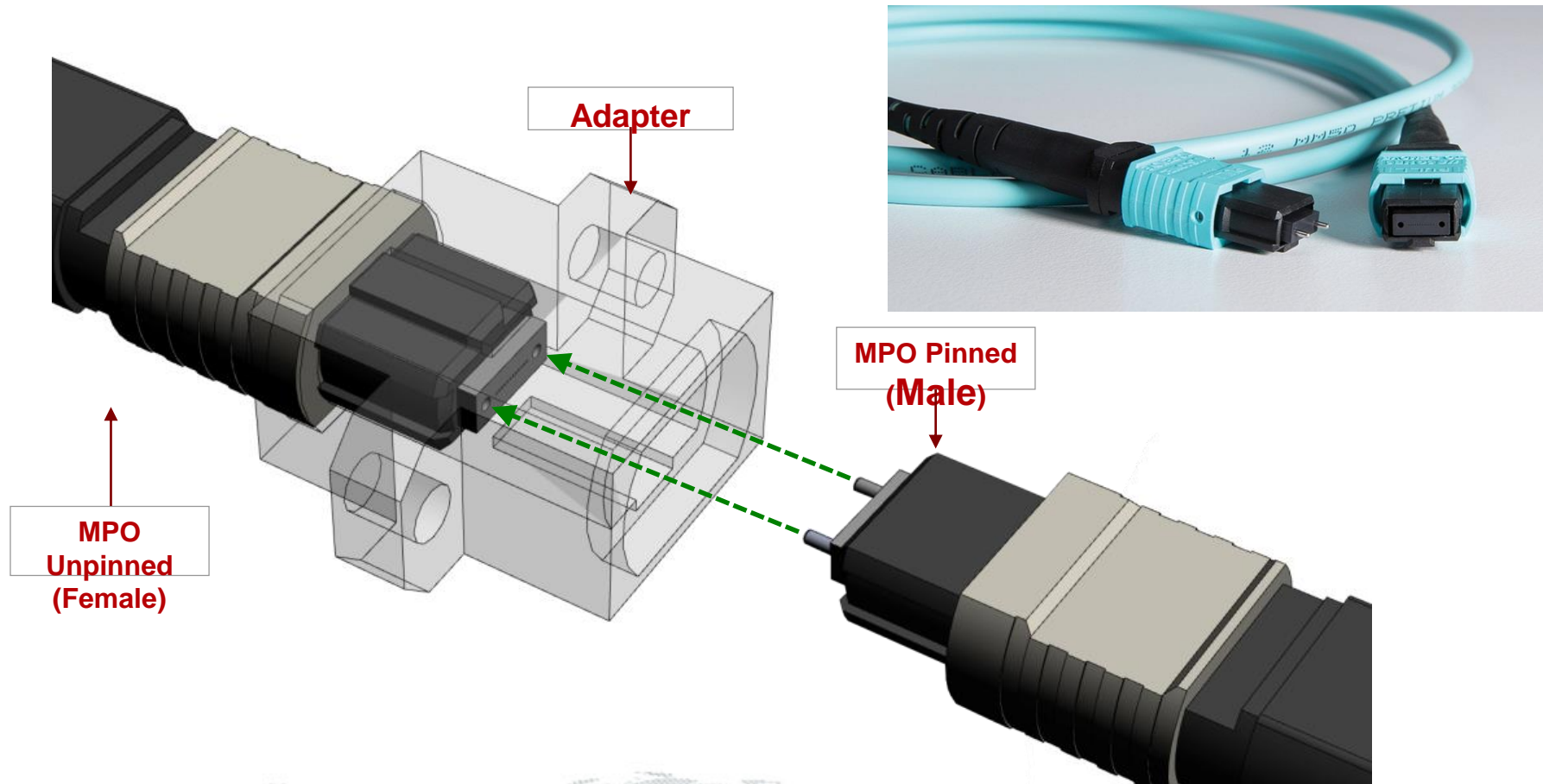


Figure 7 - Type-A:1-1 array patch cord and array cable (key-up to key-down)

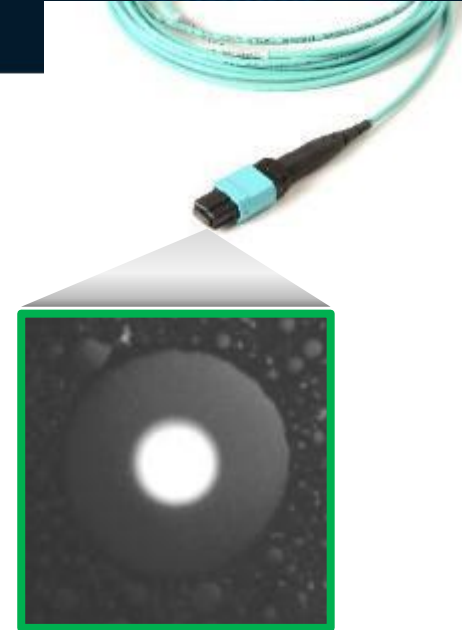
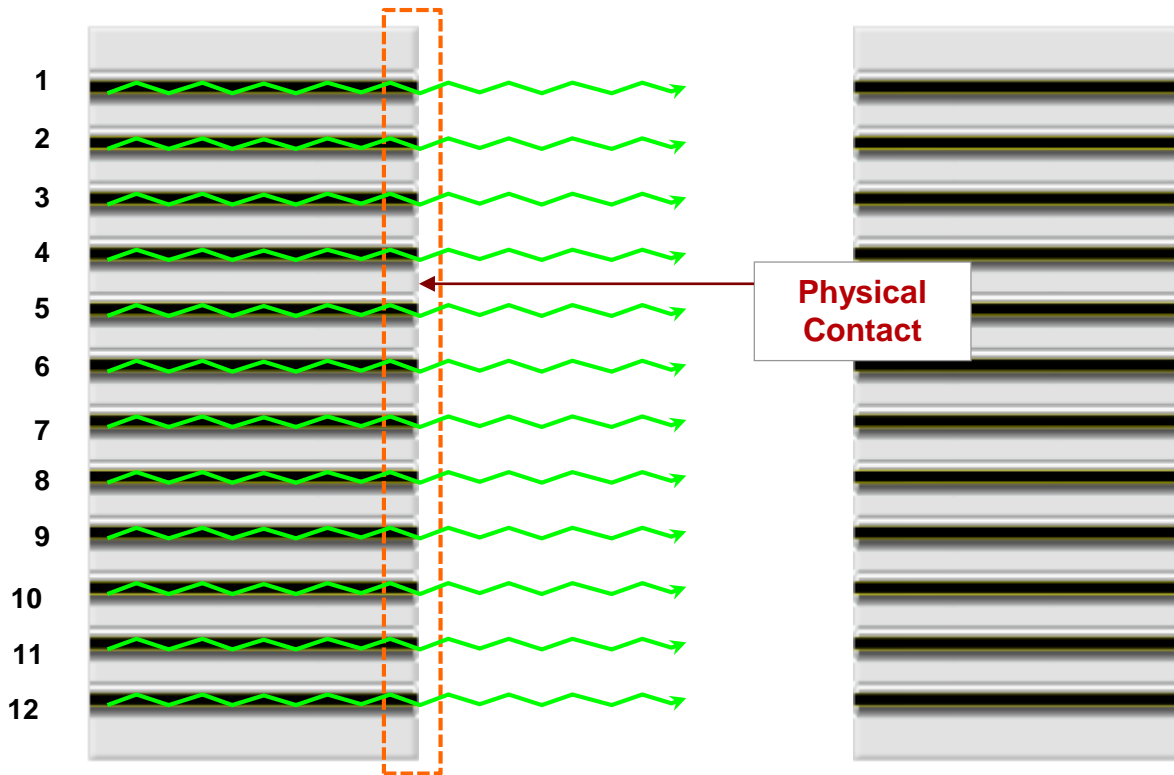


Figure 9 - Type-B:1-1 array patch cord and array cable (key-up to key-up)

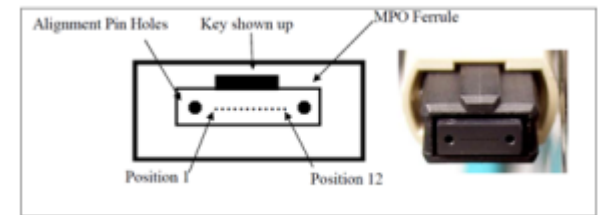
# Focused on the Connection



# Top-View Cross Section of 12 Fiber MPO

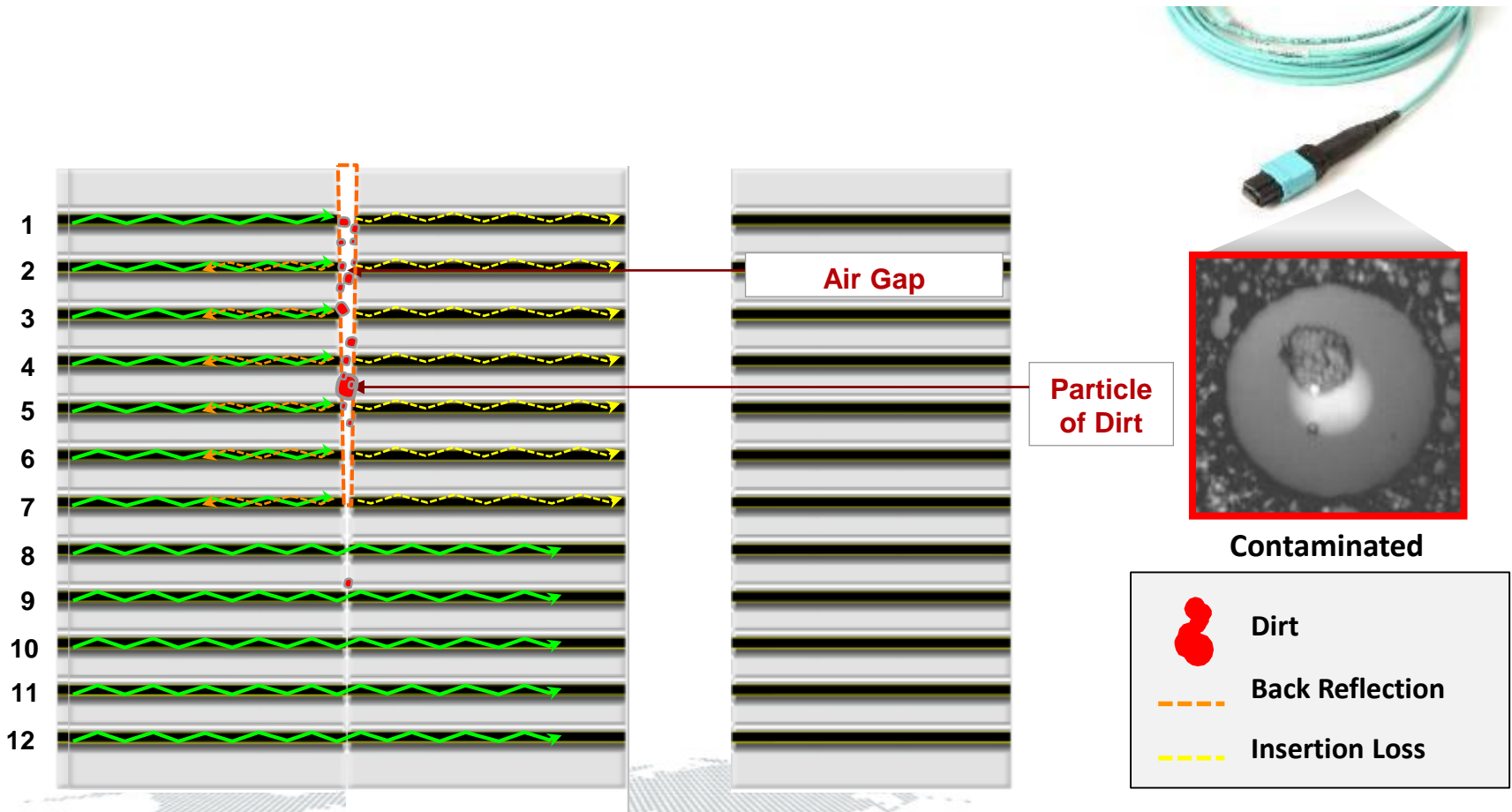


Clean



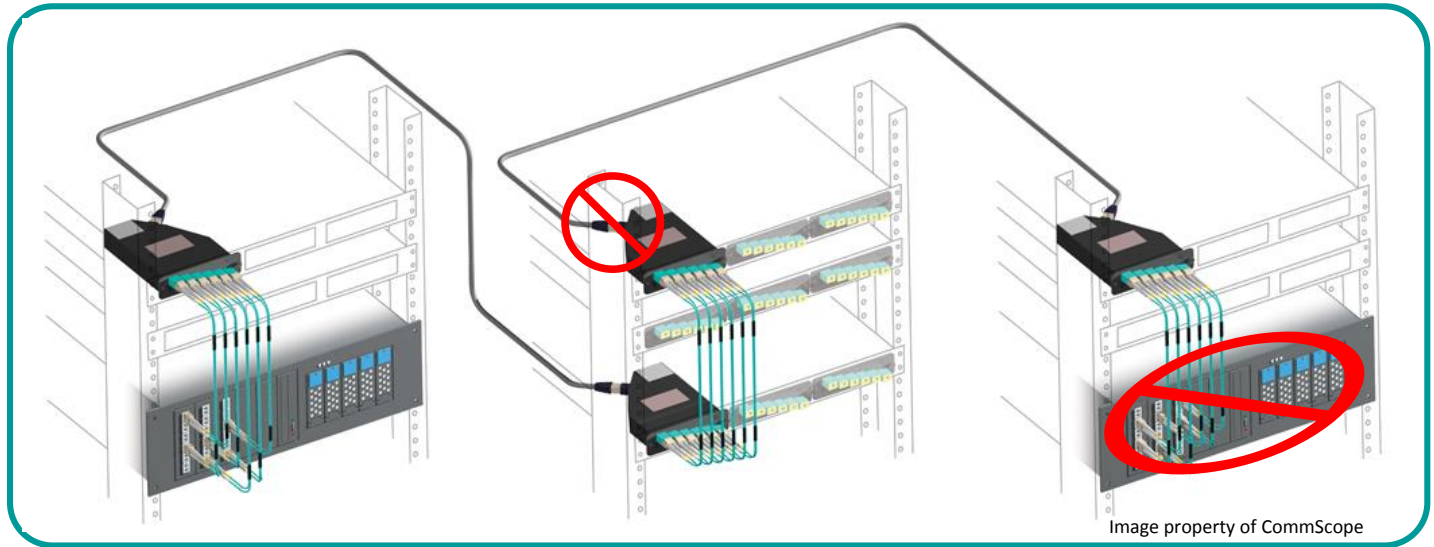
MPO Front View

# Top-View Cross Section of 12 Fiber MPO



# Impact of MPO contamination

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



# Test and Certification



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# Test Challenges for MPO

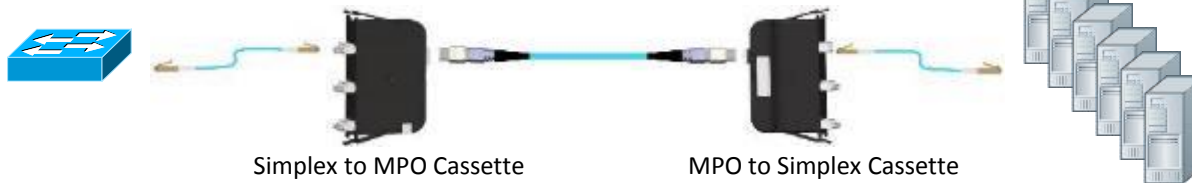
- End-face condition at ALL connection points
- When to test MPO vs. duplex/simplex
- Fiber map (polarity)
- Gender (pinned/unpinned) and its impact on reference methods and types of cables
- QSFP to LC connections
- Loss test vs. OTDR test



# Data Center **Examples** of MPO/Ribbon Fiber **Testing**

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

- Inspect MPO connection to cassettes
- Test duplex drops



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

**4 x 10Gbps Ethernet Links**

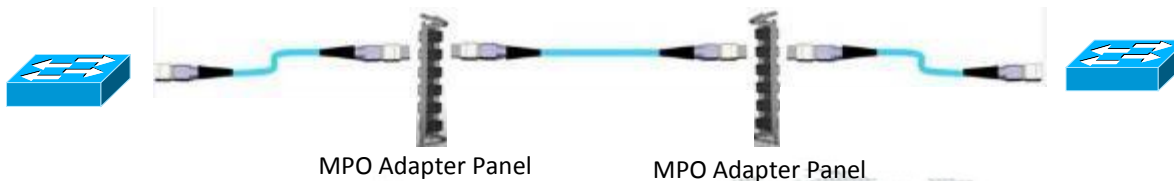
- Inspect MPO connection to cassettes and patch panels
- Test from MPO to simplex



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

**40/100Gbps Ethernet Link**

- Test MPO Links/Channels



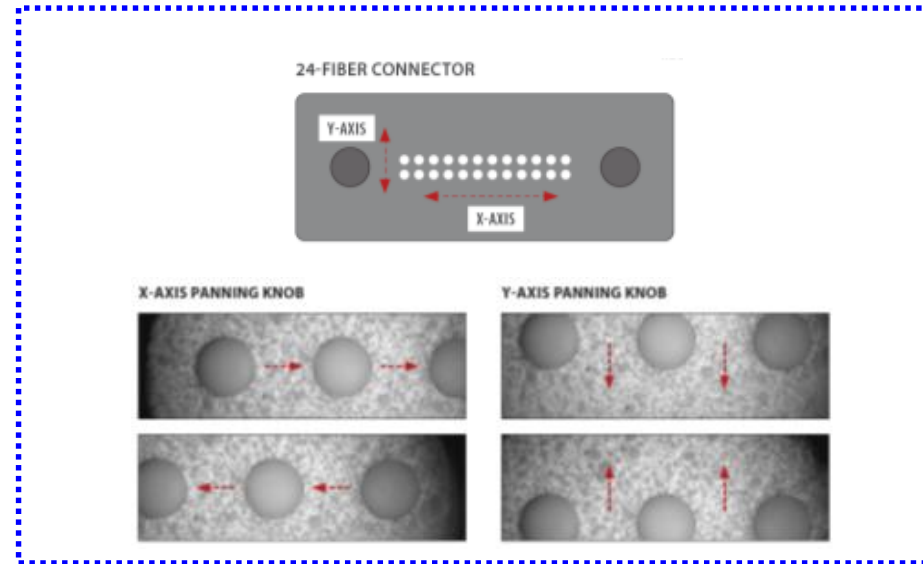
- 12 fiber MPO Link (8 fibers used)
- QSFP/CFP at both ends

# Inspect Before You Connect<sup>sm</sup>

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



# 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.

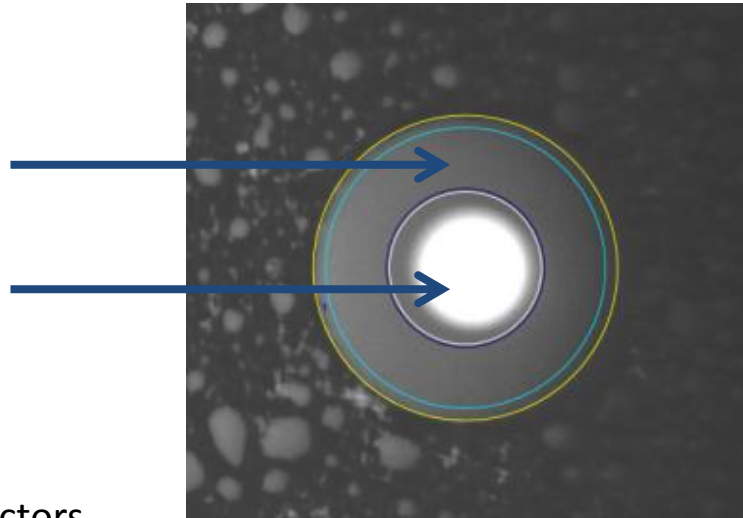
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# IEC 61300-3-35 Sets Requirements for Connector Quality

CLADDING Zone

CORE Zone



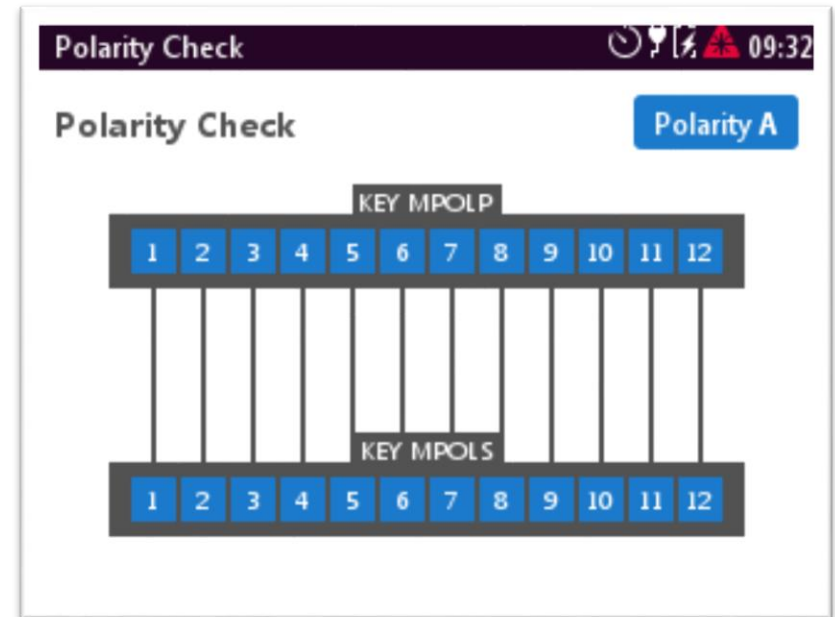
Even for MPO!

Multimode MPO Connectors

ZONE NAME (Diameter)	SCRATCHES	DEFECTS
<b>A. CORE Zone (0–65μm)</b>	no limit $\leq 5\mu\text{m}$ 0 $> 5\mu\text{m}$	4 $\leq 5\mu\text{m}$ none $> 5\mu\text{m}$
<b>B. CLADDING Zone (65–115μm)</b>	no limit $\leq 5\mu\text{m}$ 0 $> 5\mu\text{m}$	no limit $< 2\mu\text{m}$ 5 from 2–5μm none $> 5\mu\text{m}$

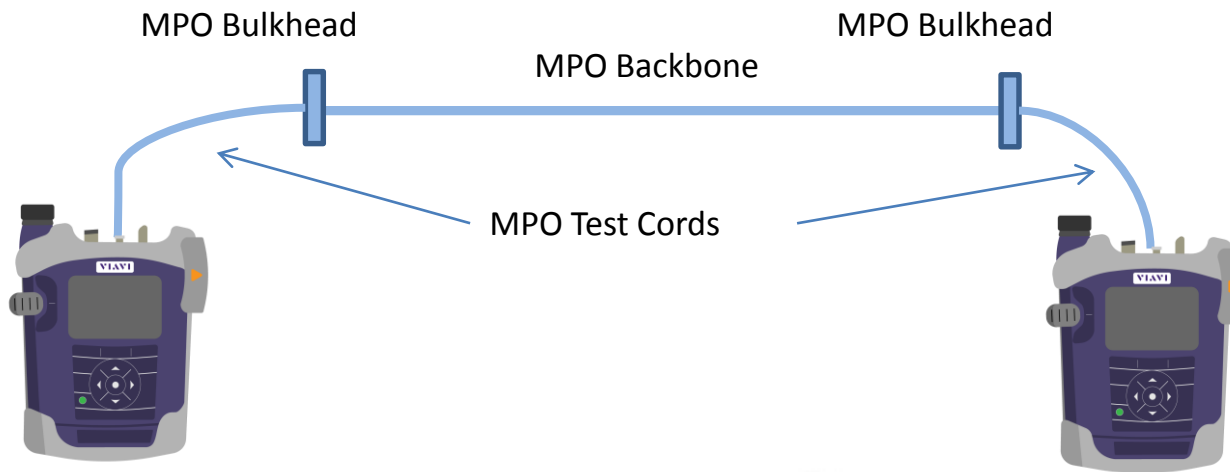
# Polarity Check (AKA Fiber Map)

- For existing installations, the end-to-end polarity is often not known
- Polarity Check tool shows the polarity of the system



# MPO to MPO Tier 1 Certification

- Test MPO Links and Channels
- Loss, length and polarity



default 15:33

**PASSED**

Limit Link Validation

Length	4.3 m	Polarity	A B C
1310 nm	Margin 0.50 dB	Loss	1.40 dB
1550 nm	Margin 0.63 dB	Loss	1.47 dB

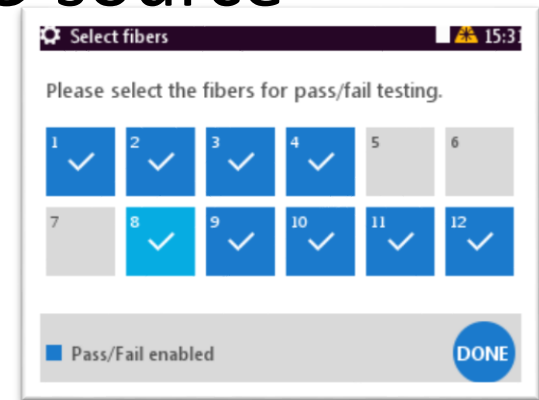
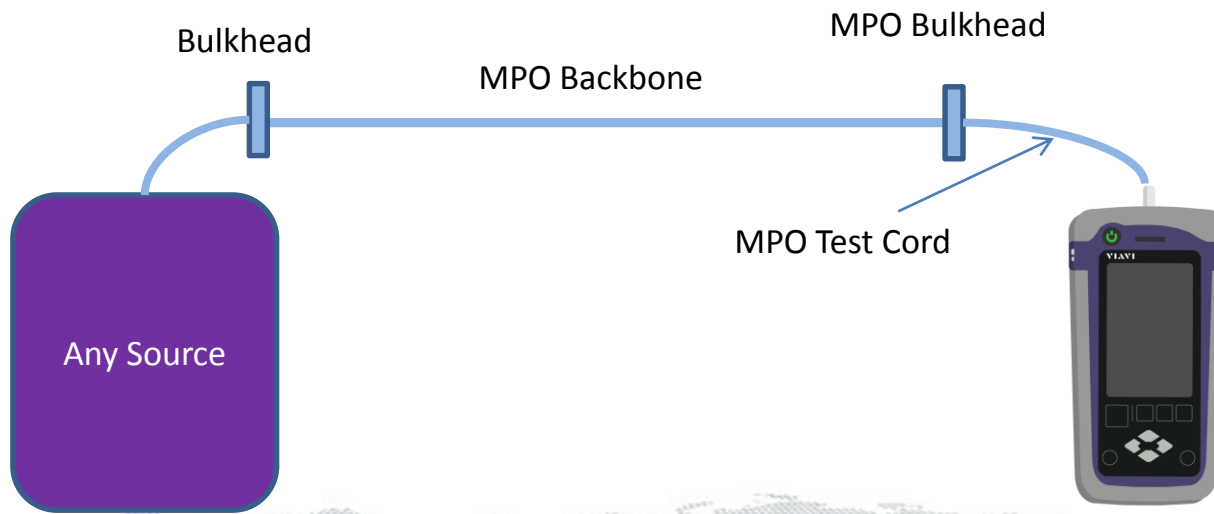
default 15:33

Limit 1.9 dB

Pol.	Fib.	Margin	Loss	Fib.	Margin	Loss
1310	1	0.82	1.08	7	0.92	0.98
	2	0.58	1.32	8	0.84	1.06
	3	0.51	1.39	9	0.58	1.32
	4	0.50	1.40	10	1.06	0.84
1550	5	0.97	0.93	11	1.12	0.78
	6	0.95	0.95	12	0.87	1.03

# MPO Power Meter

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



A screenshot of a software interface titled "Power Meter" showing test results for 12 channels. The date is 2016-06-13 and the limit is 1.90 dB. The table below shows the absolute power and loss for each channel.

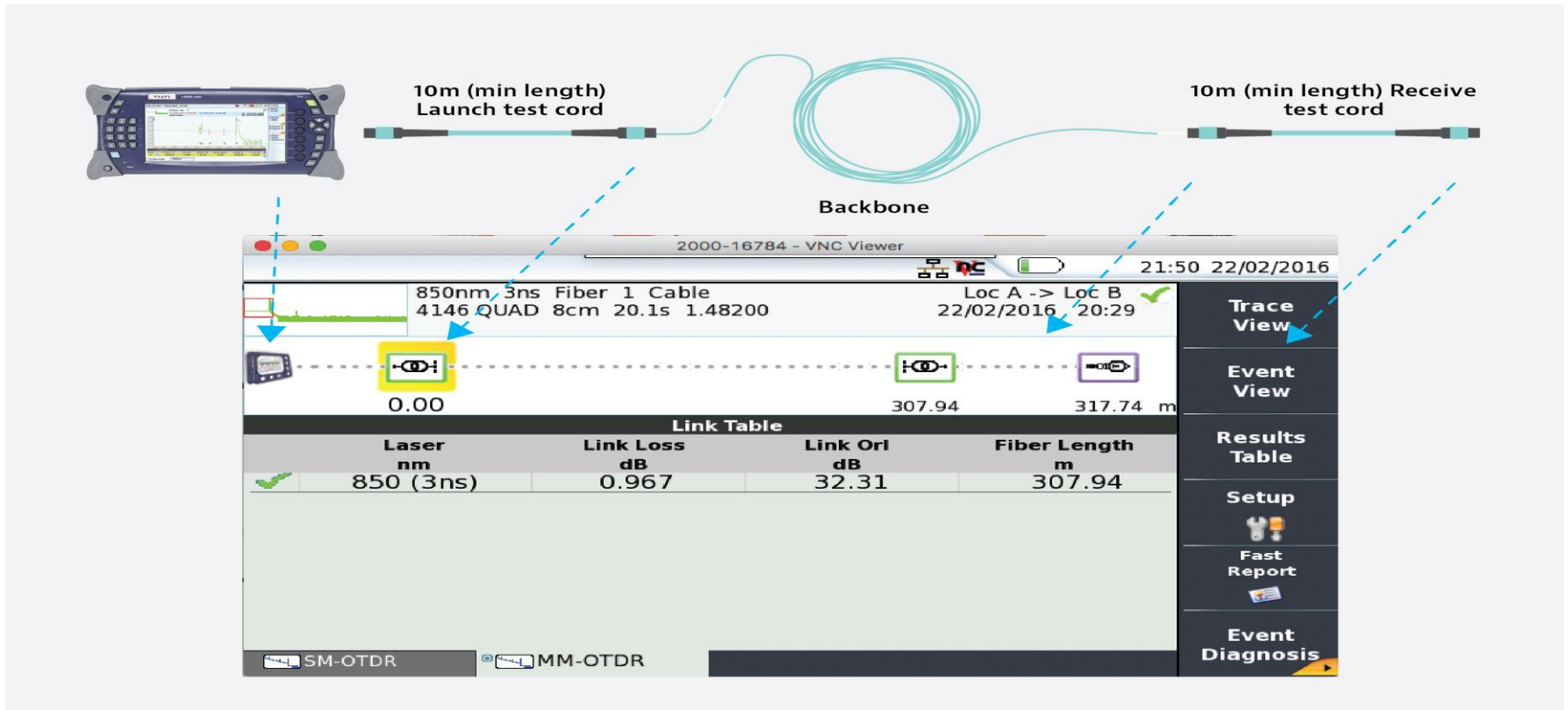
Channels	Absolute	Loss
1	-3.60	0.20
2	-3.70	0.05
3	-3.25	0.10
4	-3.30	0.10
5	-3.40	0.00
6	-3.30	0.10
7	-3.30	0.00
8	-3.20	0.00
9	-3.15	0.05
10	-3.05	0.05
11	-2.85	0.05
12	-2.95	0.00

# Tier 2 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 trouble shooting tool to find the cause AND location of excess loss (incl. breaks) and reflectance
- Requires MPO switch
- Pinned/unpinned systems require different launch and receive cords

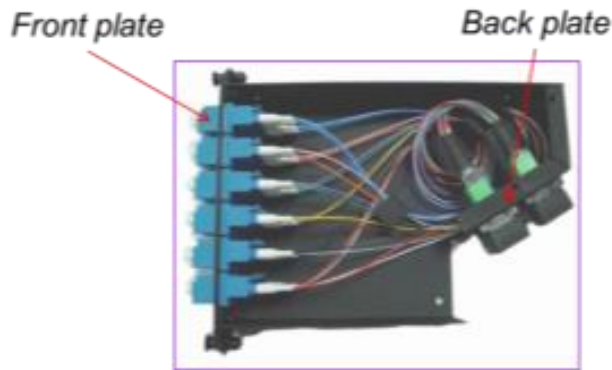


# Schematic test results (pass example)



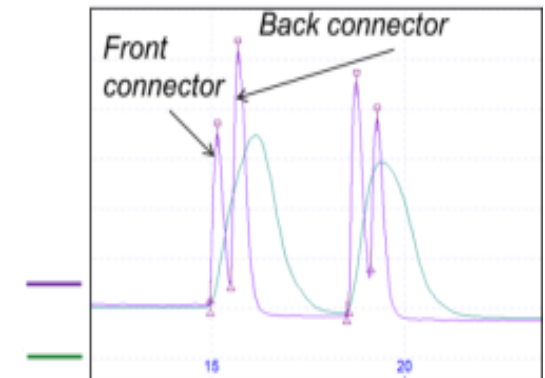
# Identify Front and Back Connectors

- 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



High res OTDR

Conventional OTDR



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

# Thank You



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