How to become a Fiber Testing Expert

Ng Chin Keong
Applications Engineer
EXFO Southeast Asia
How to become a Fiber Testing Expert

Ng Chin Keong
Applications Engineer
EXFO
Understanding Multifiber Connectors

**MPO/MTP®**
- APC
- 12 Fiber Rows
- Single Row

**Q-ODC-12®**
- UPC or APC
- 12 Fiber Rows
- Single Row

**Optitip®**
- APC
- 12 Fiber Rows
- Single Row

**MPO-12/MTP-12®**

**MPO-16/MTP-16®**
- Single Row (12/16 Fibers) or Dual Row (24/32 fibers)
# Best Practices for Optical Fiber Cabling Installation

<table>
<thead>
<tr>
<th>No.</th>
<th>Practice Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ensure connector endfaces are clean with no damage</td>
</tr>
<tr>
<td>2</td>
<td>Ensure the Loss through the Link is within the allowable limits</td>
</tr>
<tr>
<td>3</td>
<td>Submit Clear Documentation</td>
</tr>
</tbody>
</table>
No. 1

Ensure the Connector end faces are not damaged or Dirty.

Fixes 80% of Faults
BEST PRACTICES

1. Connector Inspection is essential in any optical fiber installation

Source: IEC standard 61300-3-35
Fiber Inspection
Cleaning Method

- If the fiber fails inspection, the user shall clean the connector and repeat the inspection process

  - Dry Cleaning

  - Hybrid Cleaning

  - Single fiber mechanical cleaner (male/female)
  - Multifiber mechanical cleaner (MTP/IMPO) (male/female)
  - Patch cord mechanical cleaner (female only)

  - Cleaning pen
    - Used to disperse optical grade solvent to clean optical connectors
  - Cleaning swabs
    - Used to clean the inside of female connectors and adaptors
  - List-free wipes
    - Used in dry cleaning procedures and also used to dry off any solvent
DIFFERENT CONTAMINATION SOURCES

Contaminations creates high Insertion Loss (IL) and/or Return Loss (RL) and degrades network performances.

Damaged = Replace
Dirty = Clean
Dusty cap (out of the bag) = Clean
Clean = Connect
Source of Fiber link failure

Strict correlation (clean vs. oil)

10-12 dB average change (clean vs. oil)

Source: EXFO Application Note 327 – Touching on Failure: Sources of Fiber Optic Issues in the Data Center, December 2015

<table>
<thead>
<tr>
<th>Connector to Connector</th>
<th>AS/NZS 3080</th>
<th>ISO/IEC 11801</th>
<th>TIA 568-C.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMF</td>
<td>-20 dB</td>
<td>-20 dB</td>
<td></td>
</tr>
<tr>
<td>SMF</td>
<td>-35 dB</td>
<td>-26 dB</td>
<td></td>
</tr>
<tr>
<td>SMF + Video</td>
<td>Not Specified</td>
<td>-55 dB</td>
<td></td>
</tr>
</tbody>
</table>

Source: Bhatt, Dama, Nicholl – Cisco Systems (2012)
No. 2

Ensure the Loss through the Link is within the allowable limits?
What is a Permanent Fibre Link

In
Connector
Splice
Pigtail
Backbone Fibre
Splice
Connector
Out
Allowable Limit - Which standard do we test to?

ISO/IEC 11801
Information technology – Generic Cabling for customer premises

ISO/IEC 14763-2
Information technology – Implementation and operation of customer premise cabling Part 2: Planning and installation

ISO/IEC 24702
Information technology – Generic Cabling – Industrial

ISO/IEC 24764
Information technology – Generic Cabling systems for Data Centres

ISO/IEC 15018
Information technology – Generic Cabling for homes

ISO/IEC 61935-1
Generic specification for the testing of elements of generic cabling in accordance with ISO/IEC 11801 Part 1: Test methods

ISO/IEC 14763-3
Information technology – Implementation and operation of customer premise cabling Part 3: Testing of optical fibre cabling

ISO/IEC 61935-3
Testing of balanced and coaxial information technology cabling Part 3: Installed cabling as specified in ISO/IEC 15018 and related standards
# Allowable Attenuation Values

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mated Ref to Ref Connection</td>
<td></td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td>MMF 0.10 dB</td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td>SMF 0.20 dB</td>
</tr>
<tr>
<td>Mated Ref to Non-Ref Connection</td>
<td></td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td>MMF 0.50 dB (new value)</td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td>SMF 0.75 dB (new value)</td>
</tr>
<tr>
<td>Non-Ref to Non-Ref at all wavelengths</td>
<td>MMF &amp; SMF 0.75 dB</td>
</tr>
<tr>
<td>Splice</td>
<td></td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td>0.30 dB</td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td></td>
</tr>
<tr>
<td>MMF All multimode fibres</td>
<td></td>
</tr>
<tr>
<td>at 850 nm</td>
<td>3.50 dB/km</td>
</tr>
<tr>
<td>at 1300 nm</td>
<td>1.50 dB/km</td>
</tr>
<tr>
<td>SMF at 1310 &amp; 1550 nm</td>
<td>OS1 1.0 dB/km</td>
</tr>
<tr>
<td></td>
<td>OS2 0.4 dB/km</td>
</tr>
</tbody>
</table>

Ref = Reference Connector  Non-Ref = Non-reference (embedded) Connector
IEC 14763-3 – Testing of Optical Fibre Cabling

Reference and Testing Methods

New Version – IEC 14763-3 2014 – Three Methods

1. Permanent Link – One Cord Reference Method B (Preferred)
   - IEC & TIA

2. Permanent Link – Two Cord Reference Method A
   - TIA

3. Permanent Link – Enhanced 3 Cord Reference Method C
   - IEC

4. Channel Test – Enhanced 3 Cord Reference Method
   - IEC
Step 1 Set Reference

One-Cord Reference Method for Optical Fibre Links

Clause 9.1.1.3 of ISO/IEC 14763-3 sets out the following method:

1. Allow the light source to warm up following the tester manufacturer’s recommendations. This could take up to 15 minutes.

2. Connect the LTC to the light source at one end and to the power meter at the other end. Ensure EF compliance of the LTC for multimode fibre.

3. Set the reference to 0.0 dB or record the reference power in dBm or watts.

Test Cords

Both multimode and singlemode fibre reference settings use the following test cords:

- LTC Launch Test Cord (2 – 10 m with reference connector at link interface end)
- TTC Tail Test Cord (2 – 10 m with reference connector at link interface end)

The LTC for multimode fibres shall meet the launch modal distribution at the output of the launch test cord. For multimode, this is also known as meeting Encircled Flux requirements.
One Cord Reference Method

Step 2 Verification Stage

The attenuation of the connectors on the launch test cord and tail test cord should be verified by connecting these cords together and verifying the attenuation of this connection is no more than the expected attenuation between two reference grade connectors.

![Diagram showing LS, LTC, TTC, and PM]

Disconnect the LTC from the power meter and connect it to the TTC using a Reference Adaptor. Connect the other end of the TTC to the power meter.

The attenuation of the reference-to-reference connection must be no greater than:
- MMF 0.1 dB,
- SMF 0.2 dB.

Note: If the attenuation is more than the allowable value, clean all end faces, inspect then reconnect and re-test. Re-set the reference if necessary. Use alternate test cords if necessary.
Step 3 Test Link

4. Connect the LTC to the cleaned fibre connector at the Near End of the link. At the far end, connect the TTC to the cleaned connector of the link.

5. Measure the attenuation of the link, which includes the two end connectors.

The Calculation Limit of Testing link attenuation is:
- For MMF: Limit = (2 x 0.5dB) + Σ (Cable attenuation) + Σ (embedded connection attenuation)
- For SMF: Limit = (2 x 0.75dB) + Σ (Cable attenuation) + Σ (embedded connection attenuation)

These formulae are from Corrigenda 1 to ISO/IEC 14763-3 Ed2 dated 17.03.2015.
Examples of Calculations of Link Limits

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mated Ref to Ref Connection</td>
<td>MMF 0.10 dB, SMF 0.20 dB</td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td></td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td></td>
</tr>
<tr>
<td>Mated Ref to Non-Ref Connection</td>
<td>MMF 0.50 dB, SMF 0.75 dB</td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td></td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td></td>
</tr>
<tr>
<td>Non-Ref to Non-Ref at all wavelengths</td>
<td>MMF &amp; SMF 0.75 dB</td>
</tr>
<tr>
<td>Splice</td>
<td>0.30 dB</td>
</tr>
<tr>
<td>at 850 &amp; 1300 nm</td>
<td></td>
</tr>
<tr>
<td>at 1310 &amp; 1550 nm</td>
<td></td>
</tr>
<tr>
<td>MMF All multimode fibres</td>
<td>3.50 dB/km, 1.50 dB/km</td>
</tr>
<tr>
<td>at 850 nm</td>
<td></td>
</tr>
<tr>
<td>at 1300 nm</td>
<td></td>
</tr>
<tr>
<td>SMF at 1310 &amp; 1550 nm</td>
<td>OS1 1.0 dB/km, OS2 0.4 dB/km</td>
</tr>
<tr>
<td>Ref = Reference Connector</td>
<td></td>
</tr>
<tr>
<td>Non-Ref = Non-reference (embedded) Connector</td>
<td></td>
</tr>
</tbody>
</table>
## Examples of Calculations of Link Limits

|--------------------------|------------------------------------------------------|
| Mated Ref to Ref Connection | MMF 0.10 dB  
|                          | at 850 & 1300 nm  
|                          | at 1310 & 1550 nm  
|                          | SMF 0.20 dB  |
| Mated Ref to Non-Ref Connection | MMF 0.50 dB  
|                          | at 850 & 1300 nm  
|                          | at 1310 & 1550 nm  
|                          | SMF 0.75 dB  |
| Non-Ref to Non-Ref at all wavelengths | MMF & SMF 0.75 dB  |
| Splice at 850 & 1300 nm | 0.30 dB  
|                          at 1310 & 1550 nm  |
| MMF All multimode fibres at 850 nm | 3.50 dB/km  
|                          at 1300 nm  | 1.50 dB/km  |
| SMF at 1310 & 1550 nm OS1 | 1.0 dB/km  
|                          OS2 | 0.4 dB/km  |

Ref = Reference Connector  
Non-Ref = Non-reference (embedded) Connector
Thank you for testing my link.

Does that mean it’s now guaranteed to run at 100Gbps?

That depends on which Transmission Standard you are using!
Examples of Calculations of Link Limits

Example 1
Consider a permanent link comprising
- Cabled optical fibre conforming to OM4 of ISO/IEC 11801
- A total length of 100m
- Two panel connections in accordance with ISO/IEC 11801
- Two optical fibre splices in accordance with ISO/IEC 11801

Loss Budget = Σ (Connector Loss) + Σ (Cable attenuation) + Σ (Splice loss)
Examples of Calculations of Link Limits

Example 1
Consider a permanent link comprising
- Cabled optical fibre conforming to OM4 of ISO/IEC 11801
- A total length of 100m
- Two panel connections in accordance with ISO/IEC 11801
- Two optical fibre splices in accordance with ISO/IEC 11801

Loss Budget = ∑ (Connector Loss) + ∑ (Cable attenuation) + ∑ (Splice loss)

Loss Budget @ 850nm = (2 x 0.3dB) + (0.1 x 3.5dB) + (2 x 0.3dB) = 1.55dB
Loss Budget @ 1300nm = (2 x 0.3dB) + (0.1 x 1.5dB) + (2 x 0.3dB) = 1.35dB
No. 3 Submit Clear Test Result Documentation.
Measurements & Reports

File preview
Multi-fiber

File preview
Single-fiber
Software Analysis

[Image of software analysis tool with various options and settings]

- Connector: MPO/MTP
- Orientation: Key Down
- Fiber config: 2x12 [2x 12]
Voice of Customers...

- Complexity of configuring the unit.
- Referencing Issues
- Choosing the wrong standard
- Calibrating the units every year
- Speed of Testing
- Have to use a separate Fibre Inspection kit at far end
- Multi Mode Encircle Flux Compliant
- Fault diagnosis or assistance
- Report Generation