Fibre optic testing best practices

Adrian Young
Senior Technical Support Engineer
Fluke Networks
November 2011 – Singapore
Inspecting and cleaning

• Keeping the output port on your test equipment clean is critical
• There are tools for doing this
  • Perfect for cleaning ports on equipment but not best practice for cleaning test reference cords
  • Does not clean the entire end face of the connector
Inspecting and cleaning

• For test reference cords, we need the entire end face to be clean, otherwise dirt/debris not on the core could move to the core and cause problems.

• Always clean wet to dry.
Inspecting and cleaning

• You can do this, but you need to be aware of its limitations

• Perfect for cleaning ports, equipment and user cords

• Not ideal for test reference cords
Inspecting and cleaning

- There are even tools for inspecting the ports on the test equipment

- Any test reference cord inserted into this port will now be dirty too

- Cross contamination is a big issue in fibre installations

Customer complaint of inconsistent readings
Can your technician inspect LCs?

- When we get a call on fibre testing, it is very rare to find an installer who has inspection equipment for LC connectors.
- You cannot test without inspection equipment.

Special LC tip for camera probe.
Inspecting and cleaning

- This is what happens when the technician has no inspection equipment

![Image of cleaning issue]

- Cleaning wipe was saturated with IPA
- Technician did not wipe it dry with a lint free wipe
Verification with a VFL

- Quality cannot be determined with a VFL.

12 dB Loss! 0.5 dB Loss!
Mechanical Connectors

- Becoming very popular
  - UniCam®
  - Qwik-LC II Connectors®
  - THREAD-LOCK® ...... there are many others

- Offer superior reflectance
  - Needed for Tier 2 OTDR testing and 10GBASE-SR

- Far better than field polishing
  - Poor/inconsistent reflectance with field polishing

- Still craft sensitive
  - Certain level of skill required
Should I be concerned about reflectance?

• From an application point
  – Multimode systems tend to be fairly tolerant of reflectance
  – Singlemode systems are not so tolerant of bad reflectance, especially in multiple connector links

• From a testing point (OTDR)
  – Need reflectance to be better than -35 dB
  – Very tricky if field polishing
Why Does FNET Suggest -35 dB?

• Most (all) suppliers of OTDRs specify deadzones with a connector reflectance of -35 dB (Multimode)

• The testing standards support this specification

ANSI/TIA 526-14-B

D.2.2 OTDR
The OTDR shall be capable of using a short pulse width (≤20 ns) and have sufficient dynamic range (> 20 dB) to achieve a measurement typically in lengths of up to 2 000 m. The OTDR should have an attenuation dead zone (see G.2.4) less than 10 m following standard connectors (i.e. reflectance of – 35 dB).

• The network standards require this specification
Why Does FNET Suggest -35 dB?

**Effects of Connector Reflectance on Total Optical Return Loss at 850nm**

- **fibre** = 100m, 50um, 1.5 dB/km
- **Connectors** = 4x, equal reflectance (x axis), 0.5 dB loss
- **Transceiver** = 10GBASE-SR with -12 dB reflectance

- **10GBASE-SR ORL Limit is 12 dB**
  - No margin if Connector Reflectance is -30 dB
  - 1.7dB over limit if Connector Reflectance is -20 dB
4G Fibre Channel with CRC Errors
Mechanical Connectors

• Still craft sensitive
  – Certain level of skill required
  – Vendors offer “test” equipment for these connectors to improve termination yields, but they are only indicators

• In an ideal world, you would shoot the fibre with an OTDR once you terminated the fibre
  – There are alternatives such as single ended fibre testers you may wish to consider
We’re almost ready to begin testing

• Equipment ports are
  – Clean
  – Inspected

• Test reference cords
  – Clean
  – Inspected

• Terminated connectors verified
  – Single end tester
The power output of some multimode sources is not well controlled.
As a result, you can end up with two different readings for the same fibre.

Source A

Source B
Calibration

- The Power Meters are calibrated
- Sources are NOT calibrated for launch conditions
- We need to control the launch condition for multimode sources
- This we refer to as **Encircled Flux**

\[
EF(r) = \frac{\int_{0}^{r} xI(x)dx}{\int_{0}^{R} xI(x)dx}
\]

- Optical Power intensity at each increment of radius \( r \)
- Total Power Intensity in radius \( R \)
Encircled Flux

Mode controllers

Caution
Do not disconnect the outputs on the source (1 and 2).

Test

Reference test cord
Fiber link
Reference test cord
Smart remote

FLUKE networks

Bicsi
Encircled Flux

• Do I need this?
  – ANSI/TIA-526-14B requires this
  – IEC 61280-4-1 edition 2 requires this
  – Cabling vendors offering warranties may not

• What should you do?
  – Talk to your cabling vendor offering the warranty
  – Take your multimode source and compare the loss using a mandrel to a mode controller, your source may be very close to EF compliance
Test Methods

• ANSI/TIA-568-C defines test method
  – Method B for multimode
  – Method A.1 for singlemode

• ISO/IEC 11801:2010
  – 1 Jumper or 3 Jumper; multimode or singlemode
TIA Testing #1
Reference made

* Mandrel used only for 850/1300 nm testing
TIA Testing #2
Cords removed from input port only

* Mandrel used only for 850/1300 nm testing
TIA Testing #3

Good cord inserted into input port

What is a good cord?

How do I know if this cord is any good?
TIA Testing #4
Checking your patch cords

≈ 0 dB loss for the cable

Connect them together and run a loss test

If the cords are good, the loss should not exceed 0.75 dB............
TIA Testing #4
Checking your patch cords

≈ 0 dB loss for the cable

≤ 0.1 dB for multimode
≤ 0.2 dB for singlemode

0.75 dB indicates lousy cords, you should not accept this. When testing to TIA, most cabling vendors offering a warranty will want to see better than 0.5 dB.

ISO/IEC 14763-3: We call them test reference cords (TRCs), where….

≤ 0.1 dB for multimode
≤ 0.2 dB for singlemode
TIA Testing #5
Disconnect

* Mandrel used only for 850/1300 nm testing
Connect to the fibre link

- ≤ 0.35 dB @ 850 nm
- ≤ 0.15 dB @ 1300 nm

Loss budget @ 850 nm = 0.75 dB + 0.35 dB + 0.75 dB = 1.85 dB

Loss budget @ 1300 nm = 0.75 dB + 0.15 dB + 0.75 dB = 1.65 dB

* Mandrel used only for 850/1300 nm testing
1 Jumper – ISO/IEC 11801:2010
IEC 14763-3; Multimode

≤ 0.35 dB @ 850 nm
≤ 0.15 dB @ 1300 nm

fibre under test

100 m (328 ft)

≤ 0.30 dB
≤ 0.30 dB

Loss budget @ 850 nm = 0.30 dB + 0.35 dB + 0.30 dB
= 0.95 dB

Loss budget @ 1300 nm = 0.30 dB + 0.15 dB + 0.30 dB
= 0.75 dB
1 Jumper – ISO/IEC 11801:2010
IEC 14763-3; Multimode

≤ 0.10 dB @ 1310 nm
≤ 0.10 dB @ 1550 nm

Loss budget @ 1310 nm = 0.50 dB + 0.10 dB + 0.50 dB
= 1.10 dB

Loss budget @ 1550 nm = 0.50 dB + 0.10 dB + 0.50 dB
= 1.10 dB

* Mandrel used only for 850/1300 nm testing
TIA is looking at that 0.75 dB

- **ANSI/TIA-568-C.0-3 (Draft)**
  - Will emphasize application limits
  - Suggesting 0.75 dB may not be suitable for some applications
  - Align with IEEE 802.3 maintenance Task Group operating under IEEE Project 802.3bh to support 10GBASE-SR to 400 m for OM4 fibre

- Expect TIA to change the 0.75 dB mated pair loss requirement, it is over 20 years old!
Gotcha – ISO/IEC 11801:2010

• What happens if your test equipment does not have the same input port as the link you are testing?
IEC 14763-3 defines a 3 Jumper Reference method

But you have no idea how good these really are

If you test equipment does not have LC input ports, you cannot verify the TRCs
IEC 14763-3 #2
Remove field calibration cord

* Mandrel used only for 850/1300 nm testing
IEC 14763-3 #3
Connect to fibre link

≤ 0.35 dB @ 850 nm
≤ 0.15 dB @ 1300 nm

Loss budget @ 850 nm = 0.20 dB + 0.35 dB + 0.20 dB
= 0.75 dB

Loss budget @ 1300 nm = 0.20 dB + 0.15 dB + 0.20 dB
= 0.55 dB

*Mandrel used only for 850/1300 nm testing*
Is that 0.20 dB correct?

You referenced out 0.10 dB to start with
The mated connector pair allowance is ≤ 0.30 dB

So the resulting mated pair allowance is actually ≤ 0.20 dB

≤ 0.20 dB @ 850 nm
≤ 0.15 dB @ 1300 nm

fibre under test

≤ 0.20 dB

* Mandrel used only for 850/1300 nm testing
Loss Budgets - TIA

• Does not work for data centers

10GBASE-SR requirement is 2.6 dB @ 850 nm

The loss here would be 4.05 dB; not good enough
Loss Budgets – what you need

• The cassette has to be better than two adapters of 0.75 dB each

10GBASES-SR requirement is 2.6 dB @ 850 nm

The loss here would be 2.55 dB; GOOD
How do I test and make sure it is 10GBASE-SR Compliant?

- Calculate your loss budget into your design
- Create a Custom Test Limit

Where the MPO cassette is treated as one connector pair (adapter)
- Then if the tester shows PASS, you know the link is 10GBASE-SR compliant
Tier 2 (OTDR) testing now specified in both ISO/IEC and ANSI/TIA

- Field polishing connectors continues to be the biggest issue when OTDR testing is specified
- OTDRs rely on good reflectance in order to assess the loss at a connection
- ISO/IEC 11801:2010 requires reflectance testing, but the limits are too relaxed for accurate multimode OTDR measurements to take place on shorter links
  - Multimode ≤ -20 dB
  - Singlemode ≤ -35 dB (ANSI/TIA is ≤ -26 dB)
OTDRs fire a pulse of light into the cable and measure the backscatter.

The change in backscatter is used to calculate the loss, for example:

Tier 2 (OTDR) testing now specified in both ISO/IEC and ANSI/TIA.
Tier 2 (OTDR) testing now specified in both ISO/IEC and ANSI/TIA

- But when the reflectance is bad, the loss cannot be accurately assessed, as in the example below:

\[ \text{Negative loss reporting due to bad reflectance} \]
Reflectance in connectors

• If light sees a change in refractive index, there will be a reflection.
• The most common causes are:
  – Air gap between the connectors
  – Dirt/contamination
  – Residue left behind by the cleaning solution
• In a perfect world, there would be no air gap between the mated connectors but in reality, there is always a small air gap, also known an “undercut”:

  ![Diagram of fiber with undercut](image)

  - The very best factory terminated connectors will have an undercut better than 50 nm (that’s 0.05 µm).
  - The amount of undercut you see will depend on your polishing technique.
It took almost over 100 m for the event to recover
The reflectance was -26 dB, minimum TIA requirement

Tier 2 (OTDR) testing now specified in both ISO/IEC and ANSI/TIA

Negative loss reporting due to bad reflectance
Summary

• Inspection equipment is not optional
  – Does the technician have tips for LC or MPO/MTP?
• VFLs
  – Just because you see light does not mean the fibre is good
• Pre-test your fibre terminations
  – Either with an OTDR or single ended tester
• Encircled flux
  – Talk to your cabling vendor to see if they require it
• Link loss budgets
  – Look at the application requirements for loss and length
Thank you for your time

Harry.Potter@flukenetworks.com