# Fibre Optic Installation Guide

When you are asked to install a fibre optic cable there are many things to consider but as a minimum you will need to consider the following details and ask questions.:

## (1) Basic Information

1. Cable design including Fibre type (singlemode OS1 OS2 or multimode OM1 OM2 OM3 OM4 OM5). Does the cable design match the environment, is there armouring in the cable?

2. Joint design both intermediate route and termination joints – check that the joints are suitable for the cable design – do the joints and cassettes have the space to accommodate the fibre count and the number of fibres per tube. Is there a sensible way to store fibre from the main cable and is the fibre route inside the joint tight.
   Are there any places in the joint where fibre is unprotected or vulnerable. Could it be bent or damaged. Does it hang loose or could it be fouled by other users working inside the joint. Can strength members be anchored securely. If there are connectors or patch panels in the joint is there sufficient room for the fibres and cables so that tight bends are not induced in the cable or connector boots

3. Cable Route Diagram – pay particular attention to size and position of manholes, how many 90 degree bends there are in the route, places where cable could get snagged or caught during installation. Also look at how cables enter buildings. Also check that the cable route is suitable for the bend radius of the cable. (both the radius during installation and the installed radius which will be different)

4. What type of system traffic will be carried particularly the data speed and potential upgrade speed. Higher speeds at 10Gbit/s and above need to be matched to the right cables i.e. 350metres OM3, 500 metres OM4 or singlemode

5. What wavelengths are to be used and is the system using LEDs or lasers (more common in modern systems) – optical sources used in testing should be similar to those used in the transmission equipment, so if the equipment uses LEDs the tester should be an LED. Most systems today use lasers so a laser tester should be used.

6. Connector types – Modern systems often use SFP modules as the source/receiver and these are usually fitted with the small LC connectors. LC connectors are not ideal for use in patch panels because they are not as robust as the larger SC, FC or ST connectors. So for patching if the system is singlemode and you have a choice, then choose a connector which has an Angled Polish and Physical Contact design (APC) Such as SCAPC. This will minimise reflections in the system which is important at high data rates >2.5 Gigabit/s. Angled connectors can be easily recognised because they are Green in colour.

7. Does the cable need to be earthed or bonded across a joint – if so, earthing clamps will be required.

8. Is the cable to be ducted, directly buried or on an aerial route – the correct cable and fittings will need to be ordered.

9. Are there any splicing specifications? – what is the acceptable loss of a splice? True Splice loss is the average of the splice loss measured in both directions with an OTDR.

10. What tests are required? Insertion Loss Measurement (ILM) and or OTDR. For short distance cables under 1000 metres, perhaps ILM will be sufficient.

    What results need to be presented:
    2 way ILM
    2 way OTDR and does the customer need printouts or trace data or both
    Do they need a 2 way splice loss spreadsheet?
    Do they need to test at 1 wavelength or 2 wavelengths?

    The more that is needed the more time consuming the job will be and the more post processing you will need to carry out. Post processing can take days to complete depending on the number of fibres and length of cables e.g. 48 fibre cable connects 2 sites, there are two termination joints and 2 intermediate joints.

    1st Termination joint 48 fibre will take around 5.5 hours to complete
    2nd Termination joint 48 fibre will take around 5.5 hours to complete
    1st intermediate joint 48 fibres will take around 6 hours to complete
    2nd intermediate joint 48 fibres will take around 6 hours to complete

    1 hour to test for ILM
    30 minutes to draw up the ILM report
    2.5 hours to test with OTDR in both directions and 2 wavelengths
    2.5 hours to print every trace.

Note: An excel spreadsheet of bi directional losses will take time to produce as each splice has to be averaged in both directions and with 2 wavelengths, 4 splices per fibre and 48 fibres that is a total of 384 calculations. Allow 2 to 3 hours for the preparation of such a report.

## Sample Loss Test Report

### Loss Test Report

| | |
|---|---|
| Test Reference | R0A15002 |
| Cable ID | N2145 |
| Test Location A | Manchester NOC |
| Test Location B | Bolton NOC |
| Test Engineer | R.Stephen |
| Date | 15/08/2014 |

| Equipment Used | Serial No | Cal Due date |
|---|---|---|
| FHP2A04 | 60021483 | 12/08/2014 |
| FHS2D02 | 970012198 | 12/08/2014 |
| | | |
| | | |

| Ref A to B (dBm) 1310 | Ref A to B (dBm) 1550 | Ref B to A (dBm) 1310 | Ref B to A (dBm) 1550 |
|---|---|---|---|
| -7.50 | -6.80 | -7.20 | -6.10 |

| | Reading A to B (dBm) | | Loss A to B (dB) (=Ref - Reading) | | Reading B to A (dBm) | | Loss B to A (dB) (=Ref - Reading) | | Loss Difference A to B - B to A | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fibre No | 1310 | 1550 | 1310 | 1550 | 1310 | 1550 | 1310 | 1550 | 1310 | 1550 |
| 1 | -10.40 | -8.30 | 2.90 | 1.50 | -9.90 | -7.80 | 2.70 | 1.70 | 0.20 | 0.20 |
| 2 | -10.80 | -8.10 | 3.30 | 1.30 | -10.30 | -7.90 | 3.10 | 1.80 | 0.20 | 0.50 |
| 3 | -10.60 | -7.90 | 3.10 | 1.10 | -10.80 | -7.70 | 3.60 | 1.60 | 0.50 | 0.50 |
| 4 | -10.40 | -7.30 | 2.90 | 0.50 | -10.60 | -8.30 | 3.40 | 2.20 | 0.50 | 1.70 |
| 5 | -10.40 | -7.90 | 2.90 | 1.10 | -10.40 | -7.70 | 3.20 | 1.60 | 0.30 | 0.50 |
| 6 | -10.30 | -7.30 | 2.80 | 0.50 | -10.40 | -8.30 | 3.20 | 2.20 | 0.40 | 1.70 |
| 7 | -10.80 | -7.70 | 3.30 | 0.90 | -10.20 | -7.90 | 3.00 | 1.80 | 0.30 | 0.90 |
| 8 | -10.80 | -8.30 | 3.30 | 1.50 | -10.60 | -7.30 | 3.40 | 1.20 | 0.10 | 0.30 |
| 9 | -10.60 | -8.30 | 3.10 | 1.50 | -10.40 | -7.90 | 3.20 | 1.80 | 0.10 | 0.30 |
| 10 | -10.40 | -8.10 | 2.90 | 1.30 | -10.40 | -7.30 | 3.20 | 1.20 | 0.30 | 0.10 |
| 11 | -10.80 | -7.90 | 3.30 | 1.10 | -10.30 | -7.70 | 3.10 | 1.60 | 0.20 | 0.50 |
| 12 | -10.60 | -7.30 | 3.10 | 0.50 | -10.80 | -8.30 | 3.60 | 2.20 | 0.50 | 1.70 |
| 13 | -10.40 | -8.30 | 2.90 | 1.50 | -10.80 | -8.30 | 3.60 | 2.20 | 0.70 | 0.70 |
| 14 | -10.40 | -8.10 | 2.90 | 1.30 | -10.60 | -7.90 | 3.40 | 1.80 | 0.50 | 0.50 |
| 15 | -10.30 | -7.90 | 2.80 | 1.10 | -10.40 | -7.30 | 3.20 | 1.20 | 0.40 | 0.10 |
| 16 | -10.40 | -7.30 | 2.90 | 0.50 | -10.80 | -8.30 | 3.60 | 2.20 | 0.70 | 1.70 |
| 17 | -10.40 | -7.70 | 2.90 | 0.90 | -10.60 | -8.10 | 3.40 | 2.00 | 0.50 | 1.10 |
| 18 | -10.40 | -8.30 | 2.90 | 1.50 | -10.40 | -7.90 | 3.20 | 1.80 | 0.30 | 0.30 |
| 19 | -10.30 | -8.30 | 2.80 | 1.50 | -10.40 | -7.30 | 3.20 | 1.20 | 0.40 | 0.30 |
| 20 | -10.80 | -8.10 | 3.30 | 1.30 | -10.20 | -7.70 | 3.00 | 1.60 | 0.30 | 0.30 |
| 21 | -10.60 | -7.90 | 3.10 | 1.10 | -10.60 | -8.30 | 3.40 | 2.20 | 0.30 | 1.10 |
| 22 | -10.40 | -7.30 | 2.90 | 0.50 | -10.40 | -8.30 | 3.20 | 2.20 | 0.30 | 1.70 |
| 23 | -10.50 | -7.80 | 3.00 | 1.00 | -10.40 | -8.20 | 3.20 | 2.10 | 0.20 | 1.10 |
| 24 | -10.70 | -8.10 | 3.20 | 1.30 | -10.30 | -8.10 | 3.10 | 2.00 | 0.10 | 0.70 |

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Opticus
Fibre Optic Products & Training

# Fibre Masterclass Note 72

## Sample BiDirectional OTDR Splice Loss Report

| | | | | | |
|---|---|---|---|---|---|
| A End | Manchester | Splice Loss Limit | 0.10 | Job | V20FNN |
| B End | Bolton | Connector Limit | 0.6 | | |
| Wavelength | 1310nm | Date | 2/1/15 | | |

Manchester to Bolton

| 1310nm | Manchester End | | | | | | | | | Bolton End | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distance from Manchester | | | | | | | | | | | |
| | km | 2.2 | 3.5 | 6.6 | 8.8 | 11 | 13.2 | 15.4 | 17.6 | 19.8 | 22 | |
| Event | Connector | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Connector |
| Fibre 1 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 1.00 |
| Fibre 2 | 0.70 | 0.10 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.50 | 0.01 | 0.70 | 2.00 |
| Fibre 3 | 0.60 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.02 | 0.60 | 1.20 |
| Fibre 4 | 0.60 | 0.50 | 0.01 | 0.60 | 1.00 | 0.05 | 0.50 | 0.01 | 0.01 | 0.02 | 0.60 | 1.10 |
| Fibre 5 | 0.50 | 0.01 | 0.02 | 0.50 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.50 | 0.90 |
| Fibre 6 | 0.70 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.70 | 0.10 | 0.70 | 1.50 |
| Fibre 7 | 0.60 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 12.00 |
| Fibre 8 | 0.50 | 0.50 | 0.06 | 0.02 | 0.60 | 0.50 | 0.50 | 0.70 | 0.01 | 0.02 | 0.50 | 1.20 |
| Fibre 9 | 0.50 | 0.50 | 0.50 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.90 |
| Fibre 10 | 0.70 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.60 | 0.70 | 1.50 |
| Fibre 11 | 0.60 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 4.00 |
| Fibre 12 | 0.60 | 0.60 | 0.60 | 0.60 | 1.00 | 0.60 | 0.60 | 0.60 | 0.60 | 0.70 | 0.60 | 2.00 |

Bolton to Manchester

| 1310nm | Bolton End | | | | | | | | | Manchester End | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distance from Manchester | | | | | | | | | | | |
| | km | 22 | 19.8 | 17.6 | 15.4 | 13.2 | 11 | 8.8 | 6.6 | 3.5 | 2.2 | |
| Event | Connector | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Connector |
| Fibre 1 | 0.90 | 0.01 | 0.02 | 0.01 | 0.02 | 0.03 | 0.03 | 0.01 | 0.02 | 0.03 | 0.02 | 0.50 |
| Fibre 2 | 0.30 | 0.30 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.30 | 0.30 | 1.20 |
| Fibre 3 | 0.50 | 0.50 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.50 | 0.50 | 1.10 |
| Fibre 4 | 0.60 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.60 | 0.60 | 0.90 |
| Fibre 5 | 0.30 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 1.20 |
| Fibre 6 | 0.50 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.50 | 0.01 | 0.01 | 0.60 | 1.10 |
| Fibre 7 | 10.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.90 |
| Fibre 8 | 0.60 | 0.01 | 0.01 | 0.01 | 0.60 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 2.00 |
| Fibre 9 | 0.50 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.60 | 0.01 | 0.02 | 1.10 |
| Fibre 10 | 0.60 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.90 |
| Fibre 11 | 0.30 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.80 | 0.60 | 1.20 |
| Fibre 12 | 0.50 | 0.01 | 0.02 | 0.02 | 0.01 | 0.03 | 0.50 | 0.02 | 0.01 | 0.01 | 0.60 | 1.10 |

Manchester to Bolton Two way average

| 1310nm | Manchester End | | | | | | | | | Bolton End | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distance from Manchester | | | | | | | | | | | |
| | km | 2.2 | 3.5 | 6.6 | 8.8 | 11 | 13.2 | 15.4 | 17.6 | 19.8 | 22 | |
| Event | Connector | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Connector |
| Fibre 1 | 0.55 | 0.31 | 0.32 | 0.31 | 0.31 | 0.32 | 0.32 | 0.31 | 0.31 | 0.31 | 0.31 | 0.95 |
| Fibre 2 | 0.95 | 0.20 | 0.16 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.26 | 0.01 | 0.50 | 1.15 |
| Fibre 3 | 0.85 | 0.26 | 0.26 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 | 0.55 | 0.85 |
| Fibre 4 | 0.75 | 0.55 | 0.31 | 0.31 | 0.51 | 0.03 | 0.26 | 0.01 | 0.02 | 0.02 | 0.31 | 0.85 |
| Fibre 5 | 0.85 | 0.01 | 0.02 | 0.26 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.26 | 0.60 |
| Fibre 6 | 0.90 | 0.31 | 0.01 | 0.01 | 0.26 | 0.01 | 0.01 | 0.01 | 0.36 | 0.06 | 0.36 | 1.00 |
| Fibre 7 | 0.75 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 11.00 |
| Fibre 8 | 1.25 | 0.26 | 0.04 | 0.02 | 0.31 | 0.26 | 0.26 | 0.65 | 0.01 | 0.02 | 0.26 | 0.90 |
| Fibre 9 | 0.80 | 0.26 | 0.26 | 0.31 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.70 |
| Fibre 10 | 0.80 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.31 | 0.36 | 1.05 |
| Fibre 11 | 0.90 | 0.31 | 0.41 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 2.15 |
| Fibre 12 | 0.85 | 0.60 | 0.31 | 0.31 | 0.51 | 0.55 | 0.32 | 0.31 | 0.31 | 0.36 | 0.31 | 1.25 |

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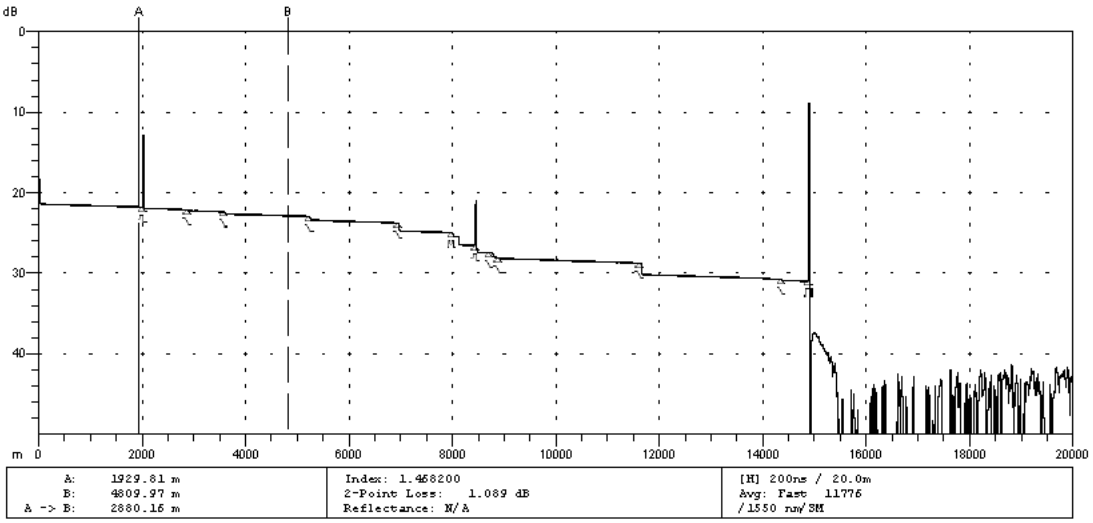
# Sample OTDR Trace Report

Manchester Bolton Fibre Cable
8 fibre singlemode

Anritsu NetWorks/OTDR - Version 4.1
Date: 08-Jan-15 Time: 16:33

Final ManBol1550.002.SOR 25017 m/1.001 m




```
 -------------------- Page    1 --------------------
[   Language: EN                                     ]
[   Cable ID:                                        ]
[   Fiber ID: 2                                      ]
[ Wavelength: 1550                                   ]
[   Org. Loc:                                        ]
[  Term. Loc:                                        ]
[ Cable Code:                                        ]
[  Condition: OT                                     ]
[   Operator:                                        ]
[    Comment:                                        ]
[   Supplier: Anritsu                                ]
[ OTDR Model: MT9083B-063                            ]
[        S/N: 6200863811                             ]
[ Optics Mod:                                        ]
[        S/N:                                        ]
[   S/W Rev.: 5.20                                   ]
[      Other:                                        ]
 ------------------------------------------------------

Primary Trace: Final ManBol1550.002.SOR
         Date: 17-Oct-13          Range:      25017 m
         Time: 13:12         Resolution:      1.001 m
 Product Type: MT9083B-06   Pulse Width:        200 ns
  Opt. Module:                    Index:   1.468200
   Fiber Type: Singlemode    WaveLength:       1550 nm
FAS Thresholds:            Horz. Shift:       0.00 m
         Loss:     0.10 dB  Vert. Shift:       0.00 dB
  Reflectance:   -60.00 dB No. Averages:      11776
  Fiber Break:     3.00 dB
  Backscatter:   -81.50       Trace Type: Anr SR4731
  Trace Flags: Analysis
          ORL: N/A

Analysis Results -- Final ManBol1550.002.SOR
```

| Feature #/Type | Location (m) | Event (dB) | Event (dB/Km) | Loss (dB) | Refl (dB) |
|---|---|---|---|---|---|
| 1/R | 2006.54 | 0.37 | 0.185 | 0.18(2P) | -40.96 |
| 2/N | 2870.86 | 0.17 | 0.196 | 0.11 | |
| 3/N | 3568.65 | 0.12 | 0.177 | 0.26 | |
| 4/N | 5225.79 | 0.32 | 0.191 | 0.44 | |
| 5/N | 6944.22 | 0.39 | 0.228 | 0.99 | |
| 6/G | 7984.27- 8205.97 | 0.18 | 0.175 | 1.52 | |
| 7/R | 8439.93 | 0.09 | 0.208 | 0.85 | -47.67 |
| 8/N | 8704.53 | 0.04 | 0.164 | 0.58(2P) | |
| 9/N | 8872.09 | 0.03 | 0.191 | 0.11(2P) | |
| 10/N | 11612.18 | 0.58 | 0.213 | 1.41 | |
| 11/N | 14355.33 | 0.60 | 0.219 | 0.13 | |
| 12/E | 14882.51 | 0.10 | 0.182 | >3.00 | -14.23 |

```
Overall (End-to-End) Loss: 9.57 dB
```

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## (2) A Fibre Installation Outline

The following shows the recommended procedure for a fibre installation.

1. Define Operational Requirement including topology
2. Survey site and define implementation parameters
3. Develop and Agree implementation and responsibilities
4. Prepare Bill of Materials
5. Order cables, components and installation equipment
6. Delivery & installation of termination enclosures
7. Test Cables on delivery
8. Complete Civil engineering and duct work
9. Install internal tray work, trunking and conduits
10. Install route cables (internal & external) with spare loops
11. Joint any midspan joints
12. Test route cables if necessary
13. Attach optical connectors to fibre ends & install patchcords
14. Test completed cable subsection
15. Prepare Test Reports

## (3) What equipment do I need to test optical fibres ?

The following table shows the type of equipment you can use in order to test an optical cable.

| Instrument | Type of Test | Other equipment needed |
|---|---|---|
| **Visible light source** | Fault location (in patch panels)<br>*Continuity* –<br>Short range to 5km (1mW version)<br>Medium range 14km (7mW version)<br>Connector damage | None<br>None<br>None<br>None<br>None |
| **Meter** | Power Output<br>End to End Loss Test<br>Continuity - Very long range (0 metres to 330km) | None<br>Source<br>Source |
| **Source** | End to End Loss Test<br>Continuity - Very long range (0 metres to 330km) | Meter<br>Meter |
| **Microscope** | Connector damage | None |
| **Fibre Identifier** | Signal presence through buffered fibre (mid span) | Modulated Source |
| **Loss Set** | Power Output<br>End to End Loss Test<br>Continuity - Very long range (0 metres to 330km)<br>System Return Loss | None<br>Loss Set<br>Loss Set<br>None |
| **OCWR** | System Return Loss | None |
| **OTDR** | Backscatter Fingerprint<br>Fault location<br>Individual splice loss<br>Individual reflection test<br>Continuity - Long Range (10 metres to 200km)<br><br>System Return Loss | None<br>None<br>None<br>None<br>2km test lead for far end<br>None |
| **CD Analyser** | Chromatic Dispersion (can be incorporated in an OTDR) | None |
| **PMD Analyser** | Polarzation Mode Dispersion | None |

## (4) How much testing do I need to do?

There are three categories of test for Installed systems:

Installation

Maintenance

Restoration

Installation certification testing is the most complex, being designed to ensure the quality of the completed system and provide documented proof of this quality. This testing is typically performed after cables have been placed, and joints have been made.

Maintenance testing is less complex, and is designed to assess whether the installed system is working to specification and to provide early warning of failure. It may require a different set of skills.

Restoration testing is possibly the least complex. Find the fault, fix the fault, verify the repair quality and restore the system.

## (5) What tests will I need to carry out ?

The following table shows the type of tests commonly carried out on optical fibres and fibre systems and the equipment needed.

| **Type of Test** | **Instrument** | **Fibre of interest** |
|---|---|---|
| Power Output | Meter | All |
| End to End Loss Test | Source & Meter (or OTDR) | All |
| Backscatter Fingerprint | OTDR | All |
| Individual splice loss | OTDR | All |
| Individual reflection test | OTDR | All |
| Continuity - Short range (in patch panels) and out to 5km | Visible light source (1mW) | All |
| Continuity - Medium range out to 14km | Visible light source (7mW) | All |
| Continuity - Long range (10 metres to 200km) | OTDR | All |
| Continuity - Very long range (0 metres to 330km) | Source and Meter | Singlemode |
| System Return Loss | OCWR or OTDR | Singlemode |
| Chromatic Dispersion | CD Analyser | Singlemode |
| Polarization Mode Dispersion | PMD Analyser | Singlemode |