Training Modules & Training Notes

Some samples of the training notes used are shown at the end of this document. The course notes are supplied in printed and PDF format to all participants on the course.
The training notes used in course OP-456-61 contain over 270 slides which support the practical exercises carried out on the courses.

Opticus fibre courses are based on a series of practical exercises including OTDR testing, Insertion Loss testing, fusion and mechanical splicing, cable preparation, jointing, connector inspection and connector termination. These exercises are documented in a Training Workbook

As an illustration of the work involved, the following pages highlight the range of modules available. Courses such as OP-456-61 have standard modules but courses can be tailored to suit specific needs such as those of the Rail Industry or Subsea environments.

Practice Training Modules for OP-45x Courses

SPLICING

- Module 1 Splicing Practice
- Module 2 Fibre & Cable Preparation
- Module 3 Jointing Cables In-Line
- Module 4 Jointing - Adding a spur cable
- Module 5 Making and Testing a Termination Joint
- Module 6 Mechanical Splicing

TESTING

- Module 7 Use a Visible Light Source to check continuity and fault find
- Module 8 Insertion Loss Measurement with source and meter
- Module 9 Comparing bend losses of G.652 and G.657 fibre
- Module 10 OTDR Practice – Set up of main parameters, pulsewidth, range, resolution and averaging time.
- Module 11 Commissioning/troubleshooting of cables that have multiple reflections
- Module 12 Commissioning/troubleshooting of cables that have splices and connectors
- Module 13 Testing a Passive Optical Network which has splitters using an OTDR
- Module 14 Testing a bare fibre end using an OTDR and bare fibre adapter
- Module 15 OTDR PC Analysis & Documentation

Practice Training Modules for OP-45x Courses

CONNECTORS & TERMINATING

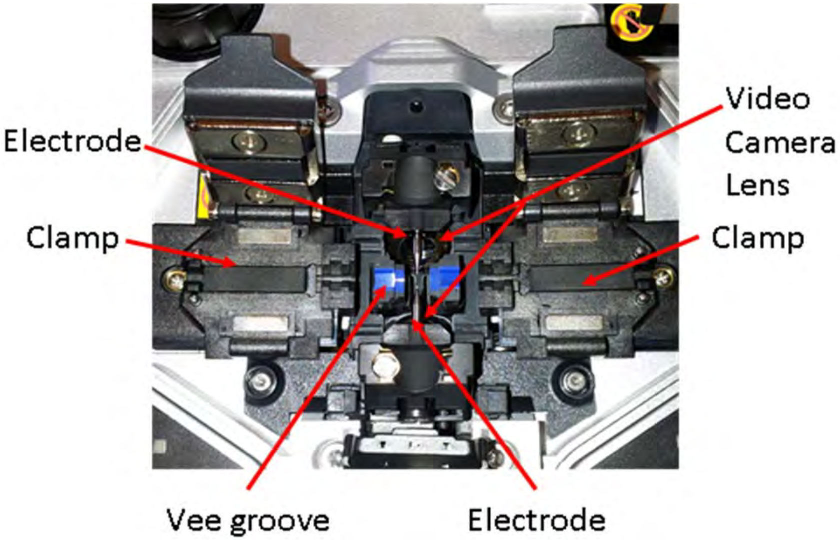
- Module 16 Connector inspection
- Module 17 Connector Cleaning
- Module 18 Connector Terminating (epoxy polish technique)
- Module 19 Connector Quality Analysis

SPECIALIST SKILLS (Options may require extra time – contact Opticus for details)

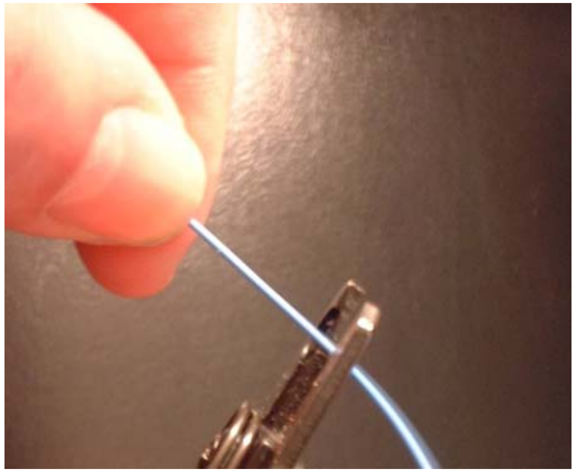
- Module 20 Safe Removal of metallic buffer tube (stainless steel) from fibre
- Module 21 Umbilical Termination into Fan Out Cable gland
- Module 22 OTDR Testing of umbilical
- Module 23 Splice On Connectors
- Module 24 Pretium / Unicam Mechanical Splice Connectors

Module 1.   Splicing Practice

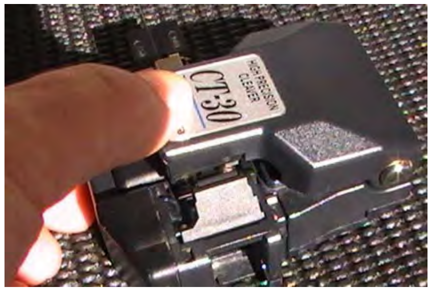
Splicer Care



Strip & Clean Fibre

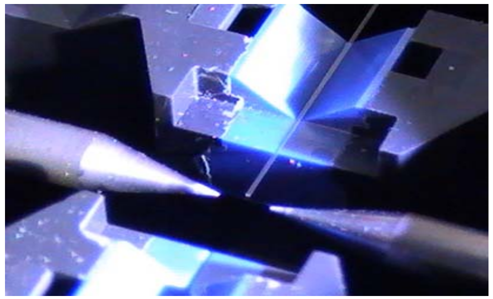


Activate the Cleaver



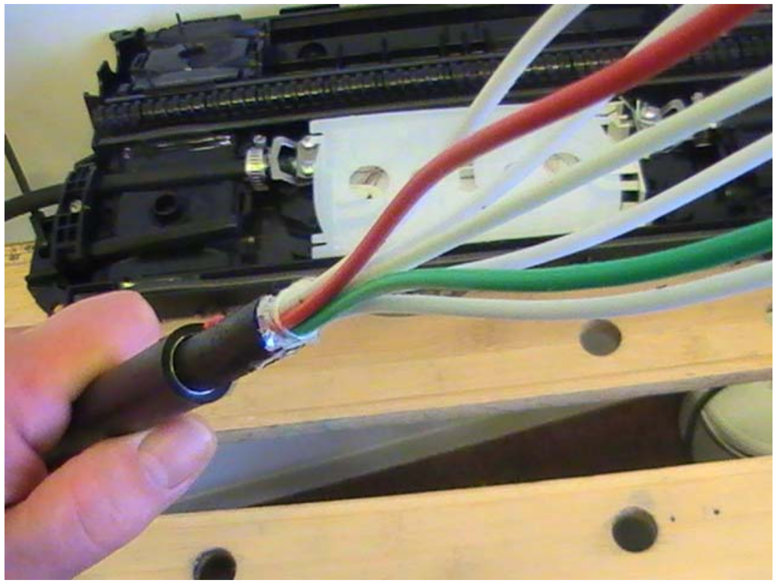
Splice protection

Place fibre in the v-groove



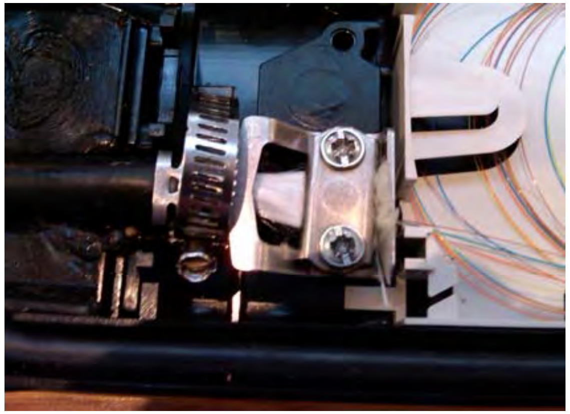
Module 2. Fibre & Cable Preparation

Using dedicated cable stripping tools you will strip armoured cables with unitube design and multi tube design



Modules 3. & 4.   Jointing Cables

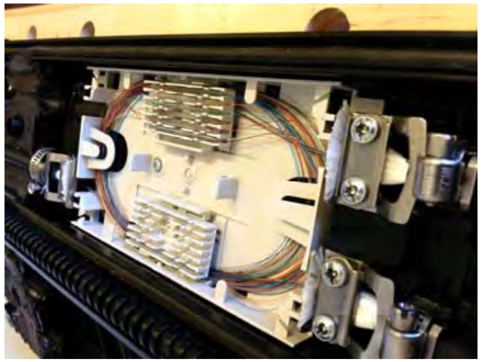
Clamp Strength members



Route the fibres carefully into the fibre organiser

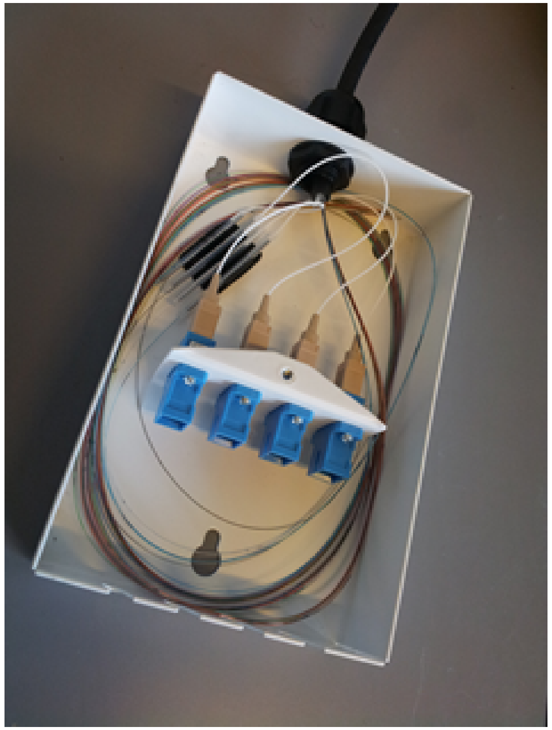
Completed joint

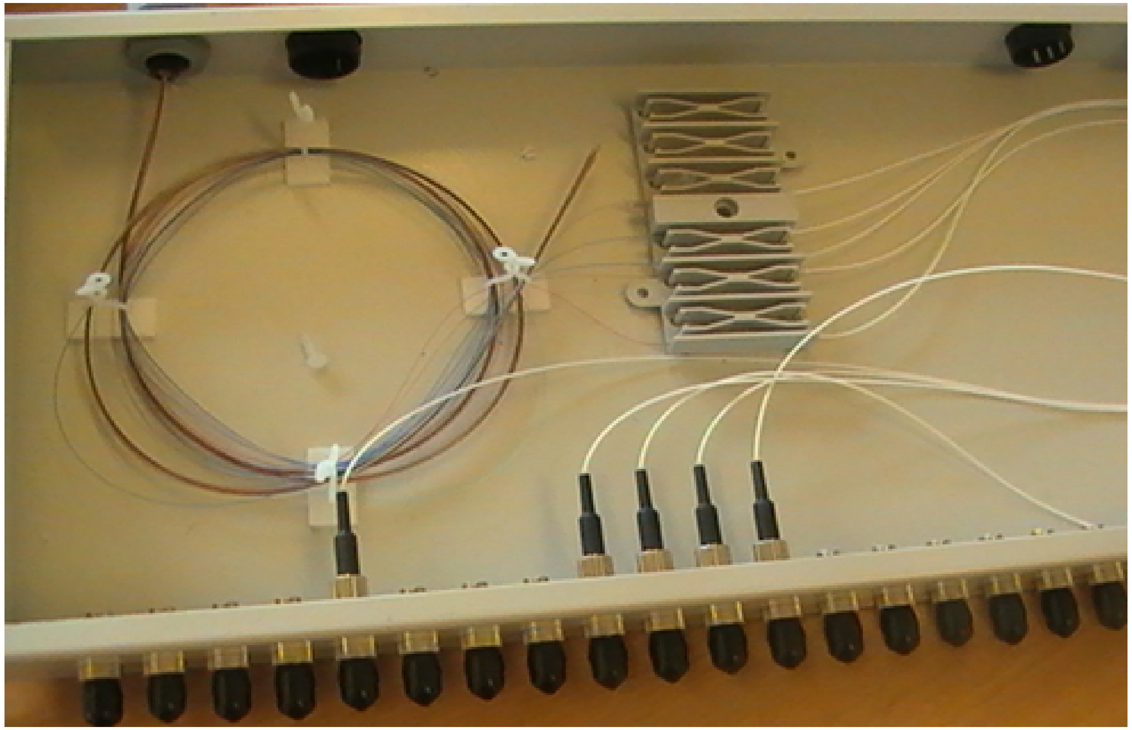
Adding a Spur cable



Module 5. Termination Joints

Making and Testing a Termination Joint and Wall Box connection
You will connect a fibre patch panel to a small wall-mount termination box, and you will test the quality of the link with a source and meter. This demonstrates how to splice pigtails on to a route cable between termination joints and how to test the link

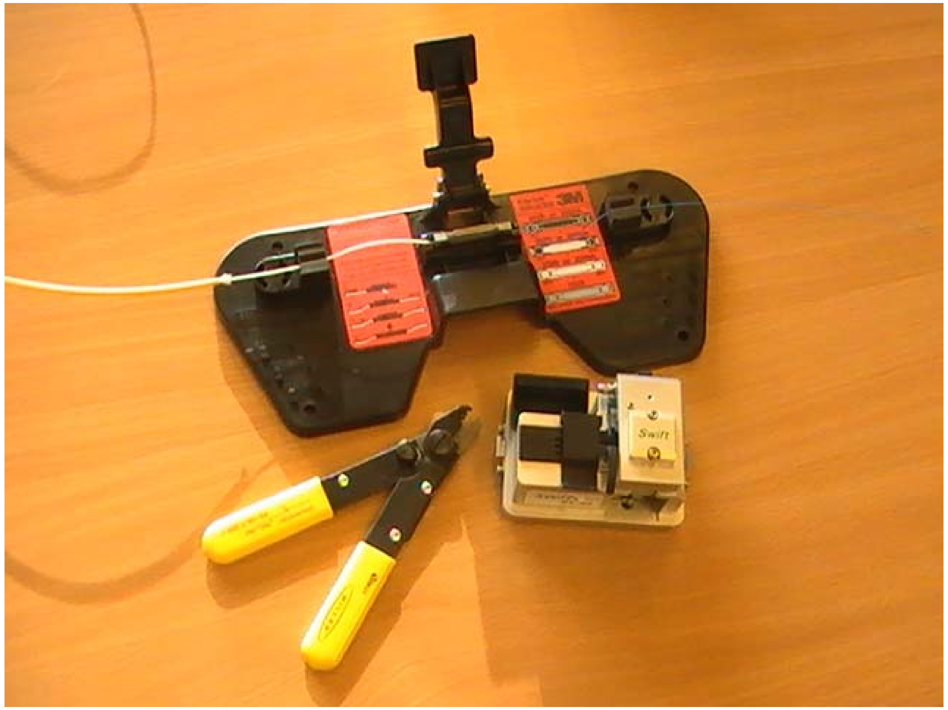


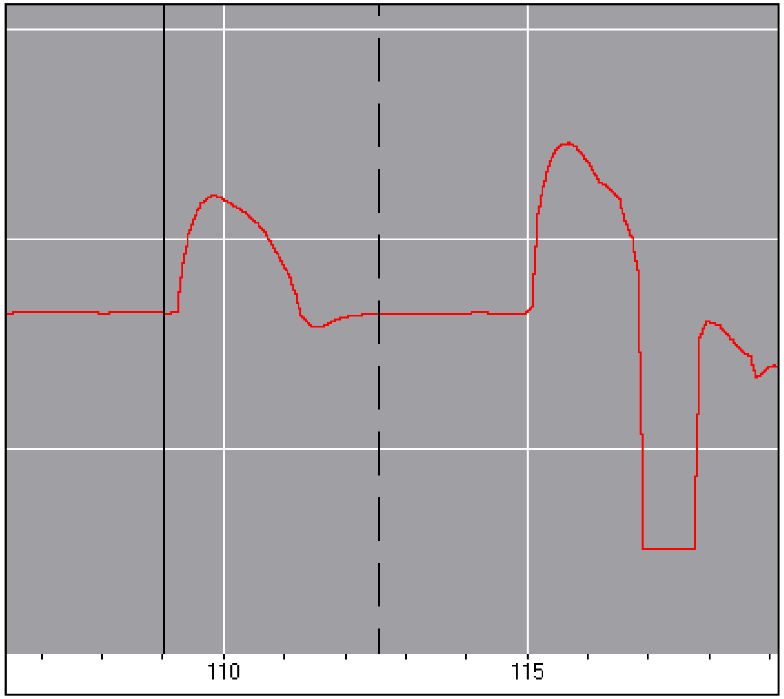


Module 6. Mechanical Splicing

Cleaving and aligning of fibres in a precision v-groove component

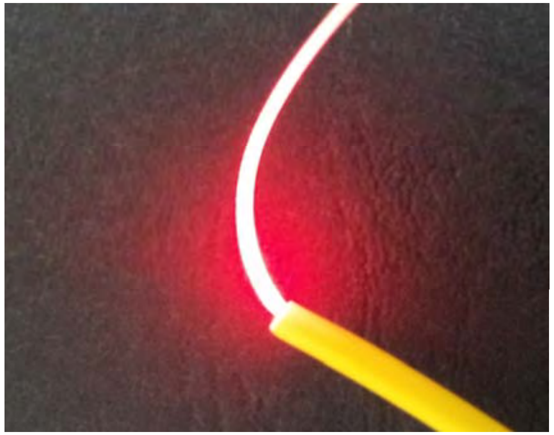
The splice is monitored using an OTDR, source and meter or visible source





Module 7. Visual Fault Location

The visible fault locator is a low cost tool that allows you to check continuity and find faults in connectors, patchcords and distribution frames.



Module 8. Insertion Loss testing

A major part of testing cables after they have been installed is to test the insertion loss using a source and meter

Reference Cord 1

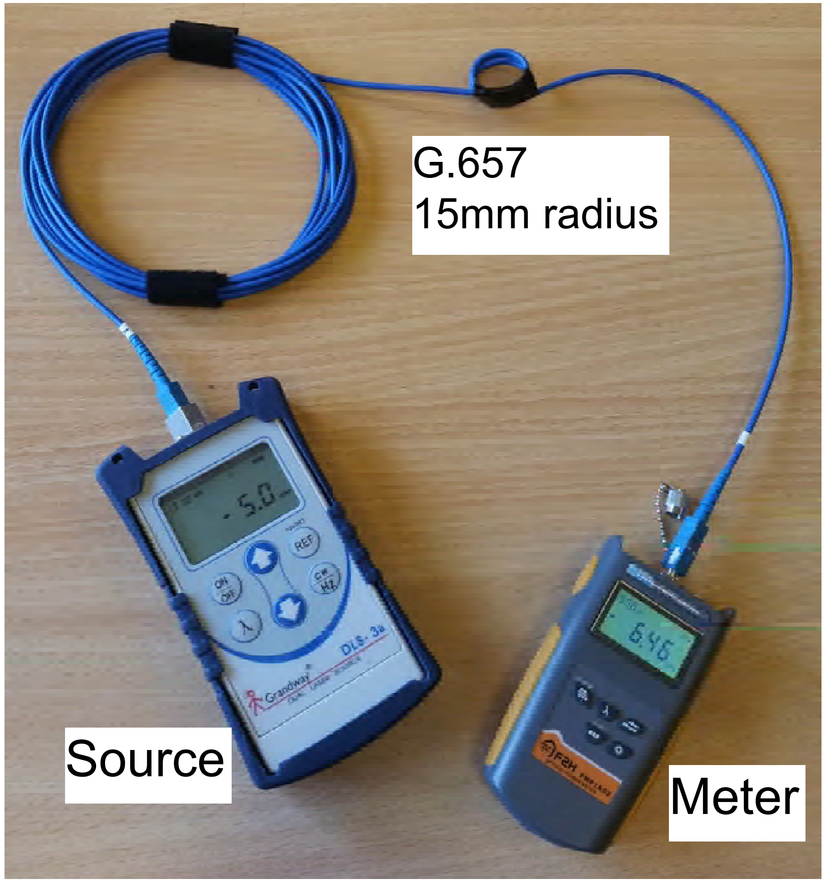
Reference Cord 2

Source

Meter

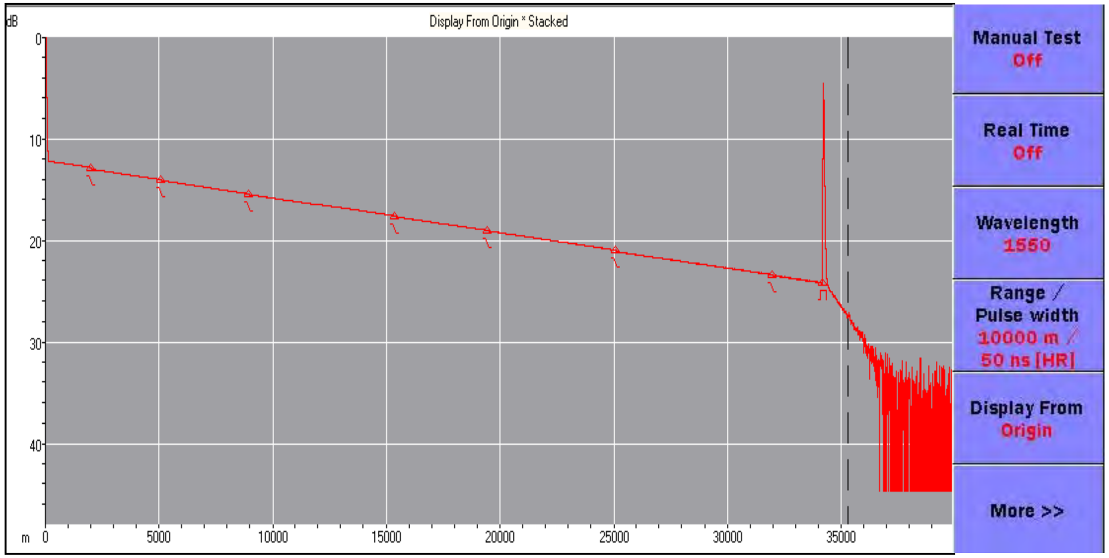
Module 9. Bend Testing G.652 & G.657

We measure the losses induced by tight bends in standard singlemode fibre (ITU spec G.652) and the new bend insensitive fibres (ITU spec G.657)



Modules 10.   OTDR Setup

Extensive practice is carried out on several cable systems – short and long range and you learn how to set the key parameters of the OTDR pulsewidth, range, averaging time. You learn how to optimise these and to measure losses, cable lengths, reflection levels and how to troubleshoot and commission an optical cable.

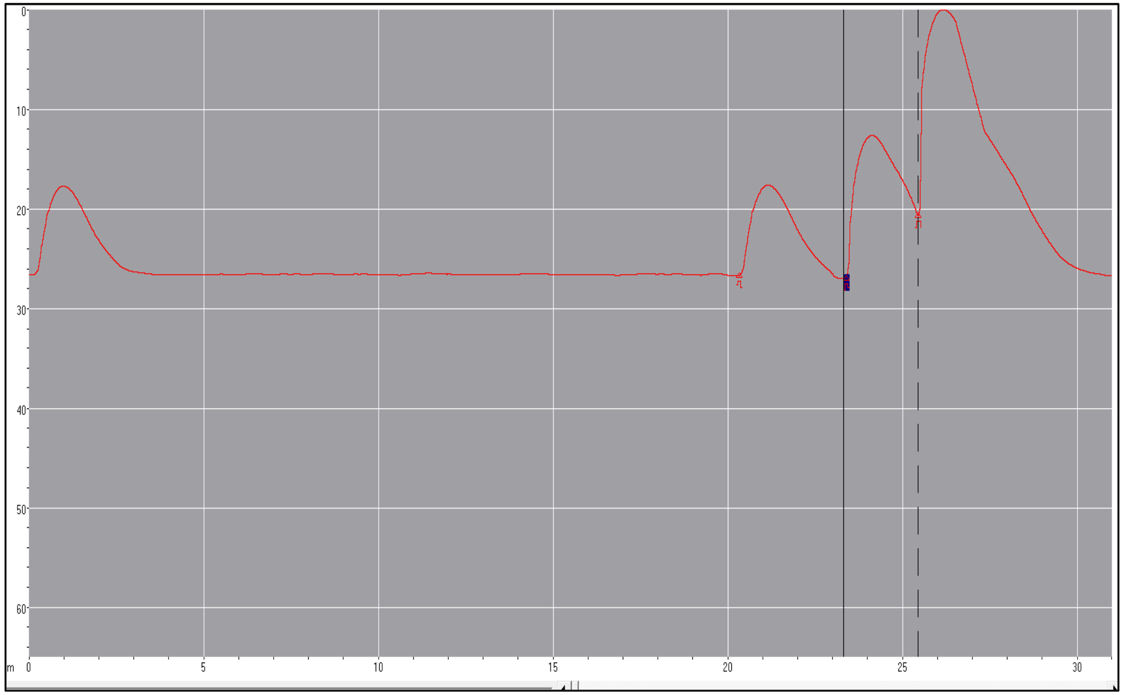


Module 11. Cables with multiple connectors

The interpretation of traces can be tricky on short cables and in this exercise you will measure and analyse events that are close together.

You will test for:

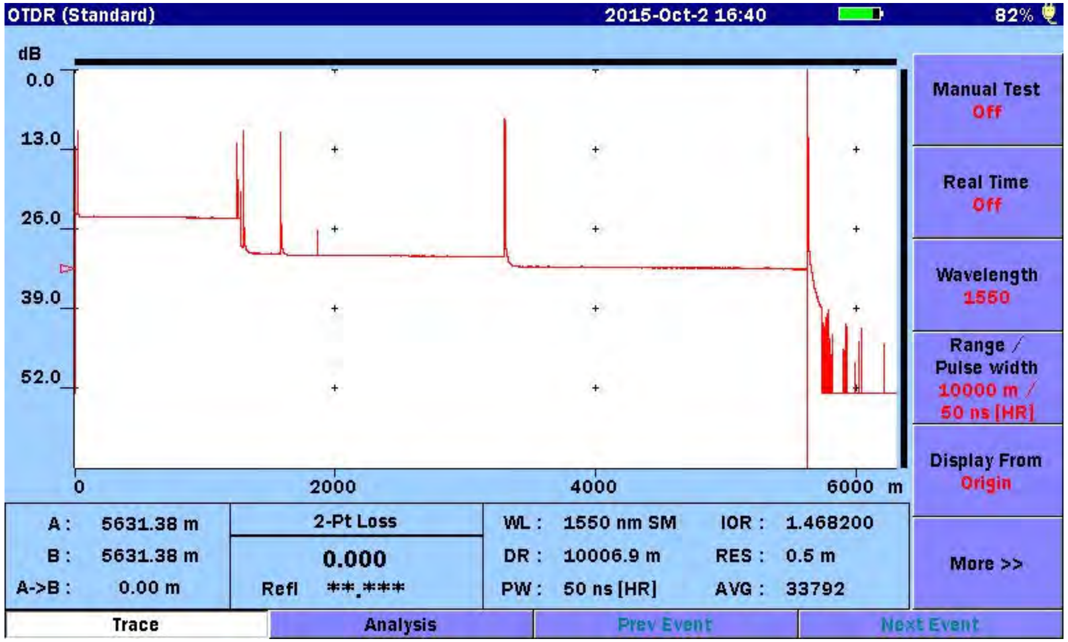
- End to end loss
- Splice and connector loss
- Component Reflectance
- Optical Return Loss
- Faults and bends



Module 12. Cables with connectors, splices and bends

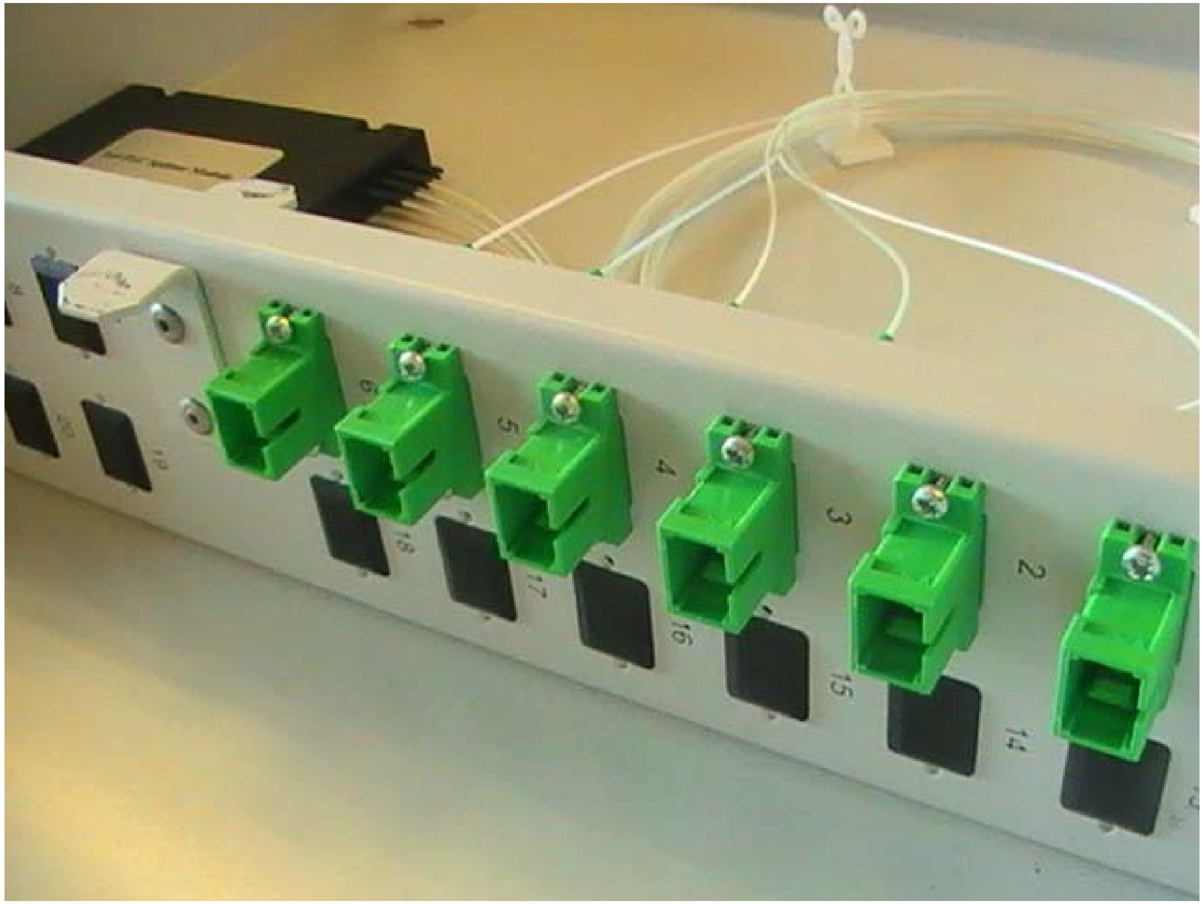
In this exercise you will measure and analyse the features on a fibre trace, and decide whether the fibre meets specification.

End to end loss
Splice and connector loss
Component Reflectance
Optical Return Loss
Faults and bends



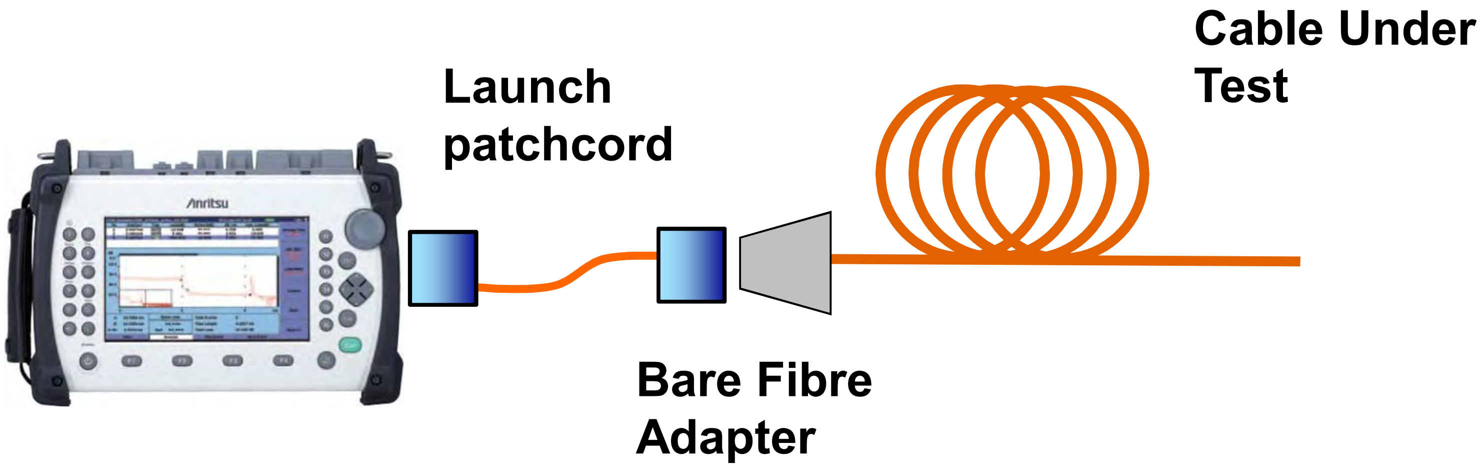
Module 13. PON Testing

The OTDR is used to troubleshoot the splitter in a Passive Optical Network (PON) which shows the superimposition of traces.



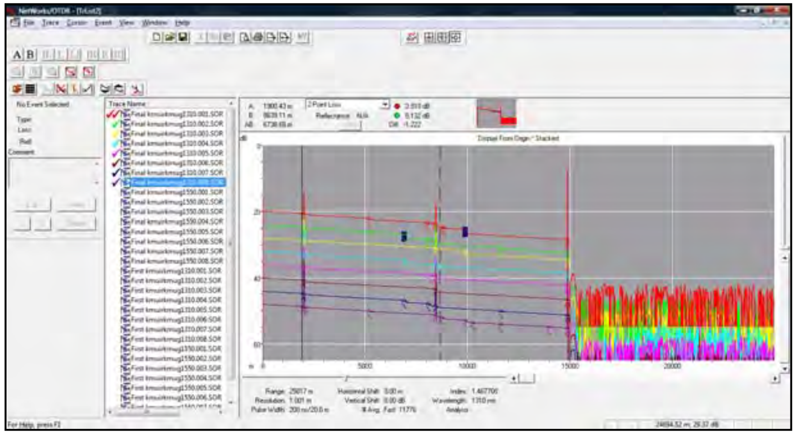
Module 14. Testing a Bare Fibre End

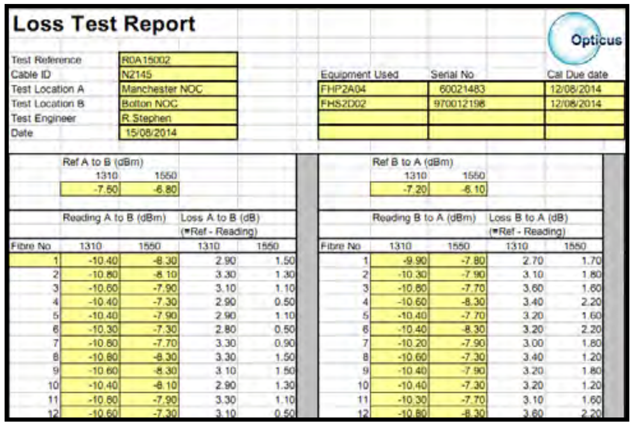
A major part of testing cable prior to installation is using a bare fibre adapter to launch light into the cable – this is a tricky process and practice is required.



Module 15. OTDR PC Analysis & Documentation

You will learn the operation of OTDR PC analysis software and look at real life examples and how to produce documentation for customers.





Loss Test Report

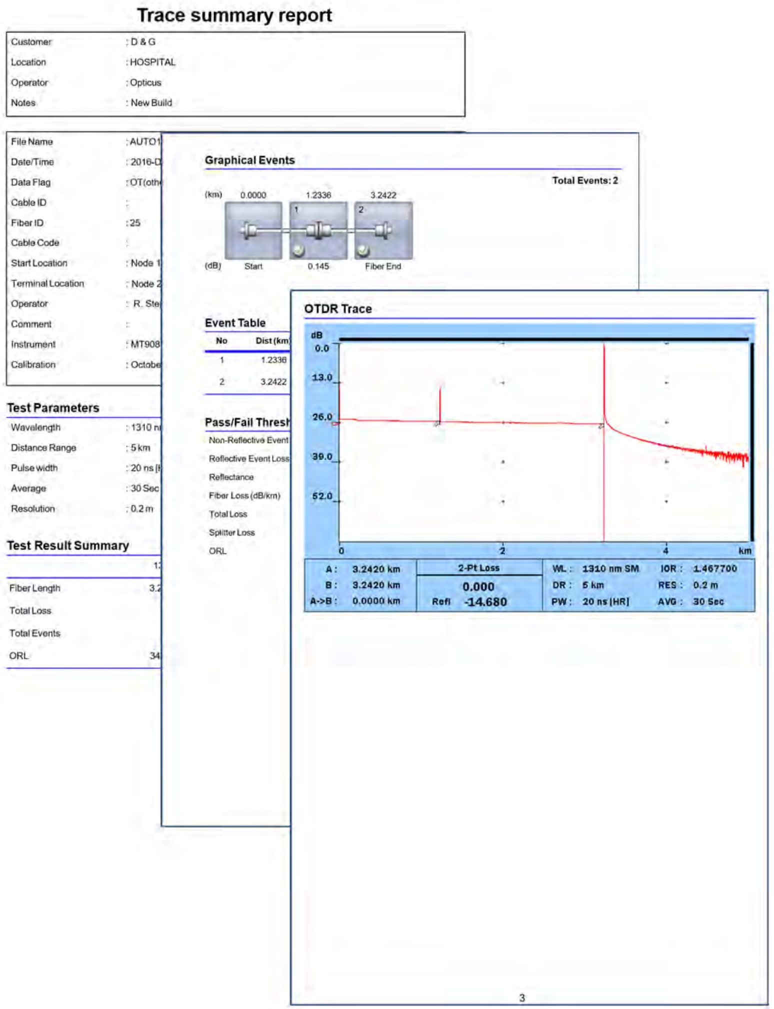
Opticus

Test Reference	RDA15002
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

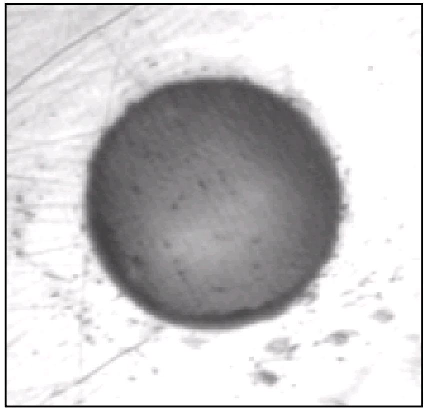
Ref A to B (dBm) 1310	Ref A to B (dBm) 1550	Ref B to A (dBm) 1310	Ref B to A (dBm) 1550
-7.60	-6.80	-7.20	-6.10

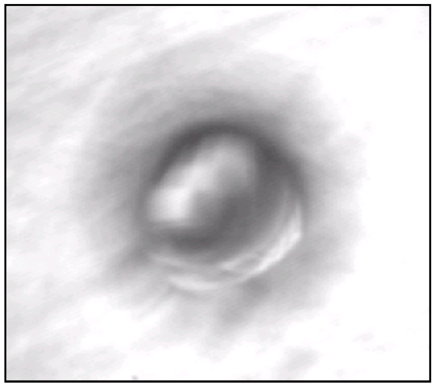
	Reading A to B (dBm)		Loss A to B (dB) (=Ref - Reading)			Reading B to A (dBm)		Loss B to A (dB) (=Ref - Reading)	
Fibre No	1310	1550	1310	1550	Fibre No	1310	1550	1310	1550
1	-10.40	-8.30	2.90	1.50	1	-9.90	-7.80	2.70	1.70
2	-10.80	-8.10	3.30	1.30	2	-10.30	-7.90	3.10	1.80
3	-10.60	-7.90	3.10	1.10	3	-10.80	-7.70	3.60	1.60
4	-10.40	-7.30	2.90	0.50	4	-10.60	-8.30	3.40	2.20
5	-10.40	-7.90	2.90	1.10	5	-10.40	-7.70	3.20	1.60
6	-10.30	-7.30	2.80	0.50	6	-10.40	-8.30	3.20	2.20
7	-10.80	-7.70	3.30	0.90	7	-10.20	-7.90	3.00	1.80
8	-10.80	-8.30	3.30	1.50	8	-10.60	-7.30	3.40	1.20
9	-10.60	-8.30	3.10	1.50	9	-10.40	-7.90	3.20	1.80
10	-10.40	-8.10	2.90	1.30	10	-10.40	-7.30	3.20	1.20
11	-10.80	-7.90	3.30	1.10	11	-10.30	-7.70	3.10	1.60
12	-10.60	-7.30	3.10	0.50	12	-10.80	-8.30	3.60	2.20



Module 16.   Connector Inspection

You will be presented with a variety of damaged and good connectors of different constructions and learn to recognise minor from critical damage and practice different methods of cleaning connectors.

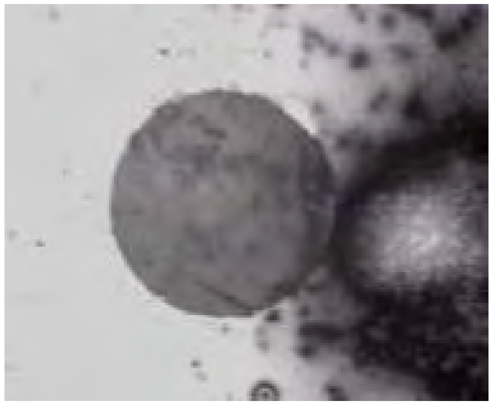




e.g. The fibre shown looks reasonable on the left but the irregular pattern of light indicates a fibre break within the ferrule.
If the microscope is refocused the jagged edge is revealed.

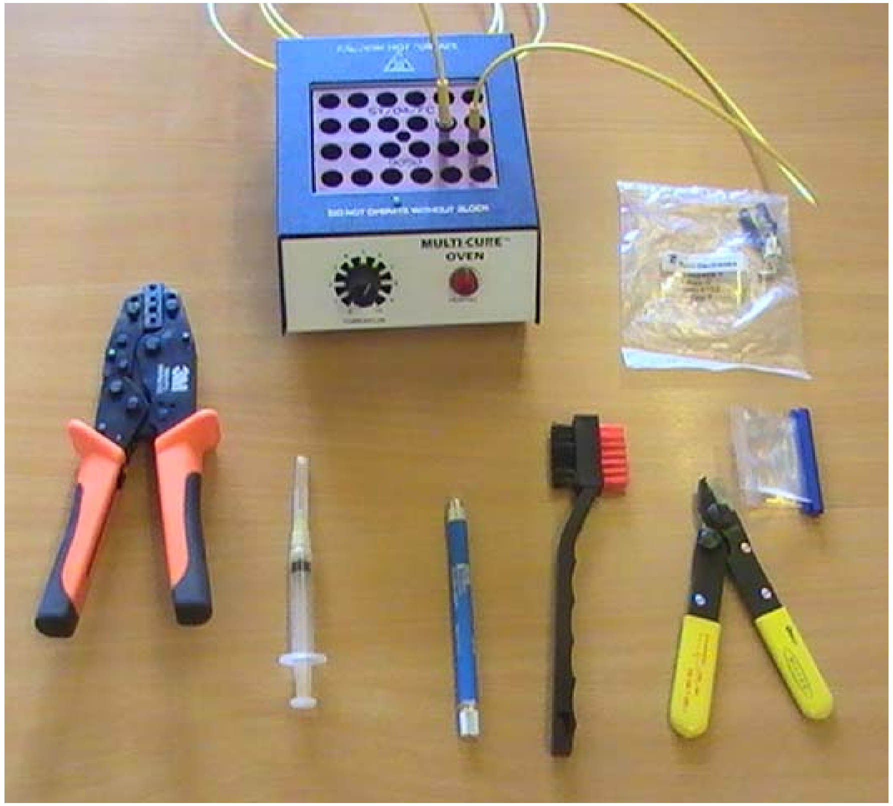
Module 17. Connector Cleaning

Practice the best methods to clean an optical connector. Whether to use a dry tissue or one soaked in alcohol, a cleaning cassette a cleaning wand.



Module 18.   Epoxy Polish Termination

Connectors are fitted and cured

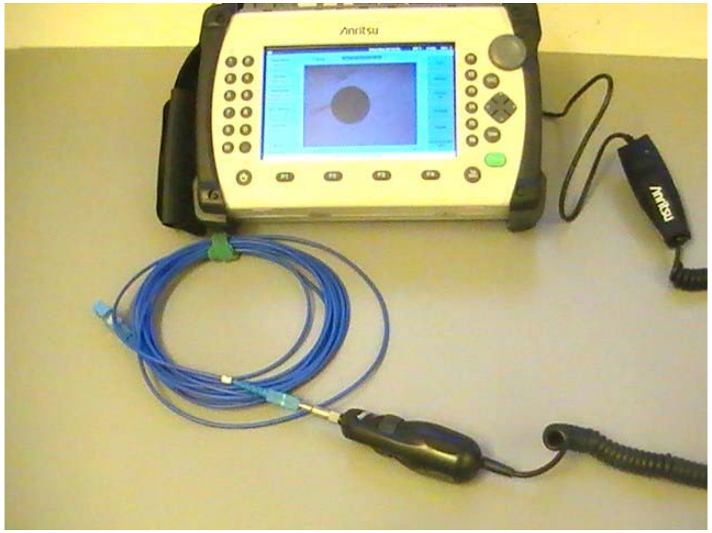


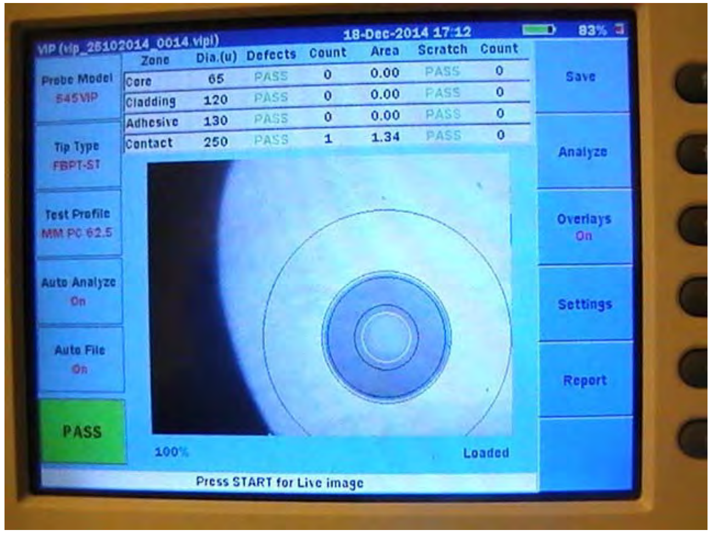
The connector is then polished using various grades of polishing film

Module 19. Connector Quality Testing

Connectors are viewed through a video microscope

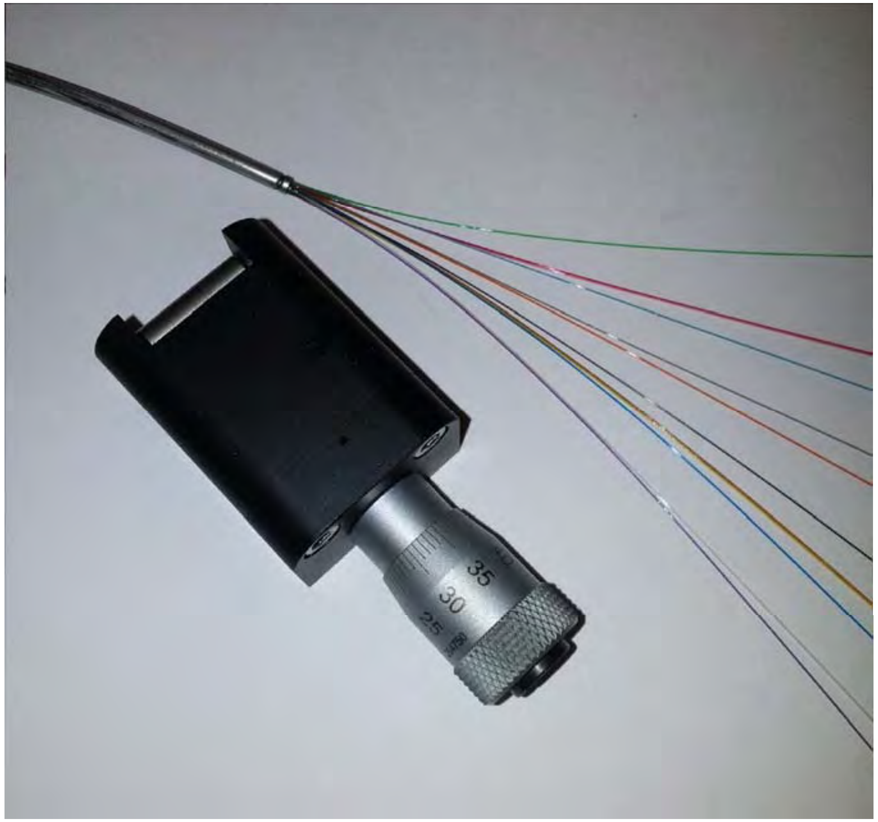
The software automatically analyses the quality of the polish for scratches and defects





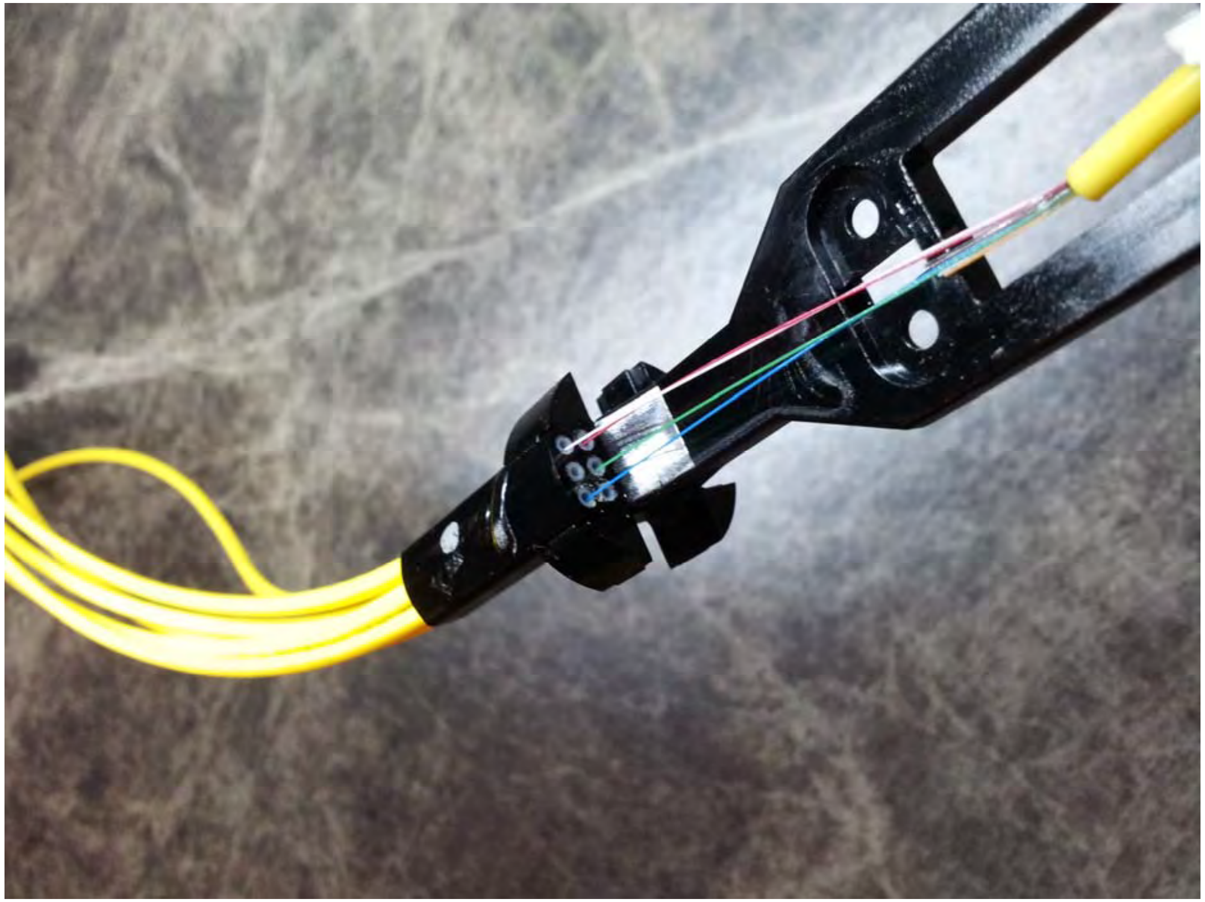
Module 20. Safe Removal of metal tube from fibre

In umbilical cables, OPGW and railway cables fibres are often buffered in metallic tubes – removal of the tubes without causing fibre damage can be a problem. You will practice techniques for removing this tubing safely.



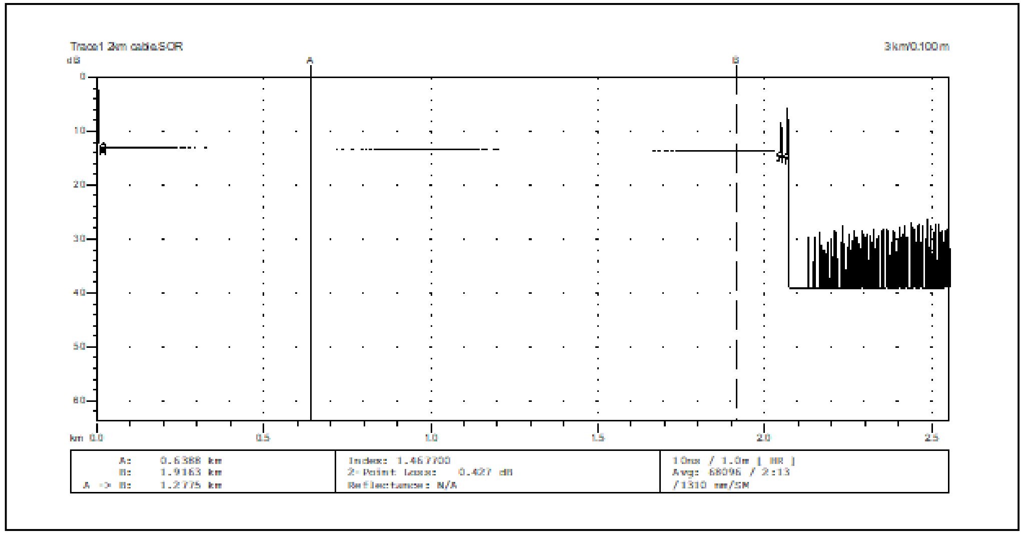
Module 21. Fan Out Termination of Umbilical cable

Umbilical cables can be directly terminated into a fan out gland



Module 22. OTDR testing of Umbilical cables

OTDR testing of umbilical cables by setting OTDR thresholds to measure dB/km slopes and discontinuities

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Analysis Results -- Trace1 2km cable.SOR

Feature  Location    Event-Event     Loss        Refl
#/Type     (km)      (dB) (dB/Km)    (dB)        (dB)

 1/G       0.0188-   0.03  1.524     0.65(2P)
           0.0299
 2/R       2.0480    0.74  0.366     0.26(2P) -57.97
 3/E       2.0673    0.05  2.425    >3.00     -51.42

Overall (End-to-End) Loss: 1.73 dB


Primary Trace: Trace1 2km cable.SOR
         Date: 10/30/09          Range:          3 km
         Time: 12:19 PM     Resolution:      0.100 m
 Product Type: MT9083A-06  Pulse Width:         10 ns
  Opt. Module:                   Index:  1.467700
   Fiber Type: Singlemode   WaveLength:       1310 nm
FAS Thresholds:            Horz. Shift:    0.0000 km
         Loss:     0.02 dB  Vert. Shift:       0.00 dB
  Reflectance:   -40.00 dB No. Averages:     68096
  Fiber Break:     3.00 dB
  Backscatter:   -78.50      Trace Type: SR4731
  Trace Flags: Analysis
          ORL: N/A
--------------------- Page   1 ---------------------
|    Language:                                      |
|    Cable ID:                                      |
|    Fiber ID:                                      |
|  Wavelength: 1310                                 |
|    Org. Loc:                                      |
|   Term. Loc:                                      |
|  Cable Code:                                      |
|   Condition:                                      |
|    Operator:                                      |
|     Comment:                                      |
|    Supplier: Anritsu                              |
|  OTDR Model: MT9083A-063                          |
|         S/N: 6200763741                           |
|  Optics Mod:                                      |
|         S/N:                                      |
|    S/W Rev.: 4.00                                 |
|       Other:                                      |
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Module 23. Splice On Connectors

New FTTx projects call for fast connections in difficult to reach areas. In this module you will learn how to do this quickly and easily with the latest fusion splicing techniques.

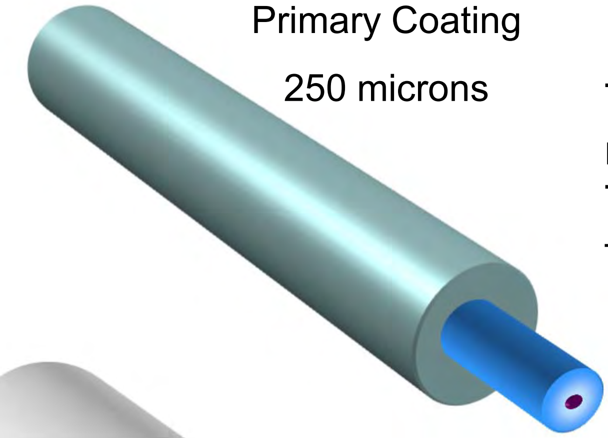
Module 24. Unicam Mechanical Splice Connectors

Mechanical Splice Connectors can be difficult to fit without high failure rates – we show the best way to minimise wasted connectors and expense

Training Notes

The following pages shows examples of the course notes which are supplied in printed and PDF format.

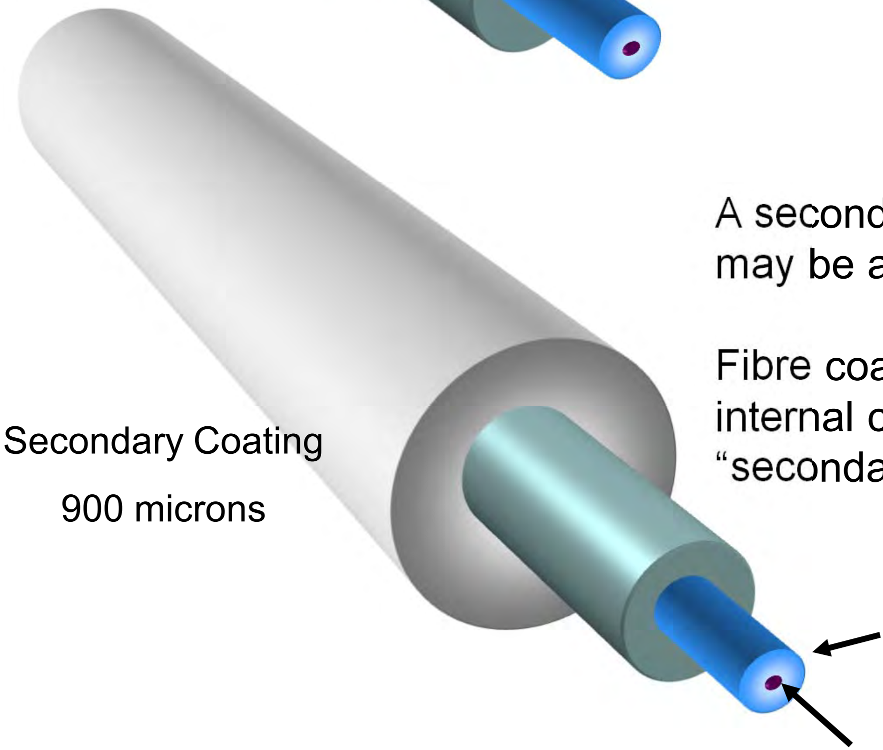
Fibre Coatings



The finished primary coated fibre will be used in the manufacture of a variety of optical cables.
The coating is essential for protection and gives the fibre flexibility. Without it the fibre is easily broken.

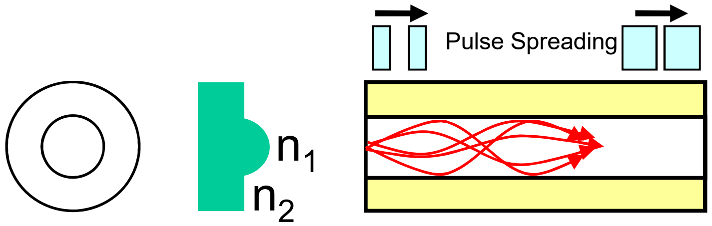
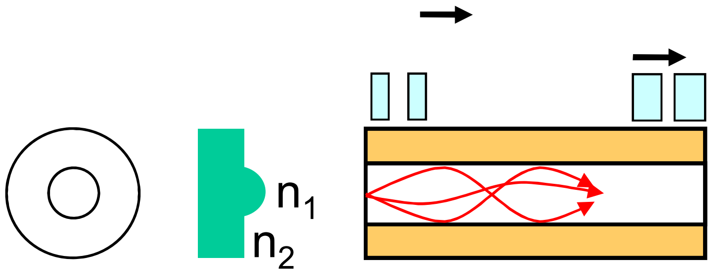
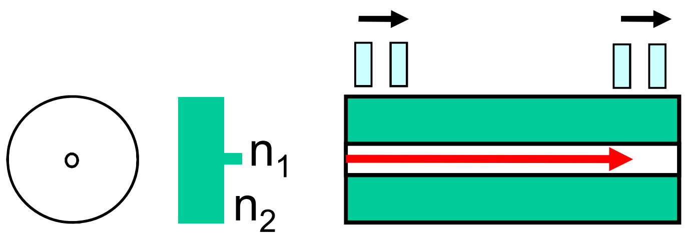
A secondary Nylon coating of 900 microns in diameter may be added to give the fibre greater protection.

Fibre coated in this way is used to make patchcords and internal cables. This fibre is called “tight buffered” or “secondary coated” or “ruggedized fibre”



Fibre Profiles

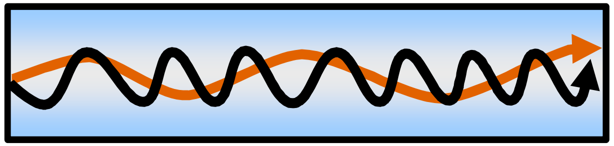
Graded Index multimode fibre slows light passing down the centre of the fibre relative to light passing to the outer part of the core. Singlemode has a very small core which restricts light to one mode only which eliminates modal problems but means that it is very difficult to launch light into singlemode fibre.

Core/Cladding diameter	R.I. Profile / Mode Diagrams	NA
OM1 Multimode Graded Index 62.5 / 125 microns		0.27
OM2 OM3 OM4 OM5 Multimode Graded Index 50 / 125 microns		0.27
OS1 OS2 Singlemode Step Index 9 / 125 microns		0.12

Opticus
OP-456-1-29

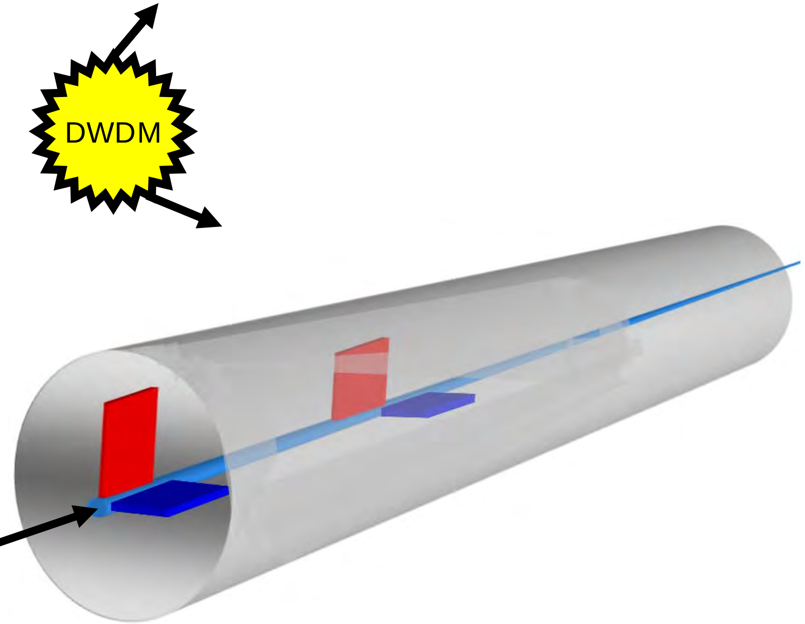
Types of Dispersion

Modal Dispersion in multimode fibres - pulses are carried by several modes travelling at different speeds resulting in pulse spreading

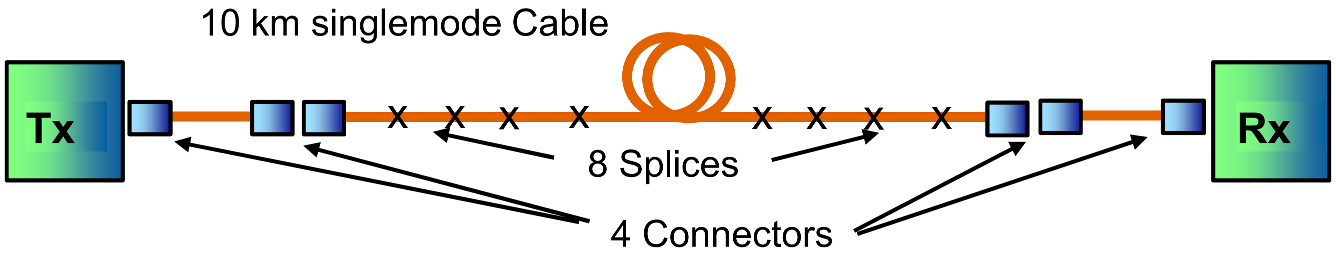


Chromatic Dispersion in singlemode fibres - pulses are carried on a narrow range of wavelengths which travel at different speeds Chromatic dispersion has two components - Material and Waveguide dispersion. By adjusting the manufacturing process for the fibre the Waveguide dispersion can be adjusted.

Polarisation Mode Dispersion in singlemode fibres – there are two polarization mode components that are normally excited equally and they travel in the same phase. However, variations in the fibre circularity and bends or pressure points can lead to a phase displacement and pulse spreading. The effect can cause degradation in the performance of high speed SDH and SONET transmission system and is particularly a problem for high speed DWDM



System budget calculations



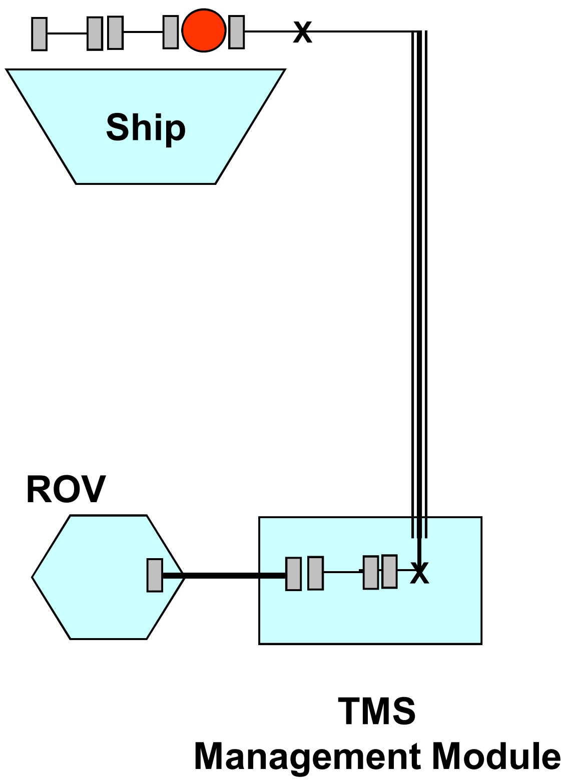
Transmitter Output	0dBm
Connector Loss	4 x 0.5 dB = 2 dB
Cable Loss	10 x 0.33 dB = 3.3 dB
Splice Loss	8 x 0.2 dB = 1.6 dB
Total Loss	***6.9dB***
Ageing & Rework Margin	5 dB
	11.9dB
Receiver Sensitivity	-30dBm

The expected loss of the system will be the sum of the Connector Loss, the Cable loss, and the Splice loss.
Loss measurements using a Source and Meter will reveal the actual attenuation.

Total losses are 6.9dB, and power reaches the receiver at -6.9dBm.
This is 23.1dB higher than the receiver sensitivity. Clearly there is no problem with range for this system, and any Ageing and Rework margins can be accommodated. However, overload of the receiver is a possibility, although this could be resolved by adding a fixed attenuator at the receiver end.

ROV Umbilical Example

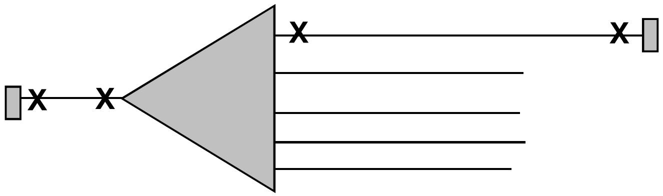
An umbilical cable between a ship and a Remotely Operated Underwater Vehicle (ROV) operates over singlemode fibres of 3km.



Transmitter Output	-4dBm at 1550nm
Connector Loss	5 x 0.5 dB = 2.5 dB
Optical Slip Ring	1 x 4 dB = 4 dB
Cable Loss	3km x 0.2 dB/km = 0.6 dB
Splice Loss	2 x 0.2 = 0.4 dB
Total Loss	***7.5 dB***
Received Level	-11.5 dBm
Receiver Sensitivity	-25dBm
Available Margin for Ageing & Rework	**13.5 dB under budget**

Passive Optical Network (PON) Example

A PON distribution Network operates at 1490nm from the Head with a feeder cable of 5km to a 1 x 32 splitter and then a maximum of 1km to the subscriber



Transmitter Output	-3dBm at 1490nm
Connector Loss	2 x 0.5 dB = 1.0 dB
Splitter	1 x 16 dB = 16 dB
Cable Loss	5 + 1km x 0.21 dB/km = 1.26 dB
Splice Loss	4 x 0.2 = 0.8 dB
Total Loss	***19.06 dB***
Received Level	-22.06 dBm
Receiver Sensitivity	-28dBm
Available Margin for Ageing & Rework	**5.94 dB under budget**

OM & OS fibre Classifications

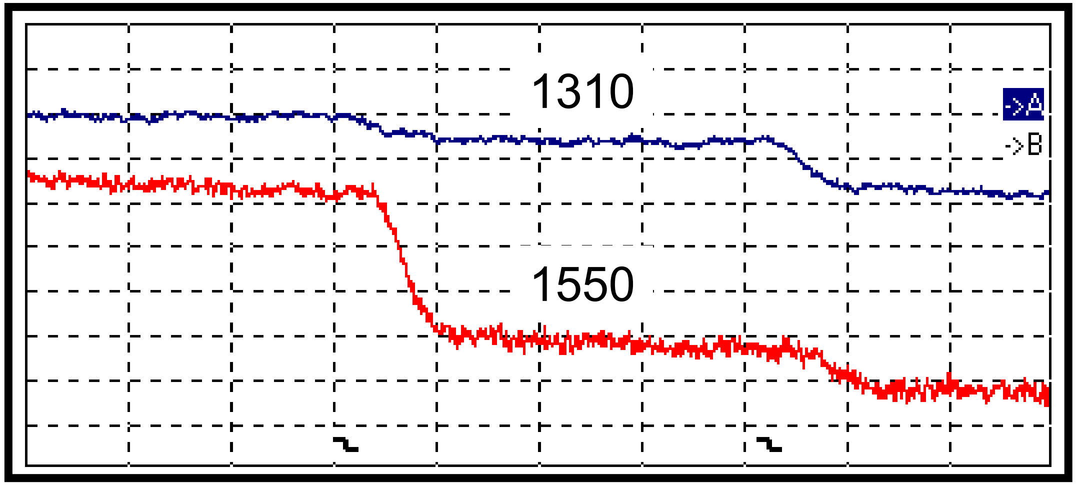
Multimode

Fibre Type	Core Size (microns)	Maximum Fibre cable attenuation (dB/km)			Modal Bandwidth (Mhz.km)			Ethernet Link Distance (IEEE 802.3)				
		850nm	953nm	1300nm	850nm	953nm	1300nm	1000-SR	10G-SR	40G-SR4 & 100G-SR10	100G-SR4 & 400G-SR16	50G-SR & 200G-SR4
OM1	62.5	3.5		1.5	200		500	275m	33m			
OM2	50	3.5		1.5	500		500	550m	82m			
OM3	50	3.0		1.5	2000		500		300m	100m	70m	70m
OM4	50	3.0		1.5	4700		500		400m	150m	100m	100m
OM5	50	3.0	2.3	1.5	4700	2470	500		400m	150m	100m	100m

Singlemode			Maximum Attenuation (dB/km)				Range for 10Gbps	
			1310nm	1383nm	1550nm		1310nm	1550nm
OS1	**9/125**	**Standard Singlemode Fibre**	1.0	N/A	1.0		10km	40km
OS2	**9/125**	**Singlemode Low water peak fibre**	0.4	0.4	0.4		10km	40km

Macrobending

0.2dB/div



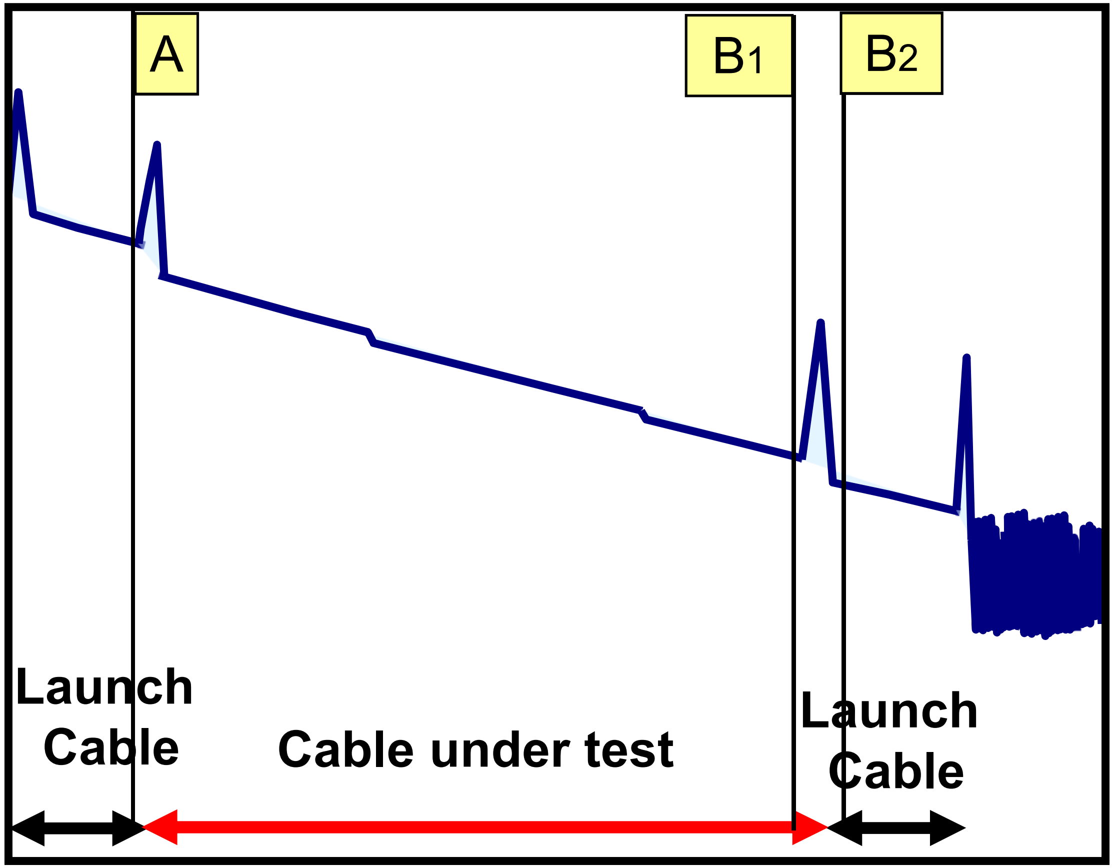
Event	1	2
1310	0.09dB	0.2dB
1550	0.63dB	0.16dB

OTDR Traces taken at 1310nm and 1550nm show the position of the bend clearly.

Event 1 has a greater loss when tested at 1550nm than it does at 1310nm indicating a bend at this location.

Event 2 shows similar losses at both wavelengths which is expected for a normal fusion splice.

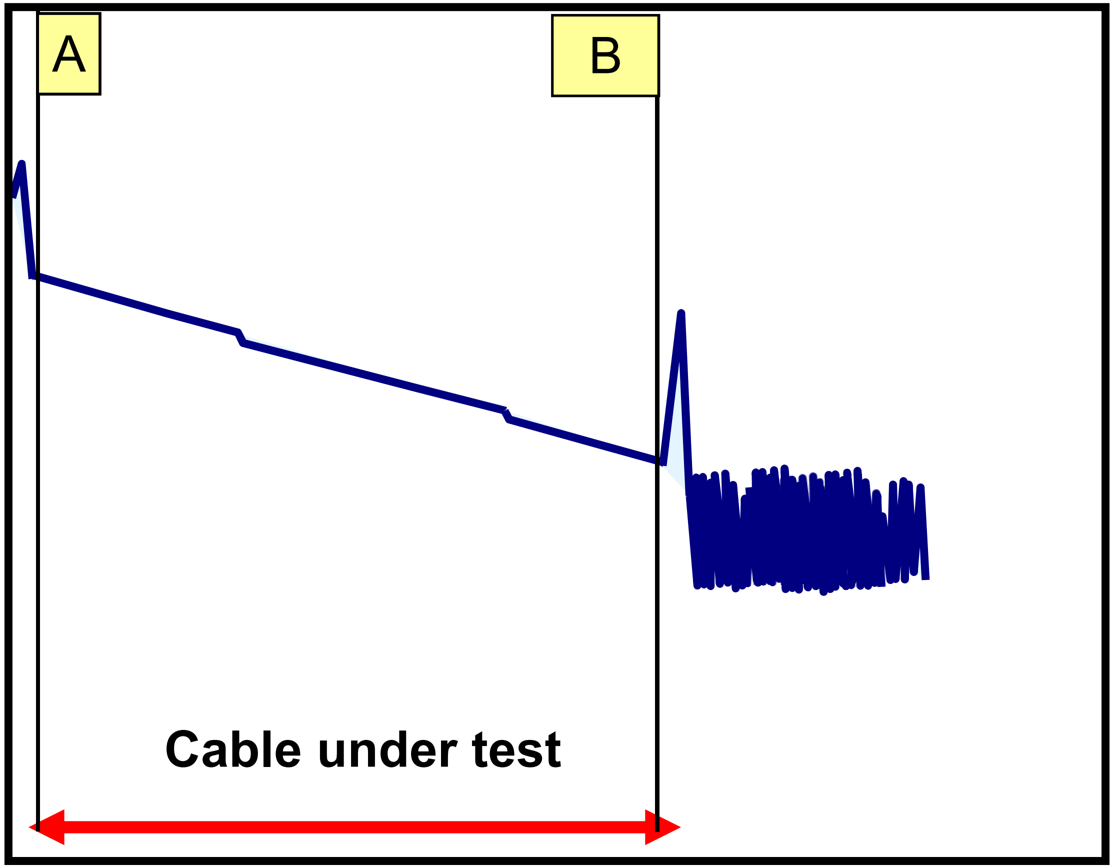
OTDR Measurements using Launch Cables



Length of the cable is measured from A to B1

Loss of the cable (including connectors) is the 2 point Loss from A to B2

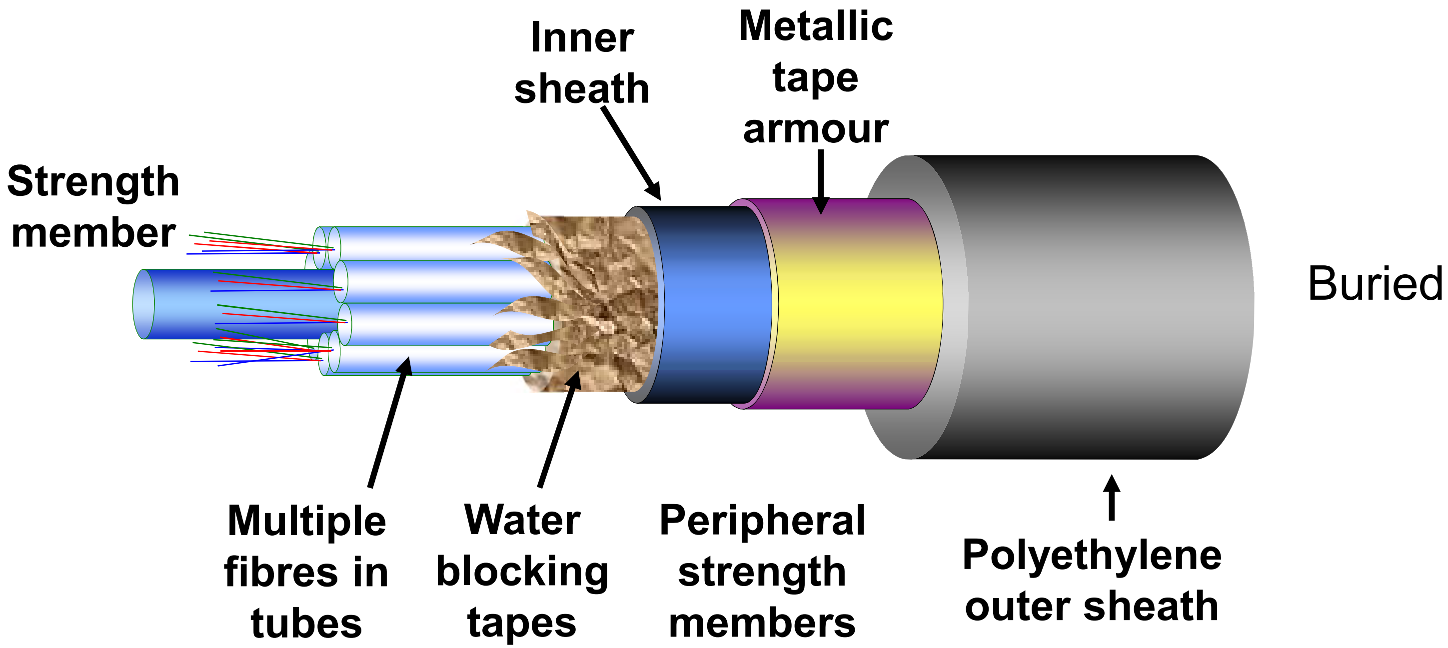
OTDR Measurements without Launch Cables



Length of the cable is measured from the origin to B (the position of B)

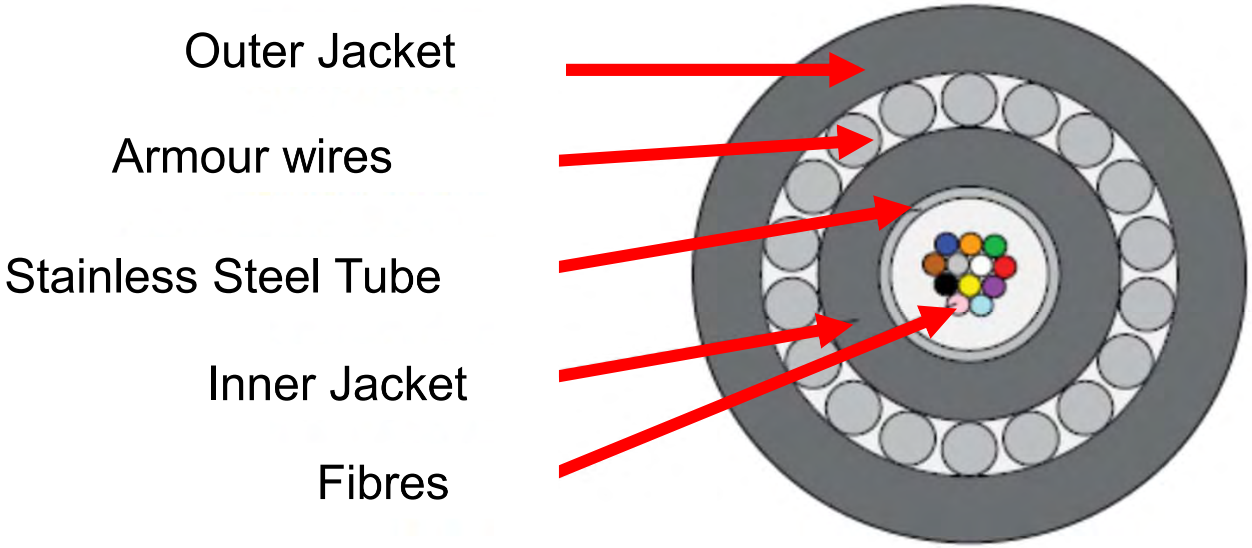
Loss of the cable (does not include connectors) is the 2 point Loss from A to B

Buried Cable Design

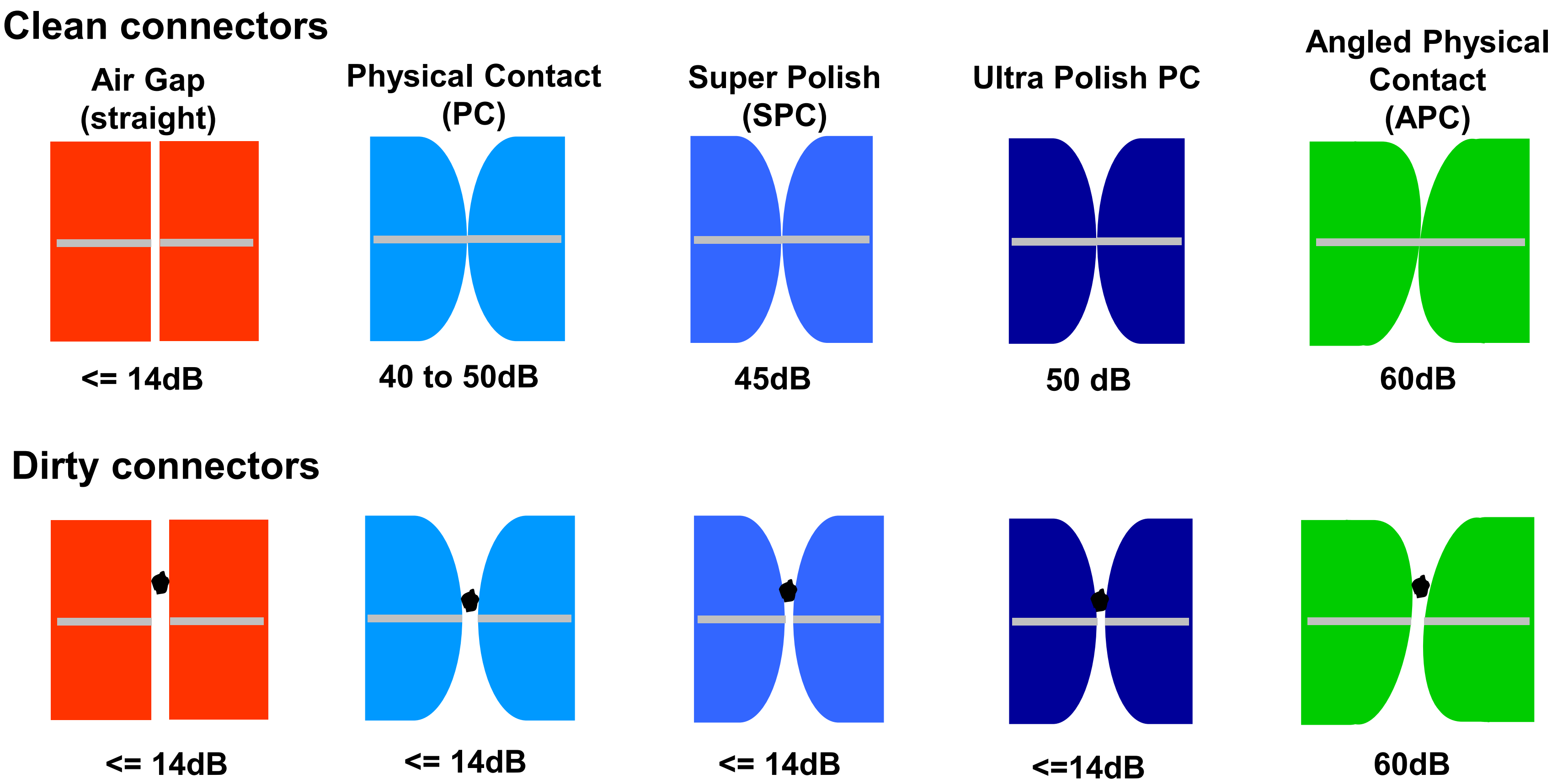


Strength members:Metallic strength members are normally steel or braided steel and if non-metallic, Kevlar or fibre glass are often used.
The tubes are normally filled with a water-blocking compound normally petroleum or silicone based. This compound can also be pumped in to the gaps between inner sheath and the water blocking tapes.

Umbilical Cables



Connector polish styles



Connector Losses and Return losses

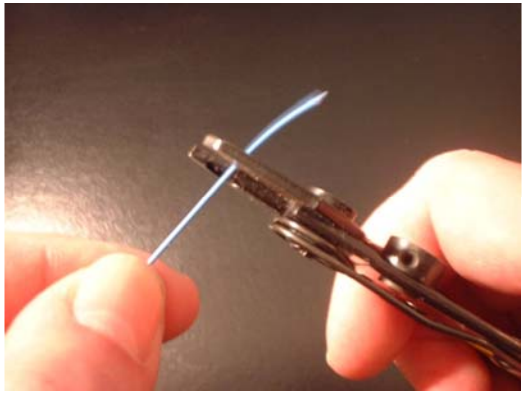
Multimode	Insertion Loss (dB) typical	Insertion Loss (dB) max	Reflectance (-dB) typical	Reflectance (-dB) max
FCPC	0.6	1	30	20
SCPC	"	"	"	"
STPC	“	“	30	25
FCSPC	“	“	35	30
STSPC	“	“	35	30

Singlemode	Insertion Loss (dB) typical	Insertion Loss (dB) max	Reflectance (-dB) typical	Reflectance (-dB) max
FCPC	0.2	0.5	40	35
SCPC	"	"	"	"
STPC	"	"	"	"
FCSPC	"	"	45	40
STSPC	"	"	"	"
FCUPC	"	"	50	45
STUPC	"	"	"	"
FCAPC	"	"	60	50
SCAPC	"	"	"	"

Stripping and Cleaning Procedure

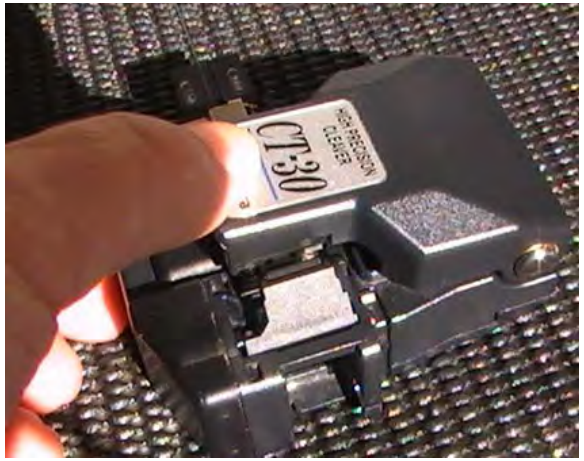
Measure or estimate the amount of fibre that needs to be stripped
This depends on the amount of bare fibre required by the cleaving tool. (30mm is normal)

Strip the fibre perhaps in short lengths if required.
Wet a cleaning tissue with a little IPA and wipe the exposed glass until it squeaks and you are sure that you cannot feel any residual coating clinging to the fibre.



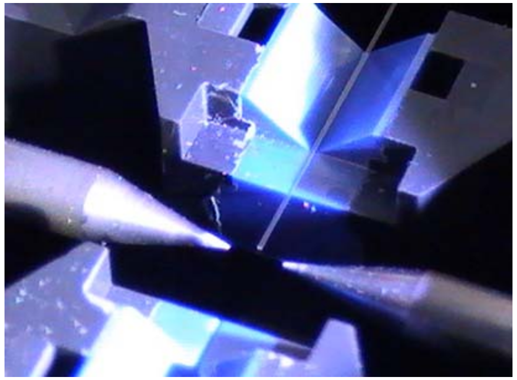
Cleaving Procedure

Activate the Cleaver



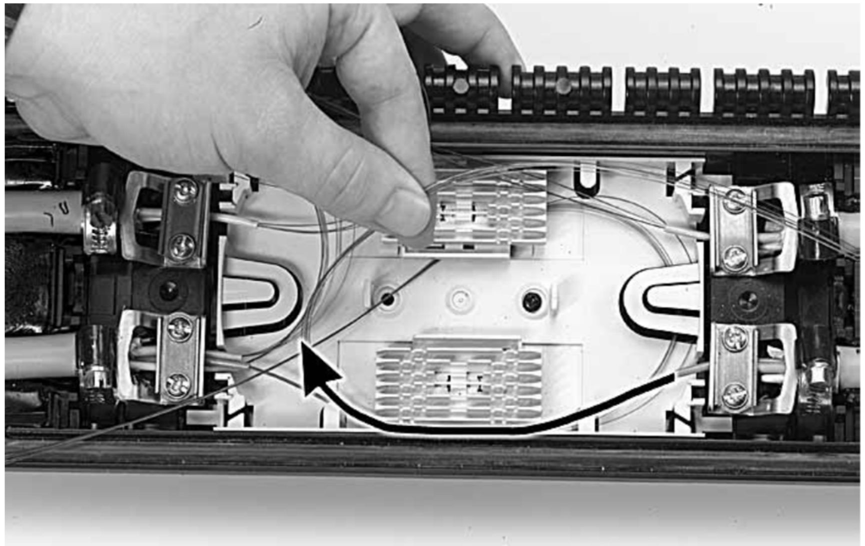
Cleaved Fibre

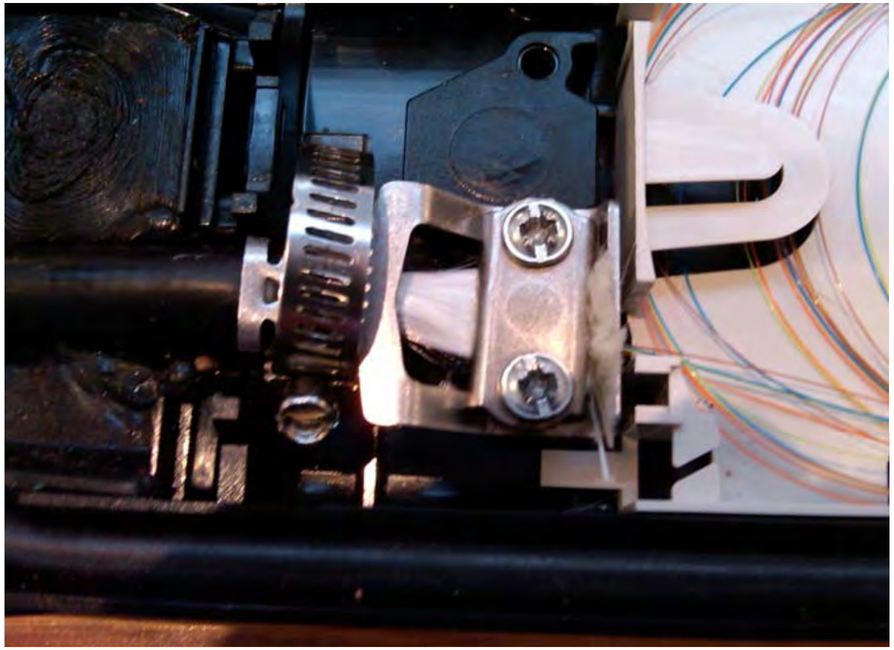
Place the fibre in the splicer vee-groove



Clamp Cable Strength Members

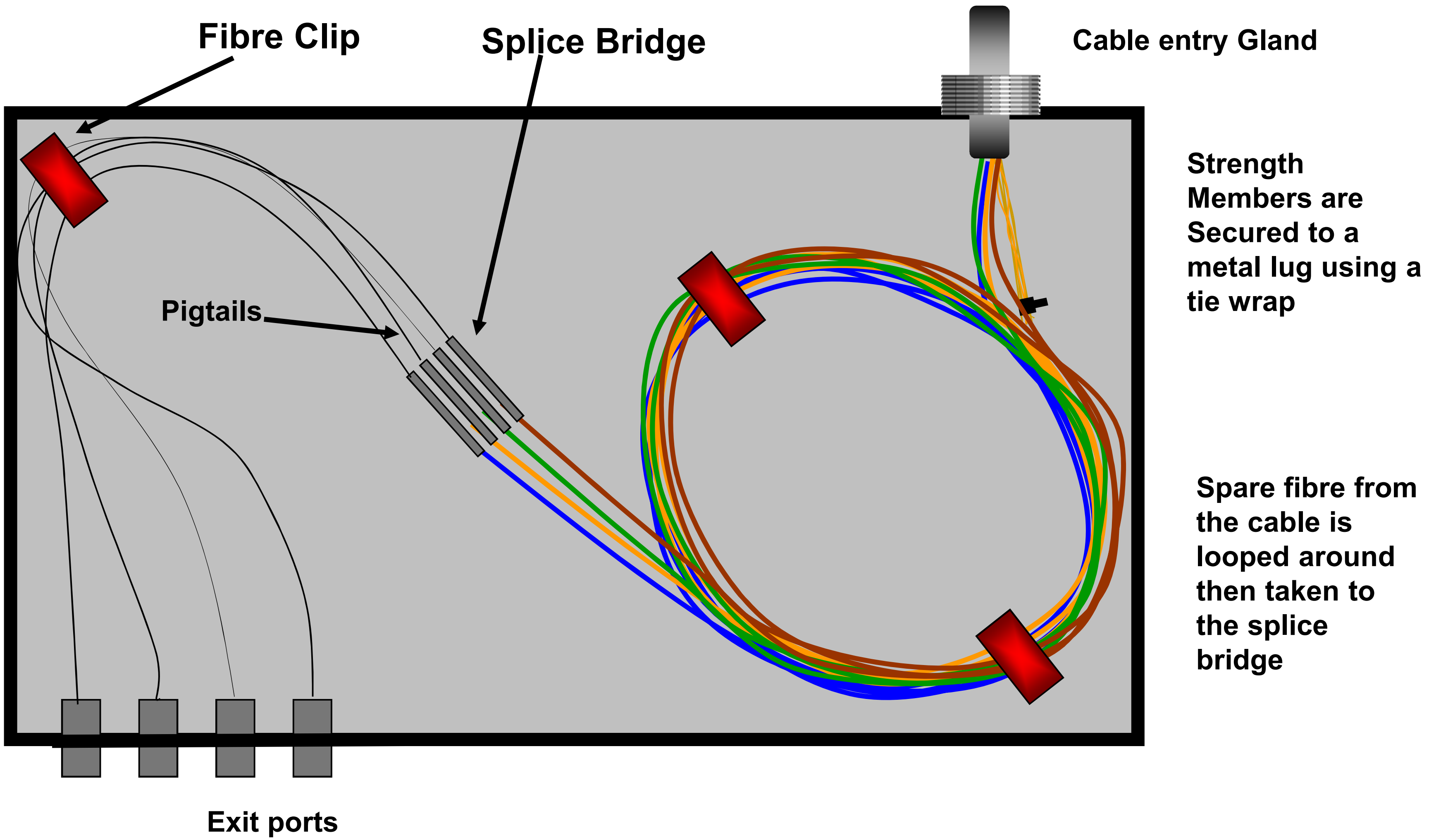
Route the fibres carefully into the fibre organiser





Central or Peripheral strength members should be secured

Simple Termination Patch Panel



Fibre Break within ferrule

The fibre shown looks reasonable on the left but the irregular pattern of light indicates a fibre break within the ferrule.
If the microscope is refocused the jagged edge is revealed