

Module 9 - Enbeam Fibre

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≡ **An Introduction to POL (Passive Optical Lan)**

The Basics of Fibre



Fibre technology has been with us for many years and proven its usefulness in many areas of communications.

Modern fibre optics is at the heart of transmission rates up to 400Gbps and the basis of Fibre to the Home (FTTh).

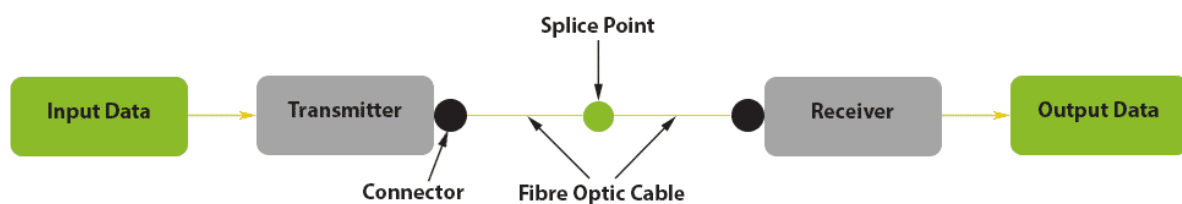
Optical fibre offers a number of advantages.



- 1 Bandwidth is extremely wide
- 2 Low loss – long transmission range
- 3 Electromagnetic Immunity - unaffected by:
 - EMP (Electromagnetic pulses)
 - RFI (Radio Frequency Interference)
 - EMI (Electromagnetic Interference)
- 4 Security – difficult to tap into
- 5 Safety – no electrical current
- 6 Lightweight
- 7 Small size

The Fibre Optic Link

A fibre optic link - not too different to a copper link - is a method of coupling two electronic circuits, including computers, telephone switches and video equipment.



This is a very simplistic view of a point-to-point fibre optic link. In reality it would include patch panels at the end of the fibre link and patch leads to connect the devices.

Fibre Optic Link Components

- Light Source: LED, VCSEL or Laser
- Connectors: Interface to light source (ST,LC,SC)
- Fibre Cable: Low loss link for the transmission of the optical signal
- Patch Panels: Enclosures housing connectors and adapters
- Pigtails: Splice on pigtails to the fibre link
- Transceiver: Light sensitive device using LED, VCSEL or Laser to transmit and receive the optical signal

Measuring Light

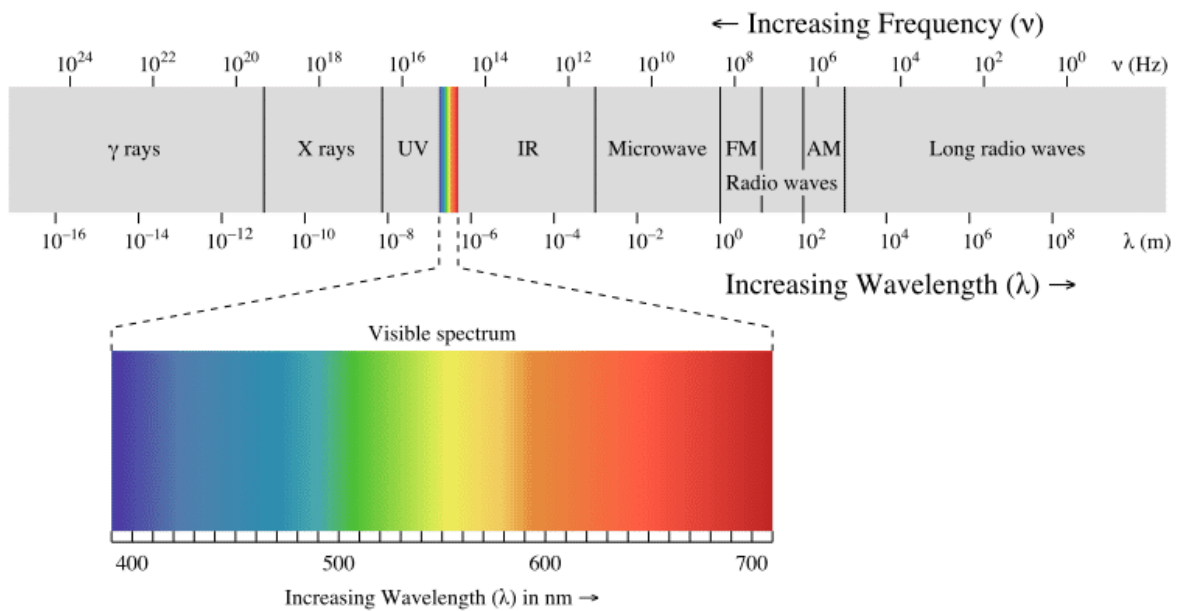
- The spectrum covers all wavelengths from Gamma rays (short wavelength) to Radio waves. 'Light' covers from Ultra Violet, through Visible to Infra Red (3 groups). Ultra Violet and Infra Red are invisible to the human eye, but can be dangerous.
- We measure radiowaves by their frequency in MegaHertz (MHz)
- We measure light by its wavelength

 Wavelength is the distance a wave travels in one cycle. This distance is extremely small where light is concerned; it is measured in nanometres, One Billionth of a metre = 1 nanometre (nm)

Wavelength = Speed of Light (300,000,000m per sec)/divided by frequency (f)

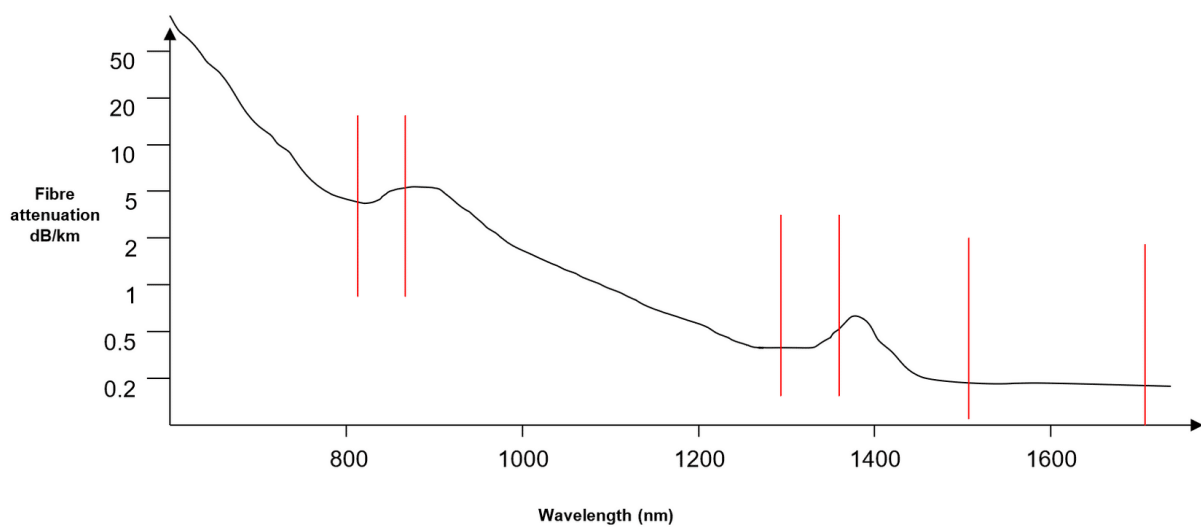
Visible Light Spectrum

A visible light source used to safely detect cracks and breaks in the fibre typically operates at 640nm. Above this level at the higher spectrum can be damaging to eyesight so always check before looking at any fibre.



Operating Wavelengths

The higher attenuation or reduction in signal strength at the lower wavelengths is down to the type of light source and type of fibre used.



Optical Sources

LEDs

- Used for Multimode at 850nm or 1300nm
- Wide beam width fills multimode fibres
- Wider spectrum (typically 50nm)
- Inexpensive

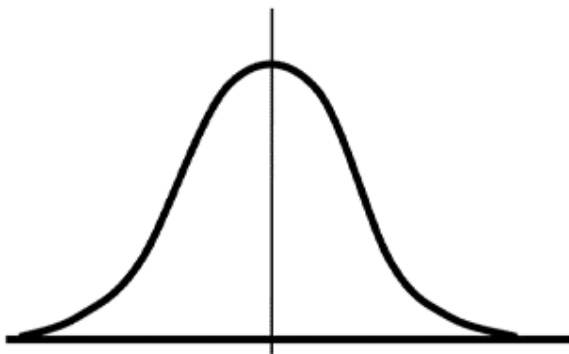
Lasers

- Used for Singlemode at 1310nm or 1550nm
- Narrow spectrum (can be less than 1nm)
- Narrow beam width (does not fill multimode fibres)

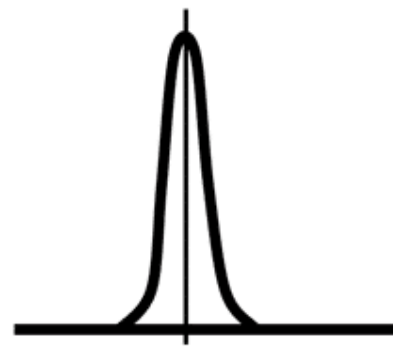
VCSELs

Vertical Cavity Surface Emitting Laser

- Used for multimode at 850nm
- Quite narrow spectrum
- Narrow beam width (does not completely fill multimode fibres)
- Much less expensive than lasers



Wavelength: LEDs

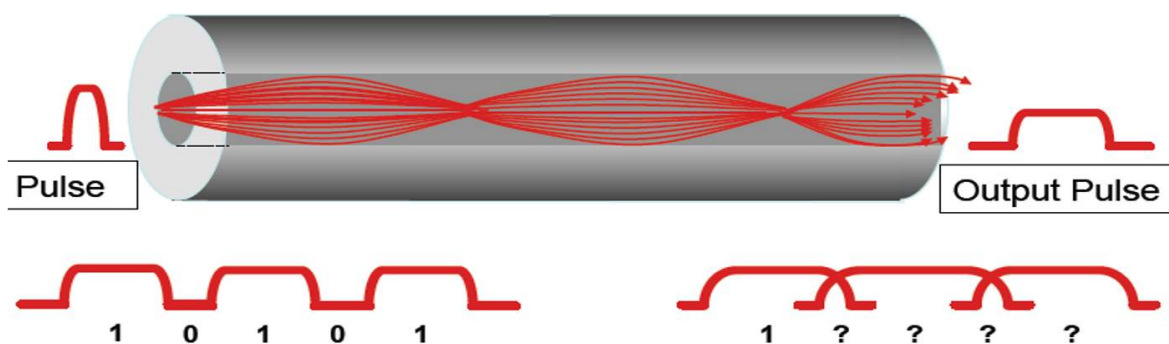


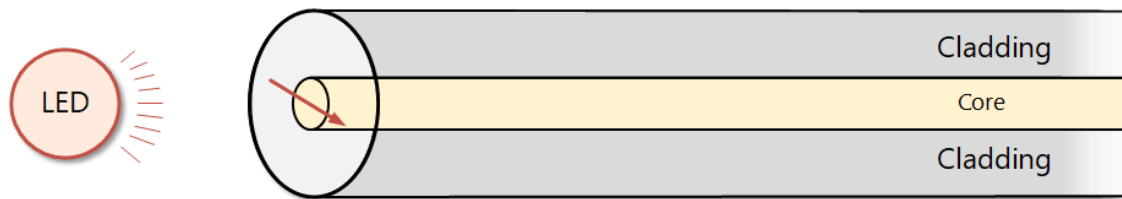
Wavelength: Lasers & VCSELs

i VCSELs are relatively low cost yet still have the capability to support 10Gbps over reasonable distances and have therefore become common place in the commercial enterprise space within buildings.

Multimode Fibre

- Multimode systems use LEDs or VCSELs which produce multimode light and are coupled to 50/125µm and 62.5/125µm fibres
- The light signal is refracted off the inside of the core of the fibre.
- Multiple signals can be transmitted in one direction at slightly different wavelengths
- One downside of multimode is Pulse Spreading
- Pulse spreading limits bandwidth (transmission carrying capacity) as well as the distance that Multimode can support
 - *Pulse spreading can be likened to the space between waves as they spread when something is dropped in water, they get smaller and further apart, this leads to the packets of information becoming less clear.*





- Classified as OM, Optical fibre Multimode in 5 Classes
- ISO & Cenelec have agreed to retire OM1 & OM2 at the next revision of the standards and will ultimately disappear, you can see why when looking at below
- OM5 is designed for use with short wavelength division multiplexers (SWDM) primarily for Data Centre use.

	OM1	OM2	OM3	OM4
1000BASE	275m	>550m	900m	1100m*
10GBASE	33m	82m	300m	550m
40 & 100GBBASE	-	-	100m	150m

i * The standard for 1000Base over OM4 fibre is 900m, however Excel has been able to improve on that to 1100m with a slightly higher quality glass.

You can see why OM1 & OM2 will disappear when looking at the distance for 10GBase-T. It is less than is possible with Category 6A Copper.

The distance for 40 & 100GBase-T is for both Parallel Optics (MPO/MTP). Using multiple fibres slightly different distances can be achieved with SWDM.

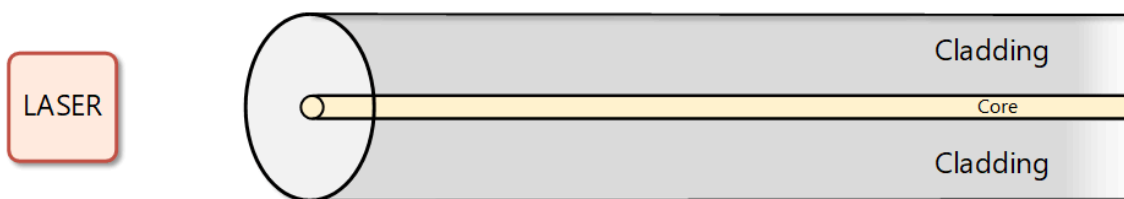
OM4 vs OM5

The below table shows that the difference in distances does not give a great deal of benefit given the additional cost. It could be argued that Singlemode fibre could work out more cost effective and provide a system capable of upgrades in the future.

	OM4	OM5
10GbE	400m	400m
40GbE	150m	150m
100GbE	150m	150m
40G SWDM4	400m	500m
100G SWDM4	100m	150m

Singlemode Fibre

- Singlemode fibre is ideal for a campus environment and is the backbone of FTTh (Fibre to the Home) given the small size and distances it can support
- Due to the high power of the laser, the light signal travels in a much narrower direct beam
- Core size is very small: 8-10 μ m
- Multiple signals can be transmitted in both directions at slightly different wavelengths
- Does not suffer from pulse spreading
- Distances possible in the tens of km
- Bandwidth into the hundreds of Gbps



- Standards for Singlemode are specified by the ITU (International Telecoms Union)
- All Singlemode fibres must meet G.652.D, whether that is OS1 or OS2 (Optical Singlemode Class 1 & 2)

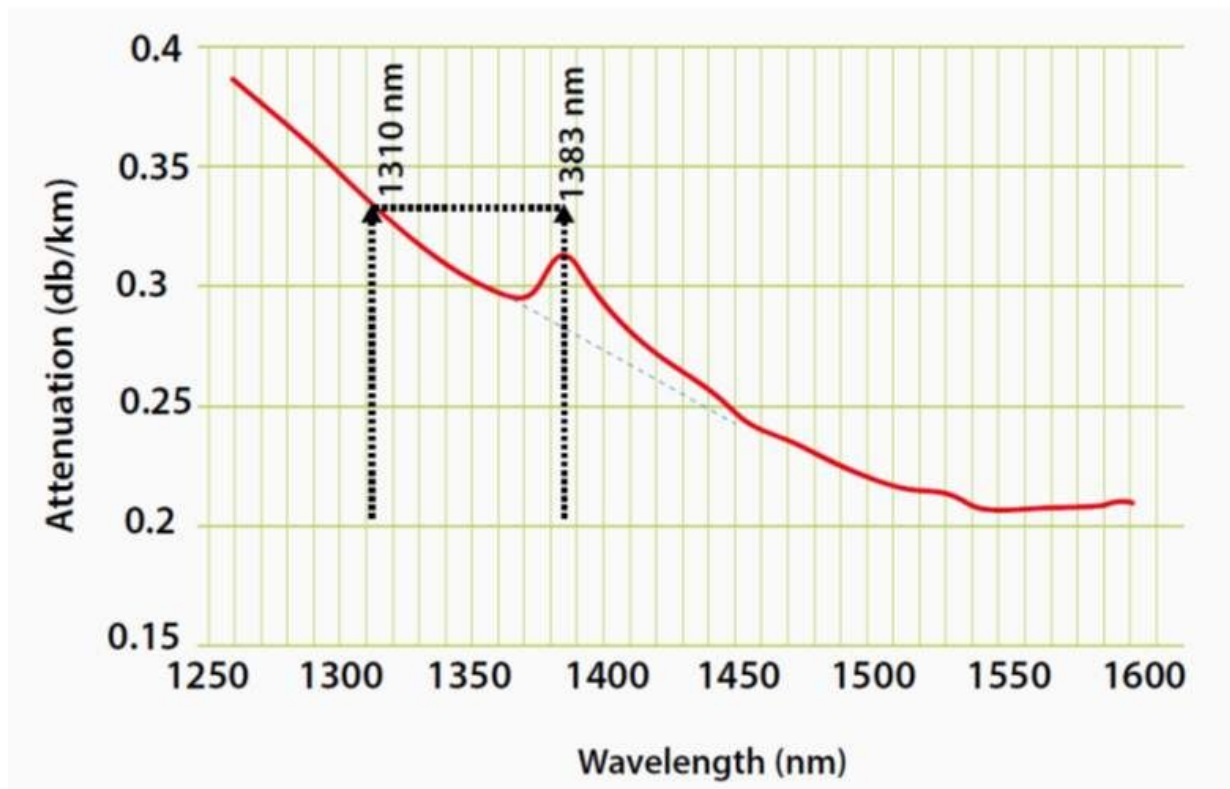
- There used to be limitations around the construction that would dictate whether the cable would meet OS1 or OS2
- All Excel Enbeam Singlemode meets the higher OS2, regardless of construction

 It is important to consider that if a cable meets G.652.D, it can also satisfy G.657.A. This covers whether a cable is bend insensitive or not and to which class. It relates to how tight the bend radii can be, which is particularly important with patch leads.

It has been used in Telecoms for a much longer period than we have used it in Datacoms, hence the ITU.

Low Water Peak

There is a term used in Singlemode Fibre which is ***Low Water Peak***, relating to the peak on the curve below.



Ethernet Application	OS1	OS2
Gigabit 1000BASE-LX	2,560m	5,000m
10 Gigabit 10GBASE-LX4	4,200m	10,000m
40 Gigabit 40GBASE-LR4	4,700m	10,000m
100 Gigabit 100GBASE-LR4	6,300m	10,000m

Ethernet Application	OS1	OS2
100 Gigabit 100GBASE-ER4	16,000m	40,000m

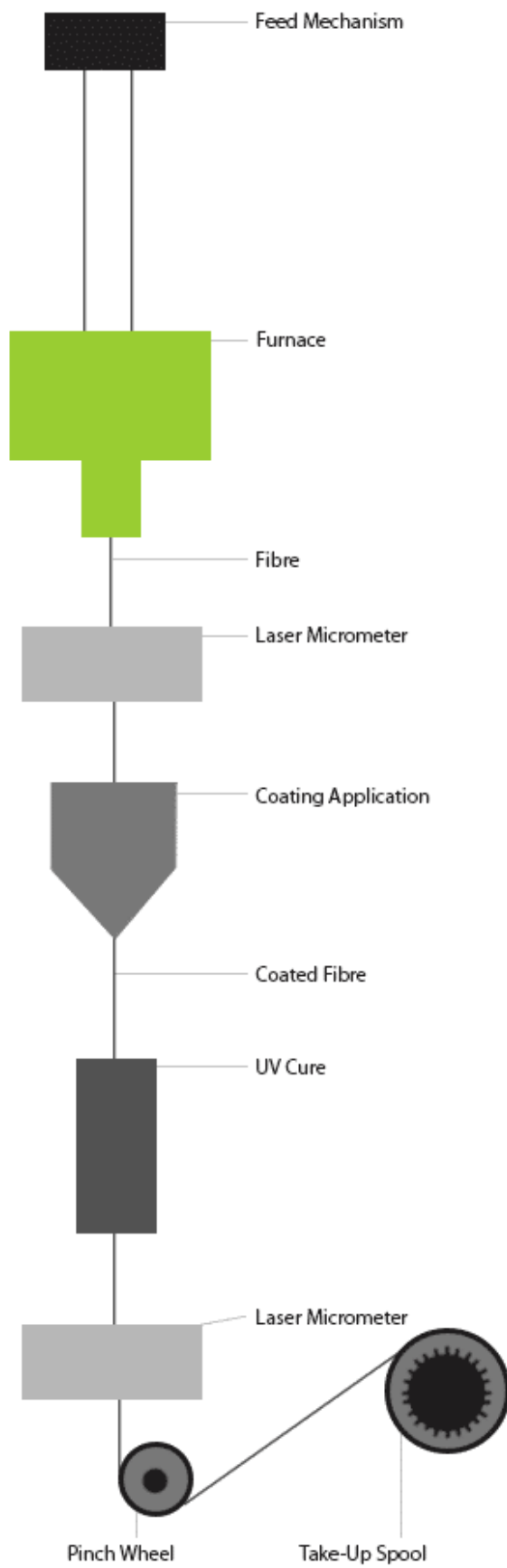


Higher bandwidth speeds have been ratified and will start to appear soon using multiple Singlemode fibres

Fibre Cable Construction

Fibre Manufacture

- The initial stage is to create a larger preform made up of a core and cladding, each has a slightly different optical index
- The next stage is to convert the manufactured preform into a thin fibre. This is done in an operation called Fibre Draw
- The tip of the preform is lowered into a high purity graphite furnace, then gravity takes over and allows the molten gob of glass to free fall until it has been stretched into a thin strand
- Once it is cooled the fibre then undergoes the two layer coating stage

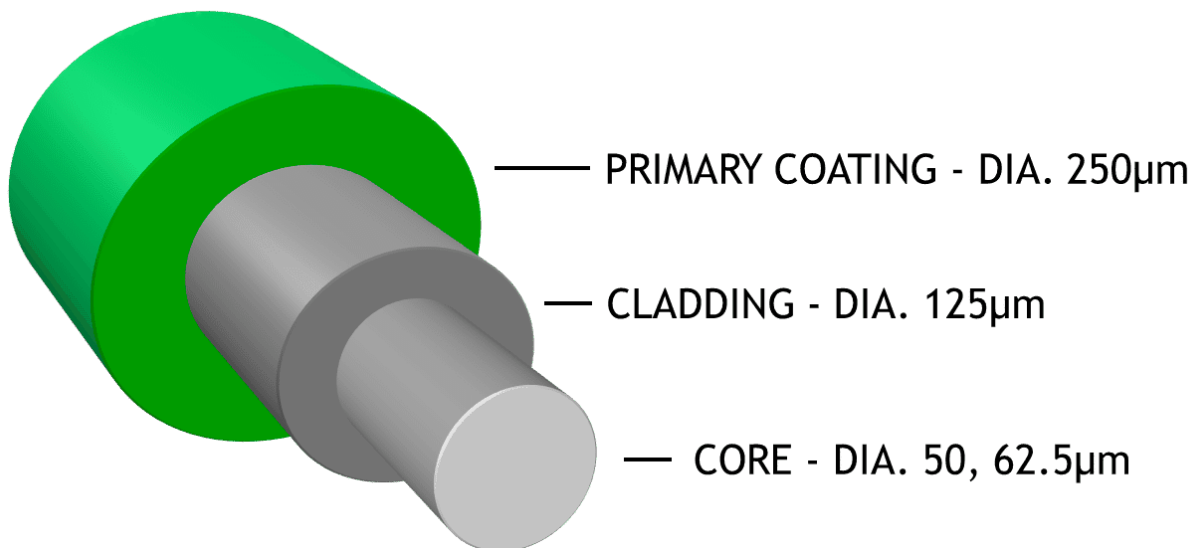


Fibre Draw Operation

During the draw process the diameter of the fibre is controlled to $125\mu\text{m}$ within a tolerance of only $1\mu\text{m}$. A laser based diameter gauge is used to monitor the diameter of the fibre. The gauge can sample the diameter of the fibres at rates in excess of 750 times per second.

A two layer protective coating is applied to the fibre; a soft inner coating and a hard outer coating. This two-part protective jacket provide mechanical protection for handling.

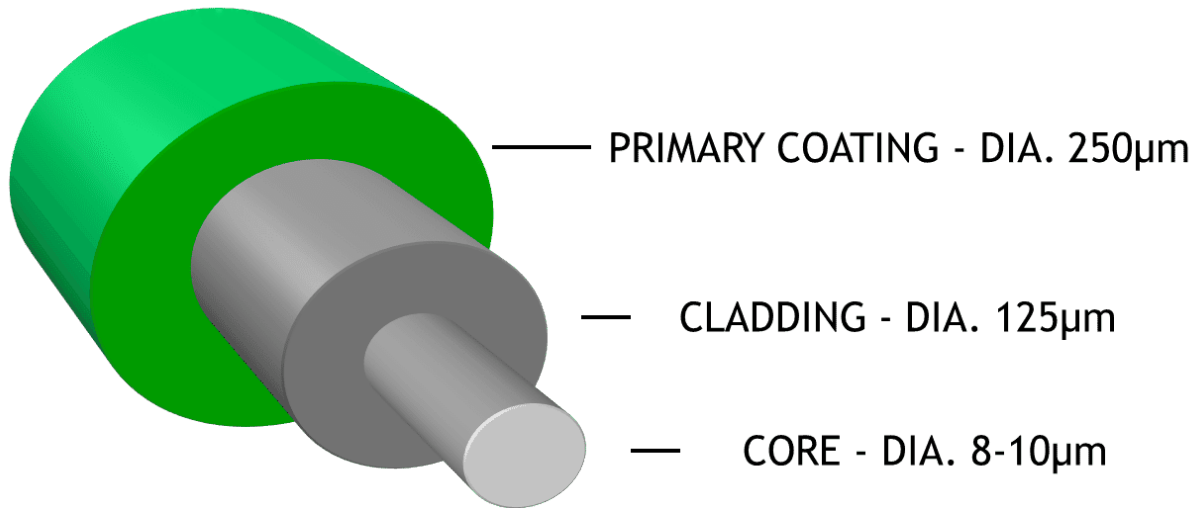
The drawing process is fully automated and requires virtually no operator intervention of the initial threading step.



Multimode Fibre

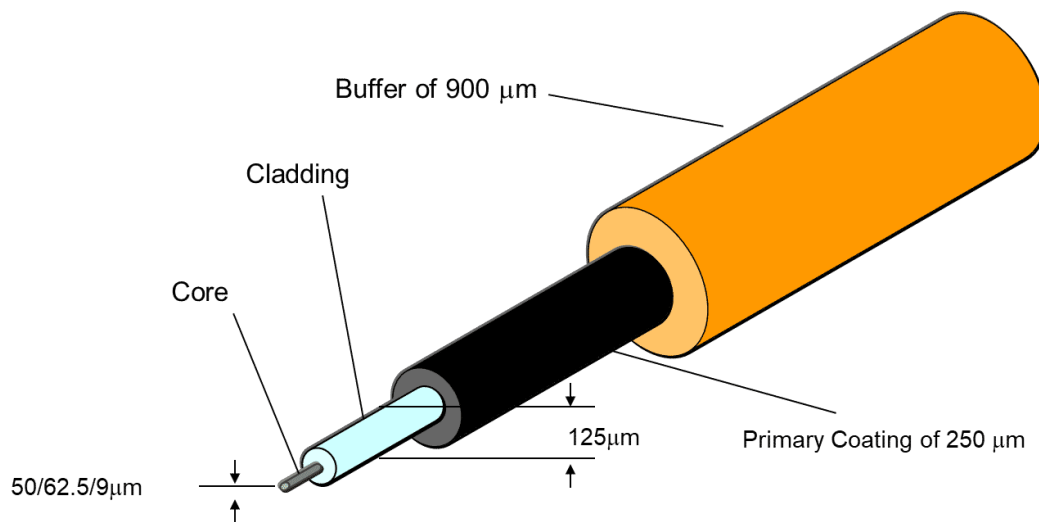
For the older OM1 and OM2 the core size was typically $62.5\mu\text{m}$ for OM3, OM4 and OM5 the core is now $50\mu\text{m}$. Fibre are referred to by their Core and cladding sizes, the latter is always $125\mu\text{m}$.

The reason the cladding is always 125µm regardless of whether it is SM or MM is down to the connector and ferrule technology



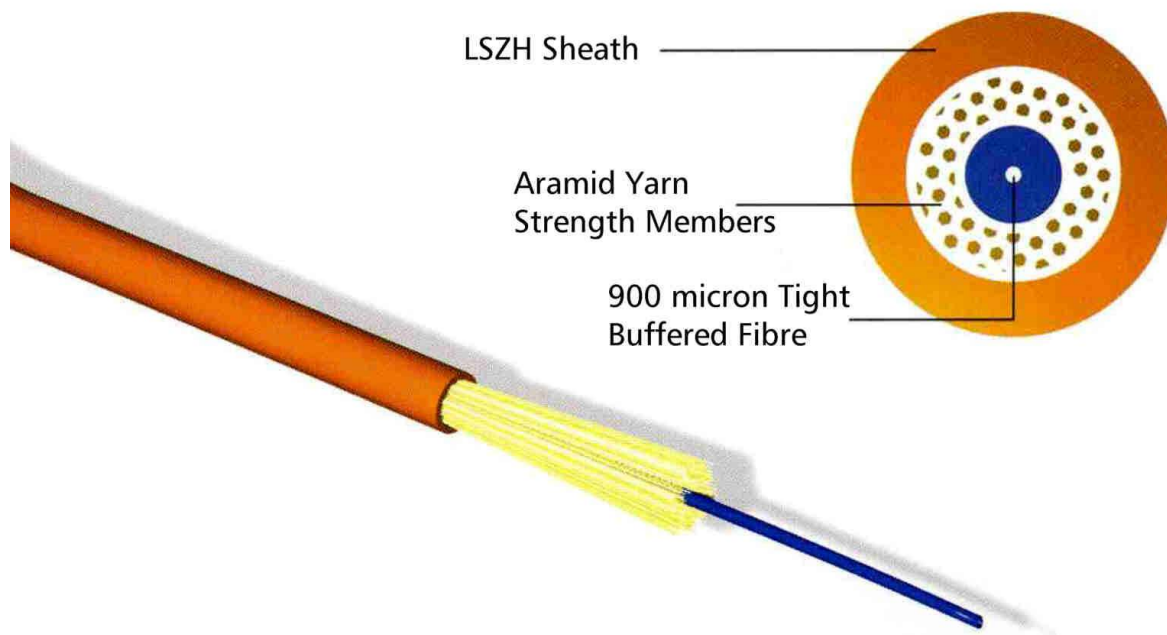
Singlemode Fibre

The primary coating is usually colour coded to help identify the fibres when terminating into patch panels. It is also carefully removed during the termination process.



Secondary Coated Fibre

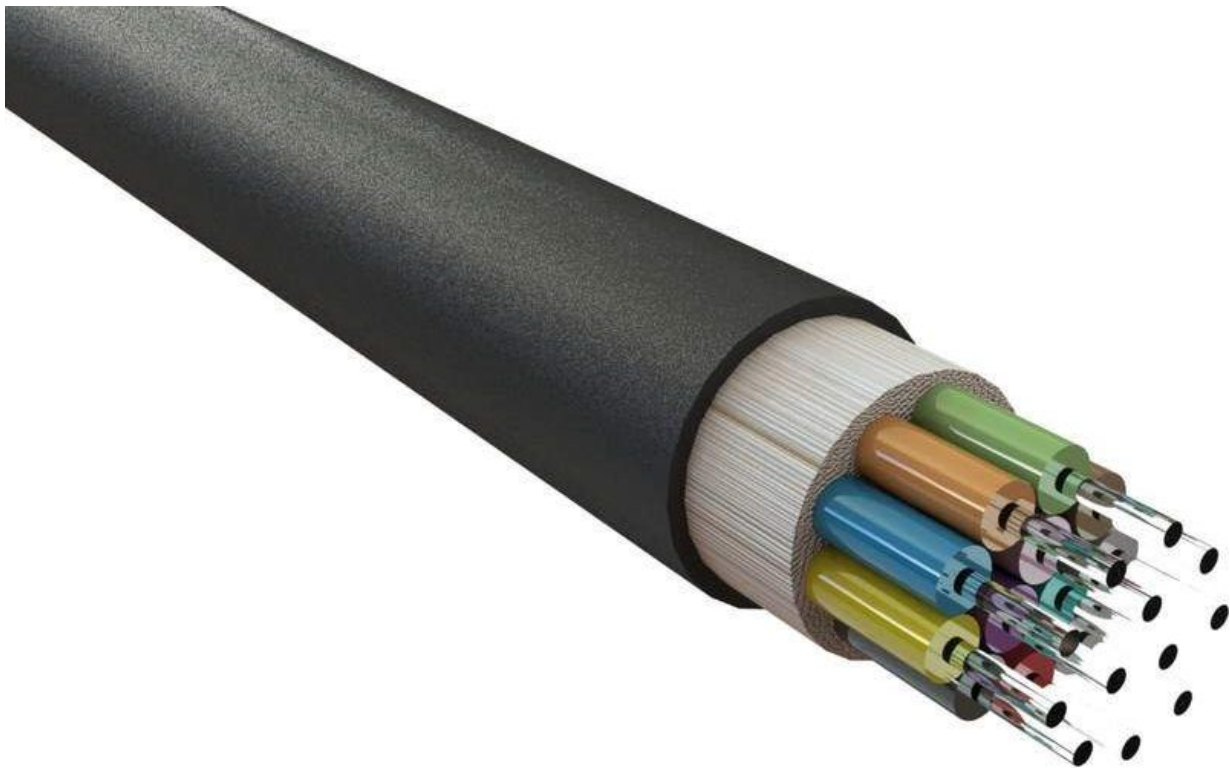
- Optical Fibre is then packaged dependent upon its use.
- The smallest version, is 900µm buffered fibre
- The typical use is the production of Fibre Pigtails
 - This can be single colour based upon its Category, typically Yellow for Single Mode or Aqua for OM3, Heather Violet for OM4 and Lime Green for OM5
 - Excel also supplies a 12 colour coded pack that match the colour code used in the Link Cable
- Pigtails are factory produced with a connector at one end, they are typically fusion spliced on to the main Fibre Link and dressed into the Patch Panel.



Tight Buffered Fibre

- Sometimes call Tight Jacketed

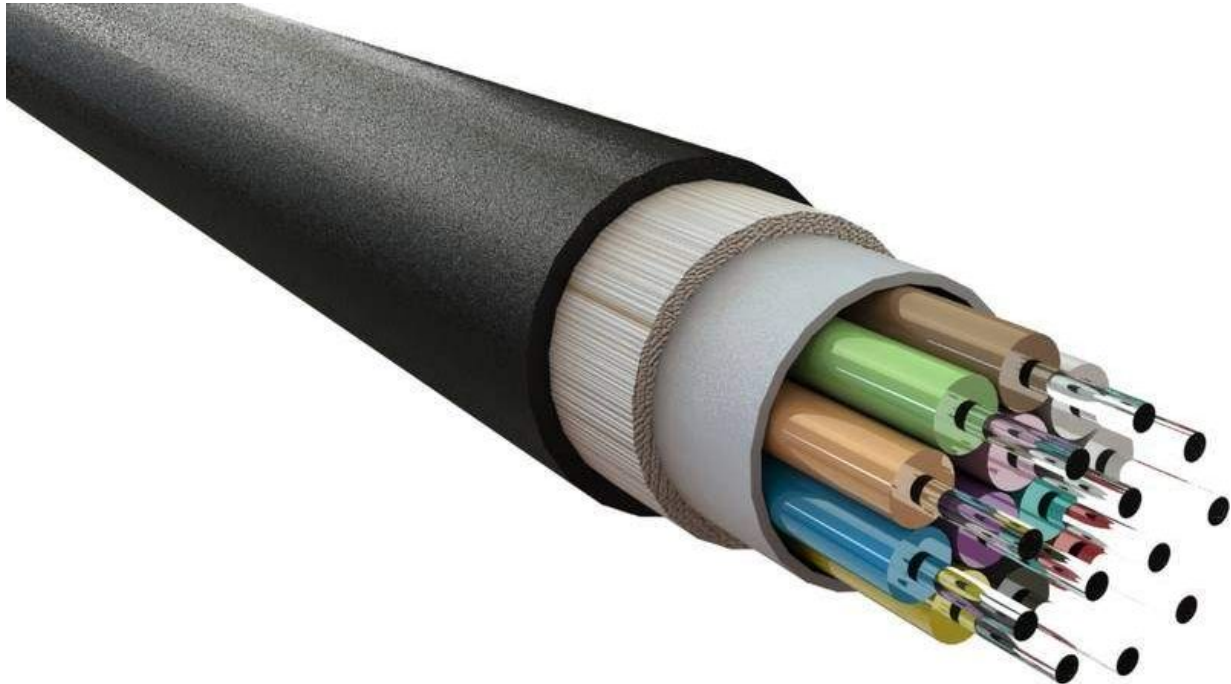
- The basic version is used for the production of Patch Leads
 - These are Simplex for SM and Duplex for MM
- 900 µm secondary coated fibre, with Aramid yarn (Kevlar) strength member and outer sheath.



Tight Buffered Bulk Fibre

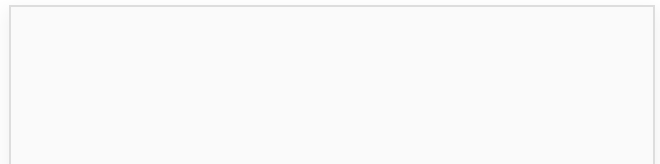
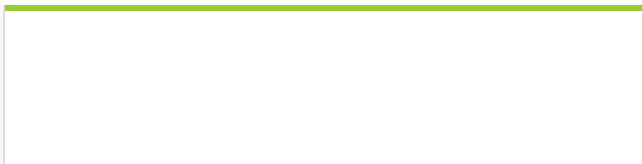
- Available in OM1, OM2, OM3, OM4, OM5 & OS2
- Core counts from 1-24
- Constructed from multiple 900µm buffered fibres
- With Aramid or Glass Rod strength member and an outer HDPE Copolymer sheath
- Buffered fibres are colour coded to T598-C for identification

These cables typically deployed within buildings with vertical risers. And used to connect comms rooms using patch panels.

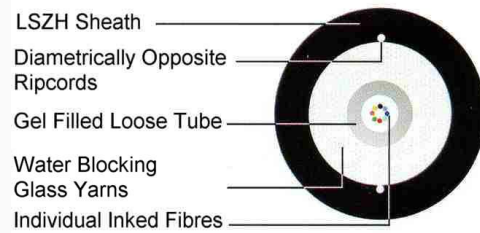


Loose Tube Fibre

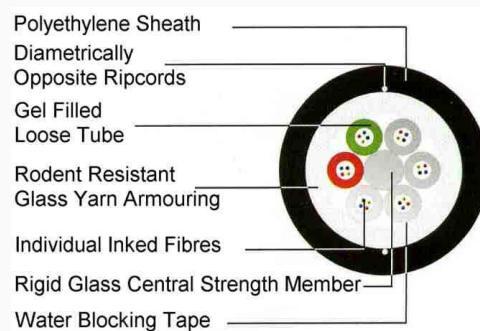
- Used for internal and inter-building links across a campus where some form of water barrier is required.
- Sometimes called a Universal Duct Cable.
- A central tube containing up to 12 colour coded 250µm primary coated fibres.
- Option for Multiple Loose Tubes with counts up to 96 (4 x 24 cores).



Loose Tube



Multiple Loose Tube



i Whilst the term Duct grade is used, this does not mean they are suitable for ducts that regularly get flooded, they are NOT submersible. Whilst both Tight Buffered and Loose Tube offer some protection they are NOT fully rodent resistant.

The original intended use of the words Duct Grade related to cables that are run in short lengths of duct between floors within a building.

Armoured Loose Tube

CST - CORRUGATED STEEL TAPE

SWA - STEEL WIRE ARMoured

CST, Corrugated Steel Tape, is fitted directly underneath the outer sheath

- Can be identified by the Blue jacket material
- A compact lightweight construction



CST - CORRUGATED STEEL TAPE

SWA - STEEL WIRE ARMoured

SWA, Steel Wire Armoured, wound underneath the outer sheath

- Black outer sheath
- Ultimate rodent protection
- Has a second sheath underneath the armouring
- Can be direct buried



Which Cable Should be Installed?

Intra Building Links

- Tight buffered fibre should be used for all routes between communications rooms, especially where vertical risers are involved
- Whilst many are sold as Internal/External, the latter only relates to short external runs around a building at high level. Even then it is recommended to provide some form of additional protection from the elements.
- You should not try to install loose tube cables in vertical risers; they are not intended for this purpose
 - a. The fibre is not tightly held in the tubes, especially gel-filled. This puts strain on the fibre and can cause it to break.
 - b. In relation to the CPR, the gel is typically a petroleum based substance that is flammable.
 - c. Dry loose tube fibres (that have a powdered substance and tape that immediately swell up when in contact with moisture) are available but they still do not support the fibre.

Inter Building Links

- The nature of the site and the environment will dictate which form of armoured loose tube construction should be used.
- Internal/External Tight Buffered cables can be used externally, but Loose Tube/Jelly filled cables are preferred.
- The term *Duct Grade* can be misleading; it means it can only be installed in a duct between floors.
 - a. It does not mean it is suitable for underground ducts that are liable to flooding, so check the integrity of the ducts and where they sit in relation to the water table.

- Most service ducts around a campus are subject to rodents, therefore some form of armoured protection is highly recommended.
- Rodents have less of an impact on Direct Burial Cables, as these typically have to be 600mm underground due to local regulations.
- Any external grade cable entering a building must be either terminated or transitioned to an internal grade within 2m of entering the building - unless the cable is enclosed in sealed metal conduit up until the point it enters the cabinet.

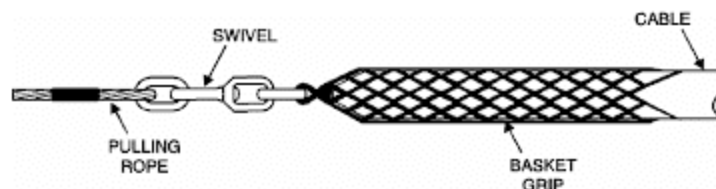
 **Blown fibre** may provide an suitable alternative in both of these environments, the pros and cons of which will be covered in the next module.

Fibre Cable Pulling

Pulling Tension

- Excel has installed Fibreglass reinforced plastic strength members
 - The cable should be installed using these strength members
- Never exceed the maximum pulling load rating for that cable
 - This can be found in the Specification Sheet for the cable
- On long runs, it is advisable to use the suitable lubricant
- If possible at least use a dedicated breakaway pulling eye

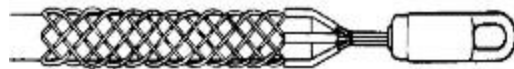
Cable Swivels



- Swivels or breakaway fuses should be used if cables are being pulled externally regardless if the method involved is mechanical or manual

- *Consult suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and specific lubricant application and use.*
- *2 adult males could generate up to 60nm pulling tension [600lb load]*

Cable Grip



Cables should not be pulled unless with a cable grip, which should be fixed to the strength member.

Pulling Rope

- An 8mm polyester or polyaramid rope must be used for optical fibre cables that are pulled by hand.
- When using a hauling winch, a 12,5mm or thicker polyester or polyaramid rope should be used as a hauling rope.

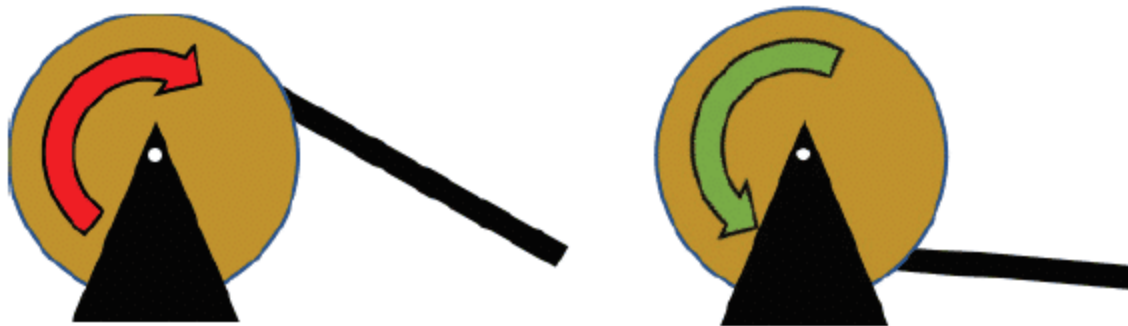
Bend Radius

- The normal recommendation for fibre optic cable bend radius is the minimum bend radius under tension during pulling, which is 20 times the diameter of the cable.
- When not under tension (after installation), the minimum recommended long term bend radius is 10 times the cable's diameter.

Avoid Twisting

Always roll the cable off the spool - never spin it off the spool end as this will put a twist in the cable for every turn on the spool. This twist in the cable will impart undue stress on the fibres inside.

Pulling Set Up



- Care must be taken due to Health and Safety
 - Many fibre cable reel/drum can be very heavy
 - Ensure you have sufficient staff to complete the task safely
- Pulling cable of the top of a reel/drum creates inertia which, if uncontrolled, can cause the reel/drum to become unstable
- In extreme cases the reel/drum can unseat from its axle stands or rollers towards the operative
- Pulling off the bottom of a reel/drum the direction it travels will be away from the operative

Technical Note

Please visit the Excel website to read our technical note entitled: "Recommendations for the pulling in of Excel Hybrid Fibre Optic Cables"

[READ NOW](#)

Fibre Attenuation Standards

The fibre cable, connectors and splices are all subject to maximum loss. Fibre cable is based on a loss per kilometer, therefore a calculation is required. Connector losses are always quoted as a mated pair.

Wavelength	Singlemode	Multimode
850nm	N/A	3.5dB/Km
1300nm	N/A	1.0dB/Km
1310nm	0.35dB/Km	N/A
1550nm	0.2dB/Km	N/A
1625nm	0.15dB/Km	N/A
Splices	<i>Mechanical or Fusion Splice Losses</i> 0.1dB Max. Video 0.3dB Max. Voice/Data	
Connectors	0.75dB Max OM4 0.5dB Max	

 OM4 has a tighter loss budget for connectors

Typical loss values are also much less with Connectors - 0.2~0.3dB Max and Splices – 0.05dB max

Fibre Connectors

Connector Requirements

- Low Loss, Typically 0.2 -0.75dB
- Repeatability of connection losses, 0.2dB per 1000 mating
- Ease of termination, without complication and expensive tooling
- Ruggedness, be able to withstand multiple handling

Types of Connector

- There are 12-15 different styles of fibre connectors - in this course, we will concentrate on the most popular versions
- Each one is typically made up of 4 main components
 - Ferrule (see note)
 - Body
 - Crimp Ring
 - Boot (2.5/3.0mm or 900µm)



- The ferrule is made from zirconia ceramic, which is an extremely hard substance also used in the production of dental crowns

- The hole in the ferrule is only a few micron bigger than the 125µm cladding on the fibre
- Ferrule diameter is either 2.5mm or 1.25mm

Straight Tip (ST) Connector

- Usually seen in legacy networks these days
- Bayonet housing for easy termination
- 2.5mm ferrule
- Crimp ring secures the aramid yard to the body of the connector



Subscriber (SC) Connector

- Push-Pull connector
- Can easily be converted into duplex with the use of a clip
- Heavily used in Fibre to the Home (FttH) and PON installations
- 2.5mm ferrule
- Available as both UPC and APC

Colour Code

Beige – No designation (usually used with OM1 & OM2)

Aqua – OM3

Heather Violet – OM4

Lime Green - OM5

Blue – OS2 UPC

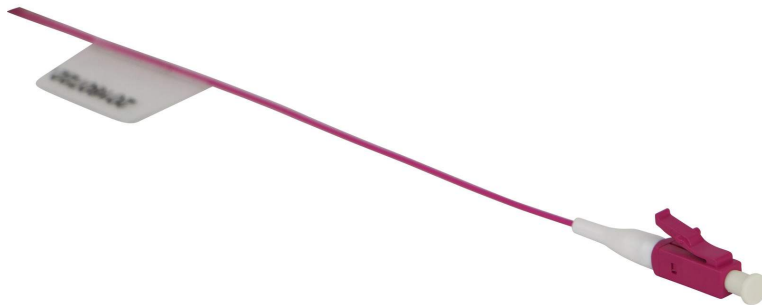
Green – OS2 APC



Lucent (LC) Connector

- Available in both duplex and simplex versions
- Small Form Factor Connector (SFF)
 - LC Duplex adapter fits the same aperture as a SC Simplex
- 1.25mm ferrule
- Was produced due to demand for High Density especially within the Data Centre

When the demand for an SFF was announced the LC had many competitors, such as the FJ, VF-45 and the MT-RJ. However, Lucent made the design 'Royalty Free' therefore anyone could make it, hence it is probably the most common connector deployed in new networks.

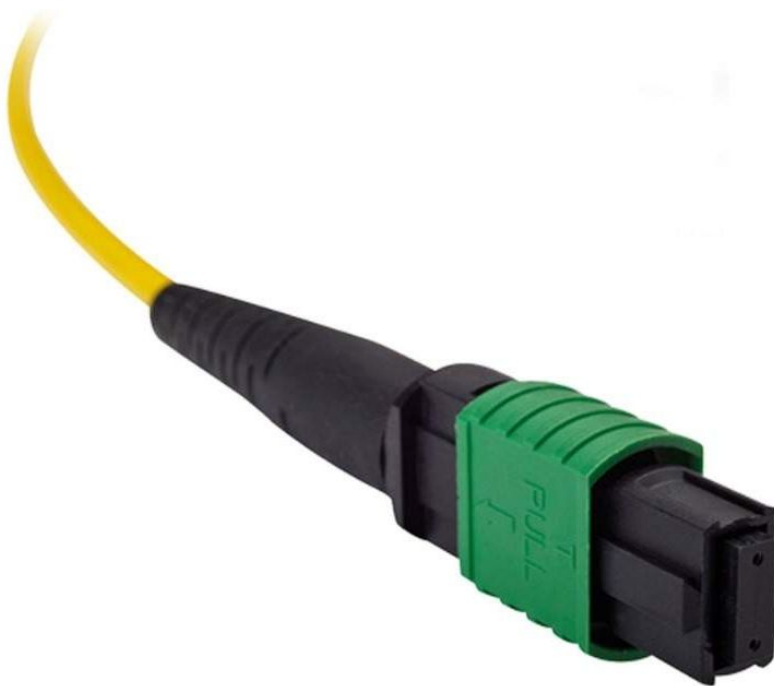


MPO or MTP

- This connector has been in common use for over 20 years now.
- MTP by USCONEC is a variation on the MPO

- **M**ultiple fibre **P**ush on-pull **O**ff
- **M**edia **T**ransfer **P**rotocol
- Key difference between MTP and MPO is that the former is 'Keyed'.
- Available is 8, 12, 16, 24 fibre versions.
- Excel uses the MTP Elite low loss connector.

Available in OM3, OM4 and Singlemode – The latter is only supplied as APC to ensure the low losses. Typically deployed in Data Centres and Main Equipment Rooms. (MERs)



Other Connector Types

- FC Connector – Almost exclusively Telecoms based
 - Designed for SM
 - 2.5mm ferrule

- Screw type connector, that looks similar to the ST
- E2000 – Used for FTTh
 - Singlemode only
 - Spring loaded front cover for dust and laser safety
 - Factory termination only

Enbeam MTP System

- **Consists of;** trunk cables, patch panels, LC cassettes, patch leads (MTP-MTP) and fanout assemblies (MTP-LC)
- **Benefits include;** factory terminated, factory tested, easy to install, fast turnaround

MTP connectors come either pinned or unpinned, these are the alignment pins referred to as 'keyed' these ensure the fibre cores are perfectly aligned to ensure the light signal travels through the connection.

Excel has followed the guidelines of EN50174 which calls for the trunk cables to be pinned and MTP Patch Leads and Fanout assemblies to be unpinned. The key reason for this is, all MTP interfaces on the hardware equipment has alignment pins.

MTP Polarity

- There is a lot of confusion about which Polarity method to use. There are 3 standard ones and a certain manufacturer has their own modified version of one of them.
 - a. EN & ISO (which are the same)
 - b. EIA/TIA have Methods A, B & C
- Excel will ask one simple question:
 - If you put light in Core 1, where do you want it to come out?
 - Core 1
 - Core 12
 - Core 2
 - If it is:
 - Core 1 – TIA Method A
 - Core 12 – TIA Method B (also the same as the recommendation of EN 50174 -1 and ISO/IEC 14763-3)
 - Core 2 – TIA Method C
- Excel's solution is to provide a system that meets TIA Method B as well as ISO and EN and if any other polarity is required it is accommodated by the use of special cassettes at one of the ends to do the changeover.

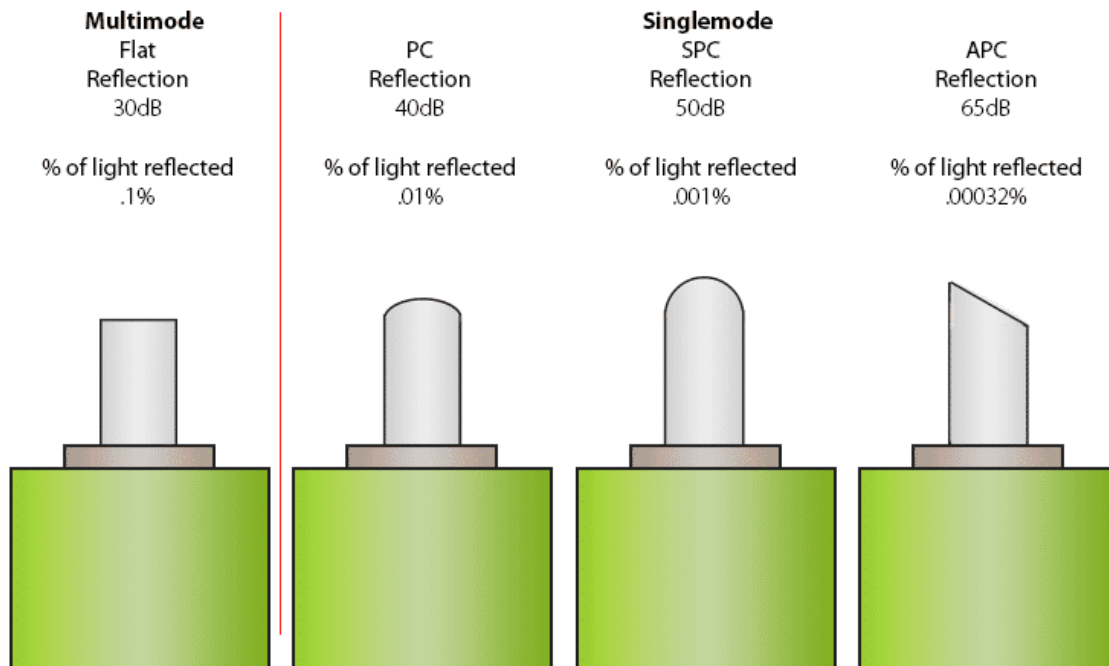


The most common method used is B, as this is the one that lines up with the MTP interfaces on the hardware equipment, as 1-4 is transmit and 9-12 is receive.

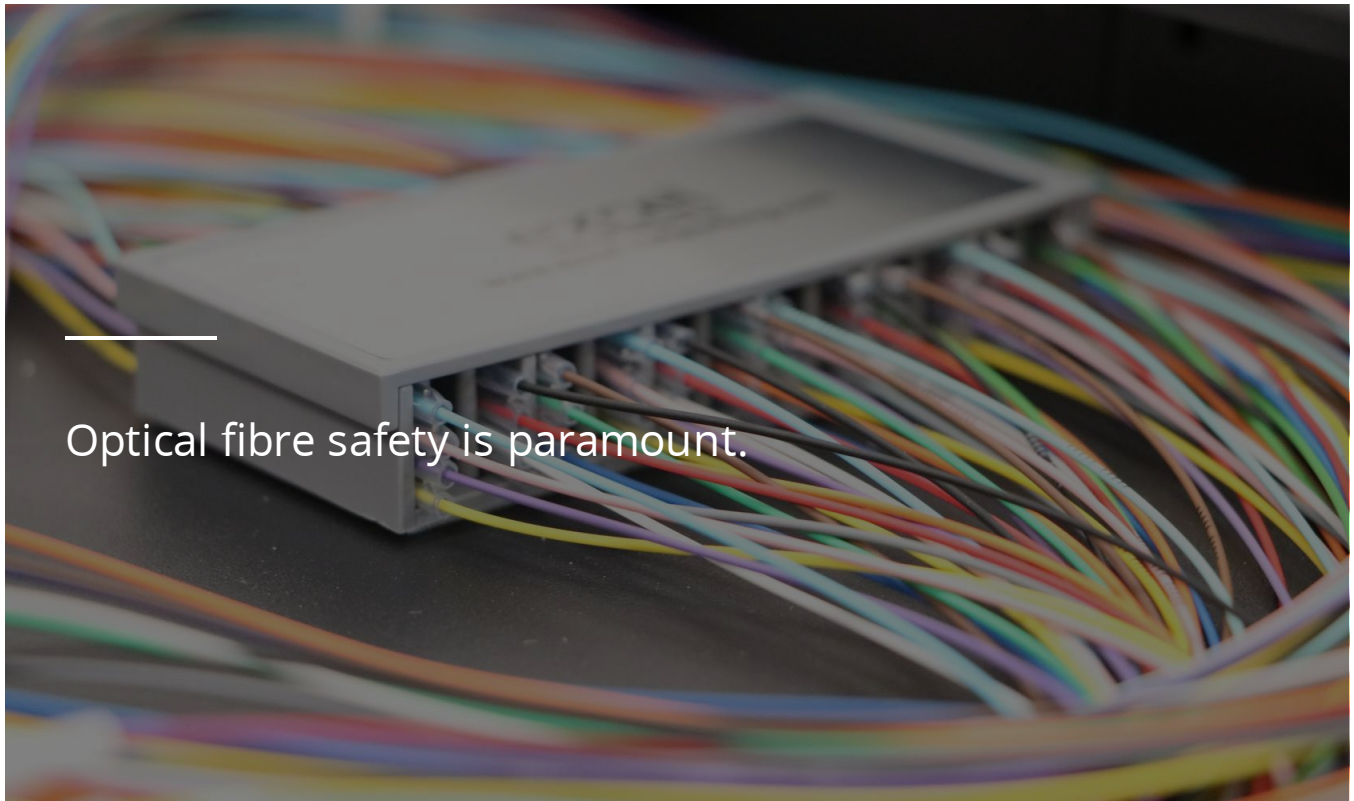
Method C is sometimes used if MTP is being used as a fast turnaround option in the Enterprise to replace traditional fibre.

Connector Polishes

- The percentage of light reflected reduces the signal.
- Nearly all modern connectors have a PC polish. (Physical Contact)
- SPC is 'Super PC' and UPC is 'Ultra PC'. All standard connectors now tend to be UPC. (Ultra-Physical Contact)
- APC is heavily used for Singlemode. (Angled Physical Contact)
- APC has an 8° angle.



Fibre Termination: Preparation



Fibre Offcuts/shards: Optical fibres can be brittle and sharp; do not allow to penetrate skin; don't ingest

Place all cleaved/waste fibre in receptacles especially designed for safe disposal (e.g. sharps bin or cinbin)

Glue and Polish or Direct Termination

Regardless of method to be used there are key tools and safety equipment required:

- Sheath Stripper
- Kevlar or ceramic shears
- Fibre stripping tool, to remove the buffer or coating
- Fibre Scribe or Cleaver
- Safety Glasses
- Fibre Disposal or 'Sharps' Bin

On top of this if you are doing **direct termination** of the connector you will need:

- Epoxy (or Anaerobic adhesive)
- Syringe (for above)
- Polishing Puck
- Polishing Paper
- Polishing Plate
- Rubber Pad

Step 1

Prepare the Fibre and Connector

1. Clean bared fibre IPA
2. Flare kevlar
3. Insert syringe into rear of connector
4. Inject epoxy
5. Insert fibre as shown
6. Insert until 900 μm butts up to rear of connector
7. Spread flared Kevlar over crimp area
8. Locate and crimp

Step 2

Curing

1. Bring up strain relief boot
2. Place connector in oven
3. Remove connector from oven
4. A small amount of epoxy should be visible on the connector face + 10 mm of fibre protruding
5. Cleave the fibre/dispose of waste (Shard)

Step 3

Polishing

1. Start with air polish on 12–30 μm paper. This is done lightly with the paper inverted
2. Clean polishing plate and equipment
3. Place 3 μm paper on plate
4. Place connector in puck and lightly polish in figure of 8

Please Note

It is recommended that if you intend to direct terminate fibres in the field you attend a dedicated practical course to practice and develop your skills.

Fusion Splicing

Fusion Splicing is the most common form of field termination. The most common problem encountered is forgetting to slide on the splice protector before you start. Mechanical Splices are also available, however these should only be used as a temporary fix.

- The initial step with fusion splicing is to ensure you slide a splice protector over one of the fibres.
- Strip the fibre down to the cladding, then cleave the fibre accurately to the correct length.
- Place the fibres into the splicer clamps carefully. The fibres have to be close but the final alignment adjustment is carried out by the Fusion Splicer.
- The splice equipment then generates a small electric arc which melts the fibres and welds them together.
- Once complete, slide the splice protector over the section spliced and place in the heat-shrink oven to complete the task.

Hot Melt

- Proprietary solution
- Uses a pre-glued connector
- A small oven is used to melt the glue, after which the fibre is inserted
- As the glue cools it holds the fibre securely
- Then follow the same steps for direct termination

Fibre Patch Panels

Excel 1U Fibre Patch Panel

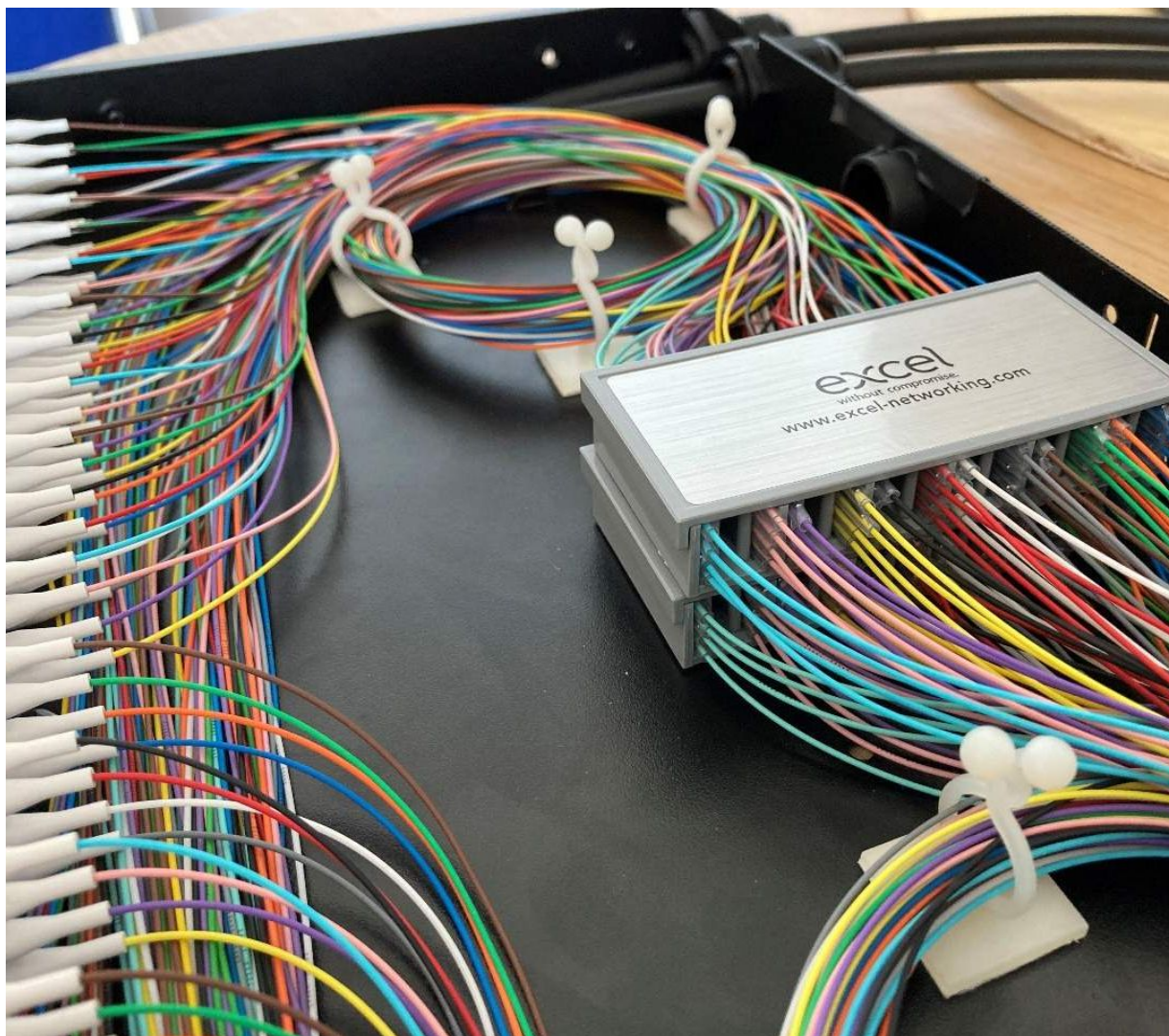


1. Multimode or Singlemode
2. Choice of Port Density e.g. 12 port LC Duplex/24 fibre
3. Complete with Management and Fixing Kit
4. Multiple rear entry points
5. Sliding Drawer Mechanism
6. Colour Coded adaptors
7. Available loaded with Pigtailed

 Adaptors are sometimes known as Couplers or alignment sleeves, as they are the mechanism that ensures the connector ferrules are precisely aligned. Each plastic body contains a sleeve either phosphor bronze or the better ones have a split zirconia ceramic sleeve.

Patch Panel Dressing

The splice protector shown is designed for 2mm Splice protectors, trying to use 3mm Splice Protectors will not work correctly. For fibre counts over 12 the code is repeated. Fibres 13-24 have a black dot or band every 70mm. For fibre 25-36 it is repeated and has 2 dots or bands.



1. Carefully dressing the fibre and pigtails in the patch panel is crucial
2. The fibre is fragile at this stage and can be easily damaged
3. Use the 'bunny' clips provided in the kit to create a consistent loop
4. The splice protectors are then housed in the holder
5. The colour code to follow is T598, which is:
 - 1 = Blue
 - 2 = Orange
 - 3 = Green

- 4 = Brown
- 5 = Slate
- 6 = White
- 7 = Red
- 8 = Black
- 9 = Yellow
- 10 = Violet
- 11 = Rose
- 12 = Aqua

Fibre Cleaning

Inspection

- The first step in fibre cleaning is always to inspect
- 85% of failing links are down to 'end-face' contamination
 - #1 fault encountered – according to Fluke Networks
- A human hair is between 50-75µm
- Cenelec published EN61300-3-35 to grade connectors

Visual Requirements for PC Polished Connectors, Singlemode Fibre, RL ≥ 45 dB		
Zone Name	Scratches	Defects
A: Core	None	None
B: Cladding	No limit ≤ 3µm None > 3µm	No limit ≤ 2µm 5 from 2µm to 5µm None > 5µm
C: Adhesive	No limit	No limit
D: Contact	No limit	None-> 10µm

Visual Requirements for PC Polished Connectors, Singlemode Fibre, RL $\geq$ 45 dB

NOTE 1 - For scratches, the requirement refers to width

NOTE 2 - No visible subsurface cracks are allowed in the core or cladding zones

NOTE 3 - All loose particles should be removed. If defect(s) are non-removable, it should be within the criteria above to be acceptable for use

NOTE 4 - There are no requirements for the area outside the contact zone since defects in this areas have no influence on the performance. Cleaning loose debris beyond this region is recommended good practice

NOTE 5 - Structural features that are part of the functional design of the optical fibre, such as microstructures, are not considered defects

 **None** means nothing allowed

No Limit means they are allowed but they must be less than the value quoted

Human Skin has natural oil, no matter how dry you think your skin is. It can have a dramatic effect on performance and it spreads on contact. The key to getting this right is to use the best fibre inspector you can afford. A small piece of debris between the connectors end-faces can cause air gaps, which results in high reflections and high losses.

Excel Whitepaper

The importance of cleanliness when handling fibre

[READ WHITEPAPER](#)

Excel Whitepaper

Best practices for fibre optic installation start with inspection & cleaning

[READ WHITEPAPER](#)

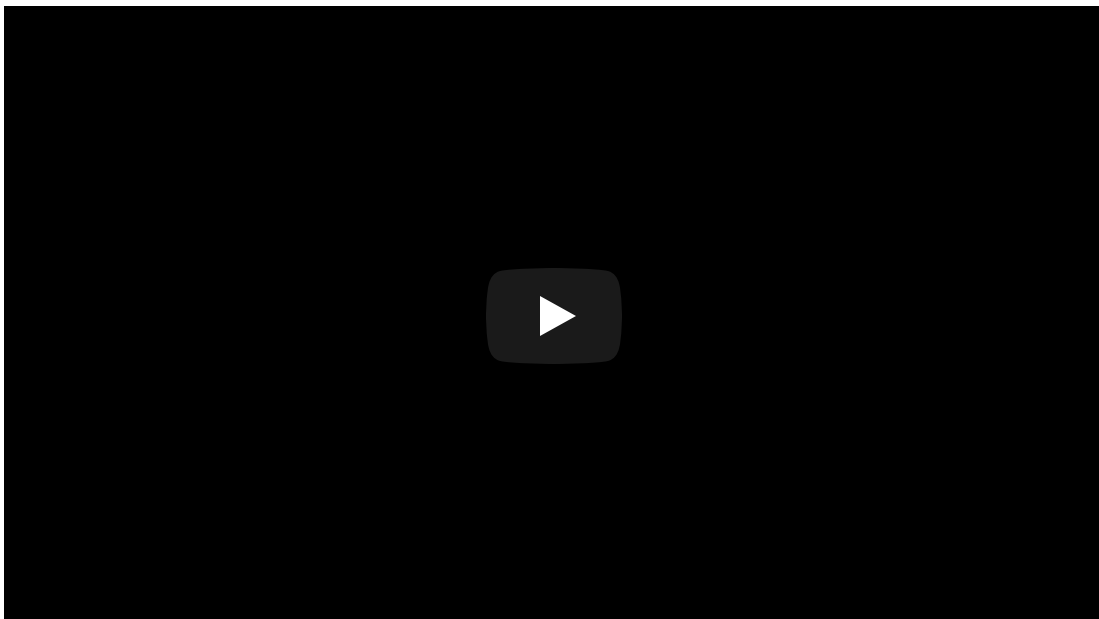
Excel Fibre Cleaning Infographic

The infographic provides useful information about keeping fibre clean and using the most effective cleaning method for your application.

[VIEW INFOGRAPHIC](#)

The following videos demonstrate the recommended fibre cleaning process using Chemtronics fibre cleaning products, available through Mayflex and Excel Networking. To watch the full library of Chemtronics fibre cleaning videos, visit our [Youtube channel](#).

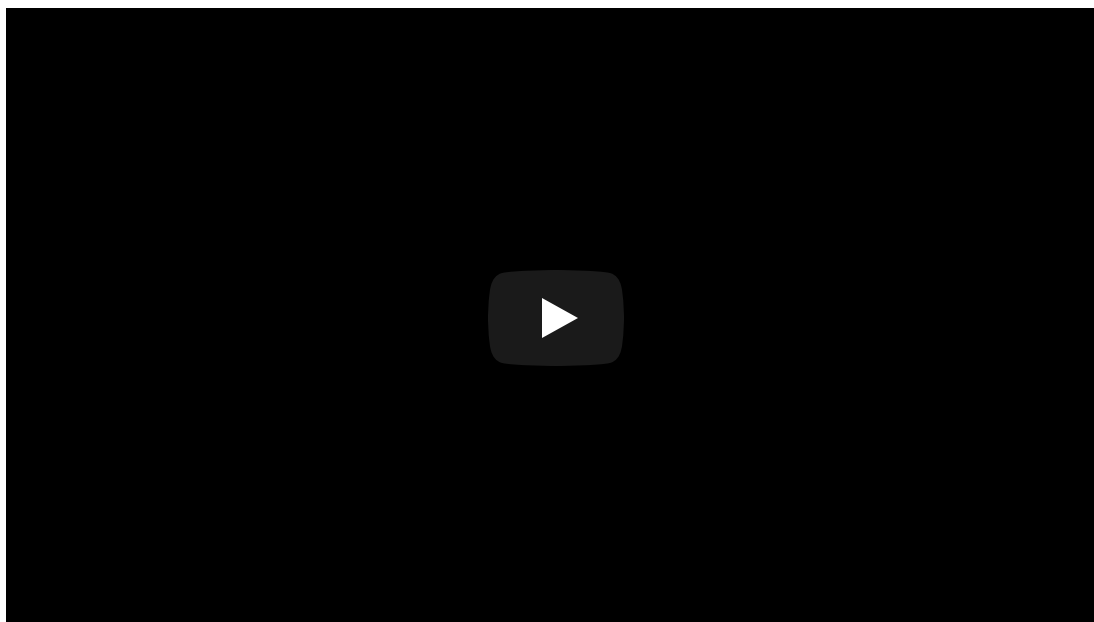
 **YOUTUBE**



ITW Combination Cleaning Process Complex

[VIEW ON YOUTUBE >](#)

 **YOUTUBE**



FOCCUS CCT VIDEO

VIEW ON YOUTUBE >

Blown Fibre

Blown fibre was originally designed for the carrier networks as an alternative to conventional fibre optic cabling methods and installation. It is based upon a tube network that is installed and fibre units that are blown in as required. It offers several advantages over conventional installations, including:

- Reduce tension on cable
- Macro and micro bends reduced or eliminated
- Flexibility in installation options
- Capacity for future growth
- Lower cable attenuation
- It uses multiple fibres
- Fibres that are blown out can be reused
- The blows can be cascaded
- It is a total cable solution
- It offers integrity and extra length
- The tube can be tested before the fibre is blown in

One key feature is speed of repair, if a traditional fibre cable is damaged the old one needs to be removed from the route and a new pulled in, if this involves ducts or direct buried cables this can be a very time consuming task. With Blown Fibre, you repair the damaged section of tube, blow out the old fibre and blow in a new fibre unit, which results in a huge time saving.

Blown Fibre Installation

This module will only give a very quick overview. For Health and Safety reasons you will have to attend a specific practical course before you become qualified to install Blown Fibre. Please speak to your Mayflex or Excel sales representative for more information, or email admin@excel-networking.com.

Step 1

Install the Tube Network

- The initial stage is to install the tube network, available from 1-24 tube units.
- Care needs to be taken regarding the bend radius. Lots of bends can cause difficulty in blowing the fibre units.

Step 2

Set up Equipment

- It is then a case of setting up the blowing equipment and compressor, as you will be dealing with 10bar of pressure safety is critical, hence the specific course

Step 3

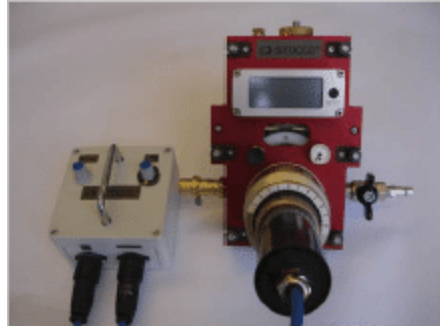
EPFU



- The EPFU (enhanced performance fibre unit) are available in 4, 8 & 12 core counts and come in returnable EPFU Dispersion Pan plastic pans containing 2Km

Step 4

MicroJet Blowing Head



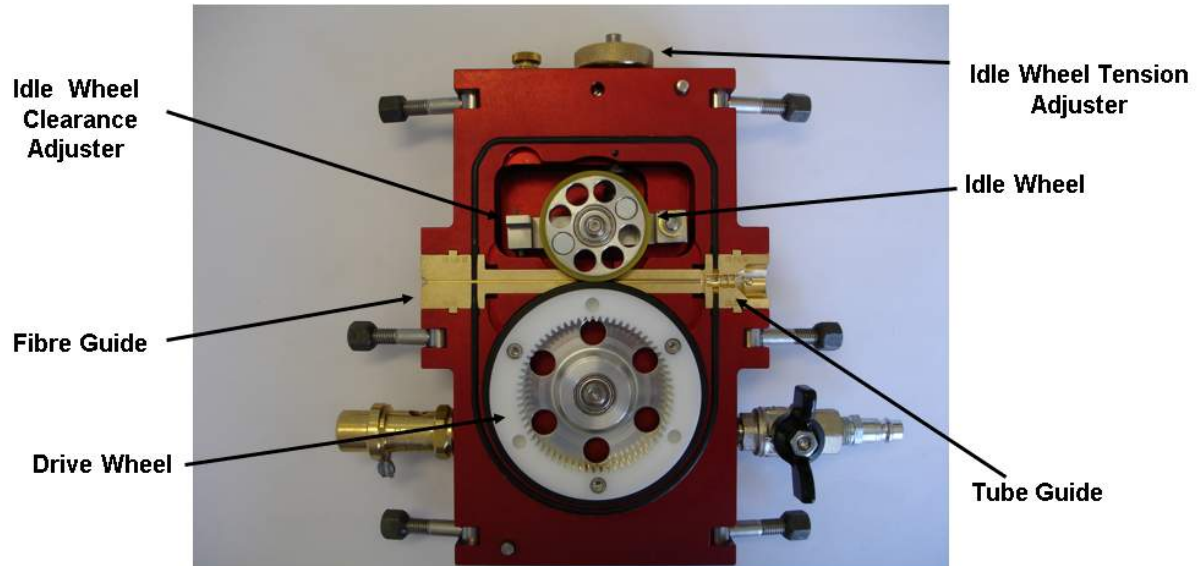
- The MicroJet Blowing Head introduces the compressed air as well as the mechanical force to push the EPFU into the microduct tube
- It has both a speed controller and clutch to avoid any damage to the fibre if it becomes stuck

Step 5

'Fly' the Fibre

- The fibre units are actually pushed into the tube and the compressed air acts like a lubricant to 'fly' the fibre down the tube

Summary



If you have designed your tube network correctly and undergone the practical training in the use of the equipment, blowing fibre is a very straightforward task.

An Introduction to POL (Passive Optical Lan)

Key Acronyms

GPON

Gigabit Passive Optical
Network

PON vs POL

- Passive Optical Network
- Passive Optical LAN

The carrier network vs In-
building Local Area Network

OLT & ONT

- Optical Line Terminal
- Optical Network Terminal

 The term GPON can be confusing, as it is actually 2.4Gbe downstream from the OLT to ONT and 1Gbe upstream

Where did it come from?

- The first system to be deployed was by Verizon
- Intended to provide Voice, Data and Video (Cable TV) to the home
- As it is based on singlemode fibre, it can support large distances without degradation in bandwidth
- Standards Based
 - ITU G984, G 987, G989
 - ANSI/TIA 568D

- ISO11801
- Carrier grade technology, extremely resilient

Key Benefits

- The term Passive comes from the fact that it doesn't have any Ethernet switches in the Midspan
- This removes the requirement for Equipment rooms full of rack and switches on every floor
 - Savings on space
 - Savings on power
 - Savings on cooling
 - Fibre is smaller than copper, therefore less space is required on containment
- All of the above leads to both Capex and Opex savings
 - The latter is a year on year saving that could be as much as 50-60%

One downside of POL, is the fact that both the OLT and ONT should could from the same vendor, due to the management system used. **Remember!** 2.4Gbe downstream and 1Gbe upstream.

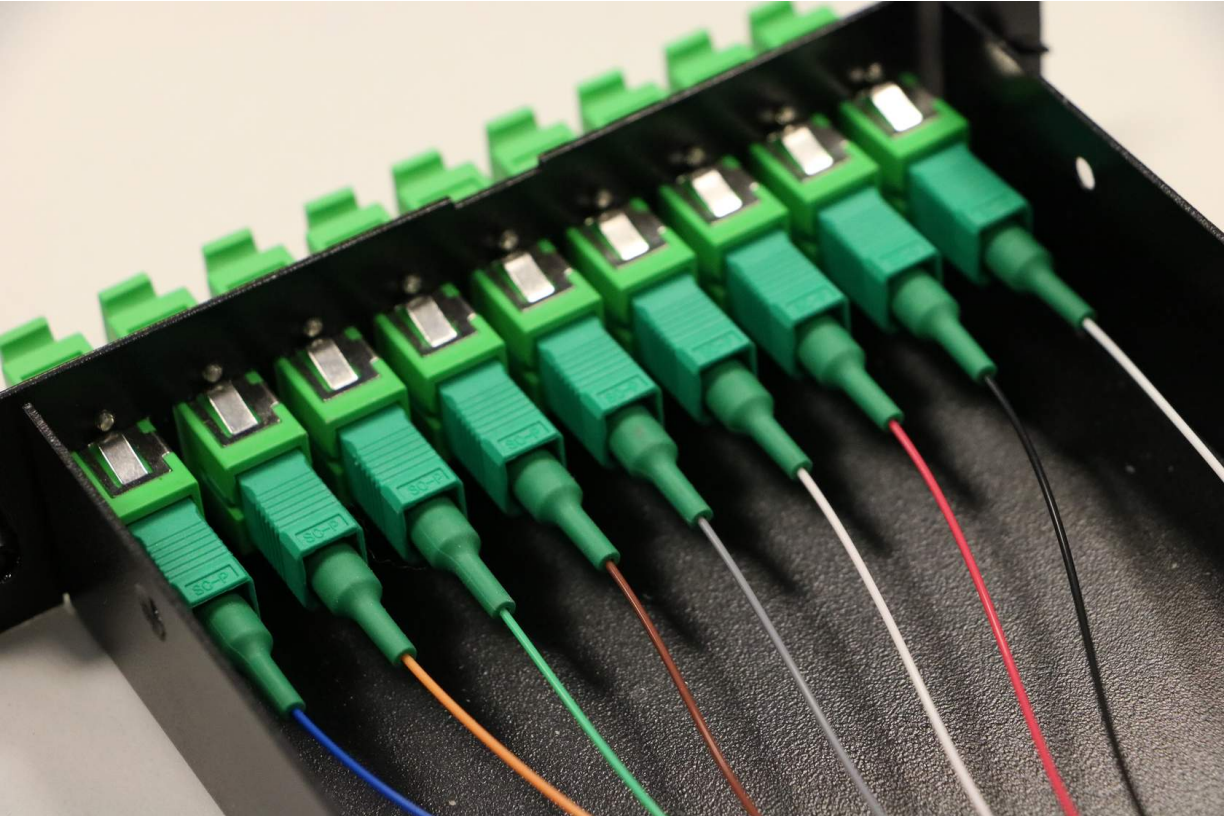
Three Key Components



OLT – Optical Line Terminal

- 48VDC Carrier Grade Chassis
- After Layer 3
- Up to 14 Line cards
- Typically 4 singlemode output ports per card
 - = 56 Outputs per chassis

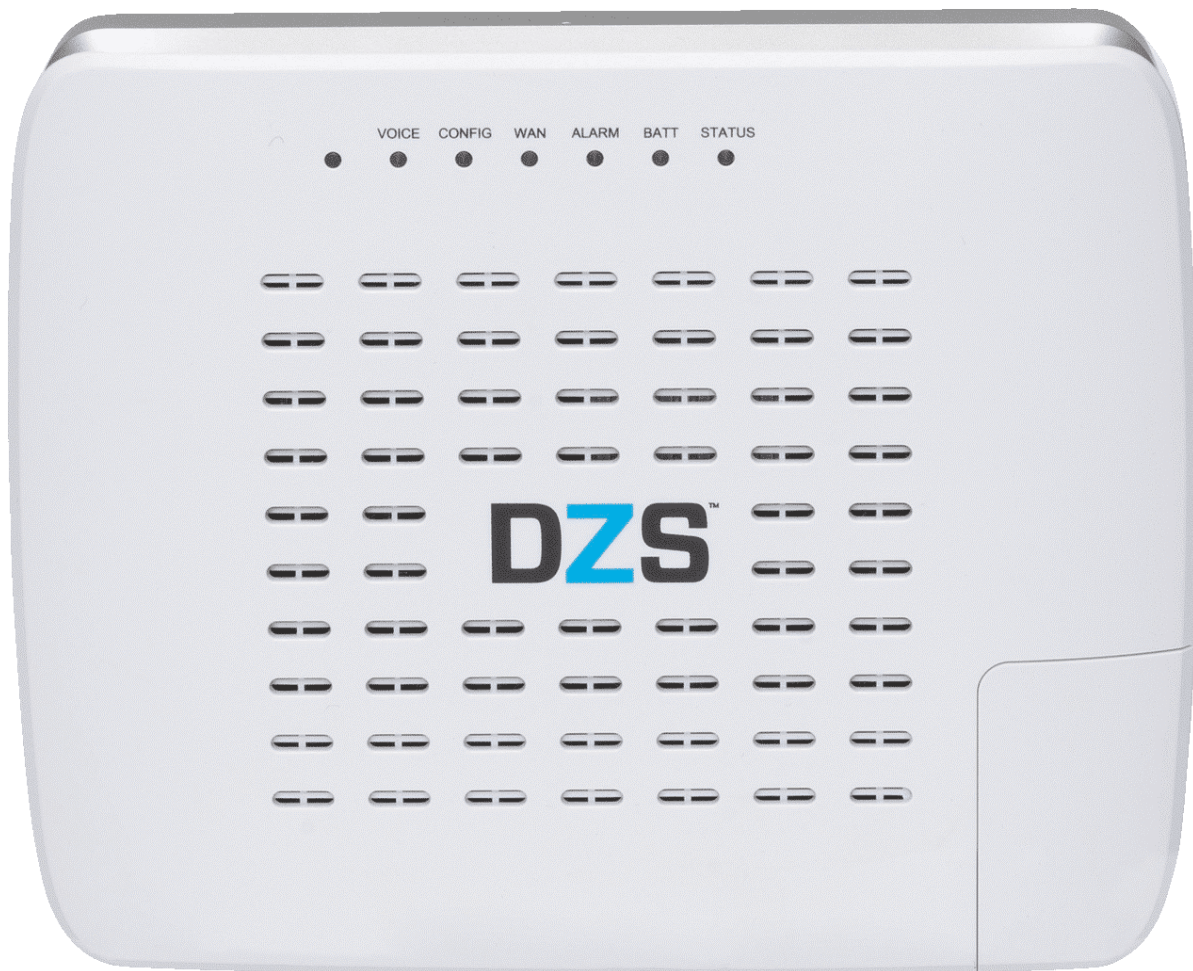
- = 1792 ONTs when 1 x 32 Optical Splitters are used



Optical Splitters

- Splitters provide optical connections in pairs
- Each 1 x 2 split equates to half of the optical power
 - 3dB
- Splitters range from 1 x 2 up to 1 x 64
- 1 x 32 is the most common split ratio for POL

Splitters can be housed in a small enclosure or cabinet at any point between the main equipment room and the end ONT, they do not require power or cooling and are totally passive.



ONT – Optical Network Terminal

- Active equipment provided by electronics manufacturers.
- Located near the user or device
- Typically 4 or 8 RJ45 (10/100/1000Gbe) outputs with optional POE
- Up to 60W of available POE (vendor specific)
- Standard HVAC is adequate

- Optional internal or external battery back-up
- POTS and COAX ports available (POTS- Plain old telephone system)
- Establishes and maintains secure AES 128 Encryption
- Supports multiple VLANs on each port

You can connect anything that requires an Ethernet, POTS or Coax (video) connection. Whilst 4 & 8 port devices are the most common you can also get 24 and 48 port rack mount ONTs