Fiber Optics

Cable Construction
Connectors
Splice
Assemblies
Testing

Fiber Optics: Fiber Cables

Fiber Optics

Fiber Optic use started in the early 1970's. Corning Glass Works developed a fiber optic cable with a loss of 20dB/km, today many fiber optics have extremely low loss- .5dB/km for Single-Mode.
During the 1980's telephone companies began to deploy fiber throughout their networks. By implementing a fiber network, telecom companies could future proof their systems backbone.

Fiber Optics is used in many applications such as: Telecommunication, High bandwidth Data, Video signaling, long distant CCTV, Communication between fire alarm panels, and much more.

Fiber Optics- Advantages

- Maintaining signal integrity in high EMI/RFI applications
- Long distant installations
- Security Issues
- Future Proofing
- Greater amount of information carrying capacity (bandwidth)
- Easy installation - light weight, simplified termination

Fiber Optics- Disadvantages

- Expensive overall installation cost
- Can not carry electrical power

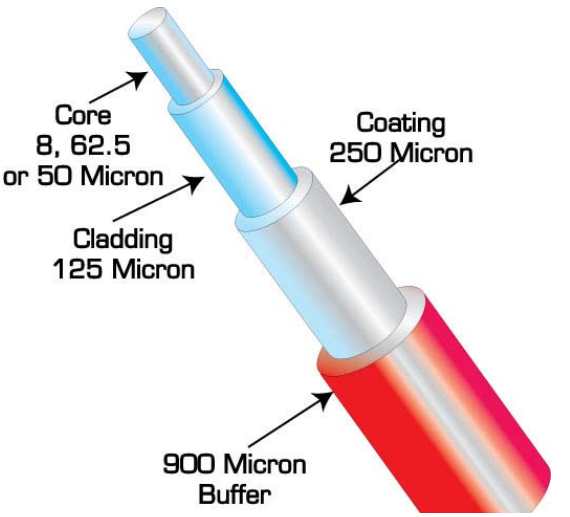
Fiber Optics: Fiber Cables

Optical Fibers

A glass optical Fiber is made of three components:

1. Core - Light Carrier of the optical fiber. It is made from a doped glass(Silica). The silica material of the core allows the light signals to be carried efficiently and effectively across the fiber.
   Sizes of the Core:
   - 8µm (8.3 or 9µm) Single Mode
   - 50µm - MulitMode
   - 62.5µm - MultiMode

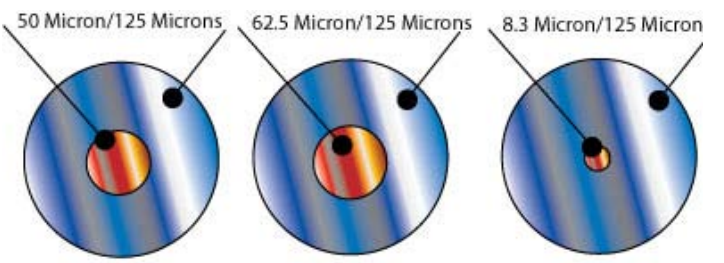
   µm - microns - 1000microns =1mm



2. Cladding - Surrounds the Cladding, it is also made from a different type of silica. The glass of the cladding is made to contain the light within the core.
   Sizes of the Cladding:
   - 125µm

3. Plastic Coating - Surrounds the Cladding and acts as a protector for the glass. The coating is implemented to protect the glass while it is shipped to the Fiber Optic Cable Manufacturers. The Coating is normally clear (color), but for all Outdoor cables the coating is color coded to help identify the individual fibers. The coating has to be removed to connect the fiber to a connector or splice.
   Sizes of the Coating:
   - 250µm

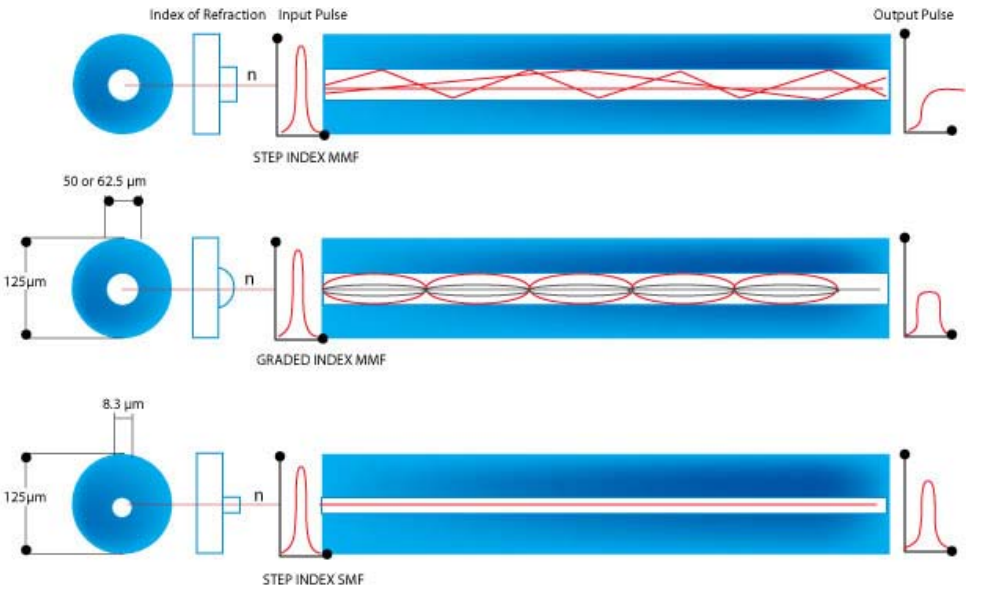
Single-Mode Fibers - 8/125µm
Single mode or path of light from a laser source.
Long Haul installations.



Multi-Mode Fibers- 50/125µm or 62.5/125µm
Multiple modes or paths of light from the LED source.
Shorter Installation

Both Single-Mode and MultiMode will handle Audio,Video, and Data simultaneously.

Fiber Optic Dispersion:



Single-Mode Fiber Cables

The Single-Mode core is 10th the size of a human hair. This fiber type uses a LASER to transmit the signals. The fiber is designed as a step index, meaning that the core has only one refractive index to carry the light signal. There is some dispersion over long distances. Chromatic dispersion is caused by the intense LASER filtering into the cladding causing pulse overlap and distorted signals.

Multi-Mode Fiber Cables

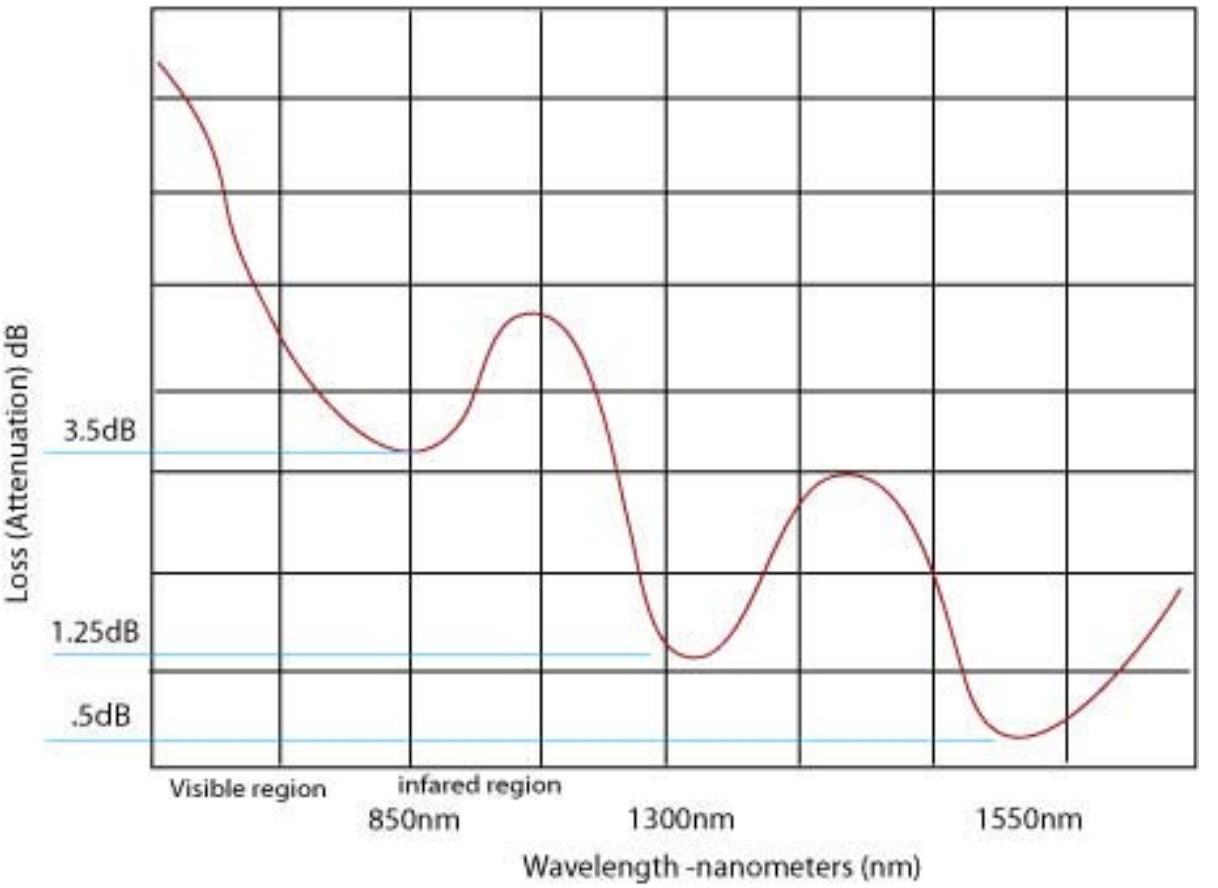
The Multi-Mode core is larger and can gather more light. This fiber uses an LED or VCSEL to transmit the light signals. A Multi-Mode core has a broader aperture over SingleMode fibers. A Multi-Mode fiber also has dispersions over longer distances. This dispersion is called Modal dispersion. A Mulit-mode core is set up with multiple rings with different refractive index characteristics. These rings allow the light to be traveled over longer distances without loss of continuity of light, but these signals can become compromised if the distance is increased too much.

Refractive Index:

Air =	1	Meaning Light travels 186,000miles/second
Normal Glass =	1.5	
Cladding =	1.46	Doped to contain the light
Core =	1.48	SingleMode - 1.47 to 1.48 different layers Mulit-Mode

Operating Wavelengths:

There are Primarily three windows of opportunity to transmit light effectively and effectively through an optical fiber. These specific wavelenths are in the infared region.
Visible light starts with Blue - approx. 400nm to Red 700nm. nm=nanometers.

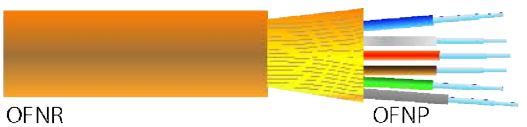


850nm - 3-4dB of loss/km. The least expensive transmitting device. Found on lower speed, shorter distant applications such as CCTV, Fire Alarm communication devices. (LED)
Used with Mulit-Mode fibers

1300nm (1310nm) - 1-1.5dB of loss/km. The second window of opportunity. Used for higher speed, longer distant Multi-mode applications. 1310nm is used for Single-Mode shorter distant applications. LED or VCSEL.

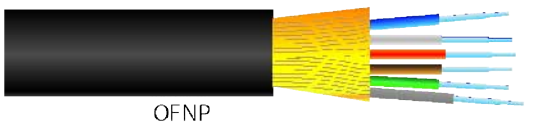
1550nm - .5dB of loss/km. This is the second window of opportunity for SingleMode transmission. This wavelength is used for extremely long distant high bandwidth applications.

Fiber Optic Cable Types

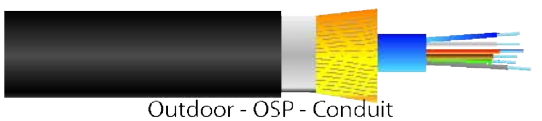


OFNR
M9X039 - 6 Fiber
M9X042 - 12 Fiber
M9C006 - 4 Fiber Digital Media

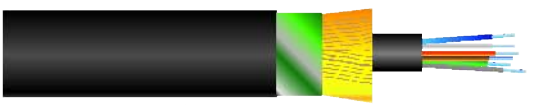
OFNP
M9X043 - 2 Fiber
M9X045 - 6 Fiber
M9X048 - 12 Fiber
M9C014 - 4 Fiber Digital Media



OFNP
M9X043T - 2 Fiber
M9X045T - 6 Fiber
M9X048T - 12 Fiber
M9X611T - 24 Fiber



Outdoor - OSP - Conduit
M9X150 - 2 Fiber
M9X152 - 6 Fiber
M9X155 - 12 Fiber



Outdoor -OSP- Direct Burial
M9X172 - 6 Fiber
M9X175 - 12 Fiber

Individual Fiber Color Code:

1. Blue	2. Orange
3. Green	4. Brown
5. Slate	6. White
7. Red	8. Black
9. Yellow	10. Violet
11. Rose	12. Aqua

Indoor Fiber Optic Cables

Indoor fiber optic cables are designed to either limit smoke vertically (Riser), or limit smoke and flame vertically and horizontally (Plenum). The cables are constructed with 900µm buffer over the 250µm coating to help facilitate a connector

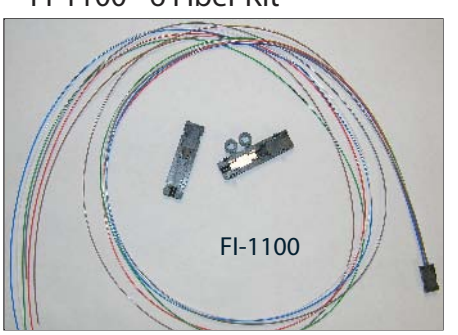
Indoor/Outdoor Fiber Optic Cables

Indoor/Outdoor fiber optic cables are designed together limit smoke vertically (Riser), or limit smoke and flame vertically and horizontally (Plenum). The cables are constructed with 900µm buffer to help facilitate a connector. They also provide water-blocking material.

Outdoor Fiber Optic Cables

Outdoor fiber cables are designed to withstand the environmental elements. They are constructed with 250µm buffers that ride loosely within a tube that is filled with water-blocking gel. The Jacket is PE. A PE jacket can not be brought indoors because of the flame and smoke it produces when flame is set to it. A outdoor cable has a limit of 50ft. entering a building to be terminated or spliced to a Indoor rated cable. Direct Burial Outdoor cables include a armored sheath for direct burial protection. A connector can not be placed directly on an outdoor fiber because of the 250µm buffer. A fan-out kit, or splice with a pre-connected pigtail must be used.

Fan out Kits:
FI-1100 - 6 Fiber Kit



Fiber Optic Connector Types

90% of the Market consists of ST, SC and LC Connector Types

ST - Straight Tip

- Used mostly in Security Applications (CCTV) because of the design is similar to a BNC Coaxial connector
- Keyed locking bayonet style
- Loss- .5-1dB per connection

Offered in the OPTIMAX Connection Kit SUMMER 2012 BRILLIANCE

SC - Square or Subscriber

- Used mostly in Data Applications because of the design is similar to a RJ45 modular plug.
- Push/Pull with floating ferrule - no disconnect
- Loss- .5-1dB per connection

Offered in the OPTIMAX Connection Kit and Brilliance Kit.

LC - Lucent or Little

- Used mostly in Data Applications because of the design is similar to a RJ45 modular plug. SFF - Small Form Factor connector
- Push/Pull with clipping hood
- Loss- .5-1dB per connection

Offered in the OPTIMAX Connection Kit and Brilliance Kit

OTHER CONNECTORS:
FC - Floating - SFF Connector
MTRJ - Mechanical Transfer Registered Jack - SFF Connector

Fiber Optic Connector Installation Kits

Optimax Kit - FI-3635

The Optimax Kit will connect ST, SC, and LC Connector Types.

The Kit is a unique design that incorporates factor polished fiber stub in a splice mechanism which provides a fast, secure and reliable termination of fiber optic cables.

The Optimax Connectors offer premium quality ceramic ferrule with Physical Contact (PC) polish for Mulit-Mode and Super Physical Contact (SPC) polish for Single-Mode

The Optimax installation consists of:

1. Cleave the Fiber
2. Insert the fiber into the connector
3. Pull the release Pin to activate the mechanical splice
4. Crimp the connector

Specifications: OPTIMAX

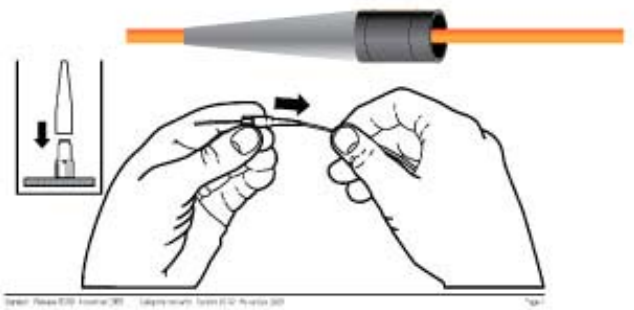
Interconnection compatibility	LC/SC/ST
Field Assembly Time 900µm	1 Min.
Insertion Loss dB	.3dB
Storage Temp.	-40˚F - 149˚F
Operating Temp.	32˚F -145˚F
Tensile Strength 900µm	3lbs.

Connectors are not reuseable after pin has been released.

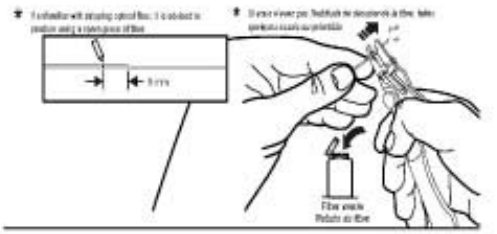
Optimax Tools and Accessories	
Catalog No.	Description
FI-3635	OPTIMAX Complete Kit
FI-3634	Installation Tool- ST
FI-3641	ST Compatible Crimp Tool
FI-8829	Fiber Cleaver
FI-8832	Microscope
FI-8835	ST 900um Connector - 62.5/125um
FI-8837	ST Universal connector- 62.5/125um
FI-1075	ST 900um Connector - 50/125um
FI-1074	ST Universal connector- 50/125um
FI-0028	SC Universal connector- 62.5/125um
FI-0029	SC 900um connector- 62.5/125um
FI-1077	SC 900um connector- 50/125um
FI-1076	SC Universal connector- 50/125um
FI-1791	ST Single-Mode 900um connector
FI-1792	SC Single-Mode 900um connector
FI-1793	ST- Accessory Kit For Jacketed Single-Mode
FI-1794	SC- Accessory Kit For Jacketed Single-Mode
FI-1981	LC 900um connector- 62.5/125um
FI-1982	LC 900um connector- 50/125um
FI-1983	LC 900um connector- Single-Mode
FI-1984	LC- Accessory Kit For Jacketed Single-Mode Fiber

Optimax ST 900µm Installation

1. Assemble Connector boot to boot body.
   Slide assembled boot onto cable



2. Strip 40mm (1.25") of jacket and coating. Strip in 5mm (.250") incre·ments

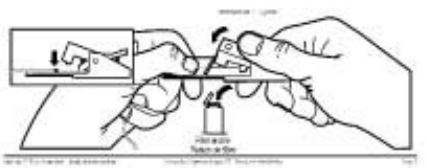


3. Mark Fiber 9mm from the bare glass.
   Clean the fiber.

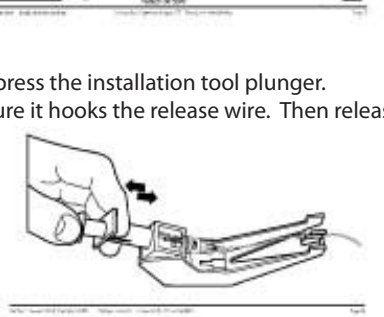
4. Load the connector body into the installation tool with release pin up. Keep dust cap boots on.

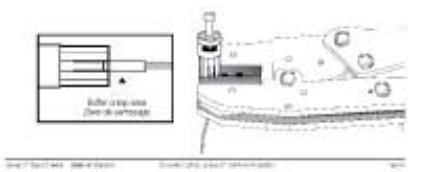
5. Cleave the fiber at 7mm. Using tweezers, disgard waste fiber into waste container.

6. Remove dust cap. Carefully insert bare fiber into the stem of the connector until you feel fbers making contact. Pen mark should be at the edge of the stem.



7. Depress the installation tool plunger.
   Ensure it hooks the release wire. Then release Pin





8. Crimp Using .068" Crimp Die
9. Slide boot onto connector body

Fiber Optic Connector Installation Kits

Brilliance Field Kit - FI-4270

The Brilliance Field Kit will connect SC, and LC Connector Types.

The Kit is a unique design that incorporates factor polished fiber stub in a splice mechanism which provides a fast, secure and reliable termination of fiber optic cables.

The Brilliance Connectors offer premium quality ceramic ferrule. The patent-pending design offers the quickest termination in the industry (less than 30seconds). The Brilliance connectors can be used up to 5-6 times.

The Optimax installation consists of:
1. Cleave the Fiber
2. Open connector cavity - activation tab
3. Insert the fiber into the connector
4. Release activation tab on the connector body.

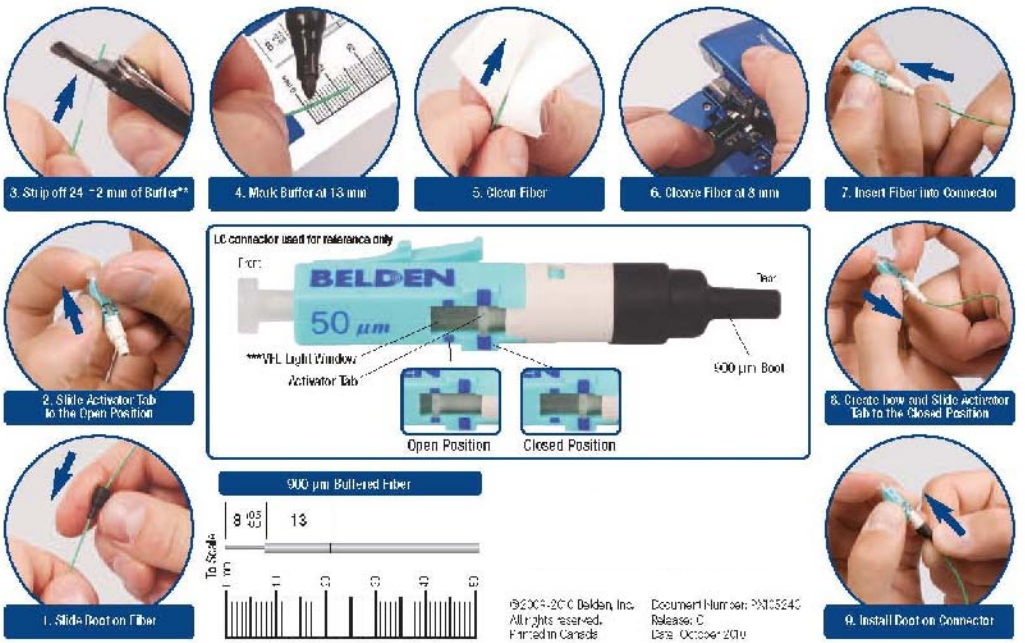
Specifications: Brilliance Connector

Interconnection compatibility	LC/SC
Field Assembly Time 900µm	30 sec.
Insertion Loss dB	.3dB
Storage Temp.	-40˚F - 140˚F
Operating Temp.	-40˚F -167˚F
Tensile Strength 900µm	1.12lbs.

Connectors are reusable up to 6 times.

Fiber*Express* Tools and Accessories	
Cat.No.	Description
FI-4270	FiberExpress Field Installable Complete Kit
LC Connectors	
FI-4240	LC - 900µm, Multimode Beige Connector, 62.5um
FI-4241	LC - 900µm, Multimode Black Connector, 50um
FI-4242	LC - 900µm, Multimode Aqua Connector, 50um
FI-4243	LC - 900µm, Single-mode Blue Connector, 8um
SC Connectors	
FI-4244	SC - 900µm, Multimode Beige Connector, 62.5um
FI-4245	SC - 900µm, Multimode Black Connector, 50um
FI-4246	SC - 900µm, Multimode Aqua Connector, 50um
FI-4247	SC - 900µm, SINGLE-MODE Blue Connector, 8um

Brilliance LC Installation



FiberExpress Brilliance® Installation Card

2. Slide Activator Tab to the Open Position

Push connector activator tab towards the front using the small line indicator as a locating reference.

If using a VFL[1] in the connection process, a red light will appear in the connector window.

7. Insert Fiber into Connector

Align the fiber tip with the rear housing by bringing both hands together for stability. Insert until you reach the buffer mark.

When fully inserted, the buffer mark should be near the edge of the rear housing of the Brilliance Connector. If not, gently back off and reseat the fiber.

During insertion an optional Support Handle[2] can be used to improve stability*.

8. Create bow and Slide Activator Tab to the Closed Position

Create a bow by bending the fiber as shown. Hold in position until activator tab is closed. To close the activator, pull connector activator tab towards rear using the large line indicator as a locating reference.

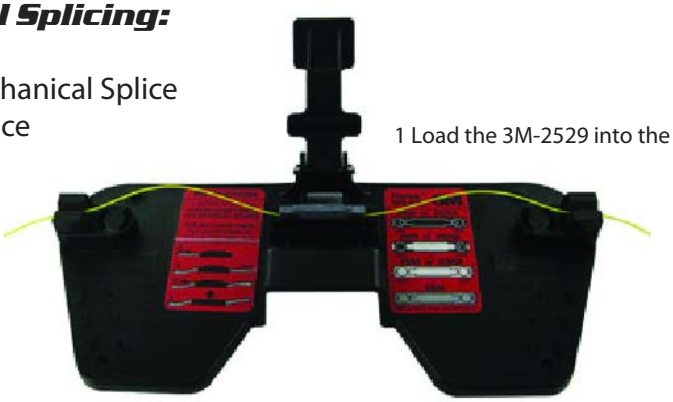
When using a VFL[1], the red light in the VFL Light Window should go out or dim substantially.

The Support Handle [2] and VFL[1] can be used together to assist during installation*.

*For complete details on this procedure refer to Installation Guide (PX105234).
** When using a field cleaver remove 40 mm of buffer.
*** Visual Fault Locator
A copy of the Guide is supplied with each installation kit, or visit www.belden.com

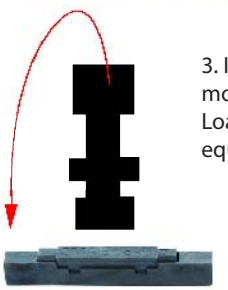
Mechanical Splicing:

3M-2501 - Tool
3M-2529 - Mechanical Splice
.5-1dB loss/splice



1 Load the 3M-2529 into the 3M-2501 Installation Tool.

2. Strip fiber cables approx. 40mm (1.25"), be sure to remove the jacket and the coating. Clean the bare fiber
Cleave the Fibers 12.5mm for indoor



3. Insert fibers in the mechanical splice. Once inserted gently move the fibers back and forth to assure center placement. Load the fibers into the holding brackets and put equal bows to hold the fibrer in place

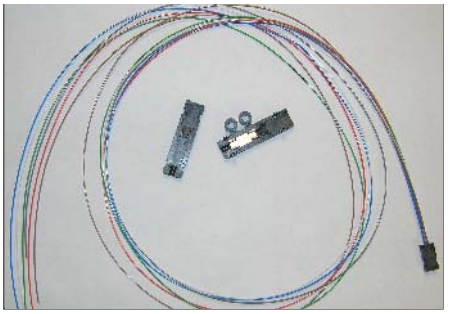
4. Rotate the lid down on the mechanical splice - until a click

Splice Tray: Mechanical Splice

FI-SPTRME
Fits into West Penn Wire Wall Mount Enclosures

Wall Mount Enclosures

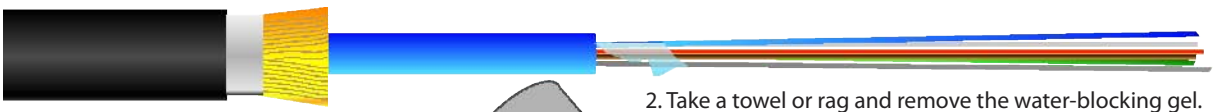
FI-WM12 - 12 Port
FI-WM24 - 24 Port
FI-WM48 - 48 Port
FI-WM100 - 100 Port



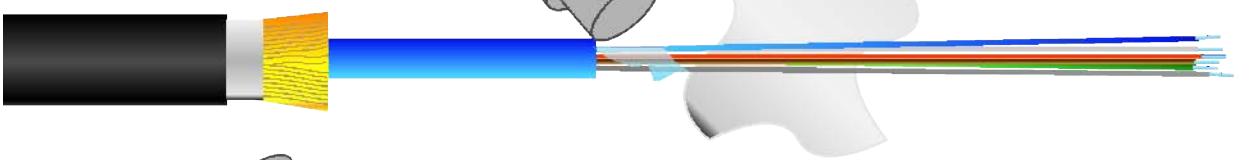
Fan-out Kit

Fan out kit is used to move a 250µm outdoor fiber to a 900µm fiber for connector assembly.
FI-1100 - 6 tube fan-out kit
FI-1101 - 12 tube fan-out kit

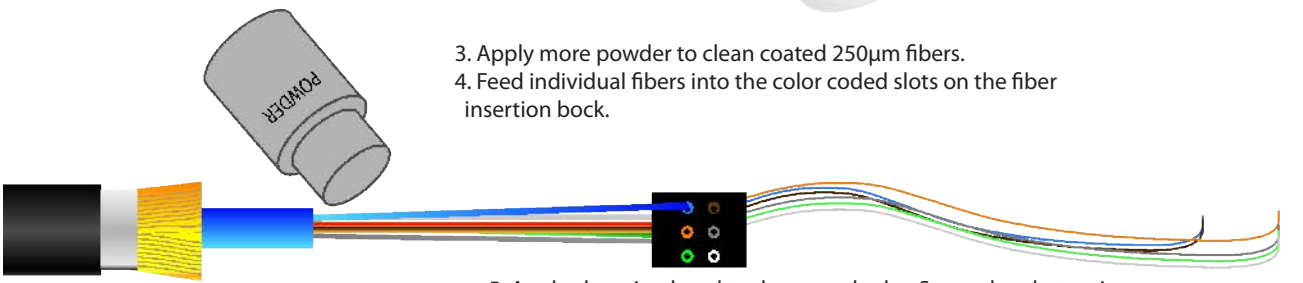
1 Strip the External Jacket away. (24-36 inches).
Strip the central tub away- expose individual 250µm Fibers
Trim away the kevlar



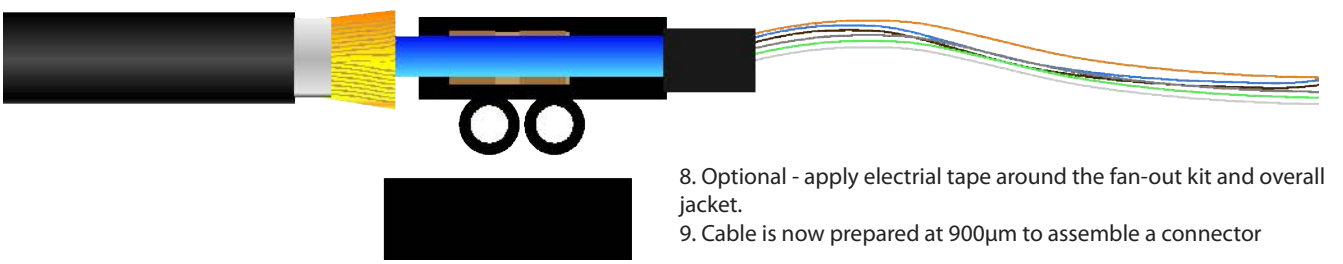
2. Take a towel or rag and remove the water-blocking gel.
Apply talc or baby powder and continue to remove gel.



3. Apply more powder to clean coated 250µm fibers.
4. Feed individual fibers into the color coded slots on the fiber insertion bock.



5. Apply clamping hood to the central tube. Secure brackets using needle nose pliers.
6. Place fiber insertion block into the clamping hood.
7. Apply the closure hood onto the clamping hood.



8. Optional - apply electrial tape around the fan-out kit and overall jacket.
9. Cable is now prepared at 900µm to assemble a connector

Fiber Optic Assemblies

Types: ST, SC, LC other MTRJ
Glass Types: SingleMode and Multi-Mode
Simplex or Duplex Design

ST Fiber Optic Assemblies	
Catalog No.	Description
FI-X001-xx	Simplex ST to ST Replace xx with:3,6,10,15,30
FI-X002-xx	Duplex ST to ST Replace xx with:3,6,10,15,30

SC Fiber Optic Assemblies	
Catalog No.	Description
FI-X001-xxSC	Simplex SC to SC Replace xx with:3,6,10,15,30
FI-X002-xxSC	Duplex SC to SC Replace xx with:3,6,10,15,30

LC Fiber Optic Assemblies	
Catalog No.	Description
FI-X001-xxLC	Simplex LC to LC Replace xx with:3,6,10,15,30
FI-X002-xxLC	Duplex LC to LC Replace xx with:3,6,10,15,30

ST to SC Fiber Optic Assemblies	
Catalog No.	Description
FI-X001-xxST/SC	Simplex ST to SC Replace xx with:3,6,10,15,30
FI-X002-xxST/SC	Duplex ST to SC Replace xx with:3,6,10,15,30

SC to LC Fiber Optic Assemblies	
Catalog No.	Description
FI-X001-xxLC/SC	Simplex SC to LC Replace xx with:3,6,10,15,30
FI-X002-xxLC/SC	Duplex SC to LC Replace xx with:3,6,10,15,30

Fiber Optic Assembly Glass Size		
Repace X with:	Core Glass Size	Description
1	50um	Standard 50micron Fiber optic glass type Multi-Mode
2	62.5um	Standard 62.5micron fiber optic glass type Multi-Mode
3	8um	8micron Single Mode fiber optic glass type SingleMode
4	50um LOF	OM3 Laser Optimized 50micron Multi-Mode

Replace xx with: 3, 6,10, 15, 30 Feet

FI-3002-15LC

SingleMode 15ft. LC to LC Assembly

Fiber Optics in the AV World:

WEST PENN WIRE

Optical Power Budget:
Cable: 50/125µm
Wavelength: 850nm
No. of Fibers: 2 - 50/125µm
Termination: Coax- RGBHV (5 BNC) and VGA (HD15) to Fiber SC
Power Budget: 7dB

850nm - 1km	= 3.00dB
SC Connectors (2)	= 1.50dB
System Safety Margin	= 3.00dB
Total Loss-	7.50dB theoretical number

Note: Extron Distance

8/125µm	30Km (18.75miles)
50/125µm	1Km (3280ft)
62.5/125µm	300m (985ft)

Optical Characteristics				
Glass Type	Code (X)	Operating Wave-length (nm)	Min. Bandwidth (MHz-km)	Max. Attn. (dB-km)
50/125µm MultiMode	A	850nm/1300nm	500/500	3.50/1.25
62.5/125µm MultiMode	B	850nm/1300nm	200/500	3.50/1.25
8/125µm SingleMode	W	1300nm/1550nm	–	.80/.50

Fiber Optics in the Security World:

WEST PENN WIRE

Security World Fiber Optics:

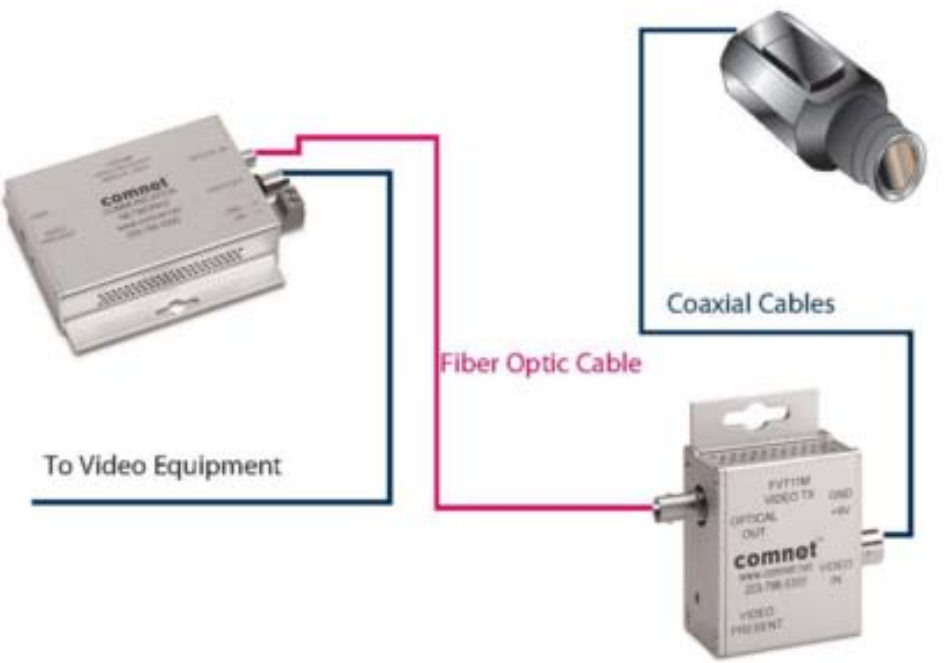
CCTV
Fire Alarm Panel Communication
Access Control Panel Communications
Intrusion Detection
Audio
Data/Control

Most fiber optic security applications utilize multimode fiber combined with ST terminations.

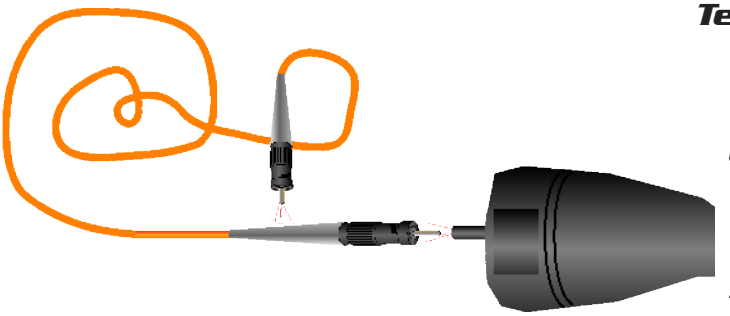
Example 1: CCTV Video

Optical Power Budget:
Cable: 62.5/125µm
Wavelength: 850nm
No. of Fibers: 1 or 2 - 62.5/125µm
Termination: Coax- BNC, Fiber Optics - ST
Power Budget: 12dB

850nm - 2.5km	= 7.50dB
ST Connectors (2)	= 1.50dB
System Safety Margin	= 3.00dB
Total Loss -	12.00dB theoretical number



Testing Methods:



Continuity Check

Flashlight - to check Continuity
FI-5000
First test done to see if light is passing through the connection points

Power Meter/Light Source

Checks fiber power budget reference
FI08513 - 850/1300/1550nm PM
FI-8513 - 850/1300nm LS
FI-1550 - 1550nm LS
This test provides information compared to an optical power budget. If your power budget is for example: 12dB and the reading is 11dB- this system will operate. Checks total loss of the fiber link.

Optical Time Domain Reflectometer OTDR

Sends a pulse down a line of fiber optic cable. It measures the reflections created by fiber loss, splices and connectors. An OTDR will precisely indicate where a problem is occuring.

Expensive equipment: WPW has access.