Fiber 101

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EXFO

Maintenance vs. Fiber Team

What are the 2 reasons that you are going to get called out?

1. ‘No Light’ condition.

   Cut cable

2. ‘Low Light’ condition.

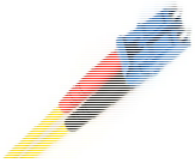
   It used to work and is now taking errors

What do you do in each case?

Fiber Basics

Advantages

- Portable and easy to handle
- Less containment and pathway space required
- No Leakage
- Nearly limitless bandwidth/capacity



= Reduced Total Cost of Ownership

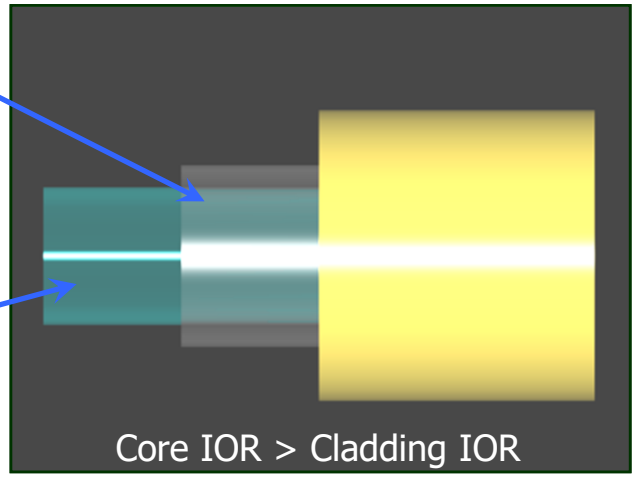
Fiber Construction

Fibers are made of glass consisting of a core and a cladding that will allow propagation of light by total internal refraction.

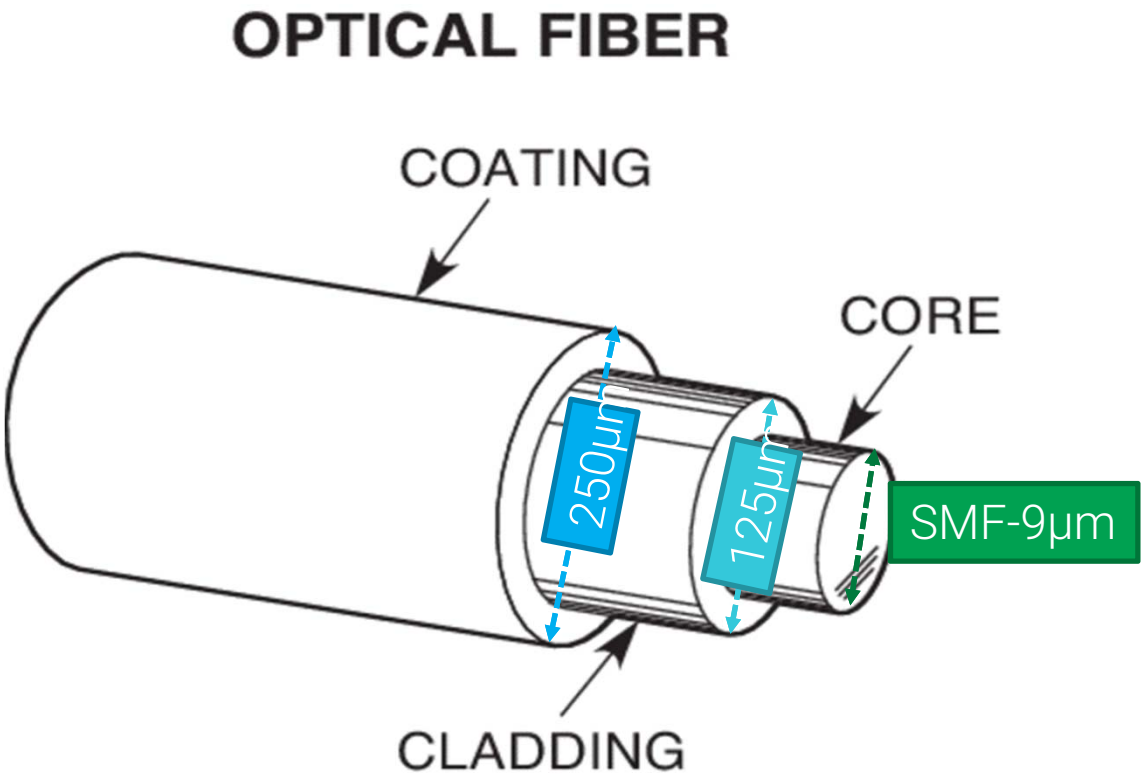
Total internal refraction is achieved in the fiber by having two different refractive indexes – the core IOR is higher than the cladding IOR

Fiber Cladding
The cladding IOR is slightly lower than the core IOR. This will "bend" the light to keep it in the core area.

Fiber Core
Will act as a "mirror tunnel" for the light propagation.

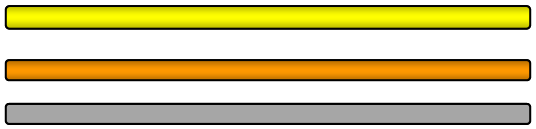


Fiber Construction



Color Codes

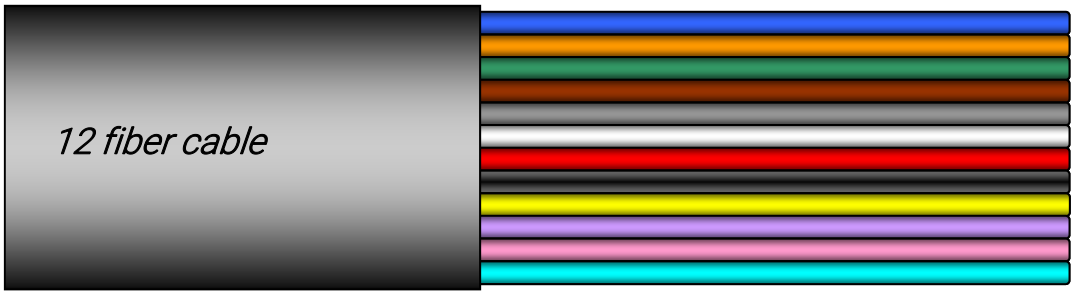
- A color code exists to identify individual or duplex fiber cables (usually patch cords):



Yellow - Singlemode 9/125

Orange or Grey - Multimode 62.5/125 OM1

- There is also a color code to identify individual fibers within a multi-fiber cable

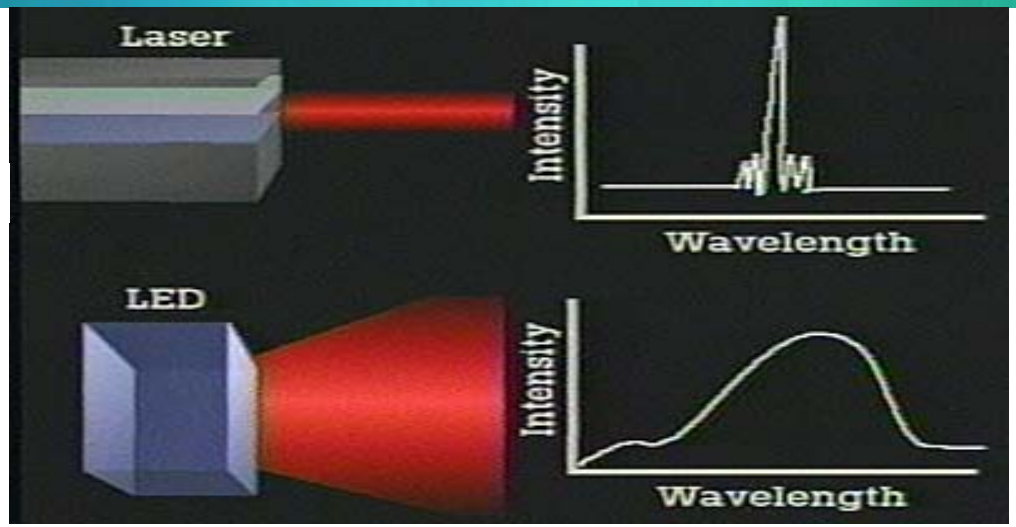


1. Blue
2. Orange
3. Green
4. Brown
5. Slate
6. White
7. Red
8. Black
9. Yellow
10. Violet
11. Pink
12. Aqua

Optical Transmission

Single Mode vs Multimode

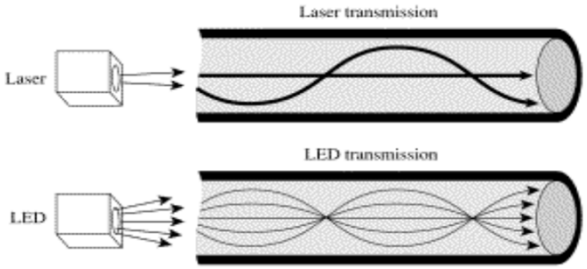
- 1310nm
- 1550nm
- Any WDM λ

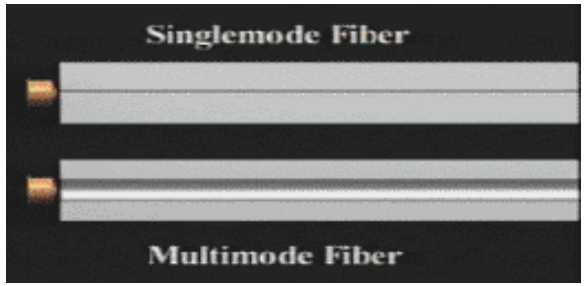


Light Amplification by Stimulated Emission of Radiation

- 850nm
- 1310nm

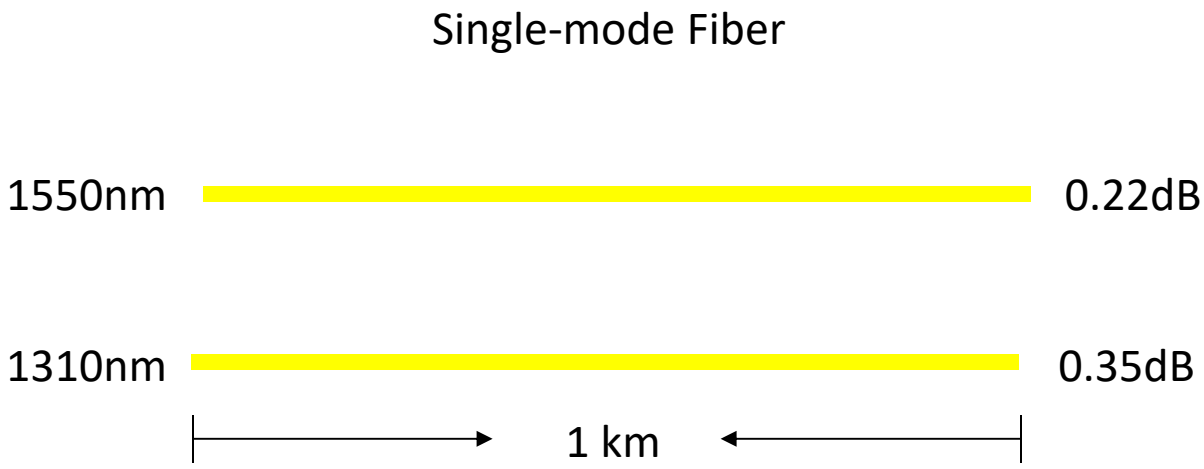
Light Emitting Diode





Singlemode Attentuation per KM

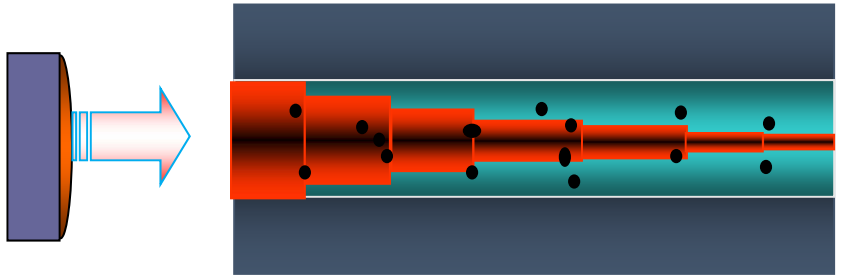
Typical Loss (Attenuation)



Attenuation

Source of Attenuation/Fiber Loss

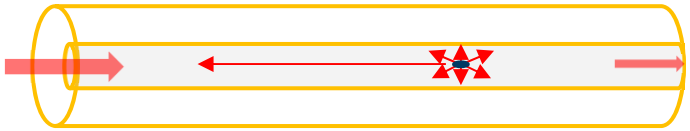
- Decrease in optical power from the transmitter to the receiver
- Link loss is theaverage main performance limitation. Determines the maximum distance between a transmitter and a receiver.
- Attenuation results from:
  1. Fiber Absorption/Scattering
  2. Connectors (.3 -.5dB ea typ)
  3. Fusion Splices (0.1dB ea typ)
  4. Macrobends



Fresnel and Rayleigh

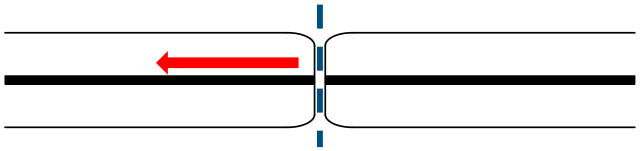
Rayleigh Scattering

- Occurs when light interacts with discrete particles in the Fiber core
- Particles can be impurities, defects or regions of mechanical stress
- Occurs along the total length of the Fiber

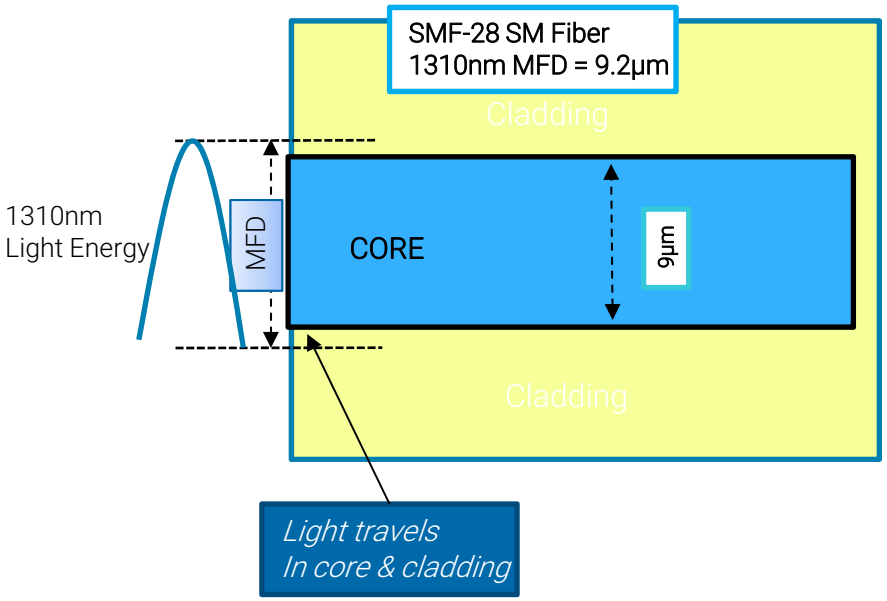


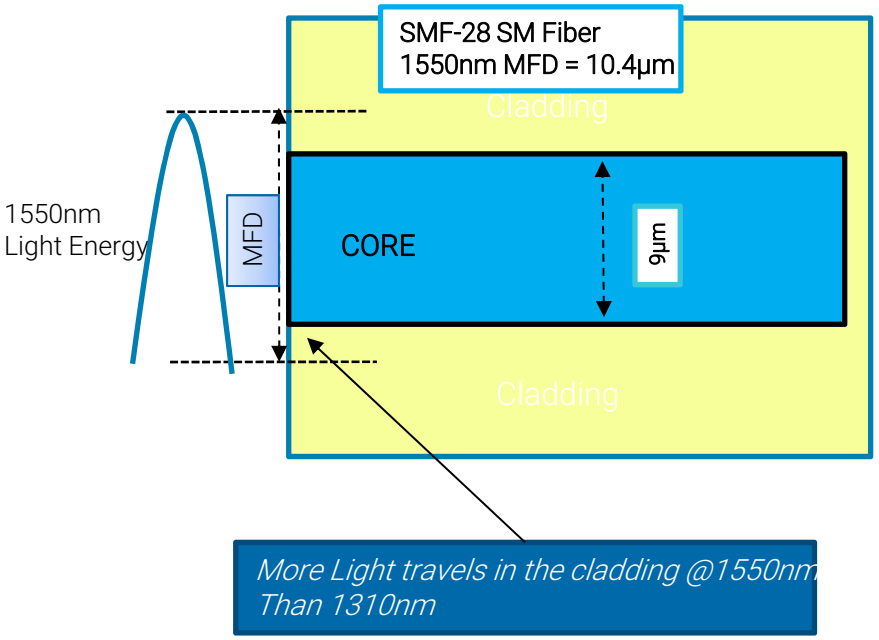
Fresnel Reflection

- The reflection of a small portion of light at a discrete interface between two media having different refractive indices
- Example – Glass to air transitions at connector interfaces or a mechanical Fiber splice



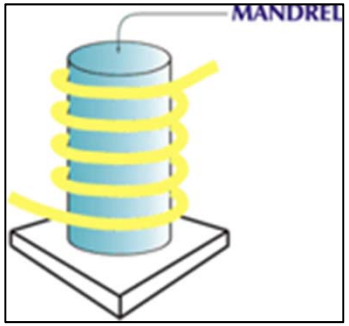
Mode Field Diameter





Macro Bends

Corning® SMF-28™ Optical Fiber

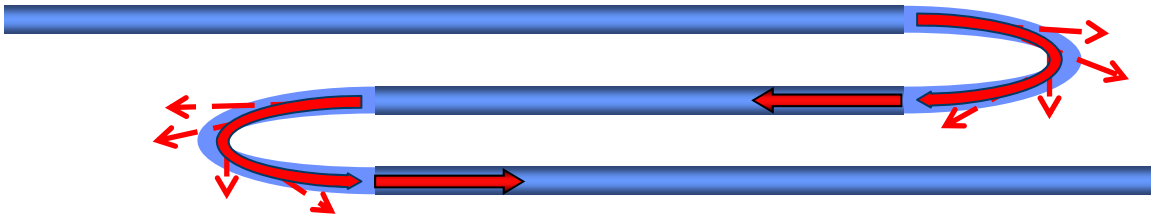


Attenuation with Bending

Mandrel Diameter (mm)	Number of Turns	Wavelength (nm)	Induced Attenuation* (dB)
32	1	1550	≤0.50
50	100	1310	≤0.05
50	100	1550	≤0.10
60	100	1550	≤0.05

*The induced attenuation due to fiber wrapped around a mandrel of a specified diameter.

1550nm twice the loss of 1310 with same bends



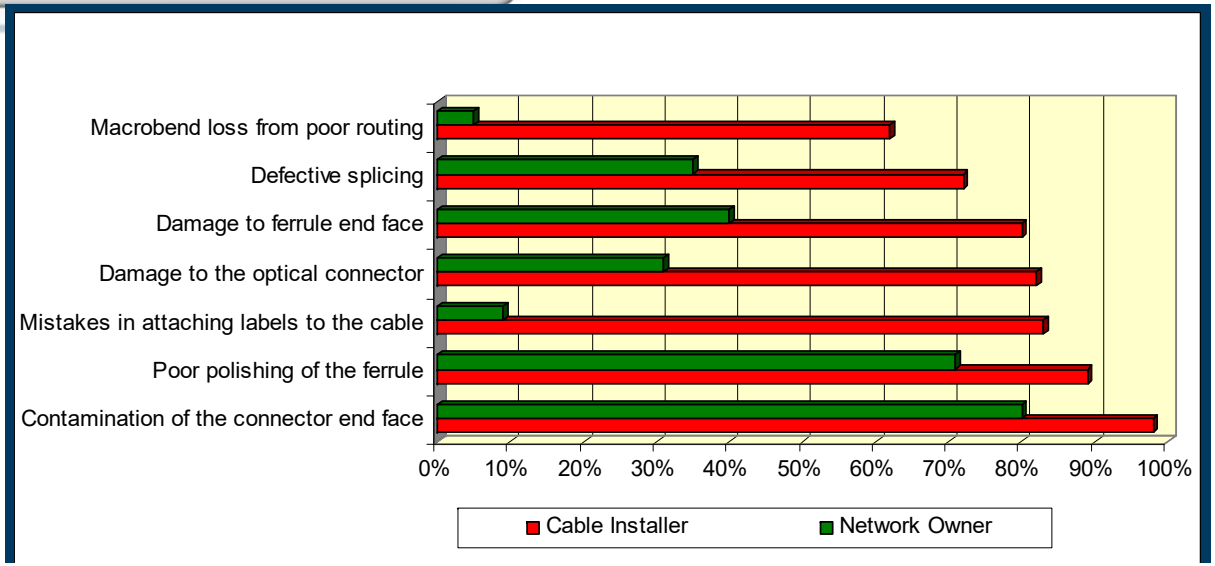
Fiber Cleaning and Inspection

Connector Contamination

No. 1 cause of network failures is contaminated connectors

- NTT-Advanced Technology Research, 2010

- **98%** of cable installers and **80%** of network owners answered “Yes” to having contamination be the root cause of a network failure.



Cleaning

Dry method

An efficient technique for removing light contaminants

Often considered the technique of choice in a controlled manufacturing environment where speed and ease of use are important factors

Advantages	Disadvantages
Convenience of readily available tools	Can possibly create electrostatic charges
Fast and easy	Not effective in removing all contaminant types



Cleaning

Wet method

The main purpose of using the wet-solvent approach is to raise dust and contaminants from the connector's endface to avoid scratching the connector

The most widely-known solvent in the industry is the 99.9% isopropyl alcohol (IPA), which removes most contaminants

Advantages	Disadvantages
Can dissolve complex soils and contaminants	Can leave residue on the ferrule when too much solvent is used and not properly dried
Eliminates the accumulation of electrostatic discharge on the ferrule	Solvent choice can be confusing with issues of performance

Cleaning

Combination method (hybrid)

Combination cleaning is a mix of the wet and dry cleaning methods

The first step in hybrid cleaning is to clean the connector end-face with a solvent and to dry any remaining residue with either a wipe or a swab

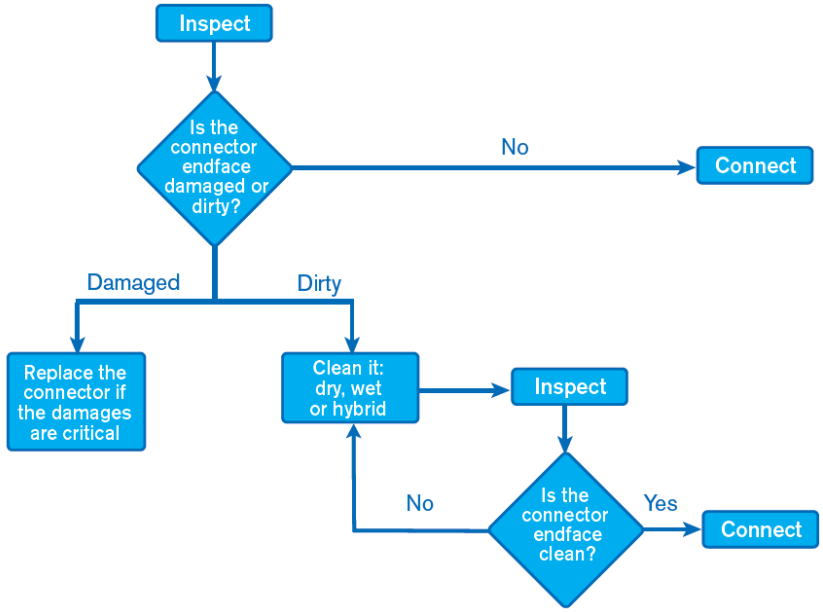
Advantages	Disadvantages
Cleans all soil types	Requires multiple products
Reduces potential static field soil accumulation	
Automatically dries moisture and solvent used in the cleaning process	
Captures soil in wiping material as an integrated aspect of cleaning procedure	
Not expensive	

Remember - Best Practices

What is the first step to any fiber testing?

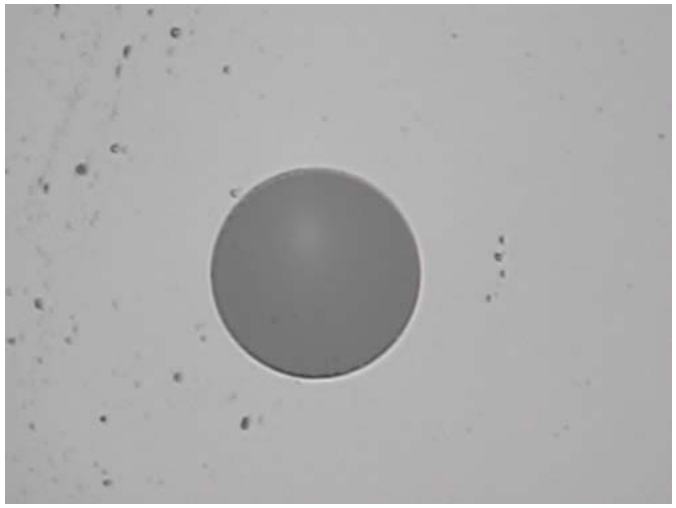
~~Cleaning~~

Connector inspection



Connector Inspection Challenges

Connector inspection requires a great amount of judgment

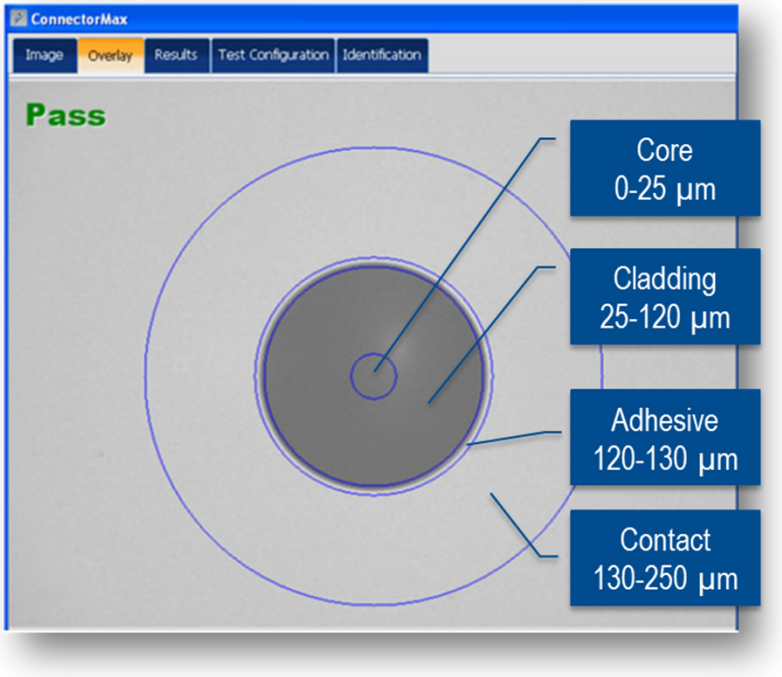


Connector Inspection Criteria

A connector end face is divided into multiple zones

Dimensions will depend on the connector and fiber type

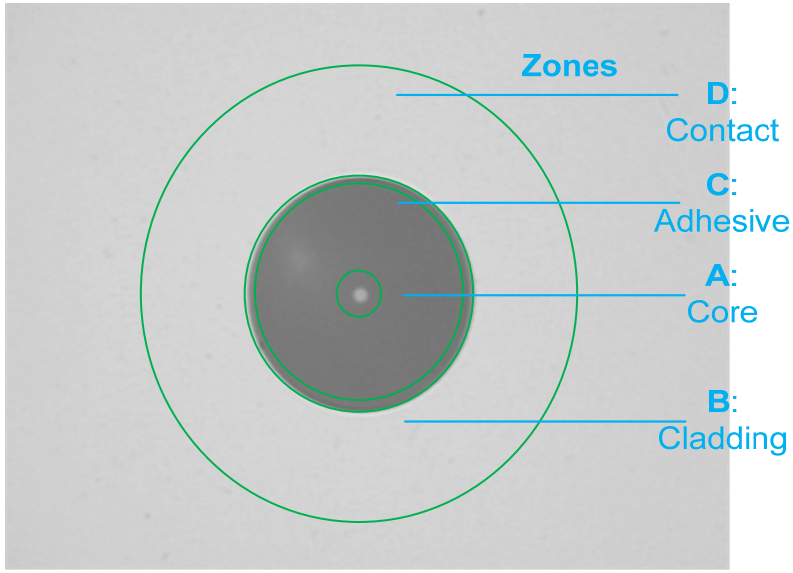
IEC zone sizes for polished connectors,
singlemode non-dispersion shifted fiber, RL ≥45 dB



IEC Fiber Inspection Standards

- Criterias are defined in the IEC & IPC standards
- Connector end-face is divided into multiple zones
  - Size will depend on connector type
- Tolerances will differ for each zones
  - Number of defects
  - Number of scratches
  - Size of defects and scratches

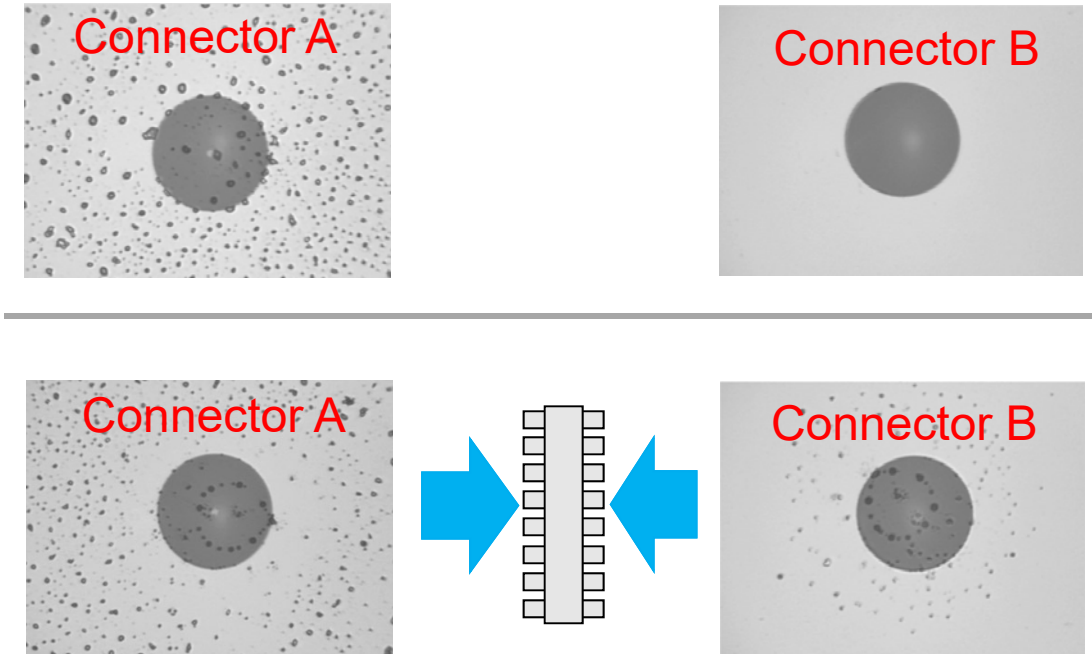
Zones	Scratches	Defects
A: Core	none	none
B: Cladding	no limit ≤ 3µm none > 3µm	no limit <2µm 5 from 2 - 5µm none > 5µm
C: Adhesive	no limit	no limit
D:Contact	no limit	None ≥ 10µm



Connector Issues

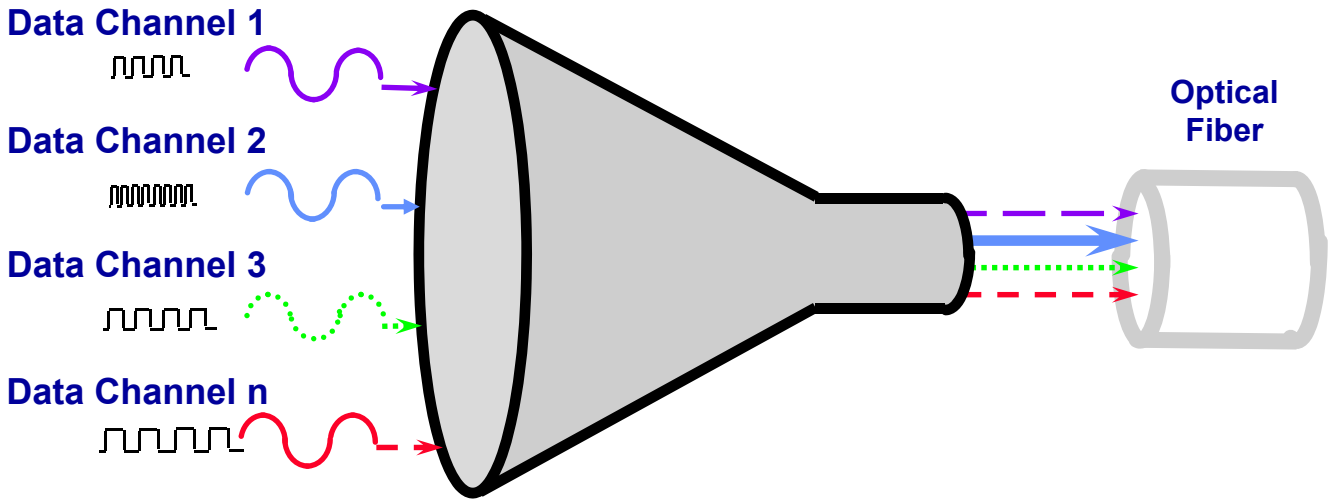
Dust/dirt residues transfer:

Residues will transfer and may create permanent damage when mating



DWDM Basics

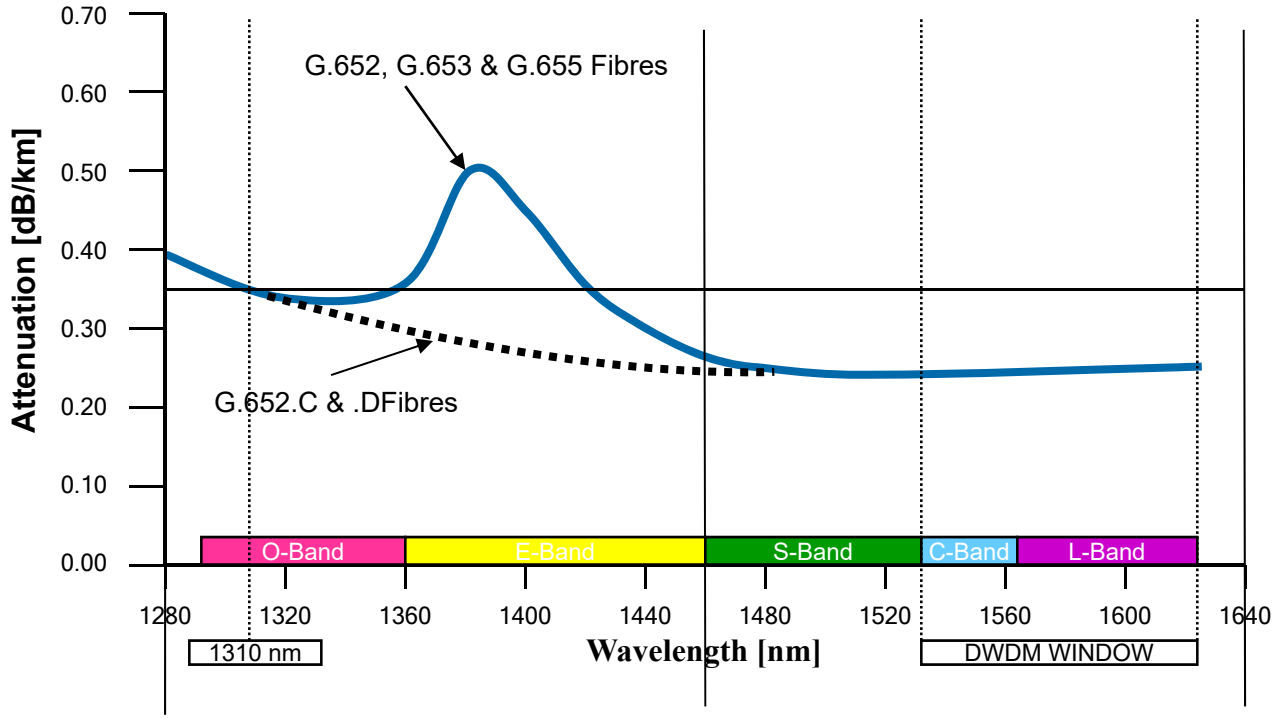
WDM –Wave Division Multiplexing



Wavelength Division Multiplexing (WDM) acts as “optical funnel” using different colors of light (wavelengths) for each signal

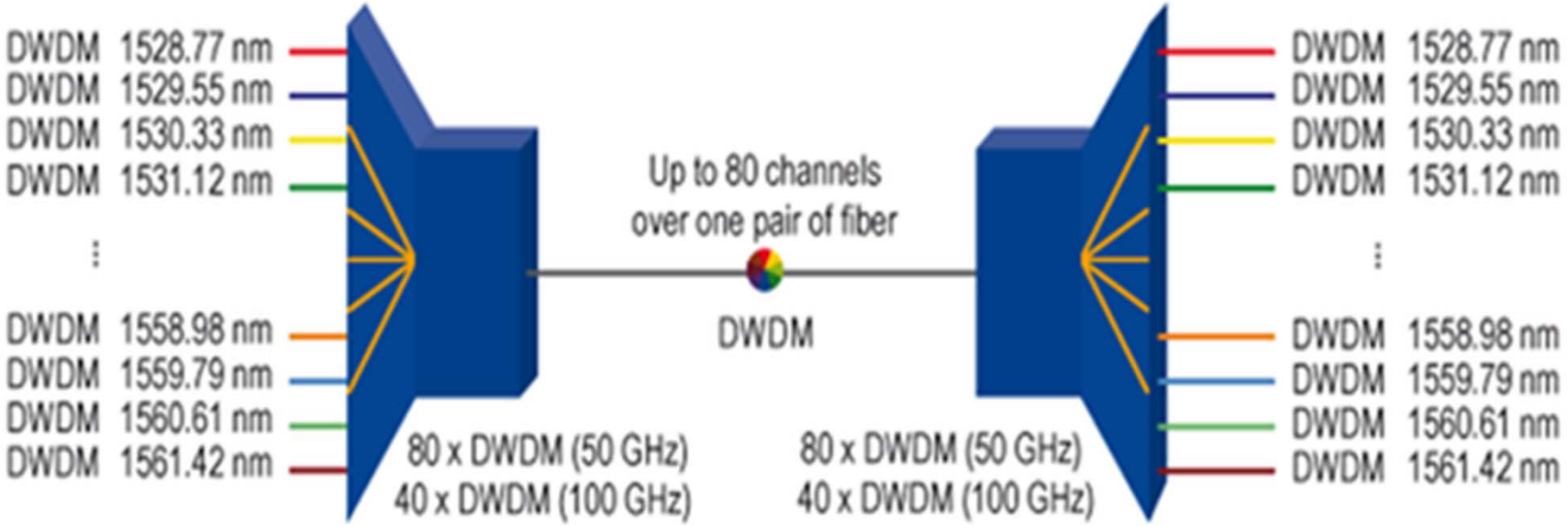
Wavelength = λ = lambda

DWDM



DWDM = C Band = Nearly flat Frequency Response

DWDM –Dense Wave Division Multiplexing

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