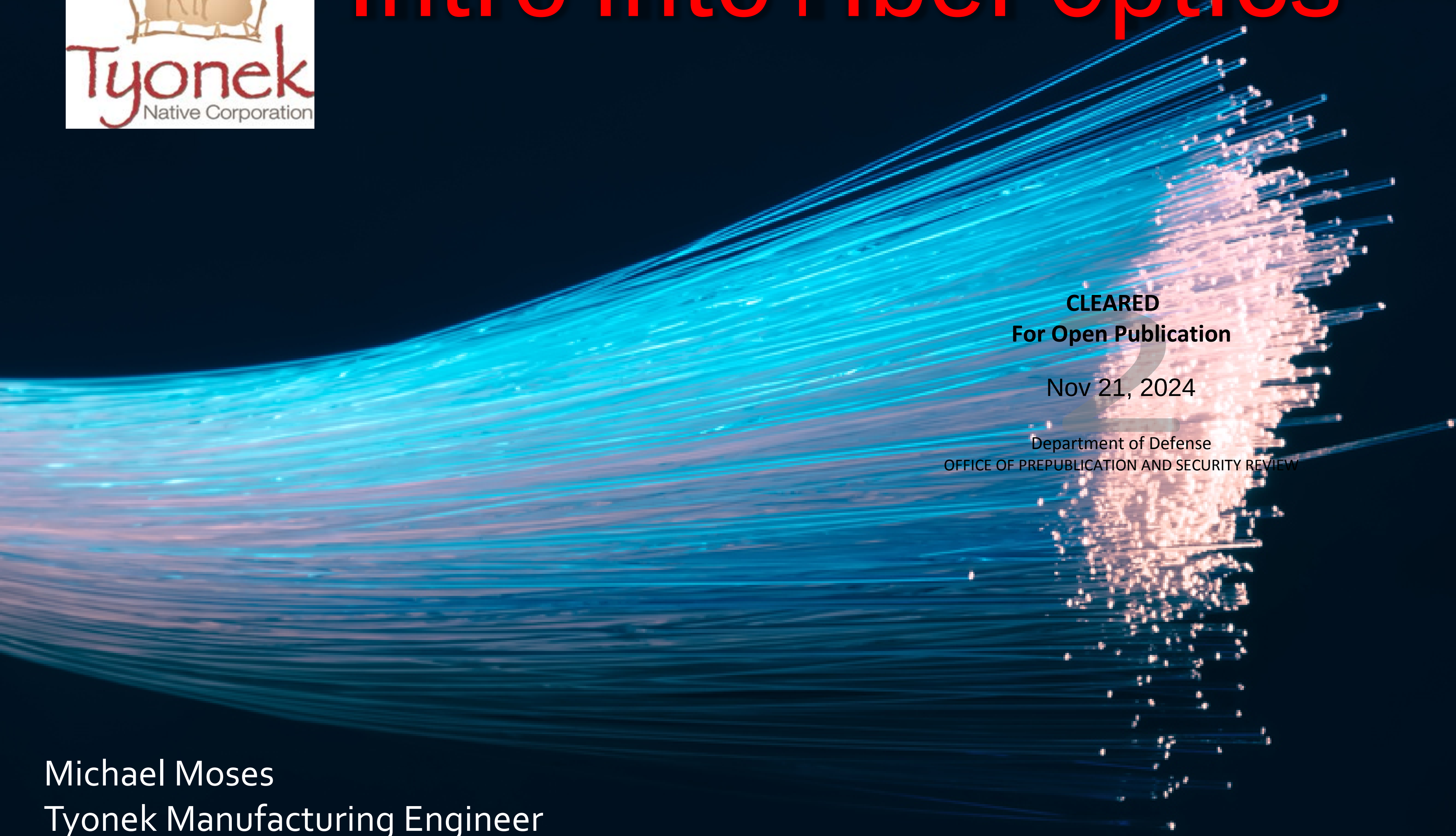
Intro into Fiber Optics



CLEARED
For Open Publication

Nov 21, 2024

Department of Defense
OFFICE OF PREPUBLICATION AND SECURITY REVIEW

Michael Moses
Tyonek Manufacturing Engineer

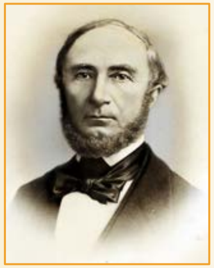
- Tyonek is an ANC (Alaskan Native Corporation) with OEM-level capabilities that provides both manufacturing and MRO expertise.
  - **Manufacturing** includes machining, welding, coatings, fabrication, assembly, cables and wire harnesses (including ***fiber optic***) and test. FEEC117 certification training provided for FO installations.
  - **MRO** services include Engineering and IPT, full-service aircraft modification and installations, ISF, Logistic support ops, contract field teams, installation and depot level support.

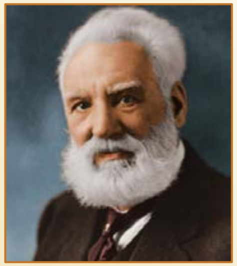
Fiber Optic experience

- AH-64/ CH-47/ UH-60 LIMWS
  - A-Kit Design Engineering
  - A-Kit Manufacture
  - Validation / Verification (Installations)
  - Develop and Publish MWOs
- C-130 ALR-69A
  - A-Kit Manufacture (Mechanical & Electrical)
  - Barron and Retrofit programs
  - Validation / Verification (Installations)

History

Before there was Fiber Optic communication as we know it today; if we think about it, communication using light has occurred throughout human history. Signal fires were used by the ancient Greeks to warn of incoming threats. But let's take a closer look on how modern fiber optic was introduced into the mainstream.





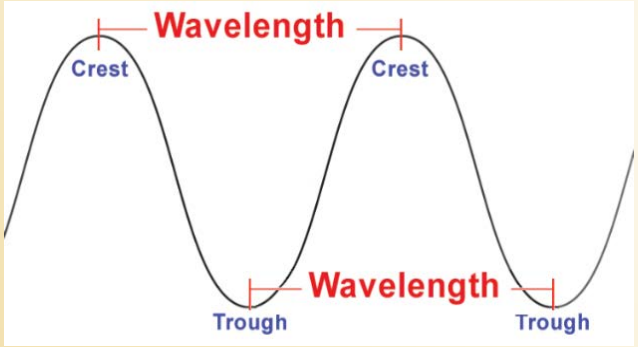
- TIR (Total Internal Reflection) was first recorded in 1841 by Jean-Daniel Colladon, a 38-year-old Swiss professor at Geneva University. While attempting to illuminate a water flow demonstration during a lecture, Colladon stumbled upon TIR. He found that the light he had piped into his tank was trapped within the flow of the water jet as it followed the naturally curved path of water until the light was dispersed as it reached several water jets. This unintended discovery would prove to be a principal component of modern Fiber Optics.
- In 1880 Alexander Graham Bell successfully transmitted speech over 200 meters with light using a mirror and a selenium resistor as a receiver. The mirror was very thin and would convex and concave as different words were spoken, altering the amount of light that was reflected and eventually received. He was quoted as saying it was his greatest achievement, greater than the telephone. However, without continuous sunlight, communication faltered, failing to provide a reliable means of communication.

History

- Until the 1950's Fiber communication was struggling with attenuation; the loss of light power over distance through a medium. From rudimentary glass cores to metal hollow tubes, data loss in the form of photons was significant and not very practical. Charles Kao and George Hockham recognized the need to develop a more reliable medium with the purification of glass fibers. In 1966 Kao and Hockham published a report proposing that a purified glass medium that can limit attenuation to less than 20 dB/km would allow for a reliable communication over long distances. The stage was now set…
- The challenge was met by Corning Glass. Donald Keck, Robert Maurer, and Peter Schultz sought to reduce attenuation from the current 1000 dB/km loss to below 20 dB/km loss; a seemingly monumental task. However, in 1970 they developed the first low loss fiber (17 dB/km); the first reliable means of communicating with fiber optics - a benchmark that is still used today!
- Finally in the 1970s, fiber was first commercially installed by AT&T and modern fiber communication principles were locked in to reshape the future on communication henceforth.

Fiber Optic Theory

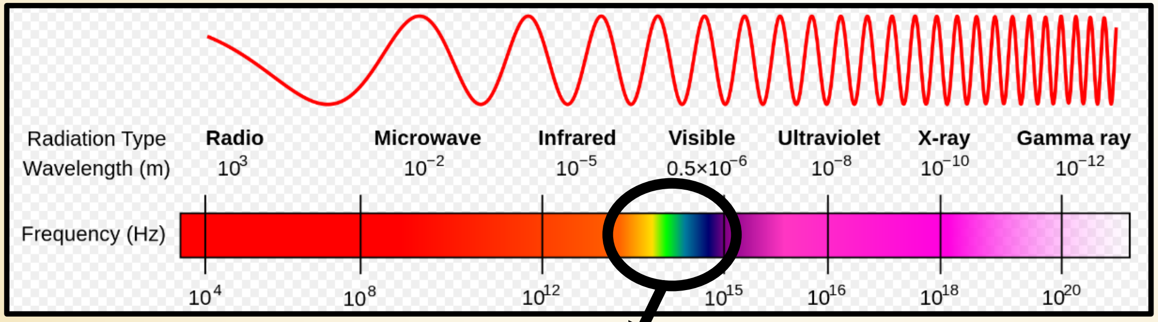
What is Fiber Optics?

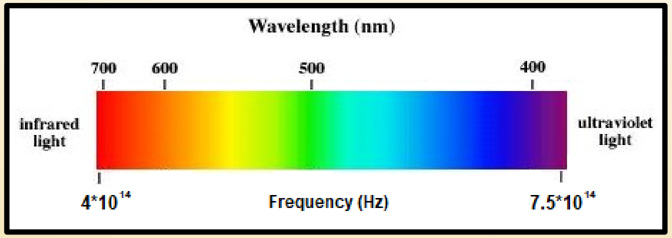


- Fiber Optics is a process through which light travels through a medium from one point to another for communication. Today, this medium consists of flexible glass fibers or plastic fibers made of polymer.
- There are two types of fiber optic cable constructions; Multimode and Single Mode. Most Multimode fiber optic components operate at wavelengths of 850 and 1300 nanometers, or nm (one billionth of a meter). Single Mode fiber optic components typically operate at wavelengths of 1310 and 1550 nm. A wavelength is the distance between two consecutive apex points of a crest/trough (measured in m, or meters).
- A wavelength's distance determines its interactive characteristics with matter, how it applies it to our everyday lives, and through observation and experimentation, we can identify how the wave was produced. Additionally, there is a relationship that inherently exists whenever we discuss wavelengths; frequency.
  - Frequency is inversely related to the length of a wave, and it is measured in Hertz, or Hz. Therefore, the longer a wavelength, the lower the frequency. This makes sense when looking at graphical representation of the electromagnetic spectrum:

Wavelengths

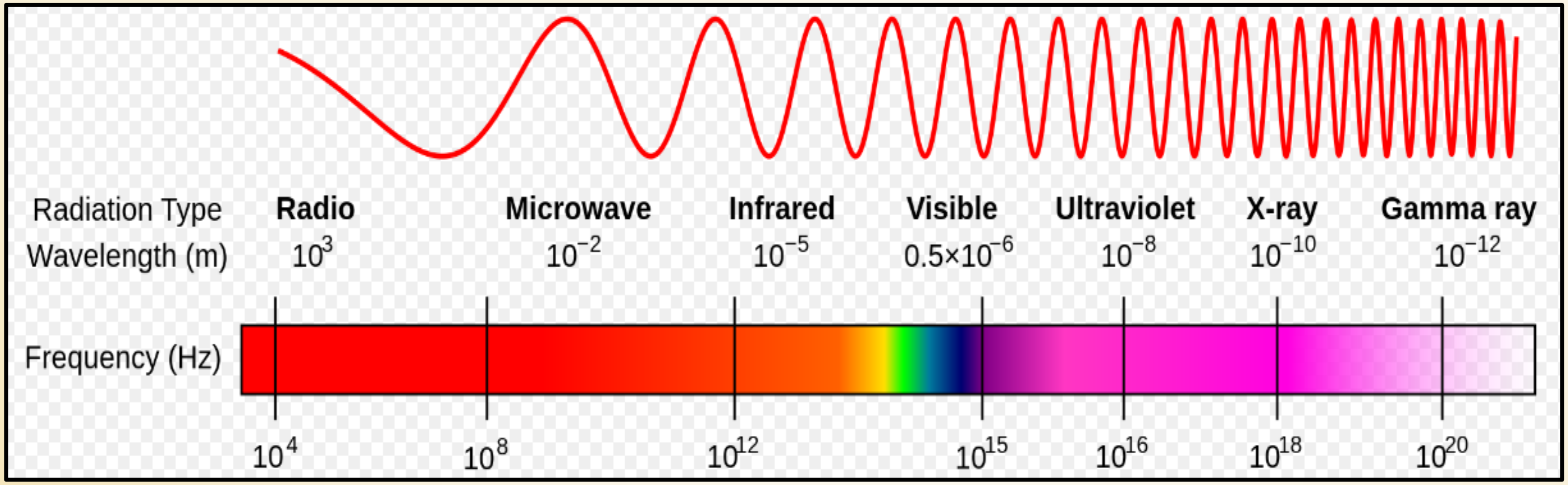
- A wavelength's distance determines its interactive characteristics with matter, how it applies it to our everyday lives, and through observation and experimentation, we can identify how the wave was produced. Additionally, there is a relationship that inherently exists whenever we discuss wavelengths; frequency.
  - Frequency is inversely related to the length of a wave, and it is measured in Hertz, or Hz. Therefore, the longer a wavelength, the lower the frequency. This makes sense when looking at graphical representation of the electromagnetic spectrum:





- The human eye can only detect wavelengths between 380 and 700 nanometers.
- The eye also operates within the 400-790 terahertz (1 trillion cycles per second) range.

Wavelengths/Principles



The Energy of a Photon determines its interactional outcomes with atomic structures!

Max Karl Ernst Ludwig Planck

$$E = hf$$

Which translates to: Energy = Planck's Constant multiplied by the Frequency of the Wavelength

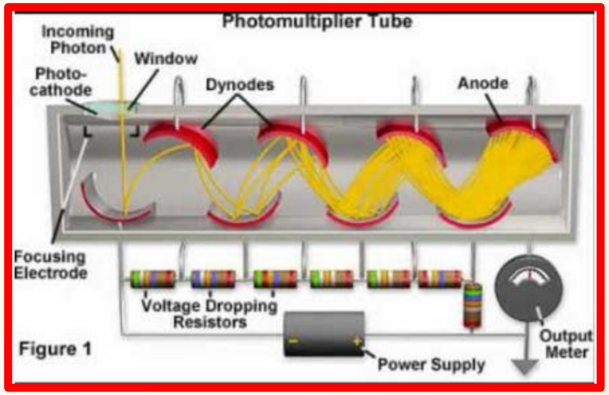
Planck's Constant = $6.62607015 \times 10^{-34}\ m^2\ kg / s$

Principles

- Current generating process using photons – The Photoelectric Effect:

[What Is The Photoelectric Effect? » ScienceABC]

Written By Ashish Last Updated On: 2 Jun 2024



Although there is no "conversion" that takes place, this phenomenon begins as photons enter the glass window. The energy of the photon, as dictated by its wavelength, strikes the first doped dynode releasing secondary electrons clinging to its surface. Electrons are stripped away from the coated dynodes, follow the cascade, and are pulled toward an anode; closing the circuit. In this instance, photons are used to activate systems based upon the presence of a predictable light source.

Why Fiber?

Parameter	Fiber Optics	Copper
Bandwidth	60 Tbps (Terabits per second) and beyond	10 Gbps (Gigabits per second)
Distance	12 Miles+ @ 10,000 Mbps	300 ft @ 1000 Mbps
Noise	Immune	Susceptible to EM/RFI interference, crosstalk and voltage surges
Security	Nearly Impossible to tap	Susceptible to tapping
Handling	Lightweight, thin diameter, strong pulling strength	Heavy, thicker diameter, strict pulling specifications
Weight/1000 ft.	4 Lbs.	39 Lbs.
Safety	Fiber Optics pose no shock or fire hazards as no electricity is carried across the cables	Shock and fire hazard safety and mitigation plans must be present

Uses in Aerospace/ Military

- Lightweight
  - **Reducing copper wire weight allows for additional system integration on the warfighter's platform!**
- Dependable
  - **High voltage equipment compliant**
  - **No cross talk/interference resistant**
- Difficult to tap into, or jam
- Ability to support large bandwidth applications
- Digital interoperability
  - **Ground-air and other service comms**


Threat Detection Systems

Uses in Aerospace/ Military

UAV applications

Ruggedized Network Racks

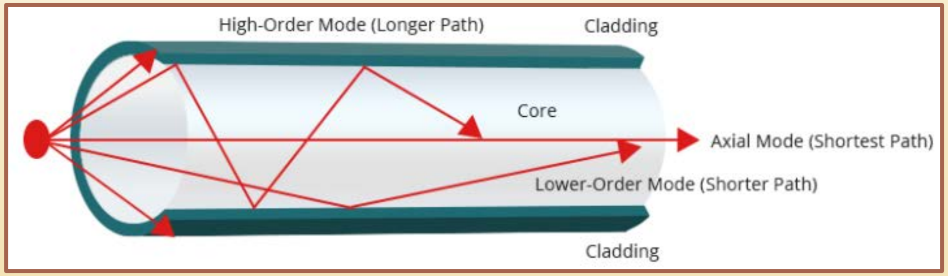
- Communications
  - Threat detection
- Weapons systems
  - Target Acquisition
- Avionics (APX-123)
  - Transponder IFF

Terms and Definitions

- **Attenuation:** The reduction in optical power as it passes along a fiber, usually expressed in decibels (dB). For fibers, we talk about attenuation coefficient or attenuation per unit length, in dB/km.
- **Bandwidth:** The range of signal frequencies or bit rate within which a fiber optic component, link or network will operate. Optical fibers can transmit either analog or digital signals.
- **Decibels (dB):** A unit of measurement of optical power that indicates relative power.
- **Optical Loss**: The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc., expressed in “dB”.
- **Optical Power**: is usually measured in dBm, aka decibels referenced to one milliwatt of power. While loss is a relative reading, optical power is an absolute measurement. You measure absolute power to test transmitters or receivers and relative power in “dB” to test loss.

Fiber Optic Challenges

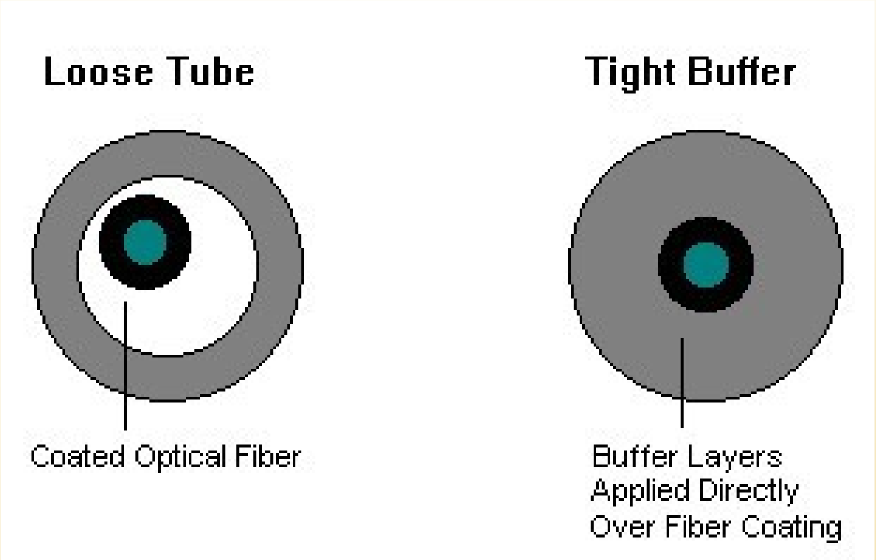
- Fiber Optic Attenuation – Loss of light (in decibels) as it travels down a fiber
  - Light Scattering occurs as a mode of light is redirected when contacting an obstructive atomic anomaly within a glass medium. 95% of power loss is said to account from scattering.
  - Light Absorption occurs as a mode of light is absorbed when passing through moisture, or impurities within a glass medium. Absorption accounts for roughly 5% of power loss through attenuation.
    - Micro/Macrobending occurs when a fiber is stressed out of a straight line or lay, due to pinching, or directional changes at installation. Scattering and Absorption events are directly correlated to the amount of bending inherent within a fiber run.
- Fiber Optic Modal Dispersion – Data transmission rate inconsistency
  - Due to the multiple rays of light traversing through the glass at varying angles, a time distortion is inevitable, especially at long fiber runs.



Fiber Optic Constructions

Fiber Optic cable is comprised of layered materials to aid environmental, structural, and operational support. There are 3 common fiber constructions

- 1. **Tight buffer/structure**: thick plastic coating on the fibers
- 2. **Loose-tube**: fibers with primary coating inside plastic tubes
- 3. **Ribbon**: fibers formed into a flat ribbon cable



Fiber Optic Construction

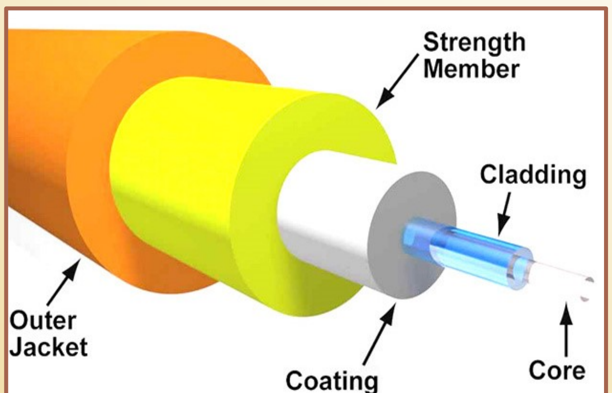
Tight Structure versus Loose Tube Fiber Protection:

- **Tight Structure:** Provides for crush resistance to fiber strands and is generally more flexible than its counterpart. However, this flexibility is susceptible to microbending which negatively impacts performance. This construction also offers smaller, lightweight fiber options ideal for smaller to moderate LAN/WAN applications.

- **Loose-tube Structure:** While maximum flexibility is less than that of a tight structure fiber, microbending is much less prominent; allowing for a more reliable rate of transmission when directional changes are required during installations. This tubular structure also provides more isolative protection from harsh environments; the ideal choice for outdoor applications.

Fiber optic manufacturing

Written By Factorama   Last Updated On: May 13, 2024

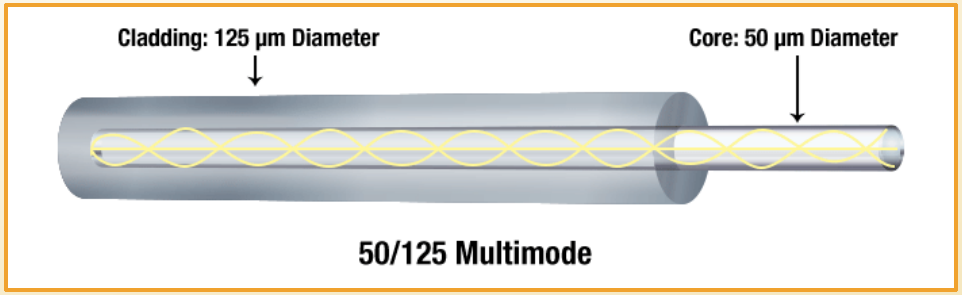


- **Jacket:** The tough outer covering on the cable.
- **Strength members**: Aramid fibers (Kevlar) used as strength members in the cable to allow pulling. The term is also used for the fiberglass rod in some cables used to stiffen and to prevent kinking.
- **Coating:** Acrylate Coating
- **Cladding:** Outside layer of the fiber that keeps light contained within the core and guides its path
- **Core:** Glass (Fiber)

Types of Fiber Optic

- **MultiMode Fiber:** Has a larger core (50 or 62.5 microns – a micron is one millionth of a meter) and is used with laser or LED sources at wavelengths of 850 to 1300 nm for short distance (typically less than 1000-foot applications).
  - Advantage - Cost effective (particularly with transmitters/receivers) vs. SingleMode Systems.

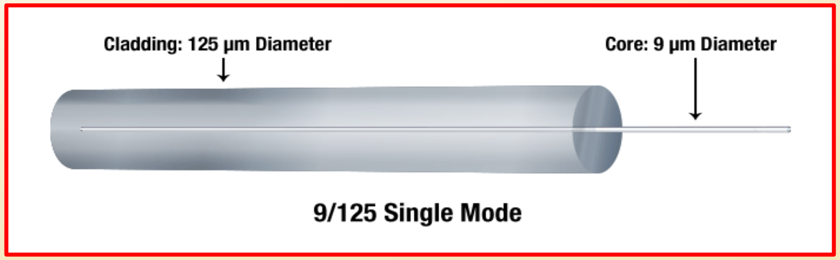
LED
Light
Source



Types of Fiber Optic

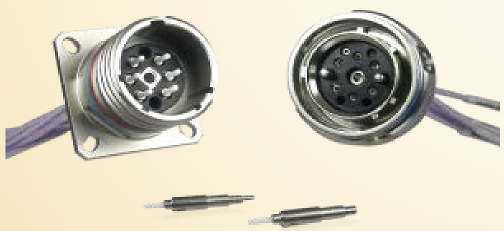
- **Singlemode Fiber:** Has a much smaller core, between 8 – 9 microns, and only transmits one mode. Signals can go very long distances at very high speeds. Singlemode is used for long distance, metropolitan, fiber to the home, and CATV with laser source wavelengths at 1310 to 1550 nm.
  - Advantage – Smaller Core (8-9um) allows for longer reliable fiber runs due to low modal dispersion and lower attenuation. Light sources, or transmitters, are generated from Lasers which provide a single wavelength, or single mode of light.

LASER
Light
Source



Fiber Optic Link

Once the fiber type and fiber cable construction has been identified we can identify the interconnecting components required to complete a link.

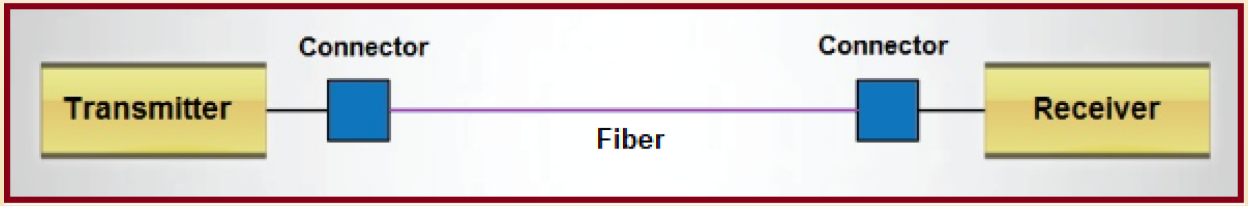


- The interconnect at each end of a fiber stand is called termini.
  - There are a variety of mil spec termini with unique characteristics. Careful consideration is needed if you want to maximize performance and reliability to the anticipated environment of your system.
  - Choosing pull-proof or non-pull-proof fiber construction will determine what contact designs shall be used.
    - Consider non-pull-proof terminations for tight structure fiber construction
    - Consider pull-proof terminations for loose tube fiber construction
- Most fiber optic connectors in aircraft applications are your typical bayonet/circular type connectors.
  - Same interconnect process as the familiar electrical connections.
  - Often the same insertion/extraction tools as the familiar electrical connectors.

Fiber Optic Link

The transmitter and receiver are the final pieces of a fiber link

- **Fiber Transmitters:** converts an electrical signal into an optical output from either a light emitting diode (LED), or laser diode.
  - LED's have much lower power outputs than lasers and are cheaper to produce.
  - LED's diverging light output pattern limits the fiber type to multimode fibers.
  - Lasers have smaller tighter light outputs and are easily coupled to Single Mode fibers, making them ideal for long-distance high-speed links.
  - Lasers are more expensive, as creating the laser cavity inside the device is more difficult. The chip must be separated from the semiconductor wafer, and each end coated before the laser can even be tested to see if it is good.
- **Fiber Receivers:** Using a photodetector, as mentioned earlier with the photo multiplier tube, these devices convert optical signals into electrical signals for system processing.



Safety Considerations

Prior to fiber optic construction, several personnel safety concerns must be addressed!

Eyes

- Safety glasses should be worn when terminating or repairing termini
- Do not look at the terminated end of fiber when light energy is present
- A VFL, or Visual Fault Locator, is a continuity checking device and is classified as a Class 2 laser. Never look directly at the light of an energized VFL!

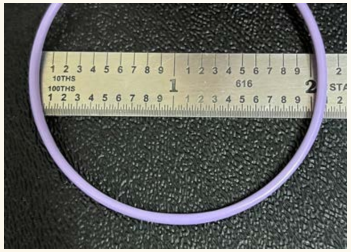
Appendages

- Be aware of small scraps of fiber that may be present
- Could become embedded under skin

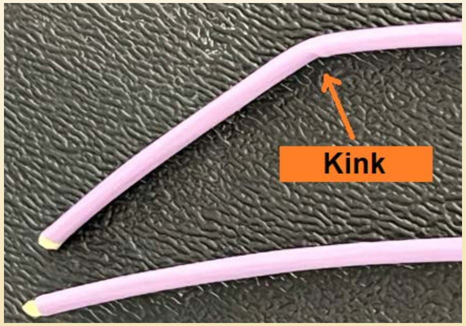
Safety Considerations

Proper Product handling is very important in maintaining product performance!

- Ensure the minimum bend radius for any given fiber is followed. Below is example of a minimum bend radius of 1 inch:



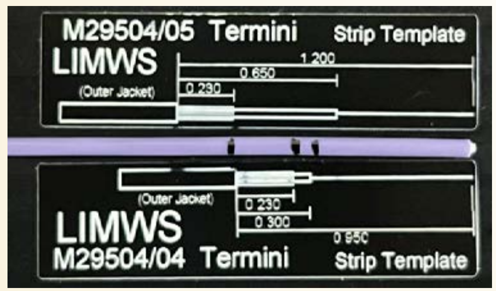
- If you believe a fiber has violated this radius, testing of the fiber is required.
- If a kinking condition is present, the fiber shall be replaced as the microbending present within the glass is likely permanent.



Terminations-Fiber Prep

For all types of adhesive/polish connectors, the termination process is similar:

- You start by preparing the cable, stripping off the outer jacket and cutting off the strength members.

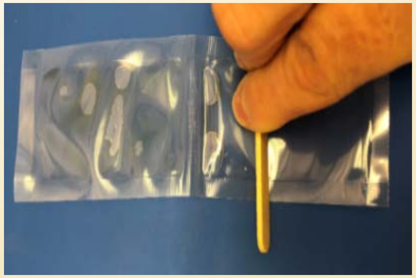


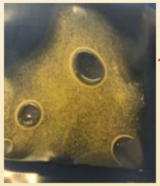
- Next you carefully strip the exposed fiber to remove the buffer coating without damaging the fiber.
- The fiber is then cleaned and carefully set aside.
- Adhesive/Epoxy is applied to the connector and the fiber is inserted and crimped/shrink sleeve secured onto the connector body.

Terminations-Epoxies

2-part epoxies are widely used for aerospace fiber optic terminations.

- Most fiber optic terminations use epoxies and other adhesives to secure the fiber to the termini.
- It is important to use only the specified adhesives, as the fiber to ferrule bond is critical for low loss and long-term reliability of the fiber.
- The goal in mixing the 2-part epoxy is minimizing bubbles. Mixing by hand is sufficient within a classroom, but a centrifuge is recommended to minimize bubble content for all production fiber!





Terminations-Crimp/Shrink

- After the exposed glass has been inserted into the epoxy-filled termini, the next step is to secure the rear of the termini with a crimp or shrink sleeve (hopefully you didn’t forget to install this).

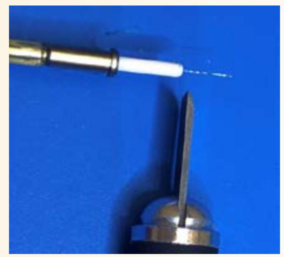
- The rear of fiber optic termini is the weakest point of the strand. Once this support sleeve is secured, the epoxy is ready to be cured.

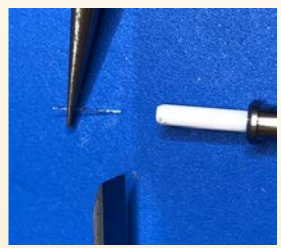
Terminations-Curing

Curing the epoxy can take 30 mins to 2 hours, depending on your requirements.

- Cover the ferrule and fiber with a curing adapter.
- Place the termini with the cure adapter installed into the curing oven and place the cable vertically over the curing oven using the cable stand.
- Ensure the termini is fully contained within the curing block
- Follow the oven manufacturer's setup procedures for programming the cure oven
- The adhesive will cure in accordance with the thermal profile.

Terminations

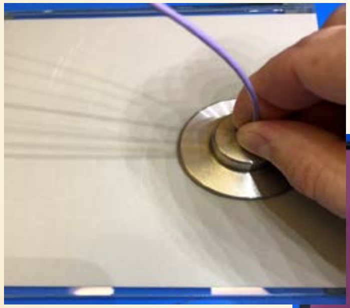




- Remove the terminus from the cure oven and allow to cool for at least 4 -5 minutes.
- Remove the cure adapter.
- Using a cleaving tool score the fiber close to the terminus tip at the epoxy interface.
- Pull off fiber with a gentle, straight pull.

Polishing-Manual

- Manufactures can choose to hand polish, but it is not recommended for production. The polish results are inconsistent, time consuming and will likely not pass interferometer testing. (not very practical either)
  - However, when in a pinch, touchup hand polishing can restore system functionality!



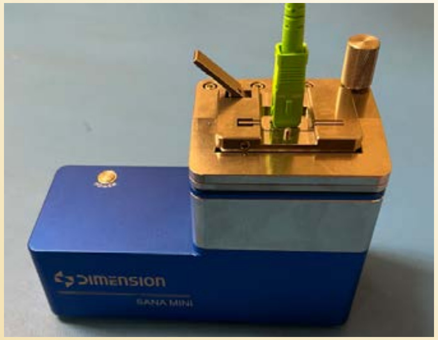
Epoxy Removal

Surface Defect Removal

Fine Polish

Polishing-Auto

- Auto Polishing provides a controlled end-face finish. There are many makes and models that provide auto sensing, water dispensing, and visual inspection systems for added efficiency.
  - Each fiber termini will require a specific polishing profile.
  - These profiles often include plate speed, surface pressure, film selection, and liquid application decisions.
  - We highly recommend using an interferometer to validate each polishing process step to ensure industry standard fiber heights, apex offsets, and rates of curvature are maintained.

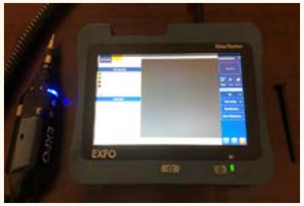


  - Each Polishing step will require inspection ensure each end-face does not require additional cleaning/touch-up!

Inspection Frequency

Inspection Device Classifications:

In-Direct



Video Probe Scope

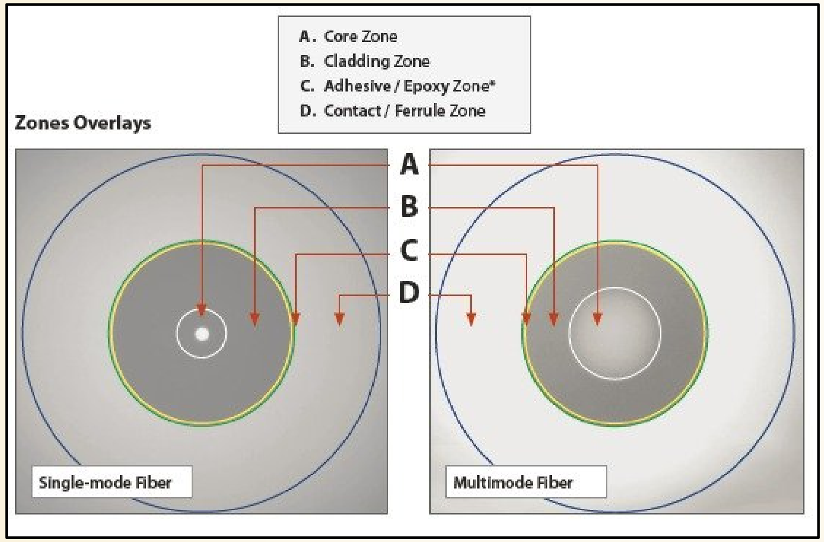
Direct

Hand-held Scope

When should I Inspect a fiber optic end-face?

- Upon incoming Inspection.
- Every time a termini is mated/demated from a connector. This includes Test!!!
- For a Multimode termini, examine the end-face with a 200x video inspection scope (at minimum) and for a Singlemode termini, examine the end-face with a 400x video inspection scope (at minimum). Ensure that each optical surface is smooth, and free of scratches, pits, chips, and debris.
- No termini should be mated, tested, or cleaned without the authority of a successful inspection!

Inspection Criteria



A successful inspection must follow this criteria

DEFECTS

Table 5-3 – Beginning of Life Visual Inspection (200X) Criteria for Multimode Optical Fiber End Face

Beginning of Life Visual Inspection Criteria				
Visual Inspection Criteria	Zone A Core Area	Zone B Cladding Area	Zone C Adhesive Bond Area	Zone D Ferrule Area
Cracks	None	None	No Limit on Size or Number	None
Chips/Pits/ Contamination	None > 1 µm	Maximum of 2 at ≤ 5 µm	No Limit on Size or Number	None > 10 µm
Scratches	None > 1 µm in Width No Limit on Number of Scratches	None > 3 µm in Width No Limit on Number of Scratches	No Limit on Size or Number	No Limit of Size or Number
Debris	None > 1 µm	Maximum of 2 Pieces of Debris at ≤ 5 µm	Maximum of 5 Pieces of Debris ≤ 10 µm in Diameter	Maximum of 5 Pieces of Debris ≤ 10 µm in Diameter

[redacted]

DEFECTS

Table 5-4 – In Service Visual Inspection (200X) Criteria for Multimode Optical Fiber End Face

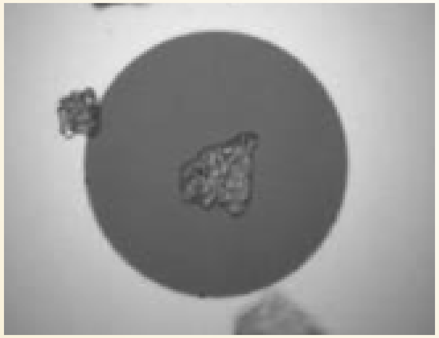
In Service Visual Inspection Criteria				
Visual Inspection Criteria	Zone A Core Area	Zone B Cladding Area	Zone C Adhesive Bond Area	Zone D Ferrule Area
Cracks	None	None	No Limit on Size or Number	None
Chips/Pits/ Contamination	Not to exceed 5 percent of total area	Not to exceed 10 percent of total area	No Limit on Size or Number	No Limit on Size or Number
Scratches	No more than 3 ≥3 µm in Width, any Length	No more than 6 µm in Width, no limit on number	No Limit on Size or Number	No Limit of Size or Number
Debris	None >3 µm	None >3 µm	Maximum of 5 Pieces of Debris ≤ 10 µm in Diameter	Maximum of 5 Pieces of Debris ≤ 10 µm in Diameter

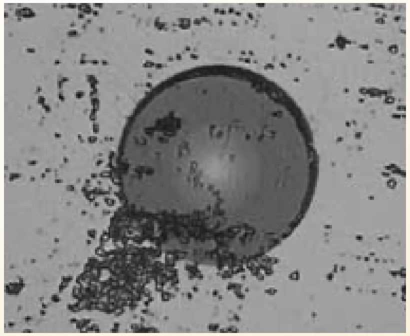
[redacted]

Cleaning / Inspection

But why should I clean a fiber optic end-face?

- Dirty fiber end-faces will not allow proper signal flow (increased attenuation) through the system
- Dirty fiber end-faces can cause total signal blockage (system failures)





- Always protect end-faces with clean dust caps/covers.

Inspection

What should I use to Inspect a Fiber Optic end-face?

- The Exfo FOVIS serves as a powerful tool when determining the acceptability of fiber optic end-face inspection event.
- With a 5.25” screen and at 400x, the resolution is magnitudes greater than the limits of any current Inspection requirement.
- Shadows and other false artifacts may be falsely included within the inspection algorithm execution. These anomalies will be obvious and will seem to be invisible to the eye.
- It is important to note that visible white scratches are less than 1um in width and are acceptable in all 4 zones of the end-face.
- The Inspector has the final say on whether an end-face passes or fails, the subjectivity is vastly reduced using the Exfo tool, but this is not the arbiter of acceptance or rejection!

Inspection

- Depending on the termini to be inspected, there are a variety of adapters available for the Exfo Fovis that can be quickly interchanged.
- Below are 3 options for 2.50MM pins, 1.60MM pin, and an adapter tip for a 1.60MM socket*.

Cleaning Frequency

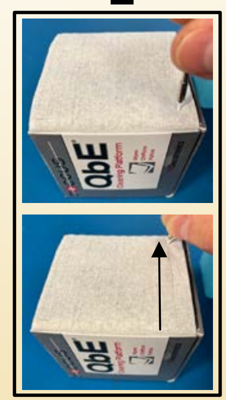
When should I clean a fiber optic end-face?

***An end-face shall be CLEANED ONLY if Inspection requires it!!!!**

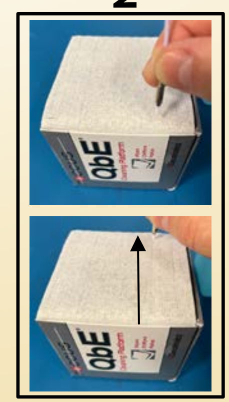
- Clean a termini end face with a wipe dampened with approved fiber optic cleaning fluid
- Isopropyl alcohol works great as-long-as it is removed prior to insertion into a connector. When choosing a cleaning wipe, it shall be of optical quality, lint-free, and non-debris generating.
- The QbE Cleaning Platform provides a consistently clean and uniform surface between end-face cleanings.
- One wet wipe, followed by one dry wipe provides optimal end-face cleaning.

Clean Method 1:

1



2

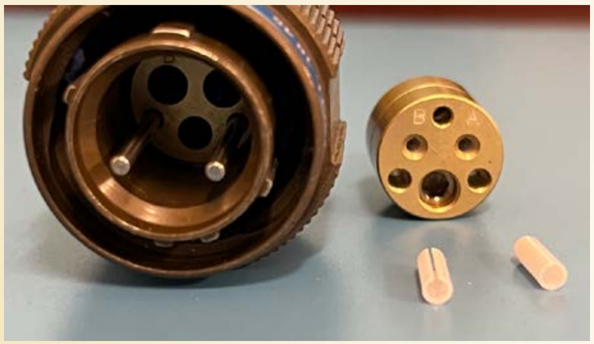


Cleaning-Method 2

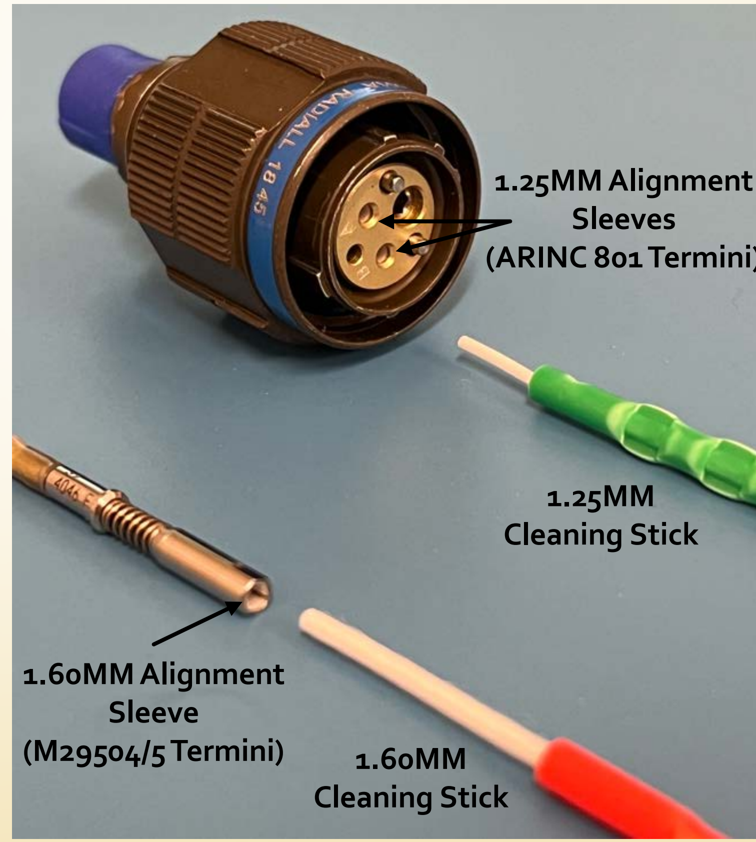
Clean Method 2: **Fiber Cleaning Sticks (Sticklers Brand)**

Cleaning-Method 2

Fiber Cleaning Sticks (Sticklers Brand)

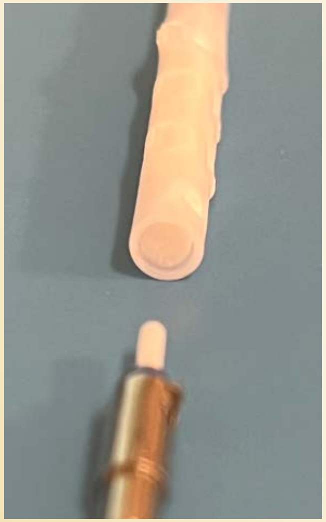


- Fiber Optic Alignment Sleeves can either fit around a termini, or nest within a connector
- Alignment sleeves are used to ensure a consistent mating condition while providing vibration resistance, surface area friction, and maintaining ferrule alignment



Cleaning-Method 2

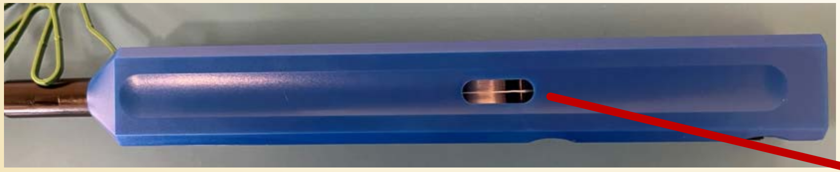
Fiber Cleaning Sticks (Sticklers Brand)



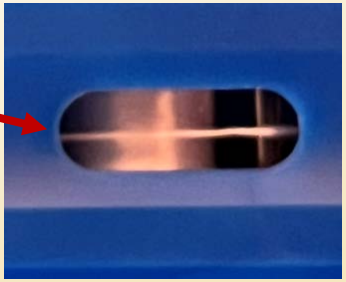
It is acceptable to dampen the end of this clean stick with optical grade cleaning solution, however it must be allowed to dry, or be removed prior to inspection.

Cleaning-Method 3

Click Cleaning Tools (IBC Brand)



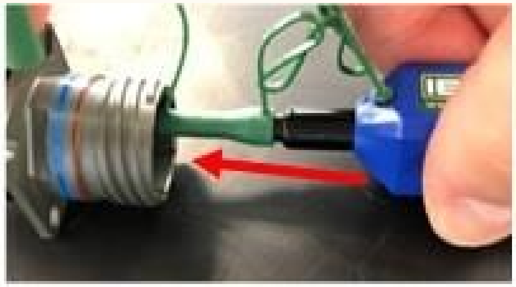
Spool Inspection Window



Prior to using a click clean tool, always verify that there is white yarn visible on the spool! If you see the **red spool**, replace the tool.

Cleaning-Method 3

Click Cleaning Tools (IBC Brand)

- Determine what size tool is needed
- Determine the gender of the termini to be cleaned
- Verify the tool has yarn covering the red spool.
- Carefully insert tip over a male or into a female termini end face
- Fully press the tool until you hear a 'click' and release tool
- A follow-up click is recommend but don't get click happy!
- Reinspect to ensure end face is acceptable

Continuity Testing

Now that we have verified that all end-faces are clean, we can perform continuity checks if population is required at install using a VFL.

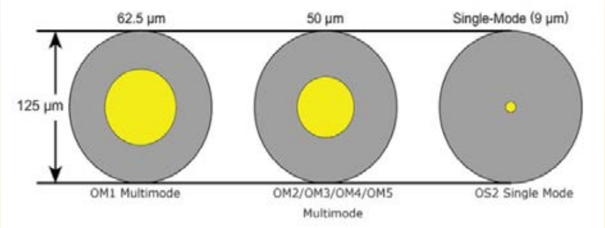
Tip:

Continuity verification can be achieved using the FOVIS, as the blue light will emit through the fiber to the opposing end-face. Because there is no direct end-face contact using the FOVIS, the potential for damaging the end-face is reduced!

- Check each fiber optic termination with a continuity tester (modified flashlight)
- **A VFL, or Visual Fault Locator, is a continuity checking device and is classified as a Class 2 laser. Never look directly at the light of an energized VFL!**
- If light is being emitted from the other end of the fiber, there is good continuity

Fiber Optic dB Loss Testing

- Loss testing is done at wavelengths appropriate for the fiber and its usage (as determined by DWG).
- Generally multimode fiber is tested at 850nm and at 1300 nm with LED sources.
- Singlemode fiber is tested at 1310 nm and at 1550 nm with laser sources.
- The system components, typically the transmitters and receivers, determine the appropriate light source and wavelength used for testing.



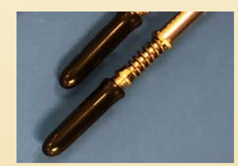
Optical Fiber Core Diameters

Fiber Optic dB Loss Testing

- Optical loss, or insertion loss: The primary performance parameter of most fiber optic components.
- Testing for loss requires measuring the total amount of optical power lost in a cable (including fiber attenuation and connector loss) using a fiber optic light source and power meter (LSPM).

Fiber Optic dB Loss Testing

- The insertion loss measurement is made by mating the cable being tested to known good reference cables with a calibrated launch power that becomes the "0 dB" loss reference.
- Reference cables are typically 1 – 2 meters long, with fiber and connectors matching the cables to be tested.
- Mating adapters should be used for testing as they are a factor in loss also. In fact, every fiber connection is expected to have some kind of power loss.
- Referencing out the meters, removes this expected loss that occurs; calculating only the new fiber strand and the loss at each termini.
- Remember that all termini shall be inspected prior to connecting to any equipment, adapter, or to another fiber cable!
- Don't forget to cover any test cables once testing has been completed.



“Lessons Learned” in the Field

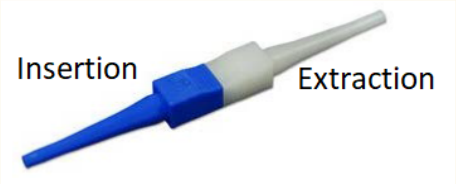
- Testing:
  - It is good practice to visually glance at every male termination after a demate has occurred.
  - Missing alignment sleeves not only create potential FOD but will likely cause insufficient test results as there is no alignment aiding the connection.
  - Here we can see an alignment sleeve from a female MQJ (Measurement Quality Jumper) has pulled out the metal sleeve; positioned over its male counterpart.
  - This is common phenomenon often found in dB loss tests. These ceramic sleeves simply slide into the metal cavity of a female termini and can be removed when a male termini is detached from a connection.

It is always good practice for the test technicians to verify sleeves are not missing from the female connectors/MQJs at each mating cycle.

“Lessons Learned” in the Field

- Populating:
  - It is best practice to use an insertion tool to populate any spring-loaded termini. Its nearly impossible properly seat this type of termini into a connector without a tool
  - You will hear a distinct clicking sound when the termini is properly seated.
  - Don’t be afraid to tug the fibber after its plugged to ensure its secured.

  - I have witnessed several faulty system tests due to unseated termini or loose connections .



Questions?

Tyonek
Native Corporation

Investing in Automation is paramount to maintaining quality expectations!