



OZ Optics

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HIGH POWER COLLIMATORS AND FOCUSERS – PIGTAIL STYLE

Features

- High power handling
- Rugged and compact design
- Low insertion loss
- Low backreflection
- Wide wavelength range
- Wide range of beam diameters
- Aspheric, plano-convex, C-lens, Axial GRIN lenses, and biconvex lenses available
- Singlemode, multimode, polarization maintaining and large mode area (LMA) fiber versions
- Diffraction limited optics
- **LOW COST!**

Applications

- Fiber optic device packaging, including wavelength division multiplexors, isolators, splitters, and integrated optics
- Source to fiber coupling
- Laser marking, laser machining

Specifications

- Wavelength: 200nm – 2100nm
- Backreflection: -40, and -60dB
- Polarization extinction ratios: 20, 25, or 30dB
- Beam diameters: 0.2 to 22mm
- Spot size: As small as <5 microns
- Wavefront distortion: $\lambda/4$ to $\lambda/10$

Product Description

OZ Optics offers a complete line of high power fiber collimators and focusers with low backreflection, designed to collimate or focus light exiting a fiber to a desired beam diameter or spot size. These devices can be used with laser diodes, fiber lasers, acousto-optic modulators and other fiber optic devices. Collimators and focusers can be used as matched pairs to couple light in and out of optical devices. This makes them ideal for fiber packaging of devices.

For collimators, the collimated beam diameter (**BD**) and full divergence angle (**DA**) depends upon the focal length of the lens (**f**), the core diameter (**a**), and the fiber numerical aperture (**NA**). The collimated beam characteristics are given by:

$$BD(mm) = 2 \times f(mm) \times NA \quad DA(mrad) = a(\mu m) / f(mm)$$

When using the above formulae, please exercise caution. Different definitions for the numerical aperture are used by fiber manufacturers. For instance, definitions based on 50 percent, 13.5 percent ($1/e^2$), 5 percent, and 1 percent intensity levels are all used.

OZ Optics standard tables list the definitions used for each fiber type, as well as conversion factors to convert values to $1/e^2$ values. OZ Optics uses $1/e^2$ definitions for its calculations of the beam diameter wherever possible.



High Power Pigtail Collimator



Pigtail LPC-04 Style Collimator with 8mm OD



12mm OD Collimator/Focuser

For fiber focusers, the exact calculation of the spot diameter (**SD**), magnification factor (**M**), and working distance (**WD**) is more difficult and depends on the properties of the lenses being used. As a first approximation, one can calculate the desired focuser characteristics using the geometric optics lens formulae:

$$\frac{1}{i} + \frac{1}{o} = \frac{1}{f}$$

$$M = -\frac{i}{o}$$

$$SD = M \times a$$

$$WD \cong i$$

Where **o**, **i** are the object and image distances respectively. Use the above formulae to determine what focal lens you require. Standard focal lengths and lenses are listed in the *Standard Tables* data sheet. http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

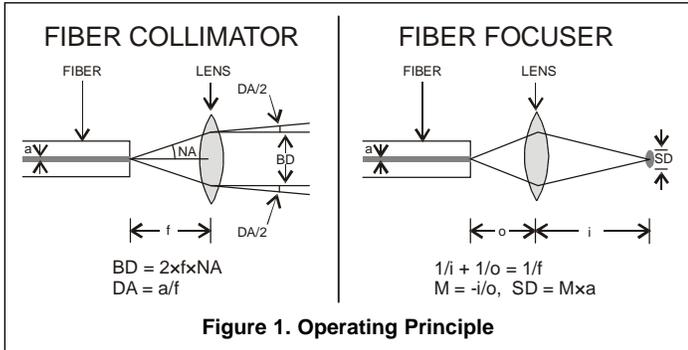


Figure 1. Operating Principle

In standard connectors the fibers are glued into place, and the fiber is polished flush with the connector ferrule tip (See figure 2A). When used with high power lasers, heat generated at the tip of the fiber causes the surrounding epoxy to break down and give off gases. These gases, in turn, burn onto the tip of the fiber, causing catastrophic damage to the fiber and perhaps the entire system. In contrast, our high power connectors feature an air-gap design, where the fiber extends into free space by 1.1 mm to 1.5 mm, providing an epoxy-free region where thermal energy is safely dissipated without burning the surrounding material.

The fiber endface itself can be finished using several different techniques, depending on the maximum power requirements and cost restrictions. The simplest method is to polish the connector, as one does in standard connector termination (See figure 2B). While this provides a smooth finish, particles from the polishing material can embed themselves in the glass, forming absorption sites where the fiber can be burned. In addition, the fiber cladding has to exceed 200 microns to successfully polish the connector.

Power handling can be improved by mechanically cleaving the fiber instead, to give an optically smooth surface without polishing, thus preventing contamination (See figure 2C). Finally, the fiber can be laser treated to anneal the endface (See figure 2D). This technique gives the highest power handling possible. In all cases the fiber can be provided with either a flat or angled endface. PM fibers can also be angle cleaved but we cannot control the angle of the cleave with respect to the stress rods of the fiber.

Another way to improve power handling in certain applications is to fusion splice a short length of "coreless fiber" to the end of single-mode or polarization maintaining fiber. This is also known as a fiber endcap. This endcap allows the light to expand to about half the diameter of the endcap before it emerges from the glass into air, reducing the power density at the glass/air interface. For standard fibers this is typically 350±25 microns long (OZ Optics can provide custom thickness endcaps). As it is this interface that is most sensitive to damage, expanding the beam increases the damage threshold. This method is only useful for fiber to free space applications, not fiber to fiber.

The end cap technique can also be used to terminate photonic crystal, or "holey" fibers. These fibers have a pattern of air holes in them, and these air holes constrain the light within the fiber. Potentially these holey fibers can give power handling that is several orders of magnitude better than conventional fibers. However, the air holes can trap dirt particles or other contaminants if left exposed on the fiber end. To prevent this, the end of the fiber can be capped with the coreless fiber, thus sealing the holes.

As an added surface, OZ Optics can AR coat the ends of the fiber, thus reducing optical losses and heat generation.

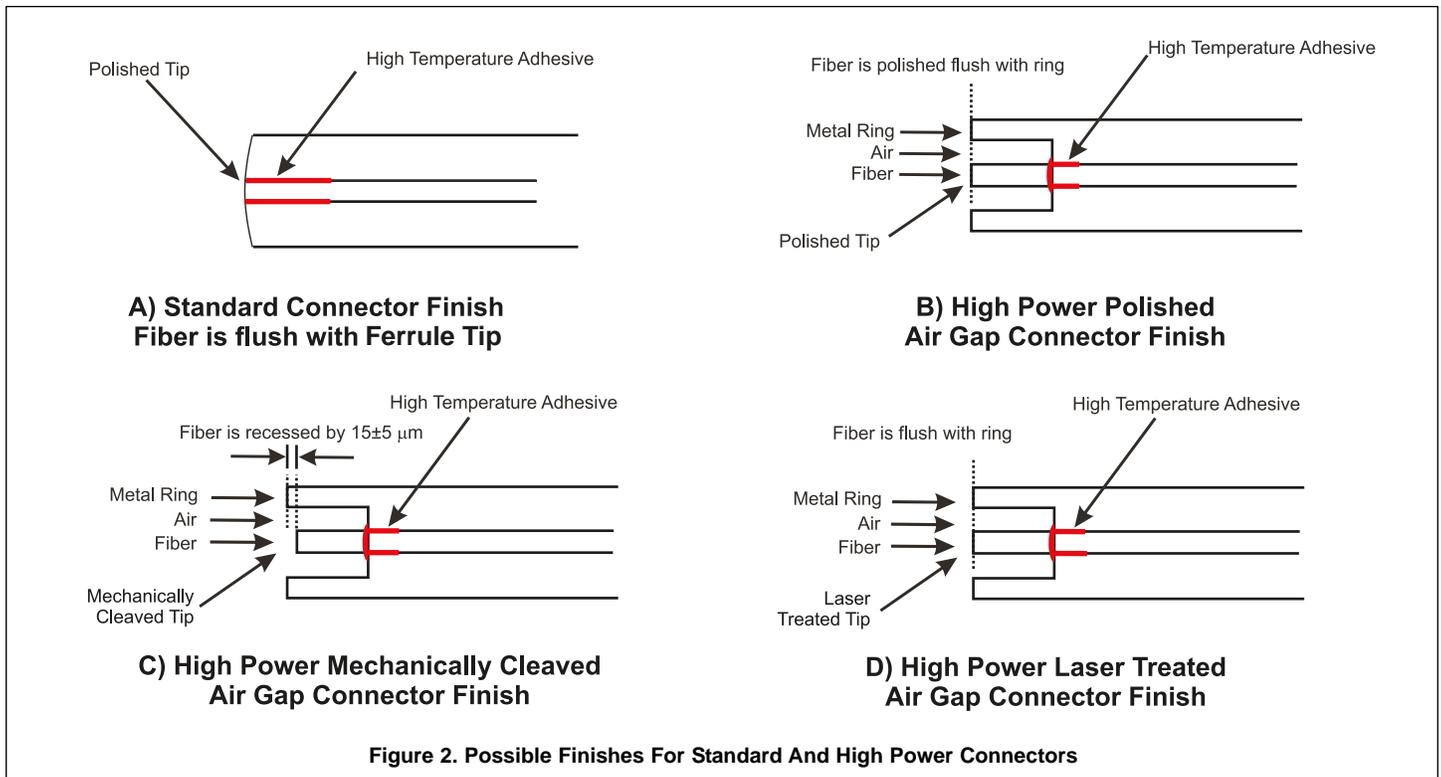
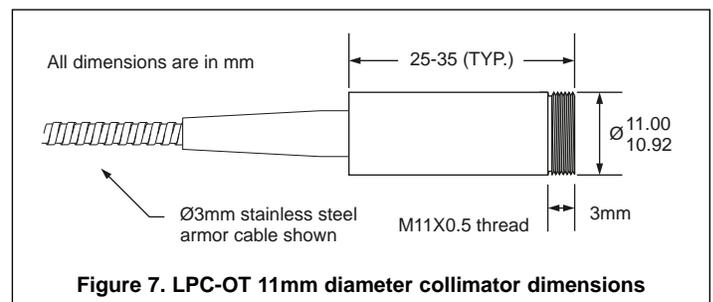
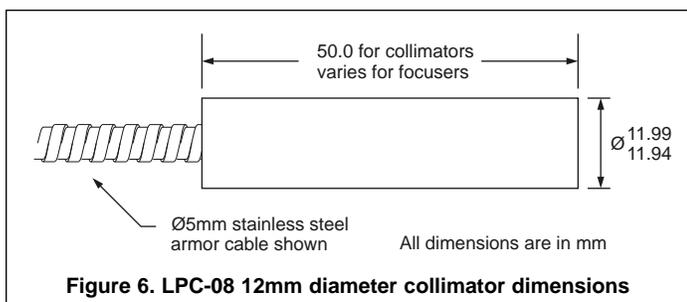
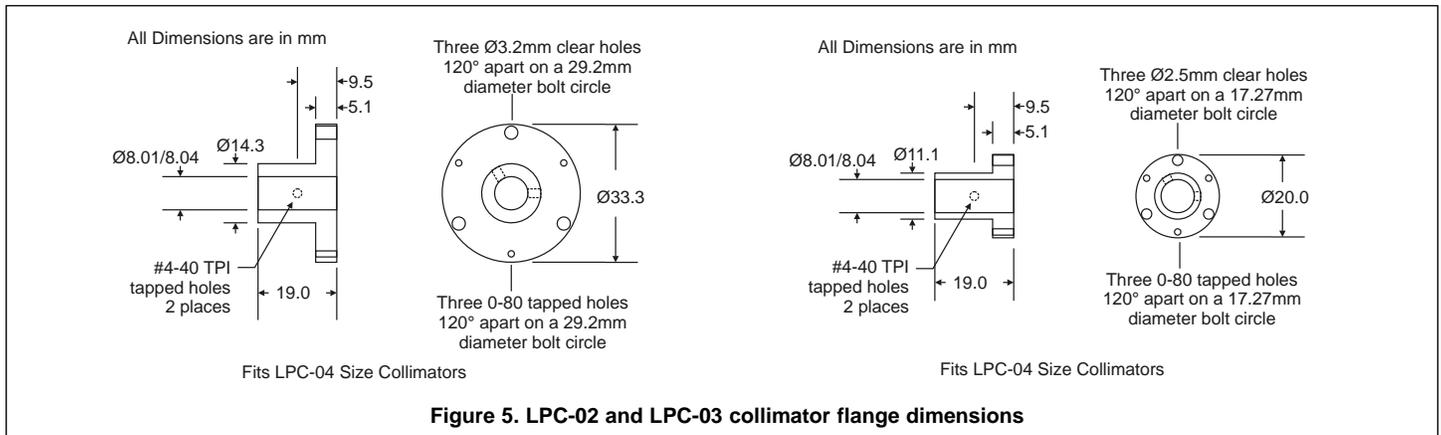
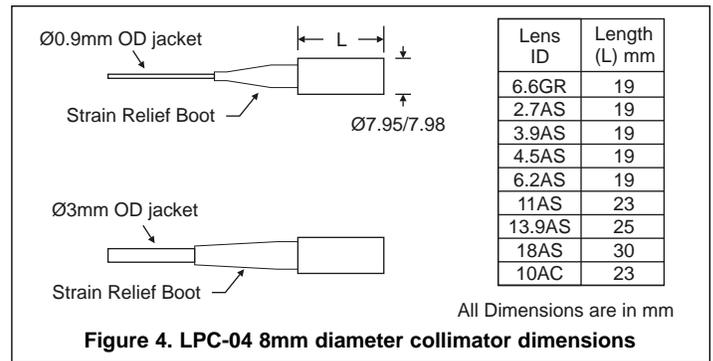
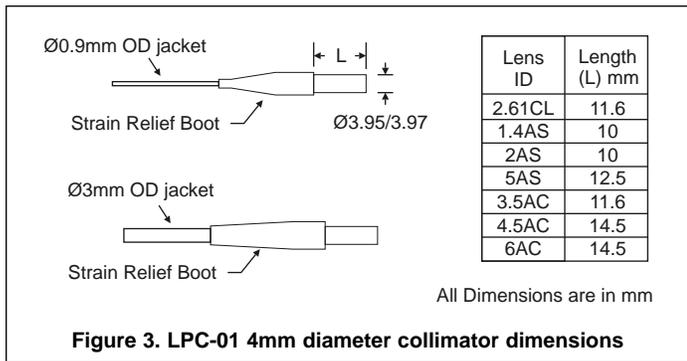


Figure 2. Possible Finishes For Standard And High Power Connectors



Test Results

The following tests were conducted on a pigtail style collimator pair attached to a fixture providing a separation of 60mm. The pair was adjusted for maximum coupling efficiency.

Temperature Range: Operating: -15°C to 55°C with 0.2dB deviation in loss.
Storage: -45°C to +75°C with less than 0.05dB residual loss.

Humidity Test: 97% humidity for 48 hours with 0.2dB deviation and less than 0.05dB residual loss (with the gap between the collimating lenses sealed against the environment).

Vibration and Shock Test: Vibration tests were performed, consisting of a 0.05 inch peak to peak displacement, sweeping from 10 to 55 Hz over 15 minutes dwell at worst resonance of 55 Hz (.02g). Each device was tested for 25 minutes per axis for a total of 75 minutes of vibration. Tests were conducted in each of the three major axes of the test unit. Shock tests consisting on 100g, 11 msec duration half-sine shocks, three times on each face for a total of 18 shocks, were also performed. Coupling loss deviation was 0.05dB with no hysteresis.

Questionnaire for Custom Parts:

1. What wavelength of light will you be transmitting through the fiber?
2. Do you need multimode, singlemode, or polarization maintaining fiber?
3. What fiber core/cladding size do you prefer?
4. If you need a collimator, what size collimated beam do you need?
5. If you need a focuser, what spot size and working distance do you need?
6. What is the maximum diameter collimator housing that you can use?
7. What is the power level you are working with? CW? Pulse parameters?
8. How low a return loss do you require?
9. How long should the patchcord be, in meters?
10. Do you need a connector on the other end of the fiber? If so, what type?
11. What type of cabling do you need?

Ordering Information for Custom Parts:

OZ Optics welcomes the opportunity to provide custom designed products to meet your application needs. As with most manufacturers, customized products do take additional effort so please expect some differences in the pricing compared to our standard parts list. In particular, we will need additional time to prepare a comprehensive quotation, and lead times will be longer than normal. These points will be carefully explained in your quotation, so your decision will be as well-informed as possible. Almost all high power components are assembled on a custom basis.

Description

Part Number

Pigtail Style Collimator: **LPC-0A-W-a/b-F-BD-f-BL-X-JD-L-HP**

A = Collimator Size

- 1 for 4.0mm OD, no flange
- 2 for 33mm OD removable flange¹
- 3 for 20mm OD removable flange¹
- 4 for 8.0mm OD no flange
- 5 for 2.5mm OD, standard length
- 6 for 2.5mm OD, short length²
- 7 for 1.6mm OD, no flange
- 8 for 12mm OD x 50mm long
- T for 11mm OD with M11x0.5 thread

W = Wavelength in nm:

(Example: Specify 633 for 633nm)

a/b = Fiber core and cladding diameters, in microns: (Example: 9/125)

See tables 1 to 5 of the *Standard Tables* data sheet for standard fiber sizes.

http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

F = Fiber Type: M = Multimode

S = Singlemode

P = Polarization maintaining

BD = Beam Diameter, in mm

f = Lens focal length and type:

See Tables 9 to 12 of the *Standard Tables* data sheet for a list of available lenses and the collimator housings they fit.

http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

L = Fiber length, in meters

JD = Jacket Diameter

- 1 = 900 micron OD hytel jacket
- 3 = 3mm OD PVC loose tube with Kevlar
- 3A = 3mm OD armored
- 3AS = 3mm OD stainless steel armored
- 5A = 5mm OD armored
- 5AS = 5mm OD stainless steel armored

See table 7 of the *Standard Tables* for drawings

http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

X = Connector code:

- X = No connector. Recommended for splicing.
- 3S = Super NTT-FC/PC
- 3U = Ultra NTT-FC/PC
- 3A = Angled NTT-FC/PC
- 8 = AT & T-ST

For high power termination, see the data sheet *High Power Fiber Optic Patchcords*.

http://www.ozoptics.com/ALLNEW_PDF/DTS0037.pdf

See table 6 of the OZ *Standard Tables* data sheet for other connectors.

http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

BL = Backreflection level:

- 35dB for multimode assemblies
- 40, 50, or 60dB for singlemode or polarization maintaining assemblies.

60dB versions are standard for 1300nm and 1550nm wavelengths only. Contact OZ Optics for other wavelengths.

Pigtail Style Focuser: **LPF-0A-W-a/b-F-M-WD-f-BL-X-JD-L-HP**

A = Collimator Size

- 1 for 4.0mm OD, no flange
- 2 for 33mm OD removable flange¹
- 3 for 20mm OD removable flange¹
- 4 for 8.0mm OD no flange
- 5 for 2.5mm OD, standard length
- 6 for 2.5mm OD, short length²
- 7 for 1.6mm OD, no flange
- 8 for 12mm OD x 50mm long
- T for 11mm OD with M11x0.5 thread

W = Wavelength in nm:

(Example: Specify 633 for 633nm)

a/b = Fiber core and cladding diameters, in microns: (Example: 9/125)

See tables 1 to 5 of the *Standard Tables* data sheet for standard fiber sizes.

http://www.ozoptics.com/ALLNEW_PDF/DTS0079.pdf

F = Fiber Type: M = Multimode

S = Singlemode

P = Polarization maintaining

M = Magnification Factor

WD = Working Distance, in mm

f = Lens focal length and type:

See Tables 9 to 12 of the *Standard Tables* data sheet for a list of available lenses and the collimator housings they fit.

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L = Fiber length, in meters

JD = Jacket Diameter

- 1 = 900 micron OD hytel jacket
- 3 = 3mm OD PVC loose tube with Kevlar
- 3A = 3mm OD armored
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- 5A = 5mm OD armored
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BL = Backreflection level:

- 35dB for multimode assemblies
- 40, 50, or 60dB for singlemode or polarization maintaining assemblies.

60dB versions are standard for 1300nm and 1550nm wavelengths only. Contact OZ Optics for other wavelengths.

¹ Smaller diameter removable flanges (11.5mm to 15mm diameters) are available on request.

² 2.5mm and 1.6mm OD short length collimators are available with 0.25mm, or 0.9mm OD jacketed fibers only.

Frequently Asked Questions (FAQs):

Q: What are the maximum power handling levels for singlemode and polarization maintaining fibers?

A: It depends on the size of the fiber core and the operating wavelength. With standard termination, singlemode fiber for 488nm can typically withstand a maximum of 1 to 3 Watts of continuous input power, in comparison 9/125 fiber can transmit 3 to 5 Watts of power. For fiber and wavelengths between these two examples the maximum power level will be somewhere between these two levels. With high power termination, these can be increased by an order of magnitude.

Q: I have a pulsed laser source. How do I select the correct fiber core size?

A: Pulsed lasers are more difficult to work with, because factors such as pulse energy duration and repetition rate must be factored into the calculation. We recommend contacting one of our sales representatives, who can determine the optimum fiber for your application.

Q: Can I connect together two fibers that are terminated with your high power connectors?

A: Because the fiber is suspended in air, one cannot mate two fibers together, as you would with regular connectors. Doing so would break the fiber. Instead one should purchase one of our lens style universal connectors. See our data sheet entitled *Universal Connectors and Hybrid Patchcords* for more information.

Q: What is the difference between a multimode fiber and a fiber bundle?

A: A multimode fiber is a single fiber, whose core is large enough to allow different paths, or modes for the light to travel within the fiber core. In contrast a fiber bundle consists of several fibers glued together to form a bundle. Each fiber carries light independently. OZ Optics normally offers multimode fibers, not fiber bundles.

Q: Are there any special handling precautions when working with high power connectors and patchcords?

A: Yes. Two factors must be kept in mind at all times. First, the fibers must be aligned and tested at low powers and only once good coupling from the laser into the fiber is achieved can the input power be increased. Second, the fiber ends must be kept completely clean, as any contamination can cause burning of the fiber. See the application notes for further details.

Q: What sort of warranty do you provide?

A: OZ Optics products are warranted against defects in materials and workmanship for a period of 1 year, unless otherwise stated, from the date of delivery to the initial enduser of the product. However if a patchcord end gets burned during installation or operation at high powers, the failure is usually due to factors outside of our control, such as misalignment or contamination. As a result failures of this nature are usually not covered under warranty.

Application Notes:

Safe installation of high power patchcords in laser to fiber delivery systems:

Important: Before using OZ Optics' fibers with your equipment, make sure that you are familiar with all operating and safety instructions provided with your source. **OZ Optics is not liable for any damage or harm caused by misuse of either the laser or of OZ Optics devices.**

1. Before attaching the provided fibers to your system, inspect both the input and output connector ends. The endfaces should be clean, shiny, and as free from contamination as possible. If not, clean the ends as outlined in the section titled Maintenance. Check the fiber ends both before connecting the fiber and also after disconnecting the fiber. It is very easy for contaminants to be transferred from one connector to another if one is not careful.
2. To avoid damage to the fibers being used, turn the source off, or reduce the power level to less than 50mW before attaching the fiber. If any optics have to be aligned, then perform the initial alignment at low power (<50mW). Only after the optics are fully aligned and locked should the laser power be increased.
3. It is recommended that the laser power be increased by only 0.25 Watts every few minutes, and that the output power from the fiber should be monitored, to ensure that the coupling efficiency is not changing with power.
4. Do not use any index matching gel, thread locking fluid, or any lubricants with the connector. Do not use in the presence of chemical fumes or oils.

MAINTENANCE

When not in use, the ends of the fiber and the connector receptacles should be covered with the supplied metal caps. This will protect the connectors from dirt and contamination. **DO NOT USE PLASTIC CAPS.** Plastic caps often are contaminated with mold release agents, which can get onto the fiber ends. This contamination is extremely difficult to see, and resists cleaning.

Air gap connectors are best cleaned by immersing them in an ultrasonic bath containing either methanol (preferred) or isopropanol (acceptable). This thoroughly cleans the connectors without physically touching the fiber ends. Please read all safety instructions for both the cleaner and the solvents before using them. Use filtered compressed air to blow any dust or dirt off the ferrule when finished. Carefully inspect the tip of the fiber under reflected light. The tip should be clean and shiny.