Optical Fibers - Minimum Bend Radius

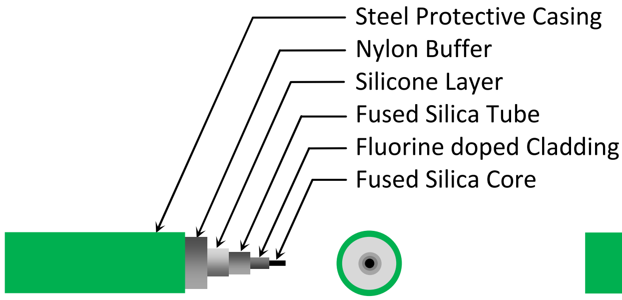
Introduction:

All Amada Miyachi America optical fibers are constructed with High-Quality Fused Silica (glass). In order to maintain optimal performance and to prevent damage, the fiber should not be bent beyond the **MBR** (*Minimum Bend Radius*). One of the biggest influences on the **MBR** is whether the fiber is carrying high power or is at rest (storage). To prevent fiber damage, fiber manufacturers typically store and ship their product on spools that are large enough so as not to stress the fiber during long-term storage. Unfortunately, there is no absolute **MBR** value where damage will occur.

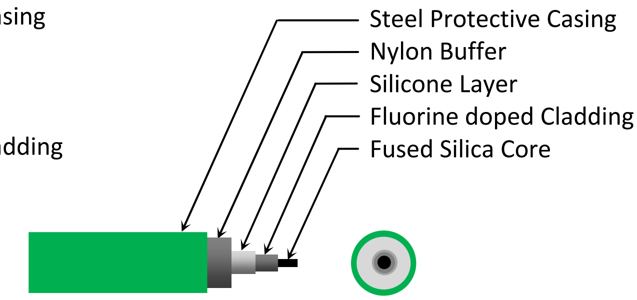
It is important to note that Amada Miyachi America Optical Fibers are not constructed like the optical fibers used in communication systems. Therefore the **MBR** information in the ANSI TIA/EIA-568B.3 standard do not apply to Amada Miyachi America Optical Fibers.

Optical Fiber Construction:

To understand the limiting factors in the **MBR**, an understanding of fiber construction is needed. When an Optical Fiber is constructed the Core and Cladding are fused/bonded during the draw process. In the smaller 100µm-300µm Fibers an additional Silica Tube is bonded to the cladding to provide additional protection. Beyond the Core/Cladding is a thin layer of Silicone (*50-100 microns thick*), followed by a layer of Nylon buffer material that provides a protective cushion layer. Finally the entire fiber is housed in a steel protective casing. When the fiber is bent, localized stresses are introduced on the Core/Cladding at the bend location. If bent too far, these localized stresses can fracture the Core/Cladding making the fiber unusable.



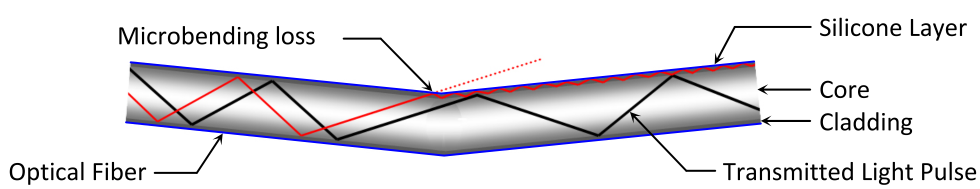
100µm and 300µm optical fibers



400µm – 1,000µm optical fibers

Bend effects on Performance:

When high power is traveling down a bent optical fiber it is subject to microbending losses. Under ideal conditions, the fluorine doped cladding acts as a waveguide keeping all transmitted power in the core. However when an optical fiber is bent, a small fraction of the core energy can enter the cladding, resulting in microbending losses and output attenuation. The light energy in the cladding is then held captive by the silicone layer (which acts as a secondary waveguide). When the cladding energy exits the fiber end it presents itself as a "halo" of light energy that has a divergence larger than the core energy. This "halo" energy can sometimes cause problems at the collimating or focusing optics and can affect the welding process. The amount of microbending losses is proportional to the tightness of the bend.



Acceptable Stress Limits:

The acceptable method in determining the **MBR** is to calculate the internal stresses on the Optical Fiber. The **MBR** can be calculated from the following formula:

$$R = \left(\frac{E \times r}{S}\right) - C_{th} - r$$

where:

R	Minimum Bend Radius, in meters (*m*)
E	Young's Modulus (70,000 N/m^2)
r	Fiber Clad Radius, in meters (*m*)
S	Stress Limit in kilo-Pascals (kPa)
C_{th}	Buffer Thickness, in meters (*m*)

To calculate the Stress (in kPa) for a specific Bend Radius, use the following formula:

$$S\,(kPa) = \left(\frac{E \times r}{(R + C_{th} + r)}\right)$$

where: $$S\,(kpsi) = \frac{S\,(kPa)}{6.894757}$$

- At any given time, a maximum stress limit of ≤ 172 kPa (≈ 25 kpsi) should be observed and not exceeded (for both storage and operation).
- In order to maintain optimal operational performance, a conservative stress limit of ≤ 103 kPa (≈ 15 kpsi) should be used in order to increase reliability and minimize microbending losses.

When these stress values (maximum vs. conservative) are applied to the Amada Miyachi America Optical Fibers, the **MBR** can be calculated.

Parameter		**Optical Fiber Core Diameter**						
		100µm	**200µm**	**300µm**	**400µm**	**600µm**	**800µm**	**1000µm**
Core Diameter (*µm*)		100	200	300	400	600	800	1000
Cladding Diameter (*µm*)		500	500	500	480	720	880	1050
Buffer Diameter (*µm*)		1300	1300	1300	1250	1400	1500	1700
r - Fiber Clad Radius (*µm*)		250	250	250	240	360	440	525
C_{th} – Buffer Thickness (*µm*)		400	400	400	385	340	310	325
MBR	@ 25kpsi (*inches*)	4.0”	4.0”	4.0”	3.8”	5.8”	7.0”	8.4”
	@ 25kpsi (*mm*)	101	101	101	97	146	178	212
	@ 15kpsi (*inches*)	**6.7”**	**6.7”**	**6.7”**	**6.4”**	**9.6”**	**11.7”**	**14.0”**
	@ 15kpsi (*mm*)	**169**	**169**	**169**	**162**	**243**	**297**	**355**

Example: The MBR (Minimum Bend Radius) for a 300µm Optical Fiber at a nominal stress of 15 kpsi should be bent no tighter than 13.4” diameter circle (6.7” radius × 2).

Published "Minimum Bend Radius" (MBR) Values:

Fiber Core Diameter (SI / GI)	Minimum Bend Radius			
	Operational [1]		Storage [2]	
100um	**7"**	**(175mm)**	6"	(150mm)
200um	**7"**	**(175mm)**	6"	(150mm)
300um	**7"**	**(175mm)**	6"	(150mm)
400um	**7"**	**(175mm)**	6"	(150mm)
600um	**10"**	**(255mm)**	8"	(205mm)
800um	**12"**	**(305mm)**	10"	(255mm)
1,000um	**14"**	**(355mm)**	12"	(305mm)

Notes:
1. Operational – MBR for an operational fiber.
2. Storage – MBR during storage.
3. English measurements rounded to nearest inch.

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