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Specialty
Optical Fibers
Innovative Fiber Optic Devices & Assemblies

Technical Memo

Bending Fiber

Every manufacturer of optical fibers will specify a minimum bend radius, in some fashion, for their fibers. Typically, bending the fiber to a radius that is tighter than this bend radius will void the warranty for that fiber.

This value is usually expressed as a multiple of the fiber glass diameter or as a proof stress level. Both of these methods of specifying the minimum bend radius rely on extensive statistical testing done in the late 1970s and early 1980s.

Depending on which manufacturer's fiber you use, you can get widely varying minimum bend radius guidelines. For most conservative manufacturers, the guideline is 300 times the glass diameter. Some of the more aggressive (and arguably more well controlled) manufacturers will specify a minimum bend radius equivalent to a 50kpsi (static) or 100kpsi (dynamic) proof stress level. This equates to approximately 50x and 100x the glass diameter, respectively. Since both of these methods rely on statistical models for predicting fiber failures, it is generally a matter of determining your risk tolerance. In both cases, the risk of failure is quite low, but the difference is measurable.

In the early days of optical fiber, most manufacturers included on-line proof testing of all optical fiber. The theory was that this would eliminate the so-called "infant mortality" of poor quality optical fiber. This is actually a textbook case of why it never works to "inspect in" quality! Soon after the development of the statistical models relating to fiber breakage, manufacturers began to realize that the process of proof testing fiber actually lowered its quality. The testing process induces flaws in the glass and makes it more susceptible to breaking. It was discovered that by stressing fiber to a significant fraction of its modulus of elasticity, the testing process would create defects which would propagate with subsequent stressing and thus lead to failure.

The net result of all this has been the virtual elimination of continuous proof testing in the specialty fiber industry. Instead, manufacturers are sampling and spending their resources and efforts on creating more consistent, controlled, and repeatable manufacturing processes. This has allowed the increasing reliance on fairly conservative statistical models for determining the allowable bend radius for a specific fiber.

With all of that out of the way... we still know that many applications require tight bends and that many fiber assemblies are made where minimum bend radius guidelines are exceeded... and those assemblies work, often for a long time. The problem with this is that it is impossible to state with any certainty which fibers can be successfully bent to smaller bend radii and by how much the guidelines can be exceeded. In these cases, the user has to accept the fact that he or she has now moved into the realm of statistics.

For short term applications, it is easier and safer to successfully exceed the guidelines since the process of

RSOF Billing: PO Box 822
Lightfoot VA 23090
Phone: (757) 645-2911
www.rsofibers.com

Shipping: 5248 Old Town Rd, Suite 12/13
Williamsburg VA 23188
Phone: (757) 645-2911
www.rsofibers.com

stress crack propagation is based on stress and time. We also know that fibers can be bent into radii much smaller than recommended and survive for long periods of time but how that is done successfully is typically guarded IP.

It is important to note that the above discussion is related to single fibers. In the event you have a bundle of fibers, you need to realize that the minimum allowable bend radius starts to increase dramatically with the number of fibers in the bundle. In those applications, the determination of the minimum bend radius for the bundle must be determined on a case by case basis by the assembly manufacturer.