Not All Optical Fiber Ribbon is Created Equal

*How to Test Whether Your Ribbon Stacks Up*

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The many positive attributes of optical fiber ribbon cable have catapulted its increased adoption in the network in recent years by major ILECs, independent telcos, and other service providers. Ribbon cable is the solution for growing network bandwidth, as its design allows for higher fiber counts and achieves the greatest fiber packing density among rival cable types. Its deployment improves speed and productivity in the field, and, in turn, decreases overall installation costs by utilizing mass fusion splicing, which is especially important for fast network restoration. Among its many other benefits, ribbon cable also resolves loose-tube shrinkage issues and surpasses other cable designs for outstanding performance under extreme environmental stress. Ribbon cable can and does deliver these promises — how well, however, depends upon the quality of the optical fiber ribbon in peelability (without resorting to chemical or potentially other harmful means), splitability, robustness in both end-access and mid-access applications, and fiber geometry.

**Ease of Peeling … A Key Criterion for Measuring Ribbon Quality**

The quality of optical fiber ribbon varies in proportion to the exclusive designs and proprietary development processes used by manufacturers. Hence, ribbon is not a commodity, but a highly differentiated product that can be evaluated foremost for ease of peelability. The peelability criterion involves the ease with which the technician or installer can remove the matrix from the optical fibers, while leaving the fiber coatings and colorings intact and free from damage. How quickly and easily the ribbon is peeled is crucial for speed and productivity in accessing, splitting, and separating the optical fibers for a given single fiber
splicing application. The matrix, which is the encapsulated coating housing the fiber, must be peeled away easily and evenly, so that there is no remaining residue. Zero residue is an important feature for achieving quality fusion splices. Matrix residue simply will not allow the fiber to fit properly into a splicer's v-groove, resulting in alignment errors and halting the fusion splicing process. Having fibers free from residue is also a fundamental requirement for users interested in connectivity; for example, most splice-on connectors will tolerate only a small deviation from a colored fiber's nominal 250 µm outer diameter.

The best quality optical fiber ribbon peels the easiest while remaining intact. It should be easily peeled by hand and should not require any special tool for end access applications. An easy test for peelability is to take the end of the optical fiber ribbon and either squeeze it or roll it within the fingertips. The matrix should break easily, allowing the quick and easy peeling by hand for hassle-free access to the undamaged fibers.

For mid-span applications, ease of peelability becomes even more crucial since the technician or installer is accessing a continuous span of often live fibers in a closure, pedestal, or fiber distribution hub. If the optical fiber ribbon is difficult to peel, the fiber may bend or break, resulting in attenuation or an interruption to service.

There are a number of techniques available for peeling the matrix material away from the fibers that comprise a ribbon. Mechanical or chemical means are employed in mid-span peel kits from various manufacturers. Mechanical peel methods involve some means of adhering the matrix material to a static surface; the ribbon’s fibers are then pulled away from the static surface, leaving the matrix material behind (Figure 1).
The process is repeated on the opposite side, leaving bare fibers for some finite span (Figure 2).

A key feature of the mechanical peel method is to initiate a known and well-defined point of matrix separation, and to this end a number of these kits employ both double-sided tape and fast-setting glue (often cyanoacrylate is used – See Figure 3). The glue forms a much stronger bond, thereby creating the point of initial matrix separation. Ribbons that demonstrate poor peelability require many such “spots” of glue along the entire span of ribbon. These gluing methods, however, pose a serious problem in lower temperatures —the glue may not cure in cold weather, possibly rendering the kit useless.

Chemical means of removing or softening the matrix material may also have negative side effects. Since the matrix material is most often very similar chemically to the fiber’s secondary coating layer, questions have been raised about the effect of solvents on the fiber coatings themselves. A solvent for matrix material will most likely be a solvent for the fiber coating also, causing potential damage to the actual fibers. When preparing the ribbon for a mid-span entry in order to splice and route individual fibers within a splice tray, for example, there will inevitably be some overlap where the solvent comes into contact with fibers whose matrix material has already been removed.
In such a case, fiber coating layers can be affected in two ways: the outer diameter of the coating, itself, appears to oscillate or wave along the axis of the fiber (Figure 4), and in some places there can be delamination evident between the fiber’s primary coating layer and the glass (Figure 5).

Simply, if a spray solvent and wipes are required to remove the encapsulating matrix material from the ribbon, then the ribbon fiber, itself, is of poor quality.

Mechanical methods that utilize glue and chemical softening techniques, alike, have the drawback of the chemicals themselves; such compounds are invariably volatile and can emit noxious vapors when used in a closed environment, like a splice trailer. There is also the overhead of having to store and restock such chemicals; glue, in particular, has a finite shelf-life, as well as undesirable environmental performance issues. Given these drawbacks, any mid-span kit that uses chemicals must be designed to require minimal use of them.

Essentially, the best quality ribbon for ease of peelability for mid-span applications should be manufactured so that no more than a single drop of glue and sticky tape is required to release the matrix from the fiber (Figure 6).
Quality Ribbon Achieves a Delicate Balance Between Peelability and Robustness

Although the ease of peelability is a crucial requisite for evaluating the quality of the optical fiber ribbon, the product must also, simultaneously, meet robustness qualifications. The optical ribbon fiber must achieve an easily peelable matrix for easy access to the fibers, while ensuring that the ribbon product, or a sub-unit of that ribbon, is robust enough to maintain its structural integrity when subjected to repeated bending and twisting in the handling and routing within a closure or ONT.

There are a number of ways to evaluate ribbon robustness. One fairly simple test that simulates closure/pedestal routing is “Resistance to Twist.” This test is called out in both Telcordia GR-20-CORE and ICEA-640 and involves twisting a fixed length of ribbon repeatedly back and forth, while it is held under a known and controlled tension. A ribbon must be able to withstand this tension without any separation of the fibers from the ribbon structure. A ribbon that fails this basic test will not remain intact for very long in a closure and may also, in fact, come apart within the cable structure, itself, during the rigors of cable installation and deployment.

Splitability…The Paradoxical Relationship with Robustness

A ribbon must possess the ability to be split into subunits for purposes of routing blocks of fibers; this is most often done by hand or with a specialized tool. When splitting the middle of the ribbon, as in mid-span applications, a tool is most often necessary. Each manufacturer, of course, recommends their own particular splitter tool. By some measures, this feature is the opposite of robustness – the technician wants the ribbon to come apart when and where he or she designates. The need for a tool ensures that the ribbon won’t fall apart at the wrong place or time during normal handling. Of course, the robustness criteria apply to sub ribbons separated from the main ribbon, as well.

When splitting at the end of a ribbon, preferably by hand, the ribbon should show no signs of stray fibers or excessive overhanging of the ribbon matrix, defined as less than or equal to 1-fiber width (250 micron). When splitting the middle of the ribbon with a simple splitting tool, the ribbon, again, should show no signs of stray fibers or the overhanging of ribbon matrix.

Optical Fiber Ribbon Geometry and Splicing Performance

One of the primary benefits of ribbon technology is the use of mass fusion splicing for increased productivity and speed in the field. Since mass fusion splicers are passive alignment devices (as opposed to core-aligning splicers), there are several geometrical factors intrinsic to the fibers themselves that can drastically affect splice quality. Mode Field Diameter (MFD), which is a measure of how tightly bound the light is in relation to the center of the fiber, can be a significant contributing factor for achieving a reliable splicing experience. If the MFD’s of the two fibers being spliced are not the same (“MFD Mismatch”), then optical loss will occur at the splice point. Thus, for both core alignment and passive
alignment splicers, the range of MFD for a given manufacturer's fiber is an important consideration, as is the nominal or center value. The MFD for fiber undergoing splicing should be in the ideal range of 8.6 µm to 9.5 µm ±0.6 µm. Given the choice between two different fiber products, each with the same nominal MFD values, the user should choose the fiber product from the manufacturer offering the tightest tolerance. For example, one should choose a MFD tolerance of ±0.4 µm over ±0.6 µm for a better fusion splicing experience.

Core-to-Cladding Offset or Core-to-Cladding Concentricity is another measure important for the quality of mass fusion splicing. This measures how far off the center of the fiber’s core is from the center of the outer glass diameter (the Cladding). In passive splicing only, the outer glass diameter is used to orient the fibers, which are usually aligned via fixed (often ceramic) v-grooves (See Figure 7). If the fiber cores do not align (as in the case of two poor Core-to-Clad offset values), optical loss will again occur at the splice point. Minimal Core-to-Cladding offset numbers are, therefore, critical for optimal core alignment in mass fusion splicing. The Core-to-Cladding Concentricity should be ± 0.6 µm or less for a tight distribution of low splice losses. G.652D cites a range of ± 0.6, but users should choose fibers that demonstrate a more restrictive range whenever possible.

Similarly, the Outer Glass Diameter (sometimes called Cladding OD or Glass OD) affects passive alignment, as a smaller diameter fiber will sit lower in a fixed angle V-groove, resulting in misalignment and high splice loss (See Figure 8). Since most Glass OD nominal values are 125 µm (for standard telecomm fiber), the range of Glass OD is another critical factor for successful mass fusion splicing. The lower the allowed Glass OD range, the better, with some manufacturer’s Glass OD Tolerances within ±0.5 µm.
For the best mass fusion splicing (and active core alignment) yields, seek optical fiber ribbon with the industry’s tightest tolerances on MFD range, Core-to-Cladding Offset, and Glass OD Range, which will result in lower overall splice loss averages.

**Conclusion**

To develop the best quality optical ribbon fiber, manufacturers must find that magic formula that delivers outstanding performance in peelability, splitability, robustness and fiber geometry. Some manufacturers have; some manufacturers have not. By evaluating your optical fiber ribbon against the criteria mentioned above, you can be assured that you have purchased the best quality optical fiber ribbon, which will perform reliably in any given application, unleashing the benefits of mass fusion splicing for increased productivity and low cost deployments.