A Furukawa Company

AllWave® Fiber
Fusion Splicing Compatibility

Contents ………………………………………………………………………………….. Section

1. GENERAL

1.1 Optical fiber splices are made by cleaning and cleaving the fiber ends, aligning the fibers ends, and retaining the fiber alignment during the splicing process. Mechanical splicing and fusion splicing are the two most common splicing methods. This splice compatibility study was conducted using fusion splice techniques.

1.2 Process variation during fiber manufacturing can cause fibers to differ with regards to optical and dimensional characteristics. These variations contribute to the attenuation of the fusion splice and are known as “intrinsic” splice loss. In most cases, the intrinsic splice loss cannot be reduced by the splicing process.

1.3 In contrast to intrinsic loss, extrinsic splice loss results from the fiber splicing process (fiber cleave angle, dirty or dusty fiber ends, misaligned fibers, improper arc settings, etc.) and is independent of the fiber properties. If two identical fibers are spliced together, the resultant splice loss is said to be extrinsic and depends only on the splicing method.

1.4 The Optical Time Domain Reflectometer (OTDR) is the most common measurement instrument used to measure splice loss. In general, the OTDR performs a measurement by sending short pulses of laser light down one end of the fiber. Light reflected from fiber discontinuities and backscattered from microscopic defects travels back to the OTDR where it is detected and displayed. The screen display is referred to as an OTDR trace.

1.5 Fiber attenuation (dB/km) is measured from the change in backscattered light between two points along the fiber (usually the start and end of the fiber).

1.6 Fiber splices produce both non-reflective (fusion splice) and reflective (mechanical splices) OTDR events as shown in Figure 1. Splice loss (dB) is measured by the change in backscattered light immediately before and after the splice point.

1.7 If two adjacent fibers have different backscattering properties, the true splice loss can be obscured by OTDR measurement error. This measurement error is commonly observed when two adjacent fibers have different mode field diameters (MFD). The measurement error may be either positive or negative and depends on the orientation of the fibers (e.g., large MFD to small MFD, or vice versa). Consequently, the measured splice loss will appear as an exaggerated splice loss when measured in one direction and a “splice gain” when measured from the opposite direction (Figure 2). Because of this measurement error, uni-directional OTDR splice loss measurements are only useful as estimated values of splice loss. The actual splice loss is determined by measuring the splice in both directions and averaging the two readings (bi-directional splice loss measurement).

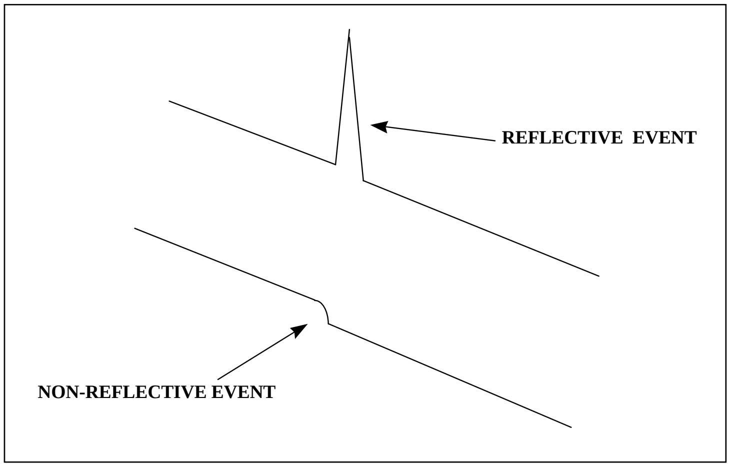

Figure 1 – Reflective and Non-reflective OTDR Events

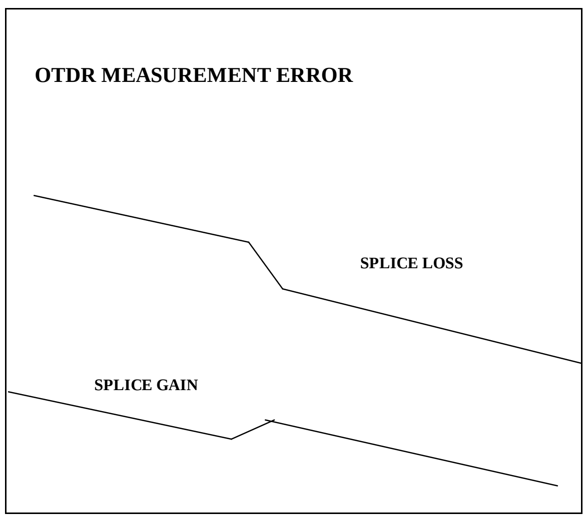

Figure 2 – Exaggerated Splice Loss and Splice Gain
Caused by OTDR Measurement Error

1.8 OFS AllWave® fiber, as well as any G652 Class D type fiber, is subject to manufacturing variations that may cause variation in MFD. Consequently, OTDR measurement error may be observed when splicing similar fiber types. OTDR measurement error may be observed in any fiber type, e.g., single mode, multimode, or non-zero dispersion fibers.

1.9 Occasionally, when two identical fibers are spliced together, there is a chance that the resulting splice loss will exceed the maximum specified loss. Typically, the splice technician assumes the high splice loss is due to extrinsic loss (bad cleave, dirty fiber, etc.) and the splice will be broken, re-spliced, and re-measured, As a rule of thumb, the fiber should be spliced no more than three times. If the high splice loss remains after the third attempt, the loss may be due to intrinsic fiber properties and the splicing process will have little or no effect on improving the resultant splice loss. In all cases, a bi-directional OTDR measurement should be used to determine the true splice loss.

2. MATERIALS

2.1 The fibers for this fusion splice study were manufactured by OFS, Corning Cable Systems, and Sumitomo Electric Lightwave. The fiber type for this study is classified as IEC G652 Class D for zero water peak (AllWave® Fiber) and reduced water peak fibers.

3. EQUIPMENT

3.1 A profile-alignment single-fiber fusion splicer manufactured by Furukawa America was used for the splice compatibility study. Splice loss was measured in both directions using an OTDR and the values were recorded. Actual splice loss was determined from the average of the bi-directional splice loss measurements.

4. PROCEDURE

4.1 Ten bobbins of OFS AllWave® fiber were randomly selected for the testing. Each bobbin was assigned a unique number and the bobbins were organized into two groups (e.g., Group1 AllWave® fiber, Group 2 AllWave® fiber) of five bobbins. Pigtail connectors were attached to the inside tail of each bobbin for connection to the OTDR. In addition, five bobbins of G652 Class D fiber were provided by both Corning and Sumitomo for the splice compatibility study. These bobbins were also numbered and connectorized as described above.

The testing began by choosing a single bobbin from Group 1 AllWave® fiber and splicing it ten times to each bobbin in Group 2 AllWave® fiber (50 splices total). Each splice was measured in both directions using the five-point measurement technique. Actual splice loss was determined from the bi-directional average of the two OTDR measurements.

A new bobbin was then selected from Group 1 AllWave® fiber and the splice testing was repeated until all bobbins from Group 1 AllWave® fiber were spliced to all bobbins in Group 2 AllWave® fiber for a total of 250 splices. Subsequently, the Corning and Sumitomo fibers were substituted for the Group 2 AllWave® fibers and the splice compatibility study was repeated for each fiber manufacturer.

5. CONCLUSION

5.1 The results of the splice compatibility test confirm that OFS AllWave® fiber is splice compatible not only to itself, but also to Corning Cable Systems and Sumitomo Electric Lightwave G652 Class D fiber. Tables 1 – 3 summarize the average, minimum, maximum, and standard deviation of the bi-directional splice loss measurements. In addition, all splice loss data is shown graphically in the histograms of Figures 3-5.

Table 1

OFS AllWave® to OFS Allwave®			
Bi-Max	**Bi-Min**	**Bi-Ave**	**Std Dev**
0.07	0.00	0.02	0.01

Table 2

OFS Allwave® to Corning			
Bi-Max	**Bi-Min**	**Bi-Ave**	**Std Dev**
0.08	0.00	0.02	0.01

Table 3

OFS AllWave® to Sumitomo			
Bi-Max	**Bi-Min**	**Bi-Ave**	**Std Dev**
0.10	0.00	0.02	0.01

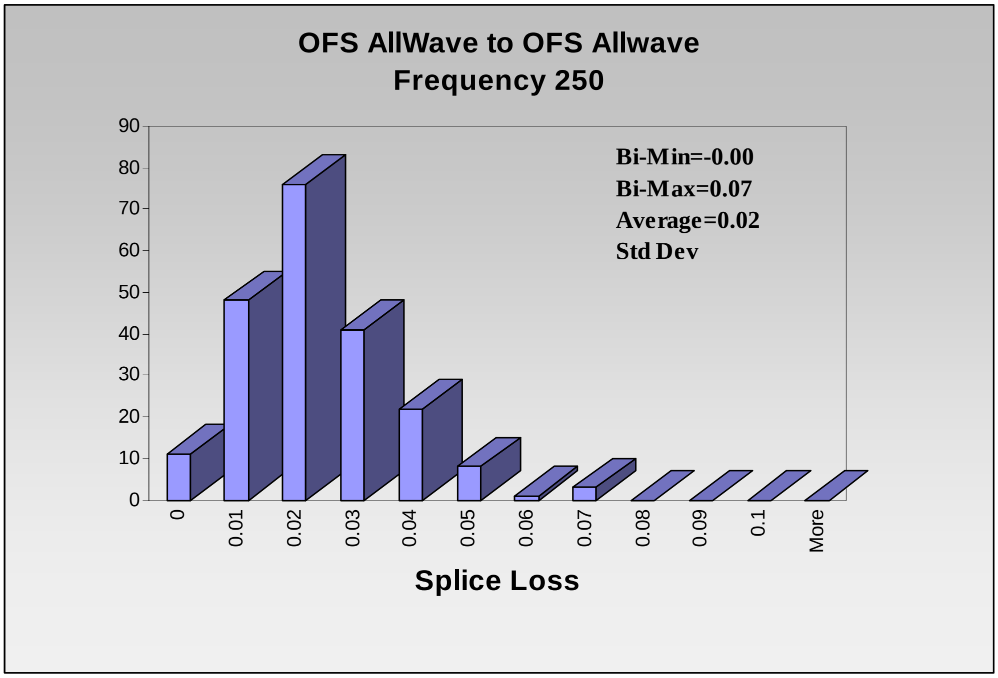

Figure 3 - Bi-Directional Splice Loss for OFS AllWave® Fiber to OFS Allwave® Fiber.

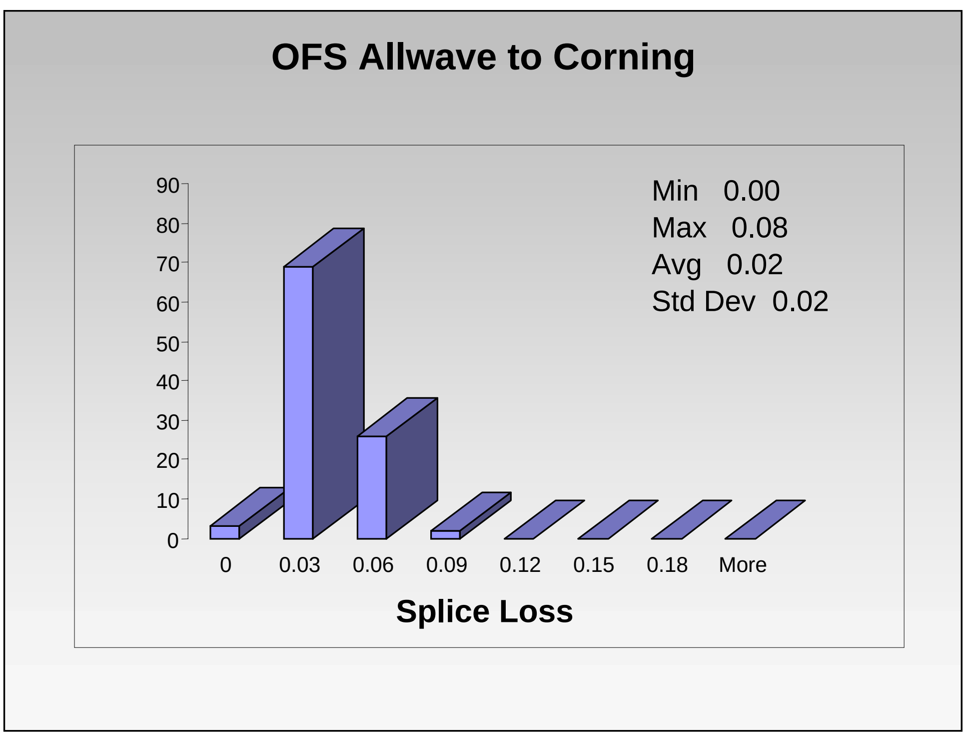

Figure 4 - Bi-Directional Splice Loss for OFS AllWave® Fiber to Corning Fiber.

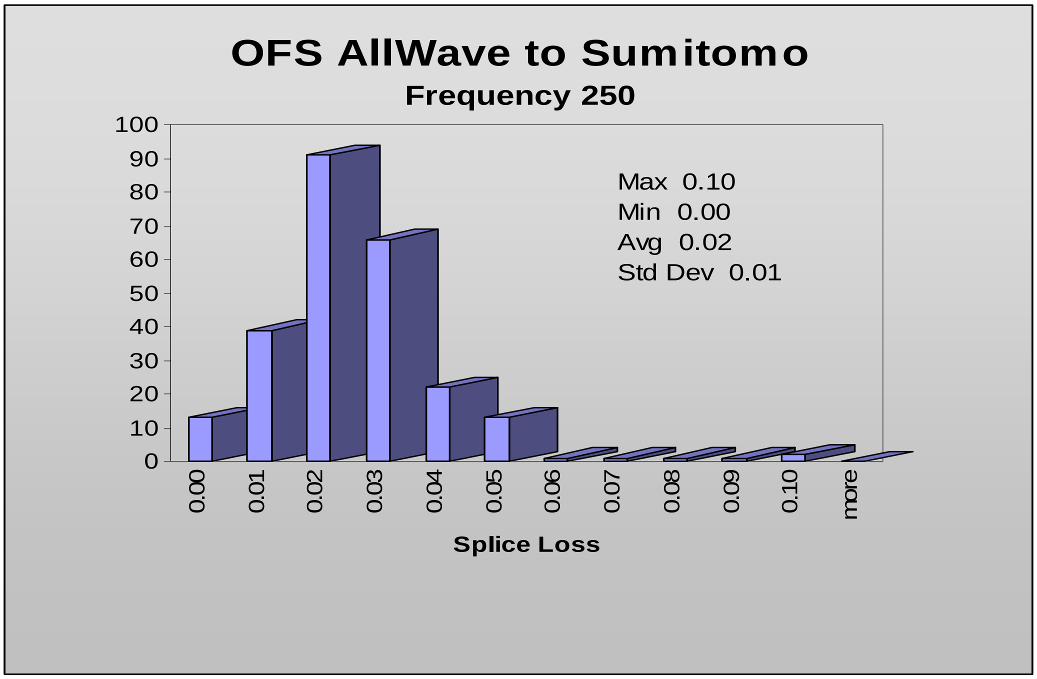

Figure 5 - Bi-Directional Splice Loss for OFS AllWave® Fiber to Sumitomo Fiber.