THE IMPACT OF NON-REFLECTIVE EVENTS IN OPTICAL FIBER COMMUNICATION CABLES

Abstract

This paper presents the impact of non-reflective events (events caused by splices, macrobends or microbends) in optical fiber transmission and also suggests ways of minimizing the losses accrued from these events. During installation of optical fibers, cables that are not properly and professionally laid (i.e. poor splicing, bending radius exceeded etc.) lead to high losses in the links which manifest as poor or interrupted networks. An Optical Time Domain Reflectometer (OTDR) was used to locate and measure these non-reflective events. The OTDR used backscatter changes in detecting the events in the fiber optics under tests and the results were displayed in OTDR traces. The non-reflective events were seen to have very high impact on the cumulative loss in the optical fiber links and contributed about 97.14% to the cumulative loss as observed in the three optical fiber cores (core 03, core 19, and core 36). Hence, minimizing the number of non-reflective events in any optical fiber communication system where possible should be the target for any optical fiber technician or engineer.

Keywords: Non-reflective event, Optical Fiber, OTDR, Cumulative loss

1.0 Introduction

As light pulses are been transmitted down an optical fiber, there are instances of disturbance (event) that obstruct the flow of these pulses and weaken the strength or reduce the power (Agrawal, 2002). This effect possibly leads to poor communication network or network failure with great adverse effects from the end users of the network. The reduction in the signal power or strength is caused by poor splicing technique or macrobends or microbends (Dharamvir, 2012). A fiber join is a type of weld where fiber ends are cut, polished, butted up to one another and fused by heat using a splicing machine shown in Figures 1 and 2. In practice, a light loss of only 0.1 dB is the current budget for power loss in a single-mode fiber join (Ilyas and Moftah, 2003). But it should be realized that 0.1 dB is quite a lot in that it represents the total loss of one-half of a kilometer of cable. A permanent joint formed between two individual optical fibers in the field or factory is known as a fiber splice used to establish long haul optical fiber links. Two types of splicing techniques obtainable include fusion splicing and mechanical splicing (Etten and Plaats, 1991). Prior to splicing both fibers must be prepared by removing the plastic buffer coatings on both fibers, cleaving fiber end and cleaning with isopropyl alcohol.

In fusion splicing the fibers are melted together to form a continuous fiber. The source of heat is usually an electric arc, but can also be a laser, or a gas flame, or a tungsten filament through which current is passed. Cleaved fiber ends are fused permanently together using splicing machine shown in Figure 2. In mechanical splicing technique, the fiber ends are cleaved, polished, and aligned with one another and the gap between them is filled with an epoxy resin which has the same refractive index as the fiber core. There are many ways of aligning the outside of the fibers. One common method is to use a glass tube into which each end of the fiber is pushed. A small amount of the epoxy resin is placed on the end of one of the fibers before insertion. Usually, there is a small hole in the tube at the point of the join so that excess epoxy can escape. There are many other methods of obtaining mechanical alignment of the outside of the fibers. V-groves, slots and alignment rods are all used. In addition, heat-shrink elastomer tubes are also used sometimes. Mechanical splicing technique has the lowest cost but not very good. Mechanical splice losses typically range from 0.05 - 0.2 dB for single-mode fiber (Agrawal, 2002).

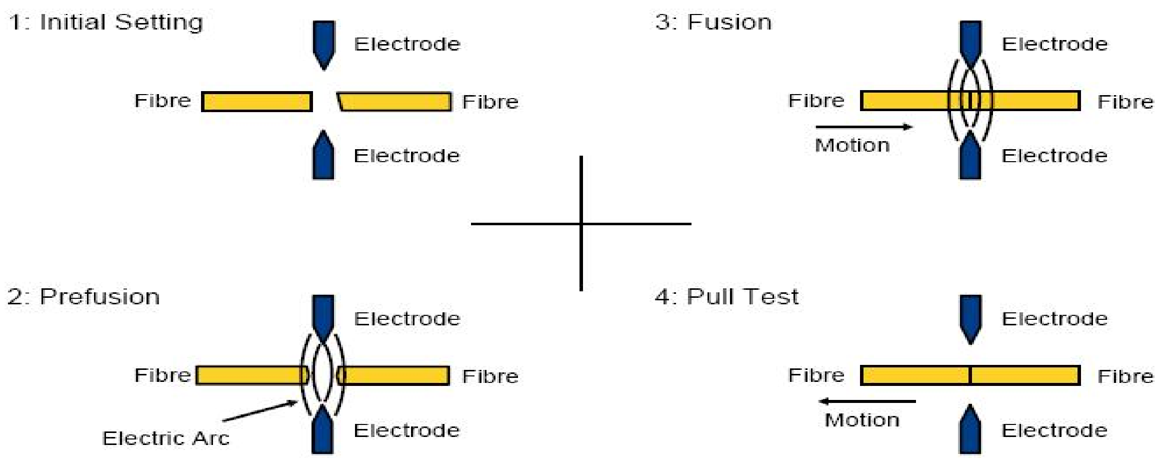

Figure 1: Fusion splicing method

Figure 2: Splicing machine

Poor splicing technique has been the major sponsor of non-reflective events in long haul optical fiber transmission links which must be avoided at all cost.

However, other factors responsible for these events include microbending and macrobending. Microbends are small microscopic bends of the fiber axis that occur mainly when a fiber is cabled. Microbend losses are caused by small discontinuities or imperfections in the fiber. External forces are also a source of micro-bends. Macrobends occur when fibers are physically bent beyond the point at which the critical angle is exceeded (Douglas, 2010). Where the critical angle is exceeded, the high order mode is refracted out of the fiber core into the fiber cladding. Macrobending is commonly caused by poor installation or handling. The losses associated with these events can be located, measured, and corrected with the aid of optical equipment called Optical Time Domain Reflectometer (OTDR)

Optical Time Domain Reflectometer (OTDR) transmits pulses of very short high-power light from laser diodes and detects the light reflected/ back-scattered as each pulse travels down the fiber (Lathief, 2014). A fraction of the pulse is scattered in several directions due to normal glass structure of optical fiber core (Rayleigh scattering) and at the points where fiber comes in contact with air or any other media like splices, joints connectors, fiber end/break (Fresnel reflections). The OTDR uses changes in ‘Back-scatter’ light pulses to detect events which are illustrated in OTDR Traces as seen in Figures 3, 4, and 5.

2.0 Materials & Methods

Materials:

1. Single-Mode Patch cords
2. Power meter
3. Optical Time Domain Reflectometer (OTDR)
4. Media Converter/Transmission Equipment
5. Flash drive

OTDR test procedures

Fiber Type: SM 36CORE

Device: MTS 6026VSR

Module: 7508 Num.8126 VSRE

The OTDR parameters were set as:

Wavelength: 1550 nm

Range (Km): 88.6673

Acq. Time: 10s

Resolution: 1.25m

Index: 1.466480

A power meter was used in testing for continuity along the cable before the measurements were taken. A single-mode patch cord was attached to the OTDR and to cable plant (Core 03) under test via the patch panel. The OTDR was preset as stated above and it emitted light power pulses along the cable in a forward direction by the injection laser. The light pulses then bounced back and were measured by the factoring out of time and distances. The backscattered light was detected by the Avalanche photodiode receiver. The output of the photodiode receiver was driven by an integrator which improved the Signal to Noise Ratio (SNR) by giving an arithmetic average over a number of measurements at one point. This signal was fed into a logarithmic amplifier and the average measurements for successive points within the fiber were plotted and recorded with the chart recorder. The media converter was then used in converting the trace to another format which was retrieved with an external drive. The same procedure was repeated for fiber core 19 and core 36 and results tabulated as seen in Tables 1, 2, and 3.

3.0 Results

Table 1: Result of CORE 03

NO.	LOC. (km)	Event Type	Loss (dB)	Cumul. (dB)
1	0.0000	Launch level	----	0.000
2	3.1085	Non-Reflective	0.076	0.076
3	6.1124	Non-Reflective	0.129	0.205
4	21.3045	Non-Reflective	0.204	0.409
5	24.6411	Non-Reflective	0.095	0.504
6	30.6974	Non-Reflective	0.215	0.719
7	39.8954	Non-Reflective	0.108	0.827
8	46.1329	Non-Reflective	0.086	0.912
9	49.1649	Non-Reflective	0.199	1.111
10	58.4292	Non-Reflective	0.096	1.207
11	61.4918	Non-Reflective	0.093	1.300
12	64.0108	Non-Reflective	0.200	1.500
13	70.1437	Non-Reflective	0.205	1.705
14	73.2037	Non-Reflective	0.079	1.783
15	76.2689	Non-Reflective	0.148	1.932
16	82.5446	Non-Reflective	0.034	1.966
17	88.5754	Reflective	---	1.966

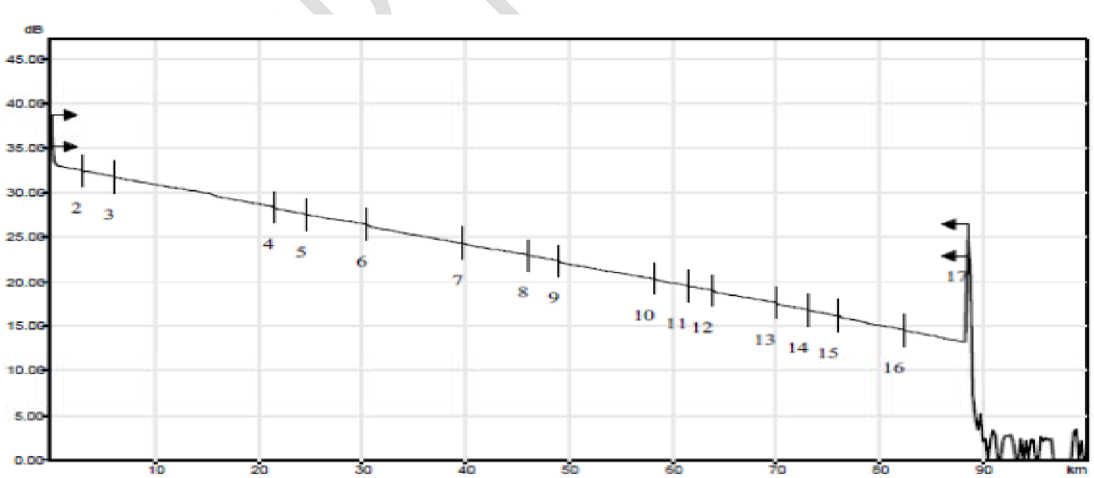

Figure 3: Core 03 OTDR Trace

Table 2: Result of CORE 19

NO.	LOC. (km)	Event Type	Loss(dB)	Cumul. (dB)
1	0.0000	Launch level	---	0.000
2	18.4649	Non-Reflective	0.091	0.091
3	21.5658	Non-Reflective	0.068	0.159
4	30.7204	Non-Reflective	0.202	0.361
5	40.0077	Non-Reflective	0.078	0.439
6	43.0295	Non-Reflective	0.090	0.529
7	52.2862	Non-Reflective	0.076	0.606
8	64.0823	Non-Reflective	0.081	0.687
9	76.3786	Non-Reflective	0.108	0.794
10	88.6673	Reflective	---	0.794

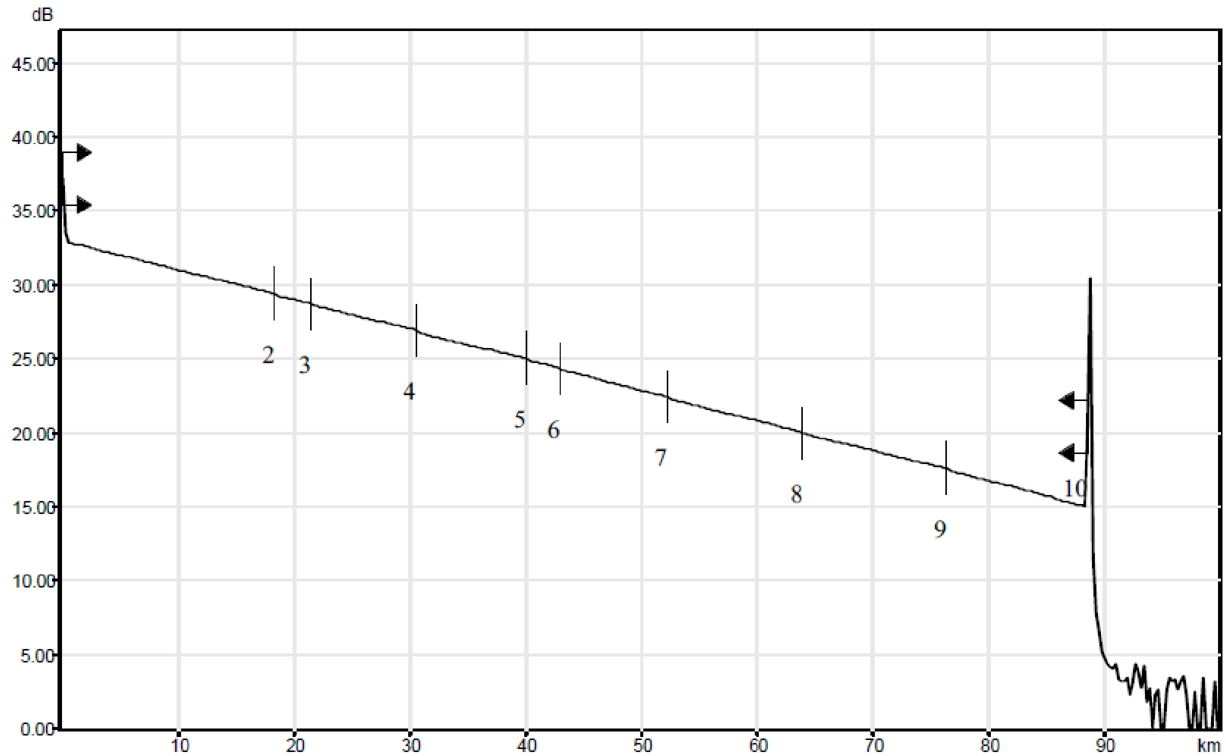

Figure 4: Core 19 OTDR Trace

Table 3: Result of CORE 36

NO.	LOC. (km)	Event Type	Loss (dB)	Cumul. (dB)
1	0.0000	Launch level	----	0.000
2	3.0932	Non-Reflective	0.114	0.114
3	9.2541	Non-Reflective	0.080	0.194
4	12.3167	Non-Reflective	0.110	0.304
5	15.8183	Non-Reflective	0.111	0.415
6	27.6527	Non-Reflective	0.147	0.562
7	30.7306	Non-Reflective	0.053	0.615
8	49.1878	Non-Reflective	0.087	0.703
9	61.3617	Positive	-0.085	0.617
10	67.1372	Non-Reflective	0.111	0.729
11	78.7776	Non-Reflective	0.066	0.795
12	79.4999	Non-Reflective	0.079	0.874
13	85.6200	Non-Reflective	0.199	1.073
14	88.6188	Reflective	----	1.073

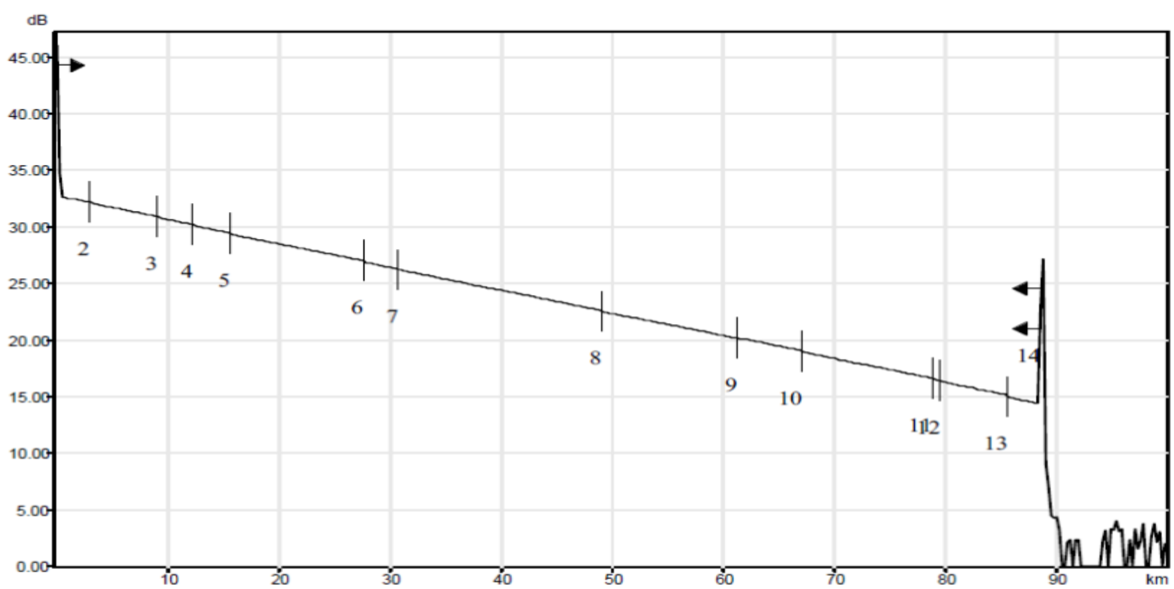

Figure 5: Core 36 OTDR Trace

4.0 Discussion

Tables 1, 2, and 3 and Figures 3, 4, and 5 present the events in cores 03, 19, and 36. The tables and figures clearly show the very high contributions of the non-reflective events on the cumulative losses. This may be attributed to high number of fusion splices, microbends, and macrobends in the fiber. Also, during installation how the optical fibers are handled during coating removal, cleaving, and splicing compromise the strength of the spliced fiber. Mechanical stripping of the fiber coating also reduces the strength significantly. By implication, the more the number of events, the higher the cumulative loss. However, the cumulative losses recorded for all the three optical fiber cores can still be reduced when quality splicing techniques are employed and macrobendings are minimized during maintenance or routine cables check.

5.0 Conclusion

Optical Time Domain Reflectometer (OTDR) a commonly used optical equipment was used to locate and measure the non-reflective events in three optical fiber transmission links. The results showed that non-reflective events had about 97.14% contributions toward the cumulative loss which is detrimental to communication network when the limit is exceeded. For the maintenance of quality and uninterrupted network fiber communication network, it is advisable to minimize the number non-reflective events where possible.

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