Volume 2, Issue 1
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Friends of Fiber Optics

We appreciate your interest in our newsletter, Eye on Fiber Optics. As this is free, feel free to distribute it. Associates can obtain their own copies by requesting it at our web site, www.ptnowire.com.

In this issue we present 2 subjects:

Full Evaluation of the Panduit Prepolished SC Connector

Pay Less and Spend More: The Lesson of Total Hardware Cost

At the end of this newsletter, you'll find lists of future subjects.

Feel free to send or call us with your comments or experiences. If you'd like to see a specific subject, let us know.

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Part 1: Evaluation of the Panduit Prepolished SC Connector

Executive Summary

Pearson Technologies evaluated the Panduit SC, no adhesive, no polish connector. Insertion losses and yield were acceptable for training. Pearson Technologies interprets these results to support the expectation that field results for trained and experienced installation personnel will be acceptable. This is the first cleave and leave product which Pearson Technologies has been able to qualify for use in its training programs.

Introduction

In Eye on Fiber, Volume 1, Issue 2, we presented an overview of our results. In this issue, we present the full report on our evaluation. Pearson Technologies Inc. provides fiber optic technical and market consulting and fiber optic training programs. We qualify every connector prior to use in our installation training programs. We consider a product qualified when the connector meets two requirements: it exhibits its stated power loss, in dB/pair,[1] and it can be installed with a training yield of at least 75 %.[2]

Prior to this evaluation, we were unable to qualify any 'no polish, no adhesive connector', hereafter, 'cleave and leave,' because no connector met these two requirements. For example, insertion losses ranged from 0.3 dB/pair to greater than 15 dB/pair. In addition, yields were consistently less than 50 %.

Out of frustration, we replaced the typical, low cost cleaver[3] in the cleave and leave tool kits with an expensive Alcoa Fujikura Ltd. [AFL] cleaver, model CT07.[4] In addition, we used visible light sources[5] to tune the

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[1]Maximum and typical losses are 0.75 dB/pair and 0.30 dB/pair, respectively.

[2]The expected yield for highly trained professional installers is higher, 95 %.

[3]Fitel product number CL-310 VL.

[4]As of 6/02, the street price of the CT07 was approximately $1500; that of the cleaver provided with the training kit, $200-$300.

[5]aka 'fault finders' and 'feature finders,'

connectors for lowest loss. In spite of these steps, we were unable to qualify any cleave and leave connector.

Our conversations with installers who had used these products indicated similar results. In a few cases, we provided clients with training on these unqualified connectors. As we expected, and regardless of manufacturer or product design, such training produced cleave and leave results inferior to those in our laboratory, with low yields and high insertion losses.

Product and Evaluation Procedure

In August of 2002, we evaluated the SC version of the Panduit Opti-Crimp connector, part number FSCMM. We used tight tube cable with the 62.5 μm core fiber.[6] The fiber had excellent geometric specifications,[7] low loss,[8] but no bandwidth specification. We used the AFL CT07 cleaver instead of that in the Panduit tool kit, because of the CT07's superior cleave angles and improved consistency relative to the standard kit cleaver.[9]

We began by installing one connector on the end of a long reel of cable.[10] With the exception of the CT07 cleaver, we followed the manufacturer's instructions. We checked the 850 nm loss of this first end with an OTDR [Figure 1]. We took this first test to obtain the most data from the small sample size.[11] The launch cable had a length of 32 m.

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[6]Source: Krone Optical Systems

[7]This statement is an inference made from installing thousands of multimode, epoxy and Hot Melt™ connectors on this cable and achieving a low average and typical loss of 0.30 dB/pair.

[8]Typical 850 nm attenuation rates were between 2.7 and 3.0 dB/km, with most values closer to the lower value.

[9]See Eye on Fiber, V1, Issue 2, p. 8

[10]More than 200 m.

[11]20 connectors

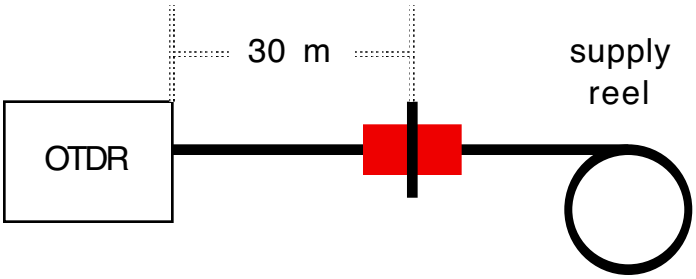

Figure 1: OTDR Check of First Connector

We cut approximately 48 feet of cable from the reel. We installed a second connector on the opposite end. We measured the insertion loss in both directions at both 850 and 1300 nm by Method A of ANSI/TIA/EIA-526-14 [Table 1].[12] We used the same reference cables for both wavelengths.

We used this test procedure in order to enable comparison to the data on more than 30,000 connector tests we've obtained since 1990. We made all these tests according to ANSI/TIA/EIA-526-14.

We cut the cable in the middle. We installed a connector on both of the new ends. We repeated the insertion loss tests, as described above. We repeated cutting and terminating the new ends, until the cable became shorter than 1 m [Figure 2]. At that length, we repeated the process with another cable of approximately 48 feet.

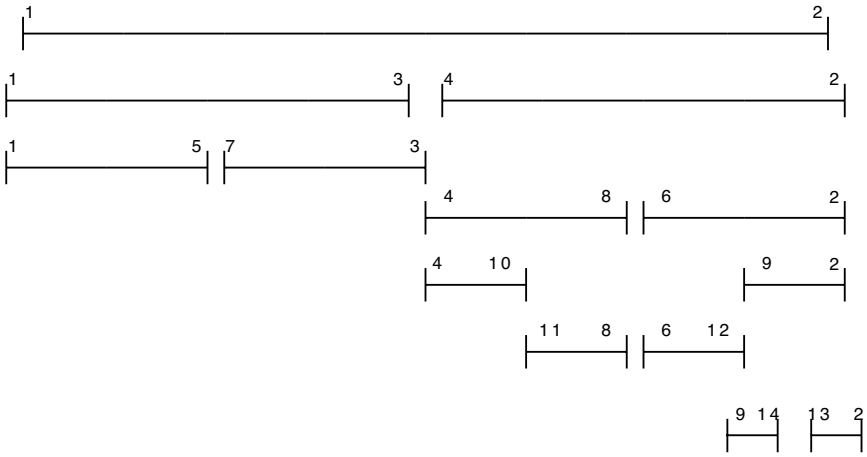

Figure 2: History of Connectors 1-14

[12]Note that the Building Wiring Standard, TIA/EIA-568-B, requires use of Method B of ANSI/TIA/EIA-526-14A with a launch cable mandrel.

Results

The insertion loss averaged[13] 0.59 dB at 850 nm and 0. 535 dB at 1300 nm [Table 1]. These are the lowest and most consistent losses we have experienced with any cleave and leave connector. If we remove the connectors with losses above 0.75 dB/pair, the averages drop less than 0.1 dB/pair [Table 2].

This insertion loss average is higher than that obtained with epoxy, Hot Melt™ or quick cure adhesive connectors with ceramic ferrules.[14] This bias towards increased loss is understandable from the construction of these connectors. These connectors contain a pre- polished fiber stub, which, by itself tends to have a 0.30 dB/pair loss. In the back of each back shell is a mechanical splice, each with typical loss of 0.10-0.15 dB. From this brief explanation, we expect typical losses in the range of 0.50-0.60 dB/pair.

The directional tests of Table 1[15], demonstrate small directional differences:

the largest directional difference is 0.11 dB;

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[13] In determining these values, we averaged the two directions.

[14] Typical values for field installed connectors is 0.30 dB.

[15] 'insertion loss' and 'insertion loss reverse'

Table 1: All Test Data

test #	PM @ connector #	62.5 reverse	850 loss, OTDR	850 nm insertion loss	reverse	directional difference	1300 nm insertion loss	reverse		directional difference	wavelength difference
0			0.83	replaced							
1			data lost								
	2	1		-0.62	-0.53	-0.09	-0.35	-0.78	note 1	0.43	-0.01
				retest	retest		retest	retest			
2	2	1		-0.66	-0.56	-0.10	-0.62	-0.62		0.00	0.01
3	3	1		-0.77	-0.70	-0.07	-0.77	-0.68		-0.09	-0.01
4	2	4		-0.38	-0.34	-0.04	-0.40	-0.34		-0.06	0.01
5	1	5		-0.81	-0.81	0.00	-0.93	-0.84		-0.09	0.08
6	2	6		-0.36	-0.30	-0.06	-0.34	-0.43		0.09	0.06
7	3	7		-0.83	-0.78	-0.05	-0.71	-0.72		0.01	-0.09
8	4	8		-0.54	-0.55	0.01	-0.51	-0.50		-0.01	-0.04
9	2	9		-0.42	-0.46	0.04	-0.39	-0.42		0.03	-0.04
10	4	10		-0.45	-0.43	-0.02	-0.38	-0.36		-0.02	-0.07
11	8	11		-0.64	-0.62	-0.02	-0.67	-0.64		-0.03	0.03
12	6	12		-0.47	-0.53	0.06	-0.44	-0.47		0.03	-0.05
13	2	13		-0.26	-0.31	0.05	-0.31	-0.33		0.02	0.04
14	9	14		-0.62	-0.61	-0.01	-0.61	-0.58		-0.03	-0.02
15	15		-0.47								
16	15	16		-0.81	-0.82	0.01					
17	15	17		-0.75	-0.78	0.03					
18			-0.42								
19	18	19		-0.78	-0.67	-0.11					
			Average=	-0.60	-0.58	-0.02	-0.54	-0.53		-0.01	-0.01
			standard deviation	0.19	0.18		0.19	0.16			

PM= power meter

Note 1: This is a problem measurement

Table 2: Data Less Than 0.75 dB/pair

test #	62.5 PM @ connector #	reverse	850 loss, OTDR	850 nm insertion loss reverse		directional difference	1300 nm insertion loss reverse			directional difference	wavelength difference
0			0.83	replaced							
1			data lost								
	2	1		-0.62	-0.53	-0.09	-0.35	-0.78	note 1	0.43	-0.01
				retest	retest		retest	retest			
2	2	1		-0.66	-0.56	-0.10	-0.62	-0.62		0.00	0.01
3	3	1		-0.77	-0.70	-0.07	-0.77	-0.68		-0.09	-0.01
4	2	4		-0.38	-0.34	-0.04	-0.40	-0.34		-0.06	0.01
5	1	5				0.00	-0.93	-0.84		-0.09	0.89
6	2	6		-0.36	-0.30	-0.06	-0.34	-0.43		0.09	0.06
7	3	7				0.00	-0.71	-0.72		0.01	0.72
8	4	8		-0.54	-0.55	0.01	-0.51	-0.50		-0.01	-0.04
9	2	9		-0.42	-0.46	0.04	-0.39	-0.42		0.03	-0.04
10	4	10		-0.45	-0.43	-0.02	-0.38	-0.36		-0.02	-0.07
11	8	11		-0.64	-0.62	-0.02	-0.67	-0.64		-0.03	0.03
12	6	12		-0.47	-0.53	0.06	-0.44	-0.47		0.03	-0.05
13	2	13		-0.26	-0.31	0.05	-0.31	-0.33		0.02	0.04
14	9	14		-0.62	-0.61	-0.01	-0.61	-0.58		-0.03	-0.02
15	15		-0.47								
16	15	16		-0.81	-0.82	0.01					
17	15	17		-0.75	-0.78	0.03					
18			-0.42								
19	18	19		-0.78	-0.67	-0.11					
			Average=	-0.57	-0.55	-0.02	-0.54	-0.53	0.01	-0.01	0.12
			standard deviation	0.18	0.17		0.19	0.16			

Note 1: Measurement error
data in gray cells excluded

the average at 850 nm was 0.02 dB; and
the average at 1300 nm was 0.01 dB.

Such small directional differences are normal and expected.[16]

These directional differences may not be due exclusively to directional effects, but may include repeatability effects. With well controlled testing, we have found the repeatability of multimode SC connectors to be 0.10 dB or less.

The difference in insertion loss between the two wavelengths is small: a maximum of 0.09 dB with an average of 0.01 dB. As indicated above, these apparent wavelength differences may be due, in part, to repeatability.

The overall yield was 15/20 or 75 %.[17] This value is the desired minimum value for training. With practice, we expect this yield to improve.

We have used the ST-compatible version of this product [FSTMM] in several training programs with similar favorable results.

Conclusions

Average insertion loss was less than the maximum stated value.

Insertion losses were consistent. Insertion losses were more consistent than those from any other cleave and leave connector that Pearson Technologies has tested.

Yield was acceptable for training. Pearson Technologies expects that yield for field installation will exceed 90 % for trained and experienced installers.

Directional differences were small.

Wavelength differences were small.

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[16]Usually, directional differences larger than 0.20 db indicate a measurement problem.

[17]Table 1 indicates that connectors 0, 3, 5, 16, and 17 were higher than 0.75 dB/pair, the maximum rating for this product.

Part 2: Pay Less and Spend More: The Lesson of Total Hardware Cost

Introduction

Frequently, I feel the urge to put numbers to some of the claims I hear. In this part, I'll examine the claim that ST-compatible connectors are less expensive than SC connectors. While the cost of an ST-compatible connector is less than that of the SC connector, the total hardware cost is not.

One of the differences between the ST-compatible and SC connectors is the density in a patch panel or enclosure: a 1U high, 19 " wide enclosure can accommodate 12 ST-compatible connectors or 24 SCs. Because of this difference, 24 ST-compatible will require two 1U enclosures or one 2U enclosure.

Cost Comparisons

We obtained all prices from the Fiber Instrument Sales [FIS] catalog. FIS prices tend to be near the lower end of the range of prices. As the price of the enclosures increases, the savings from using SC connectors increases.

We will calculate a hardware cost of connectors and enclosures. Our hardware cost is not a total installed cost, as we ignore labor and supply costs to simplify the analysis.[18] In Table 1, we present the results with the assumption that 24 ST-compatible connectors require two 1U enclosures. This table demonstrates that the total cost for the SC solution is usually less than that of the ST-compatible solution. The savings range from 20.8 % to 23 %.

Note that in the case of the Corning products, the ST-compatible solution is less expensive. This unusual result is due to the high premium Corning charges for the SC.[19] We are aware of no other connector manufacturer that charges such a high premium.

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[18]Assuming the same installation method, the difference between labor and supply costs between ST-compatible and SC connectors is small enough to be ignored.

[19]This premium may, also, be due to FIS's costing process.

In Table 2, We present the results with the assumption that 24 ST-compatible connectors require 1 2U enclosure. From this table, we see that the SC is less expensive in two of the three comparisons. But the savings is smaller than that in Table 1. This reduction is due to the fact that the cost of a 2U enclosure is less than twice the cost of a 1U enclosure.

Note the unusual Corning result: the ST-compatible solution is less expensive than the SC solution.

One More Cost Factor Favors The SC

There is one major, additional cost advantage of the SC connector: the SC connector lasts longer than the ST-compatible connector. This improved lifetime, and reduced maintenance cost, is due to the design of the SC connector. The SC connector controls the force with which two SC ferrules make contact. The ST-compatible does not: the installer controls, or does not adequately control, the force with which two ST-compatible connectors make contact.

As a result of this design difference, SC connectors are harder to damage than are ST-compatible connectors. We see this difference in our training programs: for each SC reference lead we replace, we replace 6 ST-compatible leads.

Enter the Small Form Factor Connectors

Use of small form factor [SFF] connectors can reduce the hardware cost below that of SC connectors: the SFF connectors double the SC density in an enclosure. We present our hardware cost comparisons in Tables 3 and 4. Note that in all cases, the total hardware cost of the more expensive connector is the same or lower than the total hardware cost of the less expensive connector.

Conclusion

Fiber optic data communications has had a reputation for being ‘high cost’. While that reputation was deserved in the past, it is no longer. When the network designer does a ‘total installed cost’ analysis for the network or a ‘total hardware cost’ analysis for connectors, he will determine how to

implement the lowest cost fiber solution. In many cases, these analyses will reveal that the cost of the all fiber solution is less than the cost of a fiber UTP solution.[20]

Moral

The lowest cost product do not always provide the lowest total installed cost, which, in reality, is the network designers goal.

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[20]See the Cost Comparison Model developed by Pearson Technologies and the Fiber Optic LAN Section at: www.fols.org.

Table 1: Hardware Cost of ST-compatible and SC Connectors Assuming One 0rTwo 1U Enclosures

Connector Manufacturer	connector cost ST-compatible	SC	enclosure	total hardware cost for 24 connectors ST-compatible	SC	savings $	%
3M	2.00	2.80	56	160.00	123.20	36.80	23.0%
Corning	2.00	4.50	56	160.00	164.00	-4.00	-2.5%
TYCO/AMP	2.00	2.95	56	160.00	126.80	33.20	20.8%

Table 2: Hardware Cost of ST-Compatible and SC Connectors Assuming One 1U 0r One 2U Enclosure

Connector Manufacturer	connector cost ST-compatible	SC	1U enclosure	2U Enclosure	total hardware cost for 24 connectors ST-compatible	SC	savings $	%
3M	2.00	2.80	56	80	128.00	123.20	4.80	3.8%
Corning	2.00	4.50	56	80	128.00	164.00	-36.00	-28.1%
TYCO/AMP	2.00	2.95	56	80	128.00	126.80	1.20	0.9%

Table 3: Hardware Cost of SC Connectors and LC [SFF] Connectors Assuming One or Two 1U Enclosures??

Connector Manufacturer	connector cost SC	LC	enclosure	total hardware cost for 48 connectors SC	LC	savings $	%
3M	2.80	3.30	56	246.40	214.40	32.00	13.0%
Corning	4.50	3.30	56	328.00	214.40	113.60	34.6%
TYCO/AMP	2.95	3.30	56	253.60	214.40	39.20	15.5%

Table 4: Hardware Cost of SC Connectors and LC [SFF] Connectors Assuming One 1U 0r One 2U Enclosure??

Connector Manufacturer	connector cost SC	LC	1U enclosure	2U Enclosure	total hardware cost for 48 connectors SC	LC	savings $	%
3M	2.80	3.30	56	80	214.40	214.40	0.00	0.0%
Corning	4.50	3.30	56	80	296.00	214.40	81.60	27.6%
TYCO/AMP	2.95	3.30	56	80	221.60	214.40	7.20	3.2%

note: the LC prices are FIS prices

Coming in Future Issues

The Problem With OTDR Ghosts
How to Minimize the Complications from Ghosts
Cleaning Connectors: Alcohol, Acetone or Other Liquids
The Hidden Cost of Cheap Training
Do You Need to Know About Repeatability?
Case Study: Field Fusion Splicing
Case Study: Planning, Installing and Certifying The FTTD Network
Do You Need to Know About Multimode Reflectance?
Planning to Upgrade to GbE or 10 GbE? Don't Fusion Splice Multimode Fiber!
LED vs.. VCSEL Insertion Loss Testing
Fusion Splicing Fiber from Different Manufacturers
Comparison of OTDRs
Two Tips on Using OTDRs for Training
The Three Benefits of Fiber Sales Training

Previous Articles, White Papers & Other Publications

Honey, I Shrunk the Wiring Closet!
Spreadsheet for Comparing Costs of All Fiber to Fiber and Copper Networks
Improving Fiber Network Reliability Through Choice of Certification Strategy
Maximizing Fiber Optic Network Reliability Through Choice of Installer
The Novice's 10 Minute Introduction to Fiber Optics
Myths and Reality: Fiber Vs.. Copper

Eye on Fiber, Vol. 1, Issue 1

The Six Subtilties of Accurate Singlemode Testing
Unstable Test Measurements? Don't Blame the Test Equipment!
A Personal Perspective: Concern for the Future

Eye on Fiber, Vol. 1, Issue 2

How to Test Installed Links According to TIA/EIA-568

B.1 and B.3
Evaluation of the Panduit Prepolished SC Connector
The Proof Is In: Test Data Prove the Value of a Precision Cleaver
A Pearson Personal Perspective: Will Fiber Miss the Data Networks Boat?

Training Programs and Schedules

FiberPro™ 1: The Essentials for Success, monthly in the Atlanta, GA area; available for on site presentations.

FiberPro™ 2: Do It Right the First Time, Every Time- Advanced Connector Installation and Advanced FOA Certification. See schedule on web site. Available for on site presentations.

FiberPro™ 3: Certifying and Troubleshooting Fiber Optic Cable Systems for Maximum Reliability and Advanced FOA Certification. See schedule on web site. Available for on site presentations.

FiberPro™ 4: Advanced Training and Advanced FOA Certification for Splicers, available for on site presentations.

FiberPro™ 5: Fiber Optic Network Design, Certification and Costing, 9/16-18/02 in Tampa, FL; 12/4-6/02 in Tampa, FL. 2003 presentations: January 10-12, Orlando. FL; March 5-7, Tampa, FL; May 9-11, Denver, CO; June 16-18, Atlanta, GA. Available for on site presentations.