Fiber Optic Services And Products

Pearson Technologies Incorporated

EYE ON FIBER

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PART 1: TEST REPORT FOR THE PANDUIT SC OPTI-CRIMP 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

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 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 superior cleave angles of the CT07 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 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.

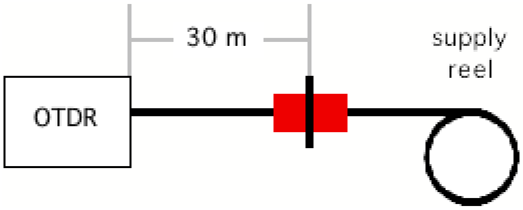

Figure 1: OTDR Check of First Connector

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.

Table 1: Test Results

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		-0.81	-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

We used this test procedure in order to enable comparison to the more than 25,000 connector tests we have 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.

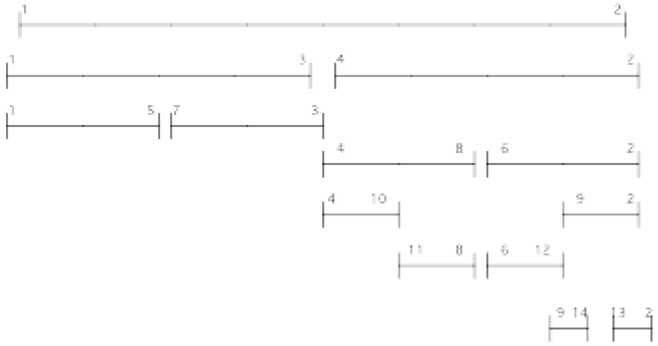

Figure 2: History of Connectors 1-14

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).

Table 1: Test Results <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	repl							

				aced							
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		-	-0.31	0.05	-	-0.33		0.02	0.04

				0.26			0.31				
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

This insertion loss average is higher than that obtained with epoxy, Hot MeltÅ 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 could 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;

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.

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 will 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 inch 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 3, 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 %.

Table 3: Hardware Cost of ST-compatible and SC Connectors Assuming One 0rTwo 1U Enclosures

Connector	connector cost			total hardware cost for 24 connectors			
Manufacturer	ST-compatible	SC	enclosure			savings	
				ST-compatible	SC	$	%
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 %

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.

In Table 4, 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 3. This reduction is due to the fact that the cost of a 2U enclosure is less than twice the cost of a 1U enclosure.

Table 4: Hardware Cost of ST-Compatible and SC Connectors Assuming One 1U 0r One 2U Enclosure

Connector	connector cost				total hardware cost for 24 connectors		savings	
Manufacturer	ST-compatible	SC	1U enclosure	2U Enclosure	ST-compatible	SC	$	%
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%

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 5 and 6. 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.

Table 5: Hardware Cost of SC Connectors and LC (SFF) Connectors Assuming One or Two 1U Enclosures

Connector Manufacturer	connector cost		enclosure	total hardware cost for 48 connectors		savings	
	SC	LC		SC	LC	$	%
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 6: Hardware Cost of SC Connectors and LC (SFF) Connectors Assuming One 1U Or One 2U Enclosure

total hardware cost for 48 connectors

Connector	connector cost						savings	
Manufacturer	SC	LC	1U enclosure	2U Enclosure	SC	LC	$	%
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

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 products do not always provide the lowest total installed cost, which, in reality, is the goal of the network designer.

Pearson Technologies Web Sites

http://www.ptnowire.com

http://www.FTTDnow.info

http://www.fiberopticlawsuits.info

http://www.sfoi.info

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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,

[6] Source: Krone Optical Systems

[7] This statement is an inference made from installing thousands of multimode, epoxy and Hot MeltÅ 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

[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.

[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

[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.

[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 the FIS costing process.

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