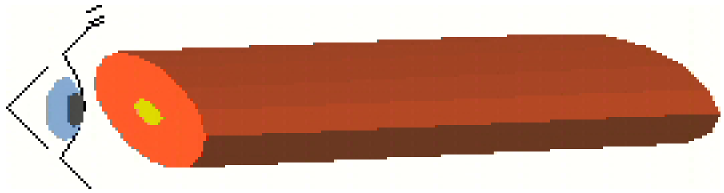

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Friends of Fiber Optics

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 four subjects: two articles on how to achieve the lowest total installed connector cost, with some surprising results, a two page summary of a presentation I'll be making at the FTTH Conference in October, and the abstract and summary section of a presentation I'll be making at the IICIT Conference in September. I hope you enjoy this issue.

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.

For Pearson Technologies Inc.,

Eric

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Part 1: Five Factors Determine the Lowest Cost Fiber Connector Installation Method

Executive Summary

There is no one simple answer to the total installed connector cost question. Instead, consideration of the five main factors that determine total installed connector cost reveals multiple installation methods may be suitable- even in a single facility.

Introduction

Twenty-one years ago, I installed my first fiber optic connector. Since that time, I've installed or supervised the installation of more than 33,000 connectors of more than 14 types by at least seven methods. Based on that experience and on recent research Pearson Technologies is conducting, I've come to the conclusion that many designers and installers are choosing the wrong method. This statement is not solely my opinion-it is supported by the conversations with many designers and installers throughout North America.

The reason for these errors is that many designers and installers are not considering all five factors that determine 'total installed cost'. Achieving the lowest total installed cost is the goal of the decision making process. In developing software for costing fiber optic installations, I have observed that five factors, connector cost, installation rate, installation yield, total loaded labor rate, and labor utilization, can, and do, result in different choices of installation method in different situations.

Characteristics of the Five Connector Installation Methods

There are five connector installation methods which dominate the fiber optic connector market [Table 1]: epoxy, or pot and polish; Hot Melt™ adhesive, an method exclusive to 3M fiber connectors; quick cure adhesives, also known as 'anaerobic' adhesives; crimp and polish, which require no adhesive; and cleave and leave', which require no adhesive and no polishing. Each of these methods has advantages and disadvantages, in reliability, in cost, in ease of installation, and in amount of training required by the installer. In this article, we shall focus on those advantages and disadvantages that influence the 'total installed cost'.

Connector cost and installation rate are directly related: as the cost increases, so does the installation rate. Connector cost ranges from 1x to roughly 6x depending on the method of installation. This relationship between rate and cost implies that the higher the total loaded labor rate, the more likely you will justify spending more on the connector to achieve a reduced labor cost per connector [Table 1].

Unfortunately, this conclusion does not included consideration of yield, which I define as number of connectors that meet power loss specification divided by number of connectors installed. As the installation rate rises, there are three consequences: the yield tends to be lower, the amount of training needed increases, and the discipline required of the installer increases. In addition, the converse seems to be true: as the installation rate falls, the difficulty becomes less, and the yield increases.

For every organization, the labor rate tends to be fixed. However, the labor utilization can vary widely, depending on the nature of the installation. I define the utilization as the amount of time spent specifically in connector installation divided by the total time required for the connector installation. The utilization depends on both the method of installation and the number of connectors installed at each location.

The extremes are the epoxy method and the cleave-and-leave method: the epoxy method requires the most set up and clean up time; the cleave and leave method, the least.

In addition, utilization is dependent on the number of connectors to be installed at each location and on the distance, or travel time, between locations. For example, a vertical riser fiber backbone cable may have 48 connectors for each of ten floors. In this example, there are 480 connectors at one location, usually the basement, and 48 connectors at each of ten locations. The labor utilization for the basement will be high, since the installer must perform one set up and one clean up for 480 connectors.

The utilization will be reduced for each of the ten floors, since the installer must perform one set up and one clean up for each group of 48 connectors. If the network is a fiber to the desk network with 4, 6 or 8 connectors at each location, the utilization will be further reduced, since the installer must perform one set up and one clean up for each group of four to eight connectors.

The labor utilization will be reduced as the distance, and travel time, between locations increases. The labor utilization for the installation of a vertical riser fiber backbone cable will be higher than the same cable system installed between ten buildings as a campus backbone.

The full analysis of these five factors indicates that there is no single solution that provides the lowest total installed cost for all networks, even in a single facility. For example, the labor rate, labor utilization, connector yield and connector cost may favor one method for the basement of a vertical riser backbone but a different method for the wall outlets of the horizontal cables of a fiber to the desk backbone.

This conclusion, different fiber optic connector installation methods for different locations in the same facility, has two consequences: increased training requirements and a slightly increased tool cost. However, for an organization that is continually installing fiber optic connectors, the increased training and tool costs become unimportant after it installs the first few hundred connectors.

Method	$ / connector	Connectors /hour	% yield	Description	Favored situation
Epoxy	low	low	high	Inject and cure epoxy; crimp; polish end	Low labor rate; large number of connectors per location
Quick cure Adhesive	low	medium	Medium to high	Inject adhesive; crimp and polish end	Low to medium labor rate; highly trained installers
Hot Melt™ adhesive	medium	medium	high	Preheat connector; polish end	Low to medium labor rate; highly trained installers
Polish, no adhesive	medium	medium	Medium to high	Crimp fiber; polish end	Low to medium labor rate; highly trained installers

Cleave and leave	high	high	Medium to Medium high	Cleave fiber; crimp fiber; no polish	Very high labor rate; highly trained installers; few connectors per location

Table 1: Characteristics of the Five Main Fiber Optic Connector Installation Methods

Conclusions

The question is: “Which is the best fiber optic connector installation method?” The simple answer is: it depends. The more complicated, but realistic, answer is: it depends on how the specifics of the installation influence the five factors. In this time of business difficulty, good decision-making is critical. Good decision-making requires determination and analysis of these five factors.

Note: Hot Melt™ is a trademark of the 3M Corporation.

Part 2: Connector Installation Cost Model: A Strategy for Profitability

Executive Summary

In this document, we present a fiber optic connector installed cost calculation model. This model is a decision making tool for installers and manufacturers of fiber optic connectors. This model enables installers to determine the installation method and product that results in the lowest total installed cost. From this cost, installers can maximize their profitability. This model helps manufacturers define the cost at which their products and installation methods will be cost competitive and profitable. This model is based on our 21 years of work with more than 33,000 fiber optic connectors, on data shared by professional installers and on our unbiased view of the connector installation process.

Section 1: Overview of The Model

In the previous part of this issue, we presented a qualitative look at choosing a connector installation method. In this part, we present a quantitative picture.

Introduction. For the last 21 years, we have worked with connectors, in field installations, in creating test leads and troubleshooting cables for our training programs, and in training more than 5000 people with more than 33,000 fiber optic connectors. We have worked with all the major installation methods and most of the connector types.

Recently, we began a project of evaluation of the cleave and leave [C&L]connectors. We began this project to resolve the large divergence between the large number of C&L connectors being sold and the consistently bad reports we received from the field.

While this project is not yet complete, we have been pleased with the initial results from testing of C&L connectors from three manufacturers. As we planned this project, we were thinking ahead to what we should do when this evaluation project is complete. We wanted to be able to make recommendations, but did not know when to recommend the C&L connectors because of their premium prices. What would happen if our project showed good results? Should we recommend the C&L connectors to our clients and trainees? Finally, under what conditions should we recommend this method?

In order to answer these questions, we needed to define the conditions under which the C&L connectors would provide the lowest total installed cost. To define those conditions, we needed a cost model.

During our work, we have performed installations for clients, we have performed oversight consulting on network design, and trained personnel in network design, for private clients, and, presently, for BICSI. During this work, we created of a series of spreadsheets for cost calculation. However, these spreadsheets did not do exactly what we wanted: to numerically define conditions so that we could choose the installation method with the lowest total installed cost. We had a number of pieces, but not all the pieces. Thus began our effort that led to this model.

This model allows the user to create a multi-dimensional cloud, within which one connector installation method will have the lowest total installed cost. This 'cloud' is defined by ranges of values for each of the seven key cost factors.

The Model Assumptions and Seven Key Cost Factors. The objective of the model is to create a numerical description of the cost factors of any connector installation. Since installation conditions vary widely, we had to develop a flexible description. This description includes seven key cost factors:

total loaded labor rate, in dollars per hour;
installation rate, in connectors per hour,
time utilization, in %;
a model for calculating time utilization;
connector cost;
consumable costs; and
process yield, in %.

Total Loaded Labor Rate. The total loaded labor rate can vary widely. We set up the model with a range from \$20 to \$80 /hour. \$35/hour represents a consensus for non unionized locations, such as Washington DC and south and central New Jersey. \$60- \$70/hour represents unionized rates for locations such as New York City, when the installers work directly for the organization that owns the installed network. \$80/hour represents the rate for an outside installation firm in a highly unionized environment.

Installation Rates. The installation rates, in connectors per hour, are based on our experience and that of professional installers who have shared their experiences with us. Some will argue with these rates. However, the focus of this model is not on the rates, but on the total installed costs. Changing the rates may change the relationships between the epoxy, quick cure and hot melt adhesive methods. However, because of the premium price of the cleave and leave products, changing the cleave and leave rates may not significantly change the relationships between the cleave and leave cost and the costs of the other three methods.

These rates assume that the cable has been prepared to expose the tight buffer tubes. Alternatively, the furcation or break out kit is installed onto a loose tube cable, which condition is the same as that of the tight tube cable with exposed tight buffer tubes. We have included no time for end preparation of the cable or for installing the terminated cable into the enclosure. This time will be independent of the connector installation method and is of no concern. In short, the connector installation rate includes the time to strip the buffer tube and primary coating, clean the fiber and install the connector.

With the exception of the cleave and leave method, the installation rates for singlemode connectors are lower than those for multimode connectors, since the singlemode connectors are polished for low reflectance. Such polishing requires increased time.

Time Utilization. The labor cost is increased to include the effects of time spent on activities other than the actual installation of the connector. We make this modification with the term ‘time utilization’. Such activities include breaks, travel time from location to location, set up, clean up, and packing of equipment at each location. No consideration is included for lock out time, which would result from inability to gain access to the location for installation. However, lock out time could be added to one of the five utilization factors.

Time Utilization Model. Time utilization is the ratio of time spent in installation to the total time spent to accomplish the installation. The time utilization model includes five factors:

a fixed time per eight hour shift for planned breaks;
a fixed time per eight hour shift for unplanned breaks; unplanned loss of time is common in field installation.
a time factor for travel to each installation location;
a time factor for all activities prior to and after the connector installation time;
the number of connectors to be installed at a location; and
the connector installation rate.

This model has great flexibility, in that each of these five factors can be changed to values appropriate for almost any installation situation. For example, the time factor for travel to the installation location can be small, medium or large. A small travel time factor is appropriate for an FTTD installation; a medium, for a vertical riser installation; or large, for installation of a campus back bone network. This flexibility allows the user to input almost any set of conditions by modifying one of these five factors.

The basic model assumes that the time utilization will be the same for all methods. However, this assumption is not true. See Section 3 for discussion of this subject.

For simplicity, we have assumed the same time utilization for multimode and singlemode connectors. With the exception of the cleave and leave connectors, this assumption is not valid, since singlemode connectors have lower installation rates than do multimode. Here, our working assumption is that singlemode connectors need be low reflectance, less than –50 dB. If low reflectance is not a concern, then the same installation rates can be assumed for multimode and singlemode connectors.

Connector Cost. The prices are realistic prices, biased neither high nor low. We have estimated these prices as being typical, or median, prices. Again, some will argue with these prices. However, the focus of this model is not on the prices, but on the total installed cost. Modification of the prices may provide a price range within which one or more methods in favored as lowest cost.

Since this is a cost model, we need not assume a connector style, or type. However, the prices we used were for the SC connector.

Feedback on a preliminary version of this cost model indicted that our connector prices were not representative of typical prices throughout the market. We believe that comment to be valid and have increased the prices to incorporate that comment.

Connector manufacturers may choose an alternative use of this model: perform the reverse calculation. What should the price for any connector be to result in a competitive total installed cost?

Consumable Costs. The model includes the cost factors for consumables, such as epoxy, polishing film, syringes, batteries for inspection microscopes, etc.. While these costs are estimates, they will not influence the total installed cost significantly.

Process Yield. In the basic model, we assume the same process yield for all installation methods. However, we believe that the yield will be different for the different methods and different situations. In general, we believe that installers with lower skill levels and reduced training will experience significantly reduced yields for the quick cure adhesive and C&L methods than for epoxy and hot melt adhesive methods. Therefore, one implicit assumption of this model is of highly trained installation personnel. However, with the appropriate yield value, this model can be adjusted to represent less well trained and relatively inexperienced personnel.

Connector Installation Methods. We present a model of the total installed cost of connectors by the four major methods: epoxy and polish, Hot Melt® adhesive, quick cure adhesive, and 'cleave and leave'. Cleave and leave is our term for connectors that require neither adhesive nor polishing. The connector installation method changes three factors in the model: connector cost, installation rate, and time utilization.

Section 2: Analysis of The Results of the Basic Model

The basic model [Table 1] provides an indication of the typical results. A simple, but slightly inaccurate, comparison of the differences between material costs and labor costs in Table 1 involves comparing lines 23 and 29: for a higher cost connector to be cost effective, an increase in material cost, line 23, must be more than offset by a reduction in labor cost, line 27. This comparison shows that the cleave and leave process cannot reduce the labor cost enough to justify its increased cost. For example, a decrease of $3.28 in labor cost is possible [cell F27-C27] but the increase if material cost is $8.61[cell F23-C23]. If the cost of the cleave and leave connector drops to $8 [cell H10], the C&L method has the second lowest total installed cost at labor rates above $50/hour.

Table 1 shows that the quick cure adhesive installation method has the lowest cost for all hourly rates between $20 and $80. If you ignore this method, the epoxy and hot melt installation methods have lower total installed costs than the C&L method, again for all hourly rates between $20 and $80.

However, the ‘what if’ columns, columns G and H, show a slightly different story. If the C&L connector cost drops to $10 [cell G10], the C&L method has a lower total installed cost than epoxy for hourly rates above

Table 1: The Basic Cost Model

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Base Total Loaded Labor rate		20	$/hr							
3	connector type		SC								
4	installation method		epoxy	Hot Melt®	quick cure	cleave &	cleave &	cleave &			
5						leave	leave	leave			
6	fiber type		multimode	multimode	multimode	multimode	what if	what if			
7	Connector Pricing Source,										
8	Manufacturer/Distributor										
9	**cost item**										
10	connector		3.00	5.50	3.00	12.00	10.00	8.00			
11	epoxy/adhesive		0.20	0.00	0.10	0.00	0.00	0.00			
12	syringe		0.01	0.00	0.03	0.00	0.00	0.00			
13	polishing film 1		0.06	0.06	0.06	0.00	0.00	0.00			
14	polishing film 2		0.06	0.07	0.06	0.00	0.00	0.00			
15	polishing film 3		0.06	0.00	0.00	0.00	0.00	0.00			
16	polishing film 4		0.00	0.00	0.00	0.00	0.00	0.00			
17	alcohol		0.05	0.05	0.05	0.05	0.05	0.05			
18	lens grade tissues		0.05	0.05	0.05	0.05	0.05	0.05			
19	misc.		0.05	0.05	0.05	0.05	0.05	0.05			
20											
21											
22											
23	TOTAL MATERIAL COST		3.54	5.78	3.40	12.15	10.15	8.15			
24											
25	time utilization		85%	85%	85%	85%	85%	85%			
26	#/hour		8	14	15	22	22	22			
27	$/connector labor at base labor rate		2.94	1.68	1.57	1.07	1.07	1.07			
28											
29	Yield, %		95%	95%	95%	95%	95%	95%			
30											
31										$/hour	
32	**TOTAL INSTALLED COST,**		6.82	7.85	5.23	13.92	11.81	9.70		20	total loaded
33	**$/ CONNECTOR**		7.60	8.29	5.64	14.20	12.09	9.99		25	labor rate
34			8.37	8.73	6.05	14.48	12.37	10.27		30	
35			9.15	9.18	6.47	14.76	12.65	10.55		35	
36			9.92	9.62	6.88	15.04	12.94	10.83		40	
37			10.69	10.06	7.29	15.32	13.22	11.11		45	
38			11.47	10.50	7.70	15.60	13.50	11.39		50	
39			12.24	10.95	8.12	15.89	13.78	11.67		55	
40			13.02	11.39	8.53	16.17	14.06	11.96		60	
41			13.79	11.83	8.94	16.45	14.34	12.24		65	
42			14.56	12.27	9.35	16.73	14.62	12.52		70	
43			15.34	12.71	9.77	17.01	14.91	12.80		75	
44			16.11	13.16	10.18	17.29	15.19	13.08		80	
45											

Table 1: The Basic Cost Model

	A	B	C	D	E	F	G	H	I	J	K
46										$/hour	
47	**% increase in cost**		0.00	15.02	(23.42)	103.89	73.04	42.20		20	
48	**relative to epoxy**		0.00	9.12	(25.79)	86.83	59.12	31.42		25	
49			0.00	4.32	(27.72)	72.92	47.77	22.63		30	
50			0.00	0.33	(29.32)	61.36	38.35	15.33		35	
51			0.00	(3.04)	(30.67)	51.61	30.39	9.17		40	
52			0.00	(5.92)	(31.83)	43.27	23.58	3.90		45	
53			0.00	(8.42)	(32.83)	36.06	17.70	(0.66)		50	
54			0.00	(10.59)	(33.71)	29.75	12.56	(4.64)		55	
55			0.00	(12.51)	(34.48)	24.20	8.03	(8.15)		60	
56			0.00	(14.22)	(35.16)	19.27	4.00	(11.26)		65	
57			0.00	(15.74)	(35.77)	14.86	0.41	(14.04)		70	
58			0.00	(17.11)	(36.32)	10.90	(2.82)	(16.55)		75	
59			0.00	(18.34)	(36.82)	7.32	(5.74)	(18.81)		80	
60											
61										$/hour	
62	**% increase in cost**		30.58	50.19	0.00	166.23	125.96	85.68		20	
63	**relative to quick cure**		34.74	47.04	0.00	151.74	114.41	77.08		25	
64			38.34	44.32	0.00	139.22	104.43	69.65		30	
65			41.48	41.94	0.00	128.30	95.73	63.17		35	
66			44.24	39.85	0.00	118.69	88.08	57.47		40	
67			46.69	38.00	0.00	110.17	81.29	52.41		45	
68			48.88	36.35	0.00	102.56	75.23	47.90		50	
69			50.84	34.86	0.00	95.72	69.78	43.85		55	
70			52.62	33.52	0.00	89.55	64.87	40.18		60	
71			54.23	32.30	0.00	83.95	60.40	36.86		65	
72			55.70	31.19	0.00	78.84	56.33	33.83		70	
73			57.04	30.18	0.00	74.16	52.61	31.05		75	
74			58.28	29.24	0.00	69.86	49.19	28.51		80	

$70. if the C&L connector cost drops to $8 [cell H10], the C&L method has a lower total installed cost than epoxy for hourly rates above $45. Ignoring epoxy and quick cure costs, we find the hot melt cost is less than the C&L cost for labor rates below $75.

There seems to be no way that the quick cure adhesive method can lose. This method combines the lowest cost ceramic connector with the fastest installation rate. However, this method has disadvantages, with a potential for reduced yield.

Adjustments of the yield, cell E29, reveals that the quick cure method has a lower cost than the epoxy until the yield is below 72% [Table 2]. At 72 % yield, the quick cure method has the lowest installed cost for all hourly labor rates above $20 . At 72 % yield, the quick cure method has the a lower than the hot melt method labor rates below $65.

This analysis indicates that installers who exceed 72 % yield can use the quick cure method to achieve the lowest total installed cost up to labor rate of $65. Such a low yield does not require much training. However, training will be required: our training with quick cure adhesives indicates an initial yield of 50-60 % for untrained personnel.

Section 3: Analysis of The Results of the Advanced Model

Section 3 is part of the purchased spreadsheet package.

Changes in the Advanced Model. We have made two types of changes in the basic model. We have changed the utilization to be more realistic; and we have changed the installation rate for the C&L method to values offered by connector manufacturers. With these changes, we have created five groups of advanced models.

In Group A, we assume realistic utilizations and the installation rates we have experienced. In Group B, we assume realistic utilizations and a typical installation rate for the C&L method of 30 connectors per hour. In Group C, we assume realistic utilizations and a maximum installation rate for the C&L method of 40 connectors per hour. We believe this value to be the upper limit for this method. In Group D, we apply the analysis to the MT-RJ connector. In Group E, we apply the analysis to singlemode connectors.

Table 2: Basic Model with Quick Cure Yield at 72%

Base Total Loaded Labor rate	20 $/hr							
connector type	SC							
installation method	epoxy	Hot Melt®	quick cure	cleave & leave	cleave & leave	cleave & leave		
fiber type	multimode	multimode	multimode	multimode	what if	what if		
Connector Pricing Source, Manufacturer/Distributor								
cost item								
connector	3.00	5.50	3.00	12.00	10.00	8.00		
epoxy/adhesive	0.20	0.00	0.10	0.00	0.00	0.00		
syringe	0.01	0.00	0.03	0.00	0.00	0.00		
polishing film 1	0.06	0.06	0.06	0.00	0.00	0.00		
polishing film 2	0.06	0.07	0.06	0.00	0.00	0.00		
polishing film 3	0.06	0.00	0.00	0.00	0.00	0.00		
polishing film 4	0.00	0.00	0.00	0.00	0.00	0.00		
alcohol	0.05	0.05	0.05	0.05	0.05	0.05		
lens grade tissues	0.05	0.05	0.05	0.05	0.05	0.05		
misc.	0.05	0.05	0.05	0.05	0.05	0.05		
TOTAL MATERIAL COST	3.54	5.78	3.40	12.15	10.15	8.15		
time utilization	85%	85%	85%	85%	85%	85%		
#/hour	8	14	15	22	22	22		
$/connector labor at base labor rate	2.94	1.68	1.57	1.07	1.07	1.07		
Yield, %	95%	95%	72%	95%	95%	95%		
							$/hour	
TOTAL INSTALLED COST,	6.82	7.85	6.90	13.92	11.81	9.70	20	total loaded
$/ CONNECTOR	7.60	8.29	7.44	14.20	12.09	9.99	25	labor rate
	8.37	8.73	7.99	14.48	12.37	10.27	30	
	9.15	9.18	8.53	14.76	12.65	10.55	35	
	9.92	9.62	9.08	15.04	12.94	10.83	40	
	10.69	10.06	9.62	15.32	13.22	11.11	45	
	11.47	10.50	10.16	15.60	13.50	11.39	50	
	12.24	10.95	10.71	15.89	13.78	11.67	55	
	13.02	11.39	11.25	16.17	14.06	11.96	60	
	13.79	11.83	11.80	16.45	14.34	12.24	65	
	14.56	12.27	12.34	16.73	14.62	12.52	70	
	15.34	12.71	12.89	17.01	14.91	12.80	75	
	16.11	13.16	13.43	17.29	15.19	13.08	80	

Table 2: Basic Model with Quick Cure Yield at 72%

							$/hour
% increase in cost relative to epoxy	0.00	15.02	1.05	103.89	73.04	42.20	20
	0.00	9.12	(2.08)	86.83	59.12	31.42	25
	0.00	4.32	(4.62)	72.92	47.77	22.63	30
	0.00	0.33	(6.74)	61.36	38.35	15.33	35
	0.00	(3.04)	(8.53)	51.61	30.39	9.17	40
	0.00	(5.92)	(10.05)	43.27	23.58	3.90	45
	0.00	(8.42)	(11.37)	36.06	17.70	(0.66)	50
	0.00	(10.59)	(12.53)	29.75	12.56	(4.64)	55
	0.00	(12.51)	(13.55)	24.20	8.03	(8.15)	60
	0.00	(14.22)	(14.45)	19.27	4.00	(11.26)	65
	0.00	(15.74)	(15.26)	14.86	0.41	(14.04)	70
	0.00	(17.11)	(15.98)	10.90	(2.82)	(16.55)	75
	0.00	(18.34)	(16.64)	7.32	(5.74)	(18.81)	80

							$/hour
% increase in cost relative to quick cure	(1.04)	13.83	0.00	101.78	71.25	40.72	20
	2.12	11.44	0.00	90.79	62.50	34.20	25
	4.85	9.38	0.00	81.30	54.94	28.58	30
	7.23	7.58	0.00	73.03	48.35	23.67	35
	9.32	5.99	0.00	65.74	42.54	19.34	40
	11.18	4.59	0.00	59.28	37.40	15.51	45
	12.83	3.34	0.00	53.52	32.80	12.09	50
	14.32	2.21	0.00	48.34	28.68	9.02	55
	15.67	1.19	0.00	43.66	24.95	6.24	60
	16.89	0.27	0.00	39.41	21.57	3.73	65
	18.00	(0.57)	0.00	35.54	18.48	1.43	70
	19.02	(1.34)	0.00	32.00	15.66	(0.67)	75
	19.96	(2.05)	0.00	28.74	13.07	(2.61)	80

Group A Analyses. In the Group A analyses, we have compared the total installed costs for 24 [work sheet A24], 6 [work sheet A6], and 4 [work sheet A4] connectors per location with installation rates we can justify from own experience.

Group B Analyses. In the Group B, we have used an installation rate of 30/hour for the cleave and leave method. We have no independent verification of this rate. However, we do not mean to imply that this rate is not possible. We believe that reality is between 30 and 40 per hour.

Group C Analyses. In Group C, we have used an installation rate of 40/hour for the cleave and leave method. We believe that this value represents an upper limit on the installation rate for this method.

Group D Analyses. In this group, we examine field installation of MT-RJ connectors.

Group E Analyses. In this group, we examine field installation of singlemode connectors.

Basic Model Summary.

Advanced Model Summary.

Part 3: How to Avoid Cursing at Cursers: An Introduction To Interpretation of OTDR Traces

Introduction

The beauty of the optical time domain reflectometer, hereafter the OTDR, is its ability to provide power loss data on almost every element [cable segment, splice and connector pair] in a fiber optic link. These data are presented in the form of a trace. With these data, the network technician can certify and troubleshoot fiber optic links and networks.

There are three difficulties during use of the OTDR. First, the OTDR has no ability to tell the technician what he is seeing. In other words, the technician must interpret the trace. Second, many trace features have multiple interpretations. Herein lies the major difficulty in trace interpretation and the origin of much confusion. And third, the technician will make accurate measurements and proper interpretations only if he knows the rules of proper curser placement. With improper curser placement, the technician will curse at the cursers. In the next thirty five minutes, we will present the information you need to avoid cursing the cursers.

Overview

Why test a fiber optic link with the OTDR? The simple answer is reliability. The OTDR can reveal conditions that can reduce reliability. With this knowledge, network technicians can remove such conditions to maximize network reliability.

As photons travel through an optical fiber, some are scattered backwards towards the input end of the fiber. The OTDR uses this back scattered light to determine the power losses of elements in a link.

The OTDR is a highly sensitive, power change measurement device. The OTDR measures the difference in power levels between the beginning and the end of a cable to determine the attenuation rate. Alternatively, the OTDR measures the difference between power levels before and after a connection, to determine connector and splice loss. By comparing these measurements to certification values, a completely different subject, the technician can certify and troubleshoot a fiber optic link.

In order to make traces, the technician adjusts five parameters of the OTDR to match the capabilities of the OTDR to the needs of the link. Once set up, the OTDR can interrogate the link. The result of this interrogation is a trace. The trace presents a picture of the loss along the link. The basic trace has five parts: two reflections, a straight line trace with a negative slope between the reflections, and two ‘dead’ zones.

Almost all OTDR traces can be reduced to a combination of the two most common traces: a trace with a non uniform, non reflective event and a trace with a non uniform reflective event. Each of these two common traces can have multiple interpretations. These multiple interpretations mean that the technician cannot create a map from the trace. Rather, he must use an accurate map to interpret the trace.

The technician can interpret a trace with a non uniform, non reflective event in four ways. Such a trace can indicate an APC connector pair, a fusion splice, a singlemode mechanical splice, or a violation of a cable performance parameter.

The technician can interpret a trace with a non uniform, reflective event in five ways. Such a trace can indicate a break in a tight tube cable, a multimode mechanical splice, a singlemode mechanical splice, an improperly made fusion splice, or a multiple reflection.

The OTDR software can analyze the trace to provide a table of attenuation rates, lengths, and connection losses. Because software is never perfect, the technician needs to know how to place cursers on the trace in order to make accurate measurements.

For most measurements, the technician will place two cursers on the trace: one curser at the beginning of a feature, the second at the end of that feature. The position of the curser will determine the fiber distance of the feature from the OTDR. The power difference between the locations of the two cursers will determine either the attenuation rate or connection loss.

In summary, the information presented herein will enable the novice OTDR user to set up the OTDR properly, make accurate measurements, interpret traces and correctly identify trace features with confidence.

Part 4: Fiber Optic Connector Update: Yesterday Today, and Tomorrow

Abstract

In this paper, we present an overview of the status of fiber optic connectors. This overview covers: the advantages, status and changes in use of connector types; results of cost analyses of installation methods; and projections of future changes. Significant results include connector type cost comparisons and installation methods cost comparisons. The connector type cost comparisons demonstrate a favorable total cost for SC connectors and a favorable cost for the installation methods of epoxy, quick cure and hot melt adhesive. These two results are the opposite of commonly held views. The favorable total cost for SC connectors results from a doubling of connector density relative to that of the ST-compatible connectors. The favorable total installed cost for epoxy, quick cure and hot melt adhesive methods results from a cleave and leave connector price premium that is not recovered through reduced labor cost.

Summary

The original fiber optic connectors were: unkeyed, non-contact, high loss, high reflectance, highly variable, single fiber, installed exclusively with the inconvenient and time consuming epoxy method. Today's connectors have evolved to: keyed, contact, low to moderate loss, low to moderate reflectance, highly repeatable, one to 24 fiber connectors installed with at least five different methods. Each of the methods addresses different installation conditions, with different methods favored under different conditions. These improvement in connectors have reduced the cost of the multimode connector from $20-$30 to about $2. Equally importantly, engineers and scientist have transferred the installation and testing to electricians, plumbers, and in some cases, high school students.

As is to be expected from typical product life cycles, older products, such as the ST-compatible and SC, are experiencing reduced market share, while the newer designs, such as the SFF and MTP®/MPO, are experiencing growth in both volumes and market share.

Changes in standards have resulted in changes in test procedures and in the equipment required. These changes are yet to be implemented by most

installers.

Changes in products and reductions in price have resulted in increased use of fiber and more specifically, of FTTD. This trend is expected to accelerate as more designers become aware of the cost advantages of FTTD.

Connectors have certainly come a long way, in cost, in performance, and in ease of installation. To my associates who have participated in this steady and significant progress, congratulations.

Note: an abbreviated version of this 24 page paper will be available in November, 2003.

Coming in Future Issues

The Impact of the New Testing Requirements: Category 1 Source and Mandrel
FOLS Cost Comparison Model: Updated Prices Indicate Improved Future for FTTD
Product Update: Evaluation of Cleave and Leave Connector Products
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

<u>Eye on Fiber, Vol. 1, Issue 1</u>
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?

Eye on Fiber, Vol. 2, Issue 1
Full Evaluation of the Panduit Prepolished SC Connector
Pay Less and Spend More: The Lesson of Total Hardware Cost

Training Programs, Presentations 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, June 16-18, Atlanta, GA; 8/15-17/03, Nashville, TN; 11/17-19/03, Tampa, FL. Available for on site presentations.
Presentation: Certifying Fiber Optic Networks For Maximum Reliability [Alternate], BICSI Conference, 8/18-21/03, Nashville, TN.
Presentation: Fiber Optic Connectors: Today, Tomorrow and Yesterday: An Update, IICIT Conference, 9/18-19/03, Orlando, FL.
Presentation: How Not to Curse at Cursers, FTTH Conference, New Orleans, LA, 10/7-9/03.