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Application Note

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Testing MT or MPO with Coated End-faces GR Testing

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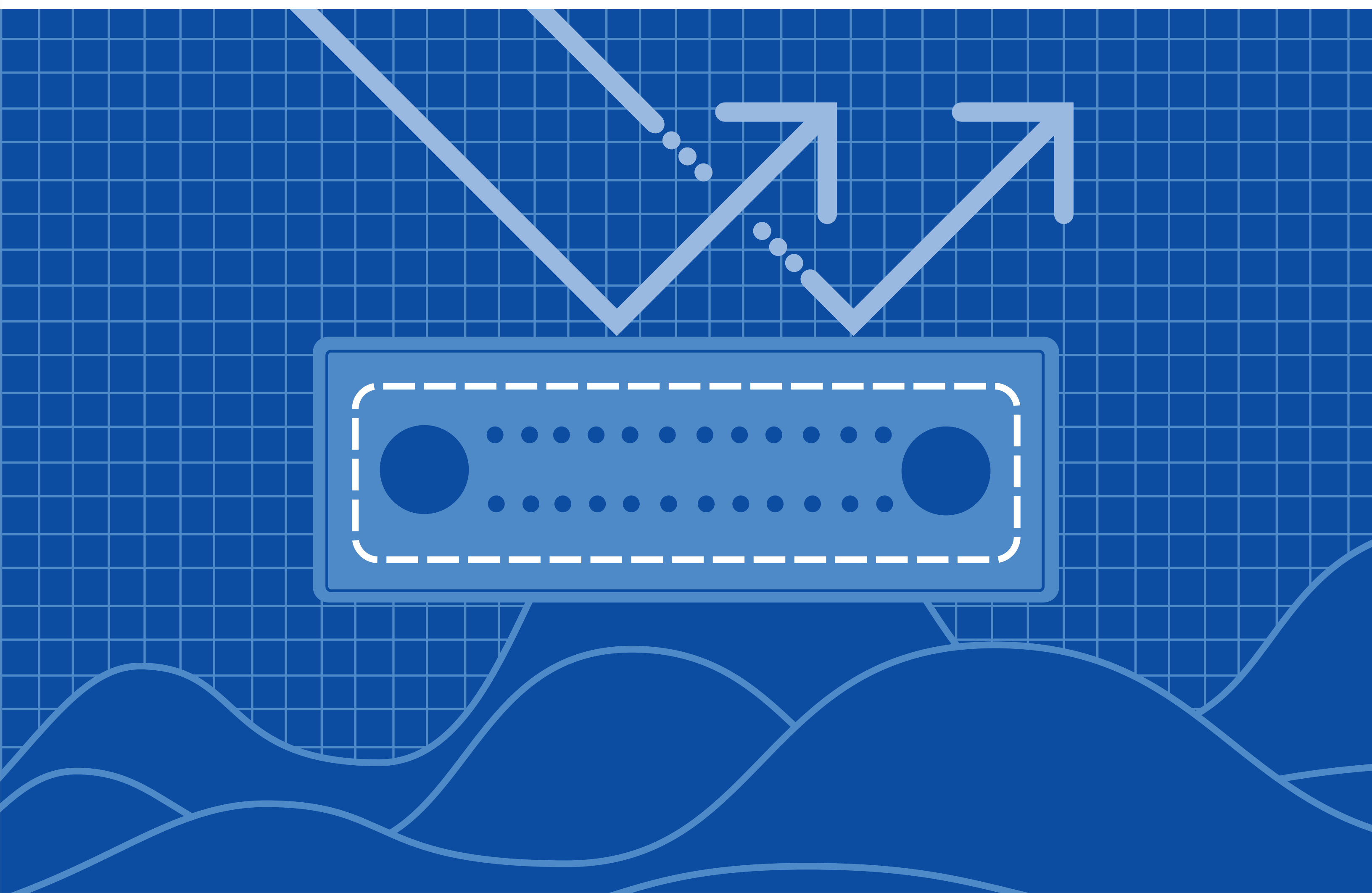

1.0 Introduction

SENKO's product line has fiber optic interconnects that at times feature durable and/or anti-reflective (AR) coatings. The purpose of the coating can vary depending on the product. However, various coatings can be added to improve the connectors mating performance in the form of Insertion Loss (IL) and Return Loss (RL), assist with better repeatability, minimize cleaning requirements, or even increase the durability of the connector. For example, SENKO MT and MPO connectors can be offered with such coatings that remain compatible with conventional MT and MPO interconnects. However, these various coatings may require a special consideration to be taken during the optical IL measurement process. A coated connector can either add or subtract a small amount of attenuation during the measurement process which can result in skewed data and confusion. For example, the referencing process can be puzzling when a coated reference end is used to test a standard non-coated compatible connector. There are also instances where testing assemblies with various coatings should be considered. One would not need to take the same considerations when a coated reference is used to test connectors with the same coating.

This compensation is not atypical or a sign of degraded performance. In fact, this is common practice and it's good to be aware of this variance with the advancements and evolution of the fiber optic market. This document will illustrate the specifics of what needs to be considered during testing and measurements of end-faces with various coatings.

2.0 Discussion

When light transfers from one media to another there will inevitably be a certain amount of reflected light which needs to be considered. This is based on the value of each media's refractive indices. Reflection R is defined in a formula below where $n_1$and n_2 are the refractive indices of two different materials respectively.

$$R = \frac{(n_1 - n_2)^2}{(n_1 + n_2)^2}$$

The optical loss due to Reflection is defined as,

$$\mathrm{L} = -10\log(1 - R)$$

For a polished uncoated fiber end, the two materials are fiber glass and air with $n_1 = 1.45$ and $n_2 = 1.00$ respectively. Using the formulas above, the calculated reflectivity R is about 3.3736% or 14.7dB with optical total loss 0.149dB per each surface. These theoretical values are often seen when test equipment measures the reflection of a clean standard polish connector.

Similarly, changes to Reflection and overall Loss are contributed to by a coating. A coating can have a different refractive index. Table 1 shows some examples of calculated insertion loss based on the refractive index of a coating.

Table 1. Examples of optical losses per surface due to AR coatings

Coating refraction index	Total IL, dB
1.33	-0.18
1.46	-0.30
1.50	-0.35
1.60	-0.54

To demonstrate the theory, SENKO set up experiments to quantify the change in loss due to the coating. The method that was used can be referred to as a cut-back method. This can be done by first referencing a coated connector with the measurement equipment. Following the reference, the coated connector is replaced by either a spliced connector with no coating, or a precisely cleaved bare fiber which can be held in a special bare fiber adapter in front of the detector. The difference between the reference and the new measurement is the adjustment that will need to be considered during measurement. Some form of compensation will need to be applied when a coated reference cable end-face is used with compatible non-coated connectors and vice versa. Thus, the goal of the experiment would be to quantify the compensation factor for various scenarios.

Four samples were used to verify the theory by considering the points below:

- The cleaving tool and splicer are verified to provide repeatable measurements prior to testing.
- The IL of equipment must be stable meaning the laser should not drift after the first reference. It may need a warmup period. Observing a stability of +/-0.01dB over 15 minutes is needed before testing.
- A minimum amount of fiber is needed to be cut back. Fiber loss can influence your results.
- The fiber management is maintained in a fixed position avoiding the influence of polarization and bending losses due to handling.

The following process can be followed to determine the difference in loss between the coated, and non-coated optical interface.

Step 1: Reference Coated MPO to set "0".

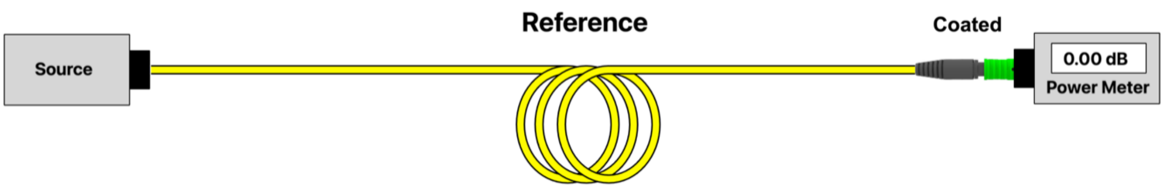

Figure 1: Initial reference of a Coated connector

Table 2. Initial referenced loss is zero across all 12 MPO Channels

Sample #	Fiber #	#1		#2		#3		#4	
		1310nm	1550nm	1310nm	1550nm	1310nm	1550nm	1310nm	1550nm
Coated MPO to be spliced with regular MPO	1	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0

Step 2a: Reference, then cut one side of Coated MPO and fusion splice the free end with a regular MPO

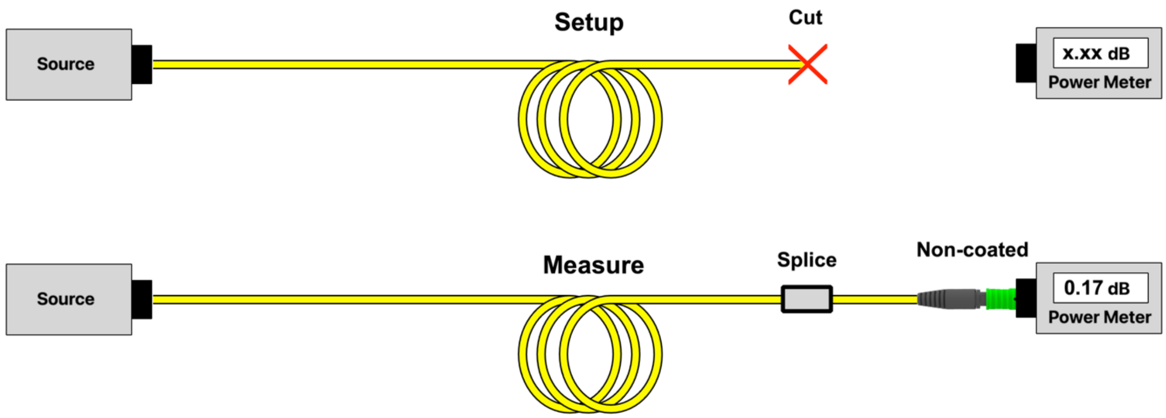

Figure 2: Step 2a of experiment reference using same cable with non-coated spliced on connector

Or, an alternate solution is to use a bare fiber adapter. Note, the cleave needs to be very clean and the use of a high-quality precision cleaver is advised when using a bare fiber adapter.

Step 2b: Reference, then cut one side of the Coated MPO. Cut, cleave, load into the bare fiber adapter, and measure.

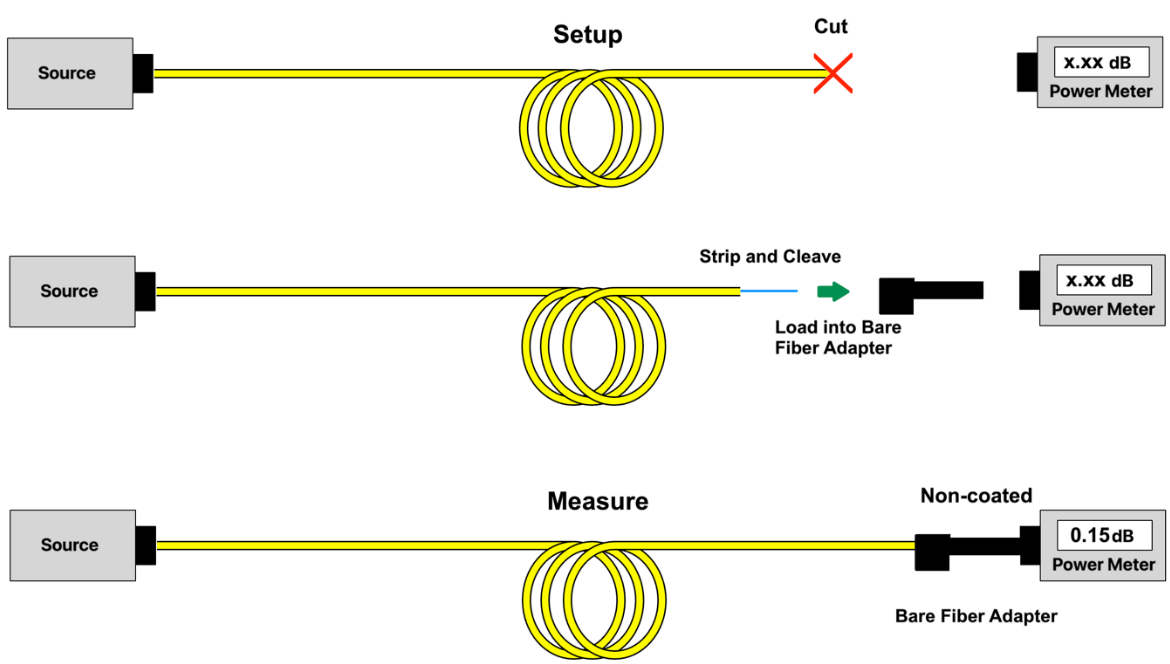

Figure 3: Alternate method using Bare Fiber Adapter

Table 3. Optical losses when coated connector is replaced with a non-coated standard connector

Sample #	Fiber #	#1		#2		#3		#4	
		1310nm	1550nm	1310nm	1550nm	1310nm	1550nm	1310nm	1550nm
Coated MPO to be spliced with regular MPO	1	0.17	0.18	0.18	0.19	0.12	0.14	0.18	0.17
	2	0.18	0.18	0.17	0.19	0.12	0.15	0.18	0.17
	3	0.14	0.16	0.14	0.17	0.13	0.16	0.19	0.19
	4	0.18	0.2	0.13	0.16	0.13	0.14	0.2	0.19
	5	0.16	0.19	0.13	0.16	0.1	0.13	0.23	0.22
	6	0.14	0.17	0.14	0.16	0.12	0.15	0.19	0.2
	7	0.15	0.17	0.17	0.19	0.12	0.16	0.18	0.18
	8	0.14	0.16	0.13	0.16	0.13	0.15	0.17	0.17
	9	0.14	0.15	0.12	0.15	0.11	0.13	0.24	0.22
	10	0.15	0.17	0.14	0.15	0.12	0.15	0.2	0.2
	11	0.14	0.17	0.12	0.15	0.11	0.16	0.18	0.19
	12	0.14	0.16	0.13	0.15	0.12	0.15	0.16	0.17
Max		0.18	0.2	0.18	0.19	0.13	0.16	0.24	0.22
Min		0.14	0.15	0.12	0.15	0.1	0.13	0.16	0.17
AVG		0.15	0.17	0.14	0.17	0.12	0.15	0.19	0.19

The above study indicates that there is an average difference of 0.15 dB between the coated and non-coated MPO. As a result, the theoretical and real measurements align with each other. For this reason, a compensation should be applied in certain test cases. The following are representations on how to apply the loss compensations and when.

Note, LC's and MPO's are used for visual representation. The same principle applies for other types of coated and non-coated connectors.

*Situation 1 - Compensation **needed***

The reference is performed with a coated MPO in the detector. The measurement is taken with a non-coated LC in the detector. This means a -0.15dB compensation should be applied to the measured IL value.

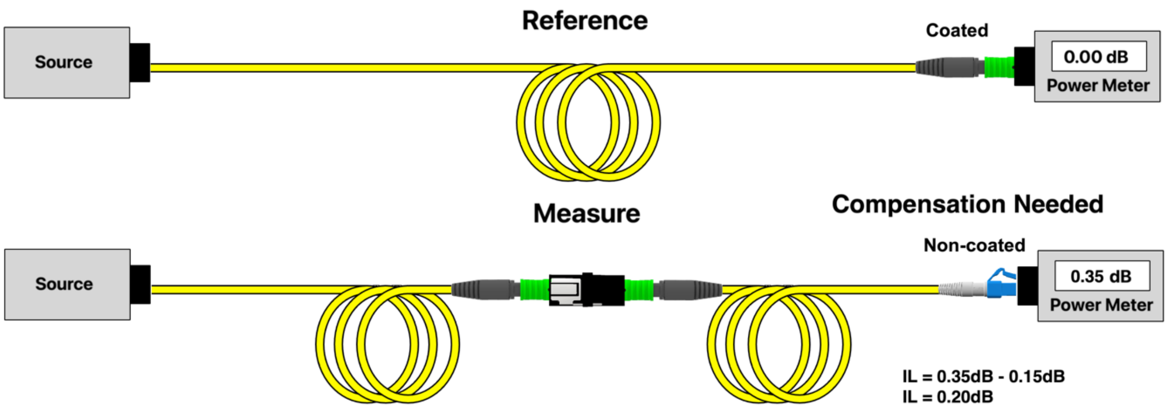

Figure 4: Coated to Non-coated

The reference is performed with a non-coated LC in the detector. The measurement is taken with a coated MPO in the detector. This means a +0.15dB compensation should be applied to the measured IL value.

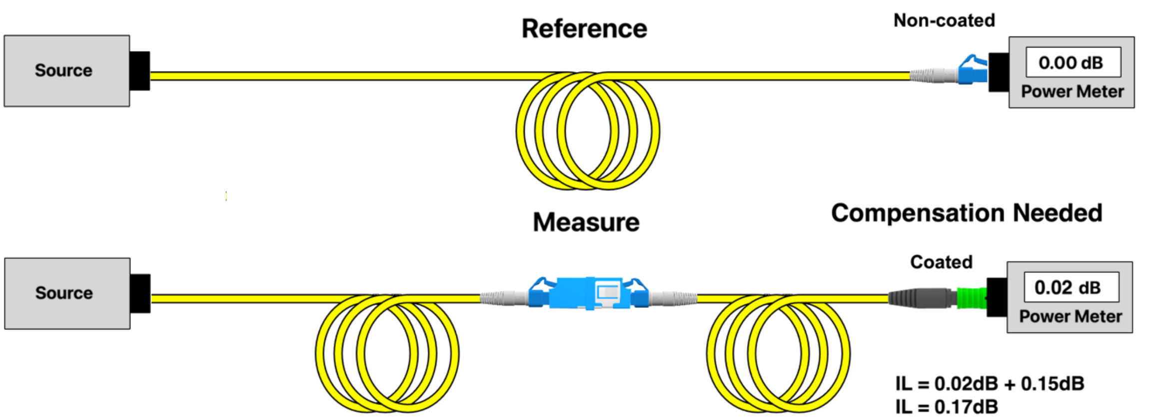

Figure 5: Non-coated to coated

*Situation 2: **No** compensation needed*

The reference is performed with a non-coated LC in the detector. The measurement is taken with a non-coated LC in the detector. This means no compensation should be applied to the measured IL value.

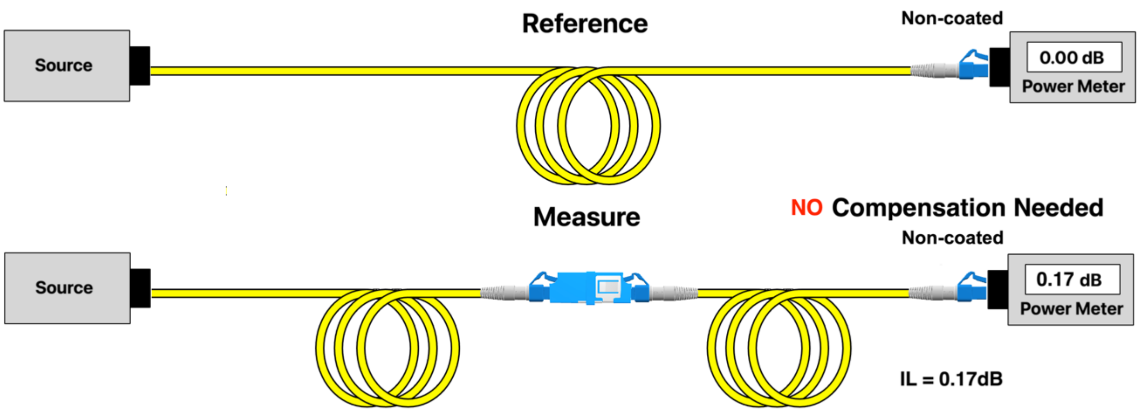

Figure 6: Non-coated to Non-coated

The reference is performed with a coated MPO in the detector. The measurement is taken with a coated MPO in the detector. This means no compensation should be applied to the measured IL value.

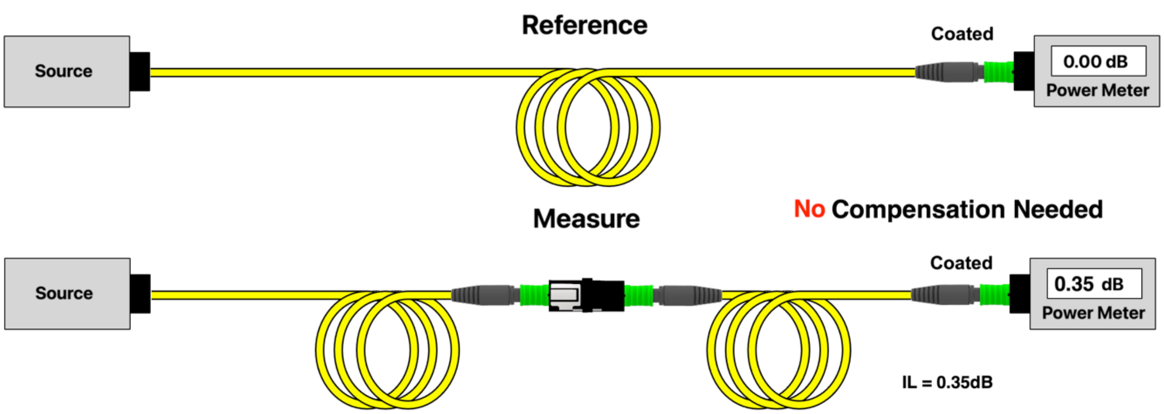

Figure 7: Coated to Coated

3.0 Summary

In conclusion, important to remember a few considerations when testing connectors with coated end faces. The difference in the refractive index between coated and uncoated connectors would require you to add or subtract a compensation factor to the data collected. This is because a reflection and loss measurement will then be referenced prior to testing the standard jumpers in order to take more accurate measurements of the loss of the standard connector alone. Referencing a master can be compared to zeroing a load cell before weighing something. Therefore, if the master test jumper has a coating on it which causes attenuation to change, and that jumper is referenced in the detector of the test equipment, the test equipment has now taken a measurement of the jumper with adjusted attenuation. Then, if you plug in a non-coated or differently coated connector in the detector to test, the data measured will have discrepancies because you would not be comparing two end faces with matching conditions. This is only the case when the master jumper and the device under test do not have corresponding coatings on their respective end faces. It is possible to apply the theoretical value, then verify it by using the cut-back method.

Thus, anytime one is using a coated connector as a master jumper, a similar quantification to the example shown above, may be necessary.

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