Fiber Optic Components for Telecom Applications going Military!

After surviving the Telecom bust in the beginning of this century some of us might be looking towards diversification strategies for products and technology. With all the government spending the military and defense market might present itself as an attractive way to do that. One of the main questions then becomes what performance specifications and standards for fiber optic components govern the military defense industry versus the commercial industry and which test standards apply. The commercial telecom industry may be used to turning to Telcordia (formerly Bellcore) for performance requirements for fiber optic components but where/who to turn to for performance requirements for the military / defense industry?

Let's try to sort some of the critical terms out first. The Telcos have been turning to Telcordia Technologies to write (with participation from the industry) Generic Requirements documents (GRs) that define performance requirements on the component and system level. These "GRs" are not standards and Telcordia is not an ANSI (American National Standards Institute) accredited standards developer (or SDO Standards Development Organization). These generic requirements documents cover design and performance criteria for common fiber optic components and other products of interest to the telecom industry. The Telco industry generally considers only two different environments when evaluating performance levels of fiber optic components. 1) Components designed for controlled environments (central office environment) and 2) components designed for uncontrolled environments (outside plant applications). Telcordia GRs provide criteria for both environmental applications. To a varying degree individual Telcos enforce that their supplier base strictly adheres and verifies that the Telcordia defined performance requirements are met.

When it comes to verification methods of those specified performance parameters Telcordia references the appropriate test and measurement standards. These standards are predominantly issued by the TIA (Telecommunications Industry Association) which is an ANSI accredited standards developer or SDO. These widely used test and measurement standards are also called FOTPs (Fiber Optic Test Procedures). FOTPs standardize a range of tests from simple optical Insertion Loss measurements to more complex Polarization Mode Dispersion measurements. FOTPs also address environmental tests ranging from vibration and shock to fluid and altitude immersion tests for fiber optic components (more about these standards at www.tiaonline.org).

If the commercial industry turns to Telcordia GRs to identify performance requirements for fiber optic components and systems, is there an equivalent body for the military industry? The answer is not immediately clear.

The Defense Supply Center Columbus (DSCC), among other duties, oversees the government's purchasing of fiber optic components. DSCC has the responsibility for MIL-STD documents that define test methods for testing various components and products. In addition DSCC controls the performance and design parameters of some fiber optic components in MIL-PRF performance standards. These MIL-PRF documents are available at the DSCC website (http://www.dscc.dla.mil/Programs/MilSpec/DocSearch.asp) and are provided for optical fiber, fiber optic cable, splices, and various kinds of fiber optic interconnects. Testing conditions specified for such components might address several environments (e.g. military aerospace and shipboard) within one document or are specific to one application (e.g. ground tactical connector). Where possible DSCC references TIA FOTP Standards as test methods for the verification of specified performance requirements even if the specified test conditions are often harsher that those referenced in Telcordia GRs. However, there are many performance requirements for which no standardized verification methods exist within TIA FOTPs. In these cases DSCC references MIL-Standards or combines MIL Standard conditions with FOTP test methods. MIL standardized test methods historically exist where no adequate commercial standards are available or where DSCC saw a need to tightly control the content including revisions to such as well as the test methods. Since adequate test methods for fiber optic components (FOTPs) have already been developed within the TIA, DSCC references such test standards as much as possible and where applicable and appropriate. In short, MIL-STD documents define test methods and MIL-PRF documents specify component design and performance criteria.

Fiber optic component standards for military aerospace applications are also published by the SAE (Society of Automotive Engineers) which is an ANSI accredited SDO. Fiber optic connector standards are addressed in the subcommittee Aerospace Electrical/Electronic Distribution Systems AE8 for example. These published performance requirements documents reference a mixture of TIA FOTPs and MIL-Standards to be used as valid test methods. Performance specifications for components used in the commercial aerospace industry are developed by ARINC.

As one can see, there is no single agency, standards body, and or industry organization writing the performance and design criteria for fiber optic components for ALL military environments. The defense industry considers a much broader and more complex range of environments for its fiber optic component specifications. It does not have the luxury of solely defining an “outside plant” and “central office” environment. Since the environmental conditions for each application (ground, flight, space, shipboard, etc) can be vastly different they demand many different test conditions and test methods. Defining performance requirements for components and systems is therefore less centralized and often left to those who develop the final products for these varying environments (the major defense contractors). These defense contractors individually write internal component specifications including performance and testing requirements. Such requirements obviously vary from contractor to contractor and from application to application.

After looking at examples of where these fiber optic component standards for the commercial and military industry are developed, let’s point out some of the differences between specified performance parameters and the associated environmental conditions and test methods for fiber optic components for communication systems.

While this probably comes as no surprise for the readers, the test conditions and performance requirements for military applications are generally harsher than those for the commercial telecom industry. Optical components are often installed in vehicles rather than stationary, hence are subject to various vibration and shock levels. Environments also change over time requiring verification at various atmospheric pressure levels and exposure to various fluids.

For example let’s take a look at one of the most common fiber optic components in communication systems, the fiber optic Singlemode connector. The following table compares an excerpt of Telcordia GR-326 test conditions against requirements for MIL-PRF-29504 fiber optic termini:

	Test Condition	Telcordia requirement (taken from GR-326)	DSCC requirement (taken from MIL-PRF-29504 /4 and /5 rev C specifications)
Vibration Testing	Vibration Profile	Sine vibration only	sine & random vibration
	Acceleration / Frequency	10g max (10Hz to 55Hz)	Test 1: 60g max (sine – 10Hz to 2000Hz) Test 2: 41.7g (random) Test 3: 49.5g (random)
	Duration (per axis)	2 hours	Test 1: 4 hours Test 2: 4 or 8 hours Test 3: 8 hours
	Temperature	At room temperature	Test 1: ambient, at +175°C, and at -55°C Test 2: @ +125°C Test 3: ambient
	Optical performance measurements	Measurement of Insertion Loss and Return Loss after each axis	Measurement of change in transmittance after the test and measurement of optical circuit discontinuities during the test

Figure 1: Telcordia GR-326 versus DSCC MIL-PRF-29504 /4 & /5 Vibration Conditions

The required measurement of optical circuit discontinuities is described in FOTP-32A (EIA/TIA-455-32A) and is typically not required for commercial telecom fiber optic components. The measurement requires a continues-wave light source to excite the connector under test and a high speed optical receiver to monitor the optical signal for short-duration optical discontinuities of specific magnitude during a vibration or shock test. Specifications are as harsh as requiring no discontinuities of ≥1 μs* and ≥2 dB* to occur during a test (* taken from draft of MIL-PRF-83526 /16). The following graph shows the results of a optical signal discontinuity test (screen capture of multi-channel discontinuity test system developed by Experior Photonics).

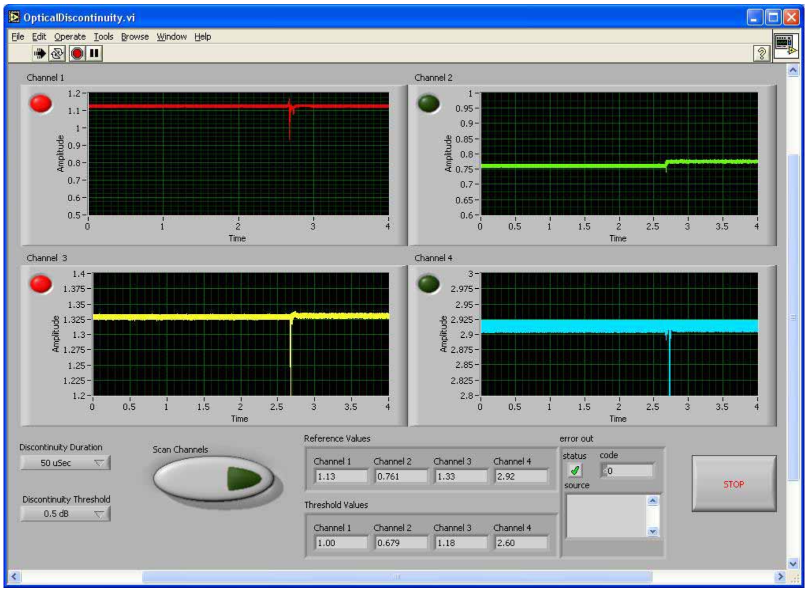

Figure 2: Measurements of signal discontinuities (as often required during military connector qualification testing)

In the above example signal discontinuities occur on channels 1 and 3 during the test. The discontinuities seen on channels 2 and 4 do not exceed the set pass criteria for time and amplitude and are therefore not indicated as a fail by the software algorithm.

Another example for differences between Telcordia performance requirements for a Singlemode fiber optic connector and DSCC specification is for mechanical shock testing. While Telcordia requires no mechanical shock testing within GR-326 the test is a requirement for military fiber optic connectors. Fiber optic connectors for shipboard applications are even required to undergo a harsher shock test called Hammer Shock. This test is specified in MIL-S-901 and constitutes a 180kg (400 pound) steel hammer swinging against a steel anvil from 1, 3, and 5 feet heights. The connector assembly under test is mounted to the opposite side of the anvil. The following picture shows a MIL-S-901 Hammer Shock apparatus with a fiber optic cable assembly mounted to the anvil.

Figure 3: MIL-S-901 Hammer Shock test with fiber optic connector assembly

Optical circuit discontinuities as described above are also measured during the Hammer Shock test shown above.

Resisting the various fluids that are used in vehicles is another common military requirement. The fluids include (but are not limited to) hydraulic oil, coolant, jet fuel, cleaning fluids and solvents, as well as seawater. Fiber optic connectors generally shall not exhibit any swelling or softening of materials, no loss of sealing capability, and must retain their markings and coloration during immersion in such fluids.

Knowing what performance requirements are applicable for the target markets is obviously important. Manufacturers should also be aware of the market specific product certification requirements (if any) applicable to fiber optic components. While Telcordia does not maintain a laboratory certification program (there is no such thing as a “Telcordia certified” testing facility!), DSCC does. To support the government’s procurement activity for components DSCC maintains a test facility certification program and only admits those products for procurement that have been tested by such DSCC approved testing facility. A list of approved testing facilities can be found at www.dscc.dla.mil/offices/Sourcing_and_Qualification/labsuit.asp

Overall, while meeting Telcordia generic requirements for fiber optic components is a good first step, military requirements typically demand the supplier to go further. While Telcordia requirements only consider the outside plant and central office (uncontrolled and controlled environments), military specifications are addressing many more use applications and environments. Therefore, one can expect to see a vastly more diverse set of requirements with harsher conditions when investigating military requirements for fiber optic components. However, knowing where to find applicable standards and requirements is always a good first step.

About the author:

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