Fiber Optic Epoxy to Alleviate Core Cracking During Termination

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One of the approved epoxies typically used for space flight 100/140 micron optical fiber terminations is the Tra-Bond F253. This epoxy is approved for space flight missions because it passes the ASTM-595-93 vacuum outgassing test and is proved to be adequate to withstand harsh environmental testing in configuration of a space flight assembly. In the past, this epoxy has been used for termination with the Johanson R2550 and the R2547 FC type space flight approved connectors. The cure schedule specified by Tra-Con for the F253 is 100ºC for 15 min and at NASA Goddard Space Flight Center, the heat is applied an additional 45 min followed by a cool down time of 30 min before removal from the oven.

Another epoxy that has passed the ASTM-595-93 test is the AngstromBond AB9119 with a Total Mass Loss (TML) of .64 % and a Collected Volatile Condensable Materials (CVCM) of 0.00%[1]. The cure schedule for this epoxy was 30 minutes at 120°C for outgas testing, while the vendor recommended minimum schedule is 100ºC for 15 min, 120ºC for 10 min or 150ºC for 5 min. Another epoxy tested was the Angstrom Bond AB9112 but it did not pass outgas testing with a TML of 4.33% and a CVCM of 1.34%. This epoxy is therefore not approved for flight use.[1]

During termination of optical fiber assemblies at NASA GSFC, unexplained core cracking occurred while heat curing the Tra-Bond F253. This occurred more often when this epoxy had been used to terminate to other types of connectors (ST and other FC types for example). Although this problem has existed for several years, it was not studied with great depth since most of the space flight manufacturing is done at very small volume where yield is less of an issue. For industry however, core cracking of multimode fiber during the cure cycle of the epoxy has been a common problem and is much more of an issue due to the high volume of manufacturing.

Imidizole cured epoxies, such as the TraBond F253 and the AngstromBond AB9119, can shrink from 3% to 7% during cure depending upon the mass. This shrinkage coupled with the high temperatures required for curing (100°C to 150°C) applies stress on the glass and may cause core cracking in multimode fiber. Single mode fiber can easily withstand the stress because it is strongly compressed. Using an amine-curing system alleviates the issues of core cracking. An example of an amine-cured epoxy is the AB9112.

Years ago, the Navy originally wanted to approve a popular imidizole epoxy but they could not accept the failure rate experienced with that system. For this reason, only amine cure systems are approved to MIL -PRF-24792A, the specification for two-part optical fiber epoxies. However, some of the amine-cure systems do not pass the vacuum

outgas requirements of ASTM E-595-93 as was seen with the testing results for the AB9112.

The AngstromBond AB9320 was developed to solve the problems previously mentioned. It has the low stress of the amine system but it yields the properties of the imidizoles. The manufacturer specifies the following options for cure schedules: 80ºC for 30-120 minutes, 90ºC for 15 – 60 minutes, or 100ºC for 10-30 minutes. Two of these cure schedules for were used for vacuum outgas testing. The results of testing the AB9320 to the ASTM-595-93 are in Table 1.

Table 1: Outgassing Test Results for AngstromBond AB9320

Cure Schedule	TML	CVCM	Pass
A: 25 Degrees C for 7 days*	1.39%	0.00%	No
B: 100 degrees C for 30 minutes	1.13%	0.00%	No
C: 80 degrees C for 2 hours	0.85%	0.00%	Yes

* This cure schedule is NOT recommended by the manufacturer and is not considered an adequate cure.

In order for the AB9320 to pass the outgas test, a cure schedule of 80ºC for two hours must be used. The lower cure temperature is more advantageous for termination of assemblies that are not rated for temperatures as high as 100°C. Many acrylate coatings are rated for 85°C making this an important reason to choose a lower cure temperature epoxy. Industry users state that this epoxy works well with multimode and single mode optical fiber and does not cause core cracking.

Although outgas test results for a space environment are favorable using cure schedule C for the AB9320, and industry reports success with termination yield, its important to verify that a terminated optical fiber assembly system functions reliably. To validate a terminated system we highly recommend testing the entire assembly for thermal effects.[2-3]

For more information please visit the websites misspiggy.gsfc.nasa.gov/photonics and nepp.nasa.gov/photonics.

References:

1. M. Bettencourt, M. Ott, "Fiber Optic Epoxy Outgassing Study for Space Flight Applications," NASA Electronic Parts and Packaging Program Publication for the Electronic Packaging Project, October 4, 2001. nepp.nasa.gov/photonics
2. M. Ott, P. Friedberg, "Technology Validation of Optical Fiber Cables for Space Flight Environments," International Society for Optical Engineering, SPIE Conference on Optical Devices for Fiber Communication II, Proceedings Vol. 4216, November 8, 2000, Boston.
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