

Thin Film Module Reliability Overview

The eTEC™ Series thin film thermoelectric modules have been proven to be reliable in the most demanding applications for optoelectronic devices. Validation testing has been conducted as defined by Telcordia's GR468-CORE specification (see Table 2), which is the most comprehensive standard for reliability testing of thermoelectric modules in the optoelectronic market.

Category	Test	Level	Additional Information
Mechanical Integrity	Mechanical Shock	Required	Condition B (1500 g, 0.5 ms), 5 times/axis
	Vibration	Required	Condition A (20 g), 20 to 2000 to 20 Hz, 4 min/cy, 4 cy/axis
Non-Powered Environmental Stress	High Temp. Storage	Required	85°C, 2000 hr
	Temperature Cycling	Required	-40°C to +85°C, 500 cycles Interim read @ 100 cycles
Powered Environmental Stress	Powered Thermal Age	Optional	Tamb=85°C, 2000 hr, 5000 hr, I=Imax
	Power Cycling (On/Off)	Required	Hot-side T =85°C, 5000 cycles (90 sec on, 30 sec off)

Table 2: Telcordia GR468-CORE Test Protocol

Mechanical Integrity

Mechanical shock experiments were performed in accordance with MIL-STD-883E Method 2002.3 that defines shock of 3000 g in a 0.3 ms pulse (5 times per axis)—this exceeds the requirement in GR-468 by 100%. Figure 13 shows a g-force response curve for the testing. Shock tests were performed on 12 HV14 modules, which exhibited an average change in AC resistance of -1.9% with a range of changes from -5.8 to +3.1%. This result indicates the HV14 TEM is well within the specified range of 1500 g.



Figure 13: Shock (g-force) as a function of time showing 3000 g pulse.

Non-Powered Environmental Stress

High-temperature storage provides a good indicator of long-term reliability, particularly as it relates to diffusion-based failure modes and interface stability. The GR-468 test conditions were set at 85°C for 2000 hours. To further stress the module and accelerate temperature dependent failure mechanisms, modules were subjected to temperatures well above the maximum operating condition of 150°C. Figure 14 shows the results of 150°C storage with read-points on the A/C resistance at 254, 432, 1190, 1526 and 2534 hours. In all cases, the A/C resistance varied less than 1% from nominal A/C resistance. This indicates there are no temperature driven changes in the thin film material, contacts or interconnects under these conditions and the modules are very stable.

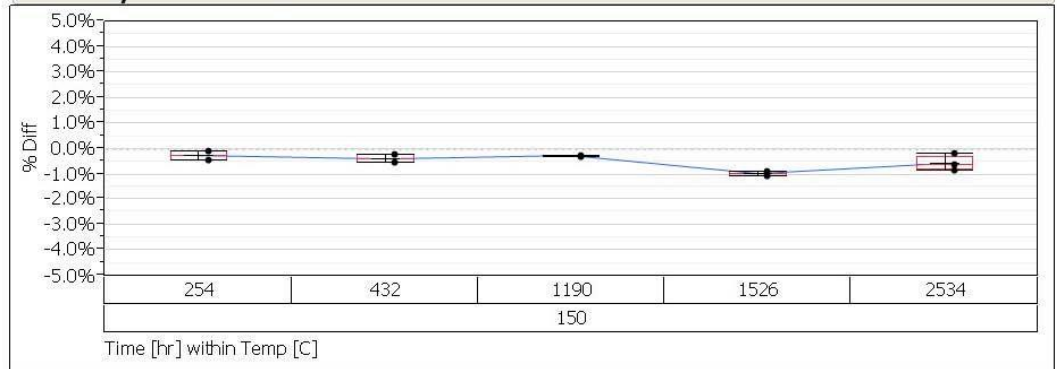


Figure 14: Percent change in AC resistance of the HV14 modules taken at different times (hours) up to 2534 hours. Less than 1% change in ACR was observed.

Powered Environmental Stress

Power cycling provides one of the most useful thermoelectric reliability tests as it simulates extreme usage by inducing large current pulses that simultaneously induce large thermal gradients in the device. These gradients produce expansion and contraction of the module that can lead to fatigue failures over time. Conducting power cycling at elevated temperatures can also induce diffusion-based failures. Figure 15 shows power cycling data of three HV14 modules at 90% of I_{max} for 100,000 cycles. In this test, the cycle period was 5 seconds on and 5 seconds off. This rapid cycling is enabled by the fast response time of the thin film module and enables more rapid accumulation of data. It also results in a rapid change in the internal stress of the devices that contributes to accelerated aging and fatigue. The ΔT of the module was monitored throughout the testing and exhibited less than a 4% change over the entire 100,000 cycle test. This far exceeded the pass/fail criteria set in GR-468 power cycling standards.

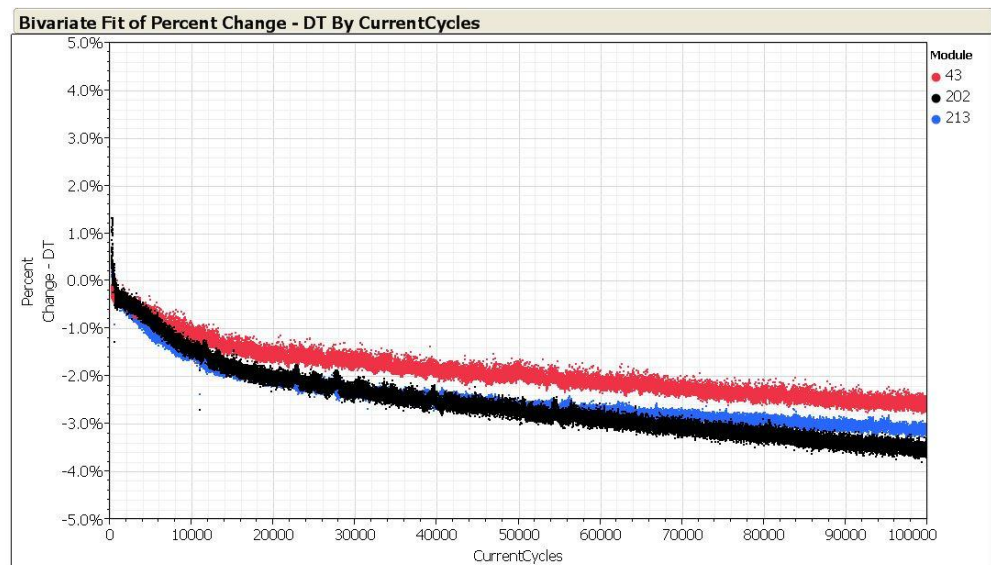


Figure 15: Change in module ΔT over 100,000 cycles at 90% of I_{max} .