THERM-A-GAP™ GEL 75VT Reliability Report

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Executive Summary

THERM-A-GAP™ GEL 75VT is a one-component, dispensable thermal interface gel material with 7.5 W/m-K thermal conductivity. It was developed to conduct heat from electronics to heat sinks or enclosures and perform reliably in vertical, high vibration, and harsh environments. The “VT” suffix in the product name stands for “vibration/vertical and tackiness” as this material was thoroughly tested during development to withstand rigorous reliability testing within vibration and vertical slump testing.

THERM-A-GAP GEL 75VT requires no mixing or secondary curing and is designed for easy application and rework. The tackiness of GEL 75VT serves the added benefit of displacing air at thin bond lines and minimizing thermal impedance. It can be dispensed at various bond line thicknesses to take up gaps created by assembly or manufacturing tolerances. This document outlines the examination of the thermal reliability of this high-performance gap filler after being subjected to long-term environmental aging under dry heat, heat & humidity conditions, and temperature cycling from -40°C to 125°C.

The thermal performance of THERM-A-GAP™ GEL 75VT was examined after being subjected to multiple environmental stress tests.

The thermal impedance of the aged samples did not experience a significant increase after any of the treatments studied. After 1000-hour dwell at 125°C, 1000 hours at 85°C/85% relative humidity, and 1000 temperature cycles from -40°C to 125°C, there was no significant increase in impedance (<5%) according to one-way ANOVA with the Tukey method for multiple comparisons.

Based on these results, THERM-A-GAP™ GEL 75VT demonstrates the ability to withstand long- term aging without a reduction in thermal performance.

1.0 Introduction

The purpose of this document is to examine the thermal reliability of this high-performance thermal gel. Samples of production-scale batches were subjected to long-term aging conditions, and the thermal performance was measured over time.

Successful survival of long-term aging is demonstrated by a lack of statistically significant increase in thermal impedance of the reliability fixtures after the full aging duration. The reliability fixtures comprise of GEL 75VT dispensed and compressed between two stainless-steel coupons, with thickness set by PTFE spacers. It is worth noting that the exact impedance value of the reliability fixture is not representative of the impedance value of the thermal interface material itself, but rather can be used as a proxy to measure changes to thermal performance over time as a result of aging under various test conditions.

2.0 Long-Term Aging

2.1. Purpose

Long term aging was performed on GEL 75VT between substrates to evaluate the thermal performance reliability over time. The material was subjected to an extended dwell time of 1000-hrs at 125ºC, prolonged temperature cycling from -40°C to 125°C, and long-term heat and humidity aging at 85ºC/85% relative humidity. Two samples were prepared for each long-term aging criteria.

2.2. Materials

2.2.1. 1” x 1” x 0.040” 316 stainless-steel coupons
2.2.2. PTFE shims, 0.040” thick
2.2.3. Clamps
2.2.4. Russells Humidity Chamber GD-16-3-3-AC
2.2.5. Sun Electronics Systems PTL-001 Temperature Cycling System
2.2.5. Blue-M B-2730-Q Oven

2.3. Sample Preparation

2.3.1. GEL 75VT was dispensed onto the center of a stainless-steel coupon.
2.3.2. The 0.040” PTFE shims were placed at each corner of the test plates.
2.3.3. A second stainless-steel coupon was placed on top of the dispensed material.
2.3.4. Two clamps were placed onto the assembly to hold the substrate at a constant thickness.
2.3.5. The above procedure was performed for all sample assemblies.

2.4. Test Procedure

2.4.1. The assemblies were removed from their clamps and one drop of 500 cSt silicone oil was applied by pipette to the outside of each stainless-steel substrate.
2.4.2. The samples were tested initially for thermal impedance at 50°C and 50 psi per ASTM D5470.

2.4.3. After testing each assembly, the silicone oil was gently removed from the outside surfaces and the clamps were place back onto the assemblies.

2.4.4. Three assemblies were subjected to each aging condition:

2.4.4.1. Dry heat aging: oven at 125°C.

2.4.4.2. Heat/humidity aging: humidity chamber at 85°C, 85% relative humidity.

2.4.4.3. Temperature cycling: thermal cycling chamber from -40°C to 125°C; 10°C/min ramp; 15-minute dwell.

2.4.5. After 500 hours of exposure to the aging conditions, the samples were removed from their respective environments, allowed to equilibrate to room temperature for at least 2 hours, and retested for thermal impedance.

2.4.6. Once tested, the samples were returned to their respective aging environments and the aging intervals were repeated until the samples had been subjected to a total of 1000 hours of dry heat or heat/humidity aging, or 1000-hr temperature cycles.

2.5. Results

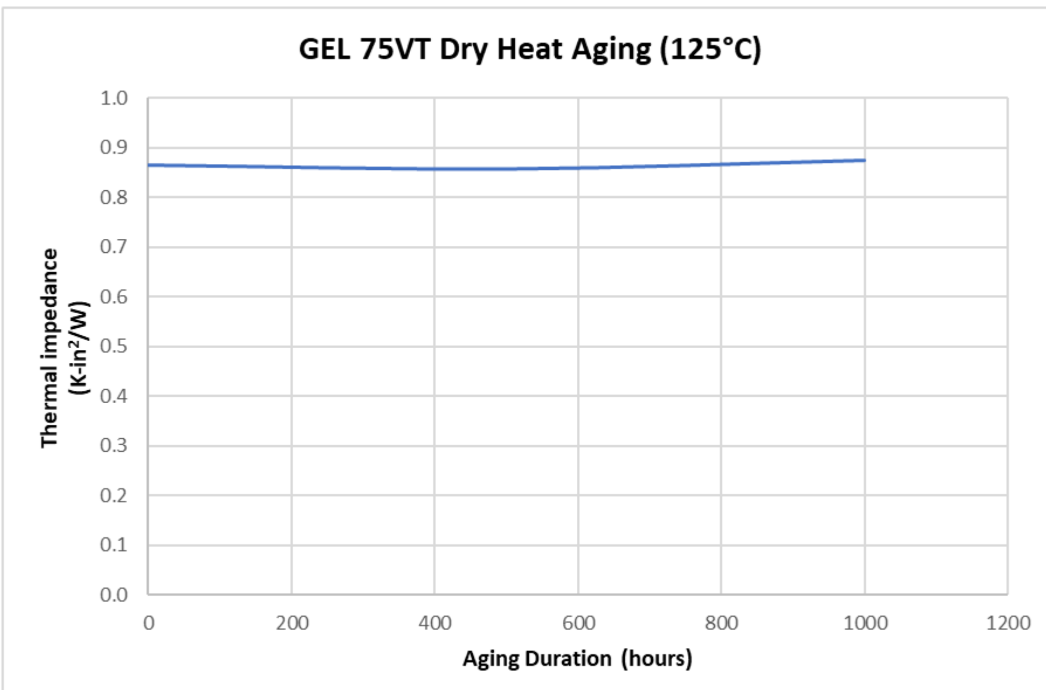

Figure 1: Thermal Impedance versus Time – Dry heat aging at 125°C

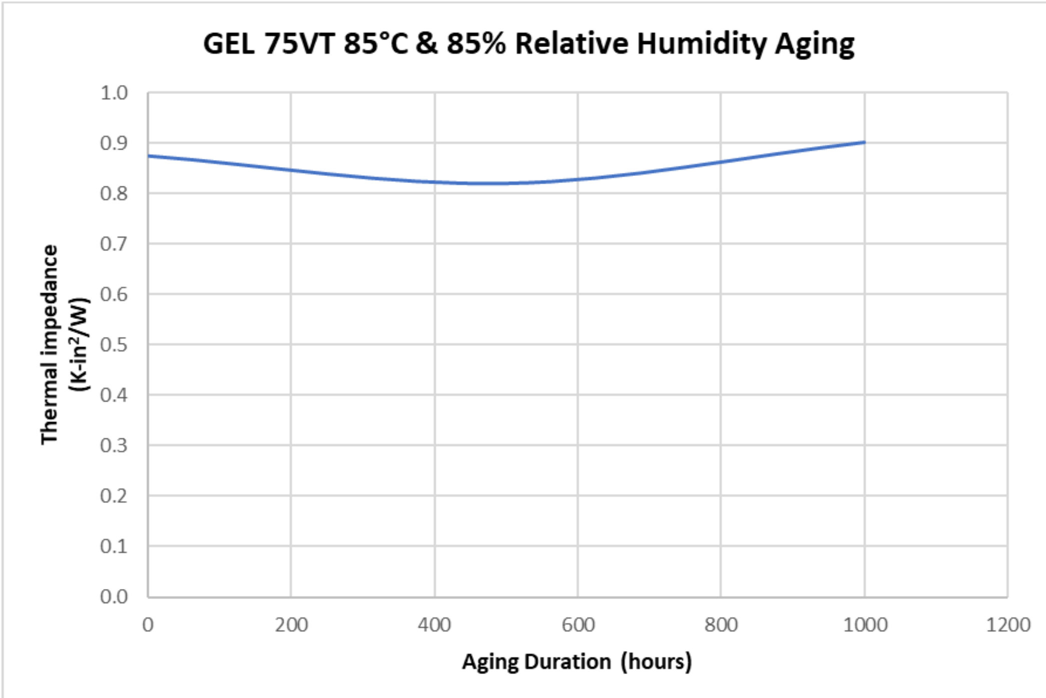

Figure 2: Thermal Impedance versus Time – Heat & Humidity aging at 85%RH and 85℃

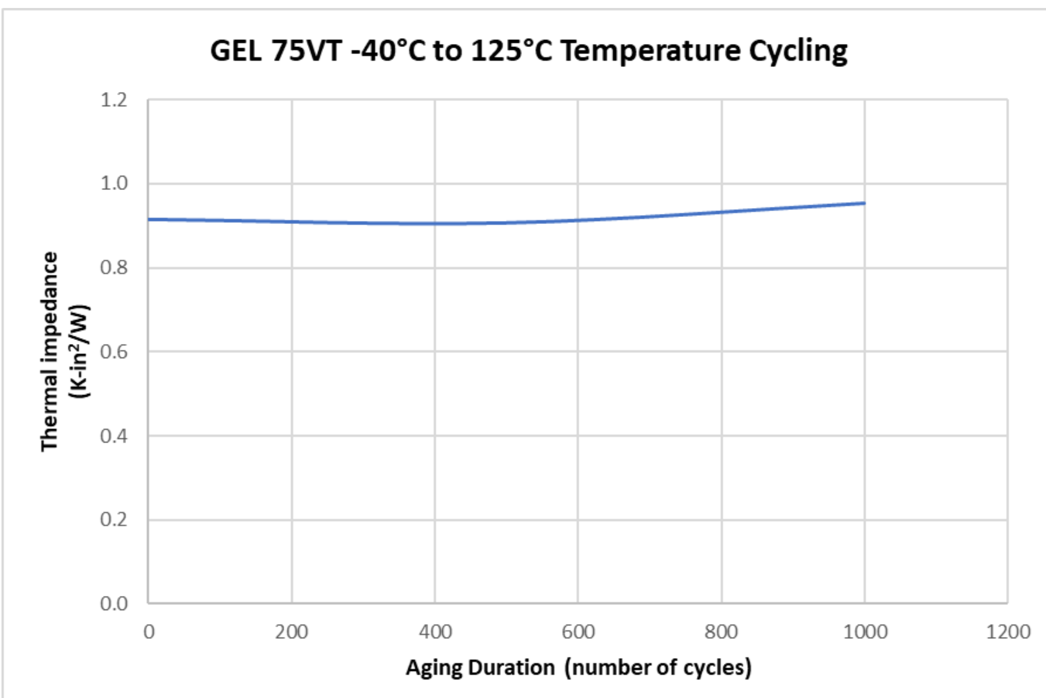

Figure 3: Thermal Impedance versus Time – Temperature cycling between -40℃ and 125℃

GEL 75VT Aging Condition	Initial Thermal Impedance (K*in^2/W)	Thermal Impedance @500h or cycles (K*in^2/W)	Percentage Change at 500 hrs or cycles	Thermal Impedance @1000h or cycles (K*in^2/W)	Percentage Change at 1000 hrs or cycles
125°C - 1	0.791	0.839	6.07%	0.85	7.46%
125°C - 2	0.94	0.875	-6.91%	0.902	-4.04%
Average	**0.866**	**0.857**	**-0.4%**	**0.876**	**1.7%**
85%/85°C - 1	0.835	0.801	-4.07%	0.852	2.04%
85%/85°C - 2	0.917	0.842	-8.18%	0.954	4.03%
Average	**0.876**	**0.822**	**-6.1%**	**0.903**	**3.0%**
-40 to 125°C-1	0.9	0.874	-2.89%	0.903	0.33%
-40 to 125°C-2	0.931	0.94	0.97%	1.005	7.95%
Average	**0.916**	**0.907**	**-1.0%**	**0.954**	**4.1%**

Table 1: Raw data of thermal aging testing

THERM-A-GAP™ GEL 75VT is a one-component, fully cured, dispensable thermal compound. The thermal performance of GEL 75VT was measured after exposure to multiple accelerated aging conditions. The aging treatments featured in this study are 1000 hours of dry heat aging at 125°C, 1000 hours of heat and humidity aging at 85°C and 85% relative humidity, and 1000 hours of temperature cycles between -40°C and 125°C. There was no statistically significant increase in the thermal impedance (< 5%) of the sample assemblies for any of the aging treatments according to one-way ANOVA with the Tukey method for multiple comparisons.

The mean impedance values after dry heat aging at 125°C, heat and humidity aging, and temperature cycling increased by 1.7%, 3.0%, and 4.1%, respectively.

3.0 Conclusion

The results of this study provide evidence that GEL 75VT maintains reliability after long-term aging. This reliability report presents the test results of GEL 75VT under controlled lab conditions. We strongly recommend the testing of thermal materials under application specific conditions to understand how the material will perform in a given environment.

TEST REPORT

THERM-A-GAP GEL75VT Reliability Report

TR919 Jan 2025 Rev. A

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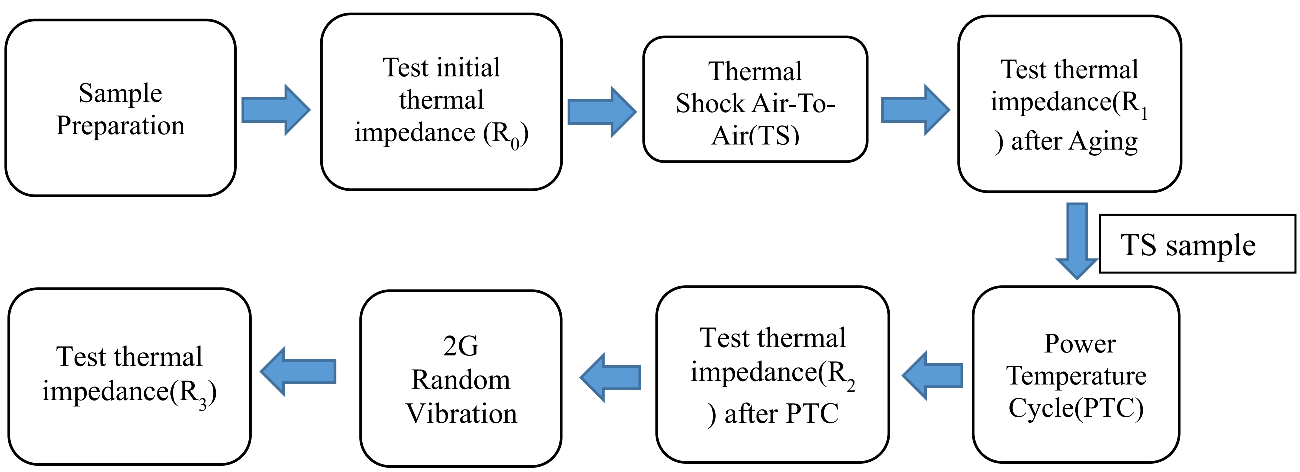
Executive Summary

GEL75VT is a high performance, cured thermal gap filler. The cross-linked structure provides superior performance and long-term thermal stability over conventional high modulus thermal gel. This material is designed to be used in applications requiring minimal thermal resistance for optimized thermal performance. This document outlines the examination of the physical and thermal reliability of this high-performance gap filler.

GEL75VT was installed in a simulated application fixture in vertical. The thermal properties measurements were taken each step of reliability tests. The reliability tests include Heat Aging Humidity Aging, Temperature Cycling and Random Vibration Tests. The test methods according to IEC and GMW standards. These standards apply to Electrical/Electronic (E/E) components for passenger or commercial vehicles and trucks. The standards describe the environmental and durability tests for E/E components based on mounting location.

The thermal performance of GEL75VT was examined after being subjected to multiple environmental stress tests. The thermal impedance of GEL75VT was not significantly affected by long term heat aging, humidity aging, temperature cycling and high-frequency vibrations.

GEL75VT exhibits superior long-term physical and thermal reliability. This material also displays excellent thermal reliability under various physical stresses. The test flow chart as below：



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1. Introduction

1.1 Purpose

The purpose of the document is to examine the physical and thermal reliability of this high-performance gap filler. Samples of manufacturing batches of GEL75VT were subjected to thermal shock test, thermal cycling test and vibration test.

1.2 Sample Set-Up Summary

GEL75VT was installed in a simulated application fixture in vertical position. The thermal properties measurements were taken each step of reliability tests. The reliability tests include Heat Aging Humidity Aging, and Tests. The test methods according to IEC and GMW standards. These standards apply to Electrical/Electronic (E/E) components for passenger or commercial vehicles and trucks. The standards describe the environmental and durability tests for E/E components based on mounting location.

2. Thermal Shock Air-To-Air (TS)

2.1 Introduction and Reference

Thermal Shock Air-To-Air (TS) according to GMW 3172 9.4.2. This test in combination with Power Temperature Cycling (PTC) shall verify that the component is immune to thermal fatigue and contact degradation that is caused by temperature changes and possible miss-matching of the CTE of materials.

2.2 Equipment and test setup

Specimens tested from -40 ºC to 85 ºC, and the dwell time at high temperature and low temperature is 15min. The temperature range conducted in the Thermal Shock test shall be adjusted for components that generate significant internal heat to compensate for the lost temperature change with a non-energized component as figure 1.

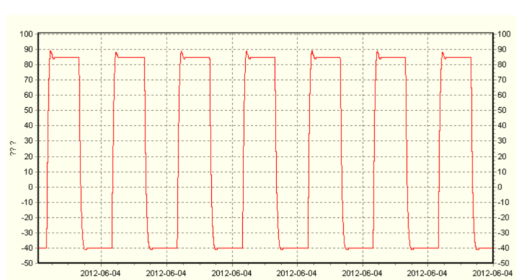


Fig.1. Espec thermal shock chamber and temperature curve

The number of thermal cycles according to GMW 3172 9.4.2 Table 33, Position

Code Letter For Temperature	Location In The Vehicle	Combined Number of TS + PTC Cycles	Number Of TS Cycles	Number Of PTC Cycles
A, B, C, and D	Inside the passenger compartment, luggage compartment, or attached to the exterior of the vehicle but not under the hood or above the exhaust system	843	632	211
E and F	Under the hood of the vehicle	1236	927	309
G, H, and I	Attached to or inside the engine (total cycles = 2248)	1248	1000	248
		Cyclic Humidity and Constant Humidity		
		1000	1000	0

ABCD as table1.

Table1. Number of thermal cycles

2.3 Procedure

Use the test methods according to ISO 16750-4, Temperature cycling. The temperature cycle testing be performed according to IEC 60068-2-14, Test Na, Change of temperature. The thermal properties measurements be taken before and after aging per ASTM D5470 at 30psi. Thermal Impedance tester as figure2.

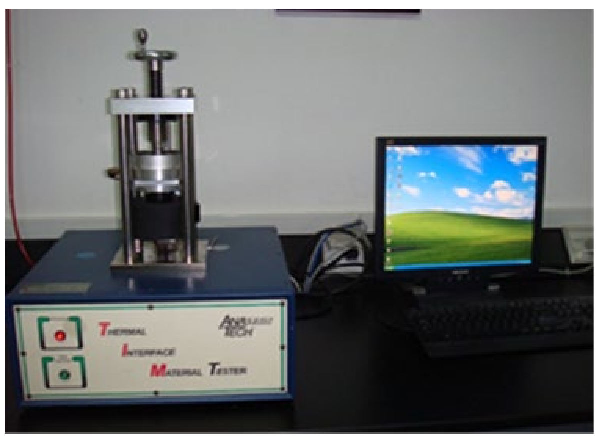


Fig.2. TIM tester

2.3.1 Sample Preparation

2.3.1.1 Dispense GEL75VT sample onto the center of 1.0inch x 1.0inch convex aluminum surface as a drop-shaped dot.

2.3.1.2 Apply 4 PTFE shims to the corners and cover with a 7inch x 7-inch sapphire glass gently to avoid sidesway. (As figure3)

2.3.1.3 Tighten the 4 PEEK screws to make sure reach a required gap thickness.

2.3.1.4 Roughness of the aluminum plate is ra1.6 and sapphire glass is ra0.02.
2.3.1.5 Specimens with 0.5 1.0 and 2.0mm thickness were prepared. 2 samples at each thickness..

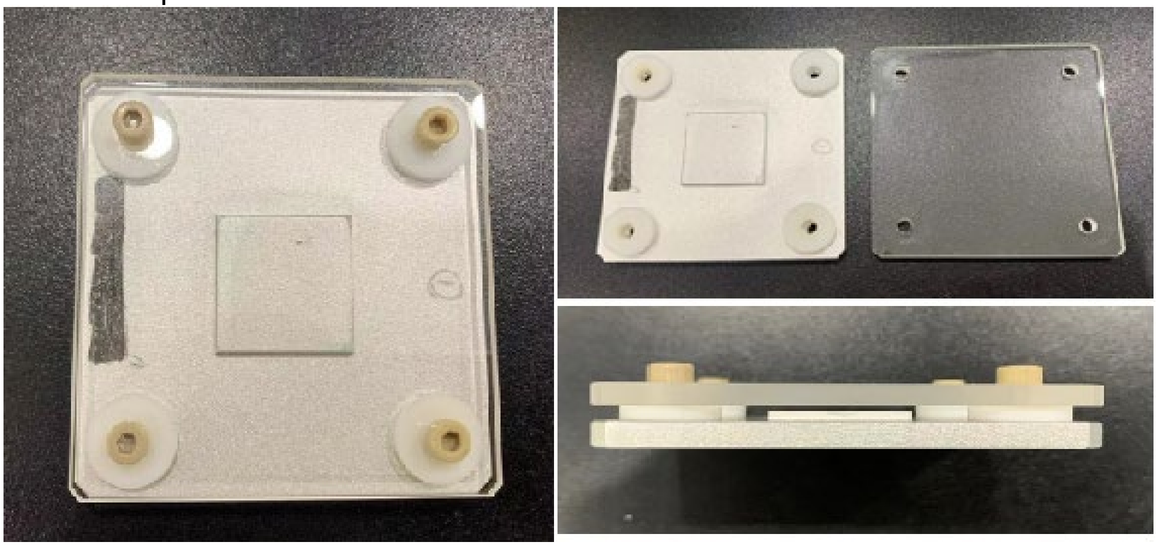


Fig.3. Simulated application fixture

2.3.2 Test Procedure

2.32.1 Test initial thermal Impedance and make record-R_0 (K-in.^2/W);
2.3.2.2 Put fixtures into Thermal shock chamber for 632cycles in vertical position.
2.3.2.3 After 632cycles remove specimens from thermal shock chamber and let specimens equilibrate to room temperature for 2 hours prior to testing.
2.3.2.4 Test thermal Impedance and make record-R_1 (K-in.^2/W) ,and monitor specimens appearance though glass.

2.4 Results

2.4.1 Result Summary Table

Samples	Specimen thickness	Initial Thermal Impedance (K*in2/W)	Thermal Impedance after Thermal Shock (K*in2/W)	Thermal Impedance Change
GEL75VT	0.5mm sample	0.621	0.634	2.09%
GEL75VT	1.0mm sample	0.856	0.872	1.87%
GEL75VT	2.0mm sample	1.321	1.331	0.76%

Table2. Test result of Thermal shock test

3. Temperature Cycling Test

3.1 Introduction and Reference

Temperature Cycling Test according to IEC 60068-2-14, Test Nb. This test shall verify that the component is immune to thermal fatigue and contact degradation that is caused by temperature changes and possible miss-matching of the CTE of materials.

3.2 Equipment and Test Setup

Specimens test from -40 ºC to 125 ºC at a 10 ºC /min speed and 15min dwell time at -40℃ and 125℃.
The number of thermal cycles according to IEC 60068-2-14, Test Nb.

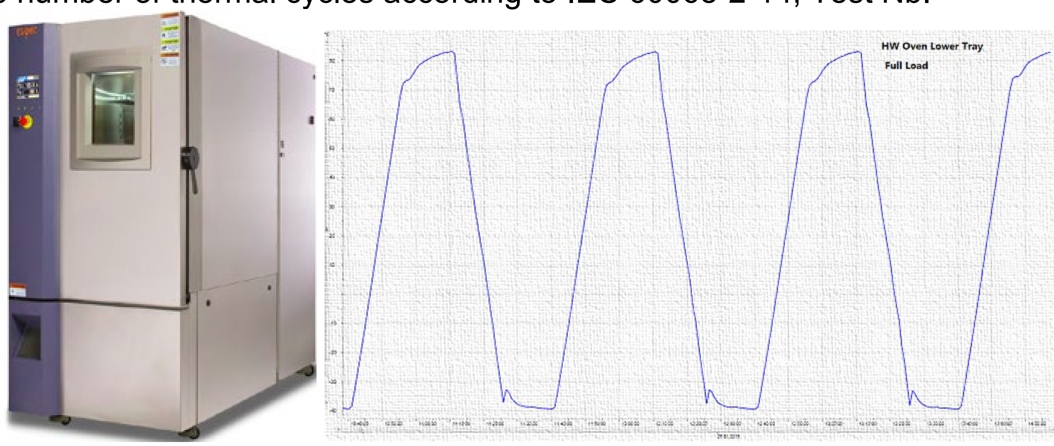


Fig.5. Espec temperature cycling chamber and Temperature curve

3.3 Procedure

Use the test methods according to ISO 16750-4, Temperature cycling. The temperature cycle testing shall be performed according to IEC 60068-2-14, Test Nb, Change of temperature. The thermal properties measurements be taken before and after TS per ASTM D5470 at 30psi. Thermal Impedance tester as figure2

3.3.1 Sample Preparation
Sample Preparation as 2.3.1

3.3.2 Test Procedure

3.3.2.1 After measured the thermal impedance R_1, then put the specimens into thermal cycling chamber in vertical position.

3.3.2.2 After 211 cycles, remove specimens from thermal cycling chamber and let specimens equilibrate to room temperature for 2 hours prior to testing.

3.3.2.3 Test thermal impedance and make record-R_2 (K-in.^2/W) and monitor specimens' appearance though glass.

3.4 Results

3.4.1 Result Summary Table

Samples	Specimen thickness	Initial Thermal Impedance (K*in2/W)	Thermal Impedance after PTC (K*in2/W)	Thermal Impedance Change
GEL75VT	0.5mm sample	0.621	0.656	5.64%
GEL75VT	1.0mm sample	0.856	0.885	3.39%
GEL75VT	2.0mm sample	1.321	1.369	3.63%

Table3. Test result of PTC

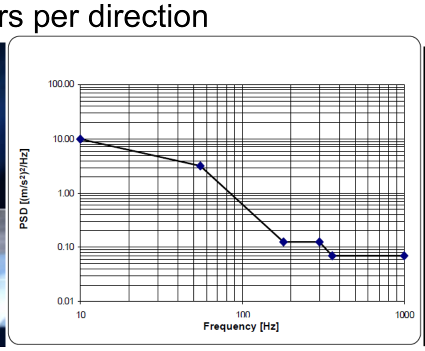
4. Random Vibration (Sprung Masses 2G Effective Acceleration)

4.1 Introduction and Reference

The GMW3172 9.3.1.2 Random Vibration was designed for automotive application.
A random vibration test was performed strictly according to GMW 3172 to evaluate the stability of the materials under high acceleration and high temperature.

4.2 Equipment and test setup

Sample preparation and test procedure according to IEC 60068-2-64, the test parameters and profile as figure6. Effective Acceleration=19.6m/s2=2.0GRMS
3 directions. 8 hours per direction



Fre-quency	Power Spectral Density
10 Hz	9.9069 $(m/s^2)^2/Hz$ = 0.1032 G^2/Hz
55 Hz	3.2245 $(m/s^2)^2/Hz$ = 0.0336 G^2/Hz
180 Hz	0.1238 $(m/s^2)^2/Hz$ = 0.0013 G^2/Hz
300 Hz	0.1238 $(m/s^2)^2/Hz$ = 0.0013 G^2/Hz
360 Hz	0.0695 $(m/s^2)^2/Hz$ = 0.0007 G^2/Hz
1000 Hz	0.0695 $(m/s^2)^2/Hz$ = 0.0007 G^2/Hz

Fig.6. Vibration Stand , Test parameters and profile

4.3 Acceptance Criteria

Minimal visible decomposition will be allowed. The acceptable level of decomposition is to be defined.
Mechanical decomposition is allowed as long as the material still remains within specification after testing.
Thermal decomposition is allowed as long as the material still remains within specification after testing.

4.4 Procedure

Use the test methods according to IEC 60068-2-64, Test Fh, Vibration, broad-band random (digital control) and guidance. The thermal properties measurements be taken before and after Vibration per ASTM D5470 at 30psi.

4.4.1 Sample Preparation
Sample Preparation as 2.3.1

4.4.2 Test Procedure

4.4.2.1 After measured the thermal impedance R_2, then fixed specimens onto vibration tester.

4.4.2.2 Set up the parameters and do the Random Vibration test.

4.4.2.3 Test thermal impedance and make record-R_3 (K-in.^2/W)

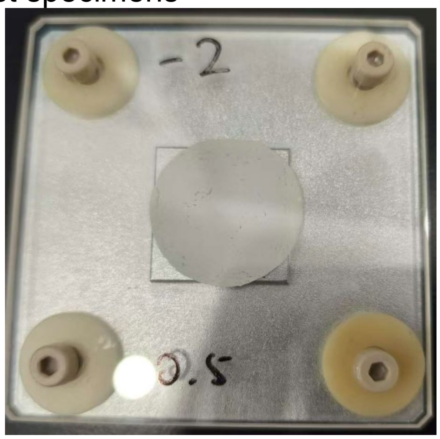
4.5 Results

4.5.1 Result Summary Table

Samples	Specimen thickness	Initial Thermal Impedance (K*in2/W)	Thermal Impedance after Vibration (K*in2/W)	Thermal Impedance Change
GEL75VT	0.5mm sample	0.621	0.661	6.44%
GEL75VT	1.0mm sample	0.856	0.891	4.09%
GEL75VT	2.0mm sample	1.321	1.372	3.86%

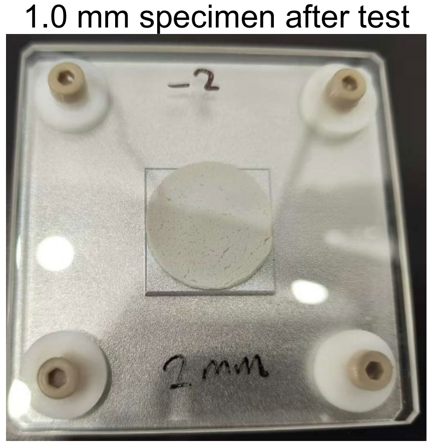
Table4. Test result of random vibration

5.0 Appearance of test specimens



0.5mm specimen after test

1.0 mm specimen after test



2.0 mm specimen after test

Specimens after thermal shock, temperature cycling and vibration test

5.1 Result Discussion
Thermal performance of GEL75VT remaining in good condition after 632 cycles of thermal shock test, 211 cycles of thermal cycling test and 2G random vibration test.
Specimens are still in good condition.
Slight cracking was observed.
No sliding was observed.

6.0 Summary and Conclusion

GEL75VT demonstrates superior stability of thermal properties, thermal impedance is not significantly affected by thermal shock, temperature cycling and vibration and long term humidity and heat aging tests.
No sliding were observed after long term reliability aging.

Footnote:
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