



THERM-A-GAP™ PAD 30 Test Report

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Executive Summary

THERM-A-GAP™ PAD 30 is a highly reliable, low-hardness, 3.2 W/m-K thermally conductive pad.

This document outlines the examination of the thermal reliability of this silicone-based gap filler pad after being subjected to long-term environmental aging.

The thermal performance of THERM-A-GAP™ PAD 30 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.

Samples were subjected to 1000-hour dwell at 125°C, 1000-hour dwell at 85°C/85% relative humidity, and a combined stress of thermal shock at -40°C to 80°C, thermal cycling at -40°C to 80°C, and random vibration frequencies equivalent to 2.0 GRMS. In all cases, there was no statistically significant increase in impedance according to one-way ANOVA with the Tukey method for multiple comparisons.

Based on these results, THERM-A-GAP™ PAD 30 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 pad. 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 PAD 30 sandwiched 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 it can be used to measure changes to thermal performance over time.

2.0 Long-Term Aging – Thermal Impedance

2.1. Purpose

Long-term aging was performed on PAD 30 between stainless-steel substrates to evaluate the reliability of thermal performance over time. The material was subjected to an extended dwell time of 1000 hours at 125°C, and long-term heat and humidity aging at 85°C and 85% relative humidity.

2.2. Materials

- 2.2.1. 1” x 1” x 0.040” 316 stainless-steel coupons.
- 2.2.2. PTFE spacers, 0.040” thick.
- 2.2.3. LongWin9389 Thermal Impedance Tester
- 2.2.4. THERM-A-GAP™ PAD 30 at 0.100” thickness

2.3. Sample Preparation

- 2.3.1. Samples were cut to 1” x 1” squares and installed onto the center of the stainless-steel coupons.
- 2.3.2. The 0.040” PTFE shims were placed at each corner of the coupon and fastened into place to maintain of 1mm gap.
- 2.3.3. The above procedure was performed for all four sample assemblies.

2.4. Test Procedure

- 2.4.1. 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 20 psi per ASTM D5470.
- 2.4.3. After testing each assembly, the silicone oil was gently removed from the surfaces.

- 2.4.4. Four 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.
- 2.4.5. After 500 hours of dry heat or heat/humidity aging the samples were removed from their respective environments, allowed to equilibrate at room temperature for at least two hours, and re-tested for thermal impedance.
- 2.4.6. Once tested, the samples were returned to their respective aging environments and the tested again after the samples were subjected to a total of 1000 hours of dry heat or heat/humidity aging.

2.5. Results

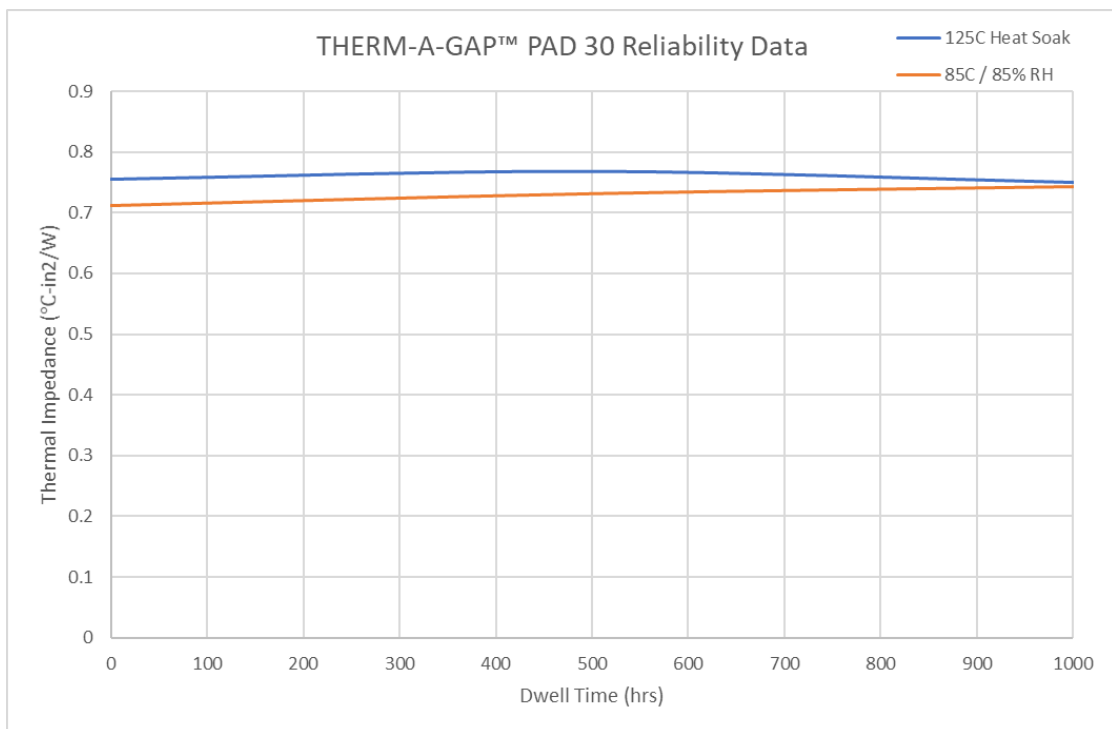


Figure 1: Dry heat aged and heat & humidity aged thermal impedance versus time

	Thermal Impedance (°C-in²/W)		
	Initial	500 hrs	1000 hrs
125°C	0.756	0.768	0.751
85°C/85%R.H.	0.713	0.732	0.744

Table 1: Thermal Impedance Results (average)

Note: The exact impedance value of the reliability fixture is not representative of the impedance value of the thermal interface material itself, but it can be used to measure changes to thermal performance over time.

3.0 Long Term Aging - Compression-Deflection Force

3.1. Purpose

This test is intended to provide data on the deflection force recorded from compressing THERM-A-GAP™ PAD 30 after it is subjected to long-term aging.

3.2. Materials

3.2.1. TA-XT Plus Texture Analyzer

3.2.2. 0.5” diameter THERM-A-GAP™ PAD 30 disks at 0.100” thickness

3.3. Test Procedure

3.3.1. Four 0.5” diameter disks of THERM-A-GAP™ PAD 30 were subjected to each stress environment, as detailed in section 2.0.

3.3.2. The samples were tested initially for compression-deflection, up to a 70% deflection rate, using a 0.025 in/min compression speed.

3.3.3. The samples were tested again at 1000 hours for their respective stress environments.

3.4. Results

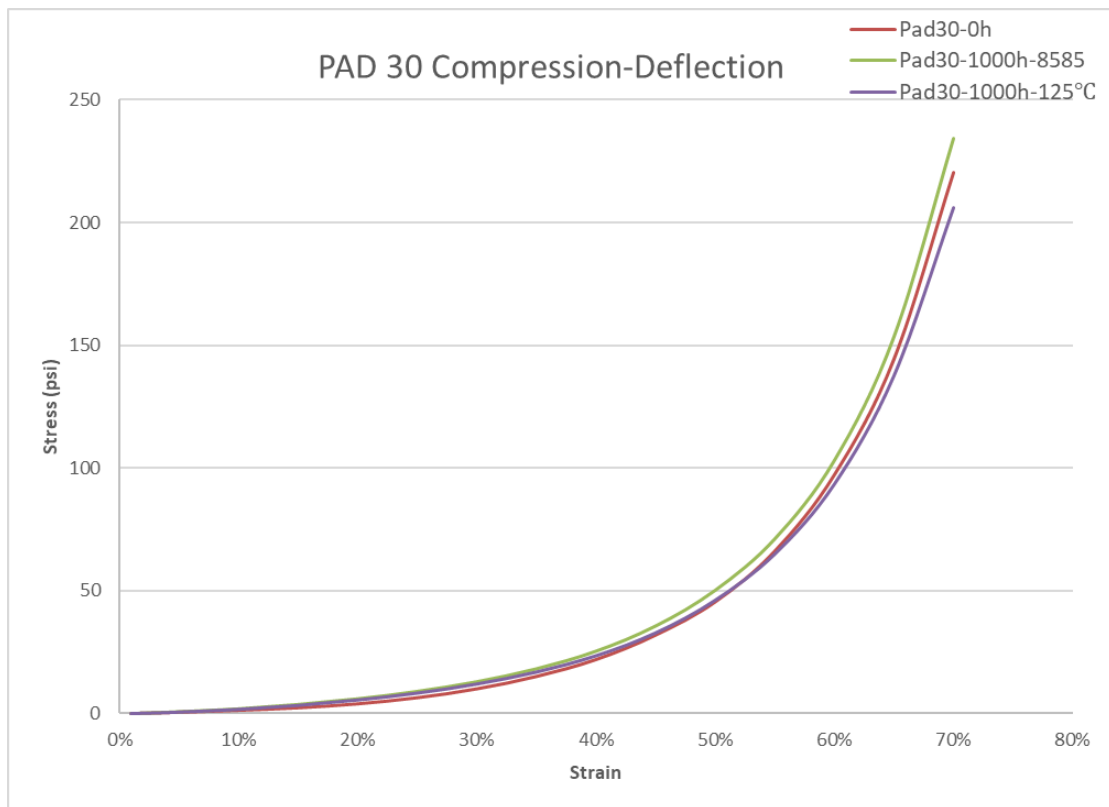


Figure 2: Compression-deflection curves for THERM-A-GAP™ PAD 30 after long-term aging.

4.0 Total Mass Loss

4.1. Purpose

This test is intended to provide data on the volatile silicone content of THERM-A-GAP™ PAD 30. Volatile silicone is of concern due to its ability to migrate and cause problems in electronics applications. The material was tested by thermogravimetric analysis (TGA) and by an independent outside laboratory.

4.2. Materials

- 4.2.1. TA Instruments Thermogravimetric Analyzer.
- 4.2.2. Small sample of PAD 30.

4.3. Test Procedure

- 4.3.1. A small amount of PAD 30 was placed onto a TGA test aluminum dish.
- 4.3.2. The sample was subjected to 125° C for three hours in a nitrogen environment and the sample weight loss was recorded.

4.4. Results

PAD 30 experienced a total mass loss of 0.034 % after a 3-hour dwell at 125°C.

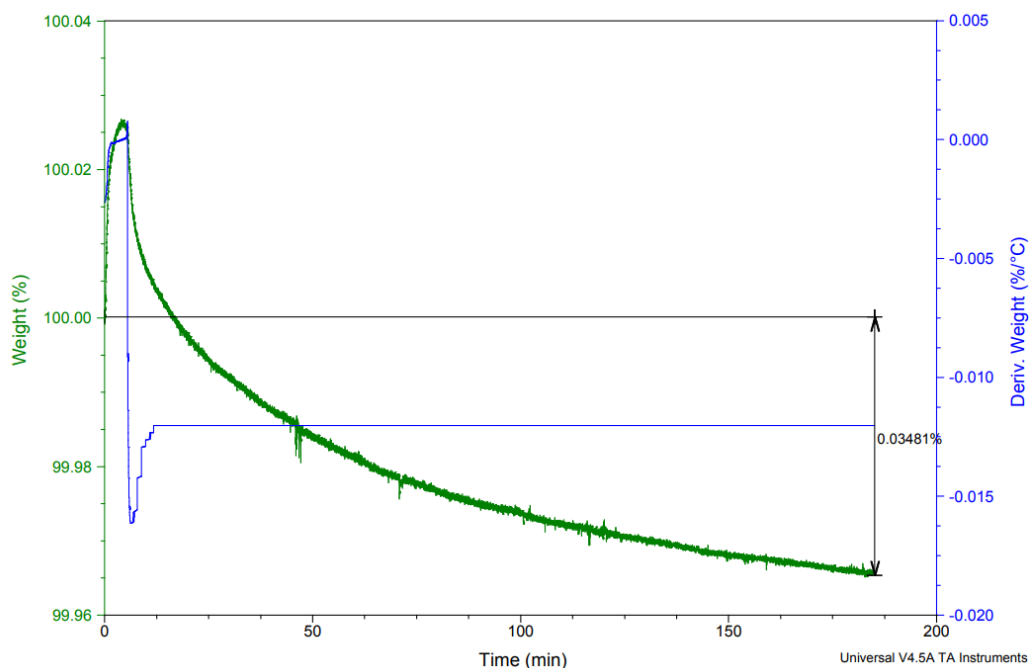


Figure 3: Thermogravimetric Analysis of PAD 30 at 125°C for 3 hours

The National Aeronautics & Space Administration (NASA) criteria for low-volatility materials limits the total mass loss (TML) to 1.0% and collected volatile condensable material (CVCM) to 0.10%.

Outgassing Results	
% Total mass loss	0.13
% CVCM	0.03

Table 2: Independent laboratory outgassing test results

Based on the independent laboratory results, PAD 30 passes the NASA outgassing criteria for low-volatility material.

5.0 Thermal Shock, Thermal Cycling & Random Vibration Testing

5.1. Purpose

This test is intended to provide data on the long-term aging and durability of THERM-A-GAP™ PAD 30 when subjected to Air-to-Air Thermal Shock (TS), followed by Power Thermal Cycling (PTC), and finishing with Random Vibration.

These test methods adhere to the GMW3172 specification for Electronical/Electronic (E/E) components for passenger or commercial vehicles and trucks based on mounting location.

5.2. Materials

- 5.2.1. Espec Thermal Shock Chamber
- 5.2.2. Power Temperature Cycle Chamber
- 5.2.3. Vibration Chamber
- 5.2.4. LongWin9389 Thermal Impedance Tester
- 5.2.5. THERM-A-GAP PAD 30 at 0.100" thickness

5.3. Sample Preparation

- 5.3.1. Three samples were prepared according to IEC 60068-2-64 with a set gap thickness of 0.040".

5.4. Test Procedure

- 5.4.1. The three samples were tested initially for thermal impedance at 50°C and 20 psi per ASTM D5470.
- 5.4.2. *Thermal Shock Air-to-Air Testing:* Samples were subjected to the below settings (see Figure 4 for additional details):
 - Temperature Min / Max: -40°C / 85°C
 - Dwell Time: 15 minutes
 - Number of Cycles: 632
- 5.4.3. After being subjected to the above settings, the samples were tested again for thermal impedance.
- 5.4.4. *Power Temperature Cycle Testing:* Samples were then subjected to the below settings (see Figure 5 for additional details):
 - Temperature Min / Max: -40°C / 85°C
 - Dwell Time: 15 minutes
 - Ramp Rate: 1°C/min
 - Number of Cycles: 211
- 5.4.5. After being subjected to the above settings, the samples were tested again for thermal impedance.
- 5.4.6. *Random Vibration Frequency Testing:* Samples were subjected to the settings detailed in Figure 7. These settings were performed for the X, Y and Z direction – each for 8 hours – for an effective acceleration of $19.6 \text{ m/s}^2 = 2.0 \text{ GRMS}$.
- 5.4.7. After being subjected to the above settings, the samples were tested again for thermal impedance. The results can be seen on

5.5. Results

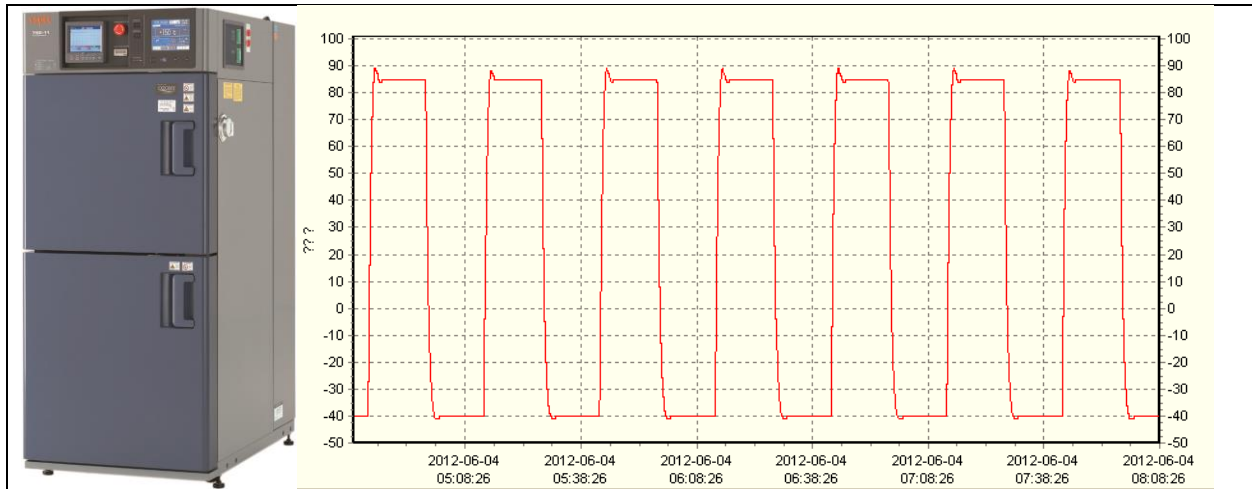


Figure 4: Espec thermal shock chamber and temperature curve.

Thermal Shock Air-to-Air (TS) transfers samples from one oven to another with a set amount of time in each oven. This rapid transfer (~30 second transfer time) allows samples to quickly reach the desired temperature.

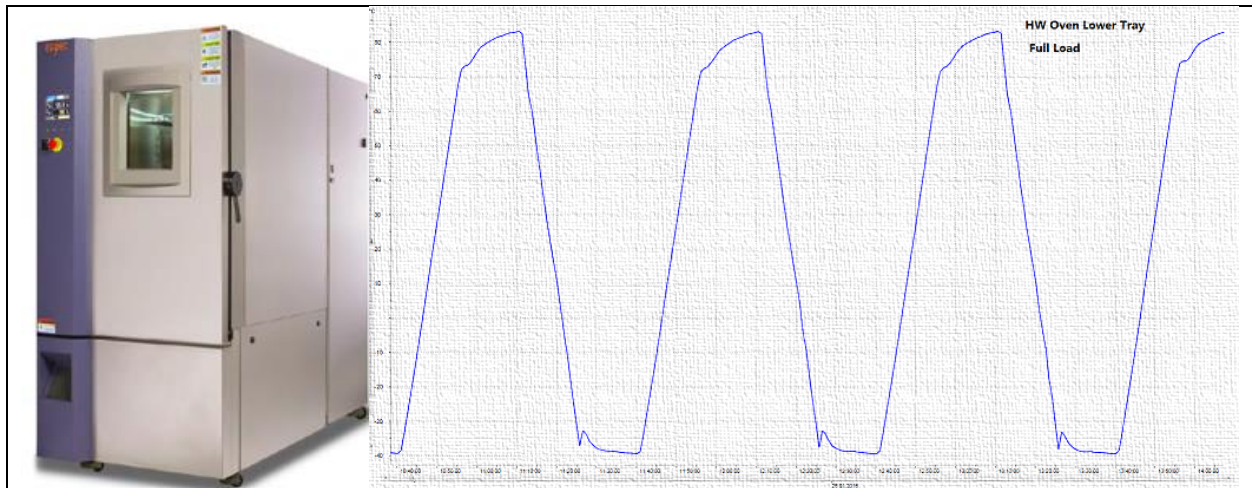
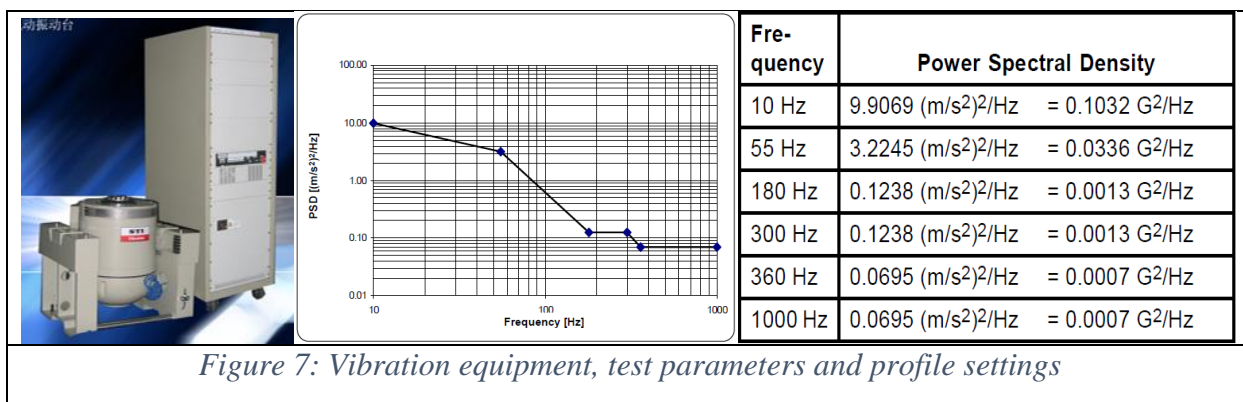


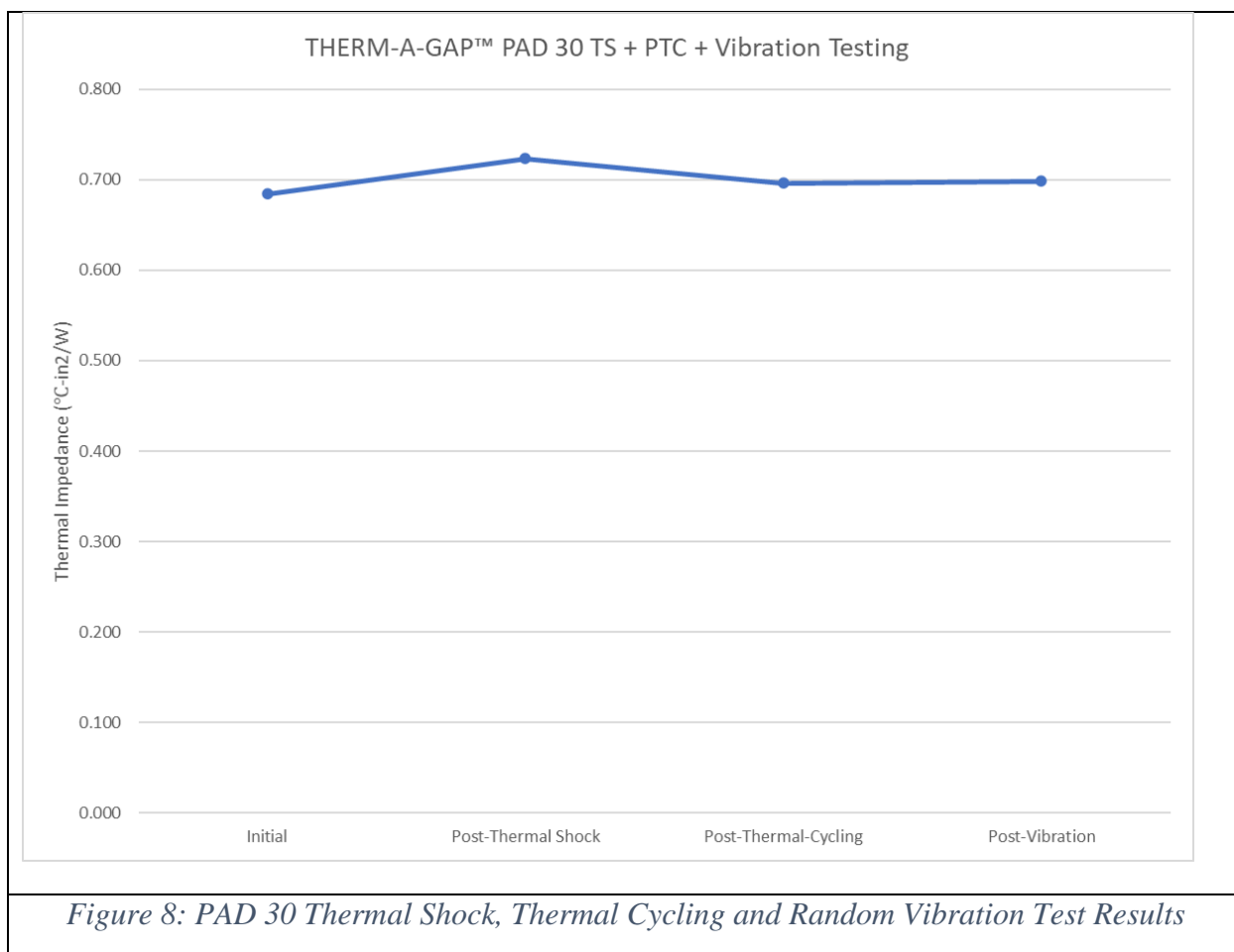
Figure 5: Espec temperature cycling chamber and temperature curve.

Power Temperature Cycle (PTC) is a single-oven chamber that ramps the internal temperature up/down at a specified speed to a set min/max temperature.

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

Figure 6: Number of TS and PTC cycles Per GMW 3172 9.4.2 Table 33.





	Initial	Post-Thermal Shock	Post-Thermal-Cycling	Post-Vibration
Thermal Impedance (°C-in²/W)	0.684	0.723	0.696	0.698

Figure 9: Thermal Impedance results (average)

Note: The exact impedance value of the reliability fixture is not representative of the impedance value of the thermal interface material itself, but it can be used to measure changes to thermal performance over time.

6.0 Results

To summarize the above results, THERM-A-GAP™ PAD 30 is highly reliable after long-term aging in multiple environments.

The mean impedance values after dry heat aging saw a decrease of 0.7%. For heat and humidity aging and thermal shock + thermal cycling + random vibration aging, we see an increase of 4.3% and 2.0%, respectively.

In addition, the physical and chemical properties of the pad remained unchanged as we see an outgassing result of 0.03% and virtually no change to the compression-deflection curves post-stress.

The results of this study provide evidence that PAD 30 maintains reliability after long-term aging.