Therm-A-Gap Gel 30 Reliability Report

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Chomerics Division of Parker Hannifin
77 Dragon Court, Woburn, MA 01888
781-935-4850

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Executive Summary

Therm-A-Gap Gel 30 is a high performance, fully cured thermal gel. The one-component, cross-linked gel structure provides superior performance and long term thermal stability over conventional thermal grease materials. This material is designed to be dispensed in applications requiring low compression forces and minimal thermal resistance for maximum thermal performance. This document outlines the examination of the physical and thermal reliability of this high performance gap filler. Samples of manufacturing batches of Therm-A-Gap Gel 30 were subjected to long term environmental aging under dry heat and heat & humidity conditions, temperature cycling from -40^{o}C to 125^{o}C, high temperature weight loss, volatile silicone content, vertical gap slump testing, thermal impedance versus pressure and thickness, as well as, X and Y axis vibration testing ramping from 10 to 1000-Hz at 85^{o}C.

Therm-A-Gap Gel 30 demonstrated a minimal weight loss of less than 0.1% after 3hrs at 125 °C based on in-house thermogravimetric analysis (Figure 2). Outgas testing conducted by a certified independent laboratory concluded the total mass loss (TML) to be 0.15% with a collected volatile condensable material content (CVCM) of 0.05%. Therm-A-Gap Gel 30 is well below the National Aeronautics & Space Associations criteria for low outgas materials, which limits materials' TML to 1.0% and CVCM to 0.10%.

The thermal performance of Gel 30 was examined after being subjected to multiple environmental stress tests. Other than an initial decrease, the thermal impedance of the material was unaffected by 1000-hrs dwell at 125^{o}C, 1000-hrs dwell at 85^{o}C/85% relative humidity, and 500 temperature cycles from -40^{o}C to 125^{o}C. This measured decrease of 7%, 10% and 7% respectively, is a result of the lower thermal impedance at the substrate/Gel 30 interface, caused by the gel wetting out the substrate surface.

Therm-A-Gap Gel 30 demonstrates physical integrity and the ability to maintain positioning in applications with varying gap thickness. At a continuous 85^{o}C dwell for 500-hrs, the material showed no vertical movement when dispensed into gaps perpendicular to gravitational forces. During vibration testing, ramping from 10 to 1000-Hz at 85^{o}C, the material has no statistically significant degradation in thermal properties or physical displacement from the testing fixture.

Based on these results, Therm-A-Gap Gel 30 exhibits superior long term physical and thermal reliability. This material demonstrates resistance to the thermal oxidative degradation associated with continuous application temperatures of up to 125^{o}C. The material also displays excellent thermal reliability under physical stress, such as vertical gap orientations and high frequency vibration applications.

1.0 Introduction

The purpose of the document is to examine the physical and thermal reliability of this high performance gap filler. Samples of manufacturing batches of Gel 30 were subjected to long term heat aging, high temperature weight loss, volatile silicone content, vertical gap slump testing and thermal impedance versus pressure.

2.0 Long-Term Aging

2.1 Purpose

Long term aging was performed on Gel 30 between aluminum nitride substrates to evaluate the thermal performance reliability over time. The material was subjected to an extended dwell time of 1000-hrs at 125^{o}C, 500 cycles temperature cycling from -40^{o}C to 125^{o}C, and long term heat and humidity aging at 85^{o}C/ 85% relative humidity.

2.2 Materials

2.2.1 Twenty-two 1.25" x 1.25" x 0.060" aluminum nitride substrates
2.2.2 Teflon Shims, 0.060" thick
2.2.3 22 clamps
2.2.4 Cincinnati Subzero model ZH-8-1-H1A0, humidity chamber
2.2.5 Sun Electronics Systems PTL-001 Temperature cycling system. (-40^{o}C to 125^{o}C; 10-min ramp; 10-min dwell times.

2.3 Sample Preparation

2.3.1 0.5-cc samples of Gel 30 material were dispensed onto the center of aluminum nitride substrates.
2.3.2 The 0.060" shims were placed at the edges of the substrate.
2.3.3 A second aluminum nitride substrate was placed on top of the material.
2.3.4 A clamp was placed onto the assembly to hold the substrates at a constant thickness of 0.060"
2.3.5 The above procedure was repeated for 11 sample assemblies.

2.4 Test Procedure

2.4.1 The assemblies were removed from their clamps and thermal grease was applied to the outside of the aluminum nitride substrates.
2.4.2 The samples are tested initially for thermal impedance at 50^{o}C and 50-PSI per ASTMD5470.
2.4.3 The thermal grease was gently removed from the outside of the assemblies and the clamps replaced.
2.4.4 Five samples were placed into a 125^{o}C oven, three samples were placed into the temperature cycling chamber and three were placed into a humidity chamber.
2.4.5 After 500-hrs of dwell time, the samples were removed from their respective environments, allowed to equilibrate at room temperature for 2-hrs, and re-tested for thermal impedance.

2.4.6 Once tested, the samples were returned to the respective ovens and the previous step was repeated at 1000-hrs of total dwell time.

2.5 Results

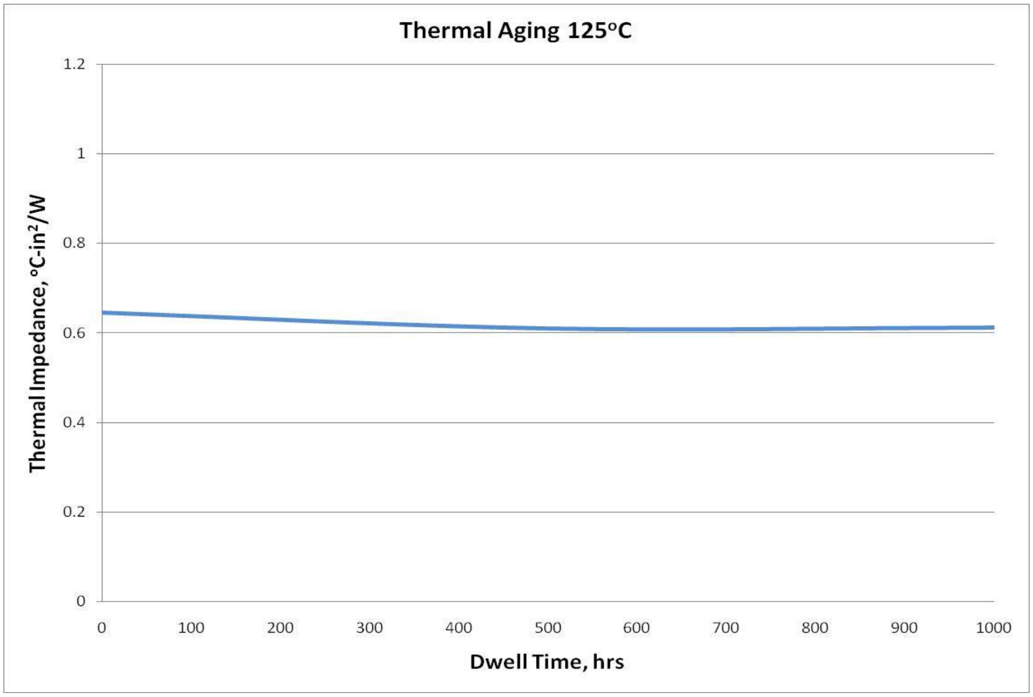

Figure 1: Heat aged Thermal Impedance versus Time

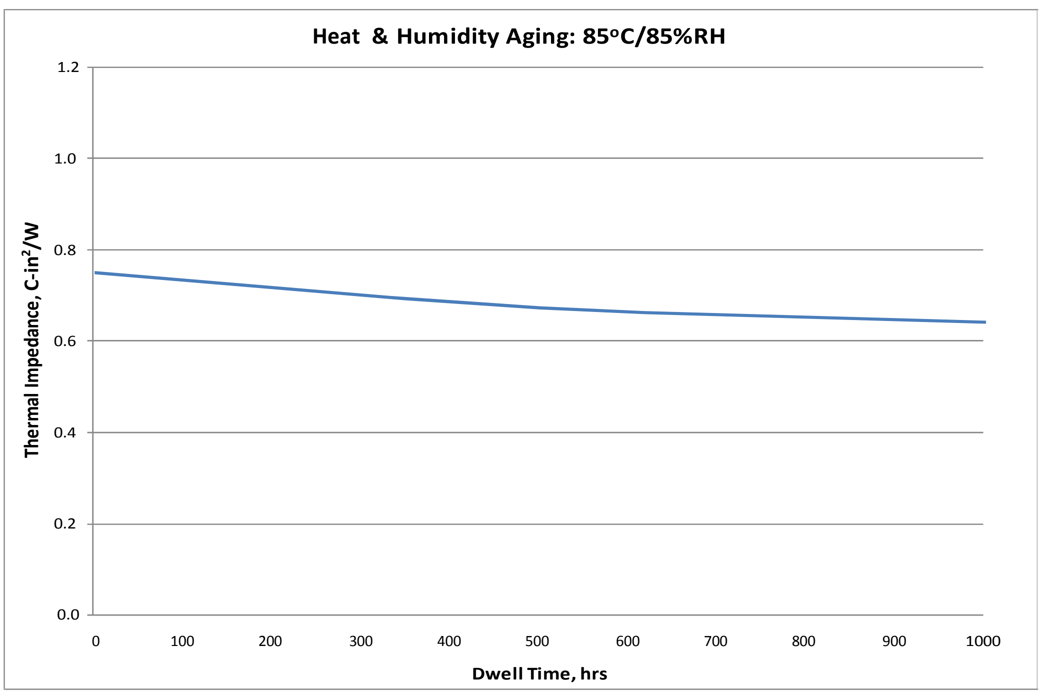

Figure 2: Heat & Humidity aged Thermal Impedance versus Time

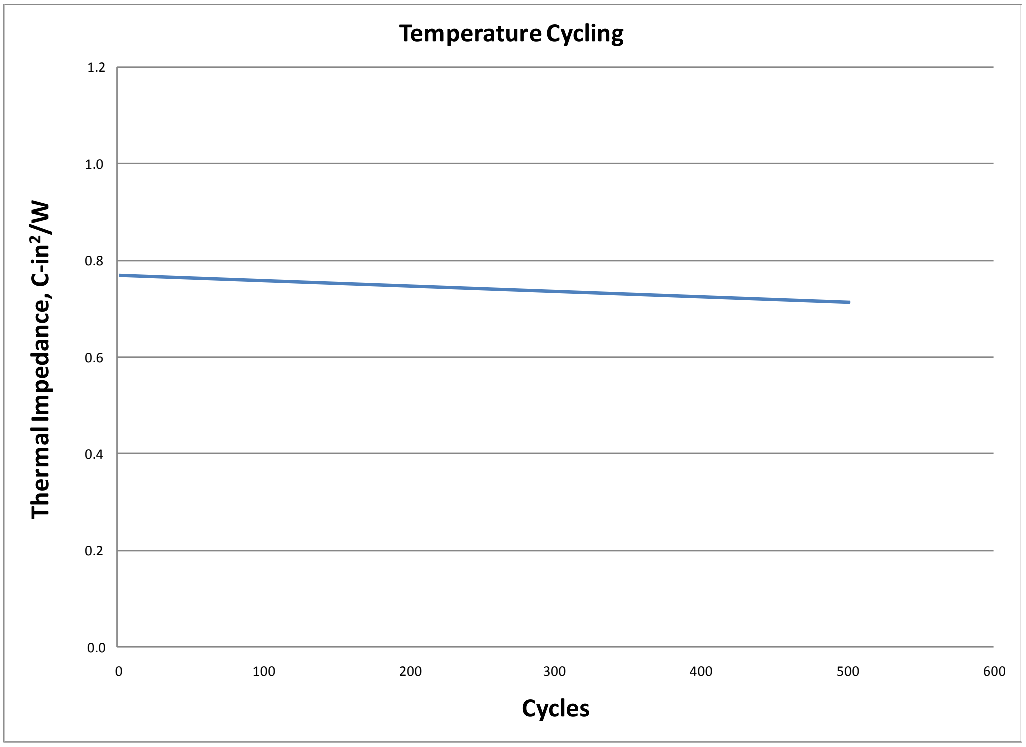

Figure 3: Thermal Impedance versus Temperature Cycling (-40^{o}C to 125^{o}C)

3.0 Total Mass Loss

3.1 Purpose

This test is intended to provide data on the temperature stability of Gel 30 and the volatile silicone content of the product. Volatile silicone is of concern due to its ability to migrate and cause problems in electronics applications. The material was tested both using in-house test method and by an independent outside laboratory.

3.2 Materials

3.2.1 Thermogravimetric analyzer Model 2950 TGA V5.4A
3.2.2 30-cc syringe of Gel 30

3.3 Test Procedure

3.3.1 Gel 30 material was dispensed in to an aluminum TGA test pan.
3.3.2 The sample is subjected to 125^{o}C for 3-hrs in a nitrogen environment and the sample weight loss is recorded.
3.3.3 A Sample syringe of Gel 30 is sent to a certified independent laboratory to undergo a mass loss and collected volatile condensable materials analysis according to ASTM E-595.
3.3.3.1 Samples are subjected to 125^{o}C dwell for 24-hrs at $7x10^{-3}$ Pa.

3.4 Results

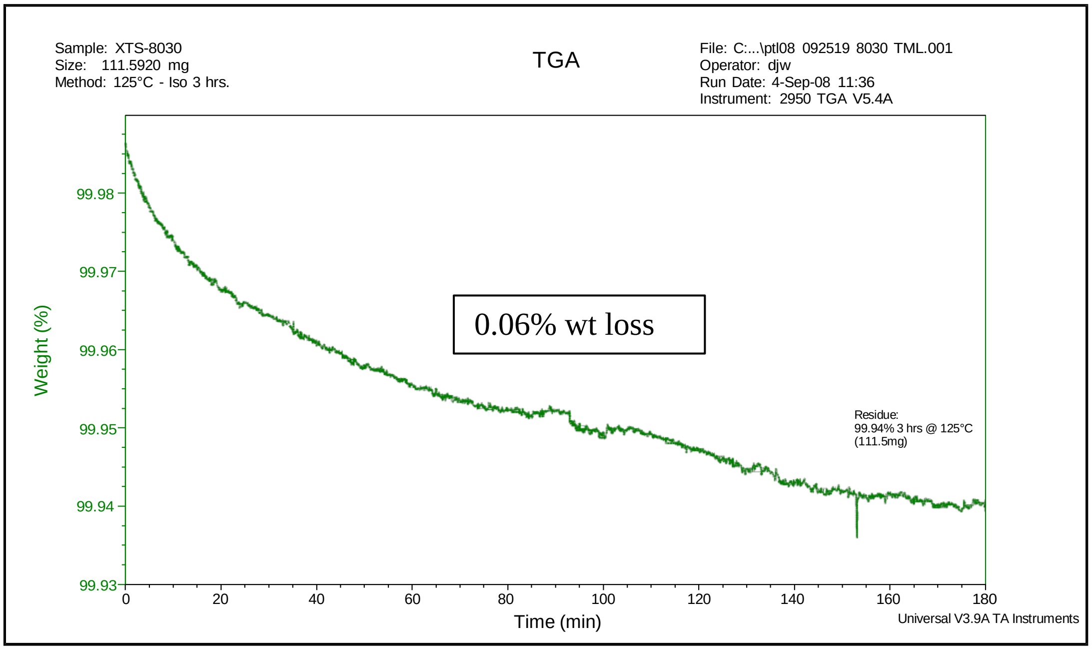

Figure 4: Thermogravimetric Analysis at 125°C for 3-hrs

The National Aeronautics & Space Associations (NASA) criteria for low outgas materials limit materials' (TML) Total Mass Loss to 1.0% and Collected Volatile Condensable Material (CVCM) to 0.10%. The table below contains the test results for Gel 30.

Outgassing Results	
%Total Mass Loss	0.15
%CVCM	0.05

Table 1: Independent Laboratory Mass Loss Results

4.0 Vertical Gap Slump Testing

4.1 Purpose

This test is intended to simulate the gravitational effects on the mechanical integrity of Gel 30, when dispensed on an application with a gap perpendicular to the gravitational force. It demonstrates the physical integrity and ability of Gel 30 to maintain its position in vertical applications with varying gap thickness at 85°C.

4.2 Materials

4.2.1 Six 4"x 4" glass panel
4.2.2 0.010" , 0.075" and 0.140" metal shims
4.2.3 12 clamps

4.3 Test Procedure

4.3.1 Three samples of Gel 30 were dispensed onto a glass panels 0.5" apart, with 1"separation from the top edge of the glass.

4.3.2 0.010" shims were placed at the edges of the panel and a second clean glass panel was placed on top. The Gel 30 samples compressed between the glass panels result in a 0.75" diameter surface contact area on each surface.

4.3.3 Two clamps are fastened to the left and right side of the assembly.

4.3.4 The previous steps are repeated for assemblies made with 0.075" and 0.140" Shims.

4.3.5 The three assemblies were placed into an 85^{o}C oven for with the panels oriented vertically, so the panels would be perpendicular to force of gravity.

4.3.6 After a 500-hr dwell time, the distance traveled from the sample's original position was recorded.

4.4 Results

Gap (inches)	Vertical Slump Distance (inches)
0.010	**0**
0.075	**0**
0.140	**0**

Table 2: Linear Travel After 500-hrs @ 85^{o}C

5.0 Thermal Impedance versus Pressure

5.1 Purpose

This test is intended to determine the effects of pressure on the thermal impedance of Therm-A-Gap Gel 30 and determine the minimum bond line achievable with this material.

5.2 Materials

5.2.1 30cc syringe of Gel 30

5.2.2 Thermal Interface Material Tester TIM Tester 1300

5.3 Test Procedure

5.3.1 15-g of Therm-A-Gap Gel 30 was dispensed onto the tester surface.

5.3.2 The samples are tested for thermal impedance at 50^{o}C and 20-PSI per ASTM D5470.

5.3.3 The previous steps are repeated for test pressures of 30, 50, 100, 150, 200, and 300-PSI.

5.4 Results

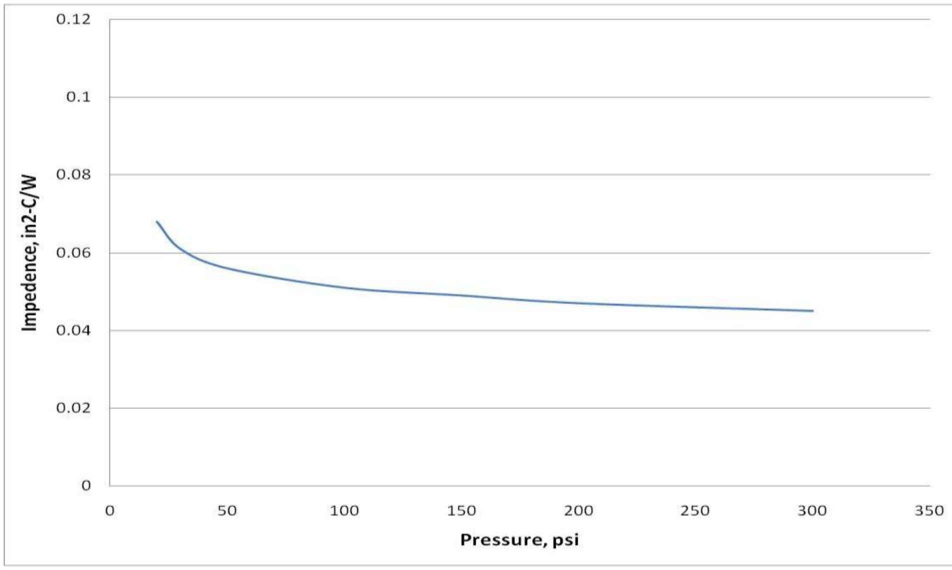

Figure 5: Thermal Impedance versus Pressure

6.0 Thermal Impedance versus Thickness

6.1 Purpose

This test is intended to determine the effects of material dispensed thickness on the thermal Impedance of Therm-A-Gap Gel 30.

6.2 Materials

6.2.1 30cc syringe of Gel 30
6.2.2 Thermal Interface Material Tester TIM Tester 1300

6.3 Test Procedure

6.3.1 15-g of Therm-A-Gap Gel 30 was dispensed onto the tester surface.
6.3.2 The samples are tested for thermal impedance at 50°C and a set height of 0.175” according to ASTM D5470.
6.3.3 The previous steps are repeated for test thickness of 0.140”, 0.090”, 0.050”, 0.025” and 0.003”.

6.4 Results

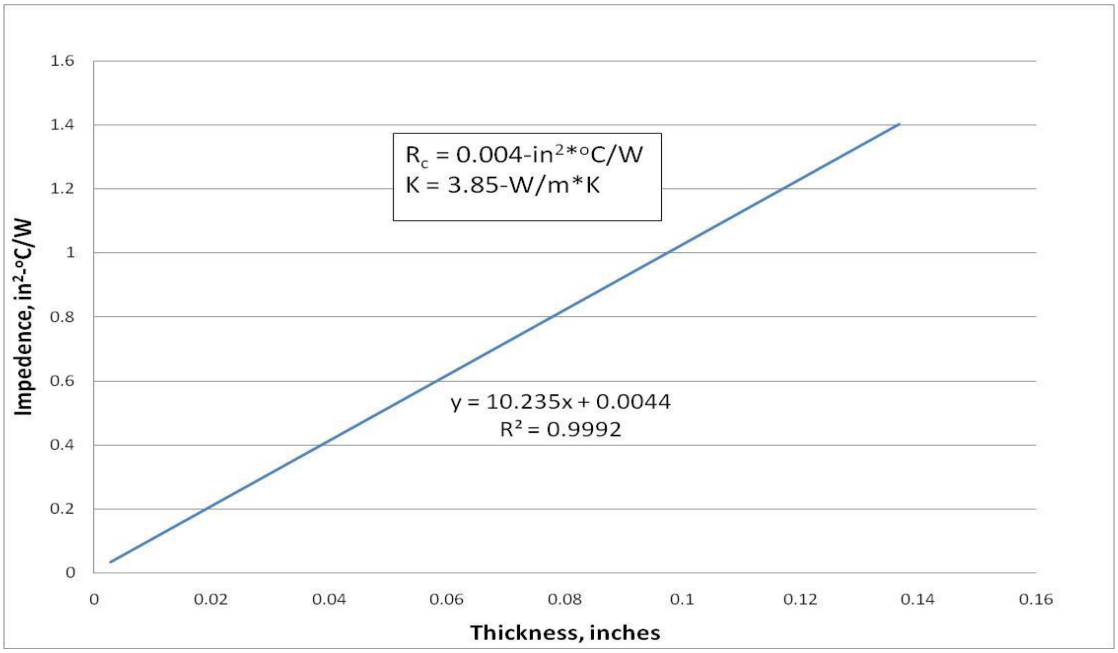

Figure 6: Thermal Impedance versus Thickness

7.0 Vibration Testing

7.1 Purpose

This test was used to determine the effect of vibration on the thermal performance of Gel 30.

7.2 Materials

7.2.1 Ceramic substrates 1.25"x1.25"x0.060"

7.2.2 plastic shims; 3/8" diameter with varying thickness

7.2.3 A 30-cc syringe of gel 30 with 10g/min flow rate

7.2.4 A 30-cc syringe of gel 30 with 20g/min flow rate

7.3 Sample Preparation

7.3.1 Three samples at each thickness are prepared for both flow rate materials.

7.3.2 Dispense the appropriate amount of Gel 30 onto the center of a ceramic substrate according to the weights listed in the table below.

Sample thickness	material Weight, g
Min. Bond line	0.2184
0.25mm	0.1936
1.5mm	1.1613
3mm	2.3226

Table 3: Sample preparation weights

7.3.3 Place the appropriate shims at the corners of the substrate. For minimum bond line samples, no shims are needed.
7.3.4 A second ceramic substrate was place on top of the material.
7.3.5 A small clamp was placed onto the assembly to hold the shims in place and maintain the sample at the appropriate thickness.
7.3.6 This sample preparation procedure was repeated for 3 samples of both the 10g/min and 20g/min batches of Gel 30 at minimum bond line, 0.25mm, 1.5mm, and 3mm sample thicknesses.

7.4 Test procedure

7.4.1 The sample assemblies were carefully removed from their clamps and thermal grease was applied to the outside of the ceramic substrates.
7.4.2 The samples were tested initially for thermal impedance at 50^{o}C and 50-PSI per ASTM D5470.
7.4.3 After recording the thermal impedance, the samples were removed from the tester, the thermal grease was removed from the outside of the assembles, and the clamps were replaced.
7.4.4 The samples were then sent to an outside testing facility and subjected to 8-hrs of vibration, ramping between 10 to 1000Hz in both the X and Y axis. The temperature was maintained at 85^{o}C.
7.4.5 After being subjected to the vibration conditions the samples were tested for thermal impedance following steps 2.6.4.1 to 2.6.4.3.

7.5 Results

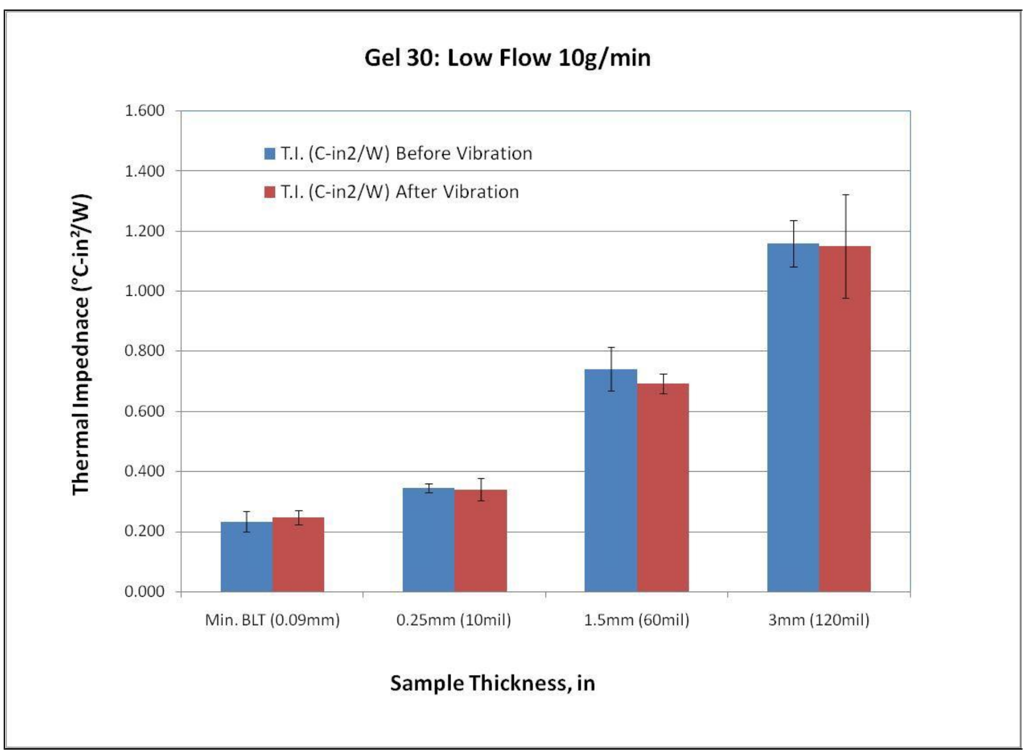

Figure 7: Vibration results for 10g/min Gel 30

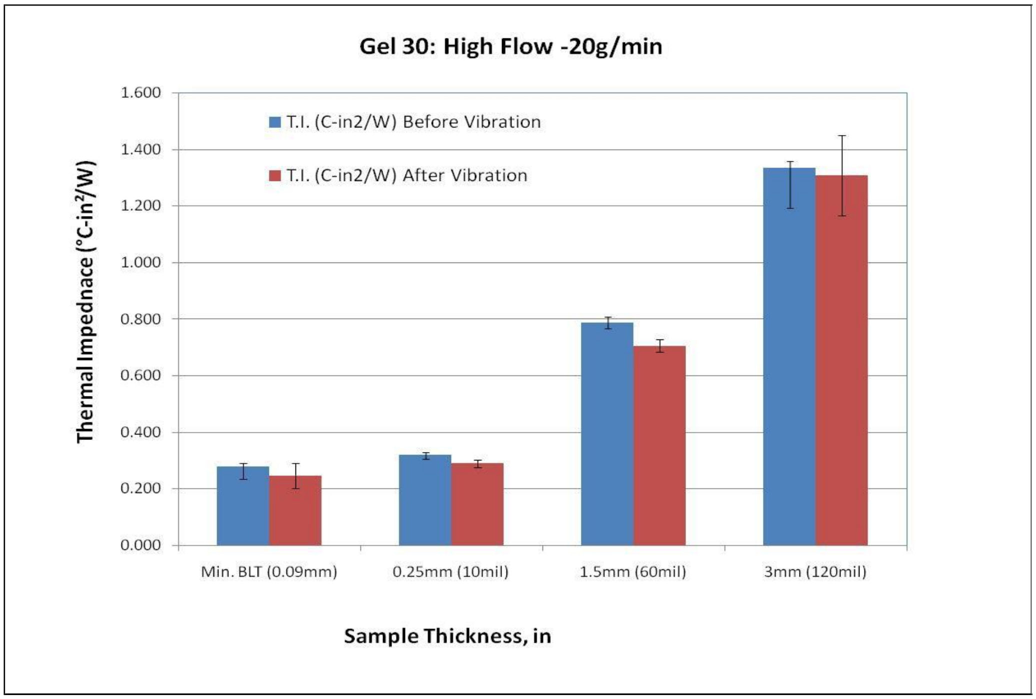

Figure 8: Vibration results for 20g/min Gel 30

8.0 Conclusion

Therm-A-Gap Gel 30 is a one-component, cross-linked gel material. This cross-linking structure provides superior performance and long term thermal stability over conventional thermal grease materials. It demonstrated minimal weight loss of less than 0.10% after 3hrs at 125 °C based on in-house thermogravimetric analysis (Figure 4). This result was confirmed by a certified independent laboratory test, which resulted in 0.15% total mass loss after 24-hr dwell at 125^{o}C.

The thermal performance of Gel 30 was examined after subjection to multiple environmental stress tests. Other than an initial decrease due to a surface wetting phenomenon, the thermal impedance of the material was unaffected by 1000-hrs dwell at 125^{o}C, 1000-hrs dwell at 85^{o}C/85% relative humidity, and 500 temperature cycles from -40^{o}C to 125^{o}C. The initial thermal impedance dropped by 7%, 10% and 7% respectively. The material displays resiliency under physical stress, as well. The thermal impedance of the material was unaffected by 8-hr vibration ramping from 10 to 1000-Hz at 85^{o}C.

Based on these results, Therm-A-Gap Gel 30 demonstrates superior long term reliability and resistance to thermal oxidative degradation associated with continuous application temperatures of up to 125^{o}C. The material also maintains physical integrity in vertical gap applications and when subjected to high frequency vibration application environments.

Footnote:

The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalog and in any other materials provided from Parker or its subsidiaries or authorized distributors.

The reported physical properties for GEL30 represent material as manufactured by Chomerics. Repackaging of GEL30 is not recommended and may result in a deviation from these properties.

Appendix A: Typical Properties

	Typical Properties	GEL 8010	GEL 30	Test Method
Physical	Color	White	Light Pink	Visual
	Flow Rate, grams/min - 30cc syringe with no tip attachment 0.100" orifice, 90psi (621 kPa)	60	20	Chomerics
	Specific Gravity	2.70	3.20	ASTM D792
	Percent Deflection @ Various Force Levels (refer to plot) (See graph below)	% Deflection	% Deflection	Modified ASTM C165 Dispensed 1.0 cc of material Brought 1" x 1" probe down to 0.100" Test rate 0.025 in/min
	Typical minimum bondline thickness, in (mm)	0.002 (0.05)	0.004 (0.10)	--
Thermal	Thermal Conductivity, W/m-K	3.0	3.5	ASTM D5470
	Heat Capacity, J/g-K	1	1	ASTM E1269
	Coefficient of Thermal Expansion, ppm/K	150	150	ASTM E831
	Operating Temperature Range, °F (°C)	-67 to 392 (-55 to 200)	-67 to 392 (-55 to 200)	--
Electrical	Dielectric Strength, Vac / mil (KVac/mm)	200 (8.0)	200 (8.0)	ASTM D149
	Volume Resistivity, ohm-cm	10^{14}	10^{14}	ASTM D257
	Dielectric Constant @100 kHz	6.3	7.0	ASTM D150
	Dissipation Factor @ 100 kHz	0.002	0.002	Chomerics
Regulatory	Flammability Rating	V-0	V-0	UL 94
	RoHS Compliant	Yes	Yes	Chomerics Certification
	Outgassing, % TML (CVCM)	1.33 (0.34)	0.15 (0.05)	ASTM E595
	Shelf Life, months from date of manufacture	18	18	Chomerics