TEST REPORT

THERM-A-GAP CIP35E Reliability Report

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WARNING – USER RESPONSIBILITY

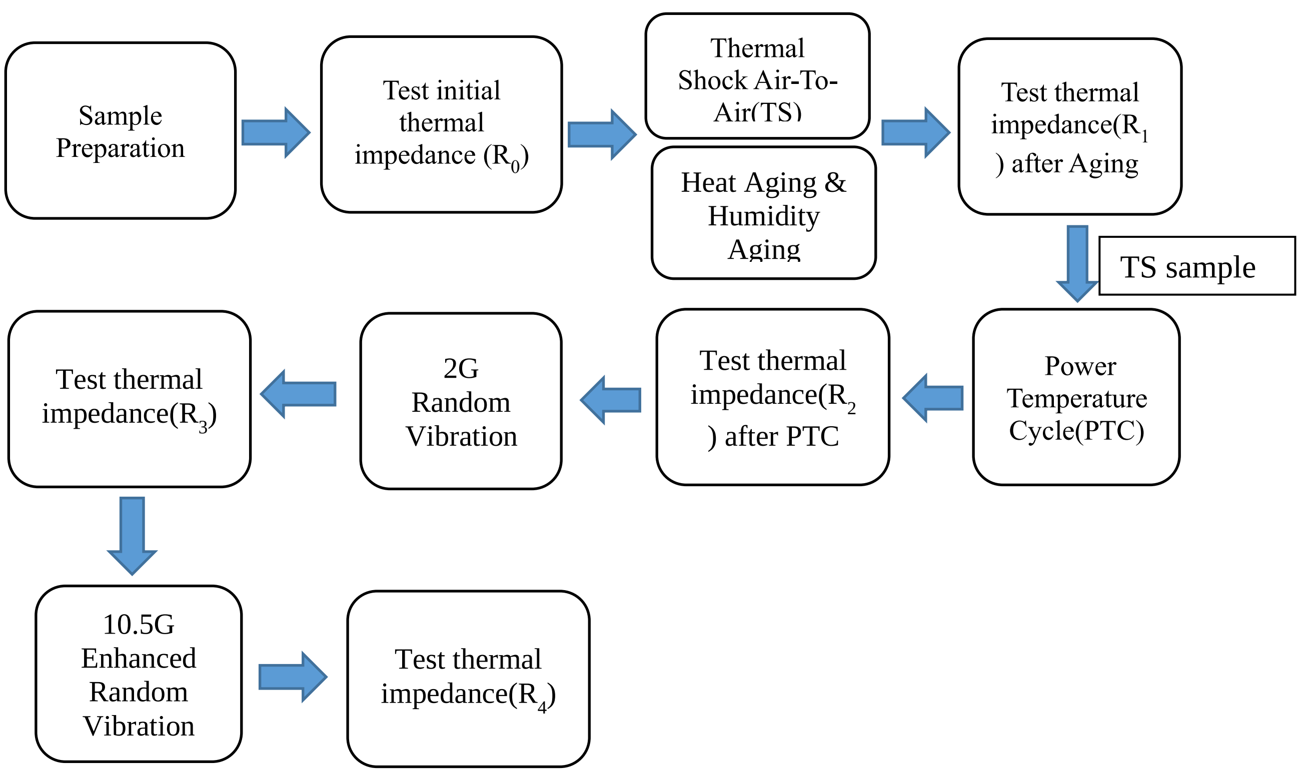
Executive Summary

CIP35E is a two-component (2k) dispensable thermal gap filler and cure-in-place material with 3.5 W/m-K thermal conductivity. The cross-linked structure provides superior performance and long-term thermal stability over conventional high modulus thermal gels. 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.

CIP35E 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 2 types of 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 CIP35E was examined after being subjected to multiple environmental stress tests. The thermal impedance of CIP35E was not significantly affected by long term heat aging, humidity aging, temperature cycling and high-frequency vibrations.

CIP35E 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 CIP35E were subjected to thermal shock test, thermal cycling test and vibration test.

1.2 Sample Set-Up Summary

CIP35E 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.

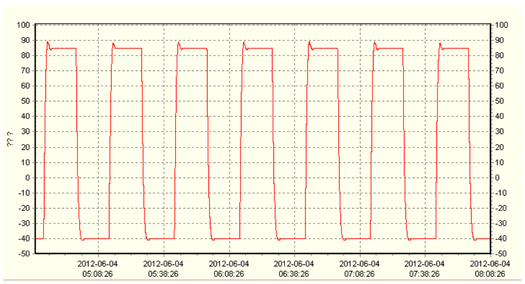



Fig.1. Espec thermal shock chamber and temperature curve

The number of thermal cycles according to GMW 3172 9.4.2 Table 33, Position ABCD as table1.

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

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.

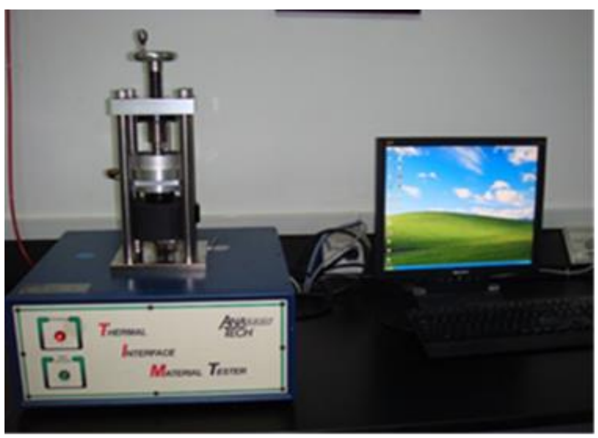


Fig.2. TIM tester

2.3.1 Sample Preparation

2.3.1.1 Dispense CIP35E 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.

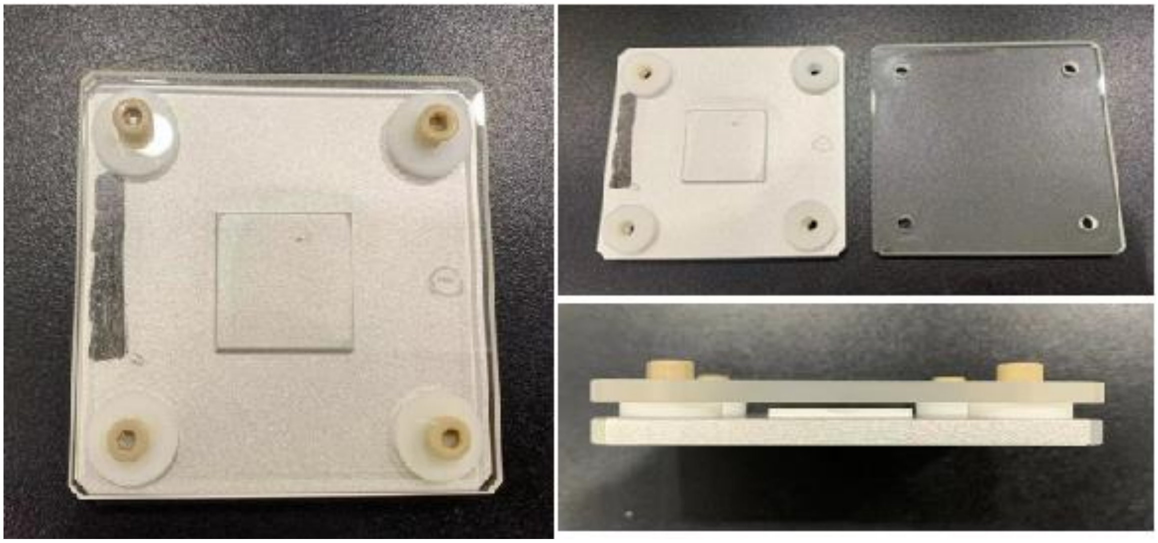


Fig.3. Simulated application fixture

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
CIP35E	0.5mm	0.705	0.721	2.27%
	1.0mm	0.88	0.898	2.05%
	2.0mm	1.414	1.448	2.40%

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 ^{o}C to 125 ^{o}C at a 10 ^{o}C /min speed and 15min dwell time at -40℃ and 125℃.
The number of thermal cycles according to IEC 60068-2-14, Test Nb.

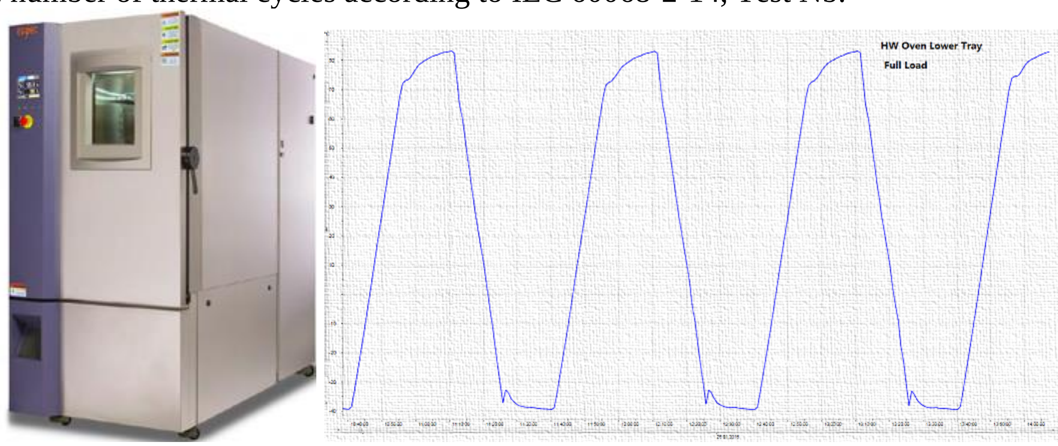


Fig.5. Espec temperature cycling chamber and Temperature curve

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 Temperature Cycling (K*in2/W)	Thermal Impedance Change
CIP35E	0.5mm	0.705	0.726	2.98%
	1.0mm	0.88	0.901	2.39%
	2.0mm	1.414	1.489	5.30%

Table3. Test result of PTC

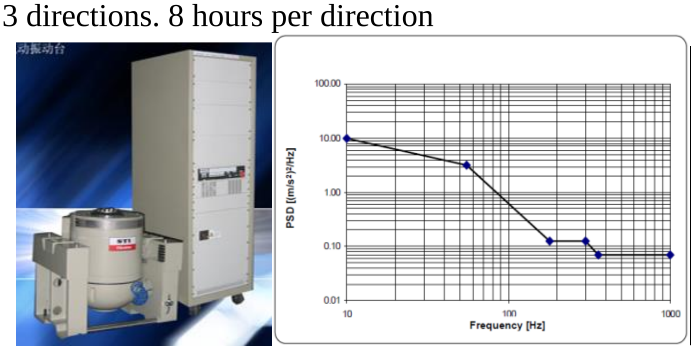
4. Random Vibration (Sprung Masses 2G Effective Acceleration)

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 2G vibration (K*in2/W)	Thermal Impedance Change
CIP35E	0.5mm	0.705	0.715	1.42%
	1.0mm	0.88	0.891	1.25%
	2.0mm	1.414	1.466	3.68%

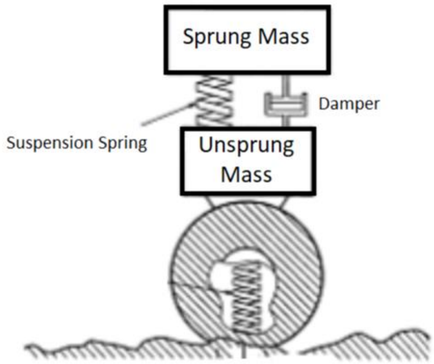
Table4. Test result of random vibration

5.0 Enhanced Vibration Test

5.1 Introduction and Reference

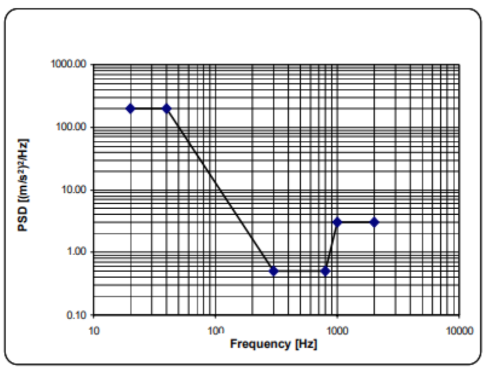
GMW3172 9.3.1.2 Random Vibration was developed for Sprung Masses automotive application at a low acceleration.

A random vibration test was performed according to GMW3172 9.3.1.3 to evaluate the stability of the materials under extremely high acceleration for Unsprung Masses automotive application.



5.2 Test setup

Sample preparation and test procedure according to IEC 60068-2-64, the test parameters and profile as figure7. Effective Acceleration=107.3m/s2= 10.95 GRMS
3 directions. 8 hours per direction



Effective Acceleration = 107.3 m/s^2 = 10.95 G_{RMS}

Fre-quency	Power Spectral Density	
20 Hz	200.0 (m/s^2)^2/Hz	= 2.0825 G^2/Hz
40 Hz	200.0 (m/s^2)^2/Hz	= 2.0825 G^2/Hz
300 Hz	0.5 (m/s^2)^2/Hz	= 0.0052 G^2/Hz
800 Hz	0.5 (m/s^2)^2/Hz	= 0.0052 G^2/Hz
1000 Hz	3.0 (m/s^2)^2/Hz	= 0.0312 G^2/Hz
2000 Hz	3.0 (m/s^2)^2/Hz	= 0.0312 G^2/Hz

Fig.7. Enhanced vibration test parameters and profile

5.3 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.

5.4 Sample Preparation
Sample Preparation as 2.3.1

5.4.2 Test Procedure

- 5.4.2.1 After measured the thermal impedance R_2, then fixed specimens onto vibration tester
- 5.4.2.2 Set up the parameters and do the Random Vibration test.
- 5.4.2.3 Test thermal impedance and make record thermal impedance (K-in.^2/W)

5.5 Results

5.5.1 Result Summary Table

Samples	Specimen thickness	Initial Thermal Impedance (K*in2/W)	Thermal Impedance after 10.95G vibration (K*in2/W)	Thermal Impedance Change
CIP35E	0.5mm	0.705	0.724	2.70%
	1.0mm	0.88	0.906	2.95%
	2.0mm	1.414	1.476	4.38%

Table5. Test result of Enhanced random vibration

5.5.2 Appearance of specimens

Specimens after thermal shock, temperature cycling and 2 types of vibration test

5.5.3 Result Discussion

Thermal performance of CIP35E remaining in good condition after 632 cycles of thermal shock test, 211 cycles of thermal cycling test and 2G / 11G random vibration test.

Specimens are still in good condition.

No cracking was observed.

No sliding was observed.

6. Constant environmental aging Test

6.1 Procedure

Use the test methods according to IEC 60068-2-2 and IEC60068-2-67, The thermal properties measurements be taken before and after aging per ASTM D5470 at 30psi. Thermal Impedance tester as figure2.

UA-2079 Humidity Chamber

6.2 Sample Preparation
Sample Preparation as 2.3.1

6.3 Test Procedure

6.3.1 Test initial thermal Impedance and make record-R_0 (K-in.^2/W);
6.3.2 Put fixtures into 125℃ air oven and 85℃/85R.H.% chamber for 1000 hours in vertical position.
6.3.3 After aging remove specimens from chambers and let specimens equilibrate to room temperature for 2 hours prior to testing.

6.4 Results

6.4.1 Result Summary Table

Sample Description	Gap(mm)	Thermal Impedance Before Aging(K-in.^2/W)	Thermal Impedance after Aging500hrs (K-in.^2/W)	Thermal Impedance after Aging1000hrs (K-in.^2/W)	%Change
CIP35E	1.5	0.852	0.850	0.848	-0.47
CIP35E	1.5	0.819	0.841	0.855	4.40
Average change%					1.97

125°C Heat Aging Test

Sample Description	Gap(mm)	Thermal Impedance Before Aging(K-in.^2/W)	Thermal Impedance after Aging500hrs (K-in.^2/W)	Thermal Impedance after Aging1000hrs (K-in.^2/W)	%Change
CIP35E	1.5	0.848	0.831	0.835	-1.53
CIP35E	1.5	0.841	0.854	0.851	1.19
Average change%					-0.17

Humidity Heat Test at 85℃ / 85% R.H.

7.0 Summary and Conclusion

CIP35E 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 cracking and no sliding were observed after long term reliability aging.

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.