

# TEST REPORT

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THERMATTACH®

*Thermal Tapes*

*404*

*405*

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Prepared by: Chomerics, div. of Parker Hannifin Corp.  
Applications Department  
16 Flagstone Drive  
Hudson, NH 03051

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CHOMERICS

 Parker Seals

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## SUMMARY OF PHYSICAL PROPERTIES

Property .....	4 4 .....	4 s .....	Test Method
Carrier .....	Kapton MT Aluminum		
Thickness, in (mm) .....	0.005 (.127)	0.006 (.152)	
Tensile Strength, psi (MPa) 3600 (25) .....	3600 (25)	3600 (25)	ASTM D412
Tear Strength, lb/in (kN/m) .....	90 (15.7)	130 (22.75)	ASTM D624
Elongation, % .....	50	5	ASTM D412
Dielectric Strength, KVac/mm .....	39.3	n/a	ASTM D149
Breakdown Voltage, Vac .....	5000	n/a	ASTM D149
Volume Resistivity, ohm-cm .....	3x10 <sup>14</sup>	n/a	ASTM D257
Thermal Impedance, °C-in <sup>2</sup> /watt .....	0.58	0.54	MIL-I-49466
(@ < 1 psi [.007MPa]) °C-cm <sup>2</sup> /watt .....	3.70	3.40	
Thermal Conductivity, watt/m-OK .....	0.37	0.46	MIL-I-49466
cal/cm-sec-OC .....	0.0009	0.0011	MIL-I-49466
Adhesive C.T.E., ppm/°C, -40 to + 150°C .....	400	400	E&C TP163*
Flammability .....	V-0	V-0	U.L. 94
Lap Shear Adhesion, psi (MPa) .....	125 (.862)	135 (.931)	ASTM 8209
Die Shear Adhesion, psi (MPa) Aluminum, 25°C .....	130 (.897)	125 (.862)	E&C TP177* *
.....			w
50oC .....	65 (.448)	65 (.448)	
.....			w
75oC .....	55 (.379)	60 (.414)	w
100oC .....	35 (.241)	40 (.276)	
.....			w
125oC .....	45 (.310)	50 (.345)	
150°C .....	50 (.345)	55 (.379)	w
.....			w
Copper, 25oC .....	120 (.828)	160 (1.10)	
150°C .....	45 (.310)	70 (.488)	w
Alumina, 25°C .....	170 (1.17)	145 (1.00)	w
150°C .....	50 (.345)	60 (.414)	w
Peel Adhesion, lb/in (kN/m) .....	1.5 (.26)	2.0 (.35)	ASTM
D1000			
Creep Adhesion, days			
250C, 12 psi (.083 MPa) .....	> 50	> 50	P.S.T.C. #7
1500C, 12 Dsi (.083 MPa) .....	> 10		10
.....	P.S.T.C. #7		

## APPLICATION PERFORMANCE - SUMMARY

Test .....	Results .....	Comments
High Humidity @ Ambient		
1000 Hours, 25°C, 95% RH .....	Pass .....	No negative effects
High Temperature/Humidity Resistance		
1000 Hours, 66°C, 85% RH .....	Pass .....	No negative effects
.....		Die shear improved
Salt Spray .....	Pass .....	No negative effects
.....		Die shear improved
Heat Aging -		
1000 Hours, 150°C .....	Pass .....	No negative effects
.....		Die shear improved
Thermal Shock, -60 > + 150°C		
10 Cycles .....	Pass .....	10% decrease in thermal performance
.....		
100 Cycles .....	Pass .....	No negative effects
Heat Aged Samples .....	Pass .....	No negative effects
Vibration .....	Pass .....	No negative effects
Vibration @ 150°C .....	Pass .....	No negative effects
Mechanical Shock .....	Pass .....	No negative effects
.....		
Solvent Exposure .....	Pass .....	10-20% decrease in performance <sup>0</sup>
.....		
Conformal Coat Compatibility .....	Pass .....	Silicone cure retarded
Potting Compound Compatibility .....	Pass	
Temperature Cycling, -40 to + 150°C .....	Pass	
1000 Cycles		
Long Term Storage .....	Ongoing	

# THERMATTACH Research Report

## High Humidity at Ambient Temperature

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to high humidity at ambient laboratory temperature for 1000 hours. Both products passed this test as shown by no decrease in adhesion or thermal performance.

Apparatus:

A) Humidity Chamber. 95 + 5/-0 % relative humidity was achieved by sealing the test specimens into a plastic container with sufficient water and insulating the container to minimize temperature fluctuations.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Test Conditions. All test specimens were sealed into the humidity chamber for 1000 hours. The chamber was located so that temperature variations were minimized.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

**Results**

A) Visual. There was no evidence of delamination, tape lifting or any other sign of adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows improved thermal performance after 1000 hours at high humidity.

C) Die Shear Strength. The data given in table 2 shows no loss of adhesion after exposure to high humidity.

Table 1. Rj-s, Rj-a :before and .after 1000 hours at 25°C, 95 -100% RH

			BEFORE	AFTER
404	TI	Rj-s, °C/W	4.84	4.88
		Rj-a, °C/w	7.82	7.47
	Motorola	Rj-s, °C/W	5.93	5.28
		Rj-a, °C/W ,	8.50	7.94
405	TI	Rj-s, °C/W	4.24	4.25
		Rj-a, °C/w	7.20	6.94
	Motorola	Rj-s, °C/W	5.43	4.96
		Rj-a, °C/W	7.79	7.75

Table 2. Die Shear strength before and after 1000 hours at 25°C, 95-% RH

Material	Test Temp.		CONTROL psi	AFTER psi
404	250C	1	126.5	306.1
		2	171.4	324.2
		3	90.0	270.1
				270.1
				288.1
				306.1
		Avg.	132.0	294.1
405	250C	1	114.3	306.1
		2	110.2	288.1
		3	151.0	396.2
				324.2
				306.1
				306.1
		Avg.	125.2	321.1

# THERMATTACH Research Report

## High Temperature / Humidity Resistance

1000 Hours, 66°C @ 85% RH

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to 1000 hours of 66°C at 85% Relative Humidity. Both products passed this test based on visual, die shear strength and thermal performance criteria.

### Apparatus:

A) Anatek Thermal Analyzer (ATA) . The ATA was used to measure Rj-s and Rj-a before and after shock testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Humidity. Fixtures were placed in the humidity cabinet in a vertical position. Temperature was raised to 66°C and the humidity was set at 85 %. No attempt was made to protect exposed metal surfaces or leads.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The test fixture was subjected to 1000 hours of 66°C / 85% RH. The individual Rj-s and Rj-a were again measured and recorded.

D) Die Shear- strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to .1000 hours of 66°C / 85% RH. and tested for die shear strength at room temperature.

Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after high humidity exposure. All exposed metal parts were corroded.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the high humidity at elevated temperature has no effect on thermal performance.

C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that the adhesive strength is significantly improved by high humidity at elevated temperature. This is most like due to increase in the modulus of the adhesive under these conditions.

Table 1. Rj-s, Rj-a before and after high temperature and humidity

			BEFORE	AFTER
404	TI	Rj-s, °C/W	5.54	5.56
		Rj-a, °C/W	8.31	8.12
	Motorola	Rj-s, °C/W	5.92	5.42
		Rj-a, °C/W	8.53	8.09
405	TI	Rj-s, °C/W	3.82	3.75
		Rj-a, °C/W	6.67	6.43
	Motorola	Rj-s, °C/W	4.60	4.49
		Rj-a, °C/W	7.27	7.16

Table 2. Die hear strength before and after high temperature and humidity.

Material	Test		CONTROL	AFTER
	Temp.		psi	psi
404	250C	1	126.5	540.2
		2	171.4	504.2
		3	90.0	576.3
		Avg.	132.0	540.2
405	250C	1	114.3	540.2
		2	110.2	540.2
		3	151.0	603.3

# THERMATTACH Research Report

## Salt Spray Resistance

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to 96 hour salt spray per MIL-STD-810D, Section 509.2. Both products passed this test based on visual, die shear strength and thermal performance criteria.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure R<sub>j-s</sub> and R<sub>j-a</sub> before and after salt spray exposure as well as to measure the temperature sensitive V<sub>be</sub> of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Salt Spray. Fixtures were placed in the salt spray cabinet conforming to MIL-STD-810D in a vertical position. No attempt was made to protect exposed metal surfaces or leads.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the R<sub>j-s</sub> and R<sub>j-a</sub> of each transistor was determined using the ATA. The test fixture was subjected to 96 hours of salt spray. The individual R<sub>j-s</sub> and R<sub>j-a</sub> were again measured and recorded.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dice were applied per aluminum panel. The fixtures were subjected to 96 hours of salt spray, inspected visually and tested for die shear strength at 25°C and 150°C.

Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after salt spray exposure. All exposed metal parts were corroded.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the salt spray has no effect on thermal performance.

C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that salt spray does not have a negative effect on the adhesive strength. The increase in shear strength is probably due to moisture increasing the modulus of the adhesive.

Table 1.; Rj-s, Rj-a before and after salt spray

			BEFORE	AFTER
404	TI	Rj-s, °C/W	5.30	5.41
		Rj-a, °C/W	8.06	8.29
	Motorola	Rj-s, °C/W	5.74	5.64
		Rj-a, °C/W	8.80	8.63
405	TI	Rj-s, °C/W	4.43	4.43
		Rj-a, °C/W	7.23	7.12
	Motorola	Rj-s, °C/W	5.16	4.98
		Rj-a, °C/W	7.96	7.73

Table 2. Die shear strength before and after salt spray.

Materi	Test Temp.		CONTROL	AFTER		
			psi	psi		
404	25°C	1	126.5	324.2		
		2	171.4	324.2		
		3	98.0	306.1		
		Avg.	132.0	318.2		
		150°C	1	40.8	44.9	
	150°C	2	49.0	59.2		
		3	65.3	59.2		
		Avg.	51.7	54.4		
		405	25°C	1	114.3	324.2
				2	110.2	306.1
3	151.0			306.1		
Avg.	125.2			312.1		
150°C	1		49.0	49.0		
150°C	2	55.1	53.1			
	3	61.3	44.9			
	Avg.	55.1	49.0			

# THERMATTACH Research Report

## Heat Aging

1000 Hours at 150°C

Summary Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to 1000 hour heat aging at 150°C. Both products passed this test based on visual, die shear strength and thermal performance criteria.

### Apparatus:

A) Oven. A forced convection Blue M oven was set at 150°C. Temperature uniformity within the oven was +/- 5°C.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after heat aging as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Heat Aging. Fixtures were placed in an forced convection hot air oven maintained at 150 +/- 2°C for 1000 hours. Fixtures were then removed and evaluated.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The test fixture was subjected 1000 hours at 150°C. The individual Rj-s and Rj-a were again measured and recorded.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06 x 1 x 4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to 1000 hours at 150°C and tested for die shear strength at room temperature.

Results.

- A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after aging. The exposed adhesive showed moderate discoloration and had lost surface tack.
- B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the thermal resistances after aging are actually lower than before testing. This change is due to several factors, including improved thermal contact, elimination of entrapped air, variability of the ATA method and stress in the transistors and thermocouples.
- C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that the adhesive strength is significantly improved by heat aging. This is probably due to increase in the modulus of the adhesive with long term exposure to high temperatures.

Table 1. Rj-s, Rj-a before and after 1000 hours at 150°C

			BEFORE	AFTER
404	TI	Rj-s, °C/W	5.04	4.60
		Rj-a, °C/W	7.63	7.18
	Motorola	Rj-s, °C/W	6.16	5.35
		Rj-a, °C/W	8.79	7.99
405	TI	Rj-s, °C/W	5.14	4.16
		Rj-a, °C/W	7.74	6.79
	Motorola	Rj-s, °C/W	5.56	4.22
		Rj-a, °C/W	7.96	6.86

Table 2: Die shear strength before and after 1000 hours at 150°C.

Material	Test Temp.		CONTROL psi	AFTER psi
404	25°C	1	126.5	450.2
		2	171.4	396.2
		3	90.0	387.2
		4		396.2
		5		378.2
		6		414.0
		Avg.	132.0	403.7
405	250C	1	114.3	504.2
		2	110.2	450.2
		3	151.0	468.2
		4		450.2
		5		459.2
		6		486.0
		Avg.	125.2	469.7

# THERMATTACH Research Report

## Thermal Shock Resistance 10 Cycles -60 to + 150°C

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to ten thermal shock cycles following ASTM D-1674 guidelines. Both products passed this test based on visual, die shear strength and thermal performance criteria.

### Apes

A) Low temperature bath. The low temperature bath consisted of a one gallon capacity insulated plastic container. 0.75 gallon of isopropanol was added to the container and sufficient finely crushed dry ice was added to cool the bath to -65 +/-5°C. Temperature was measured with a Type K thermocouple located one inch below the liquid surface. The bath was stirred before a temperature measurement was taken. Temperature was maintained by addition of dry ice.

B) Oven. A forced convection Blue M oven was set at 150°C. Temperature uniformity was +/- 2°C. Recovery time after opening the door and test specimen placement was 56 minutes.

C) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after shock testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

D) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

E) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

F) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Shock Cycle. A cycle consisted of placing a specimen into the oven at 150°C for 30 minutes and after removal from the oven, rapidly plunging the specimen into the -65°C bath for 5 minutes. The specimen was removed from the cold bath, excess isopropanol was wiped off with a towel, rapidly visually examined and the next cycle started.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The test fixture was subjected to ten shock cycles. The individual Rj-s and Rj-a were again measured and recorded.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon dies were applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to ten shock cycles, inspected visually between cycles and tested for die shear strength at room temperature.

Results

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after cycling.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the thermal resistances after shock cycling are approximately 5-10% higher than before testing. This increase is due to several factors, including thermal stress on the tape, variability of the ATA method and stress in the transistors and thermocouples.

C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that the adhesive strength is not altered by thermal shock.

Table 1. Rj-s, Rj-a before and after thermal shock

			BEFORE	AFTER
404	TI	Rj-s, °C/W	4.60	5.04
		Rj-a, °C/W	6.63	7.63
	Motorola	Rj-s, °C/W	5.88	6.16
		Rj-a, °C/W	8.30	8.79
405	TI	Rj-s, °C/W	4.82	5.14
		Rj-a, °C/W	7.44	7.74
	Motorola	Rj-s, °C/W	5.07	5.56
		Rj-a, °C/W	7.46	7.96

Table 2. Die shear strength before and after thermal shock.

Material	Test Temp.		CONTROL psi	AFTER psi
404	25°C	1	126.5	122.4
		2	171.4	106.1
		3	90.0	106.1
		Avg	132.0	115.6
	1500C	1	40.8	44.9
		2	49.0	57.1
		3	65.3	57.1
		Avg	51.7	53.1
405	250C	1	114.3	146.9
		2	110.2	142.9
		3	151.0	163.3
		Avg	125.2	151.0
	1500C	1	49.0	81.6
		2	55.1	85.7
		3	61.3	81.6
		Avg	55.1	83.0

# THERMATTACH Research Report

## Thermal Shock Resistance 100 Cycles -60 to + 150°C

Summary: Random production samples of THERMATTACH 4.04 and 405 thermal tapes were subjected to ten thermal shock cycles following ASTM D-1674 guidelines. Both products passed this test based on visual, die shear strength and thermal performance criteria.

### Apparatus

A) Low temperature bath. The low temperature bath consisted of a one gallon capacity insulated plastic container. A 0.75 gallon of isopropanol was added to the container and sufficient finely crushed dry ice was added to cool the bath to -65 +0/-5°C. Temperature was measured with a Type K thermocouple located one inch below the liquid surface. The bath was stirred before a temperature measurement was taken. Temperature was maintained by addition of dry ice.

B) Oven. A forced convection Blue M oven was set at 150°C. Temperature uniformity was +/- 2°C. Recovery time after opening the door and test specimen placement was 56 minutes.

F) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Shock Cycle. A cycle consisted of placing a specimen into the oven at 150°C for 30 minutes and after removal from the oven, rapidly plunging the specimen into the -65°C bath for 5 minutes. The specimen was removed from the cold bath, excess isopropanol was wiped off with a towel, rapidly visually examined and the next cycle started.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

D) Die Shear strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon dies were applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to 100 shock cycles, inspected visually between cycles and tested for die shear strength at room temperature after 100 cycles.

### Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after cycling.

B) Die Shear Strength. The results of the die shear strength tests are given in Table 1. The data shows that the adhesive strength is not altered by thermal shock.

Table 1. Die shear strength before and after thermal shock.

Material	Test		CONTROL	AFTER	
	Temp.		psi	psi	
404	25°C	1	126.5	122.4	
		2	171.4	106.1	
		3	90.0	106.1	
		Avg	132.0	115.6	
	1500C	1	40.8	44.9	
		2	49.0	57.1	
		3	65.3	57.1	
		Avg.	51.7	53.1	
	405	250C	1	114.3	146.9
			2	110.2	142.9
3			151.0	163.3	
Avg.			125.2	151.0	
150°C		1	49.0	81.6	
		2	55.1	85.7	
		3	61.3	81.6	
		Avg.	55.1	83.0	

# THERMATTACH Research Report

## Vibration Resistance

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to vibration by Associated Testing Laboratories of Burlington MA. Both products passed the test with no loss of adhesion or thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Vibration. Specimens were subjected to sine-wave vibration as specified in GM 9110P test procedure. Specimens were vibrated for four hours per axis in all three axes with a sweep rate of 1 octave /minute from a frequency of 10 to 1000 Hz. This method is considered more severe than the random vibration called out by GM 9103P procedure.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. There was no apparent adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is not affected by vibration.

C) Die Shear Strength. There was no loss of shear strength after exposure to vibration.

Table 1. Rj s, Rj-a before and after vibration.

		BEFORE	AFTER
404 TO-220	Rj-s, °C/W	5.93	5.89
	Rj-a, °C/W	8.53	8.65
	TO-218 Rj-s, °C/W	3.82	3.79
	Rj-a, °C/W	6.38	6.46
40 TO-220	Rj-s, °C/W	4.66	4.68
	Rj-a, °C/W	7.32	7.41
	TO-218 Rj-s, °C/W	3.06	3.27
	Rj-a, °C/W	6.00	5.95

Table 2. Die shear strength before and after vibration.

Material	Test		CONTROL	AFTER
	demo.		psi	psi
404	250C	1	126.5	159.2
		2	171.4	244.9
		3 -	90.0	193.9
				244.0
				208.2
				212.2
		Avg.	132.0	210.5
	1500C	1	40.8	61.2
		2	49.0	57.0
		3	65.3	61.2
			55.1	
			63.3	
			63.3	
	Avg.	51.7	60.2	
405	250C	1	114.3	171.4
		2	110.2	195.9
		3	151.0	218.4
				179.6
				236.7
				175.5
		Avg.	125.2	196.2
	150°C	1	49.0	57.1
		2	55.1	61.2
		3	61.3	73.5
			59.2	
			73.5	
			77.6	
	Avg.	55.1	67.0	

# THERMATTACH Research Report

## Vibration Resistance at Elevated Temperature

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to vibration at elevated temperature by Associated Testing Labs of Burlington MA. The results show that neither product is negatively affected by vibration at elevated temperature.

### Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Vibration. Specimens heated to 125°C and subjected to sine-wave vibration as specified in GM 9110P test procedure. Specimens were vibrated for four hours per axis in all three axes with a sweep rate of 1 octave /minute from a frequency of 10 to 1000 Hz. This method is considered more severe than the random vibration called out by GM 9103P procedure.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. Thermal performance was again determined after high temperature vibration testing.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. Die shear strength was determined after high temperature vibration testing.

Results.

- A) Visual. There no no signs of delamination or other signs of adhesive failure.  
 8) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is unaffected by vibration at elevated temperature.  
 C) Die Shear Strength. The data listed in Table 2 shows that vibration at elevated temperature does not have a negative affect on the shear strength of the adhesive. The room temperature strength increases and the high temperature strength remains unchanged.

Table 1. Rj s, Rj-a before and after vibration at 125°C.

			BEFORE	AFTER
404	TO-220	Rj-s, °C/W	5.85	5.77
		Rj-a, °C/W	8.60	8.64
	TO-218	Rj-s, °C/W	3.41	3.58
		Rj-a, °C/W	6.09	6.21
405	TO-220	Rj-s, °C/W	5.12	5.10
		Rj-a, °C/W	7.86	7.84
	TO-218	Rj-s, °C/W	3.29	3.25
		Rj-a, °C/W	5.99	5.98

Table 2. Die shear strength before and after vibration at 125°C.

Material	Test Temp.		CONTROL psi	AFTER psi
404	250C	1	126.5	228.6
		2	171.4	226.5
		3	90.0	224.5
		Avg	132.0	220.4
	1500C	1	40.8	63.3
		2	49.0	57.1
		3	65.3	44.9
				46.9
				53.1
		Avg.	51.7	44.9
		51.7		

TABLE 2 Cont.

Material	Test Temp.		CONTROL psi	AFTER psi	
405	250C	1	114.3	253.1	
		2	110.2	216.3	
		3	151.0	269.4	
				224.5	
			220.4		
			224.5		
	Avg.		125.2	234.7	
	1500C	1		49.0	38.8
		2		55.1	65.3
		3		61.3	51.0
				55.1	
				57.1	
				55.1	
	Avg.		55.1	53.7	

# THERMATTACH Research Report

## Mechanical Shock

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes tested for mechanical shock resistance by Associated Testing Laboratories of Burlington MA. Both products passed the test as evidenced by no loss of adhesion or deterioration of thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATAL) The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were mounted to the heat sink without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Shock. Test specimens were subjected to a half sine shock pulse of 20g amplitude and 11 millisecond duration in each axis and in both directions.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. Examination of the transistors and the dies showed no sign of delamination or other adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The results show that mechanical shock has had no effect on the thermal performance.

C) Die Shear Strength. The results given in Table 2 show that mechanical shock had no negative effect on the die shear adhesion. The room temperature shear strength of the adhesive has increased.

Table 1. Rj-s, Rj-a before and after mechanical shock.

			BEFORE	AFTER
404	TO-220	Rj-s, °C/W	5.12	5.16
		Rj-a, °C/W	7.77	7.82
	TO-218	Rj-s, °C/W	3.16	3.33
		Rj-a, °C/W	5.77	5.95
4405	TO-220	Rj-s, °C/W	4.94	4.92
		Rj-a, °C/W	7.63	7.67
	TO-218	Rj-s, °C/W	2.92	2.89
		Rj-a, °C/W	5.67	5.63

Table 2. Die shear strength before and after mechanical shock:

Material	Test Temp.		CONTROL Psi	AFTER psi	
404	25°C	1	126.5	228.6	
		2	171.4	253.1	
		3	90.0	240.8	
				249.0	
				220.4	
				242.9	
			Avg	132.0	239.1
	150°C	1	40.8	46.8	
		2	49.0	57.1	
		3	65.3	40.8	
			40.8		
			61.2		
			49.0		
		Avg	51.7	48.3	
405	25°C	1	114.3	195.9	
		2	110.2	200.0	
		3	151.0	244.9	
				208.2	
				220.4	
				261.2	
			Avg.	125.2	221.8
	150°C	1	49.0	53.1	
		2	55.1	53.1	
		3	61.3	69.4	
			44.9		
			44.9		
			49.0		
		Avg.	55.1	52.4	

# THERMATTACH Research Report

## Solvent Exposure

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were sequentially subjected to hot isopropanol, MEK, toluene and 1,1,1 trichloroethane vapors to simulate a degreasing process. This test is considered extremely severe since the thermal tape is exposed to four different solvents for a total of 24 minutes with very little time allowed for drying between exposures. Both products resisted these solvents as judged by the die shear strength and also the thermal performance of TO-220 and TO218 transistors.

### Apparatus:

A) Reflux. A two liter beaker containing the test solvent was heated to reflux and stirred by a magnetic hot plate.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples` at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

### Procedure:

A) Solvent Exposure. 100 cc of test solvent was brought to rapid reflux in the 2000 cc covered beaker. When the hot vapors reached the cover, the test specimen was inserted into the vapor and the cover was replaced. After two minutes exposure, the specimen was removed into the ambient atmosphere for two minutes. This cycle was repeated two more times. The test solvent was replaced with the next solvent and the specimen was subjected to three cycles with this new solvent. This solvent change represented a 30 minute drying period. The order of solvent exposure was Toluene, MEK, isopropanol and 1,1,1 TCA.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing during and after the solvent exposures.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each-transistor was determined using the ATA. The specimens were exposed to hot solvent vapors, allowed to dry 1 hour after the last exposure and the thermal resistances were re-measured.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The test panels were exposed to hot solvent vapors, allowed to dry 1 hour after the last exposure and the die shear tests were performed.

Results.

A) Visual. There was considerable swelling of the exposed adhesive especially when exposed to MEK and 1,1,1 TCA. Minor edge lifting was also apparent following exposure to 1,1,1 TCA.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The results show that the initial thermal resistances increase by 1096 over that of the before test values. This initial increase is most likely due to trapped solvent beneath the transistor.

C) Die Shear Strength. The results show that the die shear values are 10 - 20% lower after solvent exposure. This decrease is probably caused by factors such as trapped solvent under the dies, normal variability of the test and sample preparation.

Table 1. Rj-s, Rj-a before and after solvent exposure.

			BEFORE	1 HR AFTER
404	TO-220	Rj-s, °C/W	5.65	6.12
		Rj-a, °C/W	8.33	8.77
	TO-218	Rj-s, °C/W	3.46	4.04
		Rj-a, °C/W	6.04	6.63
405	TO-220	Rj-s, °C/W	5.15	5.60
		Rj-a, °C/W	7.83	8.27
	TO-218	Rj-s, °C/W	3.28	3.56
		Rj-a, °C/W	5.99	6.19

Table 2: Die shear strength before and after solvent vapor exposure.

Material	Test Temp.		CONTROL	AFTER
			psi	psi
404	250C	1	126.5	110.2
		2	171.4	110.2
		3	90.0	81.6
		Avg	132.0	100.7
	1500C	1	40.8	40.8
		2	49.0	42.9
		3	65.3	44.9
		Avg.	51.7	42.9

TABLE 2 Cont.

Material	Test Tem.		CONTROL psi	AFTER psi
405	25°C	1	114.3	102.0
		2	110.2	116.3
		3	151.0	116.3
		Avg.	125.2	111.6
	150°C	1	49.0	36.7
		2	55.1	65.3
		3	61.3	53.1
	Avg.	55.1	51.7	

# THERMATTACH Research Report

## Conformal Coating Compatibility

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were conformal coated with acrylic and silicone conformal coatings. Neither product affected or was affected by the acrylic coating but both products inhibited the cure of the silicone conformal coats.

Conformal Coatings The following conformal coats were evaluated:

Emerson & Cuming Unicoat S7001-1, silicone  
S7002, silicone  
UV79-20, acrylic

Procedure:

A) Coating. TO-220 transistors adhered to a black anodized heat sink with the thermal tapes. The specimens were then subjected to a simulated vapor degreasing step and dried for 30 minutes at ambient. Conformal coatings were applied by pouring a thin layer onto the specimens and were cured following the manufacturer's recommendations.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing. Specimens were also examined for conformal coat dewetting and cure.

Results.

A) Visual. Both products retarded the cure of the silicone conformal coats only where the coating was in contact with the adhesive layer. The acrylic cure was unaffected. None of the conformal coats showed signs of dewetting.

# THERMATTACH Research Resort

## Potting Compound Compatibility

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were encapsulated with a silicone potting compound base known to be sensitive to contamination induced loss of cure. Neither product caused loss of cure or any signs of dewetting.

Procedure:

A) Potting. TI TIP29 TO-220 transistors were mounted to 1" x 2.5" glass slides using 0.7" x 2" sample of 404 and 405 tape. G.E. RTV 615 base was prepared according to directions. A 0.25 inch dam was prepared around the test specimen, the potting mix was poured and cured at 150°C for 10 minutes.

B) Visual. All test specimens were examined for cure, compound wetting and any sign that the tape was interfering.

Results

A) Visual. The compound was properly cured even when exposed to the tape surface. There were no signs of dewetting and all leads and openings were completely filled.

# THERMATTACH Research Report

## Temperature Cycling, -40 to + 150-C, 1000 Cycles

Summary: Random production samples of THERMATTACH 404 and 405 thermal tapes were subjected to temperature cycling by Associated Testing Laboratories of Burlington MA. Both products passed the test with no loss of adhesion or thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted 2 per side near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

E) Temperature Chamber. A temperature chamber with a range of -100 to + 550°F and accuracy of +/- 2°F was used.

Procedure:

A) Temperature Cycling. Specimens were subjected to 1000 cycles from -40 to +150°C. A cycle consisted of a fifteen minute dwell at -40°C, heating to 150°C at 10°C / minute, a fifteen minute dwell at 150°C and cooling to -40°C at 10°C / minute.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06 x 1 x 4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. There was no apparent adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is not affected by temperature cycling. One of the devices failed during the cycling. The failure was a mechanical lead breakage and not related to the product being tested.

C) Die Shear Strength. There was no loss of shear strength after exposure to temperature cycling.

Table 1. Rj-s, Rj-a before and after temperature cycling.

			BEFORE	AFTER
404	TO-220	Rj-s, °C/W	5.85	5.69
		Rj-a, °C/W	8.60	8.28
	TO-218	Rj-s, °C/W	3.41	Device
		Rj-a, °C/W	6.09	Failed
405	TO-220	Rj-s, °C/W	5.12	5.42
		Rj-a, °C/W	7.86	8.36
	TO-218	Rj-s, °C/W	3.29	3.19
		Rj-a, °C/W	5.99	5.88

Table 2: Die shear strength before and after temperature cycling.

Material	Test Temp.		CONTROL psi	AFTER	
404	250C	1	126.5	342.0	
		2	171.4	216.0	
		3	90.0	315.0	
				270.0	
				252.0	
				234.0	
		Avg	132.0	271.5	
	150°C	1		40.8	49.0
		2		49.0	44.9
		3		65.3	49.0
				44.9	
			40.8		
			40.8		
	Avg.		51.7	44.9	

405	250C	1	114.3	216.0
		2	110.2	288.0
		3	151.0	306.0
				324.0
				378.0
				378.0
		Avg.	125.2	315.0
	150°C	1	49.0	65.3
		2	55.1	61.2
		3	61.3	57.1
			44.9	
			55.1	
			67.4	
	Avg.	55.1	58.5	

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