REV	DESCRIPTION	DATE	APPROVED
A	ECO # 0053	11/03/04	R. E. Lindberg

BONDiT™ B-45, B-481, B-482
Thermal Test Report
by
CDI

CONTRACT NO.

APPROVALS	DATE
DRAWN: R. E. Lindberg	11/03/04
CHECKED: R. E. Lindberg	11/03/04
ISSUED: R. E. Lindberg	11/03/04

RELTEK LLC
Adhesives, Sealants & Coatings
PO Box 6718, Santa Rosa, CA 95406
707-539-0539 · Phone 707-539-0875 · Fax

SIZE A	DWG A515-0403		REV A
SCALE: CAD	FSCM NO. 16326	SH 1	OF 20

TABLE OF CONTENTS

1.0 EQUIPMENT

1.01 LIST

1 Temperature Chamber
Pacific Combustion Engineering
The chamber is manually controlled using an Alnor pyrotroller controller

2 Temperature Meter
Extech 424502
This temperature meter is a duel thermo-couple input meter with duel readout (type K and type J). Both thermocouples used in this test were type K.

A. CO_2
Liquid CO_2 was used to cool the test articles to –50 degrees “F” .

1.02 SETUP

A. Temperature Chamber
The temperature was connected directly to the CO_2 canister through a high-pressure hose.

The thermocouples were fed into the chamber through the side access hole. The bead end of one thermo-couple was adjusted to allow it to rest against one of the large test samples base. The other thermocouple was allowed to hang in mid air inside of the test chamber to allow ambient air temperature within.

All test samples were set on insulating foam to prevent thermal conduction from the temperature chamber floor.

B. Temperature Meter
The meter was set to monitor both “K” type thermo-couples with digital duel readout.

1.03 CONTROL

The manually controlled temperature chamber does not allow for easily controlled cold environment. The controller opens the CO_2 valve completely during the cool down cycle. This allows the cold temperature to overshoot the desired holding temperature by 30 to 40 degrees. It takes time for the temperature to stabilize and for the controls to regulate the desired thermal changes in the test samples.

The heat side of the temperature chamber is more easily controlled due to the time lag between the temperature control change and the heating element response.

1.04 OPERATION

The operation of the temperature chamber is accomplished through the use of two toggle switches and two control knobs.

One toggle switch is the CO_2 cool enable. This switch enables the CO_2 valve that dumps the liquid CO_2 into the chamber under pressure.

1.05 TEST FIXTURES

The large sample test fixtures are to be machined out of stock aluminum. The dimensions are as follows.

O. D. = 3.5 inches
I.D. 1 = 1.25 inches
I.D. 2 = 0.9 inches
Depth = 1.0 inches

These large sample test fixtures have a slight internal slope (approx 3º), which gives the fixtures a shallow cone shape.

The small sample test fixtures are to be cut out sections of the actual aluminum antenna casting of the device to be potted. The dimensions are as follows.

O. D. = 2.25 inches
I.D. 1 = 1.25 inches
I.D. 2 = 1.25 inches
Depth = 1.0 inches

The small sample test fixtures have the hole offset from the center to one side by 0.27 inches.

2.0 TEST DEVIATIONS

2.01 TEMPERATURE

All thermal conditioning was conducted with the intention of maintaining a temperature change of 20º F in 45 minutes maximum. There were two occasions where this specification was exceeded. Both times was in the cool down portion of the cycle.

A. The first thermal anomaly occurred during the first cool down cycle on (10/11/04).

After setting the chamber up and inserting the test articles, the cool down was initiated. The overshoot of the temperature was due primarily to the non-regulation of the CO_2 volume into the chamber (human Error).

It was determined the deviation of procedure had no effect on the test articles due to the temperature anomaly being in the middle of the test parameter specified and not in either extreme.

C. During the first cold thermal cycle, the –50º F could not be reached due to the lack of CO_2 , and the minimum reached could not be held.

D. The second anomaly occurred during the first cool down cycle on (10/15/04) during an aborted cool down cycle.

The overshoot of the temperature was due primarily to the non-regulation of the CO_2 volume into the chamber (Human Error).

It was determined the deviation of procedure had no effect on the test articles due to the temperature anomaly being in the middle of the test parameter specified and not in either extreme.

2.02 CO_2

There were two occasions where the CO_2 supply was depleted. The first time (on 10/11/04) the gas supplier was slow to deliver a new canister. This resulted in a 15.9º rise in the substrate temperature. After the CO_2 supply was replenished, the test continued.

This was determined to be a realistic condition that could be encountered in the field and did not compromise the test.

2.03 THERMAL RETURN TO AMBIENT TEMPERATURE

It was determined that if the chamber remained closed the temperature would slowly return to ambient room temperature. This temperature vs. time was less than 20º F in 45 minutes, which fulfilled the test requirement.

The test articles were allowed to stand over night between the hot and cold cycles so the test could resume each day. The return to ambient temperature could not be monitored and recorded.

2.04 ABORTED CYCLE

The cold cycle conducted on October 15, 2004; was aborted due to the gas supplier not being able to deliver the CO_2 in a timely manner.

This put the test into a situation where the time required to perform the cold cycle exceeded the time available.

2.05 DEVIATION EFFECTS

The accumulated deviations as well as each individual anomaly were determined to have no effect on the outcome of the test.

3.0 BONDIT B-45TH

A sample of B-45TH was added to this test to characterize it in the temperature extremes of this test.

3.01 MIXING

The B-45TH was mixed in a ratio of 2 to 1. 2 parts A & B.
Lot Number 04010915196 P/N B200-0045-TH-04

3.02 FIXTURE PREPARATION

Cleaned all of the sample test fixtures with clean unused alcohol. The fixtures were blotted dry with a clean paper towel and placed into the test oven at 125 degrees F for 1-hour minimum.

The fixtures were allowed to return to ambient temperature before proceeding with preparation.

The small end of the larger fixture was sealed.

3.03 POURING AND CURING

I. Poured 15 oz of the mixed material into the center of the machined fixture. Wiped away any excess from the edge of the fixture.
II. Allowed the material to air cure. (Approximately 36 hours)
III. Repeated for the cast sample fixture, which holds 19 oz of material.

3.04 IDENTIFICATION

The test article was labeled BONDIT B-45TH

4.0 BONDIT B-481

4.01 MIXING

The B-481 was mixed in a ratio of 2 to 1. 2 parts A & B.
Lot Number 040908114027 P/N B200-0481-04

4.02 FIXTURE PREPARATION

Cleaned all of the sample test fixtures with clean unused alcohol. The fixtures were blotted dry with a clean paper towel and placed into the test oven at 125 degrees F for 1-hour minimum.

The fixtures were allowed to return to ambient temperature before proceeding with preparation. The small end of the larger fixture was sealed.

4.03 POURING AND CURING

I. Poured 15 oz of the mixed material into the center of the machined fixture. Wiped away any excess from the edge of the fixture.

II. Allowed the material to air cure. (Approximately 36 hours)

III. Repeated for the cast sample fixture, which holds 19 oz of material.

4.04 IDENTIFICATION

The test article was labeled BONDIT B-481.

5.0 BONDIT B482

5.01 MIXING

The B-481 was mixed in a ratio of 2 to 1. 2 parts A & B.
Lot Number 040915114029 P/N B200-0482-04

5.02 FIXTURE PREPARATION

Cleaned all of the sample test fixtures with clean unused alcohol. The fixtures were blotted dry with a clean paper towel and placed into the test oven at 125 degrees F for 1-hour minimum.

The fixtures were allowed to return to ambient temperature before proceeding with preparation.

The small end of the larger fixture was sealed.

5.03 POURING AND CURING

IV. Poured 15 oz of the mixed material into the center of the machined fixture. Wiped away any excess from the edge of the fixture.

V. Allowed the material to air cure. (Approximately 36 hours)

VI. Repeated for the cast sample fixture, which holds 19 oz of material.

5.04 IDENTIFICATION

The test article was labeled BONDIT B-482.

6.0 BONDIT B-481 PART "A" AND B-45 TH PART "B"

This portion of the test was performed but omitted from this report due to the mixture being invalid.

7.0 THERMAL DATA

All hot and cold cycles were documented manually with a digital temperature meter. Due to not having a recording device installed in the test assembly, the data readings were not evenly spaced. The graphs and data sheets reflect the times the temperatures were recorded.

See the attached thermal cycle Charts, Data sheets, and photos.

8.0 THERMAL CYCLE INSPECTIONS

First cold cycle Revealed no visual changes in any sample of the potting materials held in the sample fixtures.

First hot cycle Revealed no visual changes in any sample of the potting materials held in the sample fixtures. Exception: a small amount of crazing appeared around the perimeter of the B-481 on the small cast sample, after the first hot cycle.

After completion of second cold thermal cycle the test samples were inspected. No changes in the potting material were noted.

After completion of second hot thermal cycle the test samples were inspected. No changes in the potting material were noted.

An inspection was performed, after the third cold cycle and the test samples returned to room temperature.

The B-45TH surface and around the edges appeared to be sort of milky as though it absorbed some of the condensation. It still had very good adherence to the substrate and the mass was still the original color. The potting material cracked at the surface and appeared to be about a 1/16 inch deep. This appeared only on the small casting on the thin side after the third hot cycle. The machine casting appeared unchanged.

There was some slight cracking around the edges of the B-481 material. It did not get into the mass of the material. The material is still firmly attached to the substrate. This appeared only on the small casting on the thin side. The machine casting appeared unchanged.

The B-482 appeared unchanged on both the machined sample and the small aluminum casting.

After completion of fourth cold thermal cycle the test samples were inspected. No further change in the potting material was noted.

After completion of fourth hot thermal cycle the test samples were inspected. No further change in the potting material was noted.

9.0 FINAL INSPECTION

A final inspection was performed under a 10x / 21 microscope.

9.01 BONDiT B-45TH…. The final inspection confirmed the B-45TH still has excellent adherence to the substrate and the mass is still the original color. The potting material cracked at the surface and appeared to be about a 1/16 inch deep. This appeared only on the small casting on the thin side. It is believed that this crack is due to the material being torn by the expansion of the cast aluminum substrate during the third hot cycle.

The machine casting appeared unchanged. The BONDIT B-45 material remained very pliable throughout the test (from –50º to +150º F).

9.02 BONDiT B-481…. The final inspection confirmed that the cracking around the edges of the cast sample was superficial. These cracks did not degrade the integrity of the sample or compromise the holding strength around the perimeter of the fixture.

The cracking appears to be associated with the sharp edges of the substrate on one side of the fixture and associated with the thin metal of the opening offset. Thus the cracking of the potting at the edges can be explained by the differences in the expansion and contraction range and rate of the material and substrate.

The machined sample did not show any visible cracking or degradation in the potting or the holding strength. The sample appears as it did after the material was originally cured.

9.03 BONDiT B-482…The final inspection revealed the BONDiT B-482 to have only a very small fracture around the extreme outer perimeter of the small sample. This fracture did not extend into the body of the potting material or between the B-482 and the substrate. These fractures could not be seen with the naked eye on the rounded edge and barely evident on the sharp edge of the cast sample.

The machined sample did not show any visible cracking or degradation in the potting or the holding strength. The sample appears as it did after the material was originally cured.

10.0 CONCLUSION

10.01 Sample fixtures…. The mechanical properties of cast aluminum soundness, is strongly influenced by porosity and nonmetallic inclusions. Inclusions or particles are damaging to the material mechanical properties of the aluminum casting. The inclusions reduce the effective cross section of aluminum material and increase the porosity of the cast aluminum. The greater effect is the stress concentration when inclusions are at or near the surface of the samples. Yield strengths are typically lower.

The cast aluminum sample fixtures, due to the porosity, inclusion materials, and mass of the material, give it a higher expansion ratio over the machined aluminum stock.

The Machined aluminum sample fixture does not have the amount suspended inclusions or the hydrogen porosity as the cast aluminum sample fixture. This plus the more symmetric construction of the machined aluminum sample fixture, allowed for a more equal expansion rate between the potting materials and the substrate.

10.02 BONDiT B-45TH
The material performed well and maintained its holding strength to both of the substrate materials throughout the test. There was no separation between the substrate and the potting material.

The tear or crack present in the cast aluminum potting sample is due to the differences in the expansion characteristics of the sample fixture and the expansion characteristics of the potting.

The machined fixture is more dense and has more mass. This contributed to a more confined expansion of the substrate at temperature and did not expand beyond the physical limits of the potting material surface.

Cast aluminum is not a good substrate to use with this material when extreme temperature variations are to be encountered such as -50º F to +150º F. Although there were some problems with BONDiT B-45TH in the cast aluminum housing with a changing temperature environment, a *stable* temperature environment should not be a problem at either temperature extreme or any temperature between -50º F and +150º F..

The BONDiT B-45TH maintained very good flexibility throughout the temperature range of this test.

10.03 BONDiT B-481

The cured BONDiT B-481 material performed well and held its integrity in both the cast and machined fixtures. There was no separation between the substrate and the potting material. It held its rigidity throughout the temperature range of this test.

This potting material would be adequate to bond, seal, or pot items that require the extreme temperature environment as outlined in this test documentation.

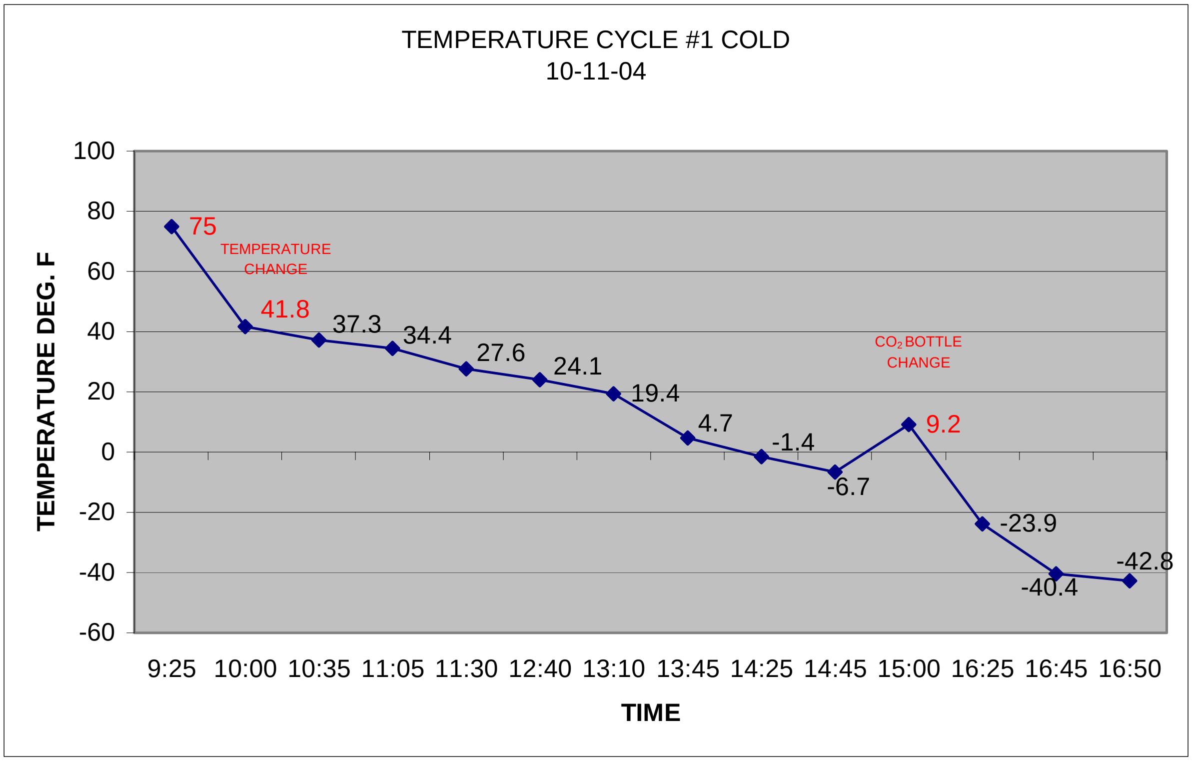
However, any sealing or potting of an item (in these changing temperature environments) using the BONDiT B-481 should be done in a containment vessel made of a material with similar thermal expansion characteristics as the cured BONDiT B-481. This will prevent any cracking around the edges of the potting due to expansion and contraction of the substrate.

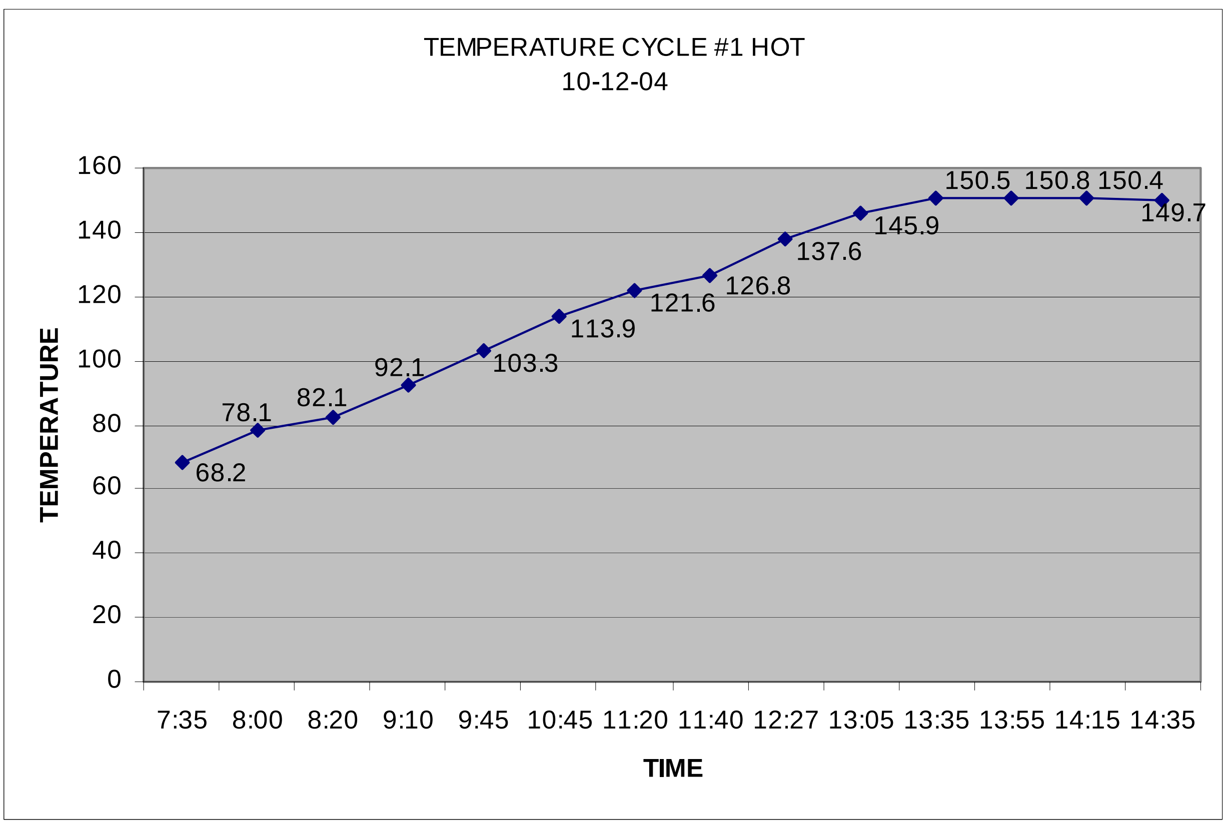
10.04 BONDIT B-482

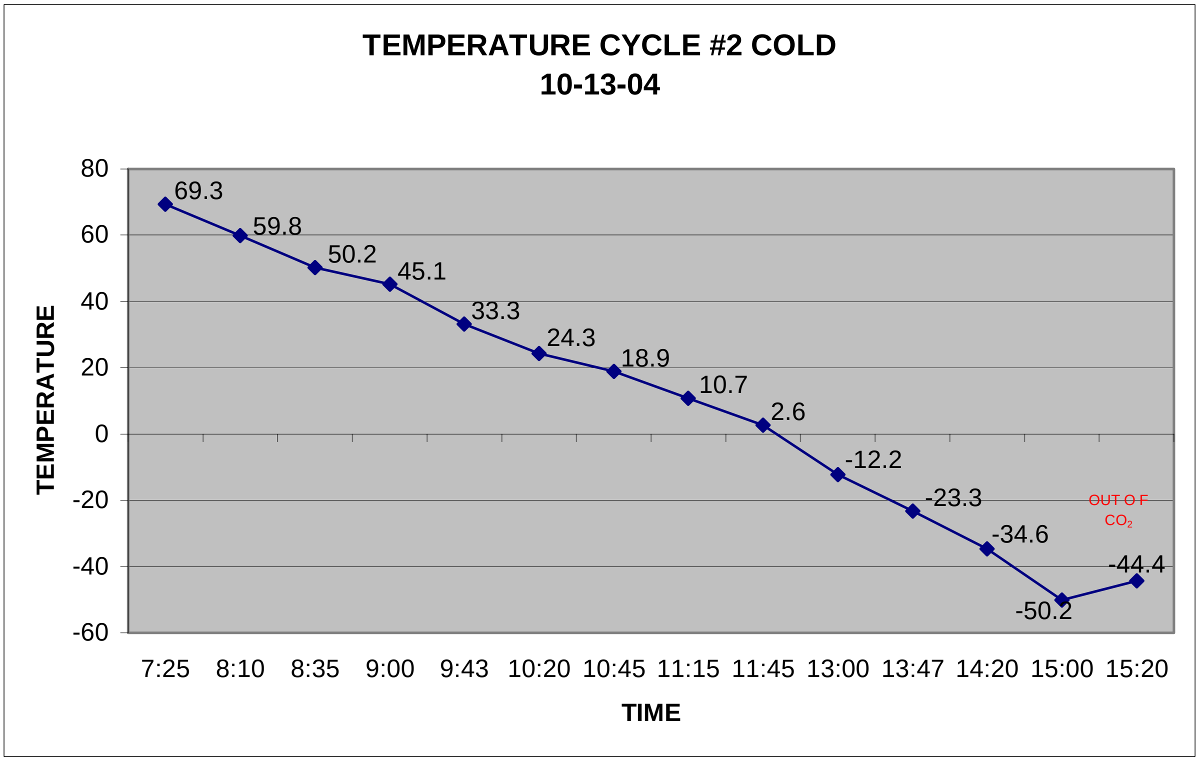
The potting performed extremely well and held its integrity in both the cast and machined fixtures. There was no separation between the substrate and the potting material.

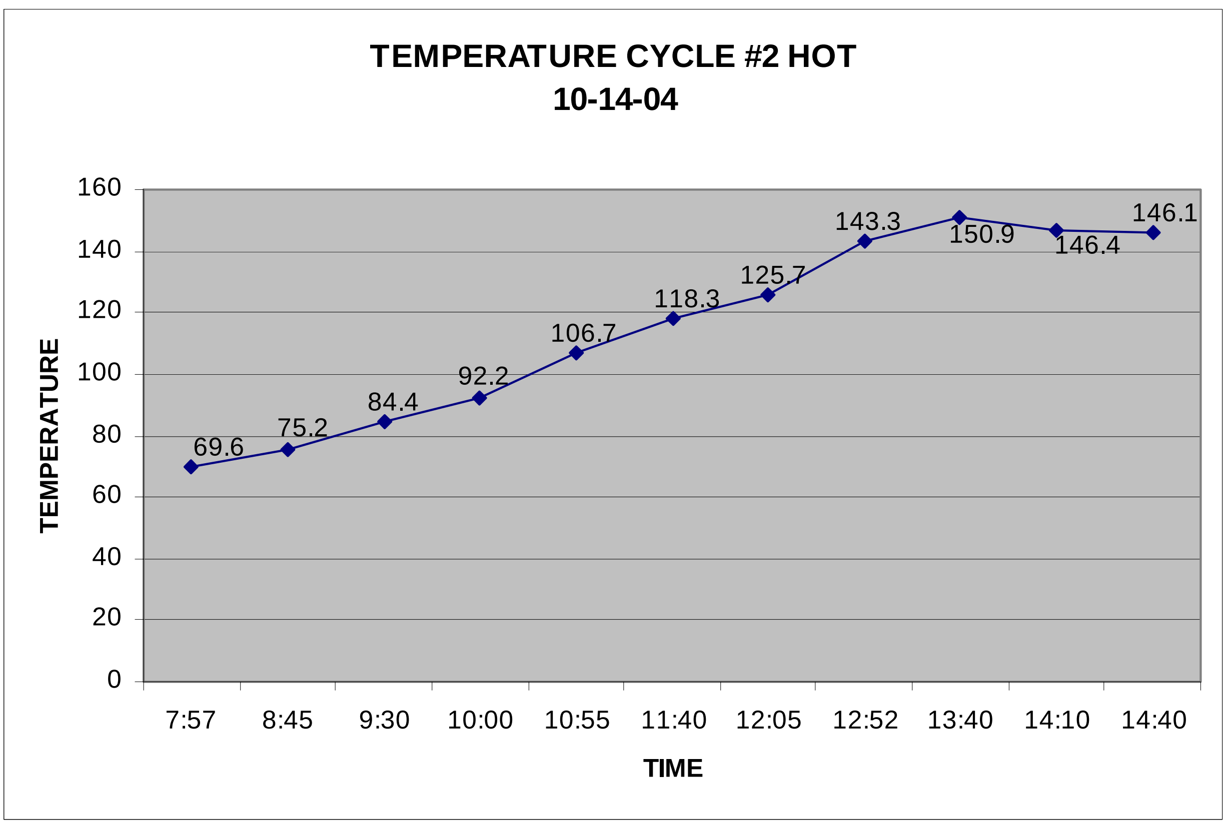
The BONDIT B-482 is elastic enough to maintain its original cured appearance and integrity at the extreme temperatures of -50º F to +150º F. It held its rigidity and integrity throughout the temperature range of this test.

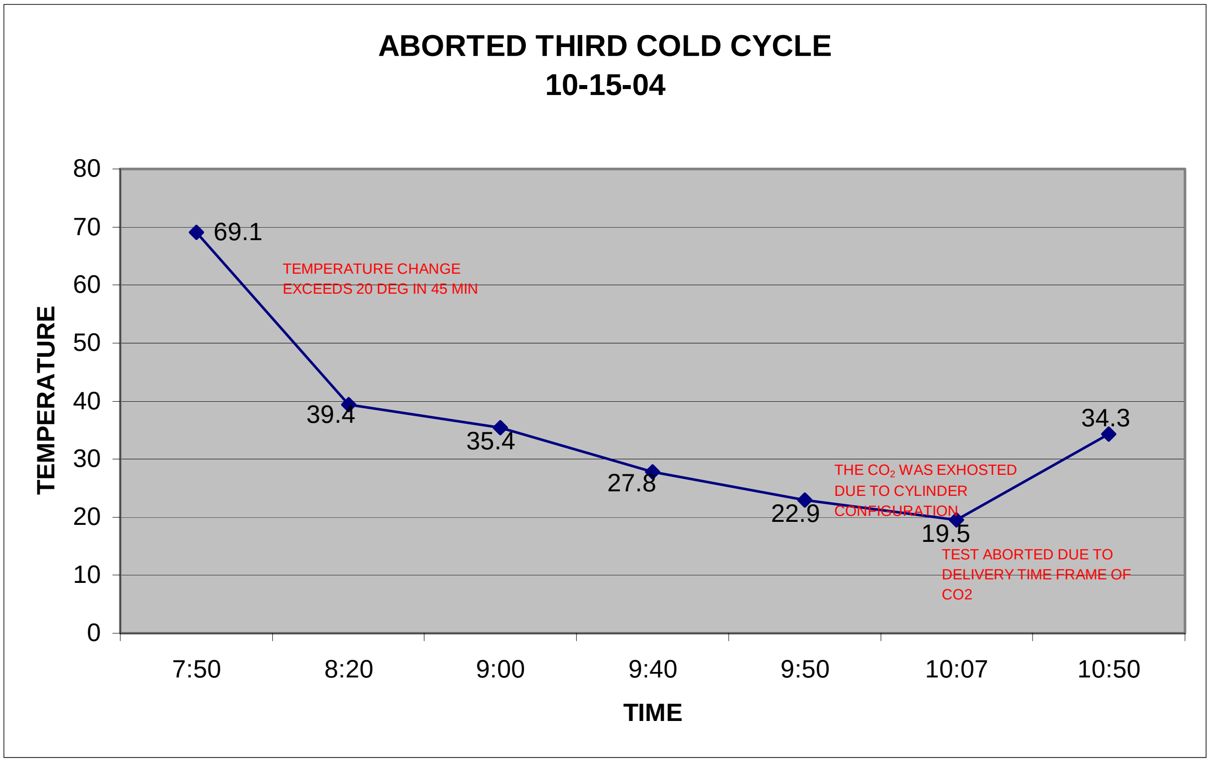
The BONDIT B-482 is excellent for bonding, potting, or sealing where rapidly changing temperature environment requires it.

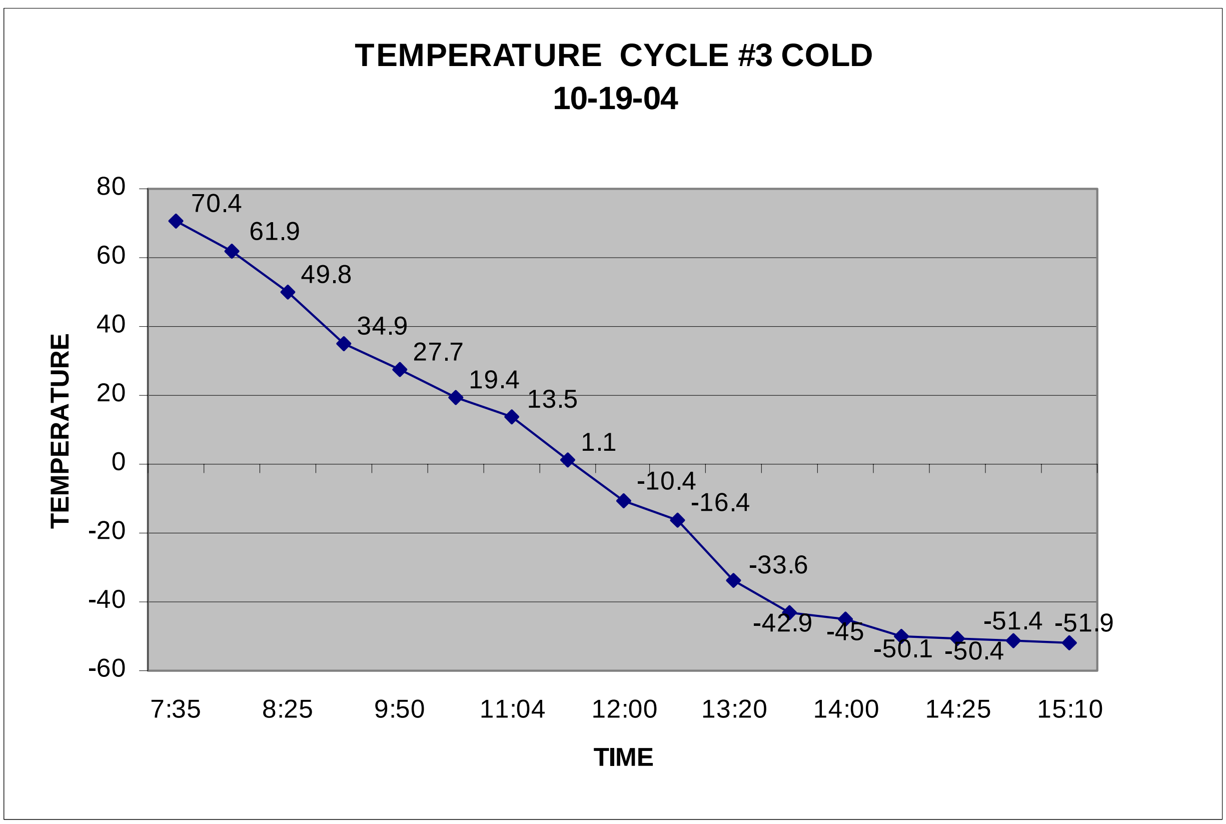

TEMPERATURE CYCLE #1 COLD
10-11-04
TEMPERATURE DEG. F
100
80
60
40
20
0
-20
-40
-60
75
TEMPERATURE CHANGE
41.8
37.3
34.4
27.6
24.1
19.4
4.7
-1.4
-6.7
CO_2 BOTTLE CHANGE
9.2
-23.9
-40.4
-42.8
9:25 10:00 10:35 11:05 11:30 12:40 13:10 13:45 14:25 14:45 15:00 16:25 16:45 16:50
TIME


TEMPERATURE CYCLE #1 HOT
10-12-04
TEMPERATURE
160
140
120
100
80
60
40
20
0
68.2
78.1
82.1
92.1
103.3
113.9
121.6
126.8
137.6
145.9
150.5
150.8
150.4
149.7
7:35 8:00 8:20 9:10 9:45 10:45 11:20 11:40 12:27 13:05 13:35 13:55 14:15 14:35
TIME

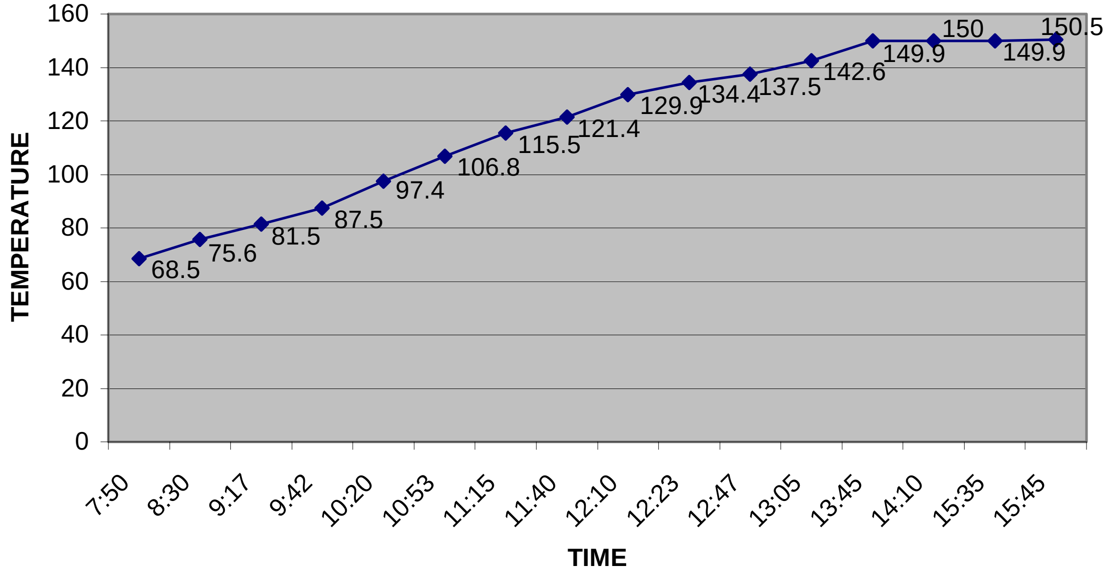

TEMPERATURE CYCLE #2 COLD
10-13-04
TEMPERATURE
TIME
80
60
40
20
0
-20
-40
-60
69.3
59.8
50.2
45.1
33.3
24.3
18.9
10.7
2.6
-12.2
-23.3
-34.6
-50.2
-44.4
OUT OF CO_2
7:25
8:10
8:35
9:00
9:43
10:20
10:45
11:15
11:45
13:00
13:47
14:20
15:00
15:20


TEMPERATURE CYCLE #2 HOT
10-14-04
TEMPERATURE
TIME
160
140
120
100
80
60
40
20
0
69.6
75.2
84.4
92.2
106.7
118.3
125.7
143.3
150.9
146.4
146.1
7:57
8:45
9:30
10:00
10:55
11:40
12:05
12:52
13:40
14:10
14:40

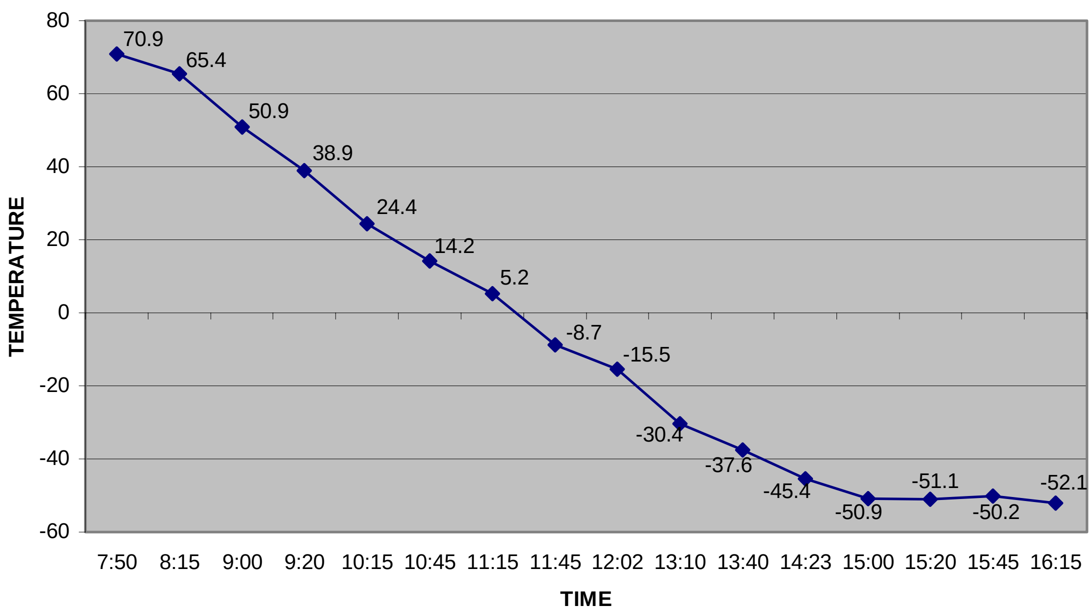

ABORTED THIRD COLD CYCLE
10-15-04
TEMPERATURE
TIME
80
70
60
50
40
30
20
10
0
7:50
8:20
9:00
9:40
9:50
10:07
10:50
69.1
39.4
35.4
27.8
22.9
19.5
34.3
TEMPERATURE CHANGE EXCEEDS 20 DEG IN 45 MIN
THE CO2 WAS EXHOSTED DUE TO CYLINDER CONFIGURATION
TEST ABORTED DUE TO DELIVERY TIME FRAME OF CO2

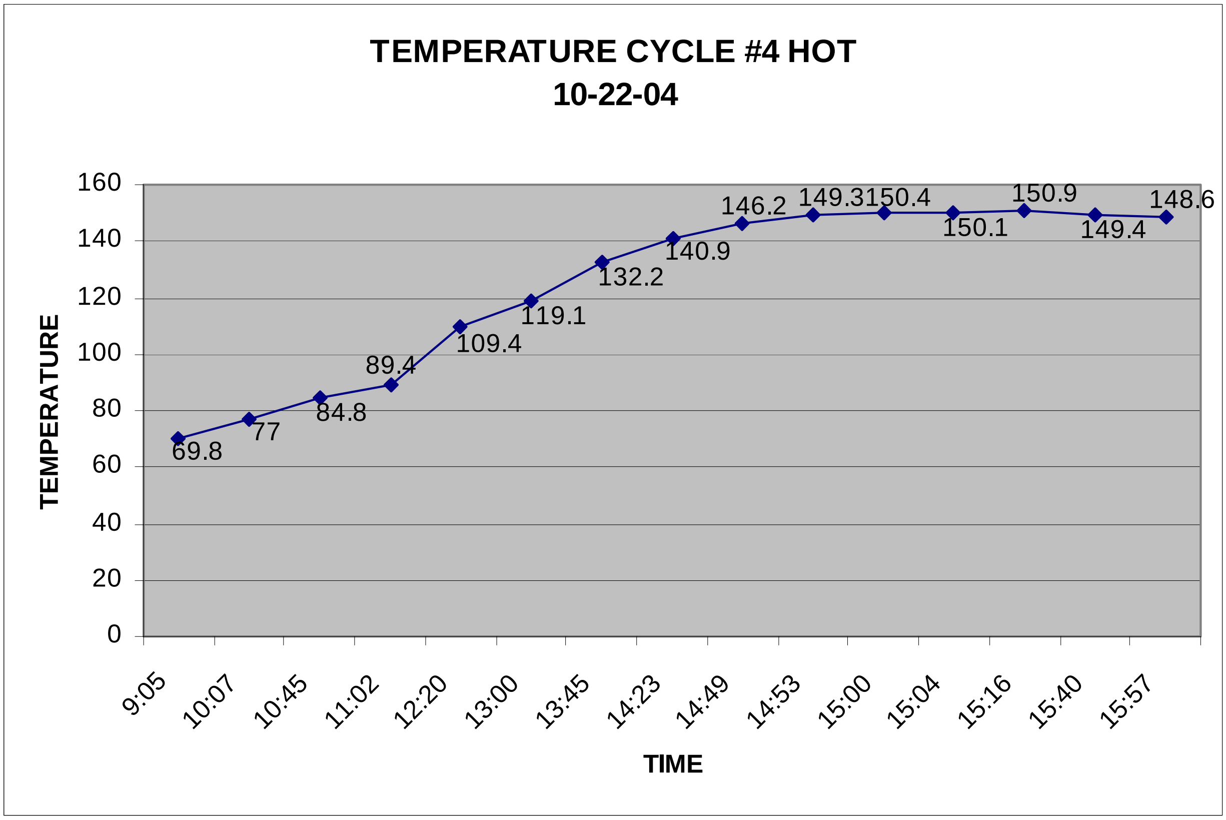

TEMPERATURE CYCLE #3 COLD
10-19-04
TEMPERATURE
TIME
80
60
40
20
0
-20
-40
-60
7:35
8:25
9:50
11:04
12:00
13:20
14:00
14:25
15:10
70.4
61.9
49.8
34.9
27.7
19.4
13.5
1.1
-10.4
-16.4
-33.6
-42.9
-45
-50.1
-50.4
-51.4
-51.9

TEMPERATURE CYCLE #3 HOT
10-20-04



TEMPERATURE CYCLE #4 COLD
10-21-04





TEMPERATURE CYCLE #4 HOT
10-22-04
TEMPERATURE
TIME
0
20
40
60
80
100
120
140
160
9:05
10:07
10:45
11:02
12:20
13:00
13:45
14:23
14:49
14:53
15:00
15:04
15:16
15:40
15:57
69.8
77
84.8
89.4
109.4
119.1
132.2
140.9
146.2
149.3
150.4
150.1
150.9
149.4
148.6

FIRST COLD CYCLE

DATE	TIME	TEMPERATURE
10/11/2004	9:25	75
	10:00	41.8
	10:35	37.3
	11:05	34.4
	11:30	27.6
	12:40	24.1
	13:10	19.4
	13:45	4.7
	14:25	-1.4
	14:45	-6.7
	15:00	9.2
	16:25	-23.9
	16:45	-40.4
	16:50	-42.8

SECOND COLD CYCLE

DATE	TIME	TEMPERATURE
10/13/2004	7:25	69.3
	8:10	59.8
	8:35	50.2
	9:00	45.1
	9:43	33.3
	10:20	24.3
	10:45	18.9
	11:15	10.7
	11:45	2.6
	13:00	-12.2
	13:47	-23.3
	14:20	-34.6
	15:00	-50.2
	15:20	-44.4

FIRST HOT CYCLE

DATE	TIME	TEMPERATURE
10/12/2004	7:35	68.2
	8:00	78.1
	8:20	82.1
	9:10	92.1
	9:45	103.3
	10:45	113.9
	11:20	121.6
	11:40	126.8
	12:27	137.6
	13:05	145.9
	13:35	150.5
	13:55	150.8
	14:15	150.4
	14:35	149.7

SECOND HOT CYCLE

DATE	TIME	TEMPERATURE
10/14/2004	7:57	69.6
	8:45	75.2
	9:30	84.4
	10:00	92.2
	10:55	106.7
	11:40	118.3
	12:05	125.7
	12:52	143.3
	13:40	150.9
	14:10	146.4
	14:40	146.1

THERMAL DATA

ABORTED COLD CYCLE

DATE	TIME	TEMPERATURE
10/15/2004	7:50	69.1
	8:20	39.4
	9:00	35.4
	9:40	27.8
	9:50	22.9
	10:07	19.5
	10:50	34.3

THIRD COLD CYCLE

DATE	TIME	TEMPERATURE
10/19/2004	7:35	70.4
	8:00	61.9
	8:25	49.8
	9:30	34.9
	9:50	27.7
	10:15	19.4
	11:04	13.5
	11:40	1.1
	12:00	-10.4
	12:22	-16.4
	13:20	-33.6
	13:50	-42.9
	14:00	-45
	14:10	-50.1
	14:25	-50.4
	15:00	-51.4
	15:10	-51.9

THIRD HOT CYCLE

DATE	TIME	TEMPERATURE
10/20/2004	7:50	68.5
	8:30	75.6
	9:17	81.5
	9:42	87.5
	10:20	97.4
	10:53	106.8
	11:15	115.5
	11:40	121.4
	12:10	129.9
	12:23	134.4
	12:47	137.5
	13:05	142.6
	13:45	149.9
	14:10	150
	15:35	149.9
	15:45	150.5

FOURTH COLD CYCLE

DATE	TIME	TEMPERATURE
10/21/2004	7:50	70.9
	8:15	65.4
	9:00	50.9
	9:20	38.9
	10:15	24.4
	10:45	14.2
	11:15	5.2
	11:45	-8.7
	12:02	-15.5
	13:10	-30.4
	13:40	-37.6
	14:23	-45.4
	15:00	-50.9
	15:20	-51.1
	15:45	-50.2
	16:15	-52.1

THERMAL DATA

FOURTH HOT CYCLE

DATE	TIME	TEMPERATURE
10/22/2004	9:05	69.8
	10:07	77
	10:45	84.8
	11:02	89.4
	12:20	109.4
	13:00	119.1
	13:45	132.2
	14:23	140.9
	14:49	146.2
	14:53	149.3
	15:00	150.4
	15:04	150.1
	15:16	150.9
	15:40	149.4
	15:57	148.6

THERMAL DATA

SAMPLE FIXTURES WITH RELTEK MATERIAL INSTALLED

THERMAL TEST SET - UP