Ball Aerospace & Technologies Corp.

M E M O R A N D U M

DATE: March 5, 2013

TO: 562/Parts Packaging and Assembly Technologies Office/Mr. J. Brusse

FROM: 541/Materials Engineering Branch/BATC/Mr. M. Shacka

SUBJECT: Evaluation of Solvent Resistance Tests for Counterfeit electrical, electronic, electromechanical (EEE) Part Detection

This work was performed in support of the NASA Electronic Parts and Packaging (NEPP) Program

Introduction

A growing awareness of counterfeit electrical, electronic, electromechanical (EEE) parts throughout the industry has occurred in the recent past. In order to reduce the risk of counterfeit EEE parts reaching any valuable hardware or equipment, various industry groups have been developing methodologies to identify suspect counterfeit parts. One methodology, referred to as "solvent test for remarking", involves exposing parts to specific solvents to assess whether the original part markings have been removed or altered and whether the device may have been subsequently remarked. Another methodology, referred to as "solvent test for resurfacing", involves exposing parts to several different solvents to assess whether the device package may have been altered by resurfacing the part to obscure the original part markings.

Jay Brusse/562 provided Code 541 with a test plan involving four different solvent tests currently being utilized by some in the industry for detection of suspect counterfeit EEE parts. These four tests are described in Table 1. The nine different EEE device types in Table 2 were provided by Code 562 to be subjected to these solvent tests. One part of each device type was subjected to each of the four different types of solvent exposure, and then visually inspected to determine if any damage had occurred to the part markings or the external package. Each solvent exposure test was performed on a new part from each device type rather than performing sequential exposures. A pre-exposure and post-exposure image was taken for each tested device.

Table 1. Solvent Tests for Detection of Suspect Counterfeit EEE Parts

Solvent Type	Solvent	Solvent Resistance Test Instructions
A	Acetone (CAS Registry Number: 67-64-1)	1. Dip a cotton swab into Acetone. 2. Wipe the swab across the surface of the part. 3. Document if the swab changes color or if the section wiped has a permanent color change or surface texture change.
B	1-Methyl 2-Pyrrolidinone (CAS Registry Number: 872-50-4)	1. Completely immerse the part in the solution and heat it to 115 ± 5 °C to 120 ± 5 °C, using a hot plate, for two to five minutes. 2. Once the part is removed from the solution, use a cotton swab to wipe the coating off. 3. Document if the swab changes color or if the section wiped has a permanent color change or surface texture change.
C	Dynasolve 750	1. Using a preheated solution of Dynasolve 750 at 105 ± 5°C, using a hot plate, completely immerse the part in the solution for 45 ± 5 minutes. 2. Once the part is removed from the solution, use a cotton swab to wipe the coating off. 3. Document if the swab changes color or if the section wiped has a permanent color change or surface texture change
D	Three parts Stoddard solvent (CAS Registry Number: 8052-41-3) with one part isopropyl alcohol (CAS Registry Number: 67-63-0)	1. Mix a solution of three parts Stoddard solvent with one part isopropyl alcohol. 2. Dip a cotton swab into the solution, and wipe the swab across the markings on the part. 3. Document if the swab changes color or if the section wiped has a permanent color change or surface texture change

*Each solvent exposure is to be performed on a new part rather than performed sequentially on the same part

Table 2. EEE Device Types Subjected to Solvent Tests

Item #	Part Type	Package Type	Part #	Manufacturer	LDC
1	Capacitor, Ceramic	Molded Case, Radial Lead	CCR06CG222JP	Kemet	8839
2	Microcircuit	Ceramic, 14 pin DIP	M38510H05051BCA	RCA	8934
3	Microcircuit	Plastic, 8 pin DIP	LM311	National Semiconductor	9024
4	Microcircuit	Plastic, 24 pin Gull Wing	LTC1272-3ACSW	LINEAR TECH	0018
5	Microcircuit	Plastic, 28 pin Gull Wing	AD9223AR	ANALOG	0015
6	Microcircuit	Plastic, 44 pin, LCC	XC18V04PC44C	XILINX	0333
7	Resistor, Metal Foil	Molded Case, Radial Lead	RNC90Y2K800TP	Vishay	9126
8	Transformer	Plastic Package, 8 pin gull wing	M21038/27-12	Pulse Electronics	9327A
9	Transistor	Plastic, 3 lead	2N3904	Motorola	8934

Conclusion

The main purpose of performing the solvent resistance tests was to determine if this test plan could potentially be used to detect suspect counterfeit devices, to assess the potential for any of these solvents to produce false positive results, and for GSFC to become familiar with these types of procedures. GSFC Code 562 believes that all nine device types provided are authentic as-received during the original procurement. Furthermore, these nine devices have remained in GSFC custody since the time of original receipt.

The summary results of these solvent tests are provided in Table 3. The results for each individual device type are provided in Tables 4 to 12.

Some general conclusions can be derived from the observation of how the solvents interacted with the provided parts.

Solvent A Test Plan-- Acetone

Solvent A had no effect on the part markings nor the external packages of any of the device types tested.

Solvent B Test Plan—1-Methyl 2-Pyrrolidinone

Solvent B caused fracturing of the external package for line item #7 – molded case radial leaded bulk metal foil resistor (see Table 10). However, the device had remained in the solvent for approximately 2 to 5 additional minutes after the beaker was removed from the hotplate prior to removal for the cotton swab test. The package fracture could have occurred during solvent exposure time beyond the required soak time. Retesting was performed using two additional parts from line item #7 limiting the solvent exposure time to the required 2 to 5 minutes. No package fractures occurred for these two devices (see Table 13).

An additional device from line item #7 was then retested using the solvent B test procedure, but this time it was left on the hot plate for a longer amount of time (approximately 5 minutes) to determine if an increased amount of heat exposure created the external package fracture. As seen in Table 14, the same type of damage did occur to the external package as occurred on the first sample that was tested beyond the required test time.

Solvent C Test Plan—Dynasolve 750

Solvent C caused significant degradation of the external package for line item #7-molded case radial leaded bulk metal foil resistor (see Table 10). The external markings were completely obliterated and the external package was significantly dissolved. However, it is exceedingly unlikely that this device is a suspect counterfeit part. For this type of molding compound, solvent C appears to be overly aggressive for use to detect suspect counterfeit components (i.e., false positive results are probable).

Solvent test procedure C also removed most of the part markings for device types #2 through #8. However, the acceptance criteria for solvent C allows for marking degradation since this solvent is primarily used to check for part resurfacing (i.e., package degradation) rather than remarking.

Solvent D Test Plan—Stoddard Solvent (i.e., mineral spirits) + isopropyl alcohol

Solvent D had no effect on the part markings nor the external packages of any of the device types tested

Discussion/Results

Four parts from each item number in Table 2 were randomly selected and placed in separate polyethylene bags. The bags were labeled to easily identify each part according to item number and solvent test which it would be exposed to according to Table 1 (Ex 1A, 2B, 3C, 4D…etc.). Each device was then photo-documented using a Nikon SMZ-U microscope. After the incoming inspection was completed, one different part from each item number was submitted to four different solvent exposure tests described in Table 1.

After the solvent resistance tests had been performed, each part was then photo-documented again using the Nikon SMZ-U microscope in order to document any changes that had occurred post solvent exposure. These images are presented below in Tables 4 through 12.

Table 3. Summary of Results from Solvent Resistance Testing

	Solvent A		**Solvent B**		**Solvent C**		**Solvent D**	
	Acetone		**1-Methyl 2-Pyrrolidinone** **See Note 5**		**Dynasolve 750** **See Notes 4, 5**		**Three parts Stoddard solvent with one part isopropyl alcohol**	
Line Item	*Marking Deteriorated?*	*Package Deteriorated?*	*Marking Deteriorated?*	*Package Deteriorated?*	*Marking Deteriorated?*	*Package Deteriorated?*	*Marking Deteriorated?*	*Package Deteriorated?*
1	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect
2	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 5**	**Yes See Note 6 See Table 5**	No Effect	No Effect
3	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 6**	**Yes See Note 6 See Table 6**	No Effect	No Effect
4	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 7**	**Yes See Note 6 See Table 7**	No Effect	No Effect
5	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 8**	**Yes See Note 6 See Table 8**	No Effect	No Effect
6	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 9**	**Yes See Note 6 See Table 9**	No Effect	No Effect
7	No Effect	No Effect	No Effect	**Package Fracture See Note 1 See Table 10**	**Yes See Note 3 See Table 10**	**Partially Dissolved See Note 2 See Table 10**	No Effect	No Effect
8	No Effect	No Effect	No Effect	No Effect	**Yes See Note 3 See Table 11**	**Yes See Note 6 See Table 11**	No Effect	No Effect
9	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect

Notes/Observations:

1. During the experiment with line item #7 and solvent B (1-Methyl 2-Pyrrolidinone), the device seemed to have experienced an external package fracture that is consistent with counterfeit properties. In order to confirm this finding, two additional line item #7 parts were tested again using the solvent B test procedure. In the initial experiment, the parts remained in the solvent after being taken off the hot plate, and while waiting for the swab wipe. In the additional tests, after the allotted time had passed, each device was removed immediately from the solvent. All three of the retested line item #7 showed no damage (Table 13). An additional line item #7 device was then retested again using the solvent B test procedure, but this time left on the hot plate for a longer amount of time (approximately 5 minutes) to determine if an increased amount of heat exposure created the external package fracture. As seen in Table 14, damage did occur to the external package.

2. The package deterioration seen with line item #7 during the Solvent C test can most likely be attributed to the aggressive nature of the Dynasolve 750. It is highly unlikely that this device is a suspect counterfeit part.

3. This particular solvent test is specified for its potential to degrade the package materials. Its effects on marking permanency are noted, but are not intended for uses as a discriminator for accept/reject results.

4. The Dynasolve solvent experienced a gradual color and phase change during the exposure time while on the hot plate (Figures 1-3). At the beginning of the experiment, the solvent was bright blue in color. Over time, the solvent transitioned to a yellowish brown color, and then to a reddish brown color. At the end of the allotted exposure time, the solvent had mostly turned into a solid state of form. This, however, did not appear to have an effect on the devices.

5. The hot plates used to heat solvents B and C are not universally consistent across the surface. The heat temperature deviations are accounted for in the error of the test plan, and the temperature of each solvent was checked three times during the duration of each test to ensure accuracy.

6. The packaging deterioration seen with line item #2, 3,4,5,6, and 8 was identified by the lifting of the packaging material during the swabbing of the device, after exposure to the solvent.

Table 4. Image Results for Line Item #1

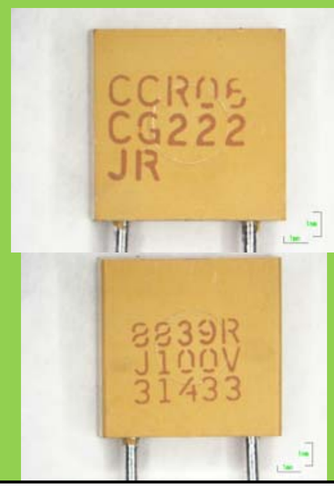
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	**1-Methyl 2-Pyrrolidinone**	**Dynasolve 750**	**Three parts Stoddard solvent with one part isopropyl alcohol**
1					

Table 5. Image Results for Line Item #2

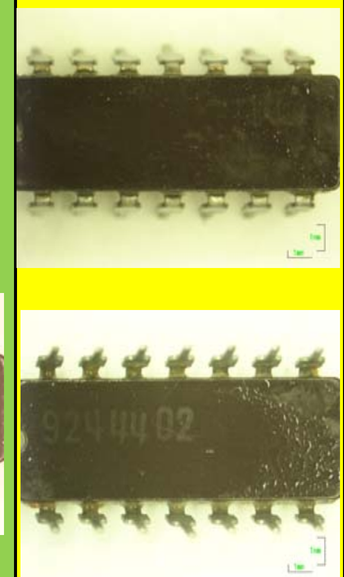
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
2					

Table 6. Image Results for Line Item #3

Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
3					

Table 7. Image Results for Line Item #4

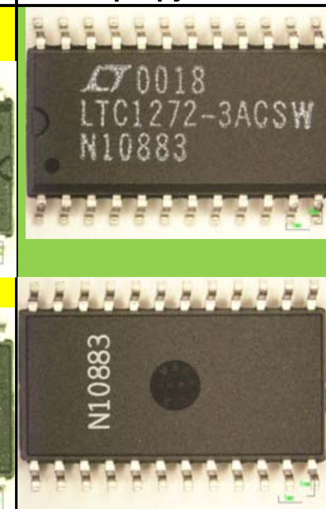
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
4					

Table 8. Image Results for Line Item #5

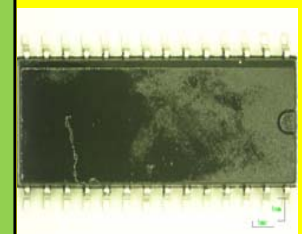
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
5					

Table 9. Image Results for Line Item #6

Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
6					

Table 10. Image Results for Line Item #7

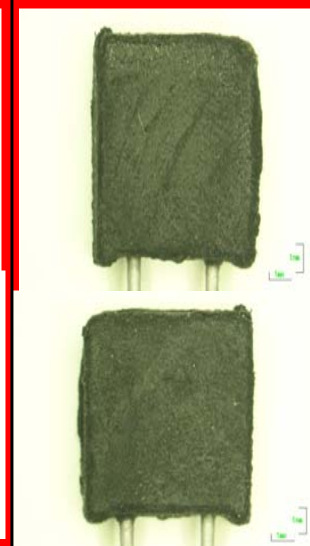
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
					

Table 11. Image Results for Line Item #8

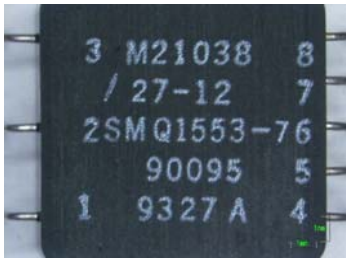
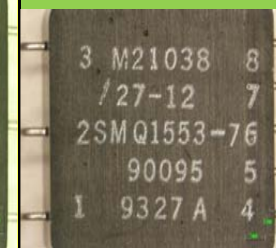
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
8					

Table 12. Image Results for Line Item #9

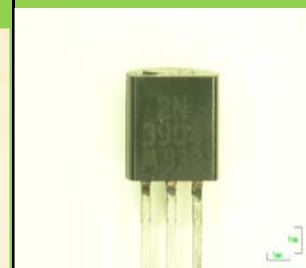
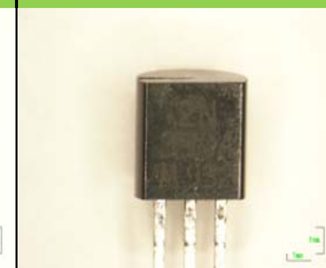
Line Item	As received	Solvent A	Solvent B	Solvent C	Solvent D
		Acetone	1-Methyl 2-Pyrrolidinone	Dynasolve 750	Three parts Stoddard solvent with one part isopropyl alcohol
9					

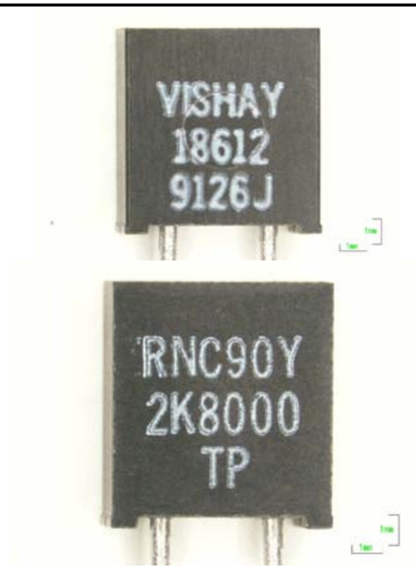
Table 13. Image Results for Line Item #7 Retest

During the initial test in Solvent B, the device package for line item #7 fractured (see Table 10). However, the exposure time in the solvent exceeded the required 2 to 5 minutes by approximately 5 minutes. These two retested samples were exposed to Solvent B, and then removed immediately after the 5 minutes had elapsed.

Line Item	As received	Solvent B Retest #1	Solvent B Retest #2
		1-Methyl 2-Pyrrolidinone	1-Methyl 2-Pyrrolidinone
7	 	 	 

Table 14. Image Results for Line Item #7 Retest With Increased Exposure Time (~10 minutes)

This retest was performed to confirm the initial test results (see Table 10) where the device package fractured after exposure to Solvent B for longer than the outlined 2 to 5 minute exposure.

Line Item	As received	Solvent B Retest #1
		1-Methyl 2-Pyrrolidinone
7		

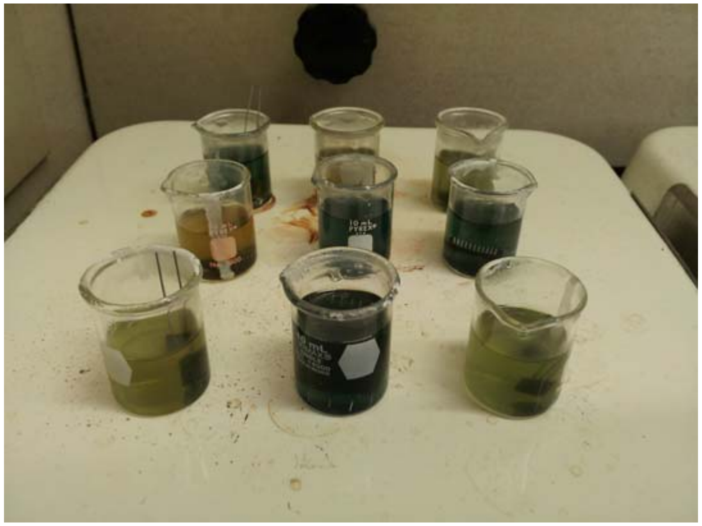


Figure 1. Solvent C (Dynasolve) Exposure at 10 minutes

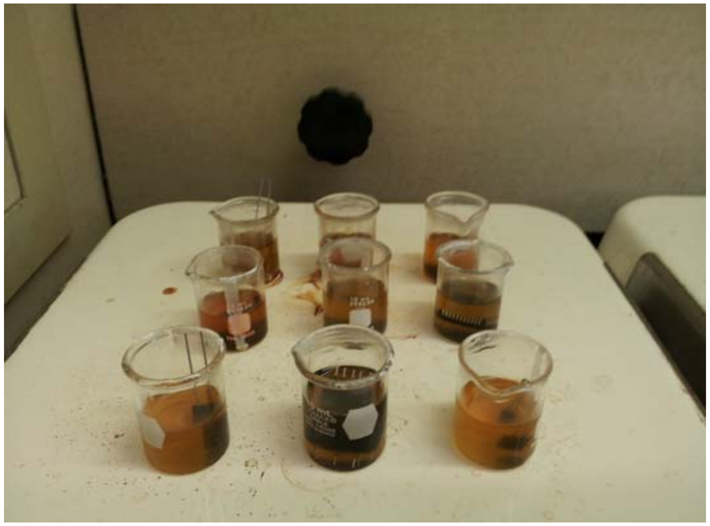


Figure 2. Solvent C (Dynasolve) Exposure at 20 minutes

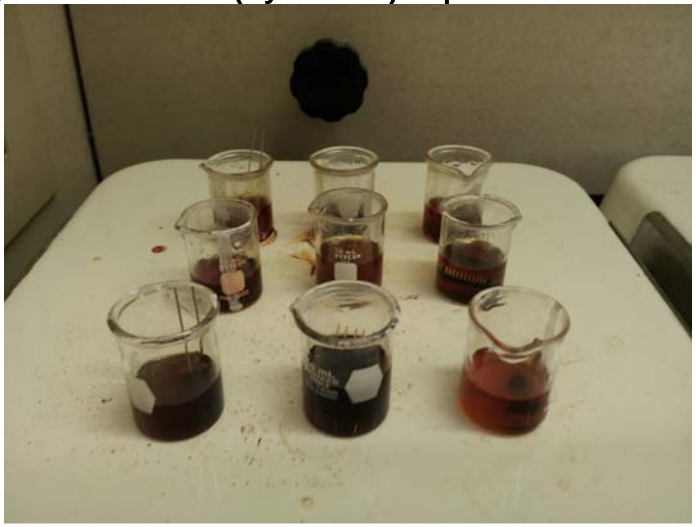


Figure 3. Solvent C (Dynasolve) Exposure at 45 minutes

Signed Copy Available Upon Request

Matthew Shacka