NASA-DOD PB-FREE ELECTRONICS REWORK PROJECT: EFFECT OF 1X AND 2X EUTECTIC SOLDER REWORK ON VIBRATION RELIABILITY

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ABSTRACT
Crane Naval Surface Warfare Center, a NASA-DOD Consortium member, added 30 test vehicles to the NASA-DOD Pb-free Electronics study (Project 2) in support of their Naval Supply Command (NAVSUP) sponsored "Logistics Impact of Pb-free Circuits/Components" project to quantify the effects of rework of Pb-free solder joints with SnPb solder. Multipass SnPb 1X and 2X rework was performed on Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components on SAC305 (24 boards) and SN100C (6 boards) soldered assemblies. Nine (9) boards were tested in drop shock, nine (9) in vibration, and eight (8) in accelerated thermal cycling test.

The boards were vibration tested for one hour each at 8, 10, 12, 14, 16, 18, 20, and 28 Grms. An event detector was used to electrically monitor and record failures. Overall, there were 461 failures out of a total of 567 components. The results appear to have a significant amount of variation. Our preliminary conclusion of this study is that, for the components reworked in this study, a qualified rework facility with a capable process can rework Pb-free boards with SnPb solder alloy and create solder joints that have reliability comparable to as-manufactured Pb-free assemblies.

Key words: rework, reliability, Pb-free SnPb compatibility

BACKGROUND
Crane Division, Naval Surface Warfare Center, a NASA/DOD Consortium member, added 30 test vehicles to the NASA/DOD study in support of their Naval Supply Command (NAVSUP) sponsored "Logistics Impact of Pb-free Circuits/Components" project.

The NAVSEA Crane project, through collaborative efforts with Science Applications International Corporation (SAIC), Purdue University, and Raytheon continues to analyze data and build a database of publicly available reliability results from consumer, military and aerospace electronics in order to assist the industry in quantifying the risks associated with choices of materials, processes, components and assemblies for Pb-free and mixed solder applications. This collaborative research and development project in Pb-free soldering has specific relevance to the reliability of rework and repair processes of new Pb-free, legacy SnPb and mixed systems using various combinations of Pb-free and legacy finished components and solder alloys in military systems.

The goal of the Crane NAVSUP project is to develop a critical evaluation of existing and new reliability data as it is developed, to fill research gaps in tin whisker formation, rework of Pb-free and Sn-Pb solder joints, and microstructural evidence for damage in reworked solder joints, and to assist in developing a strategy for DoD on military electronics affected by the Pb-free initiative, based on this in-depth critical analysis.
The original objective was to integrate the reworked test vehicles into the NASA/DOD -55°C to +125°C thermal cycling (Rockwell Collins), vibration (Boeing) and drop testing (Celestica) to minimize variation between the NASA/DOD and Crane test vehicle data sets. Due to

resource considerations vibration testing of the Crane reworked test vehicles was performed at Celestica.

OBJECTIVES

The goal of this testing was to generate initial data supporting the qualification of SnPb rework procedures for all military hardware built with Pb-free processes through analysis of thermal cycling, vibration and drop test data and subsequent testing and microsection and failure analysis.

The primary purpose of the 30 test vehicles add-on was to perform multipass SnPb rework X1 and X2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components on SAC305 and SN100C soldered assemblies. This study intends to answer the question, "Can a qualified rework facility with a capable process rework Pb-free boards with SnPb solder alloy and create solder joints that have a reliability comparable to as-manufactured Pb-free assemblies?"

This paper includes the preliminary analysis and conclusions of the vibration results of the Crane NASA/DOD Add-on. The main report and paper, including results for vibration, drop, and thermal cycling, will be available on the TEERM website [1] soon.

EXPERIMENTAL PROCEDURE

Test Vehicle

The test vehicle used in the NASA-DOD Pb-free Electronics Project is a 14.5" X 9" X 0.09" printed wiring assembly (PWA) with six 0.5-ounce copper layers, and is representative of assemblies used in defense and aerospace. Further details about the test vehicle, test vehicle assembly, and test components can be found on the NASA TEERM website [1] and in the NASA-DOD Pb-free Electronics Project Overview [2].

Figure 1. Test Vehicle used in NASA-DOD Pb-free Electronics Project.

Vibration test vehicles were assembled with SAC305 (reflow) and SN100C wave. All rework was performed using PbSn solder. Lead finish varied with component type and test vehicle number. Complete details of vehicle number, component location, package type, lead finish, and original solder can be found in the appendix. Figure 2 shows a schematic of the test vehicle with component locations.

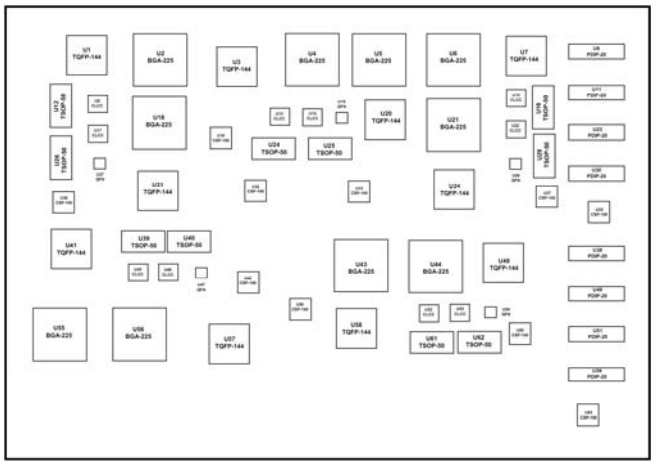

Figure 2. Test Vehicle Schematic with Reference Designators for Components.

Rework Procedure

The rework of PDIP, TSOP, TQFP and CLCC devices was performed at NSWC Crane using standard rework and repair procedures or variations thereof in accordance with IPC-7711. Repair procedures, where applicable, were performed in accordance with IPC-7721.

A total of 1072 components were removed and replaced on 30 test vehicles. One set of components was reworked once (1X) and a second set of components was reworked twice (2X). After rework, nine (9) test vehicles were subjected to drop testing, nine (9) test vehicles were subjected to vibration testing and eight (8) test vehicles subjected to -55°C/+125°C thermal cycling. Four (4) test vehicles were reworked and held in reserve not subjected to environmental testing.

Baking and Preheating

All rework sites were preheated to reduce thermal shock to the assembly and reduce process time. Using IPC procedure 2.5 Baking & Preheating, each component site reworked was placed on a 5-1/2" square conductive heater for ten minutes to raise the circuit card assembly (CCA) temperature to 125°C. Component-side temperatures were monitored with a Fluke model 52 digital thermometer. Adjacent components (within 5-1/2" heater area) requiring rework were reworked together wherever possible to minimize thermal stress to the assembly. Replacement components were staged on an adjacent preheater and transferred to the rework site.

Workmanship Standards

Component orientation, placement and soldering were inspected to IPC IPC-J-STD-001 and IPC-A-610 Class 3 requirements.

TQFP-100 and TSOP-50 Removal
Gull-wing leaded TQFP and TSOP components were removed using a 630°F soldering iron with small chisel tip and a #6 or #23 dental pick. RMA flux was applied to the leads/pads with a flux pen and each lead was individually reflowed and lifted. Residual solder was removed using IPC solder wick and blade tip procedure 4.4.1 using a flat blade tip p/n 1121-0305 with a tip temperature of 630°F.

TQFP-100 and TSOP-50 Installation
Components were placed, fluxed using a RMA flux pen and opposite corners tack soldered. IPC procedure 5.5.2 Multi-lead Method - Toe Tip was used with a single-sided chisel tip p/n 1121-0406 set at a tip temperature of 630°F.

CLCC-20 Removal
CLCC-20's were removed using a modified IPC-7711 Solder Wrap Method procedure 3.4.1. A 600°F METCAL box tip SMTC-012 was used in place of the tweezer specified in the procedure. Residual solder was removed using IPC solder wick and blade tip procedure 4.4.1 using a flat blade tip p/n 1121-0305 with a tip temperature of 630°F.

CLCC-20 Installation
CLCCs were installed using a modified IPC Solder Wire with blade tip procedure 5.6.1. The replacement components, manually tinned with SAC305, were inconsistant in solder quantity and finish. In an effort to establish better consistancy in coplanarity of residual solder thicknesses created by the tinning process, each part was fluxed and had solder manually redistributed with a Mini-Wave soldering iron tip p/n 1121-0490. Components were placed and fluxed using a RMA flux pen and soldered using same Mini-Wave soldering iron tip p/n 1121-0490. Tip temperature was 630°F.

PDIP-20 Removal
PDIP-20's were removed using IPC-7711 Through-Hole Desoldering procedure 3.1.4. Solder connections were lightly fluxed with RMA flux pen and desoldered using continuous vacuum extraction. Selected tip temperature varied from 700-800°F depending on relative thermal mass of the connection and was largely impacted by internal ground or power connections at the plated-through-hole. Incomplete extractions were resoldered and desoldered with a cooling step between each application of heat.

PDIP-20 Installation
PDIP-20's were soldered using standard through-hole soldering techniques using a 1/8" chisel tip. Tip temperature was set at 650°F.

Solder Shorts and Bridge Removal
Shorts and solder bridges were removed when necessary using IPC-7711 Draw Off procedure 6.1.3 or Braid Removal Method procedure 6.1.4.1 using a Mini-Wave soldering iron tip p/n 1121-0490. Tip temperature was 630°F.

Cleaning
All reworked components were allowed to cool and spot cleaned with isopropanol and acid brush and blotted dry with a lint-free tissue. Final cleaning was conducted prior to the end of each work shift using an AAT model 9201 aqueous cleaning system with an automated process. Drying was accomplished in a Grieve model AA-500 oven set at 150°F for two hours.

Damage Repair
During rework of TSOP components, two SMT lands were lifted. Those lifted lands were repaired using IPC Land Repair Epoxy Method procedure 4.7.1.

2X Rework
For boards requiring 2X rework of a part, the CCA was cooled and cleaned prior to completing the second round of rework.

QFN Rework
Standard QFN Rework
Pb-free QFN removal profile was baselined using a M.O.L.E.Scan process monitor. Removal profile was stored as profile #000185. As-manufactured Pb-free QFN's were removed using profile QFN Lead Free Removal #000185. (IPC Bottom Terminated Device Removal procedure 3.11).

1. Residual solder was removed from lands with solder wick and Alpha UP-78 paste flux using IPC 7711 procedure 4.4.1 Surface Mount Land method.
2. Rework site was cleaned with isopropyl alcohol.
3. A 4 mil stainless steel stencil with 1:1 aperture aspect ratio and window-paned thermal slug was aligned over QFN land sites.
4. Paste was applied to the site with Alpha OM-5100 no-clean tin-lead solder paste and stencil released.

Tin-lead QFN Installation profile was baselined using a M.O.L.E.Scan process monitor. Installation profile was stored as profile #000184.

1. Replacement QFNs were hand placed and reflowed on a Metcal/OK QX2 convection unit with QFN Tin Lead Place profile #000184. (IPC Bottom Terminated Device, Installation Pre-bump and place procedure 5.8.1.1).
2. Rework sites were spot cleaned with isopropyl alcohol and dried.
3. Batch aqueous cleaning was accomplished with an Aqueous Technologies AQ-400CL washer.
4. Devices were X-rayed per IPC Class II requirements with a VJ Electronix (Nicolet) model X-1525 x-ray unit.
5. Device areas were inspected per IPC Class II requirements.

StencilMate QFN Rework

As manufactured Pb-free QFN's were removed using profile QFN Lead Free Removal #000185. (IPC Bottom Terminated Device Removal procedure 3.11)

1. Residual solder was removed from lands with solder wick and Alpha UP-78 paste flux using IPC 7711 procedure 4.4.1 Surface Mount Land method.
2. Rework sites were cleaned with isopropyl alcohol.
3. (IPC Bottom Terminated Device Installation Pre-bump and place with stay in place stencil procedure 5.8.1.2)
4. A 4 mil thick 1:1 aperture aspect ratio StencilMate™ stencil for the part was aligned and applied to the component lands.
5. Paste was applied to the component lands with Alpha OM-5100 no-clean tin-lead solder paste.
6. Solder was reflowed on QFN lands with a Metcal/OK QX2 convection unit with QFN Tin Lead Place profile #000184.
7. StencilMate™ stencil was removed from part and cleaned with isopropyl alcohol.
8. "Bumped" QFNs were inspected for solder consistancy and coplanarity.
9. A 4 mil thick 1:1 aperture aspect ratio StencilMate™ stencil was aligned to the board lands and pressure applied to activate the adhesive.
10. Paste was applied to the stencil apertures with Alpha OM-5100 no-clean Tin-Lead solder paste.
11. "Bumped" QFN were hand placed into the pasted apertures of the board stencil.
12. QFNs were reflowed on a Metcal/OK QX2 convection unit with QFN Tin Lead Place profile #000184.
13. Rework sites were spot cleaned with isopropyl alcohol and dried.
14. Batch aqueous cleaning was accomplished with an Aqueous Technologies AQ-400CL washer.
15. Devices were X-rayed per IPC Class II requirements with a VJ Electronix (Nicholet) model X-1525 x-ray unit.
16. Device areas were inspected per IPC Class II requirements.

VIBRATION TEST PROCEDURE

Vibration testing was performed at Celestica, with the intent of duplicating the vibration testing at Boeing reported in [3] and [4]. Each board was monitored for vibration response and net resistance for all 63 components. The assemblies were attached to the table with the supplied test fixture. Each sample was subjected to the stated random profiles starting at 8.0rms for 1 hour duration in the Z axis to the assemblies. Input levels increased by 2Grms with 1 hour duration at each step up to 20Grms. A final 28Grms profile was applied for 1 hour. The vibration response levels for each card at each input level were recorded along with any resistance events during the vibration.

Instrumentation for the test is shown in Table 1. Figure 3 shows the test setup for Batch 1. Figure 4 shows the vibration PSDs for the stress step levels of the test, which are outlined in Table 2.

Table 1. Instrumentation for Vibration Test.

Description	Serial Number	Calibration Date
LDS V894 Shaker with slip table	SP5302-001/1	N/A
Spectral Dynamics SD2560 Vibration Control System	1352	07/28/2009
LDS CA4 Charge Amplifier	C0010589	09/17/2009
LDS CA4 Charge Amplifier	C0010615	09/07/2009
Control Accelerometer: Unholtz-Dickie 10B10T	5644	09/23/2009
PCB P356A08 Auxiliary Accelerometer	20456	11/19/2009
PCB P356A08 Auxiliary Accelerometer	20459	11/19/2009
PCB P356A08 Auxiliary Accelerometer	13707	11/19/2009
PCB P356A08 Auxiliary Accelerometer	13708	11/19/2009
PCB P356A08 Auxiliary Accelerometer	13849	10/28/2009

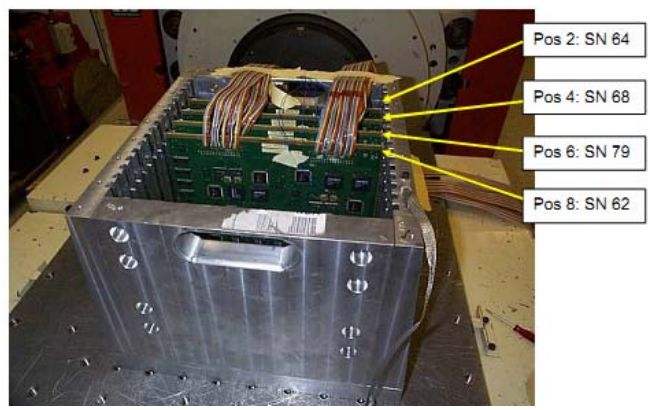

Figure 3. Test Setup for Batch 1.

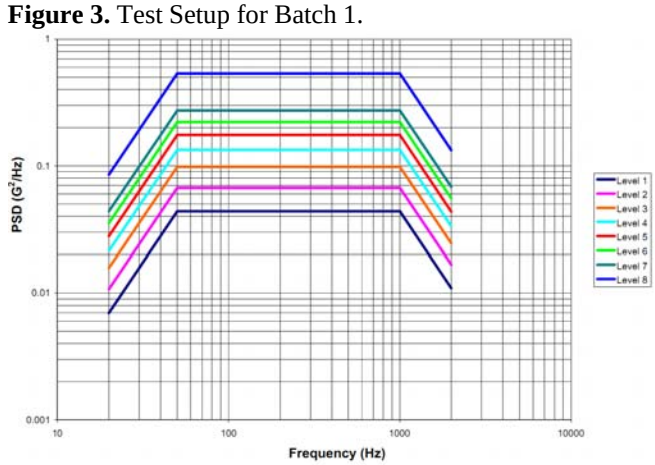

Figure 4. Vibration Spectrum.

Table 2. Vibration Profile Levels.

Level 1	Level 2	Level 3
20 Hz @ 0.00698 G^2/Hz	20 Hz @ 0.0107 G^2/Hz	20 Hz @ 0.0157 G^2/Hz
20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.0438 G^2/Hz	50 - 1000 Hz @ 0.067 G^2/Hz	50 - 1000 Hz @ 0.0984 G^2/Hz
1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.0109 G^2/Hz	2000 Hz @ 0.0167 G^2/Hz	2000 Hz @ 0.0245 G^2/Hz
Composite = 8.0 G_{rms}	**Composite = 9.9 G_{rms}**	**Composite = 12.0 G_{rms}**

Level 4	Level 5	Level 6
20 Hz @ 0.0214 G^2/Hz	20 Hz @ 0.0279 G^2/Hz	20 Hz @ 0.0354 G^2/Hz
20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.134 G^2/Hz	50 - 1000 Hz @ 0.175 G^2/Hz	50 - 1000 Hz @ 0.2215 G^2/Hz
1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.0334 G^2/Hz	2000 Hz @ 0.0436 G^2/Hz	2000 Hz @ 0.0552 G^2/Hz
Composite = 14.0 G_{rms}	**Composite = 16.0 G_{rms}**	**Composite = 18.0 G_{rms}**

Level 7	Level 8
20 Hz @ 0.0437 G^2/Hz	20 Hz @ 0.0855 G^2/Hz
20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.2734 G^2/Hz	50 - 1000 Hz @ 0.5360 G^2/Hz
1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.0682 G^2/Hz	2000 Hz @ 0.1330 G^2/Hz
Composite = 20.0 G_{rms}	**Composite = 28.0 G_{rms}**

FAILURE ANALYSIS

Cross-sectioning was performed at Celestica. Of the 9 boards, 33 parts, all representing electrical failures, were cross-sectioned. The cross-sections revealed a high degree of damage throughout the solder joints. This damage occurred across all cross-sectioned parts and did not seem to correlate to the part type, location on the board or type of solder, i.e. no significant difference between the Pb-free (non-reworked) parts and the reworked SnPb parts.

Twelve outliers, six bad fit and 22 reworked components were selected for analysis. Of these 40 initially selected parts, 7 fell off of the boards during vibration testing and as a result were not cross-sectioned. This left 33 parts in total for cross-sectioning. The cross-sections of specific components are shown in Figure 5 and listed in Table 3.

Interestingly, cross-sectioning revealed cracks in the actual copper leads of the TQFP-144 packages. This damage was observed only on parts which were not reworked and therefore the solder joint was Pb-free. A suggested reason for these failures is that Pb-free solder is stiffer than the SnPb solder and transfers more stress to the copper leads. In comparison, the alloy 42 lead frame parts all failed in the solder as opposed to the leads. In 7 cases noted above the solder failed completely and the intact parts fell off the boards during vibration testing.

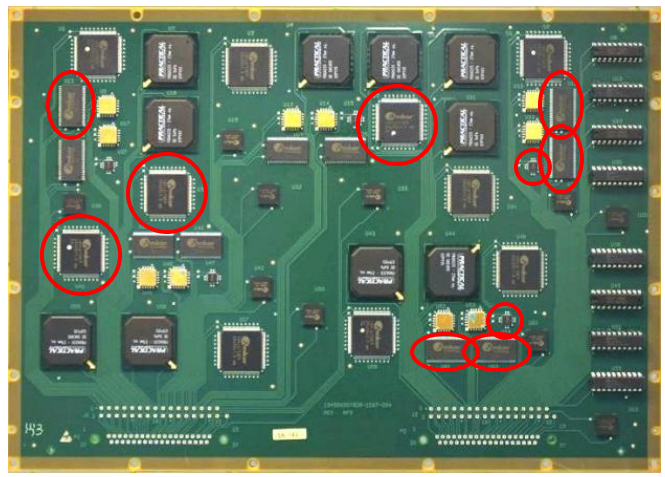

Figure 5. Locations of cross-sectioned components.

Table 3. Cross-Sectioned Components. (* represents one rework, ** represents two reworks)

Card		Package Style									
	CLCC-20	QFN-20		TQFP-144			TSOP-50				
61		U28**		U20							U62*
62					U31*					U61	
63	U52		U54*	U20	U31**	U41		U16**		U61*	U62
64											U62*
65	U52	U28**	U54*	U20		U41				U61*	U62
66										U61	U62*
67	U52		U54*		U31**					U61*	
68		U28*			U31*			U16*			
79		U28*					U12				

Selected Cross-Sections

CLCC-20

All of the tested CLCC-20s had SAC305 finishes. None of these solder joints were reworked. Solder cracks were observed around every solder joint, as shown in Figure 6.

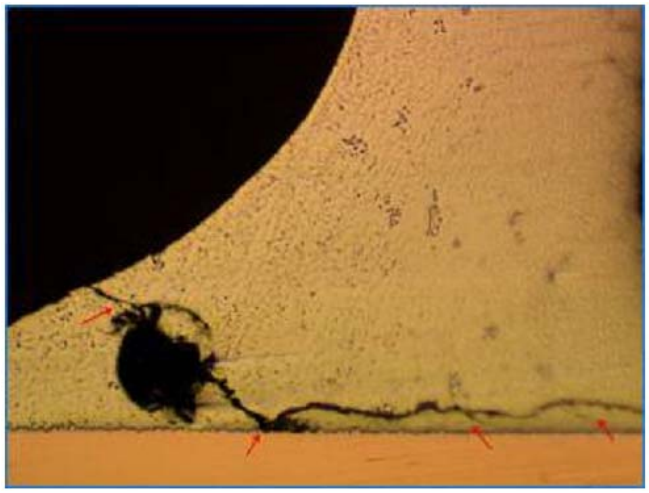

Figure 6. SN67 U52, Left Side Pad. CLCC-20, SAC 305 solder and finish, no rework performed.

QFN-20

All of the QFN-20 packages were fabricated using Sn finish and were subjected to one or two reworks with SnPb solder. Approximately half of the solder joints exhibited cracks which ran along the component pad. There does not appear to be a correlation between the cracked solder and the number of re-work cycles to which the part was exposed.

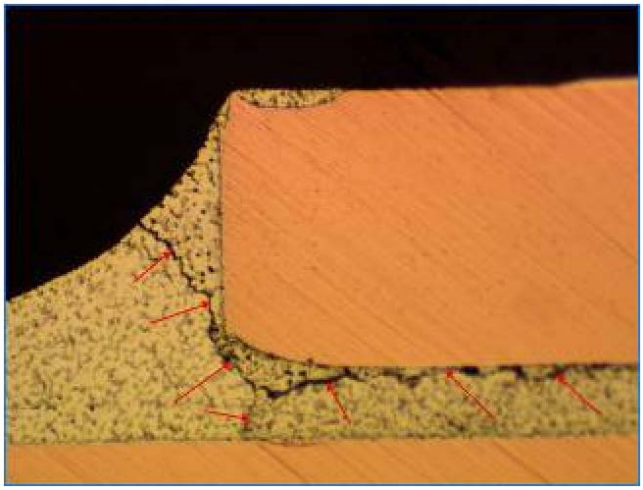

Figure 7. SN63 U54, Left Side Pad. QFN-20, SAC 305 solder and Sn finish, 1 rework with SnPb solder.

TQFP-144

All of the TQFP-144 packages were fabricated using Sn finish on the leads, and four of the nine were exposed to one or two re-work cycles with SnPb solder. All of the solder joints experienced significant cracking. Additionally, eight leads broke, all corresponding to components that did not undergo any rework and therefore contained only Pb-free solder.

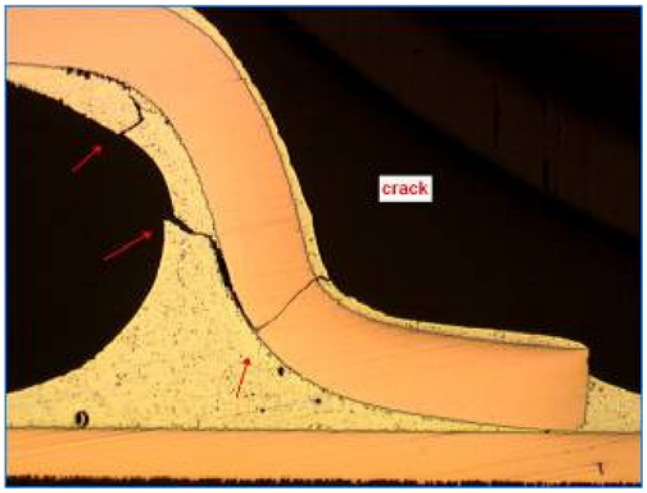

Figure 8. SN61 U20, Right Lead. TQFP-144, SAC 305 solder and Sn finish, no rework. Note that the lead is broken.

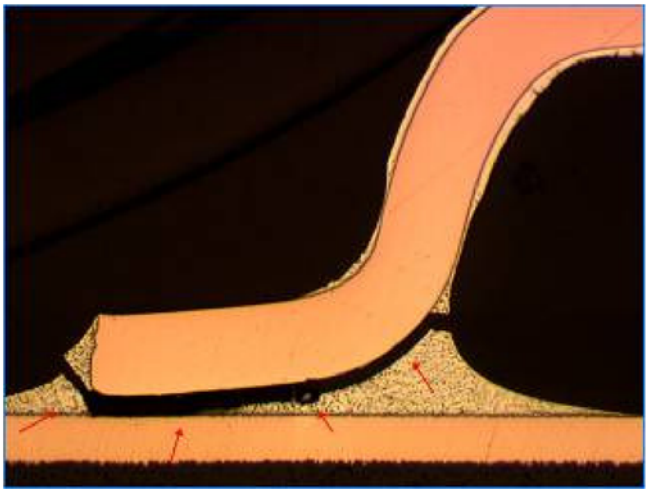

Figure 9. SN67 U31, Left Lead. TQFP-144, SAC 305 solder and Sn finish, 2 reworks with SnPb solder. Note that the lead is not broken.

TSOP-50

Among the cross-sectioned parts, all of the leads remained intact; however almost all of the solder joints experienced significant cracking. The TSOPs had finishes of either Sn or SnBi, and two thirds were reworked either one or two times using SnPb solder. There does not appear to be any correlation between the lead finish or the number of re-works with the incidence of cracking in the solder joint.

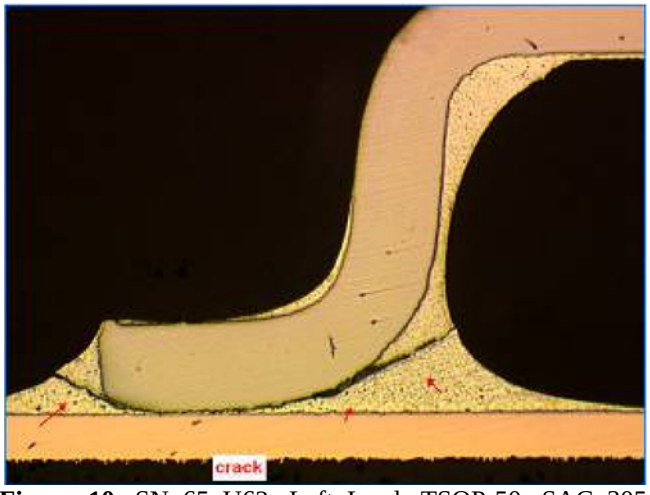

Figure 10. SN 65 U62, Left Lead. TSOP-50, SAC 305 solder and SnBi finish, one rework with SnPb solder.

RESULTS AND DISCUSSION

Comparison of Reworked Parts

A comparison of the results of the testing on the as-manufactured components vs. the reworked components is shown in Table 4. This table shows the package style of the component and identifies each by its approximate location on the board, as well as the assigned reference designator. A summary of the manufacturing conditions is included for convenience.

For each test group two statistics are included. These are the average time to failure in minutes, Tf, and the standard deviation of the time to failure, also in minutes. These statistics are shown for both the as-manufactured and the reworked conditions. In this table, any samples which did not fail have been assigned a Tf of 480 minutes, the time at which the test was suspended. This decision was made to prevent skewing the data toward earlier failure times.

In order to determine whether a significant change occurred between the two conditions, an F-test was performed on the data. The results are shown, along with the associated p-value. Any case where the p-value is less the 0.05 (5%), can be considered significant at the 95% level. For significant results we can conclude that the shift in the means between the two conditions is distinguishable from one another. In the other cases, we do not have enough evidence to reject the hypothesis that the means are the same.

Figure 11 shows a graph of the actual differences between the test groups. In this graph, the vertical axis shows the delta Tf, or the Tf of the reworked samples minus the Tf for the as-manufactured samples. If the delta Tf is positive, the average Tf for the reworked samples was higher than the average Tf for the as-manufactured parts. If the delta Tf is negative, the average Tf for the reworked samples was lower than the average Tf for the as-manufactured parts.

Looking at the graph, overall, it appears that rework had minimal effect in most cases. There are only five sets of tests where the absolute value of the delta Tf was 75 or larger. In two cases, the CLCC-20 and PDIP-20, the delta Tf was positive, and for three others, aTQFP-144 and two TSOP-50s, it was negative.

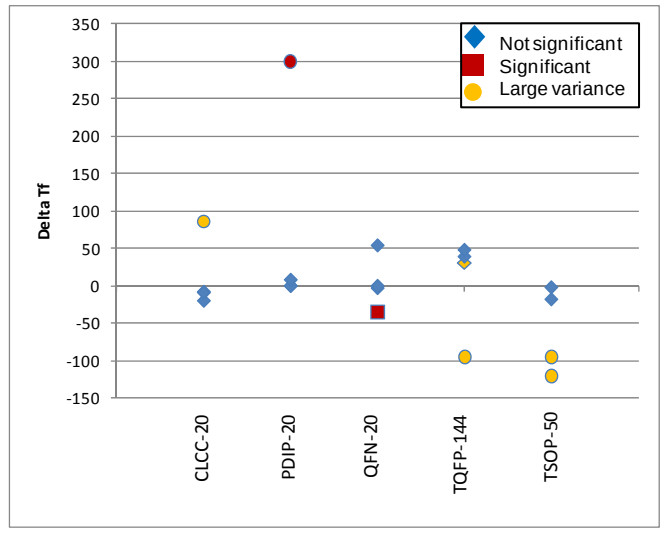

Figure 11. The difference in average Tf for each component type when comparing as-manufactured parts to reworked parts.

Starting with the cases where the reworked samples failed more quickly, there were two test runs where the reworked TSOP-50s did not perform as well as samples in the as-manufactured condition. In one run, the reworked parts failed 121 minutes earlier. This was U62, and the difference can be attributed to one outlier; an early life failure on just one reworked sample. Another TSOP, U61 failed an average of 95 minutes earlier after rework. The test results are shown in Figure 12.

This graph is shown as a box and whisker plot. The box is an icon which covers the middle half of the data. The whiskers extend out the minimum and maximum data points. The middle blue line is the median or middle data point.

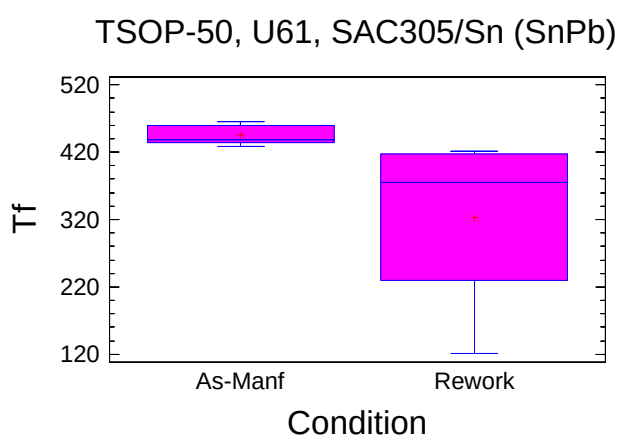

Figure 12. Test results for U61, in the as-manufactured condition and after rework.

Table 4. Results of Testing on As-Manufactured and Reworked Components.

	Conditions				Results with samples which did not fail						
					As-Manufactured		1st SnPb Rework		Statistics		
	Site	Solder	Lead	Board	Average Tf	Standard Deviation	Average Tf	Standard Deviation	F-Test	P-Value	Variance Check
CLCC-20	U52	SAC305	SAC305	ImAg	360	162	446	19	1.39	0.2763	0.001
	U45	SAC305	SAC305	ImAg	465	25	457	27	0.2	0.6654	0.9
	U46	SAC305	SAC305	ImAg	451	26	431	54	0.56	0.4793	0.215
	U53	SAC305	SAC305	ImAg	465	12	456	29	0.39	0.5533	
PDIP-20	U59	SN100C	NiPdAu	ImAg	480	0	480	0	NA	NA	NA
	U23	SN100C	Sn	ImAg	480	0	480	0	NA	NA	NA
	U30	SN100C	Sn	ImAg	150	197	158	91	0.01	0.9378	0.237
	U38	SN100C	Sn	ImAg	162	213	462	25	7.78	0.0316	0.005
QFN-20	U47	SAC305	Sn	ImAg	347	48	401	39	1.3	0.2762	0.632
	U27	SAC305	Sn	ImAg	480	0	477	4.5	1.3	0.2924	NA
	U28	SAC305	Sn	ImAg	480	0	445	32	5.47	0.047	NA
	U54	SAC305	Sn	ImAg	480	0	480	0	NA	NA	NA
TQFP-144	U57	SAC305	Sn	ImAg	271	101	310	21	0.74	0.4172	0.012
	U58	SAC305	Sn	ImAg	220	54	251	35	0.96	0.359	0.462
	U48	SAC305	Sn	ImAg	439	5	344	111	3.83	0.0914	0.00005
	U41	SAC305	Sn	ImAg	392	56	440	32	2.54	0.1553	0.352
TSOP-50	U61	SAC305	Sn	ImAg	445	5	421	111	3.87	0.0899	0.002
	U39	SAC305	Sn	ImAg	457	20	439	29	1.18	0.313	0.566
	U62	SAC305	SnBi	ImAg	472	11	351	158	0.1284	2.97	0.0002
	U26	SAC305	SnBi	ImAg	362	55	360	53	0	0.9571	0.709

The final case is a TQFP-144, U48, which failed 95 minutes quicker after rework than before. In this test run, the as-manufactured components had an average Tf of 439 minutes, while the reworked components had a Tf of 344 minutes.

In two cases, the reworked samples lasted much longer than as-manufactured samples. The most extreme example was a test run where PDIP-20, U38, lasted 300 minutes longer after rework. A graph of the results is shown in Figure 3.

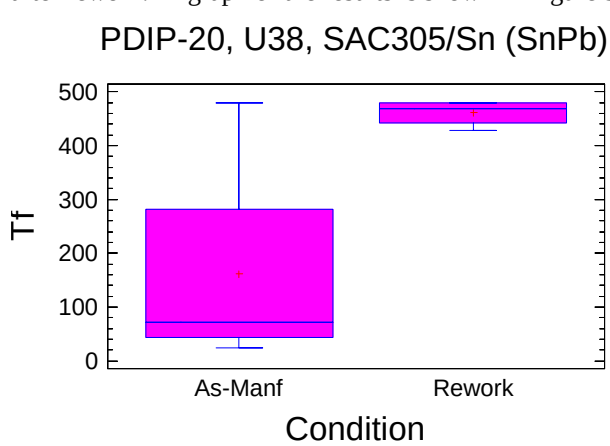

Figure 13. Results of PDIP-20, U38 in as-manufactured condition and after rework.

These extreme results are due to three early life failures of the as-manufactured components, all failing in the first 80 minutes. The final as-manufactured sample survived the test, operating successfully after 480 minutes.

Finally, a CLCC-20, U52, lasted 82 minutes longer after rework than the as-manufactured samples. Reviewing the data, this is due to one early life failure in the as-manufactured samples.

Reviewing the F-test results, there were only two cases where the differences between the "as-manufactured" and "reworked" test conditions were large enough to be statistically significant. These are denoted with red boxes on Figure 11. In all other cases, the results were not significant. Since statistical significance is a relative benchmark, this may be due to one of several factors. One factor is the difference in response between the test conditions, or the time to failure, in our case. If the difference is not large enough, the results will not be significant. Another factor is sample size. With more samples, the test will be more sensitive to smaller differences in the response. In our case, we had relatively few samples, four per test group in some cases. In order to maintain the significance level of 95%, fewer samples meant that the power of the test would be decreased. The final factor is unexplained variation in the data. It is harder to detect a "signal" in the data if there are

high levels of "noise." We have mentioned several outliers, unusual results, and dispersion of the results.

Another potential "noise" problem is large differences in variation between sample test groups. When we performed the F-tests, we tested for differences in the variation between the groups using Bartlett's Test. The p-values for the variance check are shown in Table 4. Cases where the p-value is less than 0.05 (5%) show that there is a significant difference in the variation between the sample test groups. The significant results are shown as circles on Figure 11. Difference in variation between the test groups can distort the F-test results.

A comparison of the results of the testing on the components reworked once vs. those reworked twice is shown in Table 5. Figure 14 shows a graph of the actual differences between the test groups. The results for components reworked once are remarkably similar to those reworked twice. Only two runs have an average time to failure difference greater than 75 minutes. Interestingly, in both of these cases, the components reworked twice lasted longer on the average than those reworked once.

One case where the samples reworked twice lasted longer was a TQFP-144, U34. The results are depicted in Figure 15. Note both the difference in average and variation in time to failure.

One example where the time to failure after one rework was similar to the time to failure after two reworks is TQFP-144, U07, and is shown in Figure 16. The samples that were reworked twice lasted slightly longer, but not enough to be significantly different. The variances are also not significantly different.

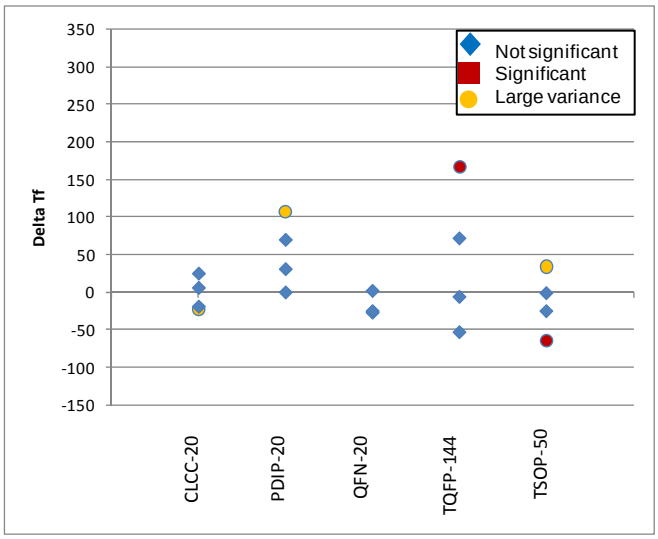

Figure 14. The difference in average Tf for components reworked once vs reworked twice.

Table 5. Results of Tests on Components Reworked Once vs. Twice.

	Conditions				Results with samples which did not fail						
					1st Rework		2nd Rework		Statistics		
	Site	Solder	Component	Board	Average Tf	Standard Deviation	Average Tf	Standard Deviation	F-Test	P-Values	Variance Check
CLCC-20	U10	SAC305	SAC305	ImAg	407	44	413	72	0.02	0.8849	0.404
	U22	SAC305	SAC305	ImAg	421	45	446	37	0.86	0.3821	0.75
	U09	SAC305	SAC305	ImAg	417	10	394	69	0.44	0.532	0.011
	U17	SAC305	SAC305	ImAg	480	0	461	38	1.3	0.294	NA
PDIP-20	U51	SN100C	NiPdAu	ImAg	323	190	393	128	0.31	0.5989	0.57
	U08	SN100C	Sn	ImAg	368	223	475	9	0.92	0.3746	0.0003
	U11	SN100C	Sn	ImAg	480	0	480	0	NA	NA	NA
	U49	SN100C	Sn	ImAg	75	87	106	124	0.13	0.7303	0.63
QFN-20	U15	SAC305	Sn	ImAg	117	48	90	49	0.67	0.4386	0.979
	U27	SAC305	Sn	ImAg	478	5	480	0	1.3	0.2924	NA
	U28	SAC305	Sn	ImAg	446	33	421	36	1.19	0.3116	0.867
TQFP-144	U07	SAC305	Sn	ImAg	258	95	330	44	2.36	0.1681	0.185
	U31	SAC305	Sn	ImAg	422	42	416	27	0.07	0.8049	0.472
	U34	SAC305	Sn	ImAg	213	145	380	11	6.78	0.0375	0.0002
	U01	SAC305	Sn	ImAg	377	33	324	73	2.13	0.1877	0.174
TSOP-50	U25	SAC305	Sn	ImAg	170	14	145	43	1.56	0.2517	0.07
	U29	SAC305	Sn	ImAg	394	71	428	17	1.07	0.3344	0.023
	U40	SAC305	SnBi	ImAg	381	12	317	46	7.15	0.0318	0.048
	U16	SAC305	SnBi	ImAg	386	28	385	34	0	0.9681	0.755

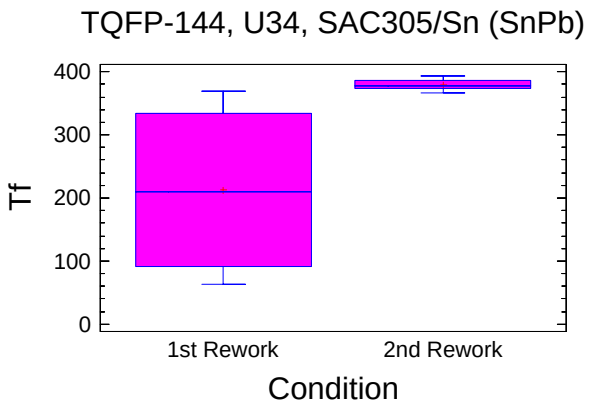

Figure 15. Results of TQFP-144, U34 after first and second rework.

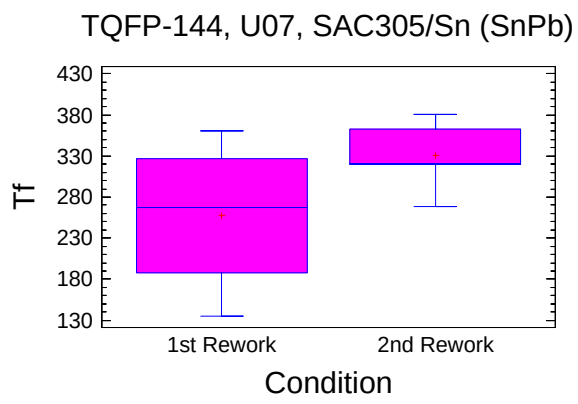

Figure 16. Results of TQFP-144, U07 after first and second rework.

These rework results are in contrast with previous results showing a negative effect due to rework [1,3,4]. Review of that data shows those results to be heavily weighted by early failures of reworked BGA's. Reworked BGA's were not evaluated for this study. Furthermore, direct site-to-site comparison of BGA data from this study to a previous study, using the same test vehicle and test parameters, show statistically significant differences between identically processed components. Of the 9 direct site-to-site comparisons possible, 7 were determined to be significantly different, with 6 of the sites having a lower average time to failure. The reasons for the difference between testers are unknown.

SUMMARY

Crane Naval Surface Warfare Center, a NASA-DOD Consortium member, added 30 test vehicles to the NASA-DOD Pb-free Electronics study (Project 2) in support of their Naval Supply Command (NAVSUP) sponsored "Logistics Impact of Pb-free Circuits/Components" project to quantify the effects of rework of Pb-free solder joints with SnPb solder. Multipass SnPb 1X and 2X rework was performed on Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components on SAC305 (24 boards) and SN100C (6 boards) soldered assemblies. Nine (9) boards were tested in drop shock, nine (9) in vibration, and eight (8) in accelerated thermal cycling test.

The boards were vibration tested for one hour each at 8, 10, 12, 14, 16, 18, 20, and 28 Grms. An event detector was used to electrically monitor and record failures. Overall, there were 461 failures out of a total of 567 components. The results appear to have a significant amount of variation, especially with respect to different vibration batches and different test locations (Boeing vs. Celestica).

Based on our statistical analysis, for the components reworked in this study, a qualified rework facility with a capable process can rework Pb-free boards with SnPb solder alloy and create solder joints that have reliability comparable to as-manufactured Pb-free assemblies.

As mentioned in the objective the main report and paper, including results for vibration, drop, and thermal cycling, will be available on the TEERM website [1] soon. In the main report we will attempt to address concerns regarding differences in batches and test locations.

REFERENCES

[1] NASA Technology Evaluation for Environmental Risk Mitigation (TEERM) Principal Center website: http://teerm.nasa.gov

[2] K. Kessel, "NASA-DOD Lead-Free Electronics Project: Overview," Proceedings of SMTA International, September 2010.

[3] T. Woodrow, "NASA-DOD Lead-Free Electronics Project: Vibration Test," Proceedings of SMTA International, September 2010.

[4] T. Woodrow, "NASA-DOD Lead-Free Electronics Project: Vibration Test," Boeing Electronics Materials and Processes Report, November 18, 2010.

APPENDIX

Table 1. Complete Data Set for Crane NASA-DOD Add-on.

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN62	18	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	331	F
1	SN64	28	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	424	F
2	SN66	20	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	381	F
1	SN68	20	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	373	F
1	SN79	20	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	378	F
2	SN61	20	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	385	F
2	SN63	20	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	388	F
2	SN65	16	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	281	F
2	SN67	16	U1	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	244	F
2	SN61	8	U2	BGA-225	BGA-225	SAC405	SAC305		0	30	F
1	SN62	8	U2	BGA-225	BGA-225	SAC405	SAC305		0	58	F
2	SN63	10	U2	BGA-225	BGA-225	SAC405	SAC305		0	74	F
1	SN64	8	U2	BGA-225	BGA-225	SAC405	SAC305		0	21	F
2	SN65	8	U2	BGA-225	BGA-225	SAC405	SAC305		0	48	F
2	SN66	12	U2	BGA-225	BGA-225	SAC405	SAC305		0	130	F
2	SN67	8	U2	BGA-225	BGA-225	SAC405	SAC305		0	34	F
1	SN68	10	U2	BGA-225	BGA-225	SAC405	SAC305		0	62	F
1	SN79	10	U2	BGA-225	BGA-225	SAC405	SAC305		0	65	F
2	SN61	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	106	F
1	SN62	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	95	F
2	SN63	12	U3	TQFP-144	TQFP-144	Sn	SAC305		0	133	F
1	SN64	12	U3	TQFP-144	TQFP-144	Sn	SAC305		0	141	F
2	SN65	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	101	F
2	SN66	12	U3	TQFP-144	TQFP-144	Sn	SAC305		0	127	F
2	SN67	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	78	F
1	SN68	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	101	F
1	SN79	10	U3	TQFP-144	TQFP-144	Sn	SAC305		0	113	F
2	SN61	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	12	F
1	SN62	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	14	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN64	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	14	F
2	SN65	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	3	F
2	SN66	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	8	F
2	SN67	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	4	F
1	SN68	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	12	F
1	SN79	8	U4	BGA-225	BGA-225	SAC405	SAC305		0	15	F
2	SN61	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	12	F
1	SN62	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	19	F
2	SN63	28	U5	BGA-225	BGA-225	SAC405	SAC305		0	480	S
1	SN64	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	14	F
2	SN65	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	6	F
2	SN66	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	11	F
2	SN67	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	4	F
1	SN68	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	14	F
1	SN79	8	U5	BGA-225	BGA-225	SAC405	SAC305		0	15	F
2	SN61	10	U6	BGA-225	BGA-225	SAC405	SAC305		0	82	F
1	SN62	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	54	F
2	SN63	10	U6	BGA-225	BGA-225	SAC405	SAC305		0	72	F
1	SN64	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	39	F
2	SN65	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	28	F
2	SN66	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	32	F
2	SN67	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	29	F
1	SN68	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	30	F
1	SN79	8	U6	BGA-225	BGA-225	SAC405	SAC305		0	41	F
2	SN61	16	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	293	S
2	SN63	20	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	361	F
2	SN65	16	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	241	F
2	SN67	12	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	135	F
1	SN62	18	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	320	F
1	SN64	20	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	363	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN68	20	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	381	F
1	SN79	16	U7	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	268	F
2	SN61	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
1	SN62	8	U8	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	50	F
2	SN63	8	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	33	F
2	SN65	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN67	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
1	SN64	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
2	SN66	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
1	SN68	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
1	SN79	28	U8	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	462	F
1	SN62	28	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	427	F
1	SN64	28	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	467	F
2	SN66	20	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	413	F
1	SN68	28	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	426	F
1	SN79	20	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	406	F
2	SN61	28	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	422	F
2	SN63	28	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
2	SN65	18	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	337	F
2	SN67	18	U9	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	340	F
2	SN61	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	431	F
2	SN63	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	431	F
2	SN65	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	424	F
2	SN67	18	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	341	F
1	SN62	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	431	F
1	SN64	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	451	F
2	SN66	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	425	F
1	SN68	28	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	471	F
1	SN79	16	U10	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	287	F
1	SN62	12	U11	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	175	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN66	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
1	SN68	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
1	SN79	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN61	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
2	SN63	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
2	SN65	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
2	SN67	28	U11	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	480	S
2	SN61	20	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	396	F
1	SN62	20	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	413	F
2	SN63	20	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	408	F
1	SN64	20	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	391	F
2	SN65	18	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	334	F
2	SN66	18	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	345	F
2	SN67	14	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	181	F
1	SN68	20	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	388	F
1	SN79	28	U12	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	423	F
2	SN61	14	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	185	F
1	SN62	14	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	191	F
2	SN63	14	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	214	F
1	SN64	14	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	187	F
2	SN65	12	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	160	F
2	SN66	14	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	222	F
2	SN67	12	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	138	F
1	SN68	12	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	157	F
1	SN79	12	U13	CLCC-20	CLCC-20	SAC305	SAC305		0	128	F
2	SN61	14	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	201	F
1	SN62	12	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	180	F
2	SN63	14	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	238	F
1	SN64	14	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	191	F
2	SN65	10	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	98	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN67	10	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	103	F
1	SN68	12	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	178	F
1	SN79	12	U14	CLCC-20	CLCC-20	SAC305	SAC305		0	124	F
1	SN62	10	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	1	84	F
1	SN64	12	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	1	136	F
2	SN66	14	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	1	188	F
1	SN68	10	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	1	113	F
1	SN79	10	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	1	64	F
2	SN61	12	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	2	132	F
2	SN63	12	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	2	122	F
2	SN65	8	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	2	24	F
2	SN67	10	U15	QFN-20	QFN-20	Sn	SAC305	SnPb	2	83	F
1	SN62	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	371	F
1	SN64	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	391	F
2	SN66	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	407	F
1	SN68	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	414	F
1	SN79	18	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	345	F
2	SN61	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	361	F
2	SN63	28	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	434	F
2	SN65	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	378	F
2	SN67	20	U16	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	366	F
1	SN62	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
1	SN64	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
2	SN66	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
1	SN68	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
1	SN79	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN63	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
2	SN65	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
2	SN67	28	U17	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
2	SN61	10	U18	BGA-225	BGA-225	SAC405	SAC305		0	89	F
1	SN62	12	U18	BGA-225	BGA-225	SAC405	SAC305		0	145	F
2	SN63	14	U18	BGA-225	BGA-225	SAC405	SAC305		0	231	F
1	SN64	10	U18	BGA-225	BGA-225	SAC405	SAC305		0	63	F
2	SN65	10	U18	BGA-225	BGA-225	SAC405	SAC305		0	108	F
2	SN66	12	U18	BGA-225	BGA-225	SAC405	SAC305		0	149	F
2	SN67	10	U18	BGA-225	BGA-225	SAC405	SAC305		0	97	F
1	SN68	12	U18	BGA-225	BGA-225	SAC405	SAC305		0	131	F
1	SN79	10	U18	BGA-225	BGA-225	SAC405	SAC305		0	106	F
2	SN61	18	U19	CSP-100	CSP-100	SAC105	SAC305		0	341	F
1	SN62	16	U19	CSP-100	CSP-100	SAC105	SAC305		0	288	F
2	SN63	20	U19	CSP-100	CSP-100	SAC105	SAC305		0	378	F
1	SN64	28	U19	CSP-100	CSP-100	SAC105	SAC305		0	424	F
2	SN65	18	U19	CSP-100	CSP-100	SAC105	SAC305		0	333	F
2	SN66	18	U19	CSP-100	CSP-100	SAC105	SAC305		0	329	F
2	SN67	16	U19	CSP-100	CSP-100	SAC105	SAC305		0	284	F
1	SN68	20	U19	CSP-100	CSP-100	SAC105	SAC305		0	374	F
1	SN79	18	U19	CSP-100	CSP-100	SAC105	SAC305		0	310	F
2	SN61	16	U20	TQFP-144	TQFP-144	Sn	SAC305		0	246	F
1	SN62	14	U20	TQFP-144	TQFP-144	Sn	SAC305		0	187	F
2	SN63	12	U20	TQFP-144	TQFP-144	Sn	SAC305		0	121	F
1	SN64	14	U20	TQFP-144	TQFP-144	Sn	SAC305		0	215	F
2	SN65	10	U20	TQFP-144	TQFP-144	Sn	SAC305		0	62	F
2	SN66	14	U20	TQFP-144	TQFP-144	Sn	SAC305		0	181	F
2	SN67	12	U20	TQFP-144	TQFP-144	Sn	SAC305		0	148	F
1	SN68	14	U20	TQFP-144	TQFP-144	Sn	SAC305		0	201	F
1	SN79	12	U20	TQFP-144	TQFP-144	Sn	SAC305		0	145	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN62	10	U21	BGA-225	BGA-225	SAC405	SAC305		0	103	F
2	SN63	10	U21	BGA-225	BGA-225	SAC405	SAC305		0	107	F
1	SN64	8	U21	BGA-225	BGA-225	SAC405	SAC305		0	34	F
2	SN65	8	U21	BGA-225	BGA-225	SAC405	SAC305		0	37	F
2	SN66	10	U21	BGA-225	BGA-225	SAC405	SAC305		0	86	F
2	SN67	8	U21	BGA-225	BGA-225	SAC405	SAC305		0	37	F
1	SN68	8	U21	BGA-225	BGA-225	SAC405	SAC305		0	46	F
1	SN79	10	U21	BGA-225	BGA-225	SAC405	SAC305		0	62	F
2	SN61	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	458	F
2	SN63	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	434	F
2	SN65	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	434	F
2	SN67	18	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	356	F
1	SN62	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
1	SN64	20	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	391	F
2	SN66	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	443	F
1	SN68	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	480	S
1	SN79	28	U22	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	2	434	F
1	SN62	28	U23	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	480	S
1	SN64	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	480	S
2	SN66	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	480	S
1	SN68	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	480	S
1	SN79	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	480	S
2	SN61	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN63	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN65	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN67	28	U23	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN61	14	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	205	F
1	SN62	12	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	167	F
2	SN63	16	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	279	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN65	14	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	231	F
2	SN66	14	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	236	F
2	SN67	14	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	202	F
1	SN68	16	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	255	F
1	SN79	14	U24	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	240	F
1	SN62	14	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	181	F
1	SN64	12	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	178	F
2	SN66	14	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	181	F
1	SN68	12	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	152	F
1	SN79	12	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	156	F
2	SN61	14	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	192	F
2	SN63	12	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	142	F
2	SN65	12	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	155	F
2	SN67	10	U25	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	89	F
2	SN61	28	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	430	F
2	SN63	20	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	379	F
2	SN65	18	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	335	F
2	SN67	18	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	304	F
1	SN62	18	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	344	F
1	SN64	20	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	369	F
2	SN66	18	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	357	F
1	SN68	16	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	292	F
1	SN79	28	U26	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	438	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN63	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN65	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	1	471	F
2	SN67	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
1	SN62	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	2	480	S
1	SN64	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	2	480	S
2	SN66	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	2	480	S
1	SN68	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	2	480	S
1	SN79	28	U27	QFN-20	QFN-20	Sn	SAC305	SnPb	2	480	S
1	SN62	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	1	425	F
1	SN64	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN66	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
1	SN68	20	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	1	408	F
1	SN79	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	1	435	F
2	SN61	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	2	450	F
2	SN63	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	2	428	F
2	SN65	20	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	2	368	F
2	SN67	28	U28	QFN-20	QFN-20	Sn	SAC305	SnPb	2	436	F
2	SN61	28	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	424	F
2	SN63	28	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	480	S
2	SN65	18	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	327	F
2	SN67	18	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	346	F
1	SN62	28	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	429	F
1	SN64	28	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	440	F
2	SN66	20	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	412	F
1	SN68	28	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	449	F
1	SN79	20	U29	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	2	409	F
2	SN61	28	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	437	F
1	SN62	20	U30	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	368	F
2	SN63	8	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	16	F
2	SN65	8	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	30	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN64	10	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	92	F
2	SN66	14	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	222	F
1	SN68	10	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	69	F
1	SN79	16	U30	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	250	F
1	SN62	18	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	351	F
1	SN64	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	449	F
2	SN66	20	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	415	F
1	SN68	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	452	F
1	SN79	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	442	F
2	SN61	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	422	F
2	SN63	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	433	F
2	SN65	28	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	432	F
2	SN67	20	U31	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	375	F
2	SN61	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	345	F
1	SN62	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	302	F
2	SN63	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	332	F
1	SN64	28	U32	CSP-100	CSP-100	SAC105	SAC305		0	426	F
2	SN65	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	322	F
2	SN66	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	341	F
2	SN67	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	306	F
1	SN68	20	U32	CSP-100	CSP-100	SAC105	SAC305		0	375	F
1	SN79	18	U32	CSP-100	CSP-100	SAC105	SAC305		0	334	F
2	SN61	20	U33	CSP-100	CSP-100	SAC105	SAC305		0	378	F
1	SN62	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	344	F
2	SN63	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	308	F
1	SN64	16	U33	CSP-100	CSP-100	SAC105	SAC305		0	291	F
2	SN65	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	310	F
2	SN66	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	358	F
2	SN67	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	317	F
1	SN68	18	U33	CSP-100	CSP-100	SAC105	SAC305		0	324	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN61	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	370	F
2	SN63	12	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	121	F
2	SN65	10	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	63	F
2	SN67	16	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	299	F
1	SN62	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	387	F
1	SN64	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	373	F
2	SN66	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	393	F
1	SN68	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	378	F
1	SN79	20	U34	TQFP-144	TQFP-144	Sn	SAC305	SnPb	2	367	F
2	SN61	16	U35	CSP-100	CSP-100	SAC105	SAC305		0	298	F
1	SN62	16	U35	CSP-100	CSP-100	SAC105	SAC305		0	265	F
2	SN63	16	U35	CSP-100	CSP-100	SAC105	SAC305		0	278	F
1	SN64	16	U35	CSP-100	CSP-100	SAC105	SAC305		0	267	F
2	SN65	14	U35	CSP-100	CSP-100	SAC105	SAC305		0	195	F
2	SN66	18	U35	CSP-100	CSP-100	SAC105	SAC305		0	359	F
2	SN67	14	U35	CSP-100	CSP-100	SAC105	SAC305		0	238	F
1	SN68	14	U35	CSP-100	CSP-100	SAC105	SAC305		0	215	F
1	SN79	18	U35	CSP-100	CSP-100	SAC105	SAC305		0	311	F
2	SN61	20	U36	CSP-100	CSP-100	SAC105	SAC305		0	402	F
1	SN62	28	U36	CSP-100	CSP-100	SAC105	SAC305		0	436	F
2	SN63	28	U36	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN64	28	U36	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN65	18	U36	CSP-100	CSP-100	SAC105	SAC305		0	311	F
2	SN66	20	U36	CSP-100	CSP-100	SAC105	SAC305		0	368	F
2	SN67	16	U36	CSP-100	CSP-100	SAC105	SAC305		0	244	F
1	SN68	18	U36	CSP-100	CSP-100	SAC105	SAC305		0	333	F
1	SN79	28	U36	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN61	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN62	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN63	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN65	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN66	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN67	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN68	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN79	28	U37	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN62	28	U38	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	443	F
1	SN64	8	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	25	F
2	SN66	10	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	61	F
1	SN68	10	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	82	F
1	SN79	28	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	480	S
2	SN61	28	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	458	F
2	SN63	28	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN65	28	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	480	S
2	SN67	28	U38	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	428	F
2	SN61	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	431	F
2	SN63	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	475	F
2	SN65	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	472	F
2	SN67	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	451	F
1	SN62	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	437	F
1	SN64	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	474	F
2	SN66	20	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	398	F
1	SN68	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	456	F
1	SN79	28	U39	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	428	F
2	SN61	20	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	365	F
2	SN63	20	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	394	F
2	SN65	20	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	383	F
2	SN67	20	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	382	F
1	SN62	16	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	275	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN66	16	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	270	F
1	SN68	20	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	380	F
1	SN79	18	U40	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	2	327	F
2	SN61	28	U41	TQFP-144	TQFP-144	Sn	SAC305		0	430	F
2	SN63	28	U41	TQFP-144	TQFP-144	Sn	SAC305		0	449	F
2	SN65	18	U41	TQFP-144	TQFP-144	Sn	SAC305		0	332	F
2	SN67	18	U41	TQFP-144	TQFP-144	Sn	SAC305		0	358	F
1	SN62	28	U41	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	461	F
1	SN64	20	U41	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	405	F
2	SN66	28	U41	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	444	F
1	SN68	20	U41	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	408	F
1	SN79	28	U41	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	480	S
2	SN61	20	U42	CSP-100	CSP-100	SAC105	SAC305		0	379	F
1	SN62	20	U42	CSP-100	CSP-100	SAC105	SAC305		0	383	F
2	SN63	28	U42	CSP-100	CSP-100	SAC105	SAC305		0	422	F
1	SN64	28	U42	CSP-100	CSP-100	SAC105	SAC305		0	455	F
2	SN65	28	U42	CSP-100	CSP-100	SAC105	SAC305		0	430	F
2	SN66	20	U42	CSP-100	CSP-100	SAC105	SAC305		0	369	F
2	SN67	20	U42	CSP-100	CSP-100	SAC105	SAC305		0	370	F
1	SN68	28	U42	CSP-100	CSP-100	SAC105	SAC305		0	424	F
1	SN79	20	U42	CSP-100	CSP-100	SAC105	SAC305		0	399	F
2	SN61	10	U43	BGA-225	BGA-225	SAC405	SAC305		0	72	F
1	SN62	10	U43	BGA-225	BGA-225	SAC405	SAC305		0	66	F
2	SN63	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	14	F
1	SN64	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	35	F
2	SN65	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	14	F
2	SN66	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	34	F
2	SN67	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	13	F
1	SN68	8	U43	BGA-225	BGA-225	SAC405	SAC305		0	29	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN61	16	U44	BGA-225	BGA-225	SAC405	SAC305		0	268	F
1	SN62	12	U44	BGA-225	BGA-225	SAC405	SAC305		0	148	F
2	SN63	12	U44	BGA-225	BGA-225	SAC405	SAC305		0	121	F
1	SN64	10	U44	BGA-225	BGA-225	SAC405	SAC305		0	64	F
2	SN65	10	U44	BGA-225	BGA-225	SAC405	SAC305		0	63	F
2	SN66	14	U44	BGA-225	BGA-225	SAC405	SAC305		0	183	F
2	SN67	10	U44	BGA-225	BGA-225	SAC405	SAC305		0	82	F
1	SN68	10	U44	BGA-225	BGA-225	SAC405	SAC305		0	70	F
1	SN79	8	U44	BGA-225	BGA-225	SAC405	SAC305		0	44	F
2	SN61	28	U45	CLCC-20	CLCC-20	SAC305	SAC305		0	480	S
2	SN63	28	U45	CLCC-20	CLCC-20	SAC305	SAC305		0	480	S
2	SN65	28	U45	CLCC-20	CLCC-20	SAC305	SAC305		0	472	F
2	SN67	28	U45	CLCC-20	CLCC-20	SAC305	SAC305		0	427	F
1	SN62	28	U45	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	462	F
1	SN64	28	U45	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
2	SN66	28	U45	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	446	F
1	SN68	28	U45	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
1	SN79	20	U45	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	416	F
1	SN62	28	U46	CLCC-20	CLCC-20	SAC305	SAC305		0	464	F
1	SN64	28	U46	CLCC-20	CLCC-20	SAC305	SAC305		0	480	S
2	SN66	28	U46	CLCC-20	CLCC-20	SAC305	SAC305		0	438	F
1	SN68	28	U46	CLCC-20	CLCC-20	SAC305	SAC305		0	461	F
1	SN79	20	U46	CLCC-20	CLCC-20	SAC305	SAC305		0	412	F
2	SN61	18	U46	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	354	F
2	SN63	28	U46	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
2	SN65	28	U46	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	455	F
2	SN67	28	U46	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	433	F
2	SN61	28	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	424	F
1	SN62	20	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	413	F
2	SN63	20	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	374	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN65	28	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN66	20	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	389	F
2	SN67	20	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	398	F
1	SN68	18	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	347	F
1	SN79	20	U47	QFN-20	QFN-20	Sn	SAC305	SnPb	1	408	F
1	SN62	28	U48	TQFP-144	TQFP-144	Sn	SAC305		0	447	F
1	SN64	28	U48	TQFP-144	TQFP-144	Sn	SAC305		0	440	F
2	SN66	28	U48	TQFP-144	TQFP-144	Sn	SAC305		0	433	F
1	SN68	28	U48	TQFP-144	TQFP-144	Sn	SAC305		0	438	F
1	SN79	28	U48	TQFP-144	TQFP-144	Sn	SAC305		0	439	F
2	SN61	20	U48	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	390	F
2	SN63	28	U48	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	431	F
2	SN65	14	U48	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	181	F
2	SN67	20	U48	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	373	F
2	SN61	8	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	9	F
1	SN62	8	U49	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	18	F
2	SN63	8	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	41	F
2	SN65	12	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	174	F
2	SN67	28	U49	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	480	S
1	SN64	16	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	290	F
2	SN66	10	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	63	F
1	SN68	8	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	38	F
1	SN79	8	U49	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	2	31	F
2	SN61	16	U50	CSP-100	CSP-100	SAC105	SAC305		0	293	F
1	SN62	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	335	F
2	SN63	16	U50	CSP-100	CSP-100	SAC105	SAC305		0	279	F
1	SN64	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	336	F
2	SN65	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	323	F
2	SN66	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	309	F
2	SN67	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	309	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN79	18	U50	CSP-100	CSP-100	SAC105	SAC305		0	307	F
1	SN62	28	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	424	F
1	SN64	8	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	60	F
2	SN66	28	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	468	F
2	SN67	28	U51	PDIP-20	PDIP/Sn-20	SnNiPdAu	SN100C	SnPb	1	480	S
1	SN68	14	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	185	F
1	SN79	20	U51	PDIP-20	PDIP/Sn-20	Sn	SN100C	SnPb	1	403	F
2	SN61	28	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	2	453	F
2	SN63	16	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	2	246	F
2	SN65	28	U51	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	2	480	S
2	SN61	28	U52	CLCC-20	CLCC-20	SAC305	SAC305		0	480	S
2	SN63	28	U52	CLCC-20	CLCC-20	SAC305	SAC305		0	421	F
2	SN65	12	U52	CLCC-20	CLCC-20	SAC305	SAC305		0	121	F
2	SN67	28	U52	CLCC-20	CLCC-20	SAC305	SAC305		0	421	F
1	SN62	28	U52	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	436	F
1	SN64	28	U52	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	450	F
2	SN66	28	U52	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	472	F
1	SN68	28	U52	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	422	F
1	SN79	28	U52	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	448	F
1	SN62	28	U53	CLCC-20	CLCC-20	SAC305	SAC305		0	480	S
1	SN64	28	U53	CLCC-20	CLCC-20	SAC305	SAC305		0	460	F
2	SN66	28	U53	CLCC-20	CLCC-20	SAC305	SAC305		0	449	F
1	SN68	28	U53	CLCC-20	CLCC-20	SAC305	SAC305		0	462	F
1	SN79	28	U53	CLCC-20	CLCC-20	SAC305	SAC305		0	474	F
2	SN61	28	U53	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
2	SN63	28	U53	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	422	F
2	SN65	28	U53	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	480	S
2	SN67	28	U53	CLCC-20	CLCC-20	SAC305	SAC305	SnPb	1	443	F
2	SN61	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	460	F
1	SN62	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN64	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN65	10	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	115	F
2	SN66	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN67	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	465	F
1	SN68	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
1	SN79	28	U54	QFN-20	QFN-20	Sn	SAC305	SnPb	1	480	S
2	SN61	14	U55	BGA-225	BGA-225	SAC405	SAC305		0	195	F
1	SN62	12	U55	BGA-225	BGA-225	SAC405	SAC305		0	158	F
2	SN63	14	U55	BGA-225	BGA-225	SAC405	SAC305		0	200	F
1	SN64	14	U55	BGA-225	BGA-225	SAC405	SAC305		0	218	F
2	SN65	12	U55	BGA-225	BGA-225	SAC405	SAC305		0	127	F
2	SN66	16	U55	BGA-225	BGA-225	SAC405	SAC305		0	280	F
2	SN67	10	U55	BGA-225	BGA-225	SAC405	SAC305		0	77	F
1	SN68	14	U55	BGA-225	BGA-225	SAC405	SAC305		0	185	F
1	SN79	10	U55	BGA-225	BGA-225	SAC405	SAC305		0	116	F
2	SN61	14	U56	BGA-225	BGA-225	SAC405	SAC305		0	227	F
1	SN62	16	U56	BGA-225	BGA-225	SAC405	SAC305		0	288	F
2	SN63	16	U56	BGA-225	BGA-225	SAC405	SAC305		0	266	F
1	SN64	12	U56	BGA-225	BGA-225	SAC405	SAC305		0	159	F
2	SN65	12	U56	BGA-225	BGA-225	SAC405	SAC305		0	180	F
2	SN66	16	U56	BGA-225	BGA-225	SAC405	SAC305		0	249	F
2	SN67	14	U56	BGA-225	BGA-225	SAC405	SAC305		0	185	F
1	SN68	12	U56	BGA-225	BGA-225	SAC405	SAC305		0	175	F
1	SN79	12	U56	BGA-225	BGA-225	SAC405	SAC305		0	143	F
2	SN61	18	U57	TQFP-144	TQFP-144	Sn	SAC305		0	313	F
2	SN63	12	U57	TQFP-144	TQFP-144	Sn	SAC305		0	121	F
2	SN65	18	U57	TQFP-144	TQFP-144	Sn	SAC305		0	341	F
2	SN67	18	U57	TQFP-144	TQFP-144	Sn	SAC305		0	308	F
1	SN62	16	U57	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	286	F
1	SN64	18	U57	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	309	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
1	SN68	18	U57	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	309	F
1	SN79	18	U57	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	343	F
1	SN62	16	U58	TQFP-144	TQFP-144	Sn	SAC305		0	250	F
1	SN64	16	U58	TQFP-144	TQFP-144	Sn	SAC305		0	271	F
2	SN66	14	U58	TQFP-144	TQFP-144	Sn	SAC305		0	233	F
1	SN68	14	U58	TQFP-144	TQFP-144	Sn	SAC305		0	215	F
1	SN79	12	U58	TQFP-144	TQFP-144	Sn	SAC305		0	130	F
2	SN61	16	U58	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	263	F
2	SN63	16	U58	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	280	F
2	SN65	16	U58	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	260	F
2	SN67	14	U58	TQFP-144	TQFP-144	Sn	SAC305	SnPb	1	200	F
1	SN62	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	480	S
1	SN64	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	480	S
2	SN66	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	480	S
1	SN68	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C		0	480	S
1	SN79	20	U59	PDIP-20	PDIP/Sn-20	Sn	SN100C		0	375	F
2	SN61	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	480	S
2	SN63	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	480	S
2	SN65	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	480	S
2	SN67	28	U59	PDIP-20	PDIP/Au-20	NiPdAu	SN100C	SnPb	1	480	S
2	SN61	20	U60	CSP-100	CSP-100	SAC105	SAC305		0	414	F
1	SN62	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN63	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN64	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	447	F
2	SN65	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN66	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN67	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN68	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN79	28	U60	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN62	28	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	466	F

Batch	Card	Gs	SITE	Style	Package	Finish	Original Solder	Reworked Solder	Reworks	T_f	Fail/ Survive
2	SN66	28	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	429	F
1	SN68	28	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	434	F
1	SN79	28	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305		0	460	F
2	SN61	20	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	414	F
2	SN63	28	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	421	F
2	SN65	12	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	121	F
2	SN67	18	U61	TSOP-50	TSOP-50/Sn	Sn	SAC305	SnPb	1	337	F
1	SN62	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	480	S
1	SN64	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	476	F
2	SN66	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	454	F
1	SN68	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	480	S
1	SN79	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305		0	468	F
2	SN61	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	454	F
2	SN63	28	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	422	F
2	SN65	10	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	115	F
2	SN67	20	U62	TSOP-50	TSOP-50/SnBi	SnBi	SAC305	SnPb	1	414	F
2	SN61	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN62	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN63	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN64	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN65	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN66	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
2	SN67	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN68	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S
1	SN79	28	U63	CSP-100	CSP-100	SAC105	SAC305		0	480	S