



NASA-DoD Lead-Free Electronics Project: Mechanical Shock Test

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1.0 Abstract

Mechanical shock testing was conducted by Boeing Research and Technology (Seattle) for the NASA-DoD Lead-Free Electronics Solder Project. This project is a follow-on to the Joint Council on Aging Aircraft/Joint Group on Pollution Prevention (JCAA/JG-PP) Lead-Free Solder Project which was the first group to test the reliability of lead-free solder joints against the requirements of the aerospace/military community.

Twenty one test vehicles were subjected to the shock test conditions (in four batches). The Shock Response Spectrum (SRS) input was increased during the test after every 100 shock pulses in an effort to fail as many components as possible within the time allotted for the test.

The solder joints on the components were electrically monitored using event detectors and any solder joint failures were recorded on a Labview-based data collection system. The number of shocks required to fail a given component attached with SnPb solder was then compared to the number of shocks required to fail the same component attached with lead-free solder.

A complete modal analysis was conducted on one test vehicle using a laser vibrometer system which measured velocities, accelerations, and displacements at one hundred points. The laser vibrometer data was used to determine the frequencies of the major modes of the test vehicle and the shapes of the modes. In addition, laser vibrometer data collected during the mechanical shock test was used to calculate the strains generated (using custom software).

After completion of the testing, all of the test vehicles were visually inspected and cross sections were made. Broken component leads and other unwanted failure modes were documented.

2.0 Background

Recently, legislation was passed in Europe to ban the use of lead (and other materials) in new electronics starting 1 July 2006. The legislation actually banning lead is called the RoHS (Restriction of Hazardous Substances). The legislation that governs the re-use and recycling of electronics waste is called the Waste from Electrical and Electronic Equipment (WEEE) Directive.

Japan also has become focused on lead-free electronics. Many of the major electronics companies (e.g., Hitachi, NEC, NTT, Panasonic) have announced lead reduction targets and the move to lead-free electronics is supported by JEITA (the Japan Electronics and Information Technology Industries Association). These companies view lead-free as a marketing tool that will allow them to gain market share from their foreign competitors.

Aerospace and military electronics are currently exempt from the European legislation. However, as the international commercial electronics industry changes over to lead-free technology in order to satisfy the European legislation, it will become increasingly

difficult for aerospace and military programs to procure electronics made with SnPb solder. For this reason, the NASA-DoD Lead-Free Electronics Project was started in 2006 to determine whether lead-free solders and finishes (before and after rework) are suitable for use in high reliability electronics. The Project is managed by NASA. The NASA-DoD Lead-Free Electronics Project includes members from the U.S. Air Force, BAE Systems, Boeing, Celestica, Harris, Lockheed Martin, NASA, NAVSEA Warfare Centers (Crane), Raytheon, Rockwell-Collins, ACI, Lockheed Martin, and Texas Instruments, among others. This project is a follow-on to the 2001 Joint Council on Aging Aircraft/Joint Group on Pollution Prevention (JCAA/JG-PP) Lead-Free Solder Project which was the first group to test the reliability of lead-free solder joints against the requirements of the aerospace/military community.

The Project members wrote a Project Plan (Reference 1) which describes the assembly of the test vehicles and the testing to be done. The testing includes thermal cycling, vibration, mechanical shock, combined vibration/thermal cycling, and copper dissolution testing.

The test vehicle designed for this project was a six-layer circuit board 12.75 inches wide by 9 inches high by 0.090 inches thick (Figure 1). The design used 0.5 ounce copper and a laminate with a high glass transition temperature (T_g of 170 degrees C, Isola 370HR). The test vehicle was populated with 63 components consisting of ceramic leadless chip carriers (CLCC's), QFN's, Alloy 42 TSOP's, TQFP's, BGA's, CSP's, and PDIP's (Figure 2). The components contained internal wire bonds so that once mounted on the test vehicle, each component would complete an electrical circuit that could be monitored during testing. Failure of a solder joint would cause a break in the electrical circuit that could be detected by an event detector. Each test vehicle also had a daisy-chain of twelve 0.016 inch diameter plated thorough holes so that the reliability of the holes could be determined. The plated through holes were filled with solder during the wave solder operation. Each component location on the test vehicles was given a unique reference designator number.

The solder alloys selected for test were:

Sn3.0Ag0.5Cu paste for reflow soldering (abbreviated as SAC305)

Sn0.7Cu0.05Ni for wave soldering and as a paste for reflow soldering (abbreviated as SN100C)

Sn37Pb for reflow and wave soldering (abbreviated as SnPb)

Sn4.0Ag0.5Cu for BGA balls (abbreviated as SAC405)

Sn1.0Ag0.5Cu for CSP balls (abbreviated as SAC105)

The SAC305 alloy was chosen because it is currently the preferred alloy for use in lead-free commercial electronics. The SN100C alloy was chosen because it has been widely used in Asia with good results. SAC405 and SAC105 are alloys commonly used in the balls on area array devices. Finally, eutectic SnPb was included to act as the control alloy.

The test vehicles were divided into two types, i.e., “Manufactured” test vehicles and “Rework” test vehicles. Both types were made using an immersion silver board finish (although an ENIG PWB finish was used on a few test vehicles). The lead-free “Manufactured” and “Rework” test vehicles were assembled using lead-free solders and lead-free reflow and wave soldering profiles. The SnPb “Manufactured” and “Rework” test vehicles were assembled using eutectic SnPb solder and SnPb reflow and wave soldering profiles and were used as the controls. A 5-mil laser cut stencil was used during paste application.

As the name suggests, selected components on the “Rework” test vehicles were reworked. The components were removed; residual solder was cleaned from the pads using solder wick; and new components were attached using either SnPb or lead-free solder.

The “Rework” test vehicles were also populated with a number of mixed technology components (i.e., SnPb paste combined with a lead-free component finish or lead-free paste combined with a SnPb component finish).

The CLCC’s with a lead-free pad finish were produced by dipping of gold-plated CLCC’s into the respective molten solders. In addition, some tin-plated TQFP’s were dipped into either molten SnPb or molten SAC305 to simulate a tin whisker mitigation process.

The component finishes used included SnPb, matte Sn, SnBi, SAC305, SAC405, and SAC105.

Table 1 lists the components used on the SnPb and lead-free “Manufactured” test vehicles; the finish on each component; and the solders used.

Table 2 lists the components used on the SnPb and lead-free “Rework” test vehicles; the finish on each component; the solders used; and which components were actually reworked.

One hundred and ninety three test vehicles were assembled at BAE Systems in Irving, TX. One hundred and twenty of these test vehicles were “Manufactured” PWA’s and seventy three were “Rework” PWA’s. Eighteen components were reworked on each of the “Rework” test vehicles (six BGA’s; six CSP’s; two PDIP’s; and four TSOP’s). In general, solder wire was used for reworking the components. The BGA’s and CSP’s, however, were replaced using flux only or by applying paste to the balls and then using a hot air rework station to form the solder joints (see Table 2). During rework of the BGA’s and CSP’s, a SnPb thermal profile was used for the SnPb “Rework” test vehicles and a Pb-free thermal profile was used on the Pb-free “Rework” test vehicles. The reflow profiles for initial assembly using either SnPb or the lead-free solder pastes are shown in Figures 3 and 4. The wave soldering profiles used for tin/lead and lead-free wave soldering are shown in Figures 5 and 6. Wave soldering with SnPb was done at BAE Systems and the lead-free wave soldering was done at Scorpio Solutions in Garfield

Heights, Ohio. The rework profiles for removing and replacing the BGA's and the CSP's using a hot air rework station are shown in Figures 7 - 10. All rework was done at BAE Systems, Lockheed Martin, and Rockwell-Collins. Each rework site focused on the test vehicles for a specific test to eliminate effects due to site-to-site variations in rework procedures.

After assembly and rework, all test vehicles were thermally aged at 100°C for 24 hours. Twenty one test vehicles were then delivered to Boeing for mechanical shock testing. These consisted of 5 SnPb "Manufactured" test vehicles; 5 Pb-free "Manufactured" test vehicles; 6 SnPb "Rework" test vehicles; and 5 Pb-free "Rework" test vehicles. All of the test vehicles had an immersion silver PWB finish except for one SnPb "Rework" test vehicle (Test Vehicle 160) which had an ENIG PWB finish.

On the SnPb "Rework" test vehicles, all of the CLCC's were finished with SAC305 (on the pads and in the castellations) and assembled with SnPb paste which resulted in lead-free solder joints contaminated with Pb after assembly (see Table 2). In addition, some of the BGA's combined SAC405 balls with SnPb solder paste which also resulted in lead-free solder joints contaminated with Pb (on reworked and unreworked BGA's). Also, some of the CSP's combined SAC105 balls with SnPb solder paste (reworked and unreworked). This mixing was done intentionally in order to determine the effects of lead-contamination upon lead-free solder reliability. Inductively coupled plasma (ICP) spectroscopy was used by Boeing to quantify the amount of Pb in these solder joints on one of the SnPb "Rework" test vehicles (see Table 3; Test Vehicle ID # 149). The solder joints were removed with a scalpel, dissolved in mixed nitric/hydrochloric acid, and the solution was analyzed by ICP spectroscopy.

On the Pb-free "Rework" test vehicles, all of the CLCC's and QFN's were finished with SnPb and assembled with SAC305 paste which resulted in lead-free solder joints contaminated with Pb after assembly (see Table 2). In addition, some of the BGA's combined SnPb balls with SAC305 solder paste which also resulted in lead-free solder joints contaminated with Pb (on unreworked BGA's). Also, some of the CSP's combined SAC105 balls with SnPb solder paste (after rework). This mixing was done intentionally in order to determine the effects of lead-contamination upon lead-free solder reliability. Again, Inductively coupled plasma (ICP) spectroscopy was used by Boeing to quantify the amount of Pb in these solder joints on one of the Pb-Free "Rework" test vehicles (see Table 3; Test Vehicle ID # 193).

All of the ICP analyses appeared reasonable with the possible exception of the two TSOP's and the BGA U43 analyses. The copper content for these components were higher than expected. It is probable that copper was removed from the test vehicle pads along with the solder when the solder joints were cut from the test vehicle using a scalpel.

3.0 Objective and Approach

The objective of this study was to determine the effects of mechanical shock environments on the relative reliability of lead-free and tin/lead solder joints (i.e., which

solder survived the longest). Modal data and strain data were also collected during this study in an effort to provide data that would be useful to those that may want to try to model the behavior of the NASA-DoD test vehicle.

An aluminum fixture was built that could hold up to six test vehicles at one time (see Figure 11). Slots were cut into the fixture to accept wedgelocks (Calmark A260-8.80T2L) that were mounted on both ends of the test vehicles with screws. The wedgelocks were designed with a special locking feature to prevent loosening from mechanical shock and were torqued to 8.5 in-lbs. Figures 12 and 13 show the NASA-DoD test vehicles mounted in the test fixture.

The electrodynamic shaker used for the test was an Unholtz-Dickie T1000W with a 360 KW amplifier controlled by a Spectral Dynamics 2550B Vibration Controller (Figures 13 and 14). The shaker input was controlled by an accelerometer mounted near the bottom of the fixture.

An understanding of the bending modes of the NASA-DoD test vehicle is important since the mechanical shock pulses should excite these bending modes which in turn will cause solder joint damage.

Before any testing was conducted, the approximate first resonance frequency of the NASA-DoD test vehicle was calculated as 82 Hz using the following equation (Reference 2, pg. 128). This equation is for a board that is firmly fixed on two opposite edges.

$$\text{Natural frequency} = 82 \text{ Hz} = \frac{3.55(D/\rho)^{0.5}}{a^2}$$

$$D = \frac{Eh^3}{12(1-\mu)}$$

$$\rho = \text{mass/area} = W/gab$$

$$a = \text{board width} = 12.75 \text{ in.}$$

$$b = \text{board height} = 9.0 \text{ in.}$$

$$h = \text{board thickness} = 0.093 \text{ in.}$$

$$E = \text{modulus of elasticity} = 4500000 \text{ lb/in}^2$$

$$W = \text{board weight} = 0.95 \text{ lbs}$$

$$\mu = \text{Poisson's ratio for epoxy/fiberglass} = 0.12$$

$$g = \text{gravity} = 386 \text{ in/sec}^2$$

A modal analysis was conducted on the test vehicle located in the top slot of the test fixture using a laser vibrometer system (Polytec Scanning Vibrometer, Waldbronn, Germany) which was suspended above the electrodynamic shaker (Figure 15). The laser vibrometer was used to measure velocities, accelerations, and displacements at 100 points on the bottom surface of Test Vehicle 75 during low level random vibration in the z-axis (the axis perpendicular to the plane of the test vehicle). Figure 16 shows the laser

vibrometer's view of Test Vehicle 75 during the laser vibrometer scan. The laser vibrometer measurements identified 4 major resonance frequencies for the NASA-DoD test vehicle at 70, 94, 391, and 998 Hz (see Figure 17). Note that the measured natural frequency of 70 Hz compares well with the calculated natural frequency of 82 Hz. The laser vibrometer data was also used to calculate a bending mode shape for each of the resonances (see examples in Figures 18 and 19).

Each "Manufactured" test vehicle was instrumented with two calibrated accelerometers as shown in Figure 20 for collecting acceleration data during the shock test. Accelerometer 1 was located at the point of maximum deflection for the first and second modes (70 and 94 Hz) and Accelerometer 2 was located at the point of maximum deflection for the seventh mode (391 Hz).

Four three-element stacked rosette strain gages were mounted on one test vehicle as shown in Figure 21 to collect strain data in the x and y directions at each test level (directions are defined in Figure 20). Strain Gages 1, 2, and 4 were Micro-Measurements Part No. WK-03-120WR-350 and Strain Gage 3 was Micro-Measurements Part No. WK-06-060WR-350.

Figures 22 and 23 show the transmissibilities and the displacements of a test vehicle vs. frequency (from accelerometer data collected during a 1 G sine sweep of a "Manufactured" test vehicle in the z-axis). Figure 23 illustrates that the most displacement (and therefore the most solder joint damage) is caused by the first resonance frequency. The resonance near 400 Hz caused approximately 56 times less displacement than the first resonance at the location of Accelerometer 1.

Laser vibrometer velocity data was also collected at 100 points on the surface of Test Vehicle 75 at several test levels during the mechanical shock test. This data was used to calculate full field peak strains in the vehicle x and y directions for all modes combined during a shock pulse (see the example in Figure 24). The calculations were performed using proprietary software developed by Millenium Dynamics Corporation (Acworth, GA). The regions of calculated maximum strain were down the centerline of the vehicle and along the edges of the vehicle (near the wedgelocks). The calculated maximum strains compared well with the strain data from the strain gages. Note that the maximum strains generated across the test vehicle (Figure 24) appear to be mostly caused by the first mode.

After collection of the modal and strain data, the test vehicles were subjected to a mechanical shock step stress test in the z-axis only (see Figure 25 and Table 4). The 21 test vehicles were divided into four groups for testing, with each group containing both SnPb and Pb-free test vehicles.

At the first stress level, the test vehicles were subjected to 100 shock pulses using the 20 G Shock Response Spectrum (SRS) shown in Figure 25 and Table 4 (5% damping). The SRS was flat from 40 to 1000 Hz. This is a standard test (i.e., the Functional Test for Flight Equipment as defined in MIL-STD-810G Method 516.6) during which the test

article is exposed to a minimum of three shock pulses. The 20 G SRS used was modified slightly from that shown in MIL-STD-810G (Reference 3). The modifications included lowering the cross-over frequency to 40 Hz to insure that the first resonance of the test vehicle was fully excited and reducing the terminal frequency to 1000 Hz.

At the second stress level, the test vehicles were subjected to 100 shock pulses using the 40 G Shock Response Spectrum (SRS) shown in Figure 25 and Table 4. This is a standard test (i.e., the Functional Test for Ground Equipment as defined in MIL-STD-810G Method 516.6) during which the test article is exposed to a minimum of three shock pulses.

At the third stress level, the test vehicles were subjected to 100 shock pulses using the 75 G Shock Response Spectrum (SRS) shown in Figure 25 and Table 4. This is a standard test (i.e., the Crash Hazard Test for Ground Equipment as defined in MIL-STD-810G Method 516.6) during which the test article is exposed to a minimum of three shock pulses.

The test vehicles were then exposed to 100 shock pulses using a 100 G SRS followed by 100 shock pulses using a 200 G SRS as shown in Figure 25 and Table 4 (Test Levels 4 and 5).

The mechanical shock test was concluded by exposing the test vehicles to 400 shock pulses using the 300 G SRS shown in Figure 25 and Table 4.

At the 300 G test level, the sides of the wedgelocks began to gradually deform. Great care had to be taken to periodically tighten the wedgelocks and to replace the wedgelocks when the deformations reduced the clamping force of the wedgelocks.

The 63 components and the PTH net on each test vehicle were individually monitored using Analysis Tech 256STD Event Detectors (set to a 300 ohm threshold) combined with Labview-based data collection software (Figure 14). The wires connecting the test vehicle to the event detector had to be glued to the surface of the test vehicle (Figure 1) to prevent them from flexing and breaking during the mechanical shock test. In addition, the wire bundles from the test vehicle were firmly clamped to the fixture in order to prevent flexing and breaking of the wires. All wire bundles were covered with a grounded metallic shield to prevent electrical noise from the shaker from interfering with the event detectors.

The accelerometer data recorded at each test level included: the SRS inputs into the fixture; the pulse shape used for each test level; and the response of each “Manufactured” test vehicle. Representative accelerometer data for each test level is shown in Figures 26 through 43. At each test level, the same pulse shape was used for each of the shock pulses. The use of an electrodynamic shaker insured that reproducible pulse shapes could be produced for each test level during testing of the four batches of test vehicles. It should be noted that the accelerations experienced by each test vehicle were much higher than the SRS accelerations input into the fixture. For example, during a 300 G shock

pulse, the centerline of the test vehicle was actually accelerating at 1000 G (at 70 Hz) (see Figure 43).

Figures 44 and 45 show the acceleration time history of a test vehicle after a 20 G shock pulse. The initial pulse deflects the test vehicle in one direction and the test vehicle then oscillates back and forth until the acceleration imparted by the pulse decays to zero.

Figures 46 through 53 show the responses of the four strain gages on Test Vehicle 75 after a 20 G shock pulse. Table 5 shows the peak strain readings from the four strain gages on Test Vehicle 75 at every test level (in the x and y board directions).

4.0 Results and Discussion

Table 6 shows the percent of each component type that failed on both the “Manufactured” and the “Rework” test vehicles at the end of the test. Notice that the QFN-20’s and the TSOP-50’s were resistant to failure due to mechanical shock.

Figure 54 shows how many shock pulses were required to fail the components on Test Vehicle 75. The failures are colored coded according to which how many shock pulses were required to cause the failure (red = 300 to 400 pulses; orange = 401 to 500 pulses; yellow = 501 to 600 pulses; green = 601 to 700 pulses; blue = 701 to 800 pulses; and purple = 801 to 900 pulses). In general, the components tended to fail first down the centerline and along the edges of the test vehicle (near the wedgelocks). Therefore, the first component failures coincide with the regions of highest strain as shown in Figure 24.

This demonstrates that the strain environment at a given location on a test vehicle can be very different from the strain environment at a different location on the same vehicle during the same test. This implies that the best practice is to directly compare identical components in identical locations on identical test vehicles. It also implies that the test solder must be used on one set of test vehicles and the control solder on a second set of test vehicles.

After completion of all shock testing, the “Manufactured” and “Rework” test vehicles were visually inspected using a HYROX Hi-Scope Compact Micro Vision System (Model KH-2200 MD2). The main goal of the inspection was to document any broken or missing leads on leaded components. This was necessary so that failures due to solder joint cracking could be distinguished from failures due to lead breakage. The secondary goal of the inspection was to document any unusual failure modes. Photographs of representative lead, solder joint, and trace failures are shown in Figures 55 through 69. The complete visual inspection results for each test vehicle can be found in Appendix A. Some components (BCA’s and CLCC’s) tended to fall off of the test vehicles during testing (see Table A-1). In addition, all wiring was visually inspected to verify that no signal wires had broken during the shock test (a broken signal wire would look like a solder joint failure to the event detectors). No broken signal wires were found.

Microsections were also done to identify major failure modes (see Figures 70 through 77).

It should be noted that all of the surface mount components survived 100 shock pulses at each of the first three test levels. This means that they effectively passed the Functional Test for Flight Equipment 33 times; they passed the Functional Test for Ground Equipment 33 times; and they passed the Crash Hazard Test for Ground Equipment 33 times. Therefore, the surface mount components soldered with SnPb and with SAC305 are both resistant to failure under mechanical shock.

At the more severe test levels, numerous components did fail electrically which allowed the relative reliability of the SnPb control solder and the lead-free solders to be compared.

The number of shock pulses required to fail each component tested is given in the tables in Appendix B. In these tables, only identical components in identical locations (strain environments) on identical test vehicles were directly compared. Since some of the test vehicles were assembled with lead-free solders and some with tin/lead solder, a direct comparison can be done to determine which solder type performed better under mechanical shock. The tables in Appendix B show the solder/component finish combinations that were tested, whether the component was reworked or not, and the number of test levels that each component survived. A “100” means that that particular component survived the entire 100 shock pulses administered at a given test level.

In addition, the overall results of the mechanical shock testing are summarized in Table 7. If a solder alloy/component finish combination performed as well or better than the SnPb control, it was assigned the number “1” and the color “green”. Solders that performed worse than the SnPb control were assigned a “2” and the color “yellow”. For those cases where both the SnPb controls and a Pb-free solder had few or no failures after 900 shock pulses, they were not ranked.

The data plots in Appendix C were used to determine the rankings presented in Table 7. Each of the plots in Appendix C groups data from components that were assembled using the same solder alloy/component finish combinations. For example, all of the BGA’s in positions U4, U5, U44, and U55 (Figure C-1) used SnPb solder/SnPb balls on the SnPb “Manufactured” test vehicles; SAC 305 solder/SAC405 balls on the Pb-Free “Manufactured” test vehicles; SnPb solder/SAC405 balls on the SnPb “Rework” test vehicles; and SAC 305 solder/SnPb balls on the Pb-Free “Rework” test vehicles. The plots in Figure C-1 allow a direct comparison between the combined failures of all of these BGA’s even though they were in different strain environments during the test.

The rankings in Table 7 are somewhat subjective since the data for some component types contained a lot of scatter and other component types had few failures which complicated the ranking process. In addition, if some of the component/solder combinations had only a few early failures, these failures did not count in the ranking process. Weibull plots were not used since the test conditions were changed during the

test (i.e., the SRS was increased every 100 pulses) which renders the Weibull parameters meaningless.

In the following sections, the solder paste used is listed first followed by the component finish (for example, SAC305/SAC405 on a BGA is equivalent to SAC305 solder/SAC405 balls).

4.1 BGA-225's

The combination of SAC305 solder/SAC405 balls generally performed as well as the SnPb/SnPb controls in mechanical shock (see Figures C-1, C-2, and C-3) although there were some early SAC305/SAC405 failures (see Figure C-1). Microsections made at the end of the test showed that the corner solder joints failed first. The SnPb/SnPb sections showed pad cratering, PWB trace cracking, and solder joint cracking on the component side (Figure 70). The SAC305/SAC405 sections showed PWB trace cracking and solder joint cracking at the component side intermetallic layer (see Figure 71). Which failure mechanism occurred first could not be determined from the microsections.

The combination of SAC305 solder/SnPb balls also performed as well as the SnPb/SnPb controls. In contrast, the combination of SnPb solder/SAC405 balls underperformed the controls (Figure C-1) on either an immersion silver or ENIG board finish. These SnPb/SAC405 components were reflowed using a SnPb reflow profile.

SnPb/SnPb BGA's reworked with flux only/SnPb balls and SAC305/SAC405 BGA's reworked with flux only/SAC 405 balls were as reliable as the SnPb/SnPb control BGA's (Figure C-2).

SnPb/SnPb BGA's reworked with SnPb/SAC405 underperformed SAC305/SAC405 BGA's reworked with SnPb/SAC405 (Figure C-3). The difference is probably because the former were reworked with a SnPb thermal profile while the latter were reworked with a Pb-free thermal profile which should have allowed complete mixing of the solders.

During rework of the BGA's, problems were encountered with electrical opens. This required that some BGA's be reworked several times instead of just once. See Appendix B to determine which BGA's were reworked multiple times. In general, multiple rework cycles did not appear to have a negative effect on the performance of the solder joints relative to their unreworked counterparts.

A number of BGA's fell off of the test vehicles during the shock test which allowed the failure mechanisms to be examined more closely.

Surprisingly, on the SnPb/SnPb BGA's that fell off, almost 100% of the solder joints failed by pad cratering. The BGA balls and associated PWB copper pads were missing from the test vehicles (Figures 55 and 56).

No SAC305/SAC405 BGA's fell off during the test. The only purely lead-free BGA that fell off was one reworked using flux only and a BGA with SAC405 balls. For this BGA,

16% of the balls remained with the PWB with the solder joints failing on the component side (although most of the remaining balls also showed signs of PWB pad cratering). The balance of the BGA balls and associated PWB copper pads were missing from the test vehicle (Figures 57 and 58).

For the SAC305/SnPb, SnPb/SAC405, and reworked SnPb/SAC405 BGA's that fell off during testing, most of the BGA balls and associated PWB copper pads were missing from the test vehicles. The use of a SnPb versus a lead-free thermal profile for rework of the SnPb/SAC405 BGA's didn't appear to influence the failure mechanism.

The above failures were on test vehicles with an immersion Ag board finish. In contrast, the failure mechanism was different for the SnPb/SAC405 and reworked SnPb/SAC405 BGA's that fell off of the one ENIG board. Between 47 and 54% of the BGA balls remained on the test vehicle, which shows a shifting of the failures to the component side of the solder balls. Although the balance of the BGA balls were missing from the test vehicles, the majority of the copper pads were still attached to the PWB.

4.2 CLCC-20's

The SnPb/SnPb controls outperformed the combinations of SAC305/SAC305, SnPb/SAC305, and SAC305/SnPb (See Figure C-4).

The amount of Pb detected in the SnPb/SAC305 and SAC305/SnPb solder joints was 24.7% and 16.5%, respectively (from ICP spectroscopy, see Table 3).

Figure 59 shows a typical crack in a CLCC solder joint.

4.3 CSP-100's

The CSP daisy chain pattern on the test vehicles was incorrect with the result that only the outer perimeter balls of each CSP formed an electrically continuous path (see Figure 78). In order for a CSP to be detected as failed, both legs of the outer perimeter needed to fail.

The relative ranking of the CSP solder/finish combinations was hindered because the CSP's at some locations had few or no failures. Therefore, the following rankings are somewhat subjective.

The combination of SAC305 solder/SAC105 balls generally performed as well as the SnPb/SnPb controls in mechanical shock (see Figures C-5 through C-7). Microsections made at the end of the test showed that the corner solder joints failed first. The SnPb/SnPb solder joints formed cracks primarily on the component side (Figure 72). The SAC305/SAC105 solder joints formed cracks primarily on the component side and also showed evidence of pad cratering (see Figure 73).

The combination of SAC305 solder/SnPb balls also performed as well as the SnPb/SnPb controls (Figure C-5). In contrast, the combination of SnPb solder/SAC105 balls underperformed the SnPb/SnPb controls (Figure C-5) on either an immersion silver or ENIG board finish. These SnPb/SAC105 components were reflowed using a SnPb reflow profile.

The SnPb/SnPb CSP's reworked with flux only/SnPb balls were less reliable than the SnPb/SnPb control CSP's while the SAC305/SAC105 CSP's reworked with flux only/SAC 105 balls performed about as well the SnPb/SnPb control CSP's (Figure C-6).

SnPb/SnPb CSP's reworked with SnPb/SAC105 and the SAC305/SAC105 CSP's reworked with SnPb/SAC105 underperformed the SnPb/SnPb controls (Figure C-7). The former were reworked with a SnPb thermal profile while the latter were reworked with a Pb-free thermal profile which should have allowed complete mixing of the solders.

4.4 PDIP-20's

Two component finishes were used on the test vehicles (Sn and NiPdAu). During assembly and wave soldering of the Pb-Free "Manufactured" Test Vehicles, components with the wrong part finish were used in some locations by mistake. See the tables in Appendix B to determine the actual part finish used at each PDIP location.

The combination of SN100C solder/Sn component finish generally performed as well as the SnPb/SnPb controls in mechanical shock (see Figure C-8) although some of the SN100C/Sn solder joints failed early. Microsections made at the end of the test showed that the corner solder joints failed before the other solder joints. The topside solder fillet would crack first followed by cracking of the lead where it necks down at the top of the PTH (see Figures 74 and 75). Another observation is that many of the PDIP's soldered with SN100C exhibited trace cracking at the corner solder joints (see Figures 64 through 67). This failure mode was not observed as often with the PDIP's assembled with SnPb solder.

The SnPb/SnPb PDIP's reworked with SnPb/Sn and the SN100C/Sn PDIP's reworked with SN100C/Sn were less reliable than the unreworked SnPb/SnPb control PDIP's (Figure C-9).

As mentioned above, several of the earliest failures on the "Manufactured" test vehicles were SN100C/Sn solder joints (for example, Test Vehicle 89 PDIP U49 and Test Vehicle 91 PDIP U38). One possible cause is that some of the SN100C joints did not have a substantial topside solder fillet (compare Figure 61 with Figures 62, 63, and 75). This could have resulted in a point of high stress concentration where the PDIP lead necked down resulting in premature failure of the lead. The trace cracking mentioned above is another possible cause for the early failures. Many of the PDIP's that failed early exhibited both failure modes so it could not be definitely determined which occurred first.

4.5 QFN-20's

The QFN's were resistant to failure under the conditions of this test. Only two QFN's failed (on Shocks 827 and 873) and they were both SAC305/Sn. Not enough failures occurred to rank the solders.

A PWB trace required for electrically monitoring QFN U15 was missing on every test vehicle due to a design error. Therefore, no data was generated for this component.

4.6 TQFP-144's

Most of the TQFP-144's had broken and/or missing leads at the end of the test (see the inspection data in Appendix A and Figures 68 and 76). Since most of the failures appeared to be due to broken leads, the scatter in the test data for all of the TQFP solder/finish combinations was small (see Figures C-10 and C-11). SAC305/Sn was equivalent in performance to SnPb/Sn, SnPb/NiPdAu (on immersion Ag), and SnPb/NiPdAu (on ENIG). SAC305/NiPdAu was superior to the SnPb/Sn controls in performance.

For this test, some Sn-plated TQFP-144 leads were dipped into either molten SnPb or SAC305 to evaluate the effectiveness of the hot solder dipping on tin whisker formation. The combination of SnPb/SnPb Dip was equivalent to the SnPb/Sn control in performance but the SAC305/SAC305 Dip performance was inferior to that of the SnPb/Sn control due to some early failures (Figure C-11).

4.7 TSOP-50's

The TSOP's that were not reworked were resistant to failure under the mechanical shock conditions of this test and the lack of failures made it impossible to rank the solder/finish combinations (i.e., SnPb/SnPb, SnPb/Sn, SAC305/Sn, and SAC305/SnBi). Unreworked SnPb/Sn on ENIG did have a few failures but they occurred late in the test.

Mixed solder/finish combinations also had few failures (i.e., SnPb/SnBi and SAC305/SnPb).

Rework had a definite negative effect on performance. SnPb/SnPb reworked with SnPb/SnPb and SAC305/Sn reworked with SnPb/Sn underperformed the unreworked SnPb/SnPb controls which had no failures (see Figure C-12).

SnPb/SnPb reworked with SnPb/Sn and SAC305/SnBi reworked with SAC305/SnBi underperformed the unreworked SnPb/SnPb and SAC305/SnBi controls which had no failures (see Figure C-13).

Figure 69 shows a typical crack in a TSOP solder joint.

4.8 Plated Through Holes (PTH's)

No PTH failures were observed.

5.0 Summary

The overall results of the mechanical shock testing are summarized in Table 7. If a solder alloy/component finish combination performed as well or better than the SnPb control, it was assigned the number "1" and the color "green". Solders that performed worse than the SnPb control were assigned a "2" and the color "yellow". For those cases where both the SnPb controls and a Pb-free solder had few or no failures after 900 shock pulses, they were not ranked. The data plots in Appendix C were used to determine the rankings presented in Table 7.

The rankings in Table 7 are somewhat subjective since the data for some component types contained a lot of scatter and other component types had few failures which complicated the ranking process. In addition, if some of the component/solder combinations had only a few early failures, these failures did not count in the ranking process.

In general, the pure lead-free systems (SAC305/SAC405 balls, SAC305/SAC105 balls, SAC305/Sn, and SN100C/Sn) performed as well or better than the SnPb controls (SnPb/SnPb or SnPb/Sn).

For mixed technologies, SnPb solder balls combined with SAC305 paste (and reflowed with a Pb-free profile) performed as well as the SnPb controls on both the BGA's and the CSP's. In contrast, SnPb solder paste combined with either SAC405 or SAC105 balls (and reflowed with a SnPb thermal profile) underperformed the SnPb/SnPb controls.

Rework operations on the PDIP's and TSOP's reduced the reliability of both the SnPb and the Pb-free solders when compared to the unreworked SnPb/SnPb controls. In contrast, rework of SnPb and SAC405 BGA's and SAC105 CSP's using flux only gave equivalent performance to the unreworked SnPb/SnPb controls. Pb-free BGA's reworked with SnPb paste and SAC405 balls (and a Pb-free thermal profile) were also equivalent to the SnPb controls.

Many of the BGA failures (SnPb/SbPb balls, SAC305/SAC405 balls, and mixed technologies) were due to pad cratering. This suggests that lead-free laminates may be the weakest link for large area array components.

6.0 Conclusions and Recommendations

The results of this study suggest that for most component types, the lead-free solders tested are as reliable as eutectic SnPb solder with respect to mechanical shock. Most of the components tested (including reworked components) successfully passed the tests

defined in MIL-STD-810G 33 times each no matter which solder was used. These tests are the Functional Test (Flight Equipment); the Functional Test (Ground Equipment); and the Crash Hazard Test (Ground Equipment).

These results suggest that the Pb-free solders tested can be used on designs that will be exposed to mechanical shock and will perform as well as currently used eutectic SnPb solder under many use conditions.

7.0 References

1. NASA-DoD Lead-Free Electronics Project Plan, August 2009.
2. Steinberg, Dave S., *Vibration Analysis for Electronic Equipment*, 3rd Edition, John Wiley & Sons, Inc., 2000.
3. MIL-STD-810G, "Environmental Engineering Considerations and Laboratory Tests", 31 October 2008.

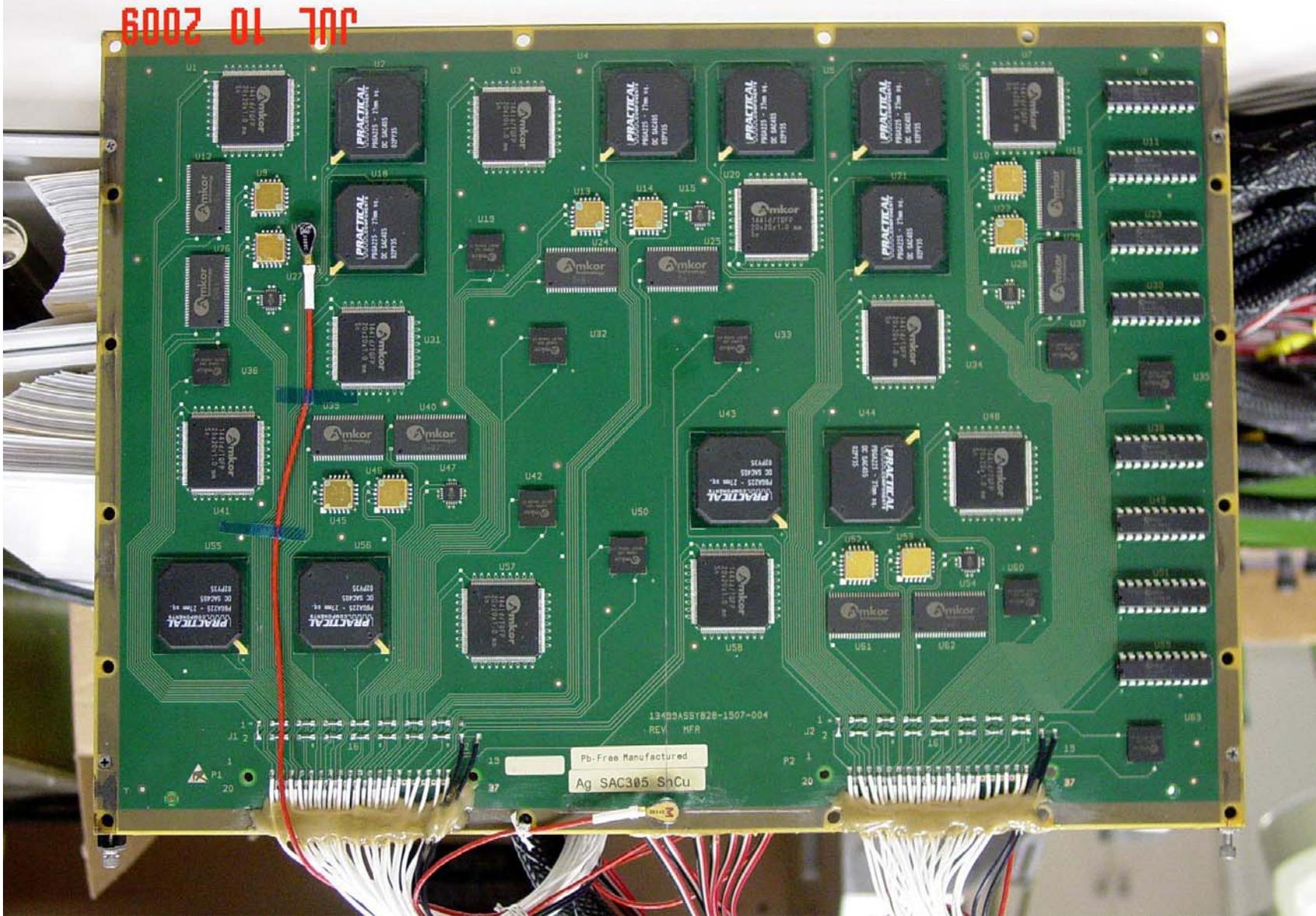


Figure 1. NASA-DoD Test Vehicle

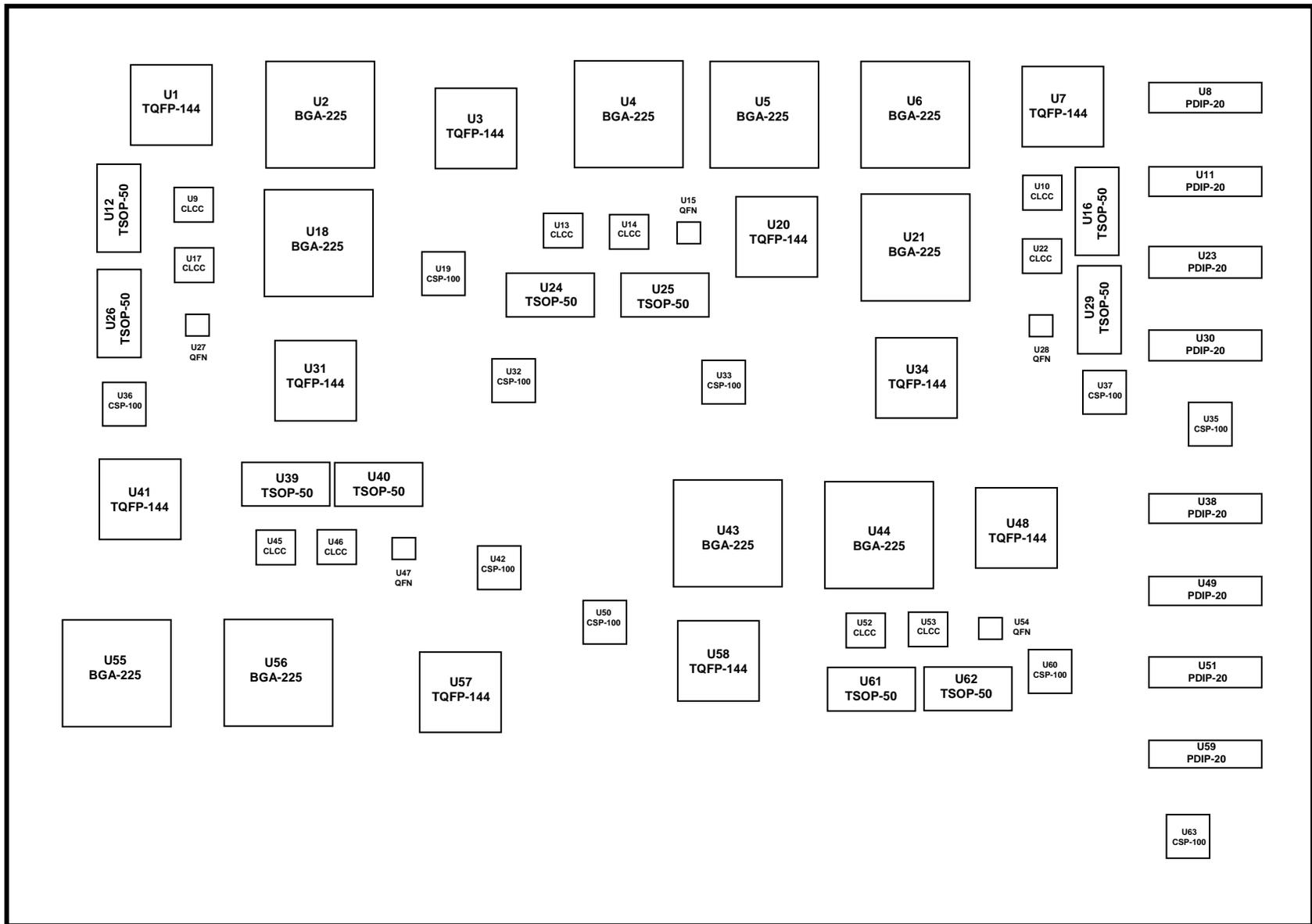


Figure 2. NASA-DoD Test Vehicle Schematic

Table 1. Assembly Matrix for “Manufactured” Mechanical Shock Test Vehicles (SnPb “Manufactured” Test Vehicles 30, 31, 32, 33 and 34; Pb-Free “Manufactured” Test Vehicles 88, 89, 90, 91 and 75)

RefDes	Component	SnPb "Manufactured" Test Vehicles			Pb-Free "Manufactured" Test Vehicles		
		Component Finish	Reflow Solder Alloy	Wave Solder Alloy	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
U18	BGA-225	SnPb	SnPb		SAC405	SAC305	
U43	BGA-225	SnPb	SnPb		SAC405	SAC305	
U04	BGA-225	SnPb	SnPb		SAC405	SAC305	
U06	BGA-225	SnPb	SnPb		SAC405	SAC305	
U55	BGA-225	SnPb	SnPb		SAC405	SAC305	
U02	BGA-225	SnPb	SnPb		SAC405	SAC305	
U05	BGA-225	SnPb	SnPb		SAC405	SAC305	
U21	BGA-225	SnPb	SnPb		SAC405	SAC305	
U44	BGA-225	SnPb	SnPb		SAC405	SAC305	
U56	BGA-225	SnPb	SnPb		SAC405	SAC305	
U09	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U13	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U22	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U46	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U53	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U10	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U14	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U17	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U45	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U52	CLCC-20	SnPb	SnPb		SAC305	SAC305	
U32	CSP-100	SnPb	SnPb		SAC105	SAC305	
U33	CSP-100	SnPb	SnPb		SAC105	SAC305	
U35	CSP-100	SnPb	SnPb		SAC105	SAC305	
U50	CSP-100	SnPb	SnPb		SAC105	SAC305	
U63	CSP-100	SnPb	SnPb		SAC105	SAC305	
U19	CSP-100	SnPb	SnPb		SAC105	SAC305	
U36	CSP-100	SnPb	SnPb		SAC105	SAC305	
U37	CSP-100	SnPb	SnPb		SAC105	SAC305	
U42	CSP-100	SnPb	SnPb		SAC105	SAC305	
U60	CSP-100	SnPb	SnPb		SAC105	SAC305	
U08	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U23	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U49	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U59	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U30	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U38	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U11	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U51	PDIP-20	SnPb		SnPb	See Appendix B		SN100C
U15	QFN-20	SnPb	SnPb		Matte Sn	SAC305	
U27	QFN-20	SnPb	SnPb		Matte Sn	SAC305	
U28	QFN-20	SnPb	SnPb		Matte Sn	SAC305	
U47	QFN-20	SnPb	SnPb		Matte Sn	SAC305	
U54	QFN-20	SnPb	SnPb		Matte Sn	SAC305	
U01	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U07	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U20	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U41	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U58	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U03	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U31	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U34	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U48	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U57	TQFP-144	Matte Sn	SnPb		Matte Sn	SAC305	
U12	TSOP-50	SnPb	SnPb		Sn	SAC305	
U25	TSOP-50	SnPb	SnPb		Sn	SAC305	
U29	TSOP-50	SnPb	SnPb		Sn	SAC305	
U39	TSOP-50	SnPb	SnPb		Sn	SAC305	
U61	TSOP-50	SnPb	SnPb		Sn	SAC305	
U16	TSOP-50	SnPb	SnPb		SnBi	SAC305	
U24	TSOP-50	SnPb	SnPb		SnBi	SAC305	
U26	TSOP-50	SnPb	SnPb		SnBi	SAC305	
U40	TSOP-50	SnPb	SnPb		SnBi	SAC305	
U62	TSOP-50	SnPb	SnPb		SnBi	SAC305	

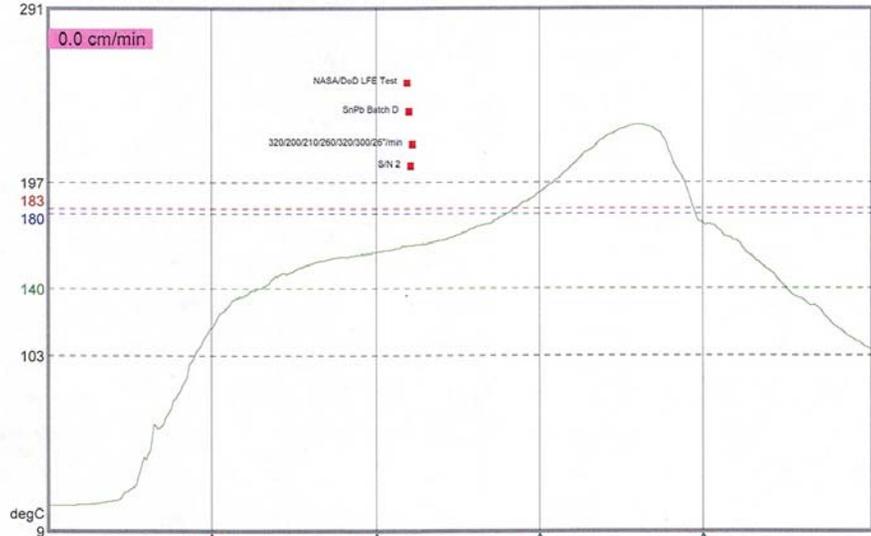
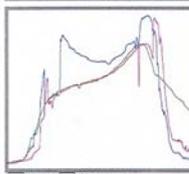
Table 2. Assembly Matrix for “Rework” Mechanical Shock Test Vehicles (SnPb “Rework” Test Vehicles 149, 150, 151, 152, 153 and 160; Pb-Free “Rework” Test Vehicles 189, 190, 191, 192 and 193. Test Vehicle 160 had an ENIG board finish)

RefDes	Component	SnPb "Rework" Test Vehicles					Pb-Free "Rework" Test Vehicles				
		Original Component Finish	Reflow Solder Alloy	Wave Solder Alloy	New Component Finish	Rework Solder	Component Finish	Reflow Solder Alloy	Wave Solder Alloy	New Component Finish	Rework Solder
U04	BGA-225	SAC405	SnPb				SnPb	SAC305			
U55	BGA-225	SAC405	SnPb				SnPb	SAC305			
U05	BGA-225	SAC405	SnPb				SnPb	SAC305			
U44	BGA-225	SAC405	SnPb				SnPb	SAC305			
U18	BGA-225	SnPb	SnPb		SAC405	SnPb	SAC405	SAC305		SAC405	SnPb
U43	BGA-225	SnPb	SnPb		SAC405	SnPb	SAC405	SAC305		SAC405	SnPb
U06	BGA-225	SnPb	SnPb		SAC405	SnPb	SAC405	SAC305		SAC405	SnPb
U02	BGA-225	SnPb	SnPb		SnPb	Flux Only	SAC405	SAC305		SAC405	Flux Only
U21	BGA-225	SnPb	SnPb		SnPb	Flux Only	SAC405	SAC305		SAC405	Flux Only
U56	BGA-225	SnPb	SnPb		SnPb	Flux Only	SAC405	SAC305		SAC405	Flux Only
U09	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U10	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U13	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U14	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U17	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U22	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U45	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U46	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U52	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U53	CLCC-20	SAC305	SnPb				SnPb	SAC305			
U32	CSP-100	SAC105	SnPb				SnPb	SAC305			
U35	CSP-100	SAC105	SnPb				SnPb	SAC305			
U63	CSP-100	SAC105	SnPb				SnPb	SAC305			
U36	CSP-100	SAC105	SnPb				SAC105	SAC305			
U50	CSP-100	SnPb	SnPb		SnPb	Flux Only	SAC105	SAC305		SAC105	Flux Only
U19	CSP-100	SnPb	SnPb		SnPb	Flux Only	SAC105	SAC305		SAC105	Flux Only
U37	CSP-100	SnPb	SnPb		SnPb	Flux Only	SAC105	SAC305		SAC105	Flux Only
U33	CSP-100	SnPb	SnPb		SAC105	SnPb	SAC105	SAC305		SAC105	SnPb
U42	CSP-100	SnPb	SnPb		SAC105	SnPb	SAC105	SAC305		SAC105	SnPb
U60	CSP-100	SnPb	SnPb		SAC105	SnPb	SAC105	SAC305		SAC105	SnPb
U08	PDIP-20	NiPdAu		SnPb			Sn		SN100C		
U23	PDIP-20	NiPdAu		SnPb			Sn		SN100C		
U49	PDIP-20	NiPdAu		SnPb			Sn		SN100C		
U59	PDIP-20	Sn		SnPb			Sn		SN100C		
U30	PDIP-20	Sn		SnPb			Sn		SN100C		
U38	PDIP-20	Sn		SnPb			Sn		SN100C		
U11	PDIP-20	SnPb		SnPb	Sn	SnPb	Sn		SN100C	Sn	SN100C
U51	PDIP-20	SnPb		SnPb	Sn	SnPb	Sn		SN100C	Sn	SN100C
U15	QFN-20	Matte Sn	SnPb				SnPb	SAC305			
U27	QFN-20	Matte Sn	SnPb				SnPb	SAC305			
U28	QFN-20	Matte Sn	SnPb				SnPb	SAC305			
U47	QFN-20	Matte Sn	SnPb				SnPb	SAC305			
U54	QFN-20	Matte Sn	SnPb				SnPb	SAC305			
U03	TQFP-144	NiPdAu	SnPb				NiPdAu	SAC305			
U31	TQFP-144	NiPdAu	SnPb				NiPdAu	SAC305			
U34	TQFP-144	NiPdAu	SnPb				NiPdAu	SAC305			
U48	TQFP-144	NiPdAu	SnPb				NiPdAu	SAC305			
U57	TQFP-144	NiPdAu	SnPb				NiPdAu	SAC305			
U01	TQFP-144	SnPb Dip	SnPb				SAC 305 Dip	SAC305			
U07	TQFP-144	SnPb Dip	SnPb				SAC 305 Dip	SAC305			
U20	TQFP-144	SnPb Dip	SnPb				SAC 305 Dip	SAC305			
U41	TQFP-144	SnPb Dip	SnPb				SAC 305 Dip	SAC305			
U58	TQFP-144	SnPb Dip	SnPb				SAC 305 Dip	SAC305			
U29	TSOP-50	Sn	SnPb				SnBi	SAC305			
U39	TSOP-50	Sn	SnPb				SnBi	SAC305			
U61	TSOP-50	Sn	SnPb				SnBi	SAC305			
U16	TSOP-50	SnBi	SnPb				SnPb	SAC305			
U40	TSOP-50	SnBi	SnPb				SnPb	SAC305			
U62	TSOP-50	SnBi	SnPb				SnPb	SAC305			
U12	TSOP-50	SnPb	SnPb		SnPb	SnPb	Sn	SAC305		Sn	SnPb
U25	TSOP-50	SnPb	SnPb		SnPb	SnPb	Sn	SAC305		Sn	SnPb
U24	TSOP-50	SnPb	SnPb		Sn	SnPb	SnBi	SAC305		SnBi	SAC305
U26	TSOP-50	SnPb	SnPb		Sn	SnPb	SnBi	SAC305		SnBi	SAC305

Mixed SnPb/Pb-Free
Sn Plating Dipped for Whisker Mitigation

M.O.L.E.(r) STATUS
 Max Internal T: 27C
 Battery: 4.246
 Points: 424
 Active: X234XX
 Interval: 00:00:01.0
 Date: 12/02/07
 Time: 09:25:47 V08.58

Tool status box
 NASA/DoD Lead Free
 26"/min
 826-00004-205



Preheat = ~ 120 seconds @140-183°C
Peak temperature target = 225°C
Reflow target:
60-90 sec above 183°C
Ramp Rate = 2-3 °C/sec

	Value	C1 = 00:01:24 r	C2 = 00:02:48 r	C3 = 00:04:12 r	C4 = 00:05:36 r	Units
open						
bad t/c						
below U50 CSP center edge	119	159	192	174		degC
trailing end U4/U55						
open						
open						

	T Above Ref	Low = 140	Med = 180	Hi = 183	Cure Factor	Units
open						
bad t/c						
below U50 CSP center edge	00:04:32	00:01:37	00:01:32	0%		Time
trailing end U4/U55						
open						
open						

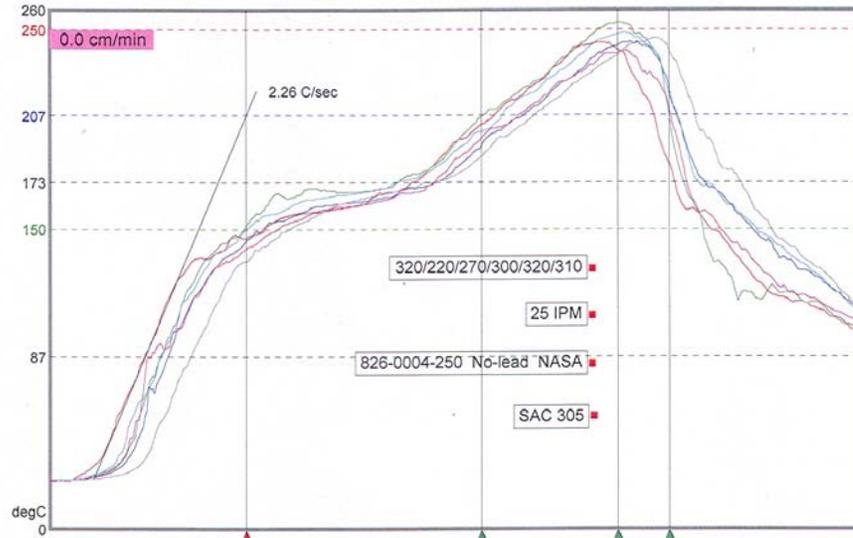
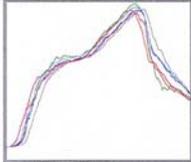
	Statistics	Minimum	Minimum X	Maximum	Maximum X	Average	Std Deviation	Units
open								
bad t/c								
below U50 CSP center edge	23	00:00:00 r	228	00:05:00 r	143.9	56.1		degC
trailing end U4/U55								
open								
open								

Source: BAE Systems

Figure 3. Reflow Profile for SnPb Solder Paste

M.O.L.E.(r) STATUS
 Max Internal T: 28C
 Battery: 4.599
 Points: 433
 Active: 123456
 Interval: 00:00:01.0
 Date: 02/12/80
 Time: 23:39:33 V08.58

Tool status box
 NASA no-lead
 320/220/270/300/320/310
 SAC 305 826-0004-205



Preheat = 60-120 seconds @150-190°C
Peak temperature target = 243°C
Reflow target:
~30-90 seconds above 220°C

Value	C1 = 00:01:43 r	C2 = 00:03:48 r	C3 = 00:05:00 r	C4 = 00:05:27 r	Units
South of U37 CSP	146	203	239	182	degC
North of U32 hybrid	144	193	242	218	degC
North of U42 CSP	151	207	253	204	degC
North of U4	140	196	238	209	degC
South of U58	149	199	248	216	degC
North of U36 CSP	134	187	237	238	degC

T Above Ref	Low = 150	Med = 207	Hi = 250	Cure Factor	Units
South of U37 CSP	00:03:57	00:01:24	00:00:00	0%	Time
North of U32 hybrid	00:04:17	00:01:21	00:00:00	0%	Time
North of U42 CSP	00:04:02	00:01:38	00:00:19	0%	Time
North of U4	00:03:54	00:01:21	00:00:00	0%	Time
South of U58	00:04:29	00:01:33	00:00:00	0%	Time
North of U36 CSP	00:04:15	00:01:25	00:00:00	0%	Time

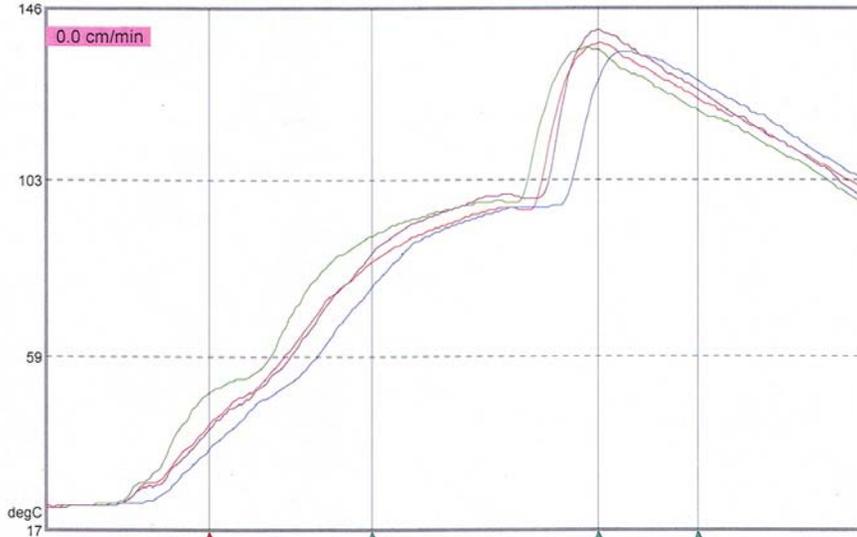
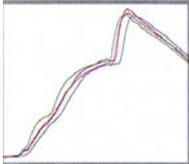
Statistics	Minimum	Minimum X	Maximum	Maximum X	Average	Std Deviation	Units
South of U37 CSP	24	00:00:00 r	243	00:04:48 r	151.6	56.7	degC
North of U32 hybrid	24	00:00:00 r	244	00:05:06 r	151.9	59.8	degC
North of U42 CSP	24	00:00:06 r	253	00:04:59 r	152.7	63.2	degC
North of U4	24	00:00:00 r	239	00:05:04 r	148.5	58.2	degC
South of U58	24	00:00:00 r	248	00:05:02 r	156.3	60.1	degC
North of U36 CSP	24	00:00:04 r	246	00:05:18 r	150.6	63.5	degC

Source: BAE Systems

Figure 4. Reflow Profile for SAC305 Solder Paste

M.O.L.E.(r) STATUS
 Max Internal T: 37C
 Battery: 4.775
 Points: 249
 Active: 1234XX
 Interval: 00:00:01.0
 Date: 01/06/80
 Time: 05:06:42 V08.58

Tool status box
 Lety WS MFG #1 6/19



**Solder Pot Temperature = 250°C
 Peak Board Temp. (Top) = 144°C
 Conveyor Speed: 110 cm/min**

Value	C1 = 00:00:49 r	C2 = 00:01:38 r	C3 = 00:02:46 r	C4 = 00:03:16 r	Units
• Near U44	43	83	137	123	degC
• Near U35	37	77	127	127	degC
• Near U41	51	89	135	120	degC
• center of board	42	85	140	125	degC
• Sensor 5 Location.					
• Sensor 6 Location.					

T Above Ref	Low = 150	Med = 180	Hi = 183	Cure Factor	Units
• Near U44	00:00:00	00:00:00	00:00:00	0%	Time
• Near U35	00:00:00	00:00:00	00:00:00	0%	Time
• Near U41	00:00:00	00:00:00	00:00:00	0%	Time
• center of board	00:00:00	00:00:00	00:00:00	0%	Time
• Sensor 5 Location.					
• Sensor 6 Location.					

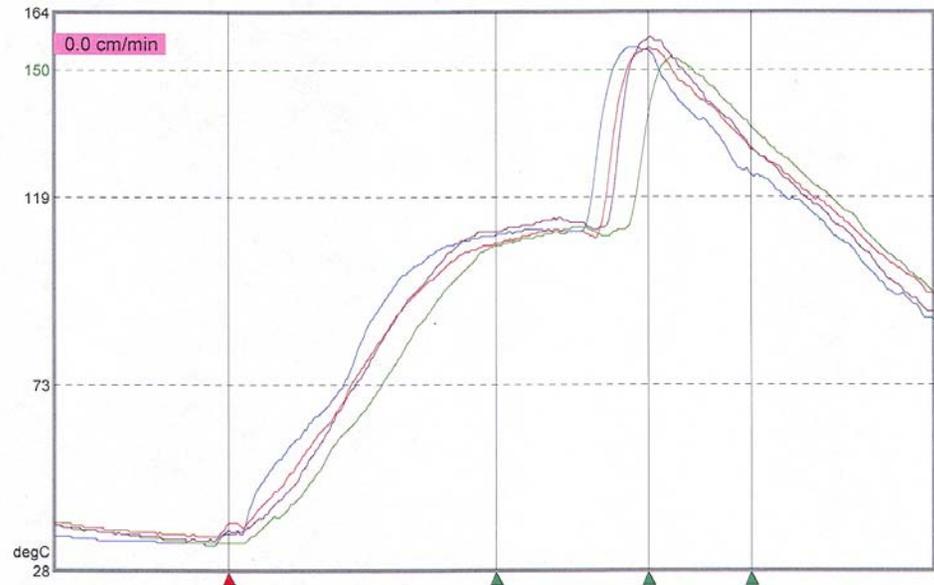
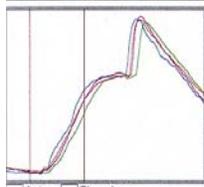
Statistics	Minimum	Minimum X	Maximum	Maximum X	Average	Std Deviation	Units
• Near U44	22	00:00:02 r	137	00:02:46 r	84.3	36.6	degC
• Near U35	22	00:00:00 r	134	00:02:52 r	81.6	37.7	degC
• Near U41	22	00:00:00 r	136	00:02:42 r	86.4	35.1	degC
• center of board	22	00:00:00 r	140	00:02:46 r	84.9	37.5	degC
• Sensor 5 Location.							
• Sensor 6 Location.							

Source: BAE Systems

Figure 5. Wave Soldering Profile for SnPb Solder

M.O.L.E.(r) STATUS
 Max Internal T: 32C
 Battery: 4.687
 Points: 385
 Active: 1234XX
 Interval: 00:00:01.0
 Date: 01/06/80
 Time: 04:19:02 V08.58

Tool status box
 Lety WS PBFREE #3 6/19

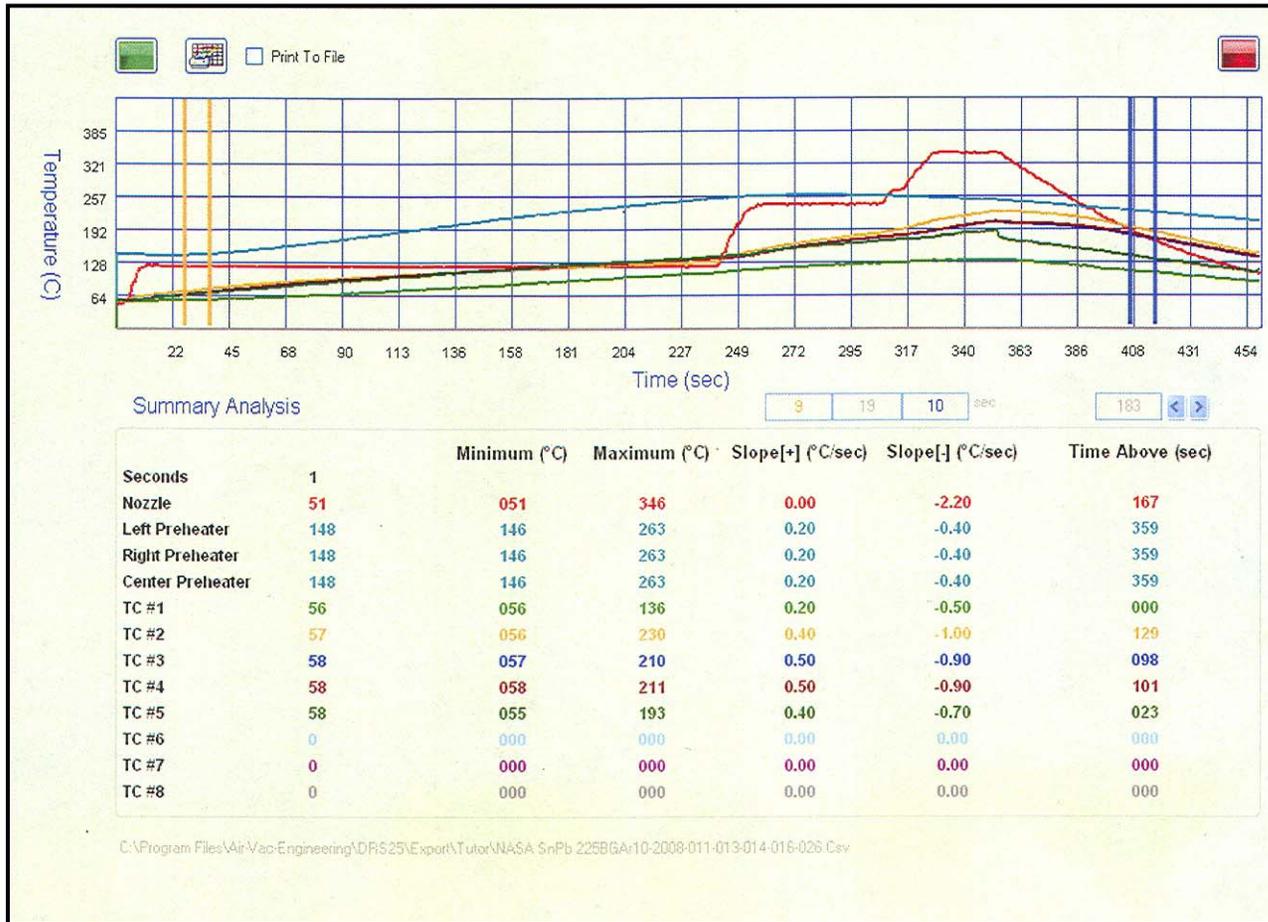


Solder Pot Temperature = 265°C
Peak Board Temp. (Top) = 157°C
Conveyor Speed: 90 cm/min

Value	C1 = 00:01:16 r	C2 = 00:03:13 r	C3 = 00:04:19 r	C4 = 00:05:04 r	Units		
• Near U44	39	108	156	131	degC		
• Near U35	37	110	155	124	degC		
• Near U41	34	107	139	136	degC		
• center of board	38	111	158	131	degC		
• Sensor 5 Location.							
• Sensor 6 Location.							
T Above Ref	Low = 150	Med = 180	Hi = 183	Cure Factor	Units		
• Near U44	00:00:20	00:00:00	00:00:00	0%	Time		
• Near U35	00:00:21	00:00:00	00:00:00	0%	Time		
• Near U41	00:00:15	00:00:00	00:00:00	0%	Time		
• center of board	00:00:24	00:00:00	00:00:00	0%	Time		
• Sensor 5 Location.							
• Sensor 6 Location.							
Statistics	Minimum	Minimum X	Maximum	Maximum X	Average	Std Deviation	Units
• Near U44	36	00:00:58 r	156	00:04:19 r	91.4	38.3	degC
• Near U35	34	00:01:06 r	156	00:04:10 r	91.4	38.1	degC
• Near U41	34	00:00:58 r	153	00:04:29 r	88.4	39.1	degC
• center of board	35	00:00:58 r	158	00:04:20 r	90.8	39.1	degC
• Sensor 5 Location.							
• Sensor 6 Location.							

Source: BAE Systems

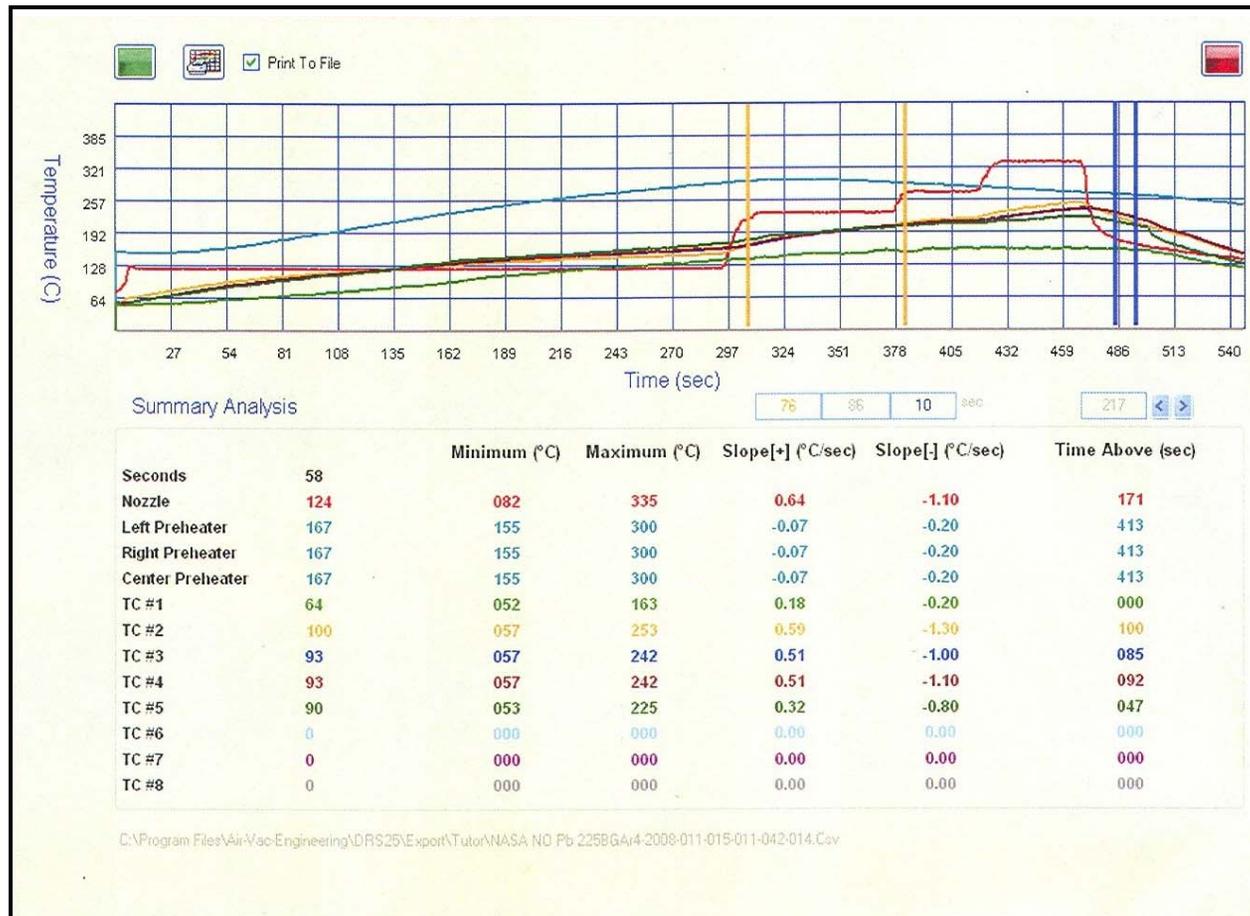
Figure 6. Wave Soldering Profile for SN100C Solder



SnPb 225 BGA	Nozzle	Preheater	Trigger Point
Preheat	125	300	110 board
Presoak	225	200	139
Soak	245	200	180
Ramp	275	200	182
Reflow	345	200	209
Max board temp	136		
Max body	230		
Max ball	211		
Dwell	98 sec		

Source: BAE Systems

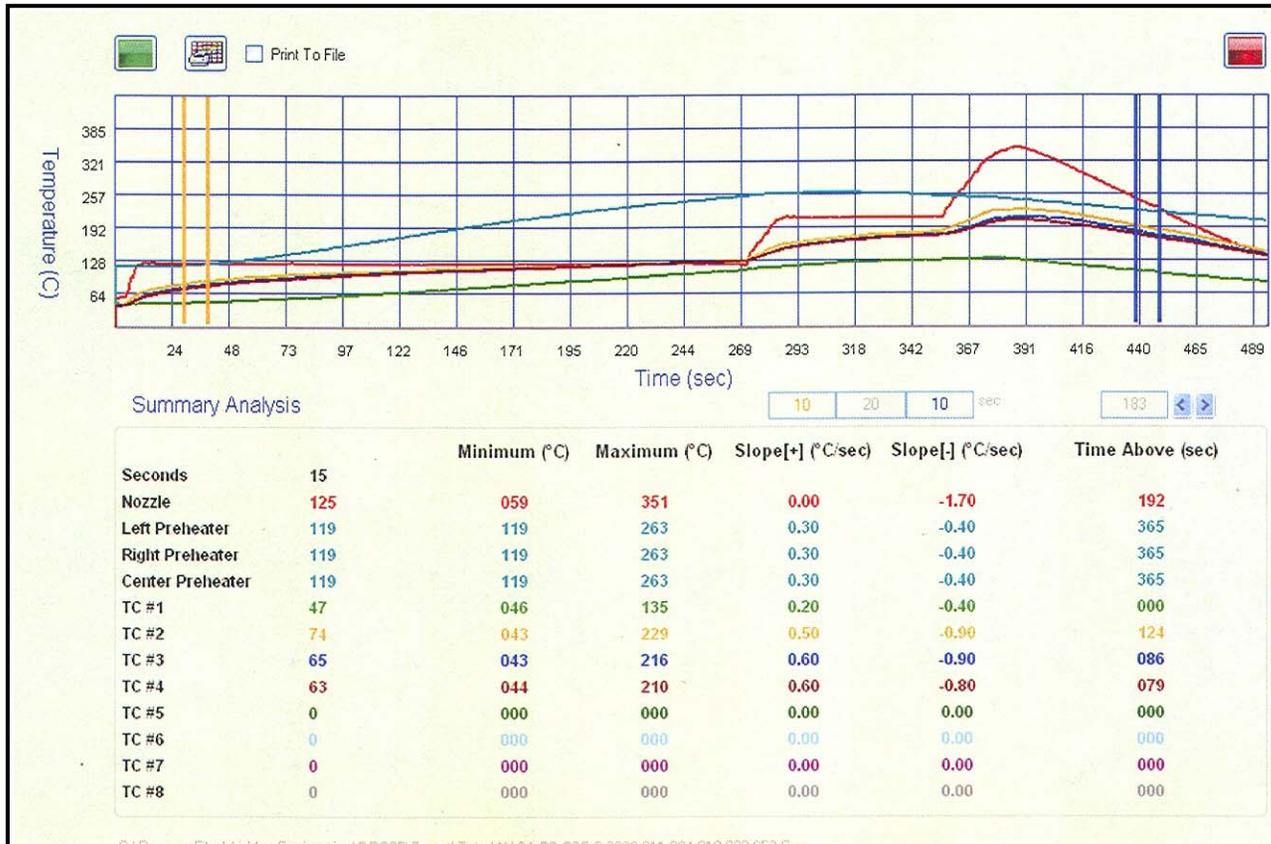
Figure 7. Air-Vac Profile for SnPb "Rework" Test Vehicles (BGA Removal and Replacement)



	Pb-Free 225 BGA	Nozzle	Preheater	Trigger Point
Preheat	125	325	140 board	
Presoak	225	200	169	
Soak	235	200	205	
Ramp	275	225	216	
Reflow	335	250	240	
Max board temp	163			
Max body	253			
Max ball	242			
Dwell	85 sec			

Source: BAE Systems

Figure 8. Air-Vac Profile for Lead-Free "Rework" Test Vehicles (BGA Removal and Replacement)



SnPb CSP	Nozzle	Preheater	Trigger Point
Preheat	125	300	110 board
Presoak	215	200	139
Soak	215	200	180
Ramp	275	225	182
Reflow	335	225	209
Max board temp	135		
Max body	229		
Max ball	216		
Dwell	86 sec		

Source: BAE Systems

Figure 9. Air-Vac Profile for SnPb "Rework" Test Vehicles (CSP Removal and Replacement)



Pb-Free CSP	Nozzle	Preheater	Trigger Point
Preheat	125	325	140 board
Presoak	225	200	169
Soak	235	200	205
Ramp	275	200	216
Reflow	305	200	235
Max board temp	163		
Max body	254		
Max ball	236		
Dwell	67 sec		

Source: BAE Systems

Figure 10. Air-Vac Profile for Lead-Free "Rework" Test Vehicles (CSP Removal and Replacement)

Table 3. Chemical Analysis of Solder Joints Contaminated with Pb (by ICP Spectroscopy)

Component	Ref. Des.	Test Vehicle ID	Reworked?	Component Finish	Board Finish	Solder	%Ag	%Cu	%Pb	%Sn	%Bi	%Au
BGA-225	U04	149	No	SAC405	Ag	Sn37Pb	3.46	0.94	3.77	91.71	0.00	0.13
BGA-225	U04	193	No	Sn37Pb	Ag	SAC305	0.31	0.26	33.91	65.44	0.00	0.08
BGA-225	U43	193	Yes	SAC405	Residual SAC	Sn37Pb	3.13	3.18**	5.52	88.07	0.00	0.10
CLCC-20	U09	149	No	SAC305	Ag	Sn37Pb	1.35	0.49	24.68	73.48	0.00	0.00
CLCC-20	U09	193	No	Sn37Pb	Ag	SAC305	1.92	0.39	16.46	81.19	0.04	0.00
CSP-100*	U33	149	Yes	SAC105	Residual Sn37Pb	Sn37Pb	0.90	0.73	1.81	96.23	0.00	0.33
CSP-100*	U33	193	Yes	SAC105	Residual SAC	Sn37Pb	0.83	0.63	4.43	93.82	0.00	0.29
QFN-20	U15	193	No	SnPb	Ag	SAC305	3.39	0.85	0.93	94.83	0.00	0.00
TSOP-50	U16	149	No	SnBi	Ag	Sn37Pb	0.44	2.68**	35.73	61.06	0.09	0.00
TSOP-50	U16	193	No	SnPb	Ag	SAC305	3.53	6.10**	1.51	88.86	0.00	0.00

*PWB Cu pads had to be cut from the CSP balls. This operation also removed that end of each ball.

** Copper may have been removed from the PWB pads when the solder joints were cut from the test vehicle.

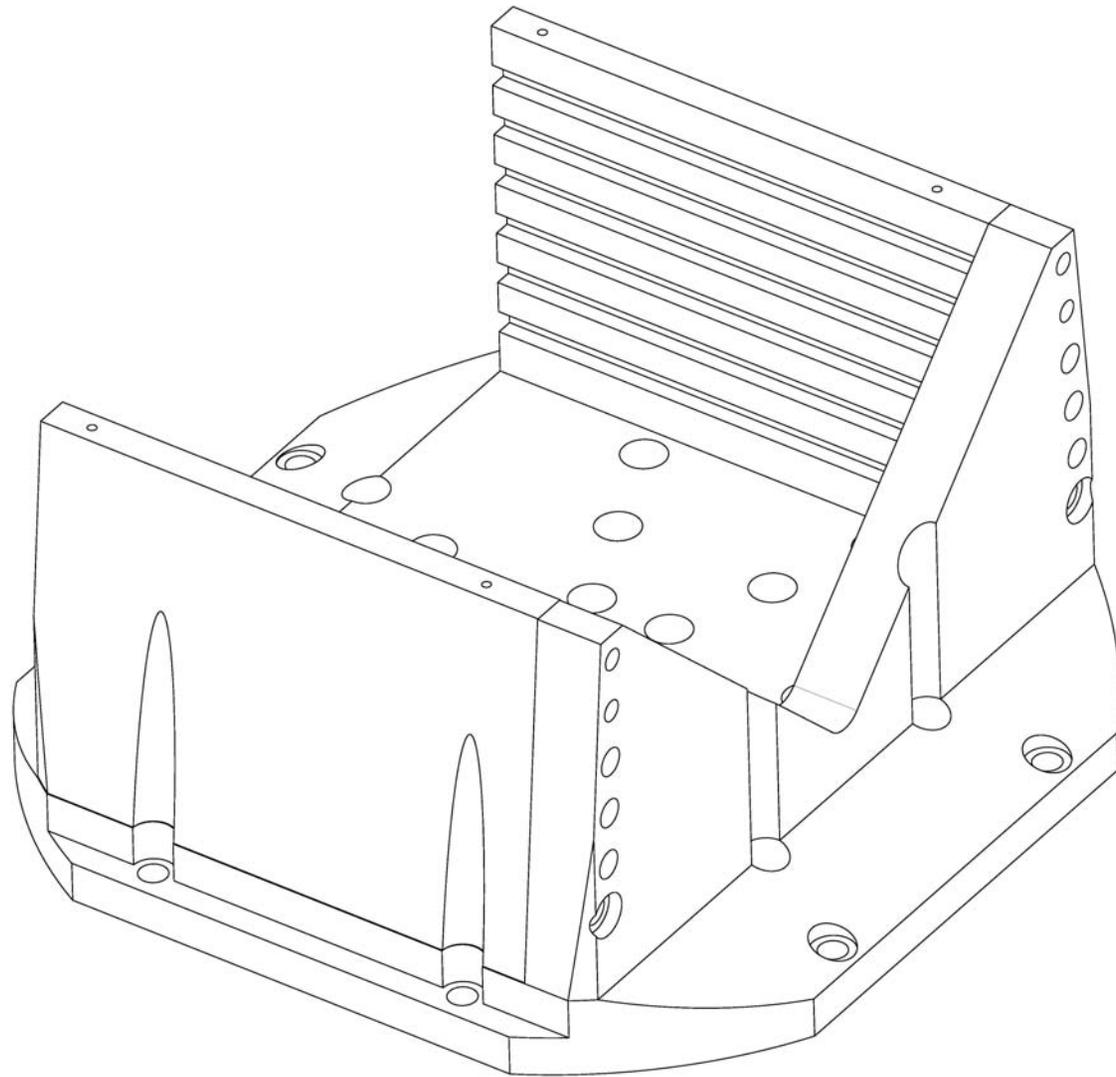


Figure 11. Fixture for Holding Mechanical Shock Test Vehicles

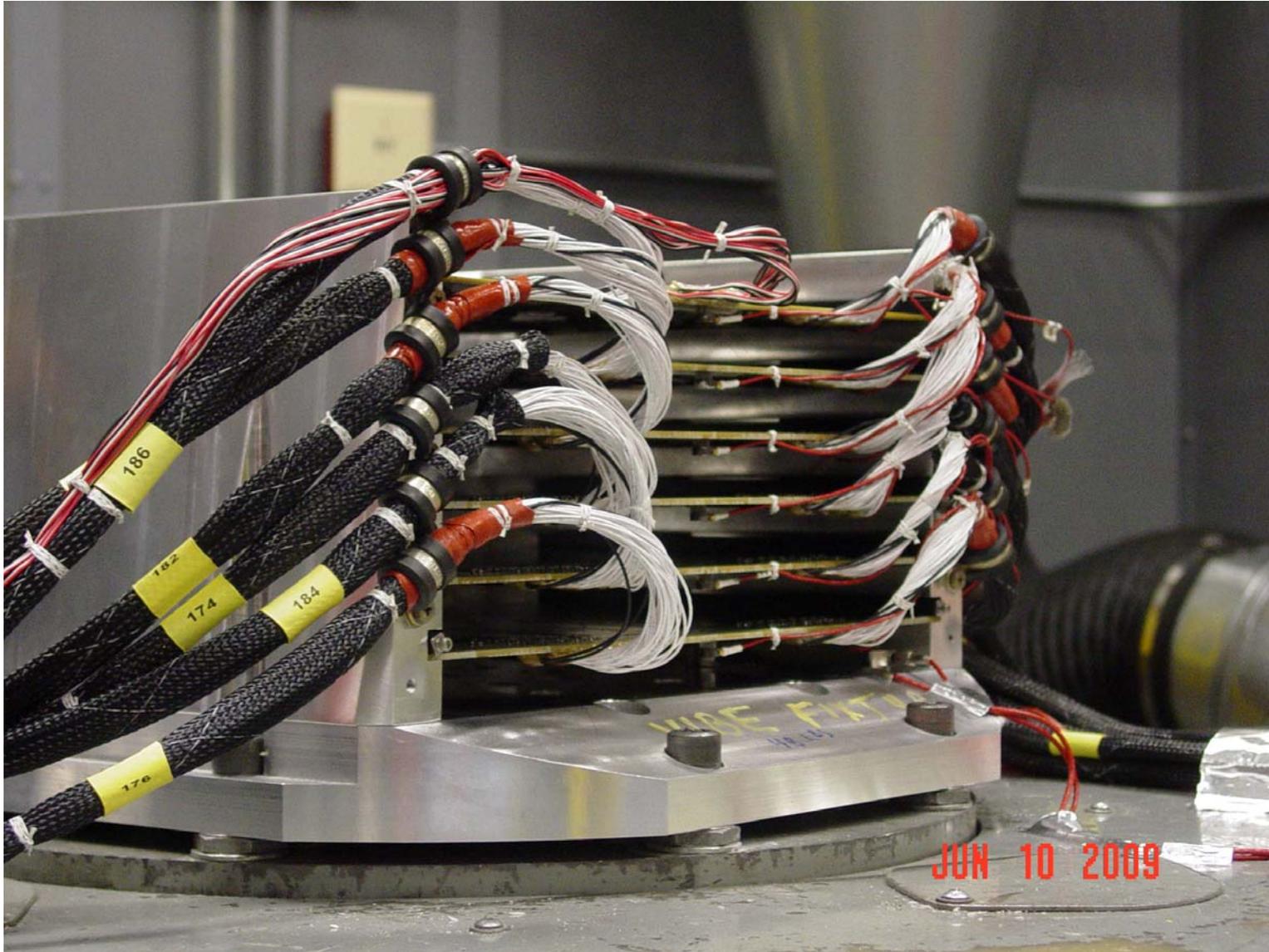


Figure 12. Test Vehicles in Fixture

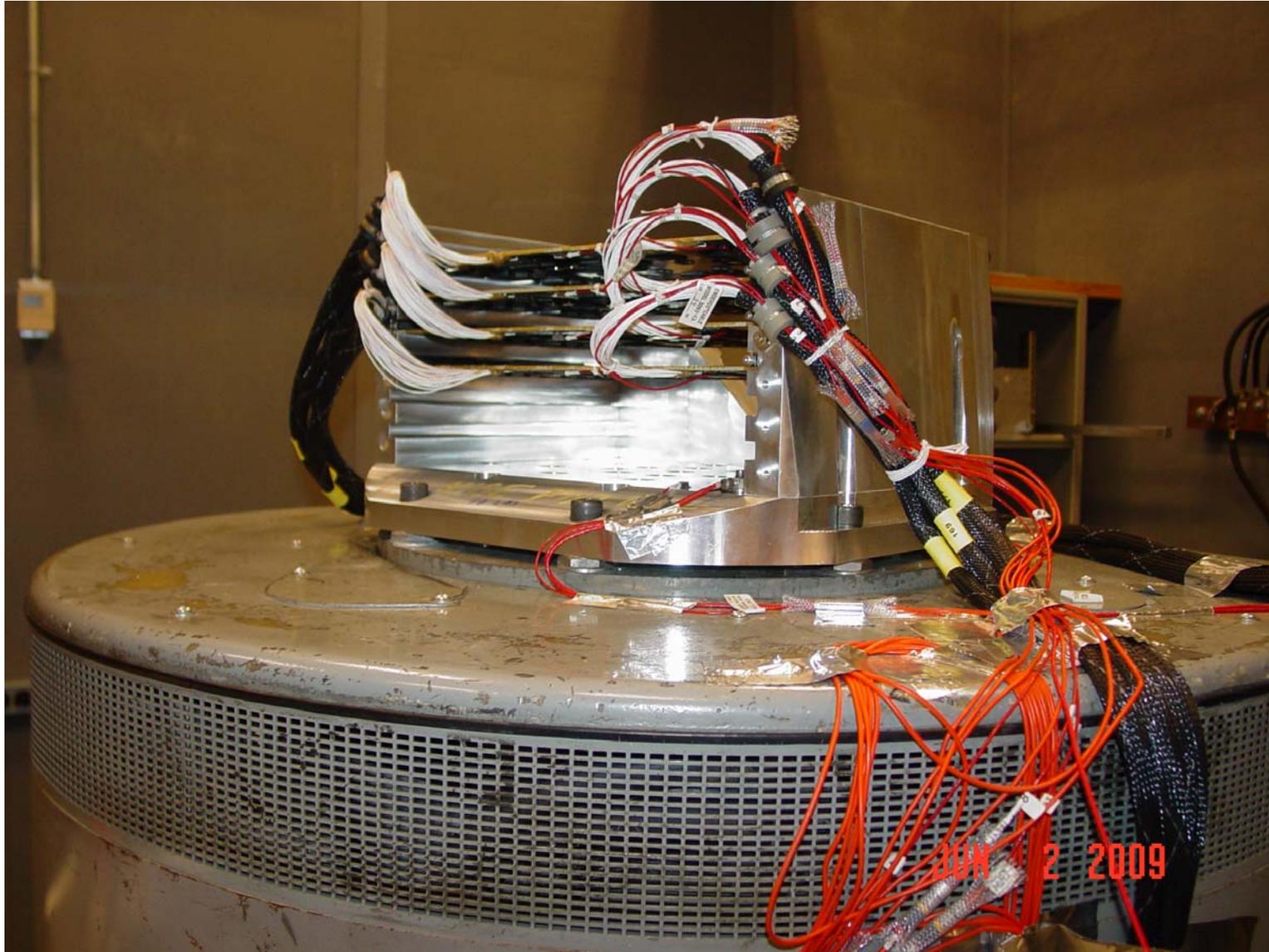


Figure 13. Test Vehicles in Fixture Mounted on the Electrodynamic Shaker



Figure 14. Shaker Controller and Event Detectors



Figure 15. Laser Vibrometer Mounted Over Fixture

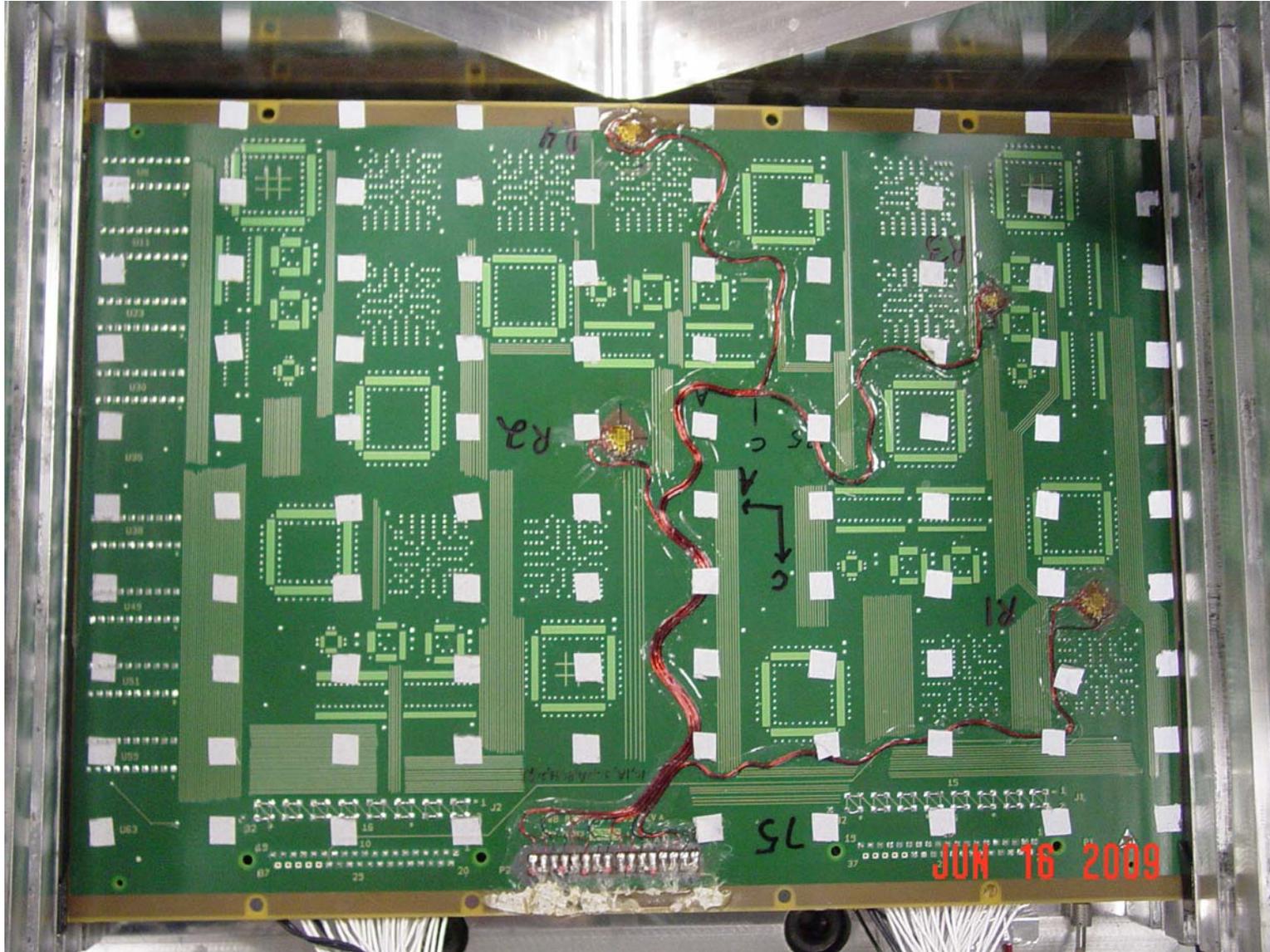


Figure 16. Laser Vibrometer View of Test Vehicle 75

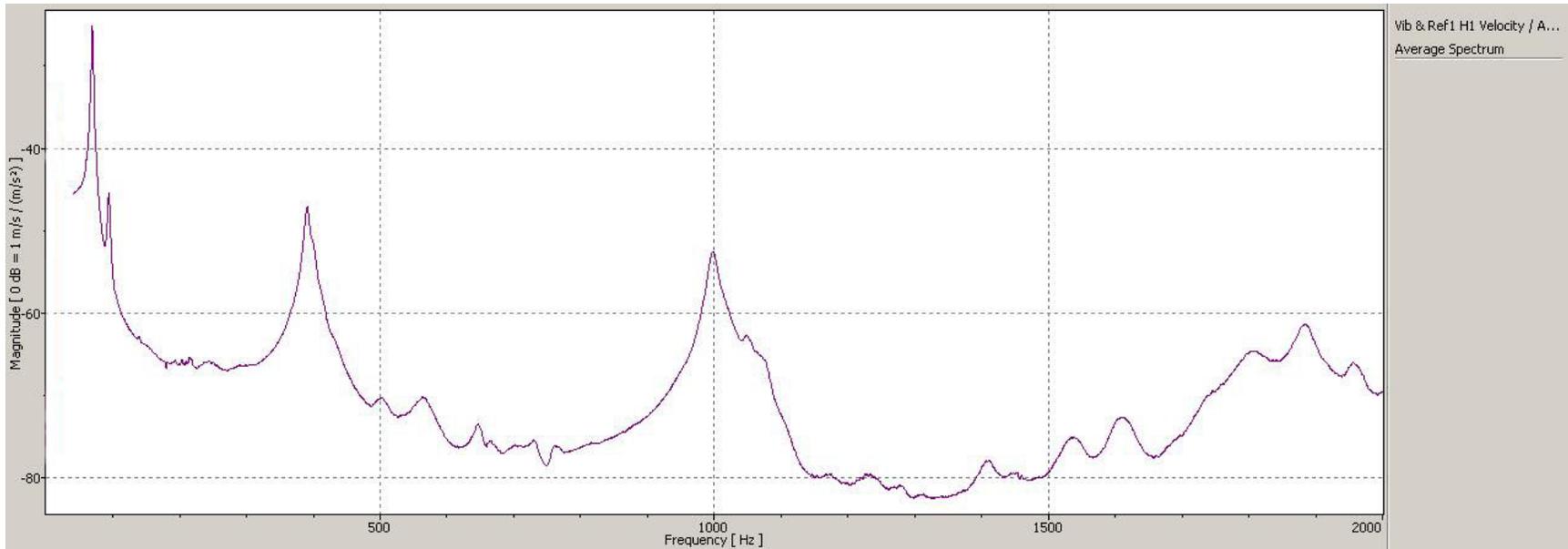


Figure 17. Modal Analysis of Test Vehicle 75 using the Laser Vibrometer

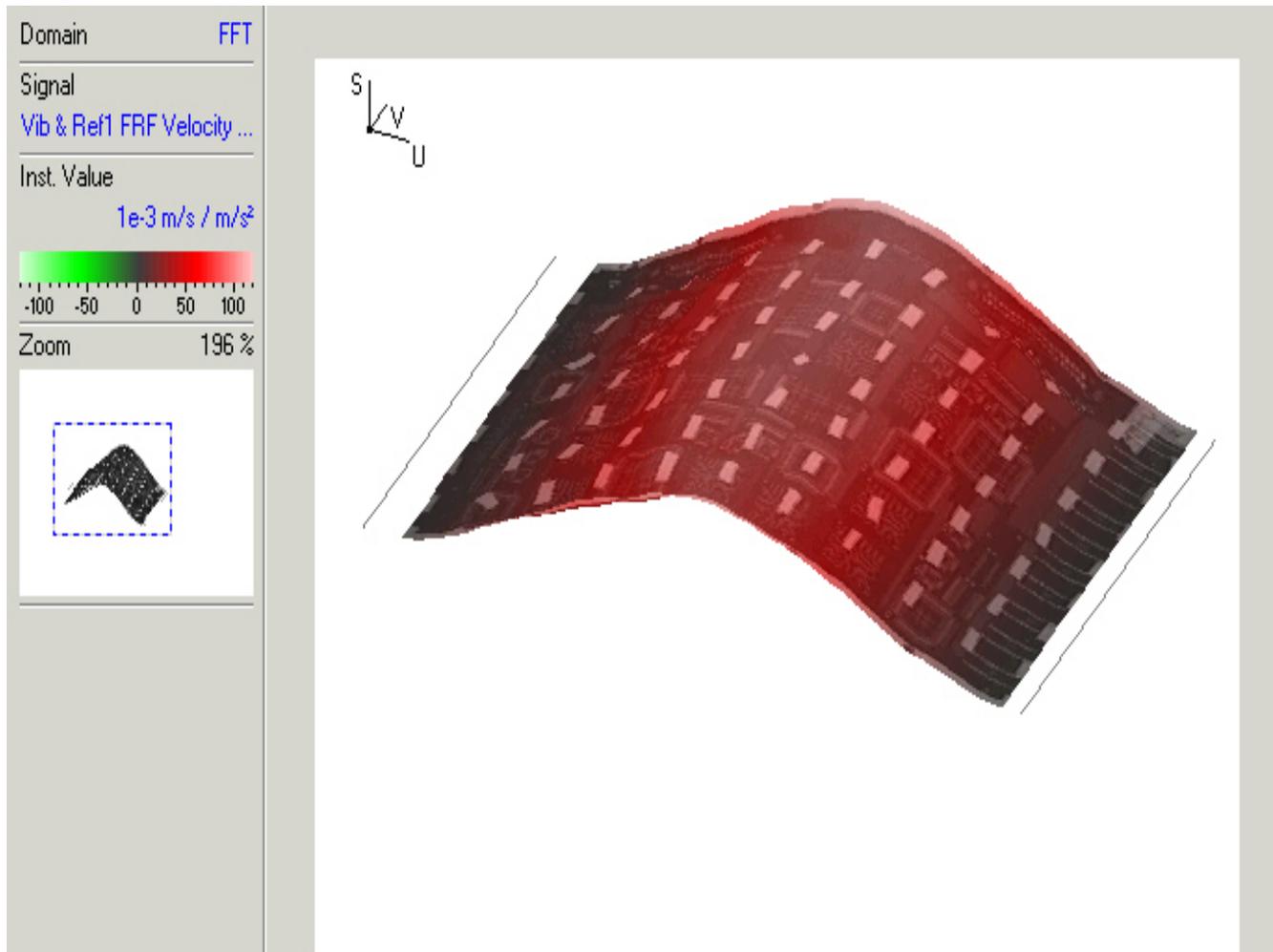


Figure 18. Mode Shape at 70 Hz

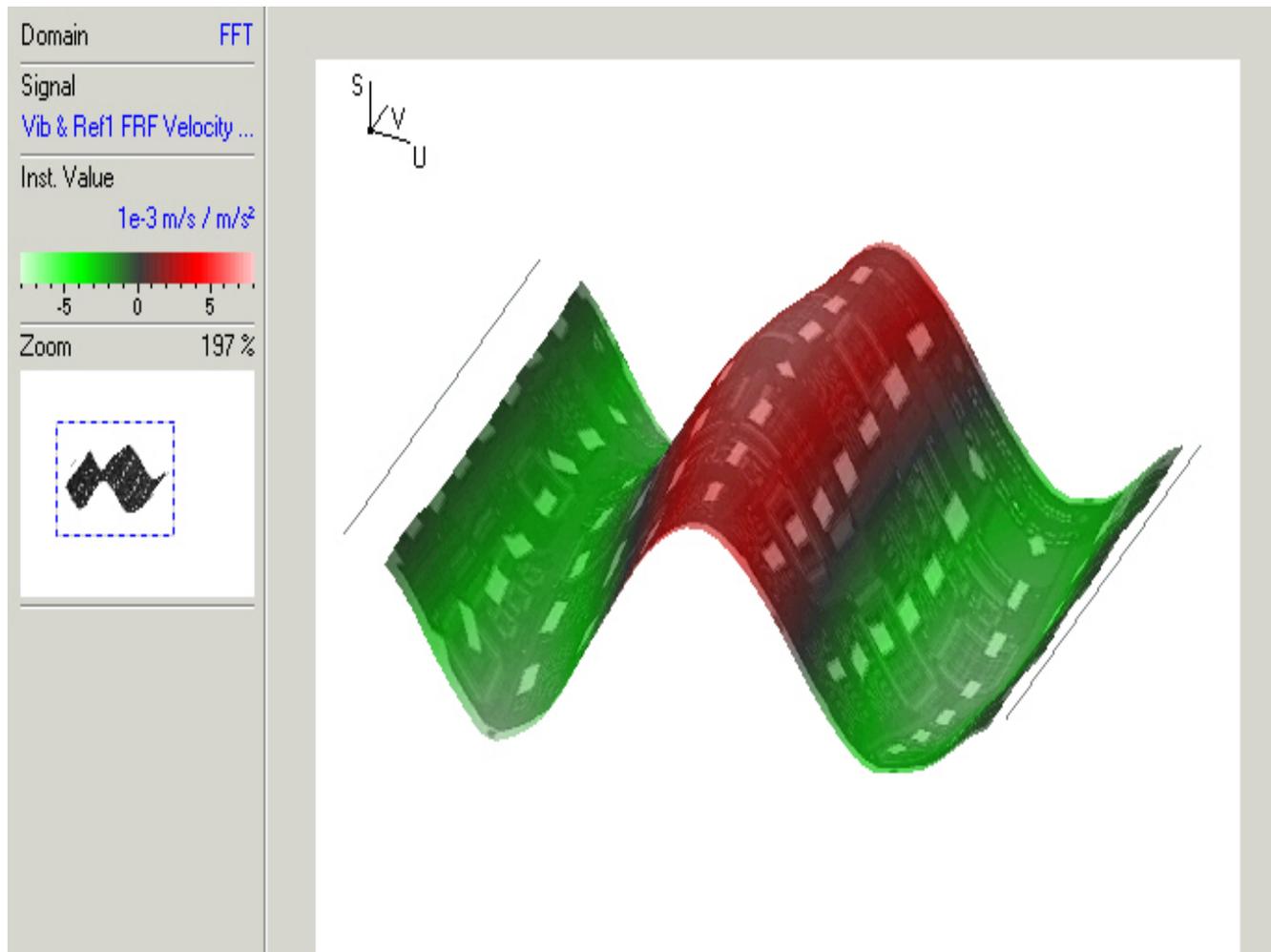


Figure 19. Mode Shape at 391 Hz

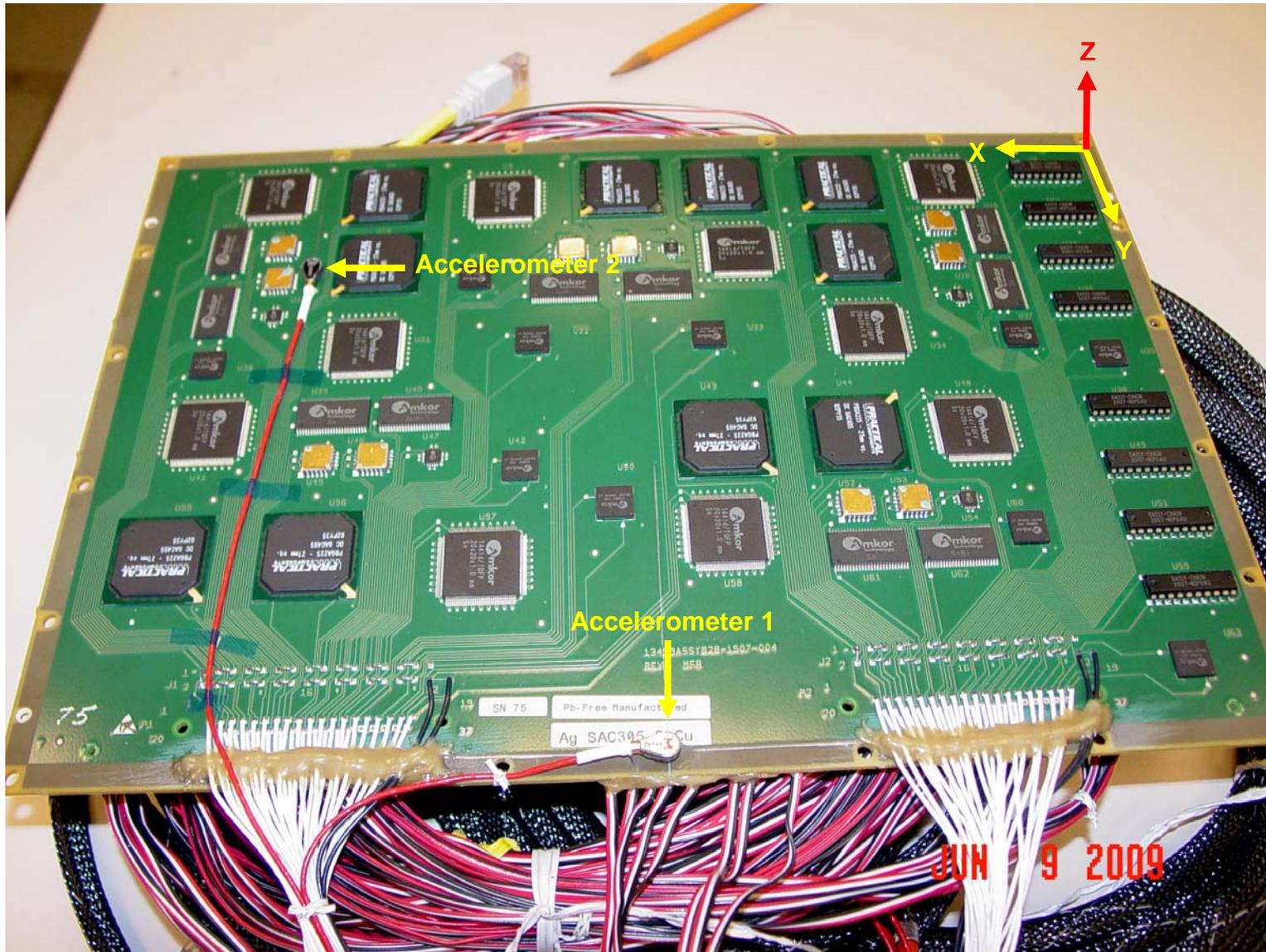


Figure 20. Accelerometer Placement on Test Vehicle 75

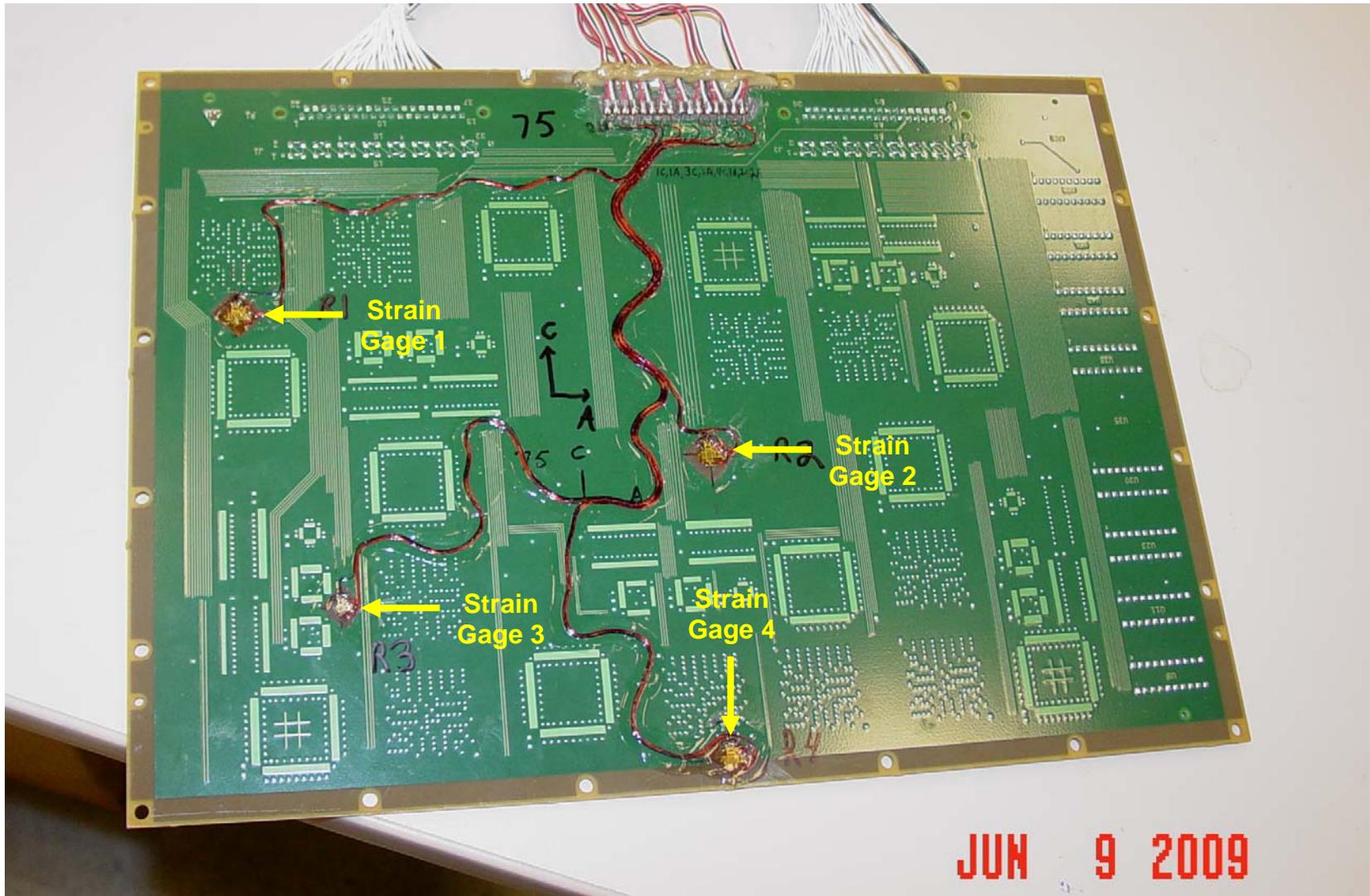
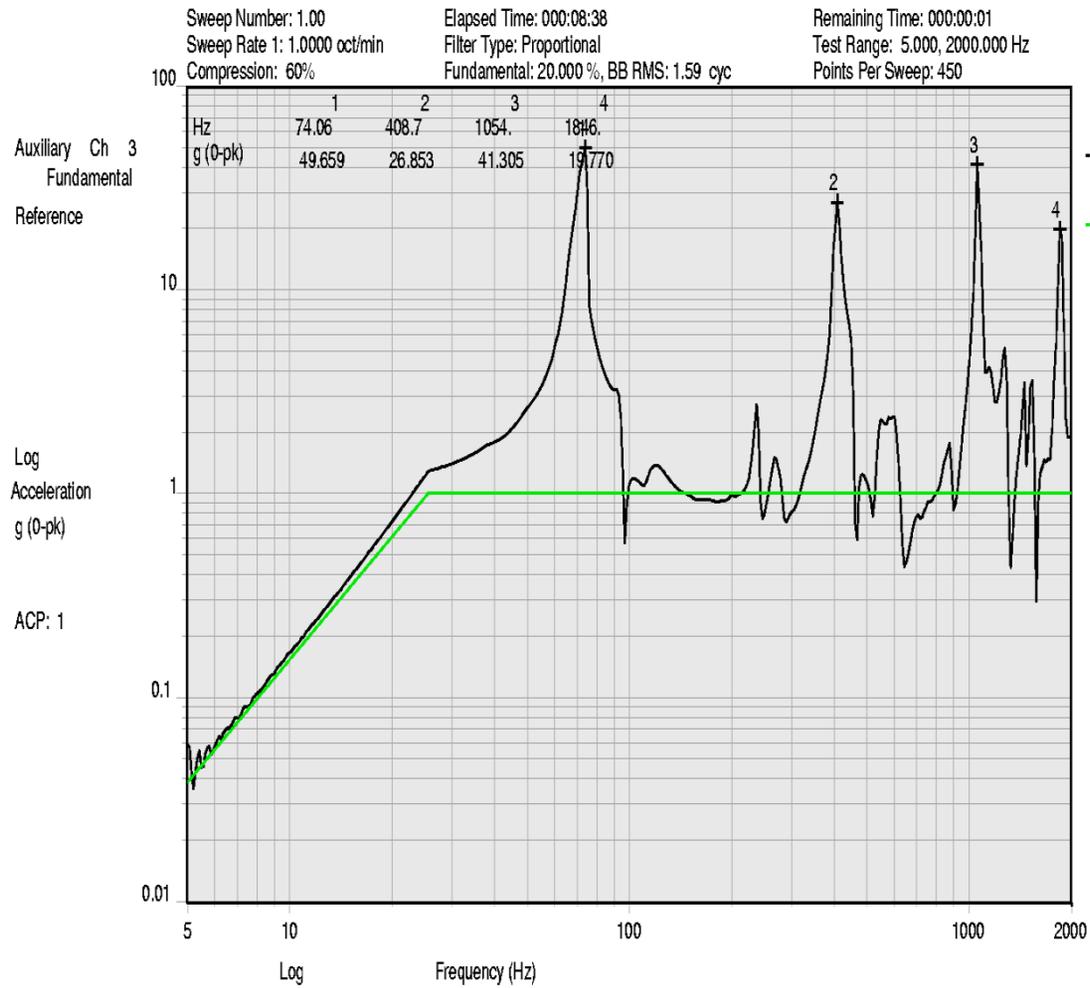


Figure 21. Strain Gage Placement on Test Vehicle 75

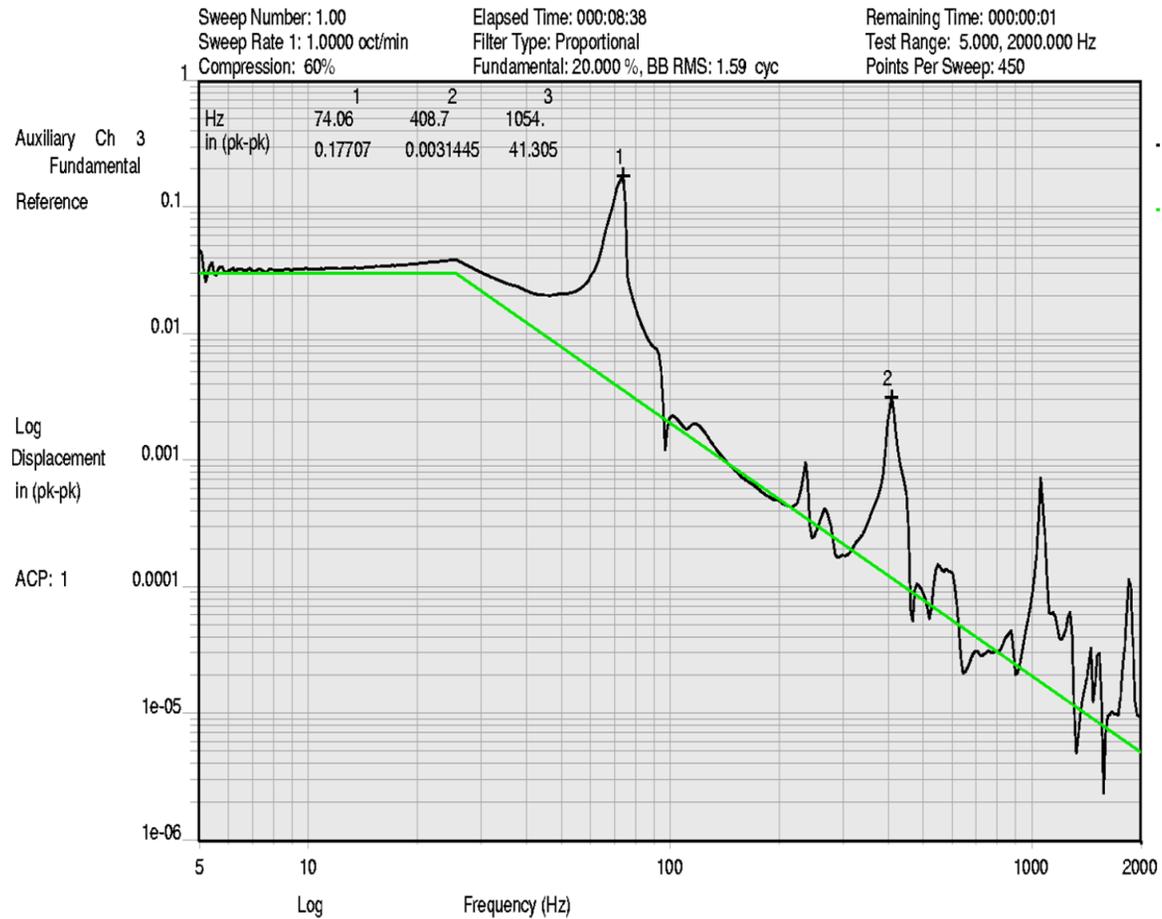


3z Board #89, connector edge center

13:31:37
 02-Jun-2009

CITAP 907 No Lead, Circuit boards: 30,31,88 and 89
 Run#4 Z-axis, 1Gpk Sine Scan ,
 Test Name: tn2122_1Gpk.008

Figure 22. Transmissibilities at Each Major Resonant Frequency Measured During a 1G Sine Sweep (Accelerometer 1, Test Vehicle 89)



13:31:47
02-Jun-2009

CITAP 907 No Lead, Circuit boards: 30,31,88 and 89
Run#4 Z-axis, 1Gpk Sine Scan,
Test Name: tn2122_1Gpk.008

3z Board #89, connector edge center

Figure 23. Displacements Measured During a 1G Sine Sweep (Accelerometer 1, Test Vehicle 89)

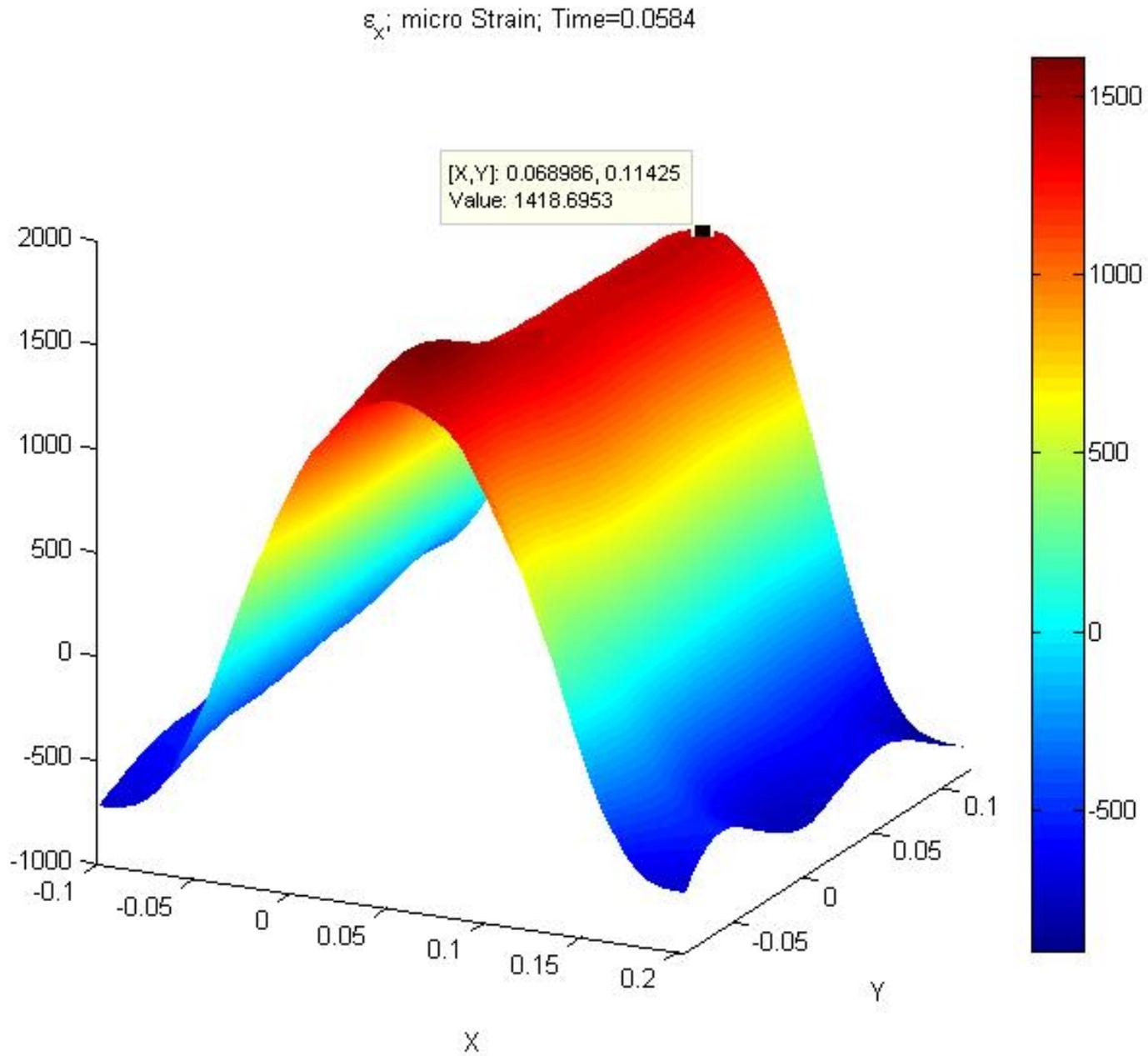


Figure 24. Peak Strains during 100 G Shock Pulse from All Modes Combined (Test Vehicle 75, in microstrain)

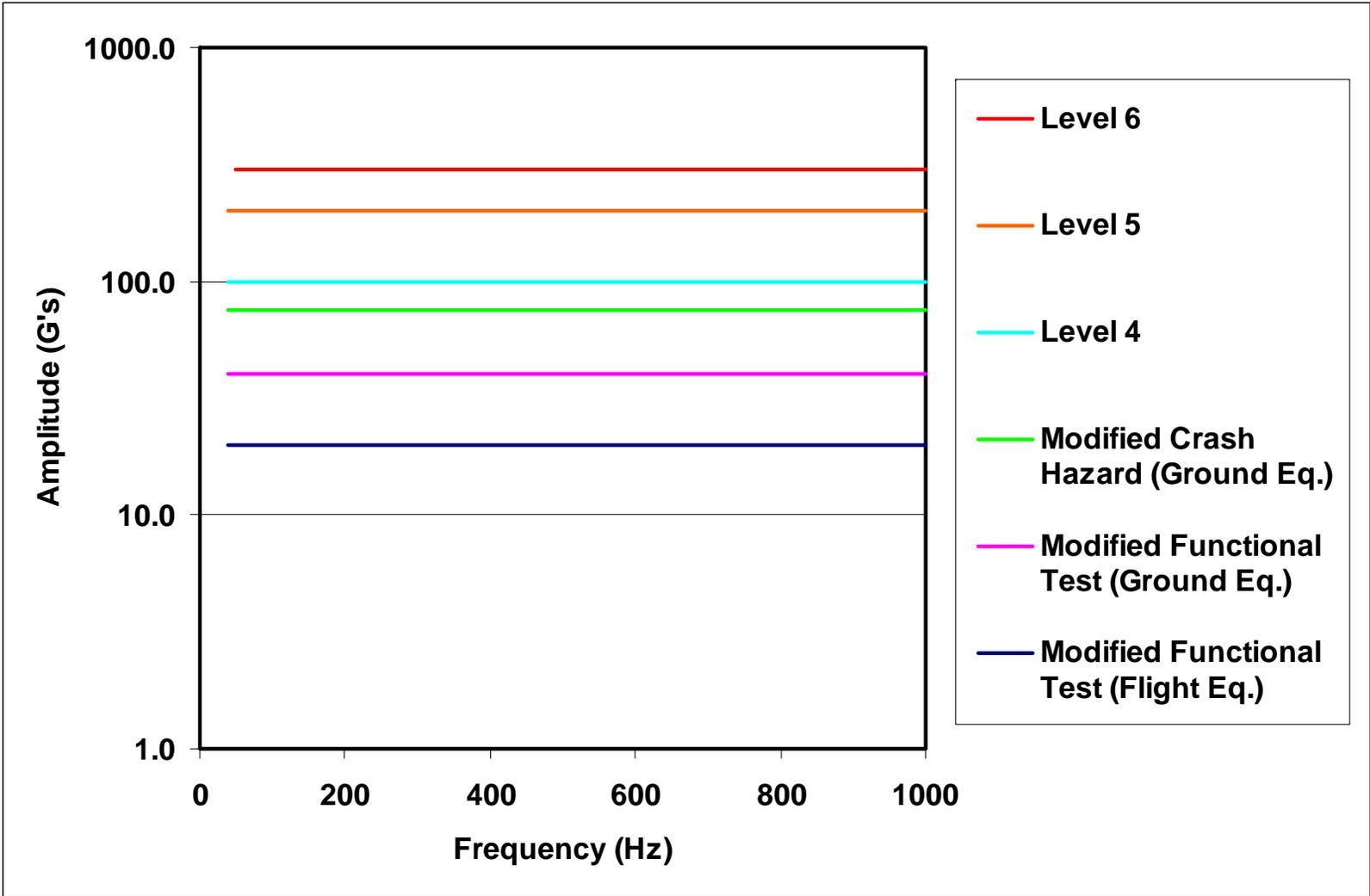
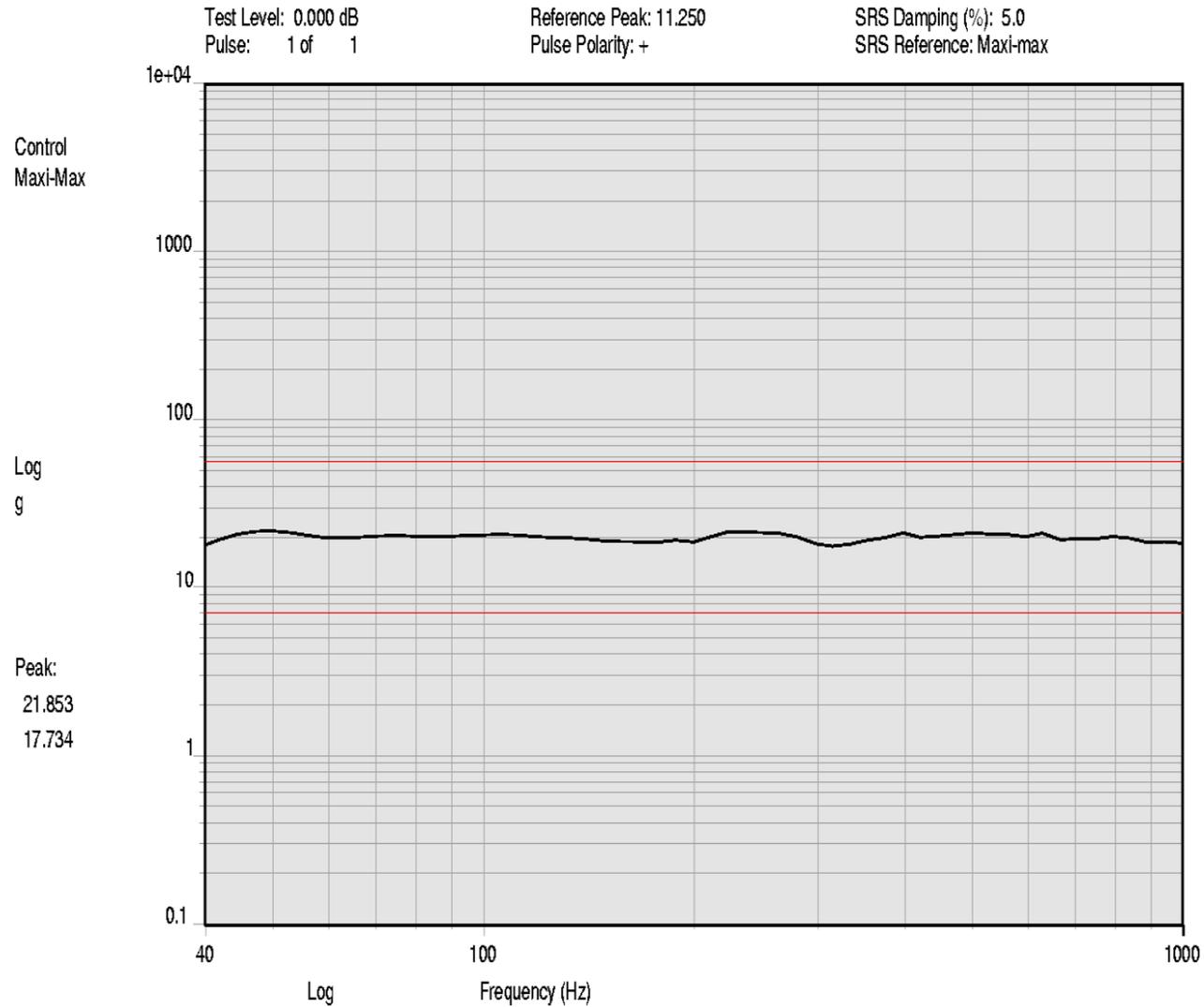


Figure 25. Mechanical Shock SRS Test Levels

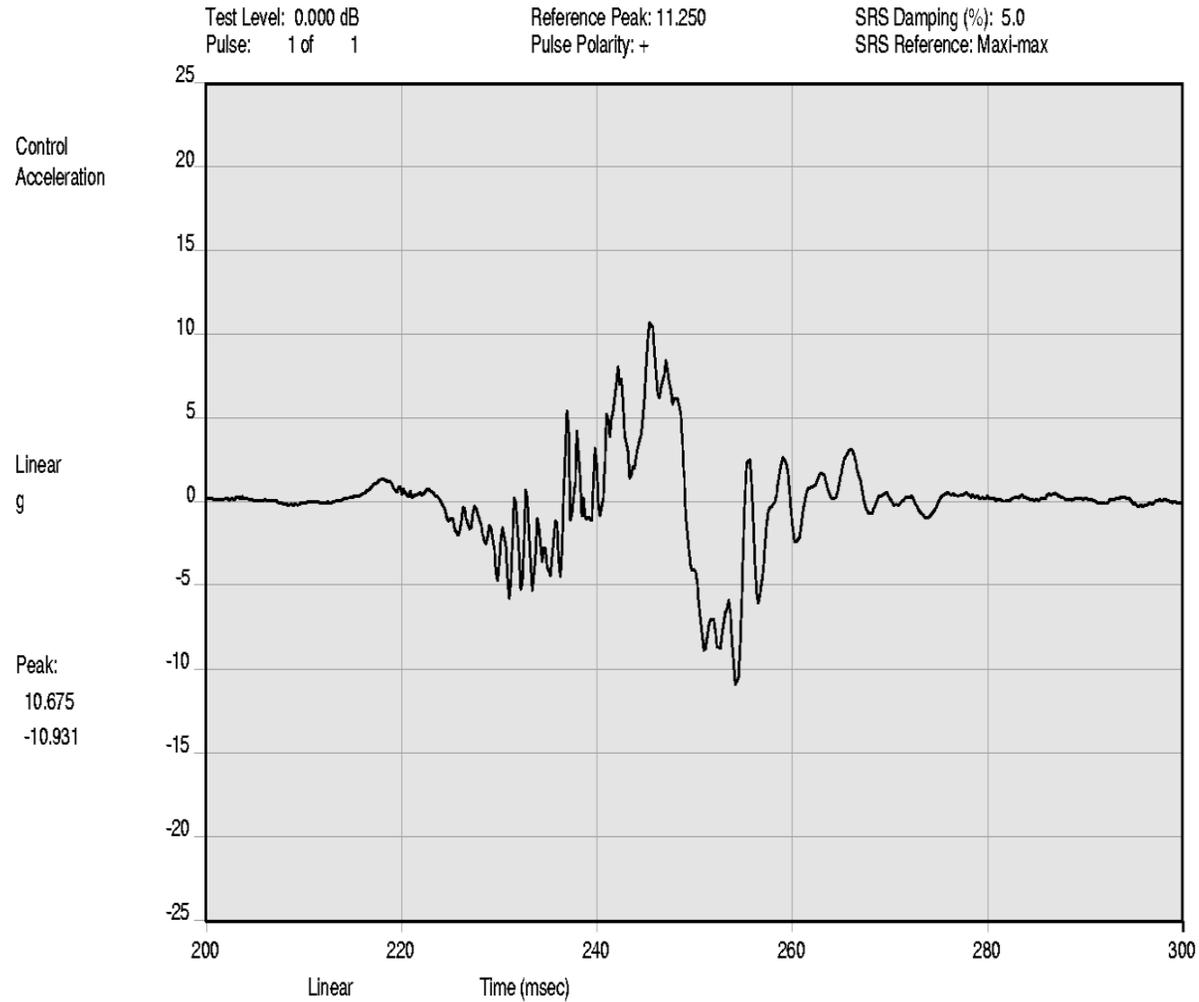
Table 4. Mechanical Shock SRS Test Levels (5% Damping)

Test Level	Amplitude (G's)	SRS Frequency Bandwidth	Pulse Duration (milliseconds)	Shocks Per Level
Level 1. Modified Functional Test for Flight Eq.	20	40 to 1000 Hz	<30	100
Level 2. Modified Functional Test for Ground Eq.	40	40 to 1000 Hz	<30	100
Level 3. Modified Crash Hazard	75	40 to 1000 Hz	<30	100
Level 4	100	40 to 1000 Hz	<30	100
Level 5	200	40 to 1000 Hz	<30	100
Level 6	300	50 to 1000 Hz	<30	400



16:28:03.3 CITA907 No Lead, Circuit Boards: #30,31,88,89 Pulse #10 #1Z, Control base outboard by wall
Tue Jun 02 2009 Run #5 Z-axis, Level#1 20g, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_20g-40hz_a.003

Figure 26. 20 G SRS Input (Accelerometer on Fixture)



16:28:03.3
Tue Jun 02 2009

CITAP 907 No Lead, Circuit Boards: #30,31,88,89 Pulse #10
Run #5 Z-axis, Level#1 20g, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_20g-40hz_a.003

#1Z, Control base outboard by wall

Figure 27. Pulse Used to Create 20 G SRS Input (Accelerometer on Fixture)

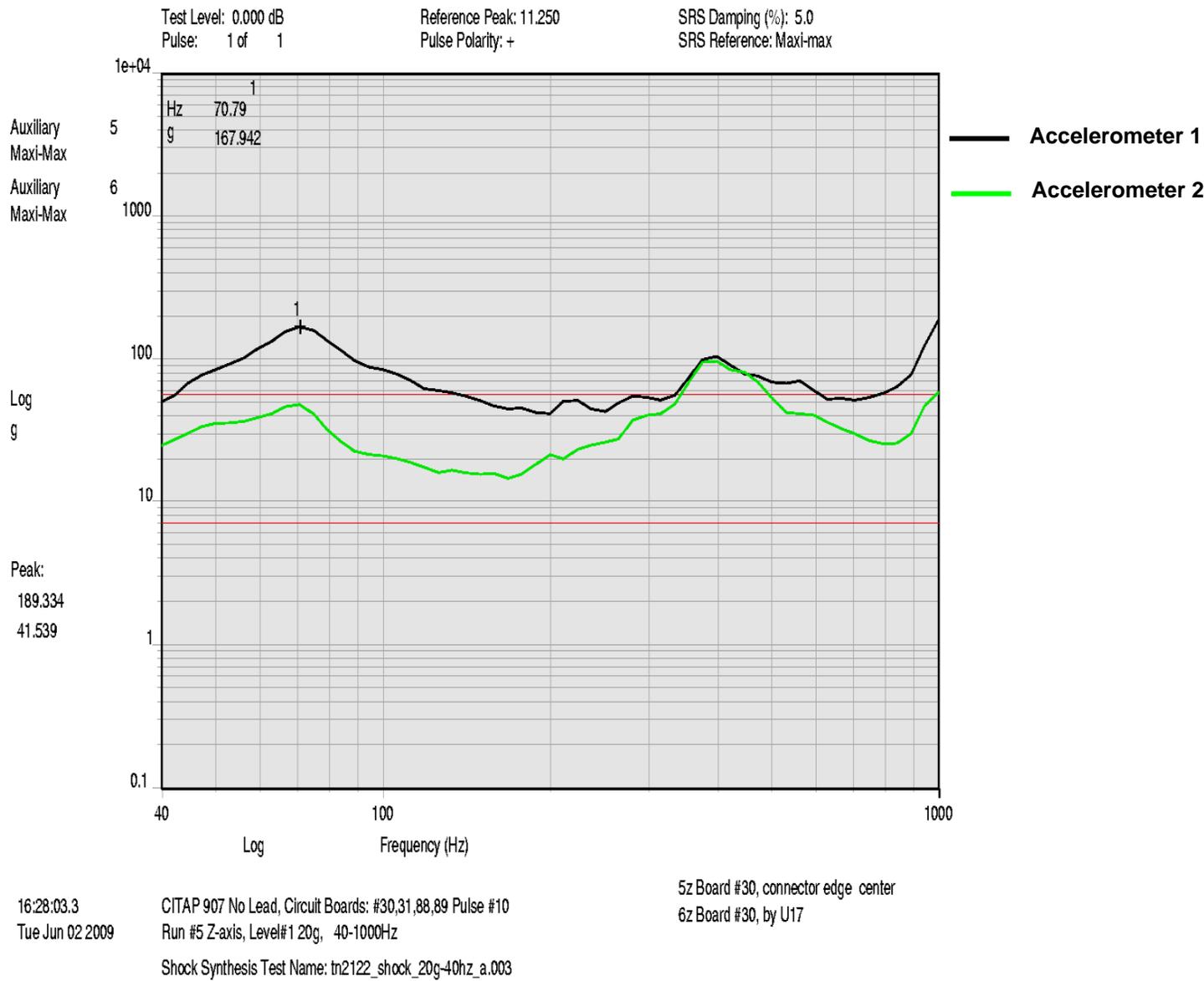
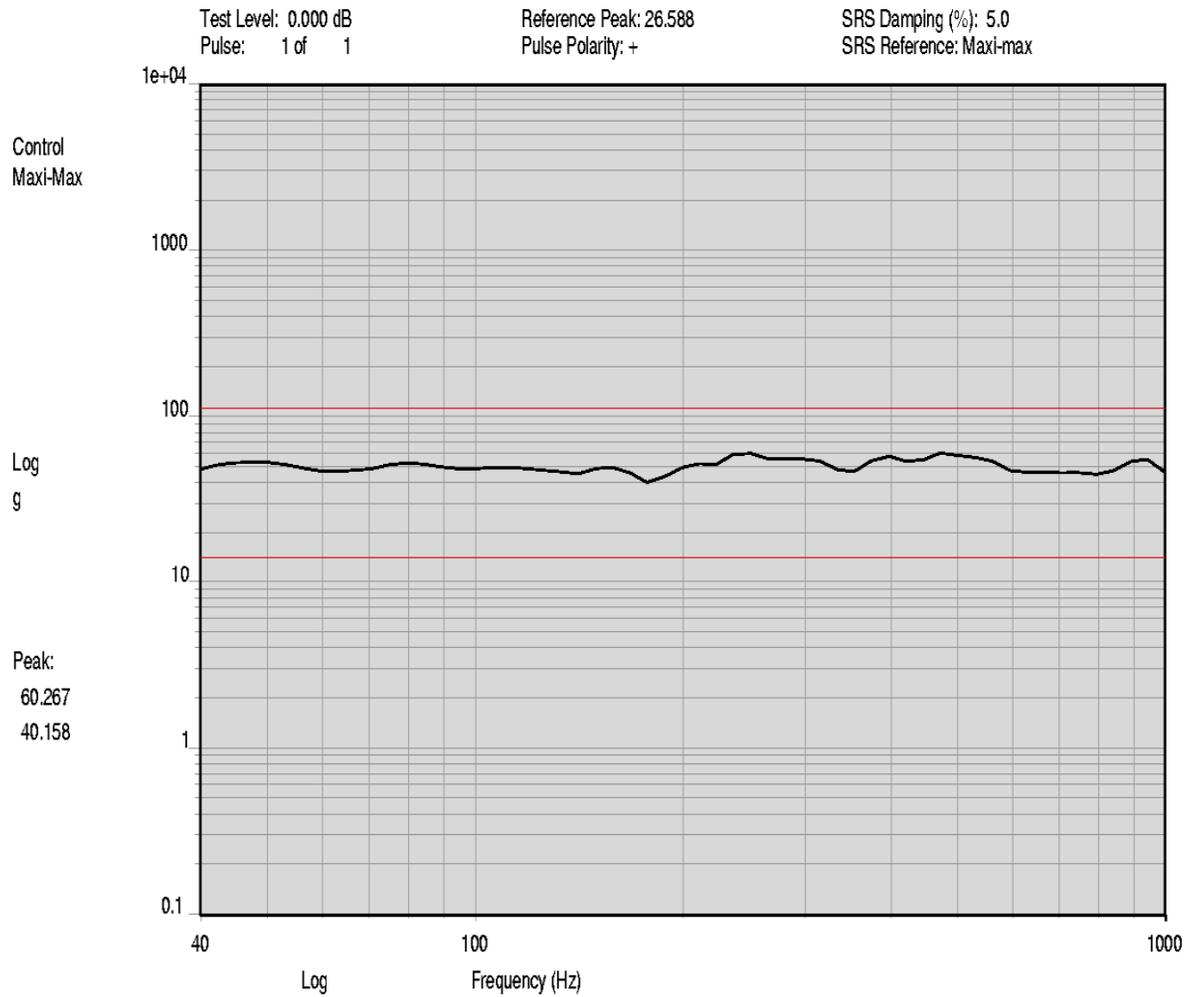


Figure 28. Test Vehicle SRS Response to 20 G SRS Input (Test Vehicle 30)



08:48:02.8 Thu Jun 11 2009 CITAP 907, No Lead Circuit boards: S/N's: 75,32,90,33,91,34 Pulse#100 Run 20, Z-axis, Level #2, 40G SRS Shock Synthesis Test Name: tn2122_shock_40g-40hz_a.004 #1Z, Control base outboard by wall

Figure 29. 40 G SRS Input (Accelerometer on Fixture)

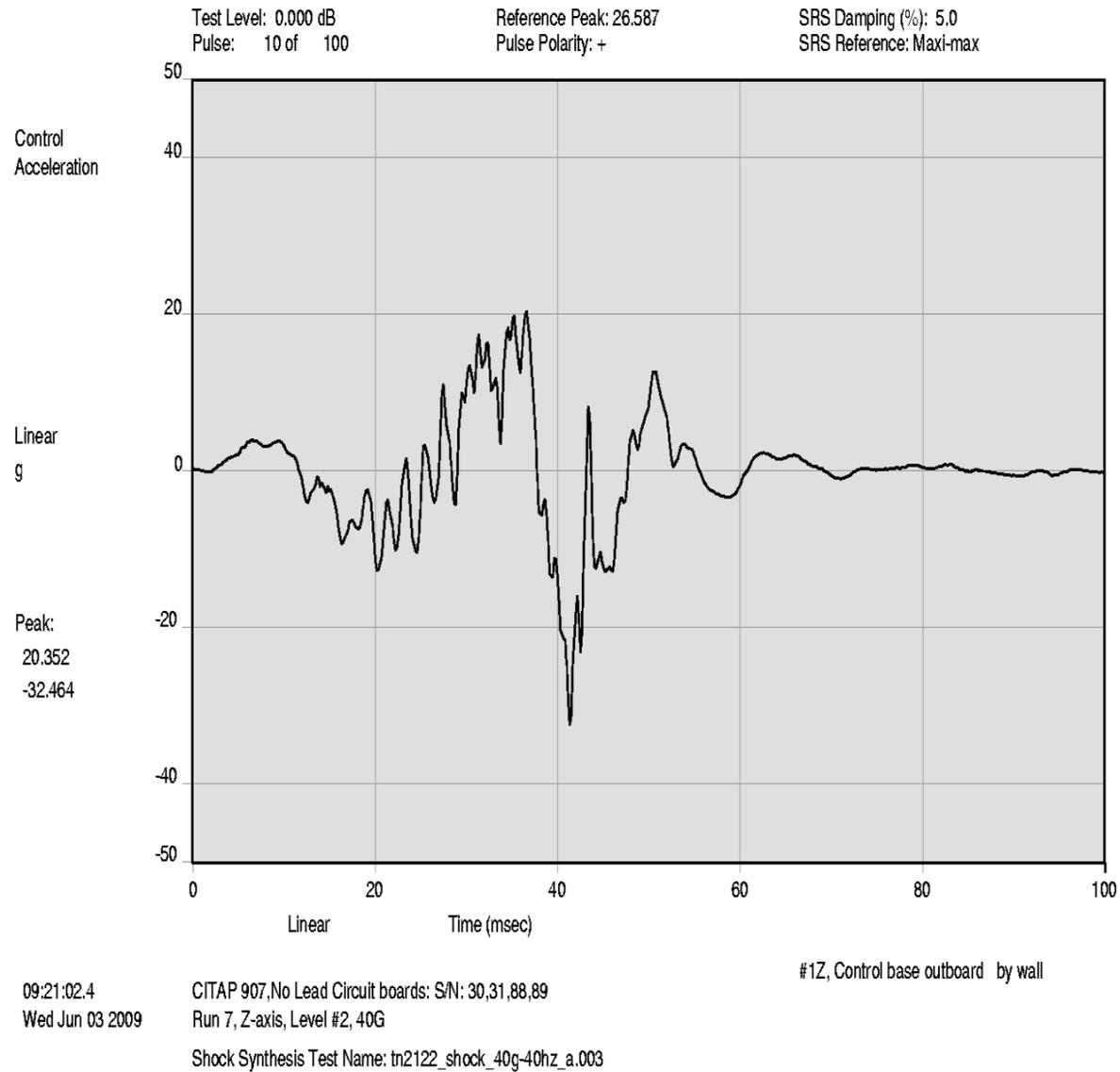
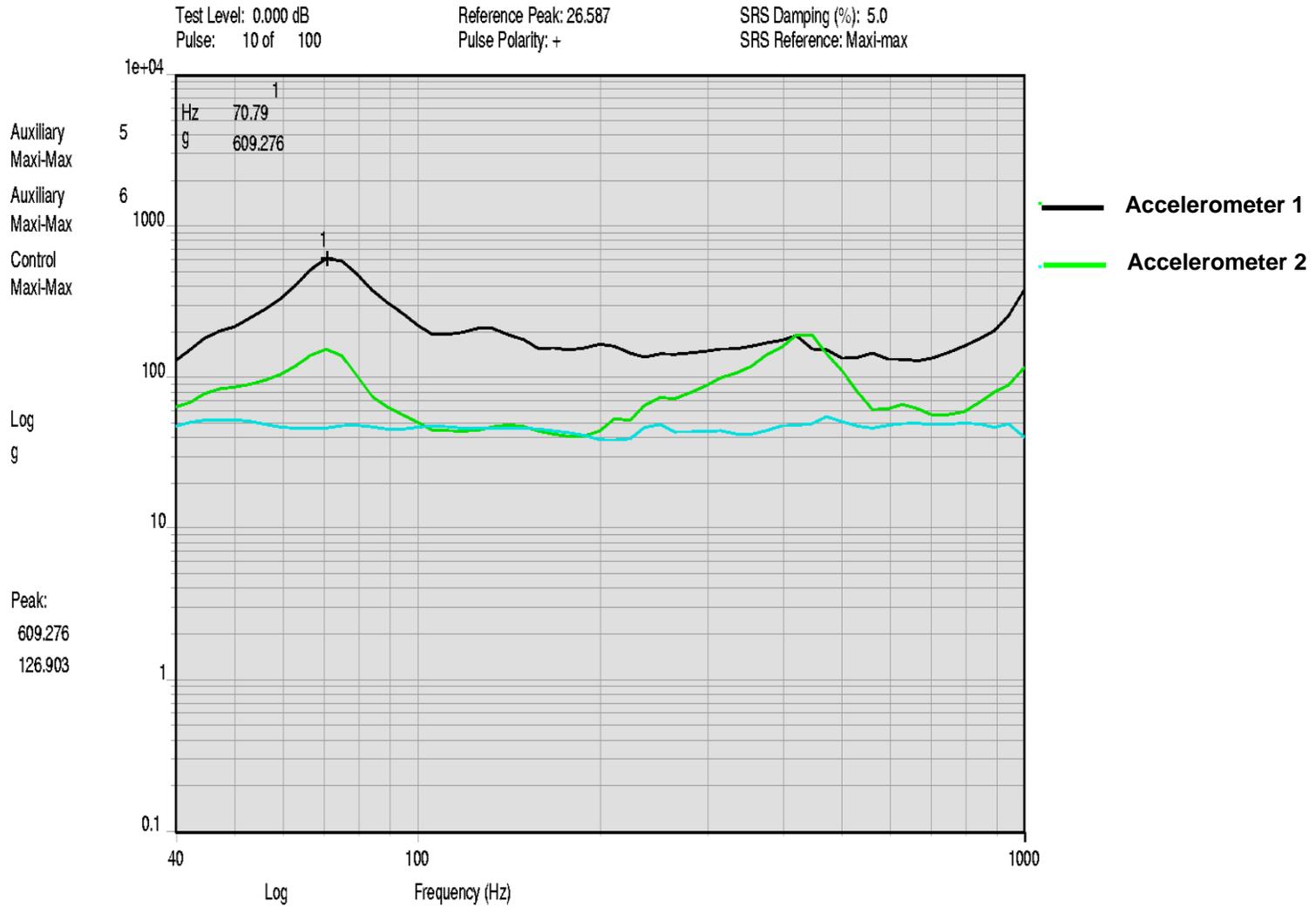


Figure 30. Pulse Used to Create 40 G SRS Input (Accelerometer on Fixture)



09:21:02.4 CITAP 907, No Lead Circuit boards: S/N: 30,31,88,89 5z Board #30, connector edge center
Wed Jun 03 2009 Run 7, Z-axis, Level #2, 40G 6z Board #30, by U17
Shock Synthesis Test Name: tn2122_shock_40g-40hz_a.003 #1Z, Control base outboard by wall

Figure 31. Test Vehicle SRS Response to 40 G SRS Input (Test Vehicle 30)

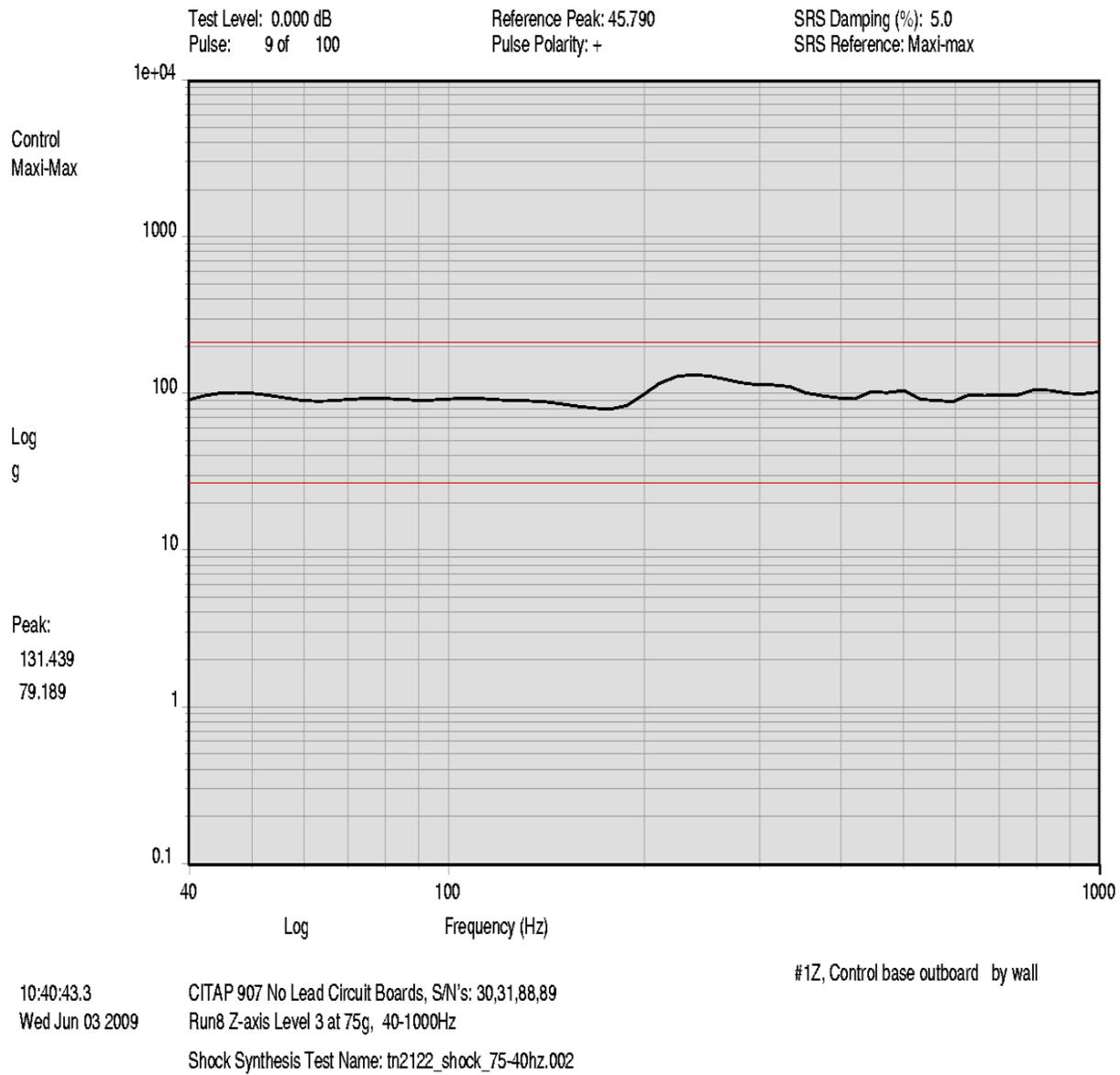
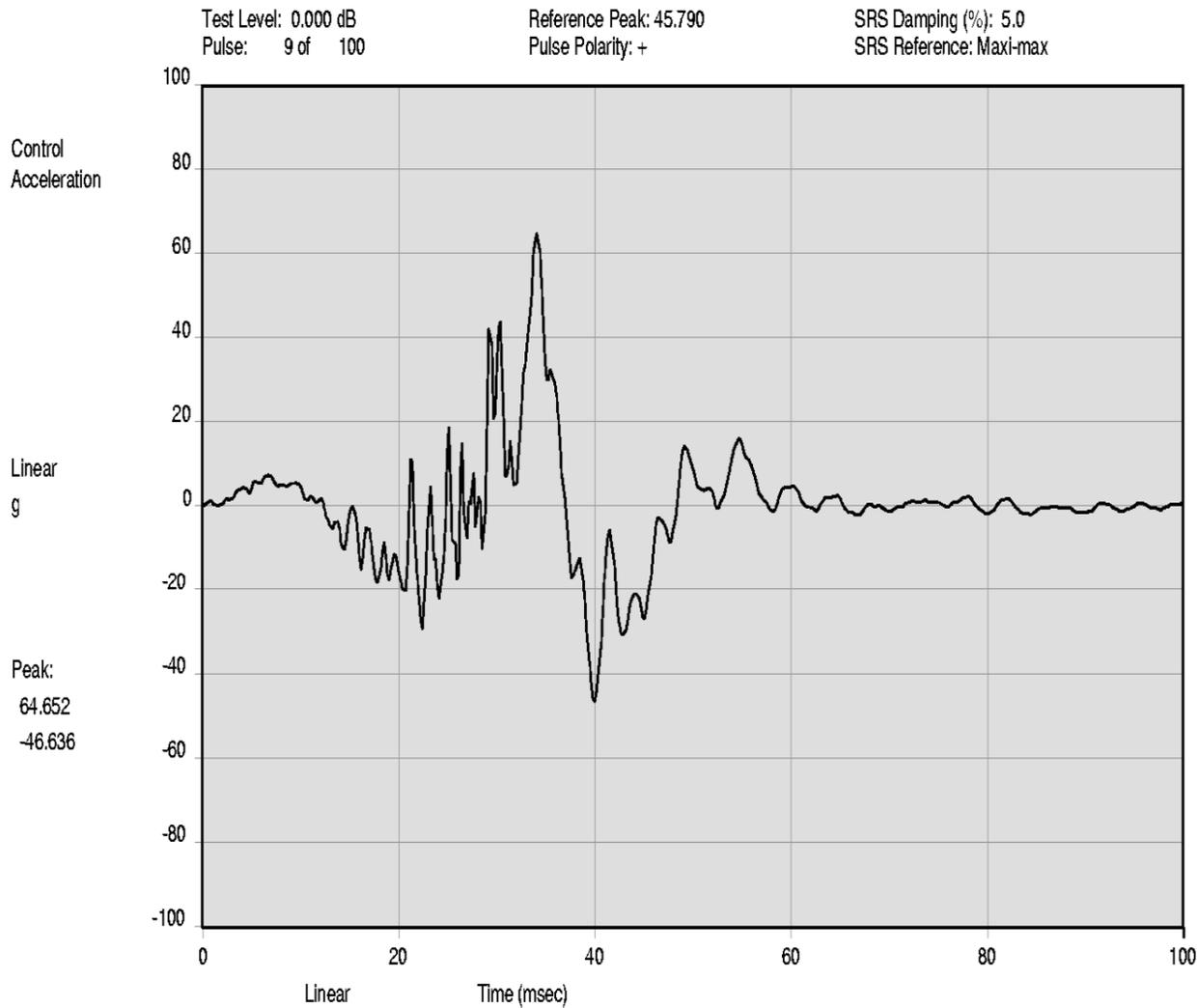


Figure 32. 75 G SRS Input (Accelerometer on Fixture)

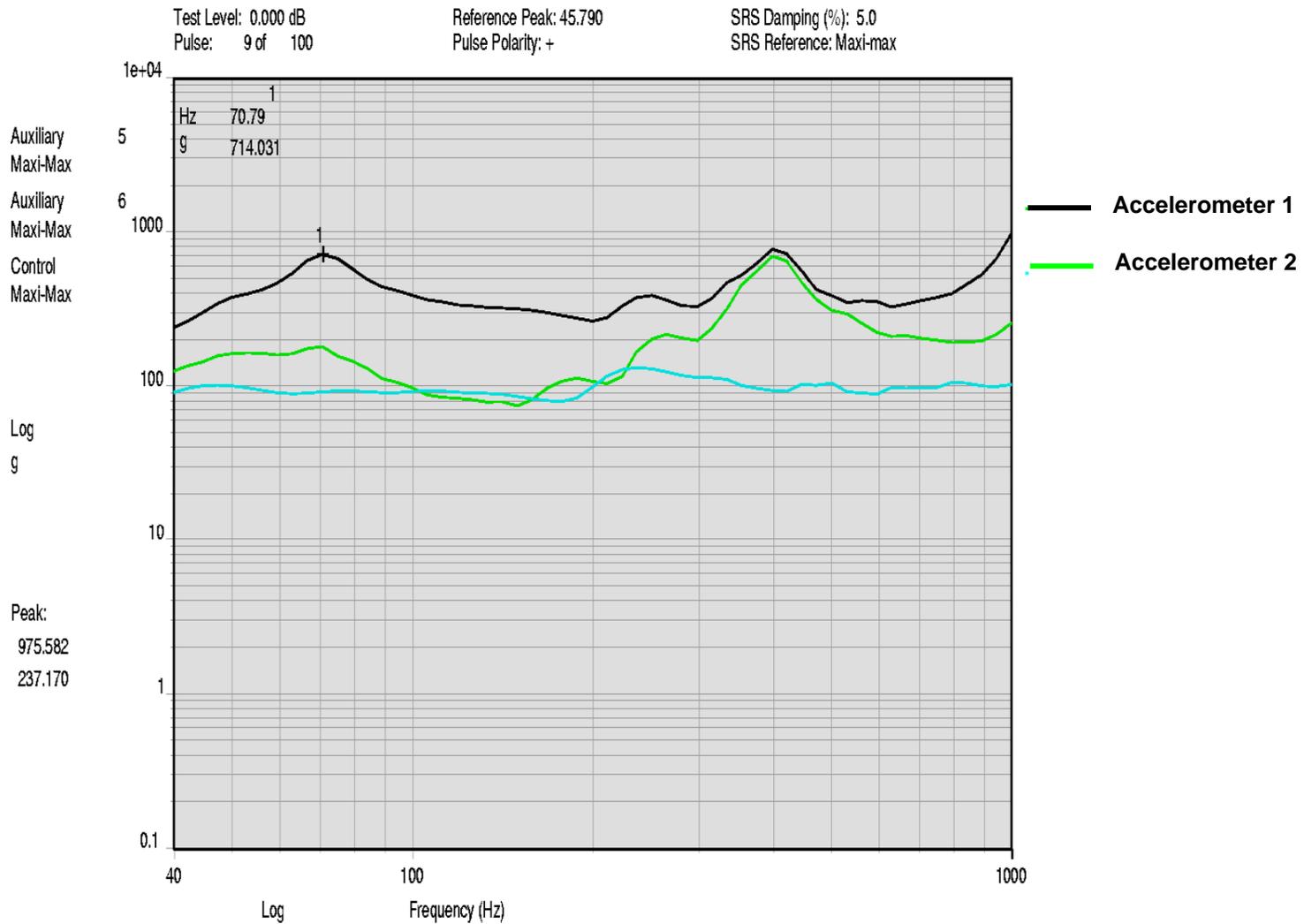


10:40:43.3
Wed Jun 03 2009

CITAP 907 No Lead Circuit Boards, S/N's: 30,31,88,89
Run8 Z-axis Level 3 at 75g, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_75-40hz.002

#1Z, Control base outboard by wall

Figure 33. Pulse Used to Create 75 G SRS Input (Accelerometer on Fixture)

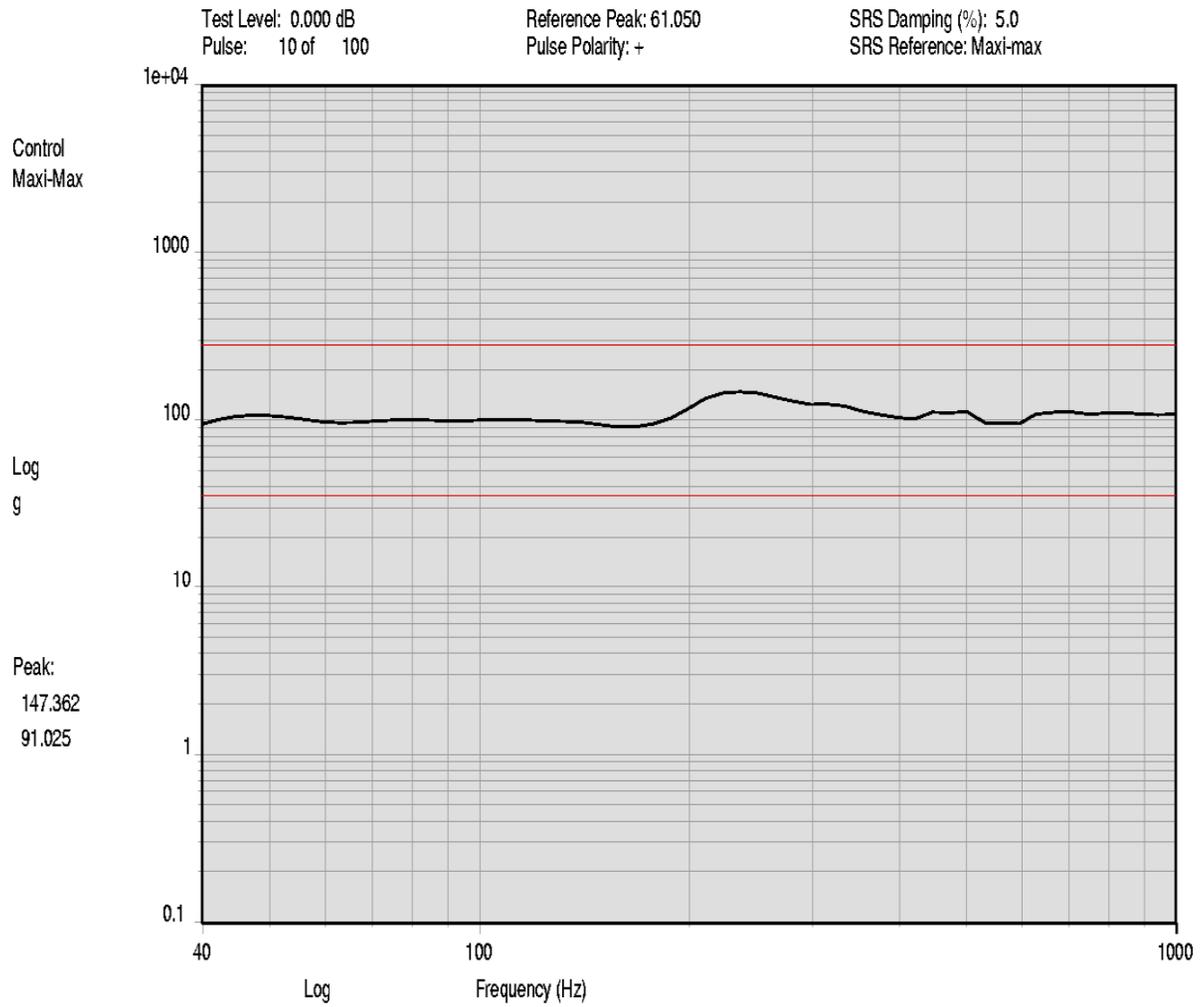


10:40:43.3
Wed Jun 03 2009

CITAP 907 No Lead Circuit Boards, S/N's: 30,31,88,89
Run8 Z-axis Level 3 at 75g, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_75-40hz.002

5z Board #30, connector edge center
6z Board #30, by U17
#1Z, Control base outboard by wall

Figure 34. Test Vehicle SRS Response to 75 G SRS Input (Test Vehicle 30)



12:59:39.8
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 9 Z-axis, level4 100G, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_100-40hz_b.001

#1Z, Control base outboard by wall

Figure 35. 100 G SRS Input (Accelerometer on Fixture)

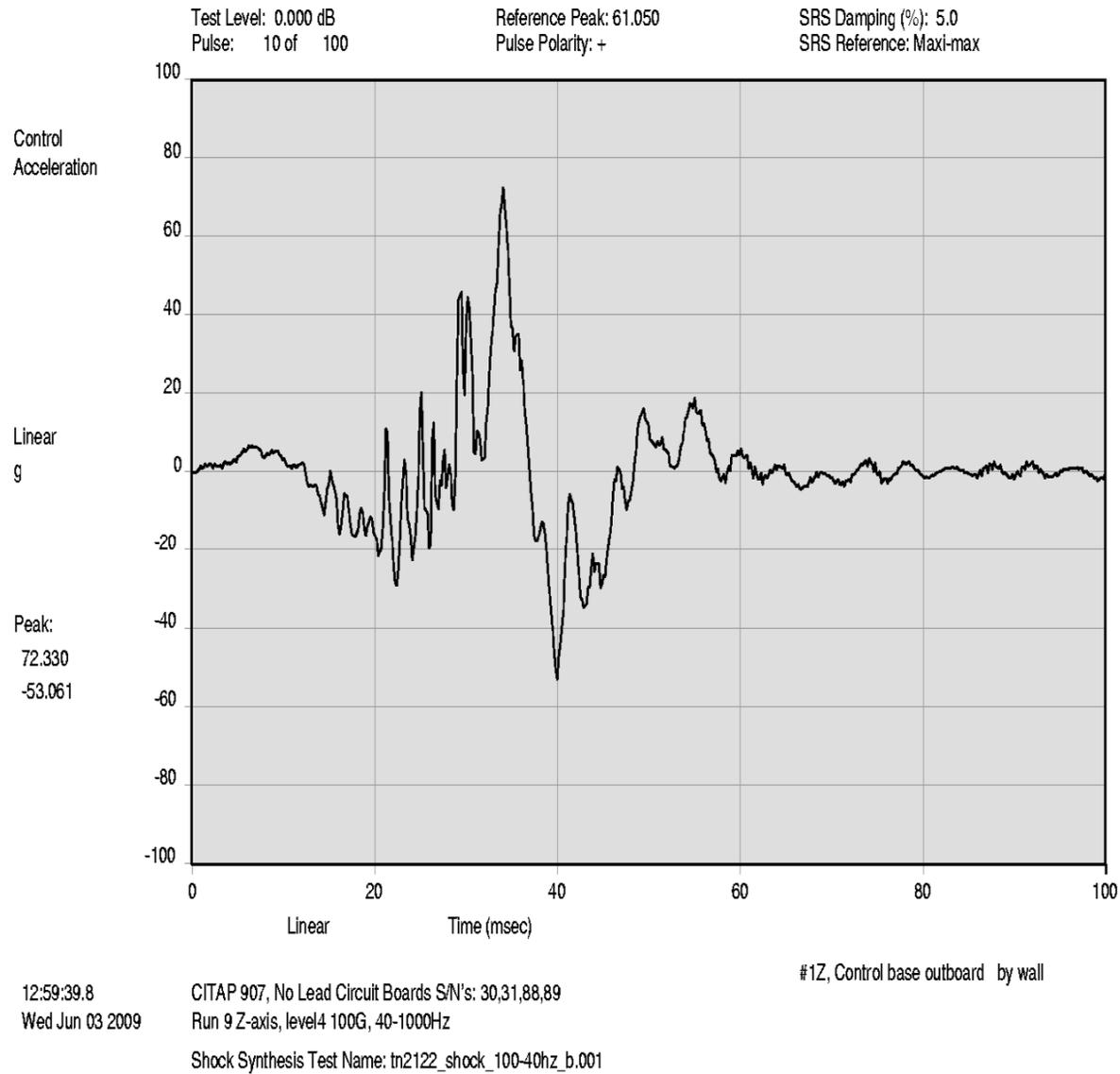
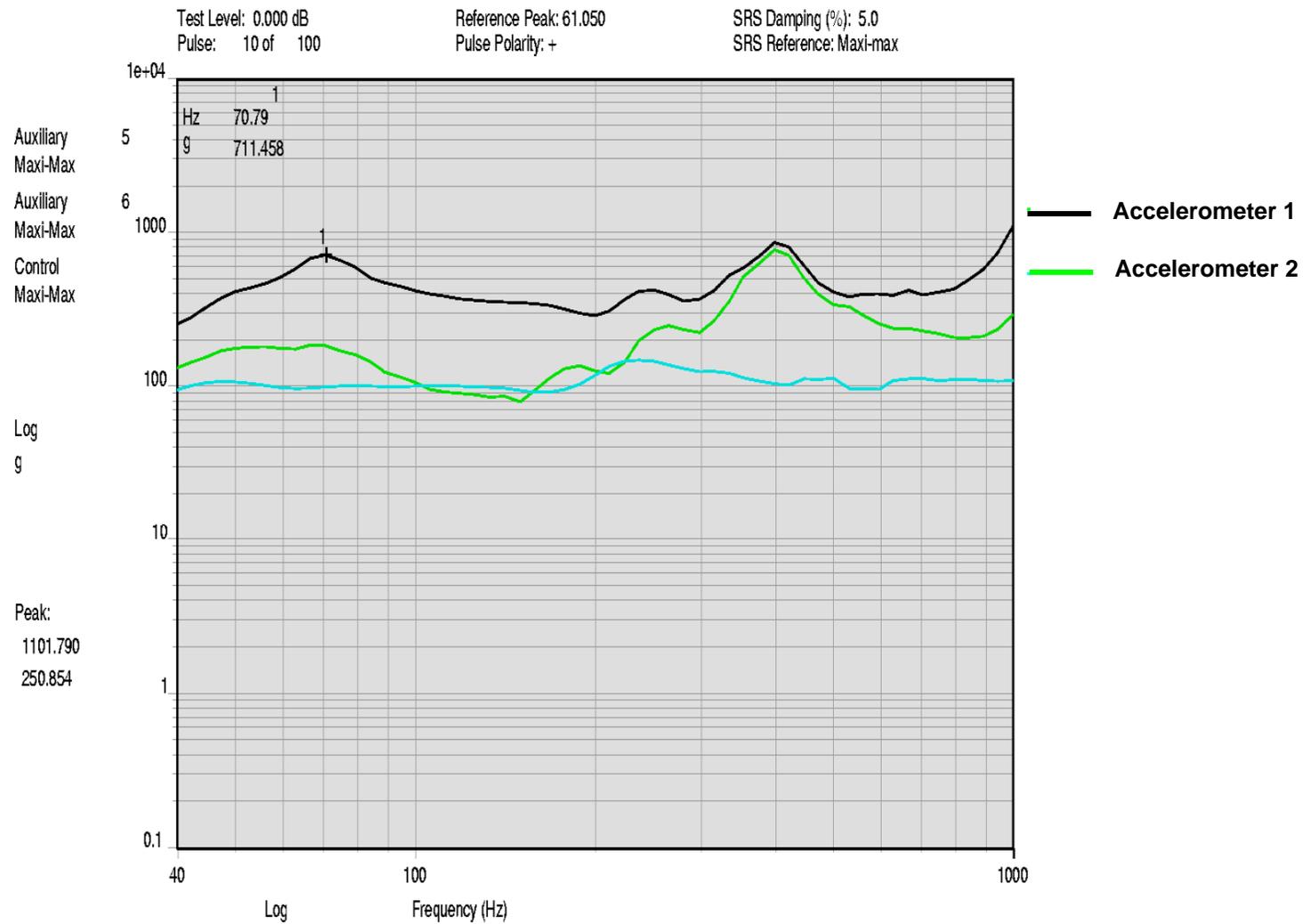


Figure 36. Pulse Used to Create 100 G SRS Input (Accelerometer on Fixture)

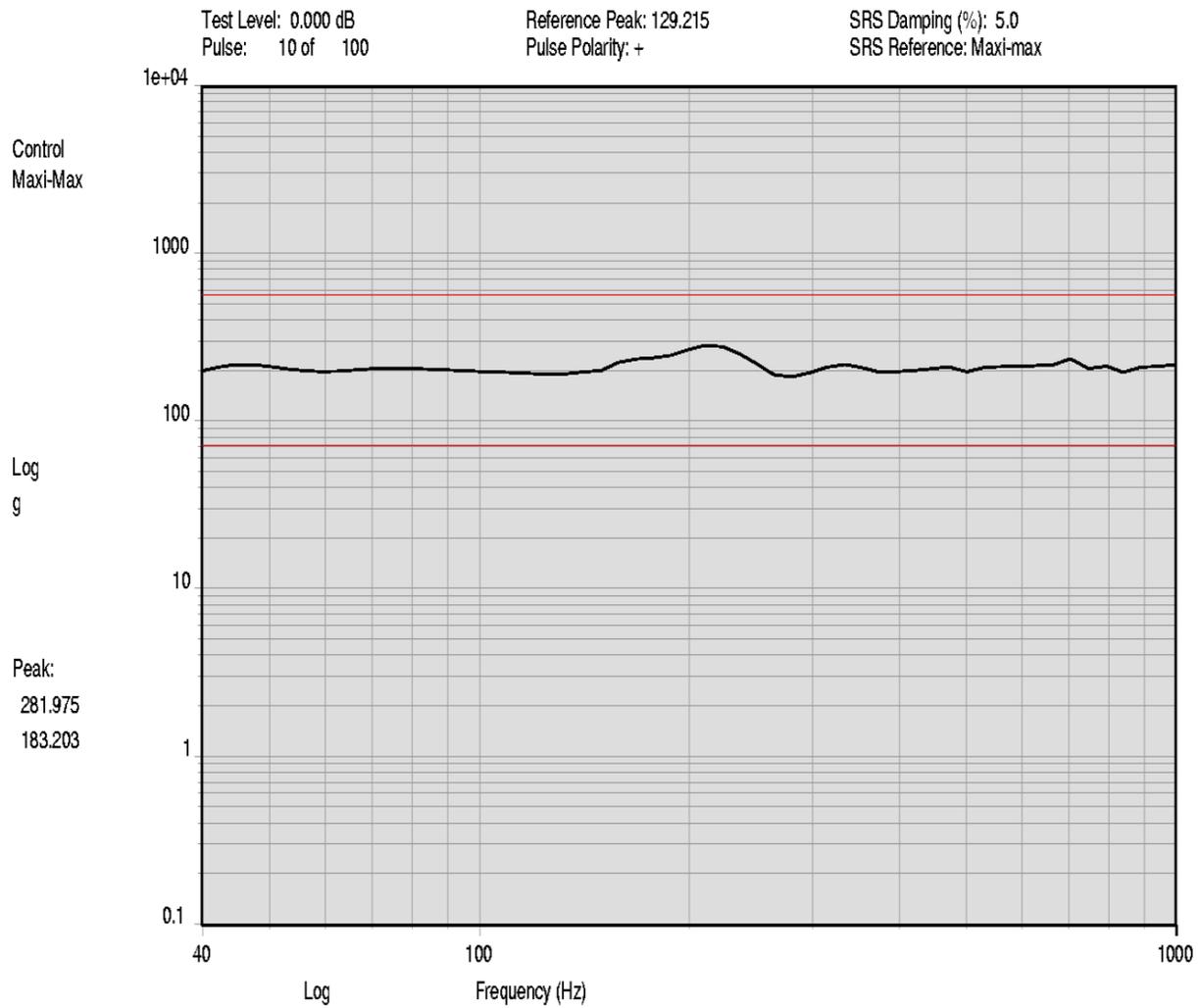


12:59:39.8
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 9 Z-axis, level4 100G, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_100-40hz_b.001

5z Board #30, connector edge center
6z Board #30, by U17
#1Z, Control base outboard by wall

Figure 37. Test Vehicle SRS Response to 100 G SRS Input (Test Vehicle 30)

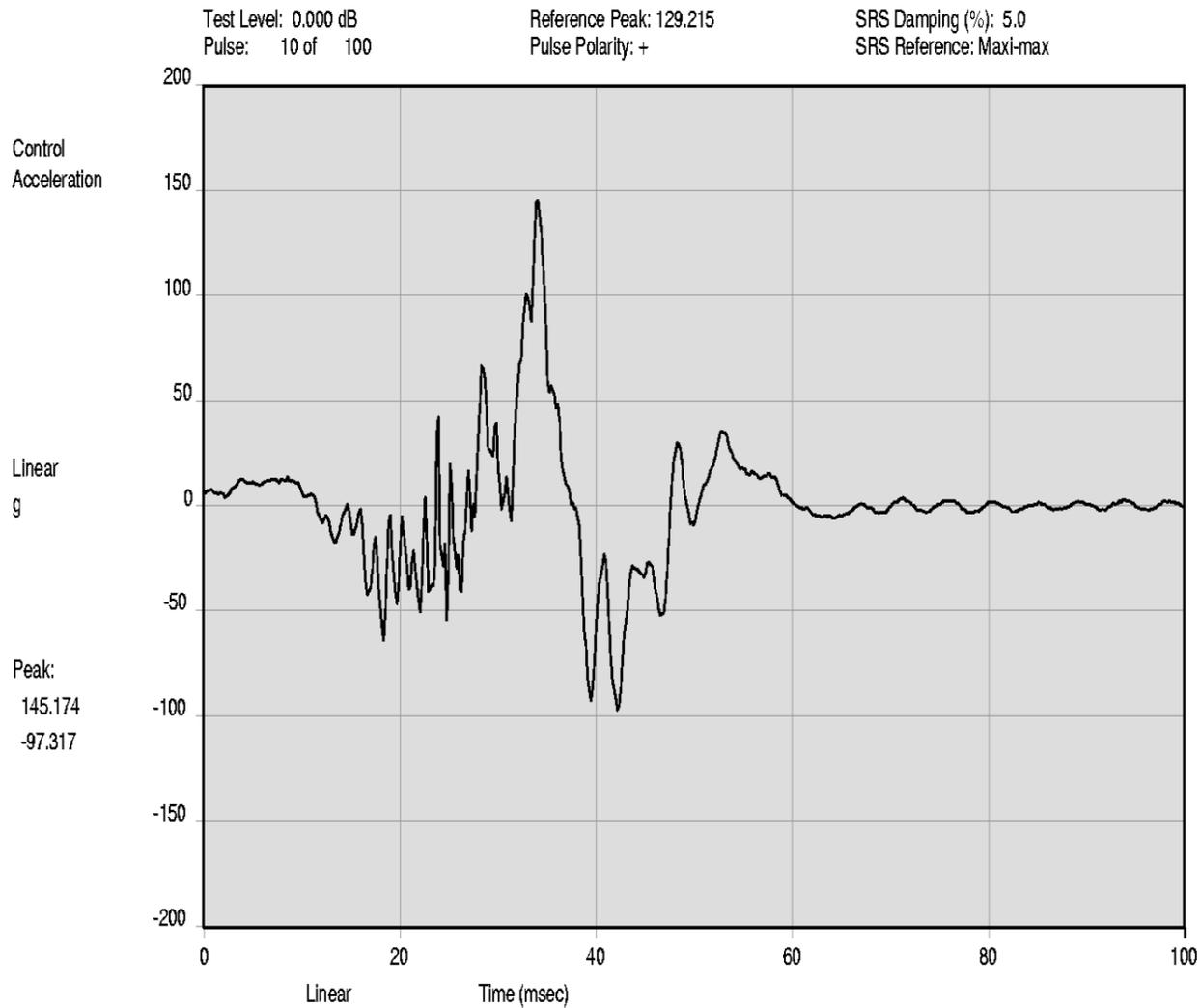


14:01:24.8
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 10 Z-axis, level-5 200G, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_200-40hz_a.001

#1Z, Control base outboard by wall

Figure 38. 200 G SRS Input (Accelerometer on Fixture)

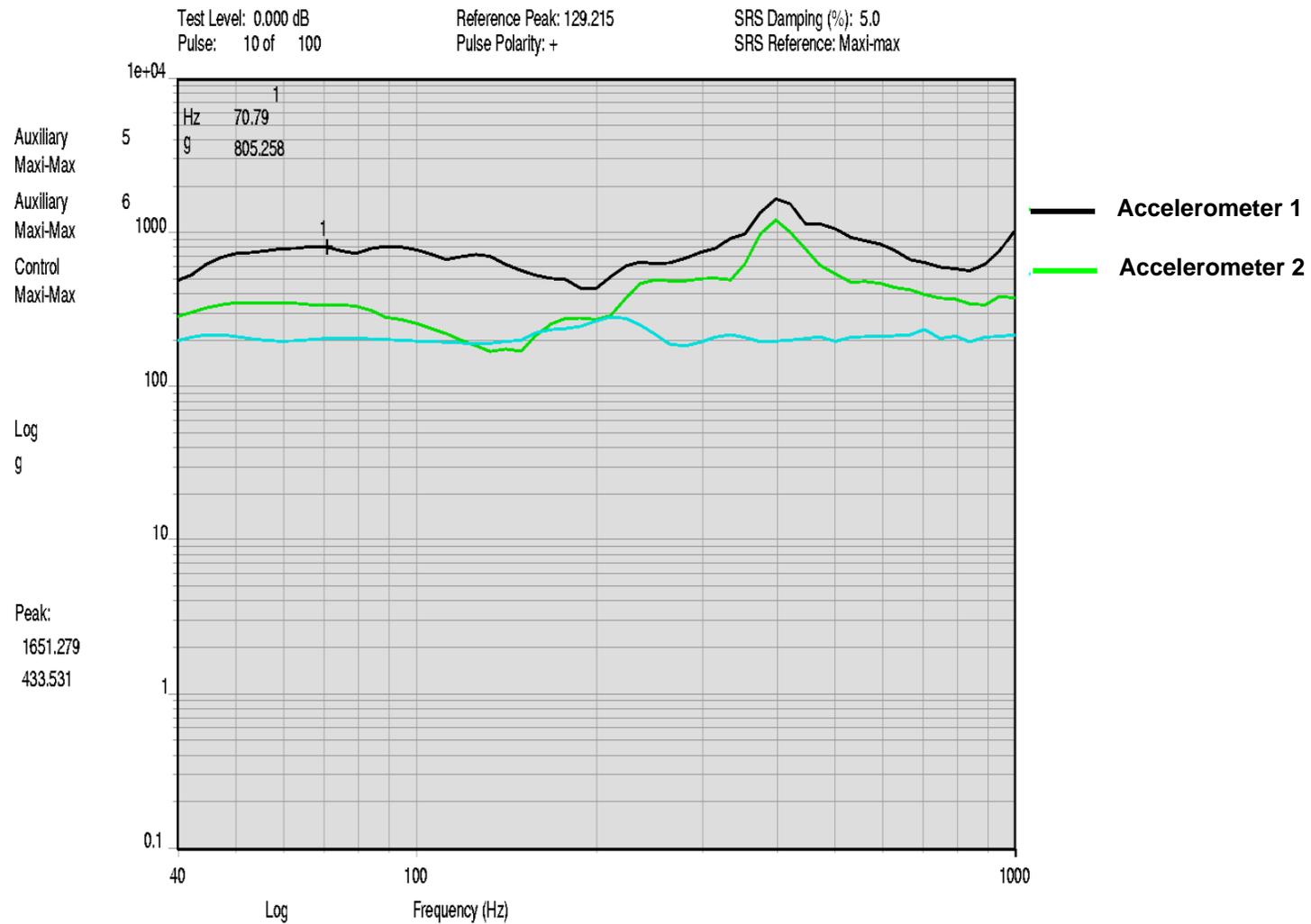


14:01:24.8
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 10 Z-axis, level-5 200G, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_200-40hz_a.001

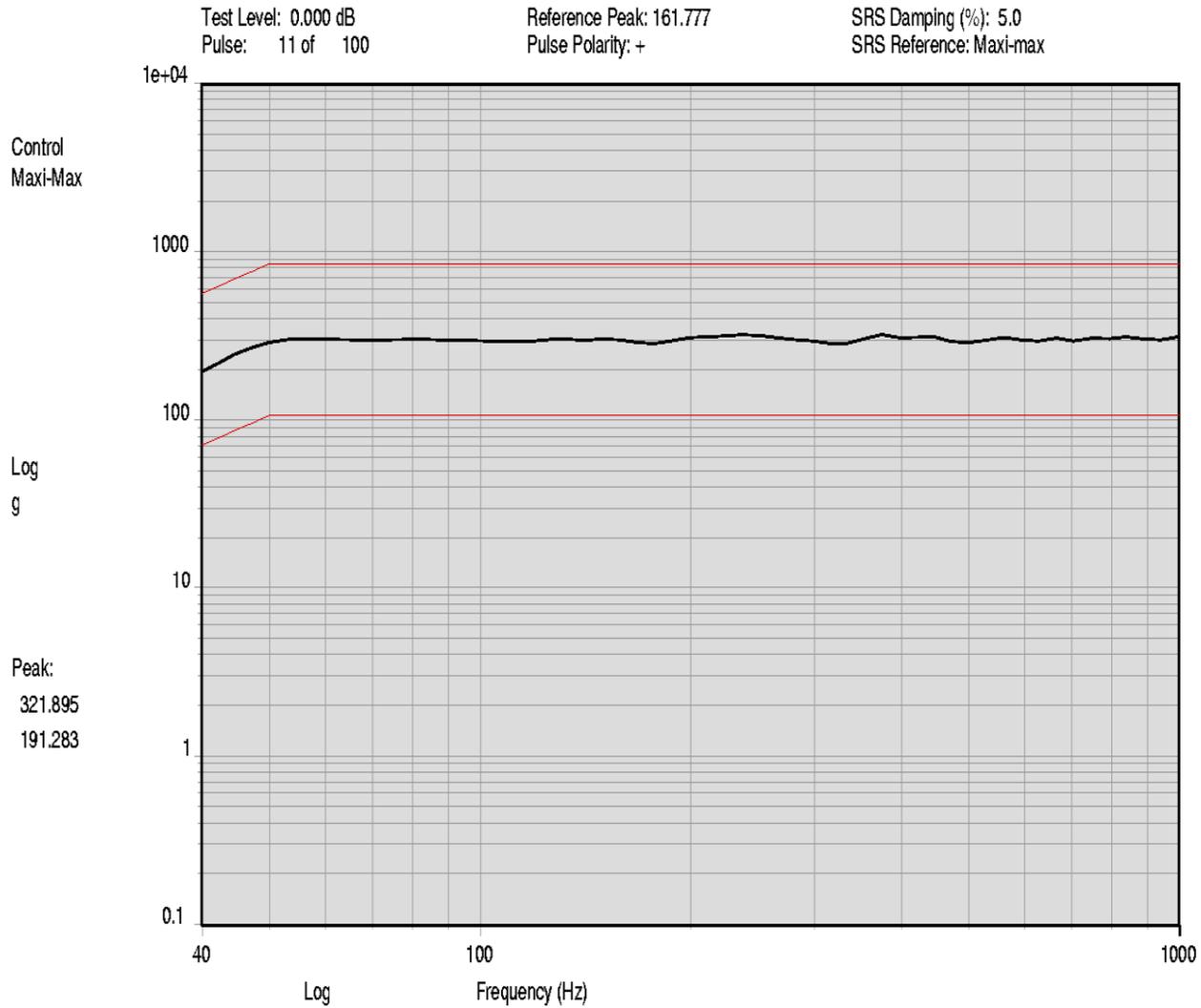
#1Z, Control base outboard by wall

Figure 39. Pulse Used to Create 200 G SRS Input (Accelerometer on Fixture)



14:01:24.8 CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89 5z Board #30, connector edge center
 Wed Jun 03 2009 Run 10 Z-axis, level-5 200G, 40-1000Hz 6z Board #30, by U17
 Shock Synthesis Test Name: tn2122_shock_200-40hz_a.001 #1Z, Control base outboard by wall

Figure 40. Test Vehicle SRS Response to 200 G SRS Input (Test Vehicle 30)

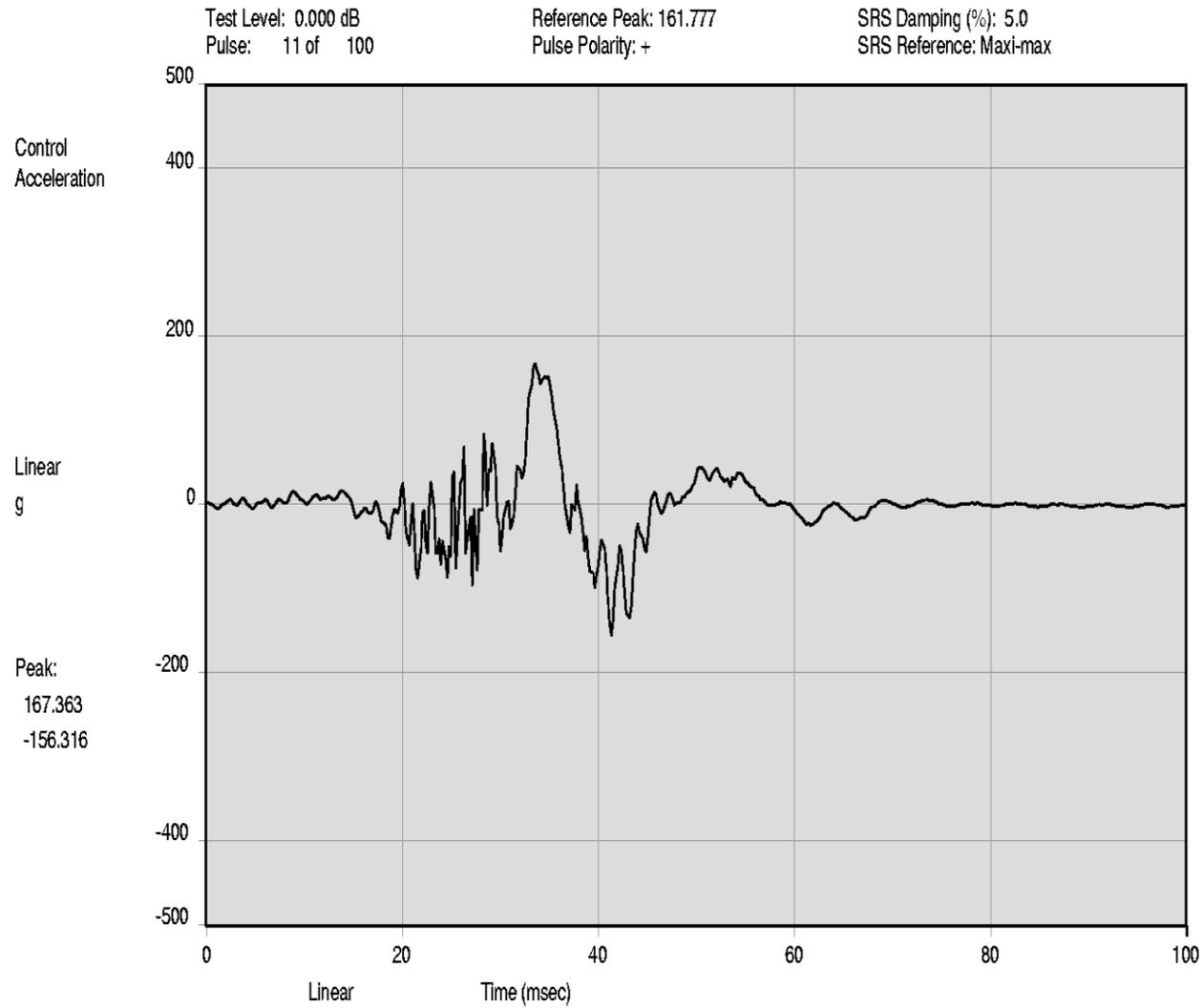


14:42:25.2
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 11 Z-axis, level-6 300G, 40-1000Hz
Shock Synthesis Test Name: Mech_shock_wood_300-50hz_a.001

#1Z, Control base outboard by wall

Figure 41. 300 G SRS Input (Accelerometer on Fixture)

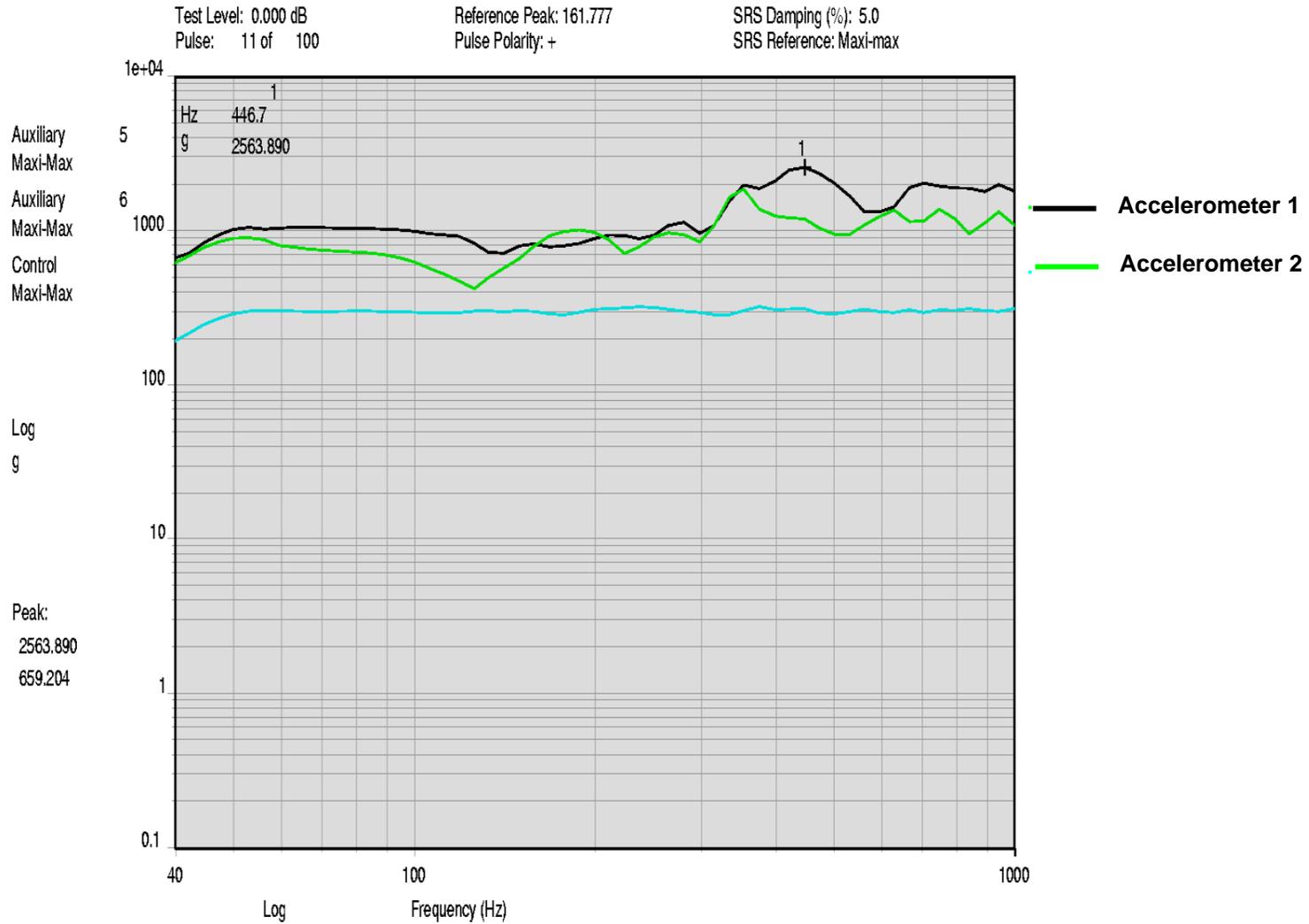


14:42:25.2
Wed Jun 03 2009

CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89
Run 11 Z-axis, level-6 300G, 40-1000Hz
Shock Synthesis Test Name: Mech_shock_wood_300-50hz_a.001

#1Z, Control base outboard by wall

Figure 42. Pulse Used to Create 300 G SRS Input (Accelerometer on Fixture)



14:42:25.2 CITAP 907, No Lead Circuit Boards S/N's: 30,31,88,89 5Z Board #30, connector edge center
Wed Jun 03 2009 Run 11 Z-axis, level-6 300G, 40-1000Hz 6Z Board #30, by U17
Shock Synthesis Test Name: Mech_shock_wood_300-50hz_a.001 #1Z, Control base outboard by wall

Figure 43. Test Vehicle SRS Response to 300 G SRS Input (Test Vehicle 30)

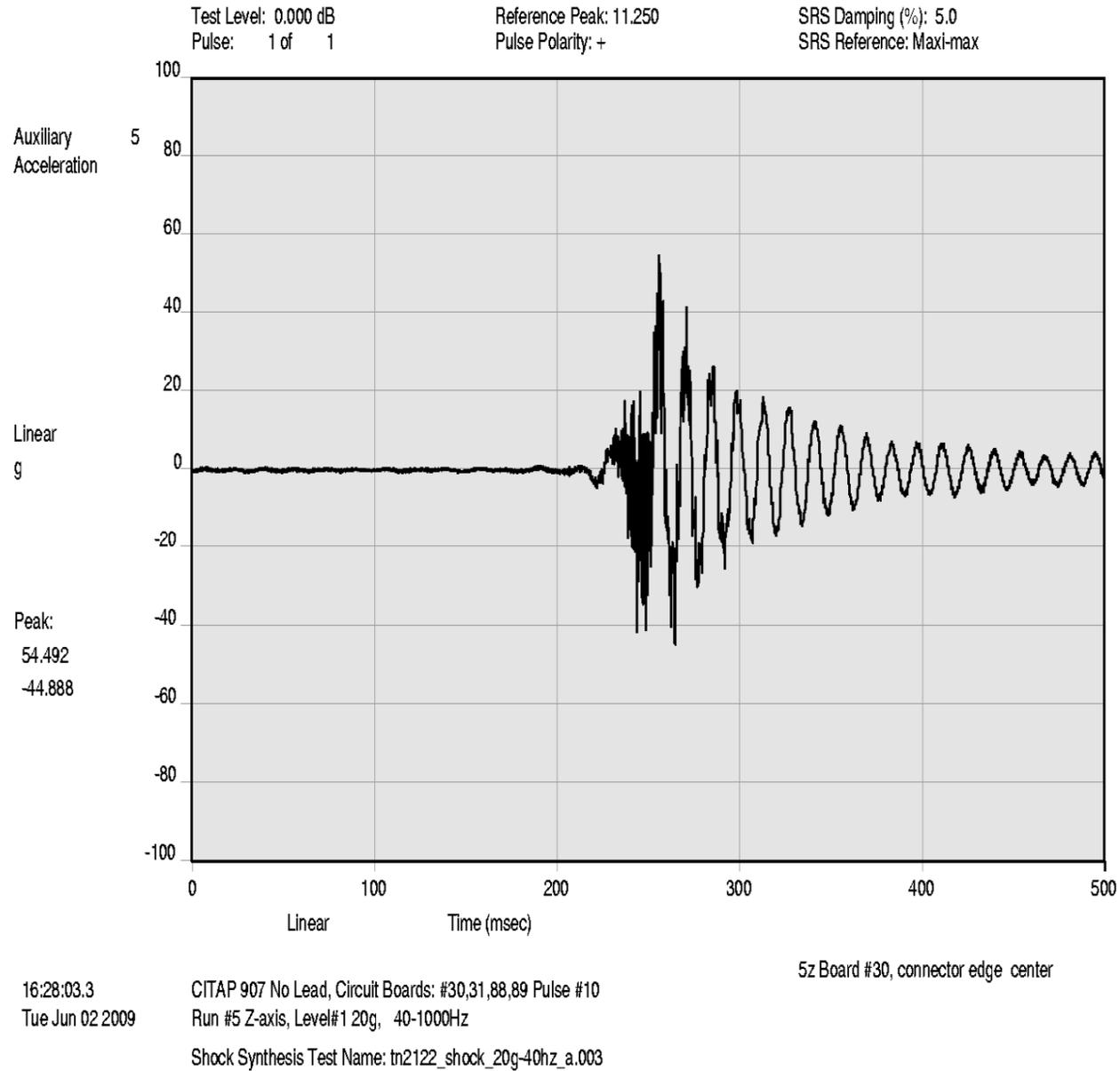
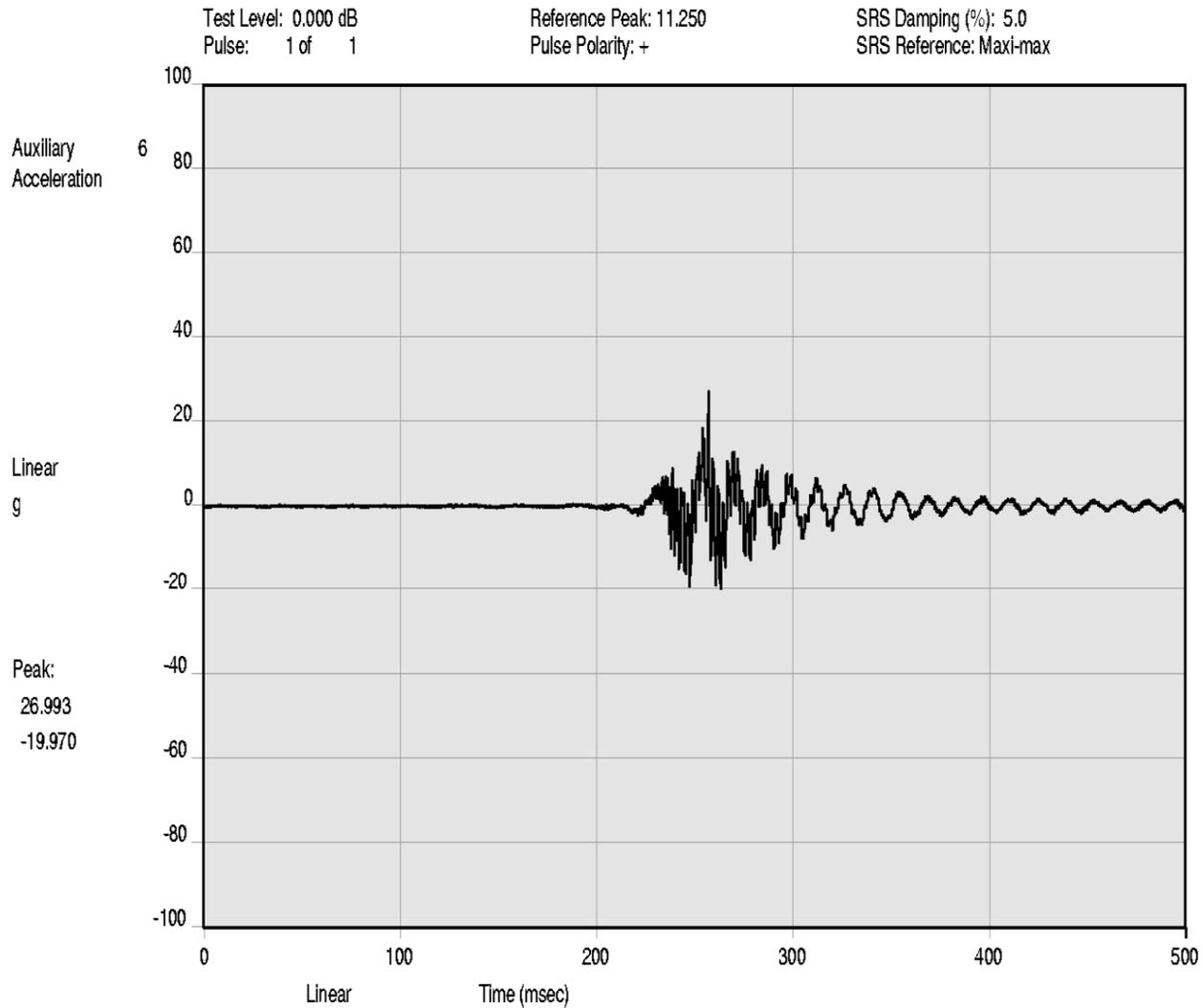


Figure 44. Test Vehicle Time History Response to 20 G SRS Input (Test Vehicle 30, Accelerometer 1)



6z Board #30, by U17

16:28:03.3
Tue Jun 02 2009

CITAP 907 No Lead, Circuit Boards: #30,31,88,89 Pulse #10
Run #5 Z-axis, Level#1 20g, 40-1000Hz
Shock Synthesis Test Name: tn2122_shock_20g-40hz_a.003

Figure 45. Test Vehicle Time History Response to 20 G SRS Input (Test Vehicle 30, Accelerometer 2)

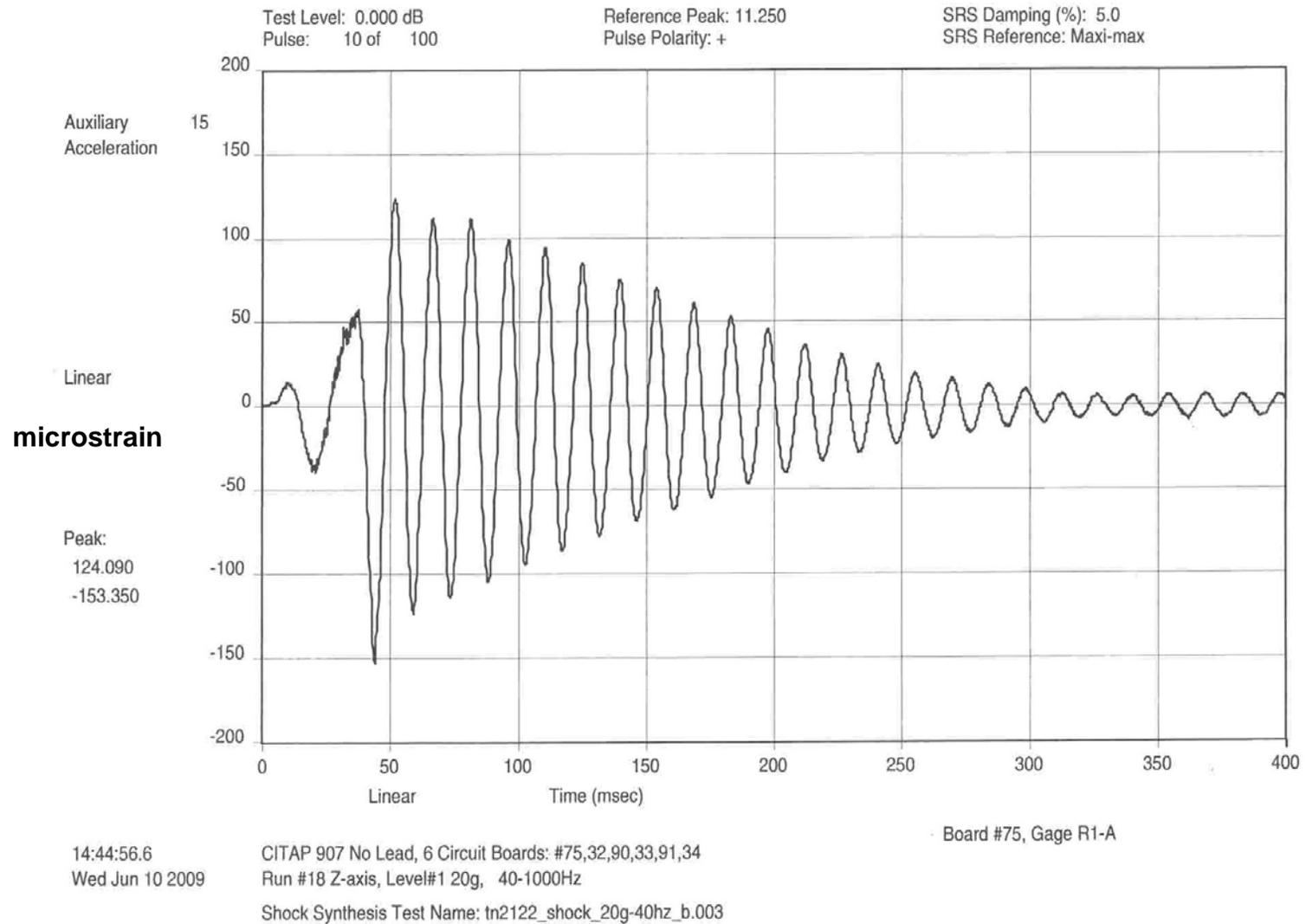


Figure 46. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 1, x-Direction)

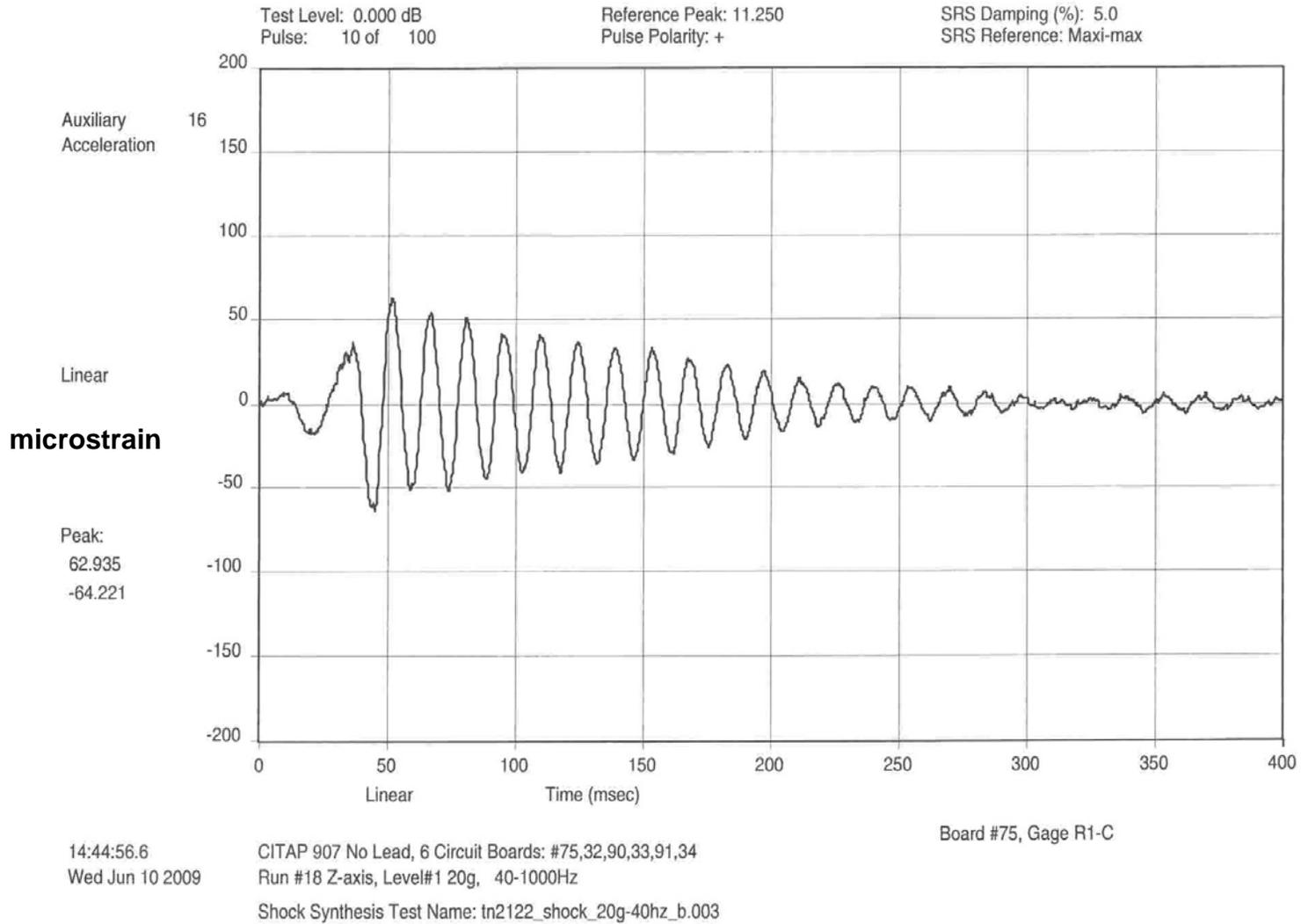


Figure 47. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 1, y-Direction)

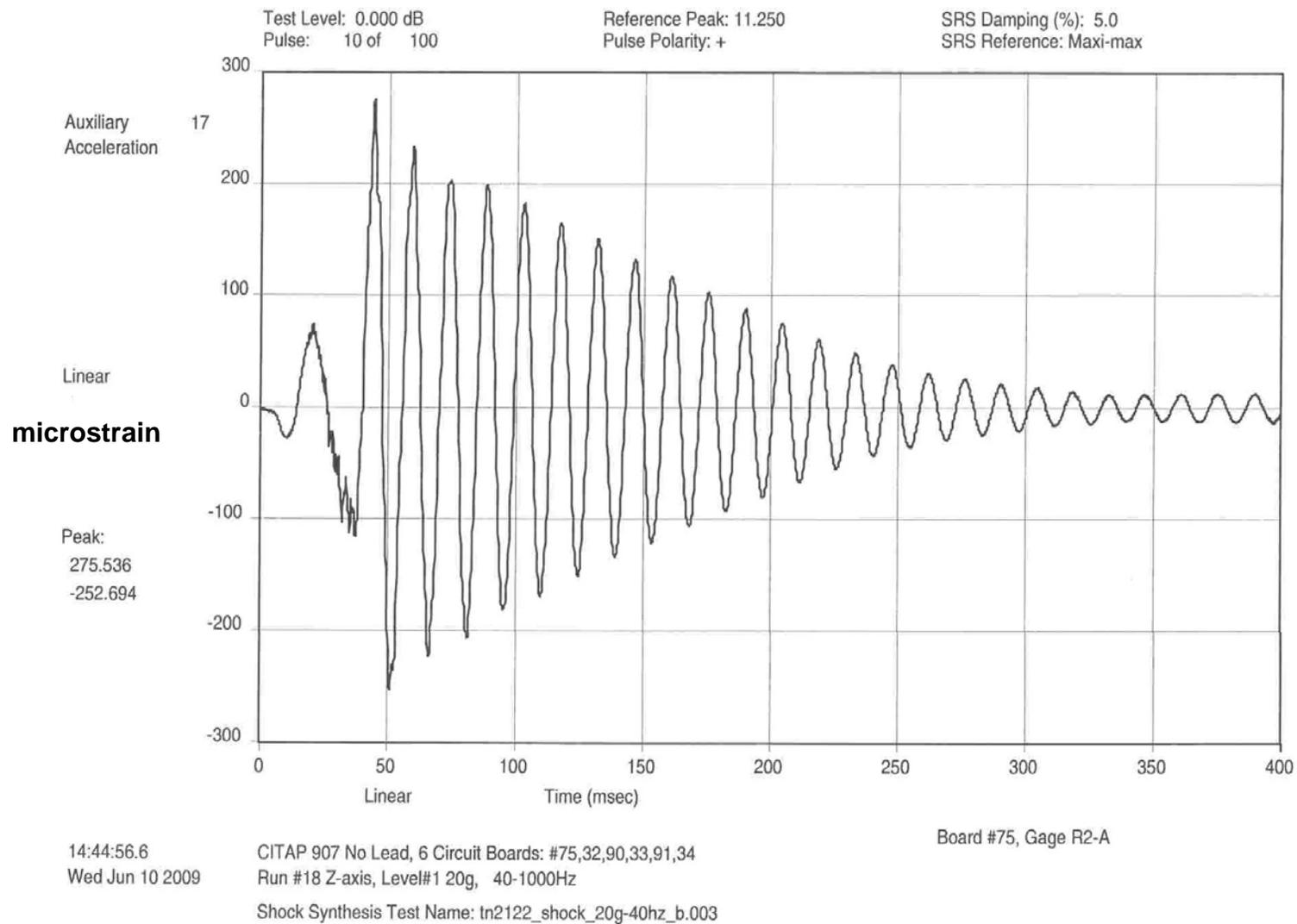


Figure 48. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 2, x-Direction)

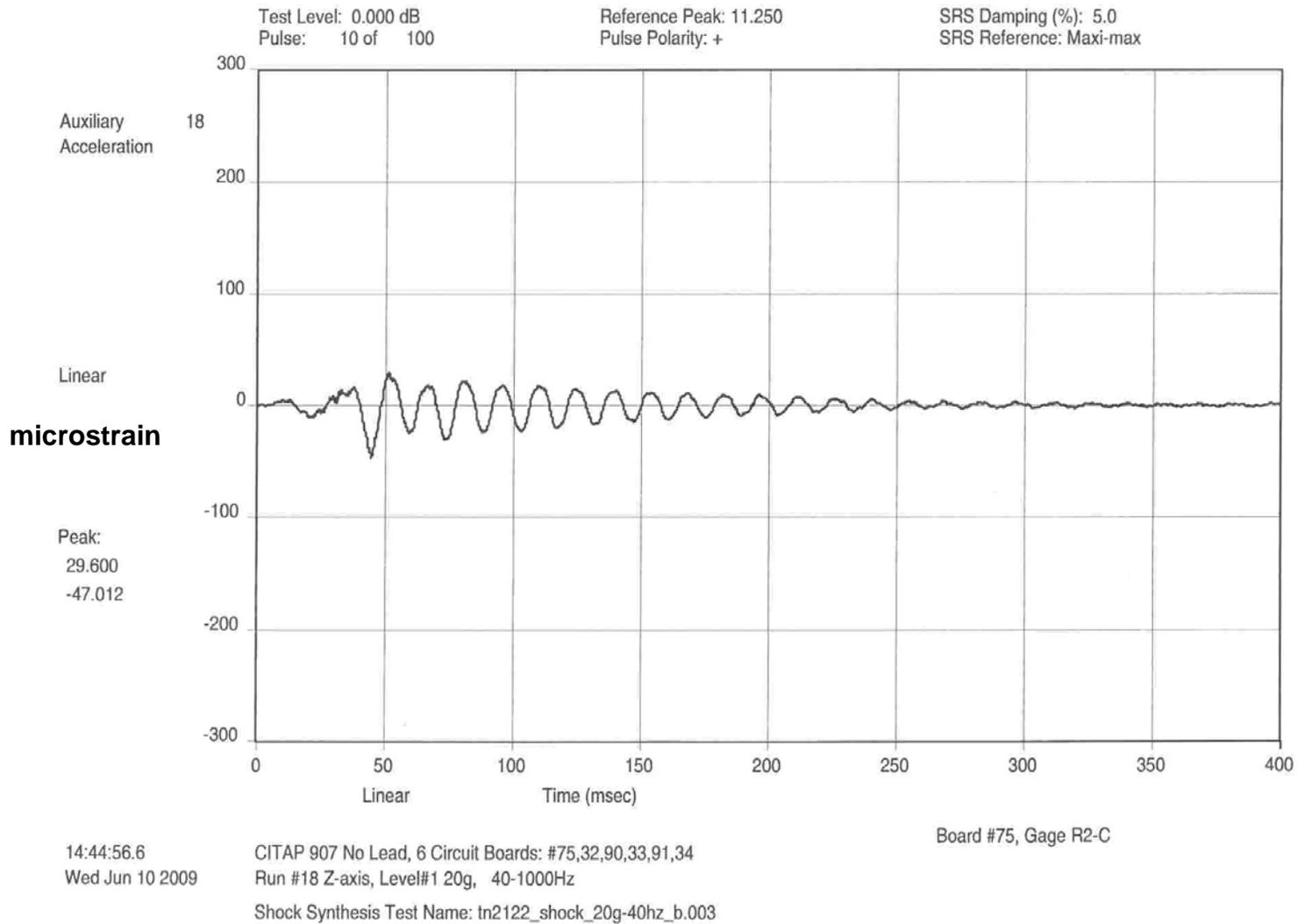


Figure 49. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 2, y-Direction)

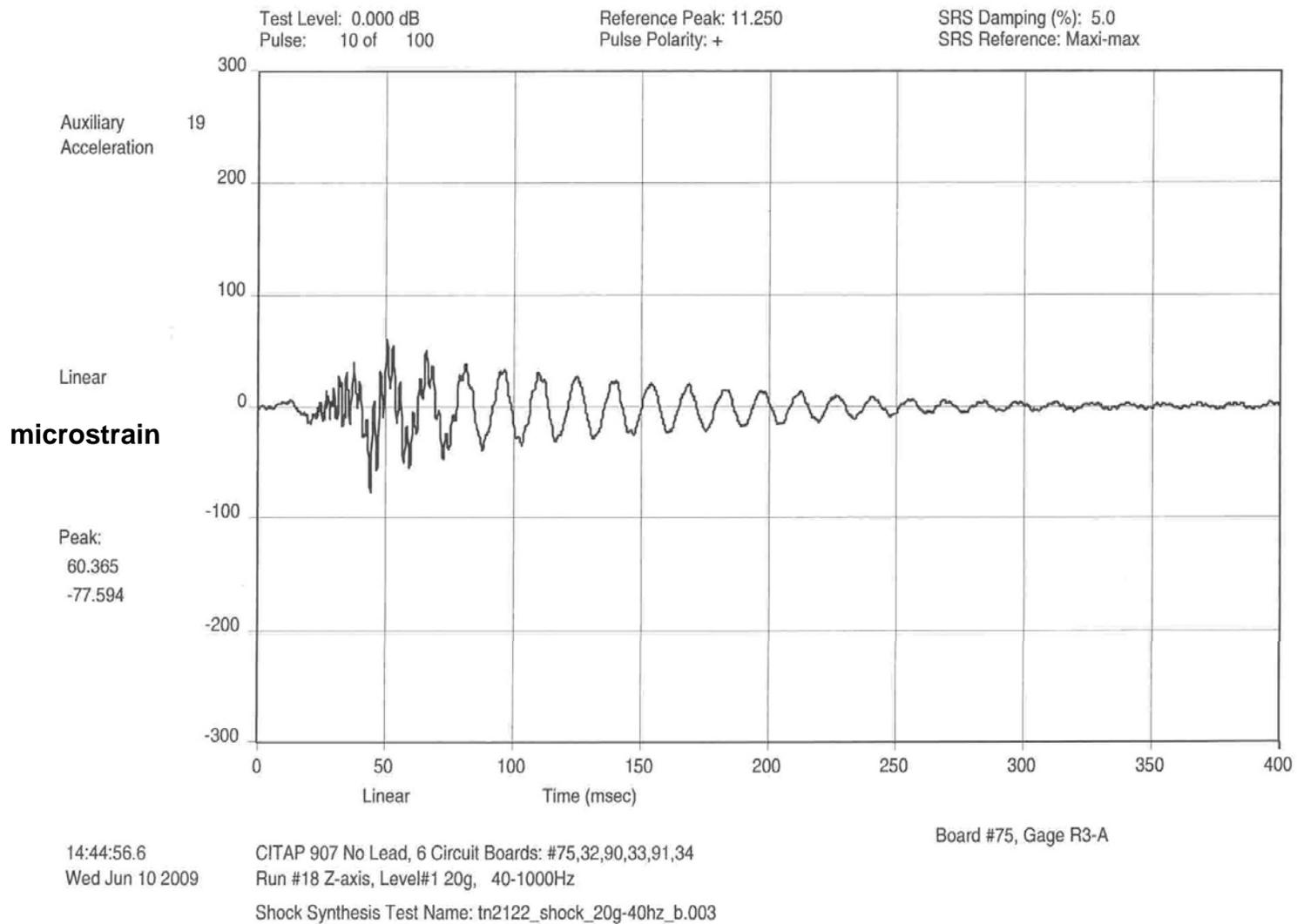


Figure 50. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 3, x-Direction)

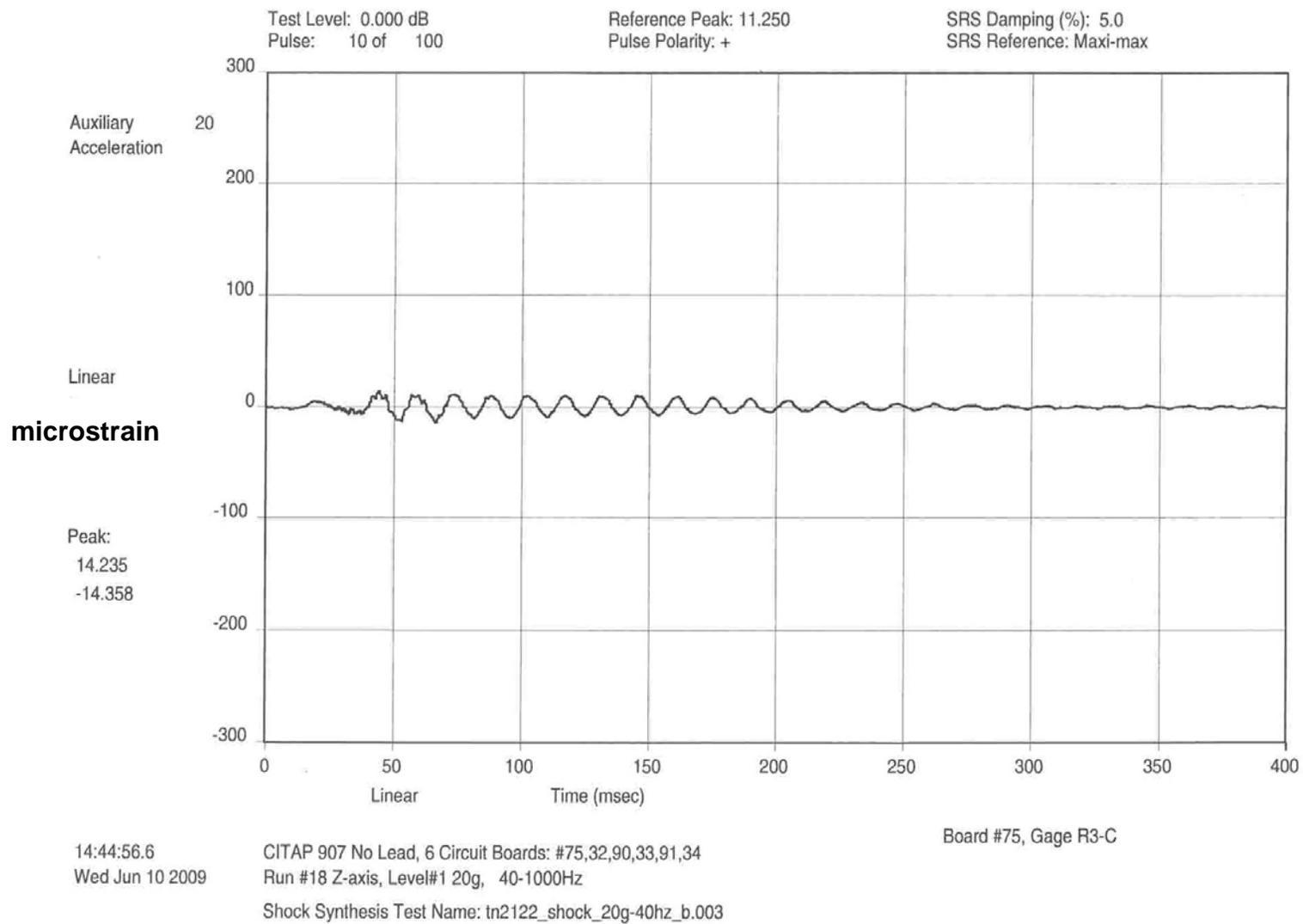


Figure 51. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 3, y-Direction)

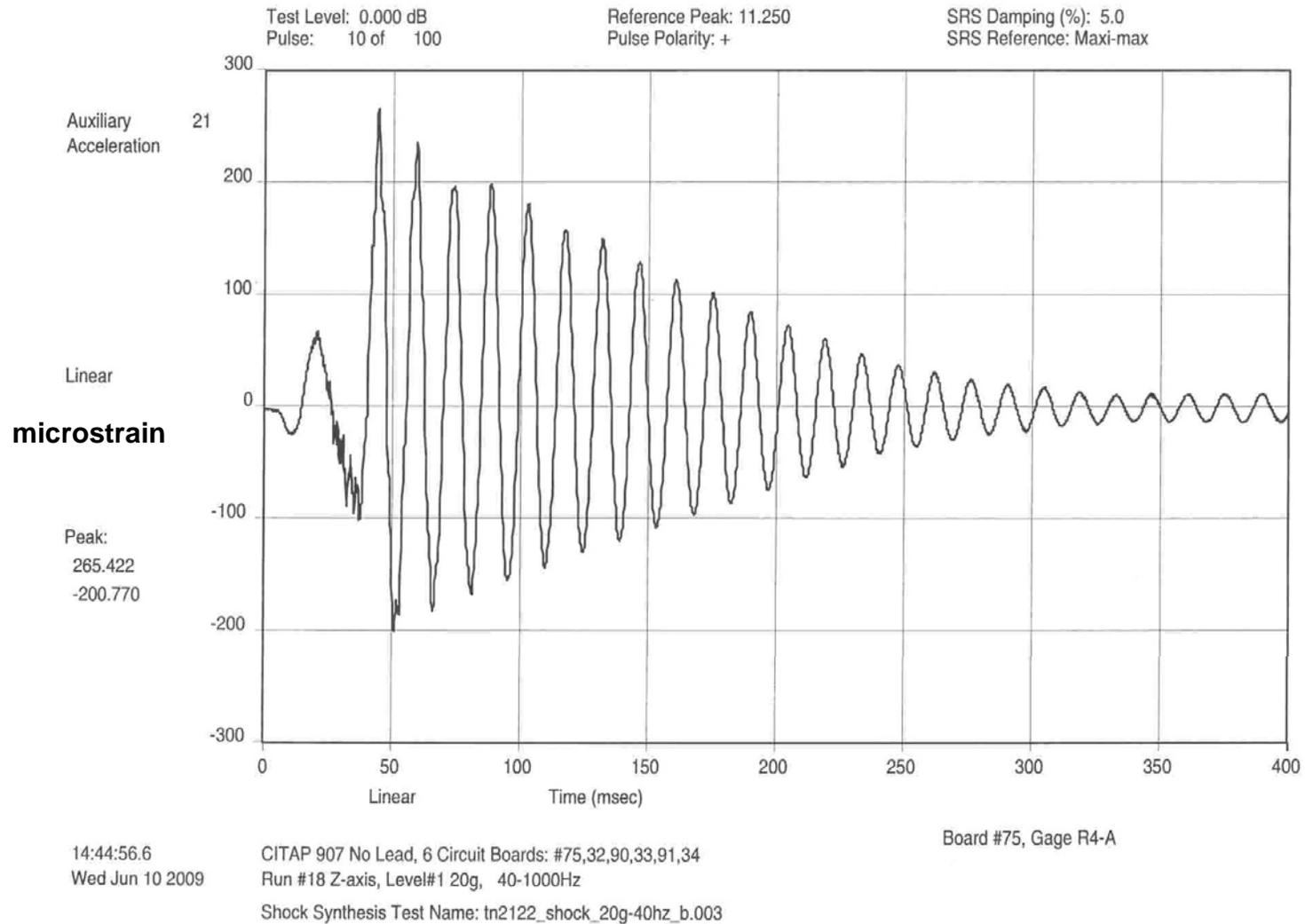


Figure 52. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 4, x-Direction)

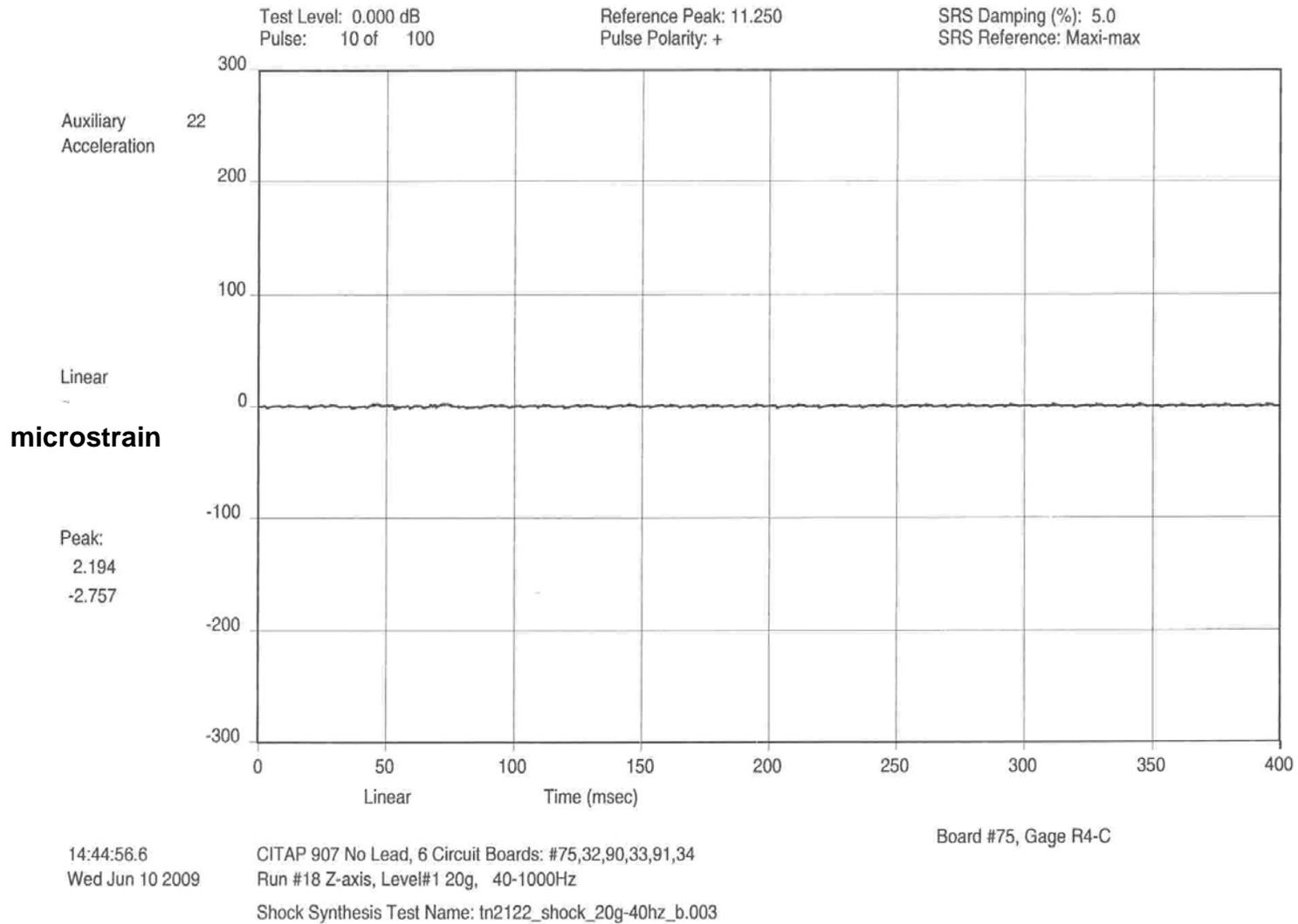


Figure 53. Test Vehicle Time History Strain Response to 20 G SRS Input (Test Vehicle 75, Strain Gage 4, y-Direction)

**Table 5. Maximum Strain Gage Readings for All SRS Test Levels
(Test Vehicle 75, in microstrain)**

SRS Test Level (G's)	Strain Gage 1 x-Direction	Strain Gage 1 y-Direction	Strain Gage 2 x-Direction	Strain Gage 2 y-Direction	Strain Gage 3 x-Direction	Strain Gage 3 y-Direction	Strain Gage 4 x-Direction	Strain Gage 4 y-Direction
20	-153	-64	276	-47	-77	-14	265	-3
40	462	-180	760	-108	183	-63	754	-11
75	568	-282	1274	-168	355	111	1180	-18
100	655	-304	1434	-171	408	-126	1350	-27
200	715	-424	2376	-207	709	43	2209	-41
300	572	-597	2925	-224	1315	175	2967	-46

Note: Maximum strains recorded by each gage may not have occurred at the same time

Table 6. % of Components Failed (Includes Mixed Solders)

Component	% of Components Failed During Mechanical Shock Testing			
	"Manufactured" Test Vehicles		"Rework" Test Vehicles	
	SnPb	Pb-Free	SnPb	Pb-Free
BGA-225	94	96	95	100
CLCC-20	22	30	22	30
CSP-100	32	26	42	38
PDIP-20	53	73	54	58
QFN-20	0	10	0	0
TQFP-144	70	62	68	80
TSOP-50	4	0	22	20

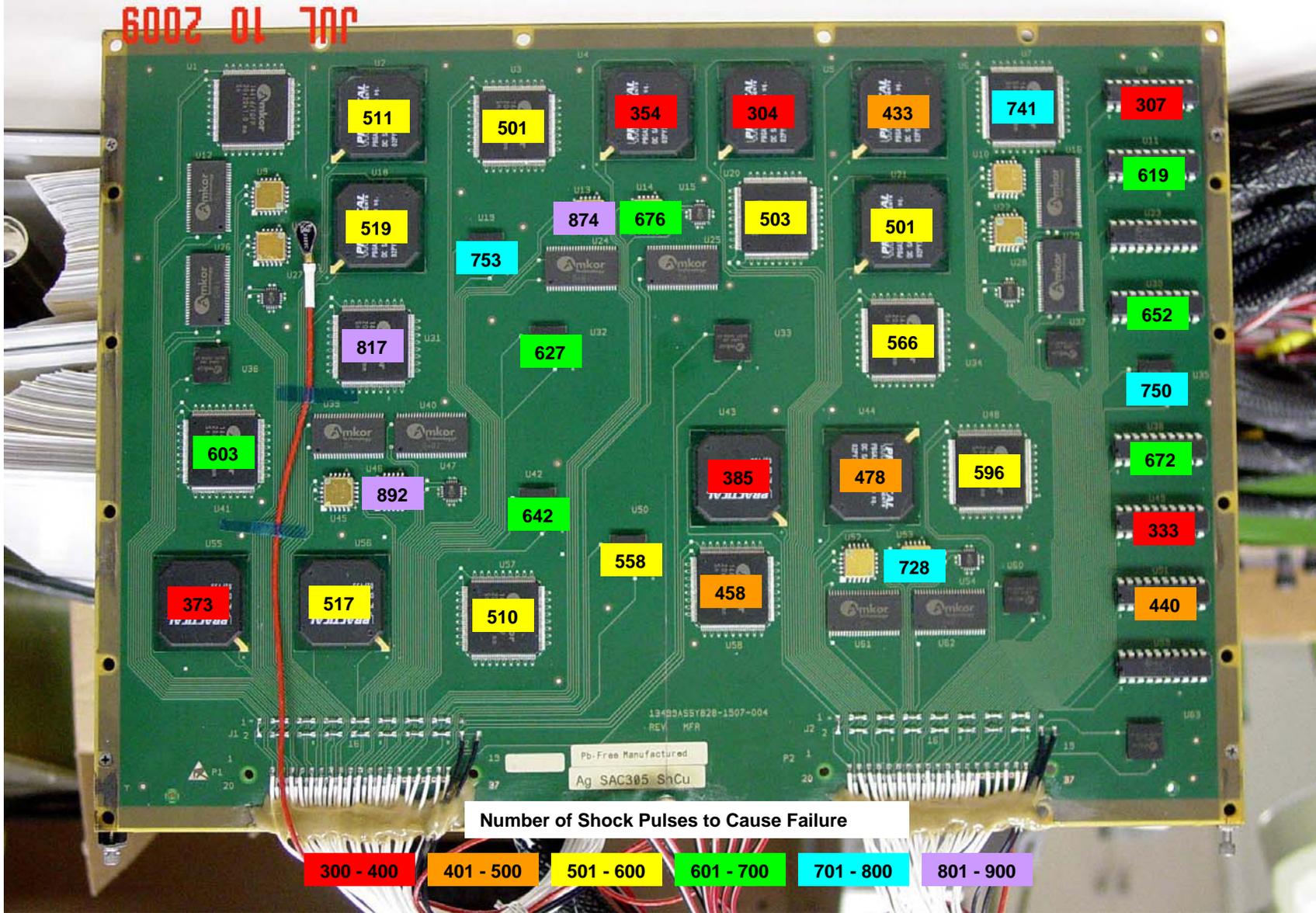


Figure 54. Number of Shocks Required to Fail Components (Test Vehicle 75 Data)

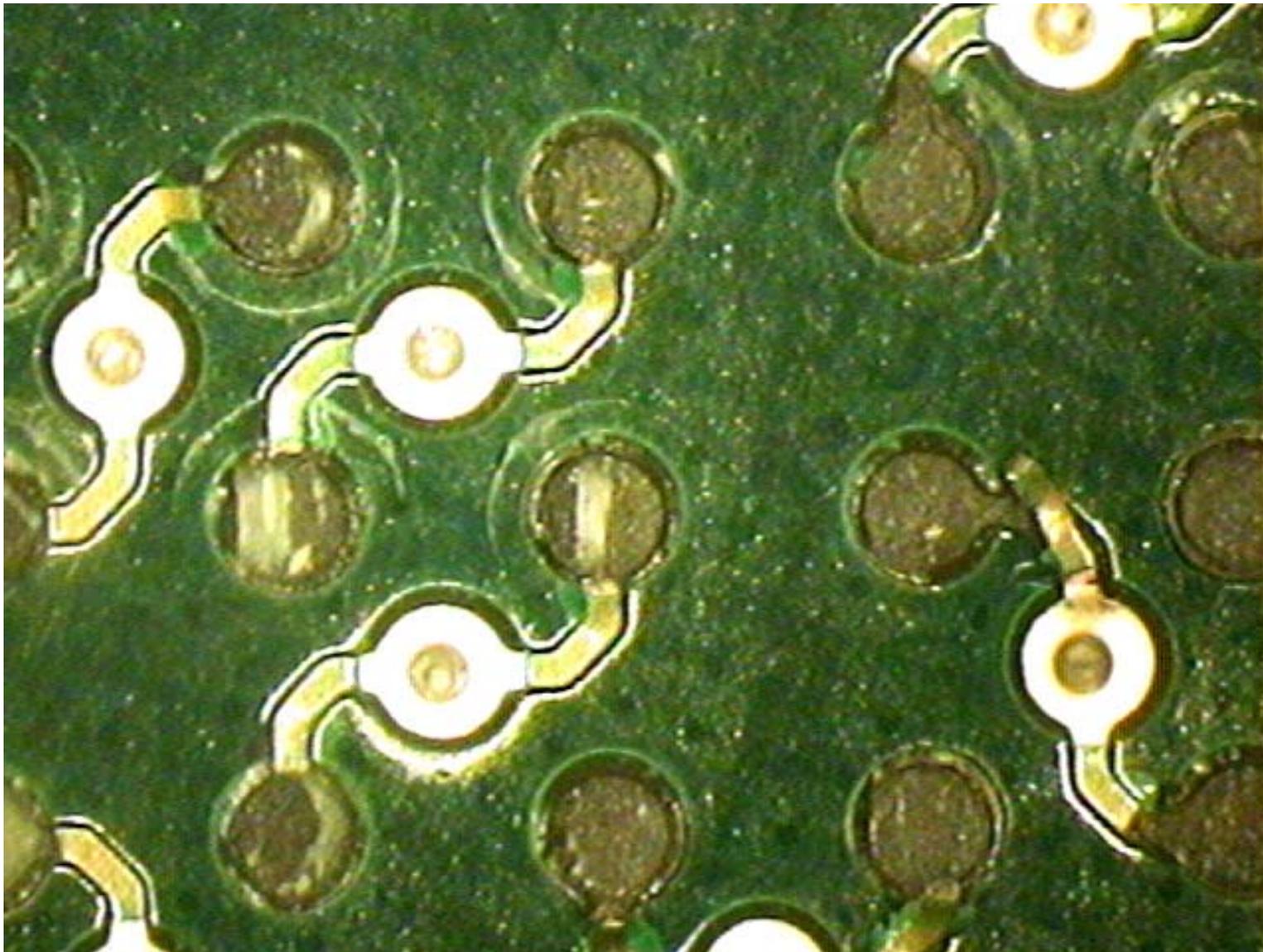


Figure 55. Test Vehicle 30 BGA U2 with Missing Pads (SnPb Solder/SnPb Balls)

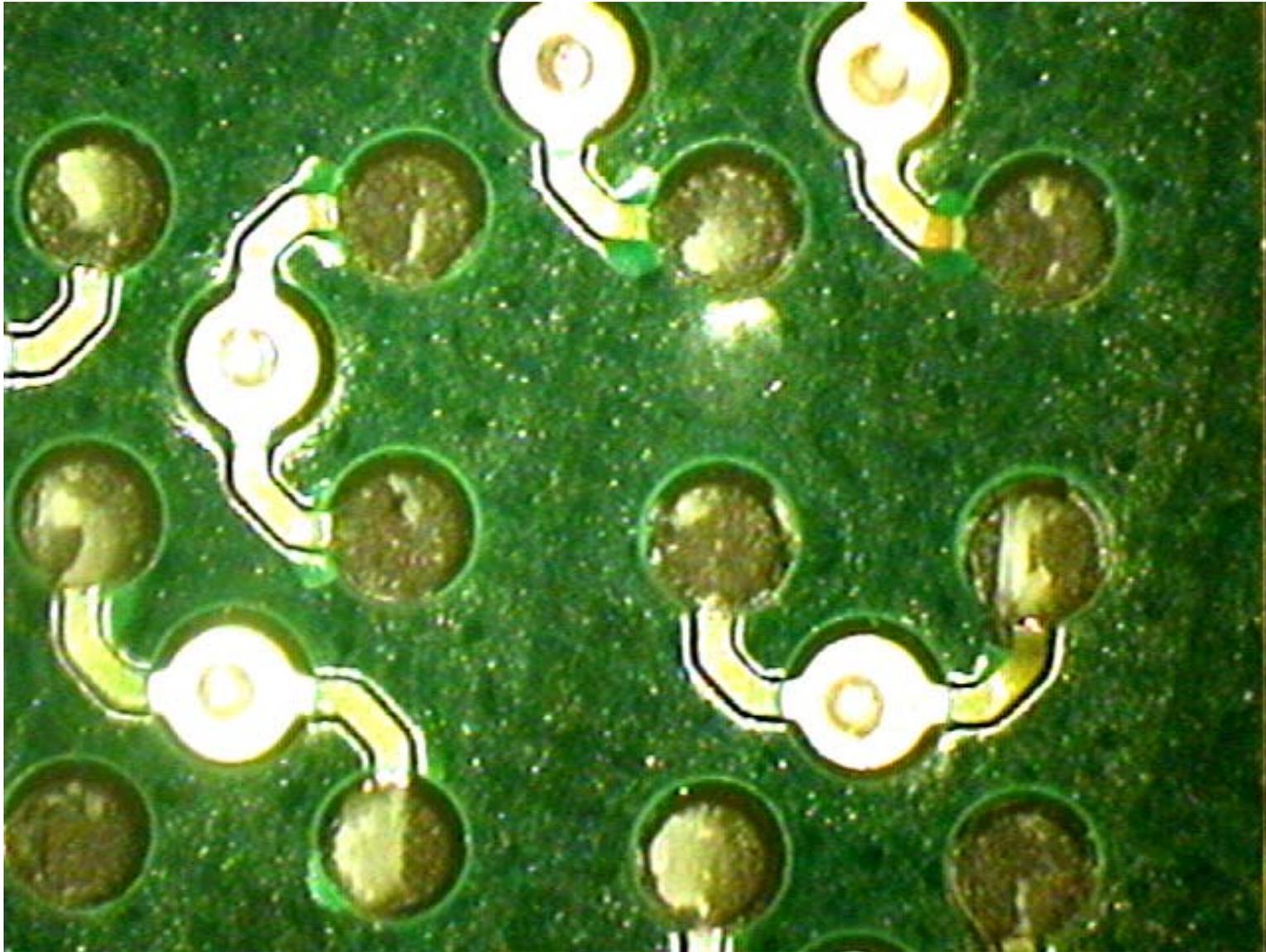


Figure 56. Test Vehicle 30 BGA U4 with Missing Pads (SnPb Solder/SnPb Balls)

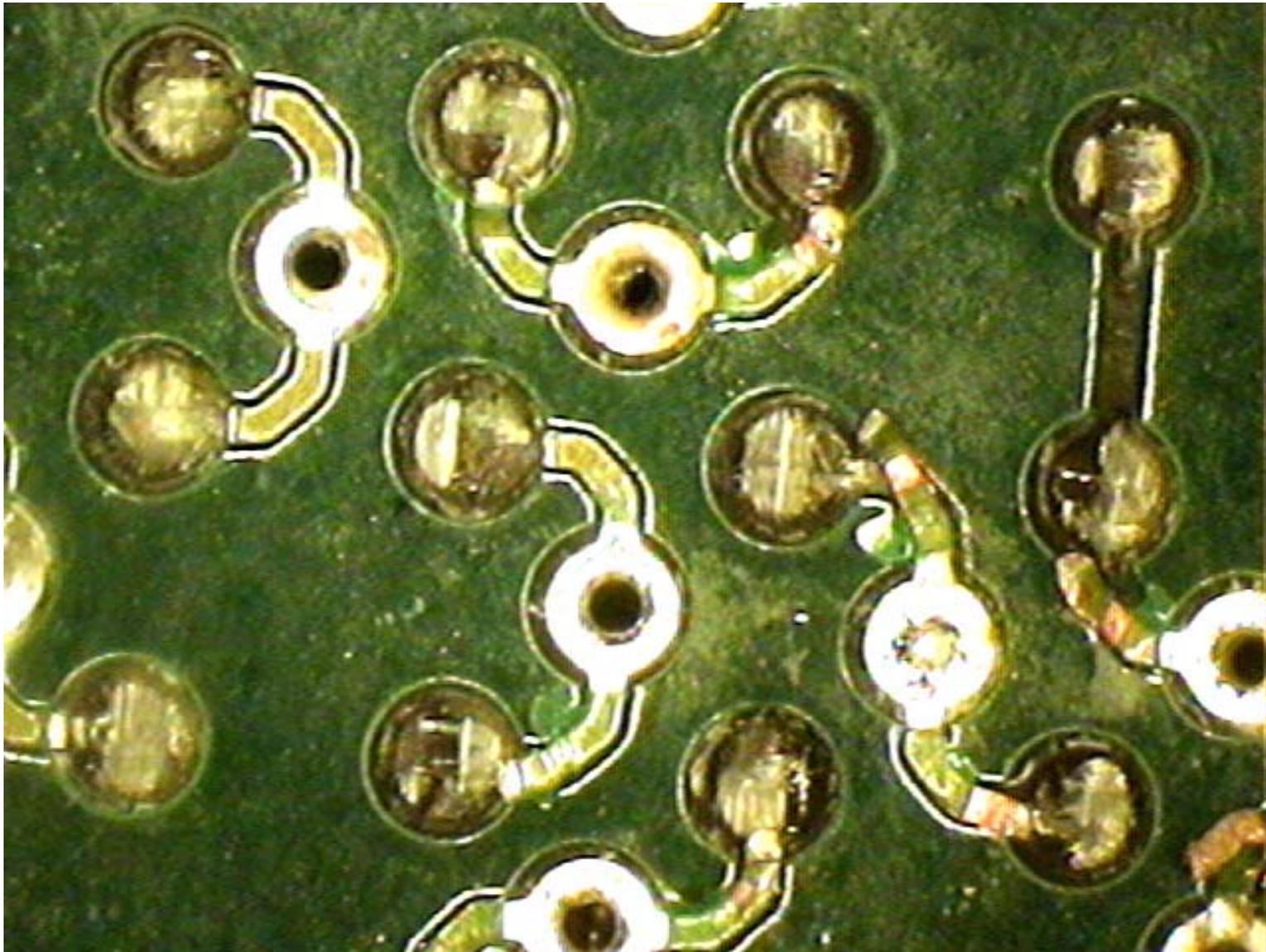


Figure 57. Test Vehicle 193 BGA U21 with Missing Pads (Flux Only/SAC405 Balls)

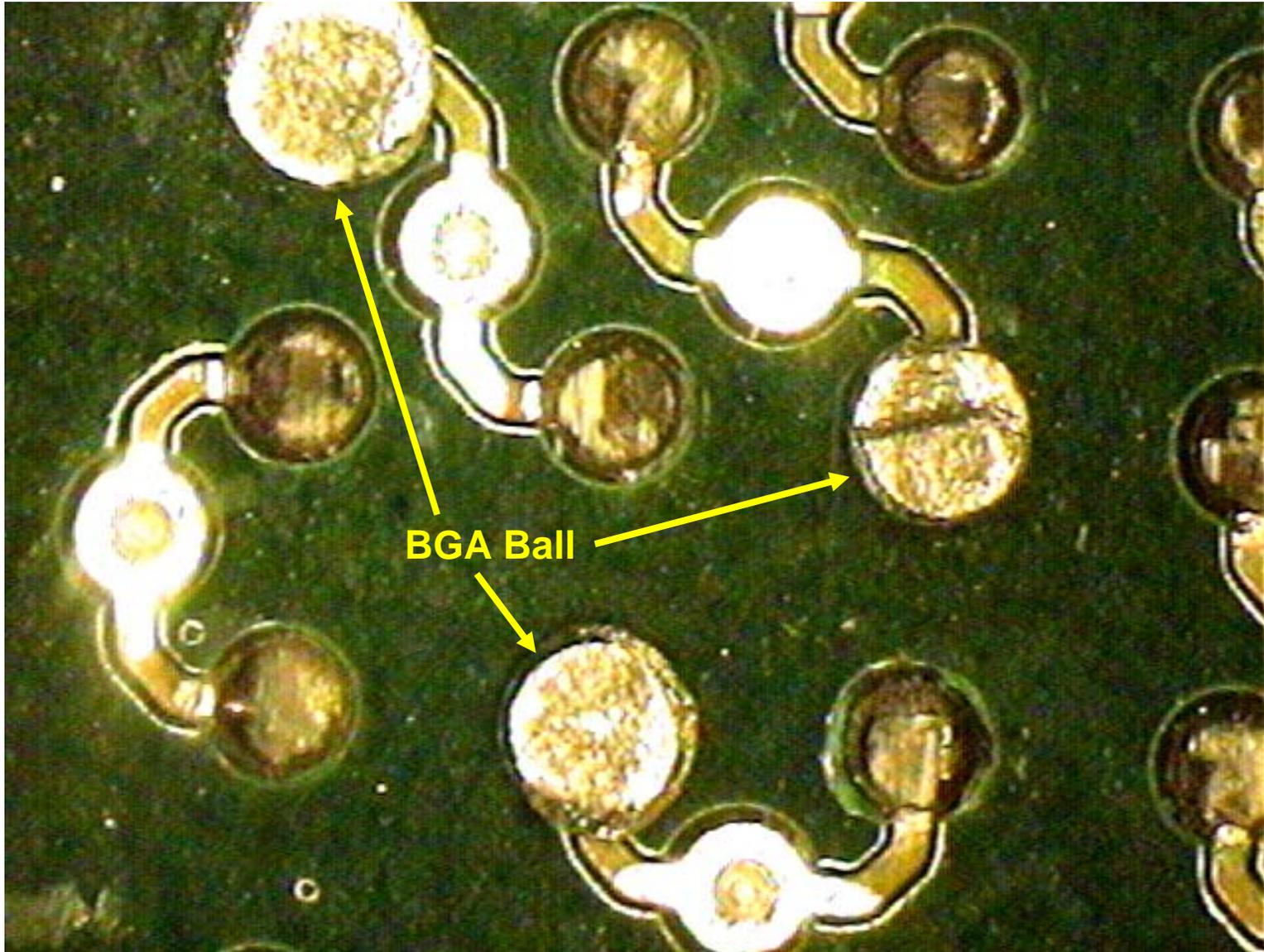


Figure 58. Test Vehicle 193 BGA U21 with Missing Pads (Flux Only/SAC405 Balls)

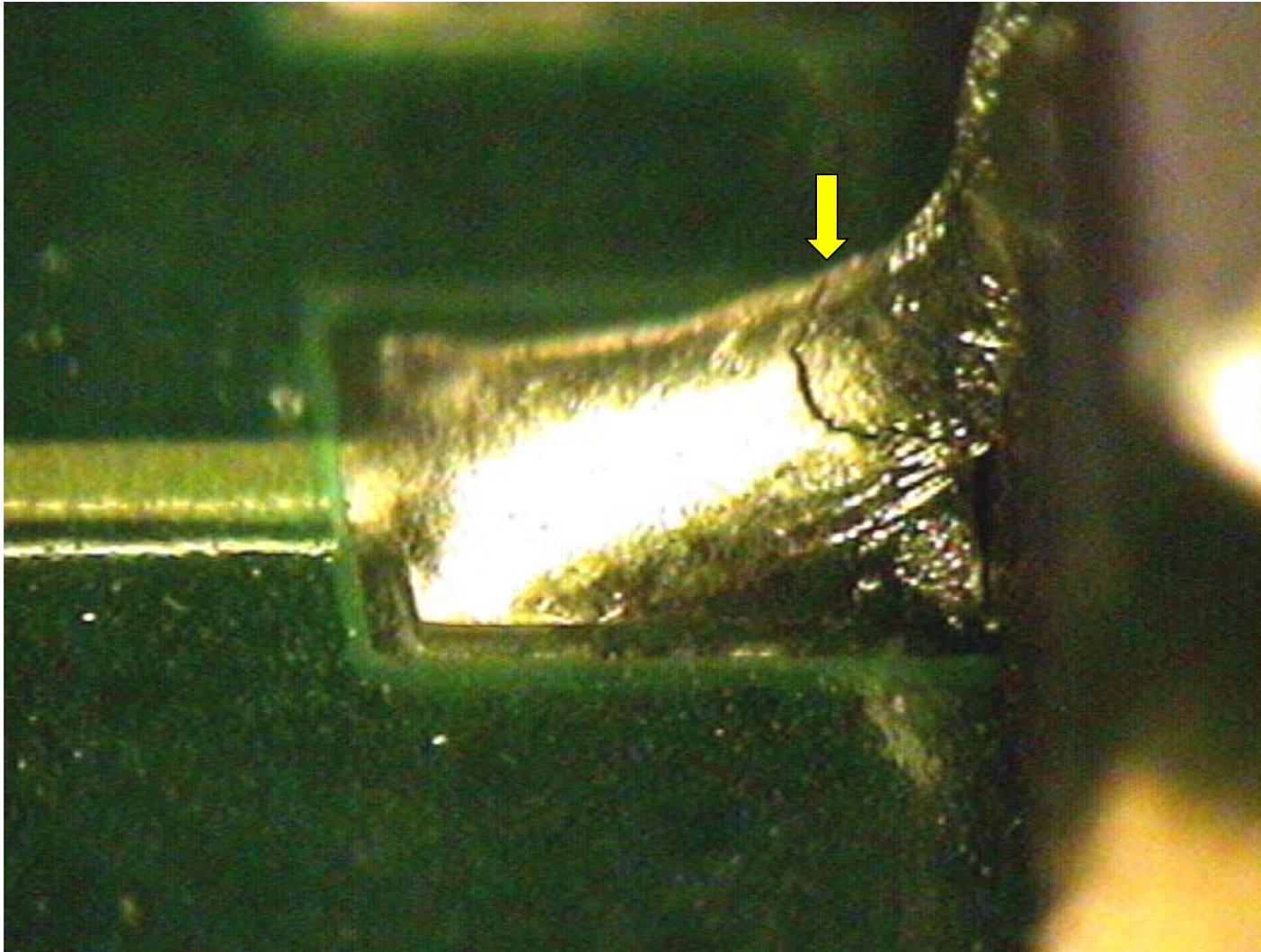


Figure 59. Test Vehicle 191 CLCC U10 (Cracked SAC305/SnPb Solder Joint)

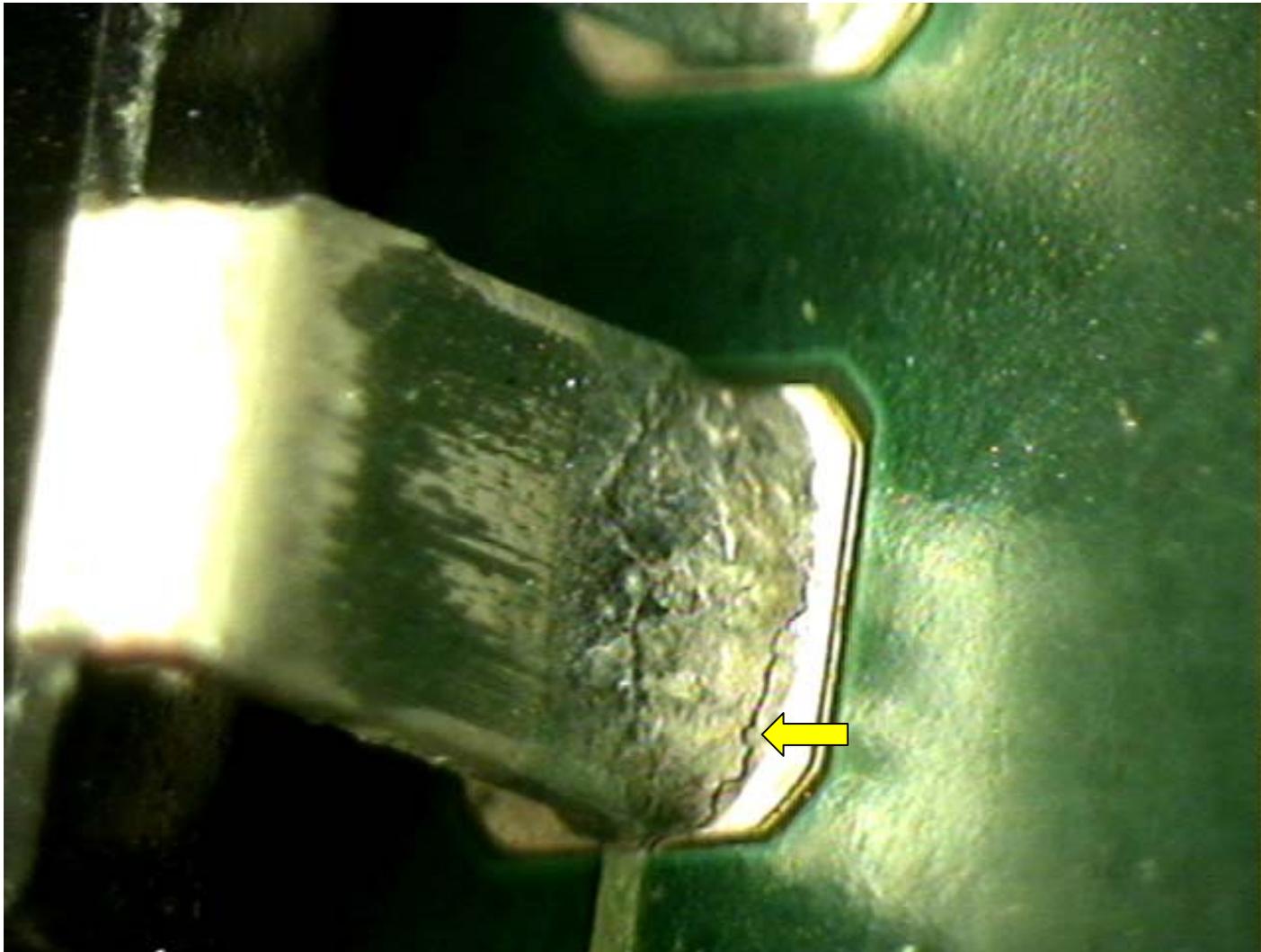


Figure 60. Test Vehicle 34 PDIP U8 (Cracked SnPb Solder Joint)

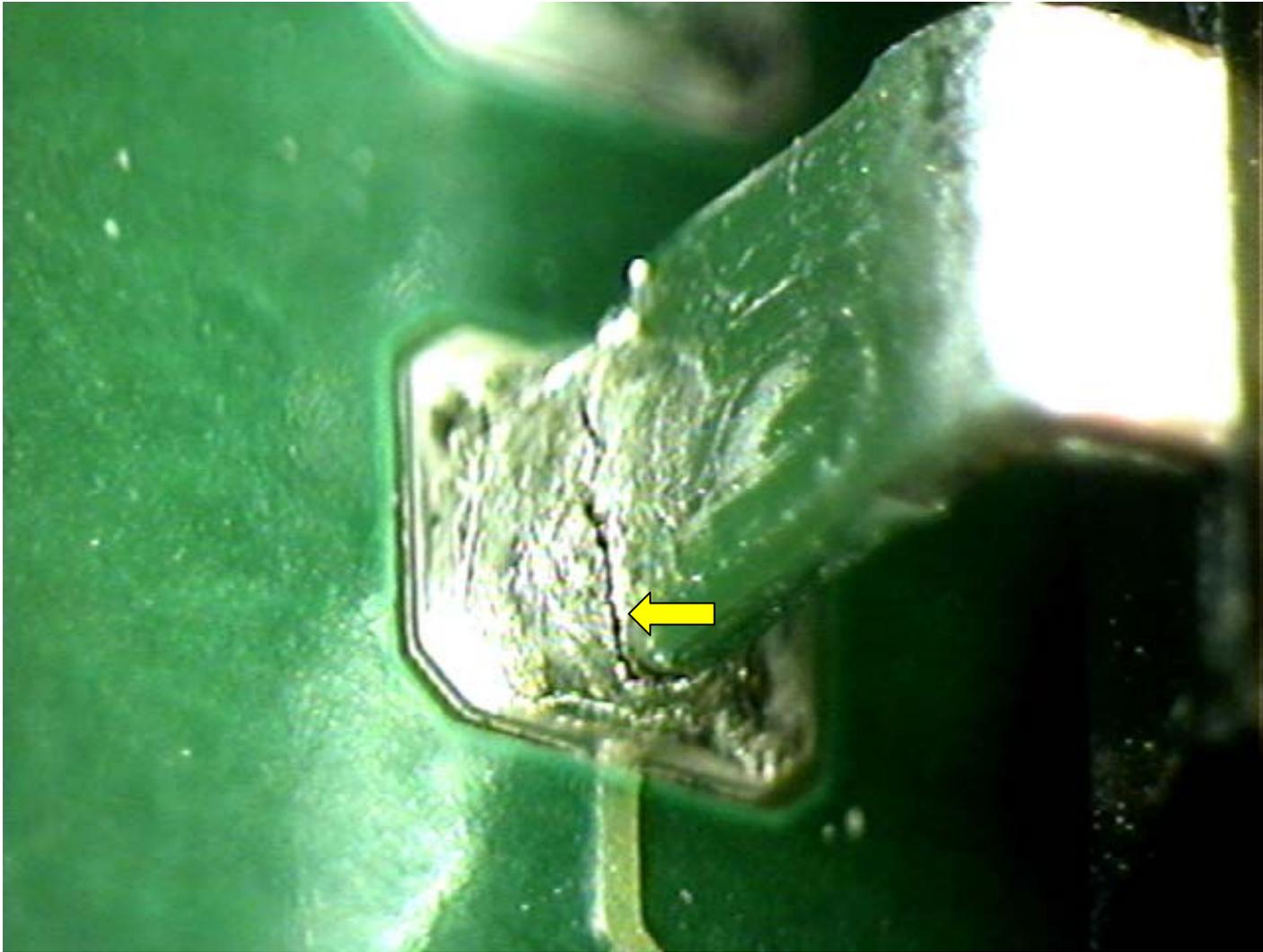


Figure 61. Test Vehicle 89 PDIP U51 (Cracked SN100C Solder Joint)

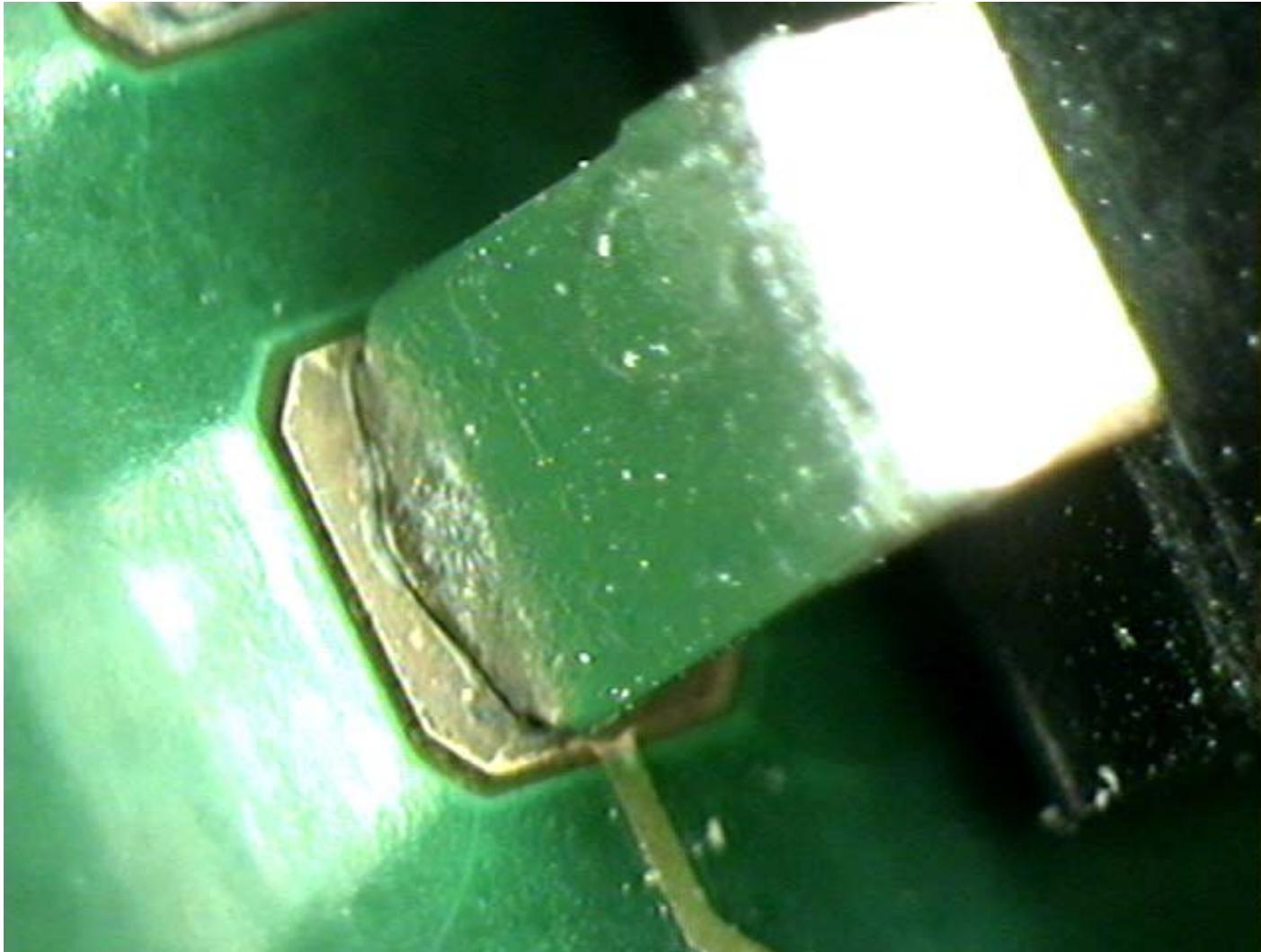


Figure 62. Test Vehicle 89 PDIP U8 (SN100C)

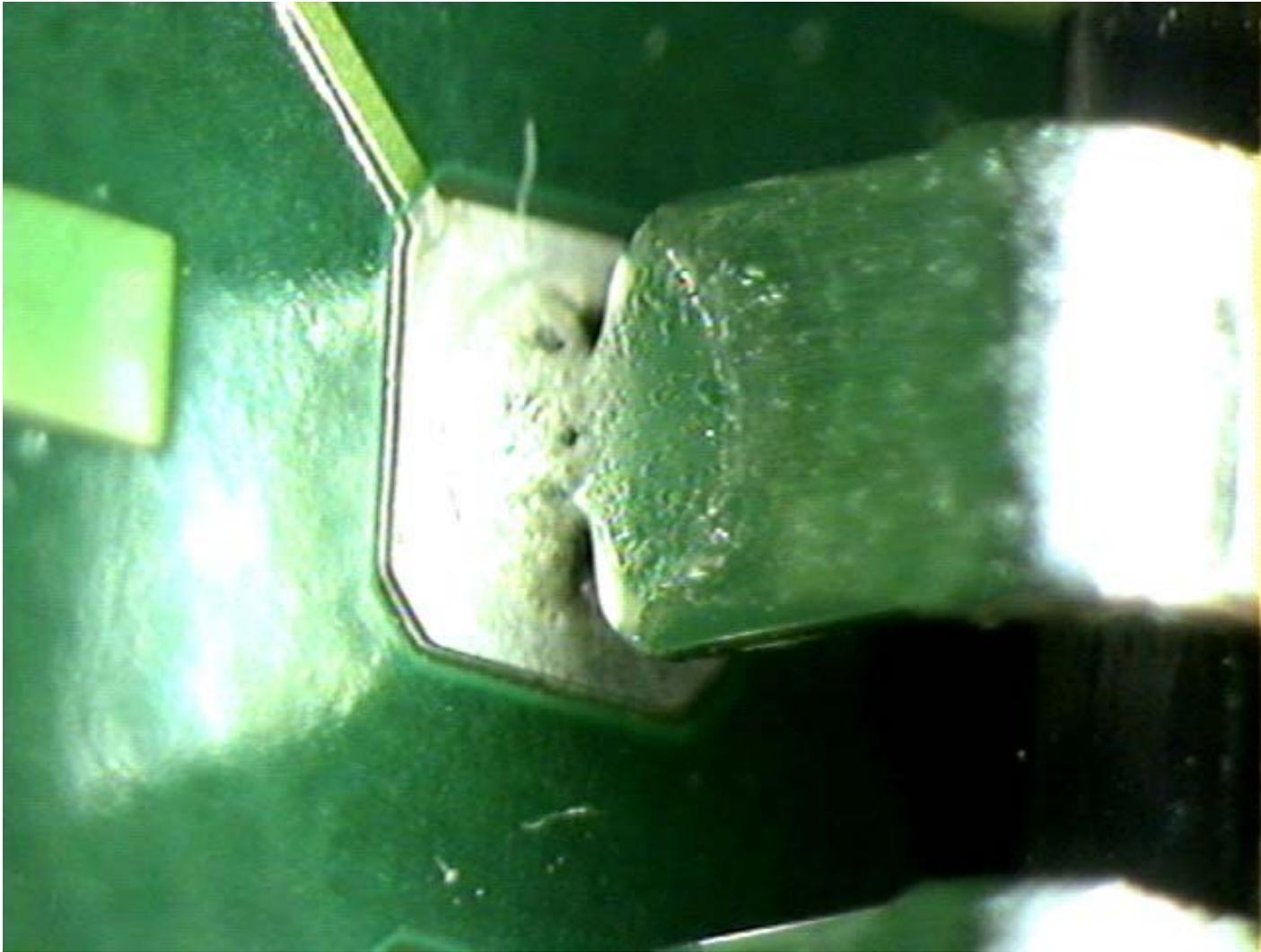


Figure 63. Test Vehicle 89 PDIP U51 (SN100C)

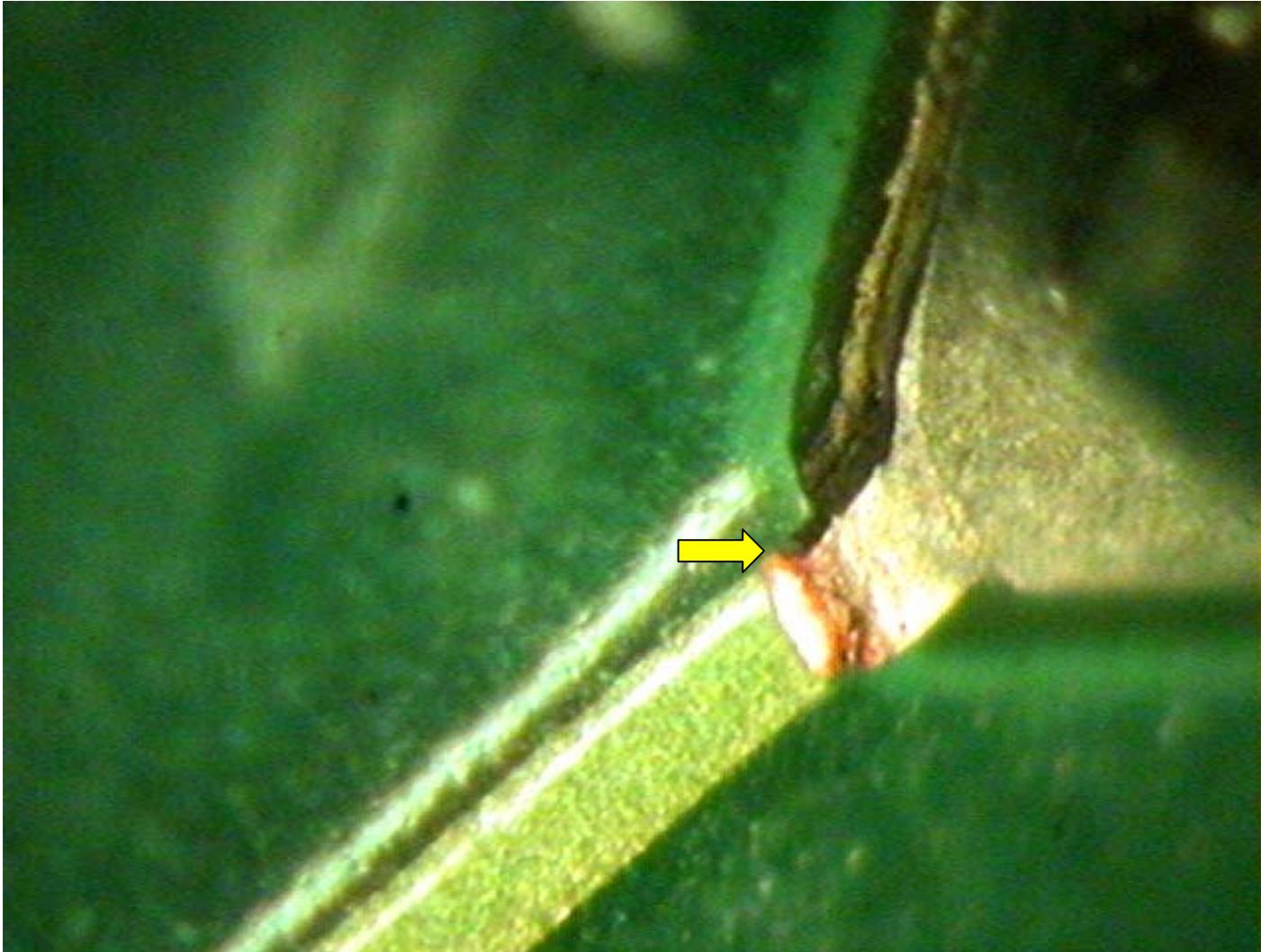


Figure 64. Test Vehicle 89 PDIP U30 (Cracked Trace, SN100C)



Figure 65. Test Vehicle 89 PDIP U30 (Cracked Trace, SN100C)

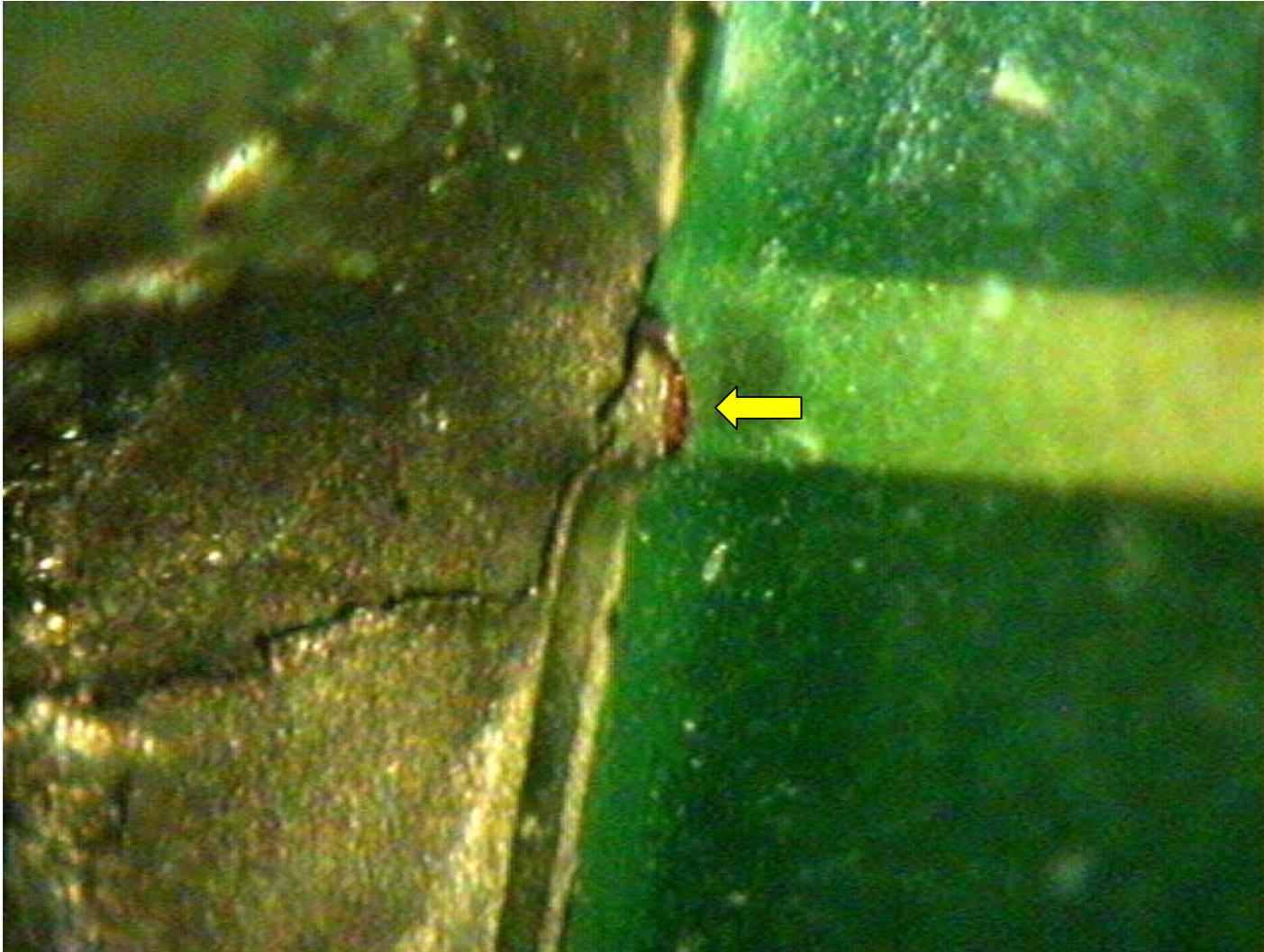


Figure 66. Test Vehicle 89 PDIP U30 (Cracked Trace, SN100C)

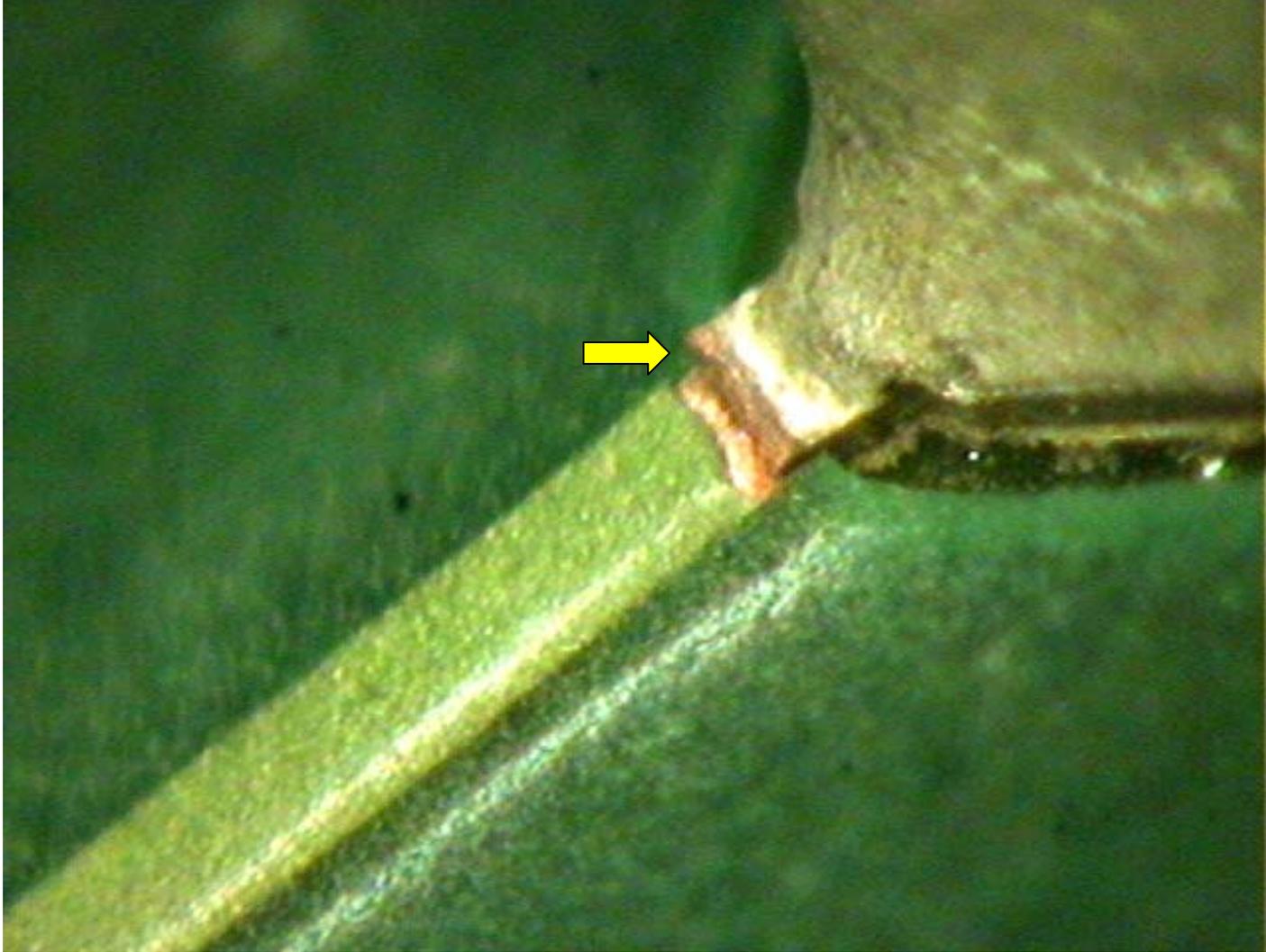


Figure 67. Test Vehicle 89 PDIP U38 (Cracked Trace, SN100C)

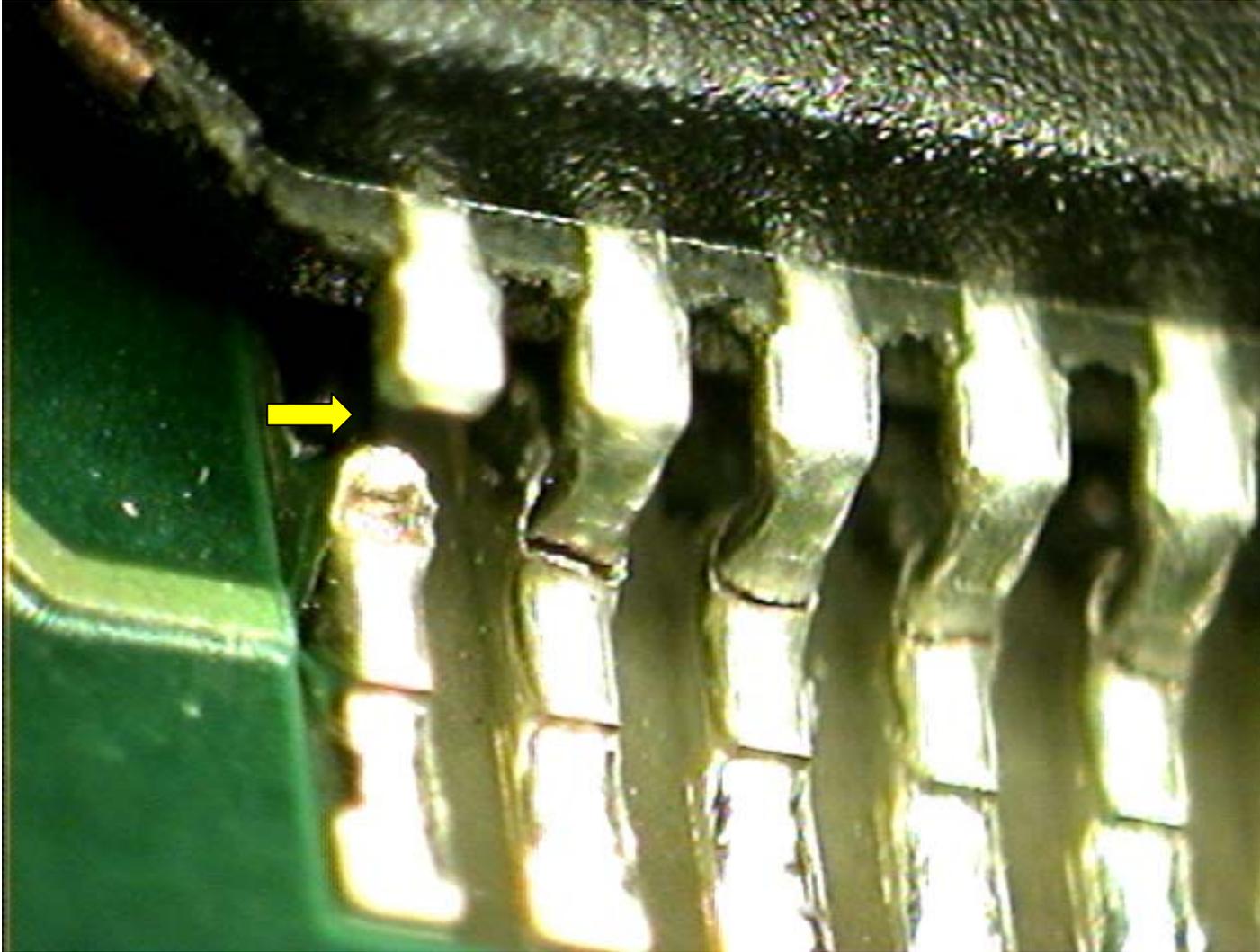


Figure 68. Test Vehicle 89 TQFP U3 (Cracked Leads, Missing Lead)

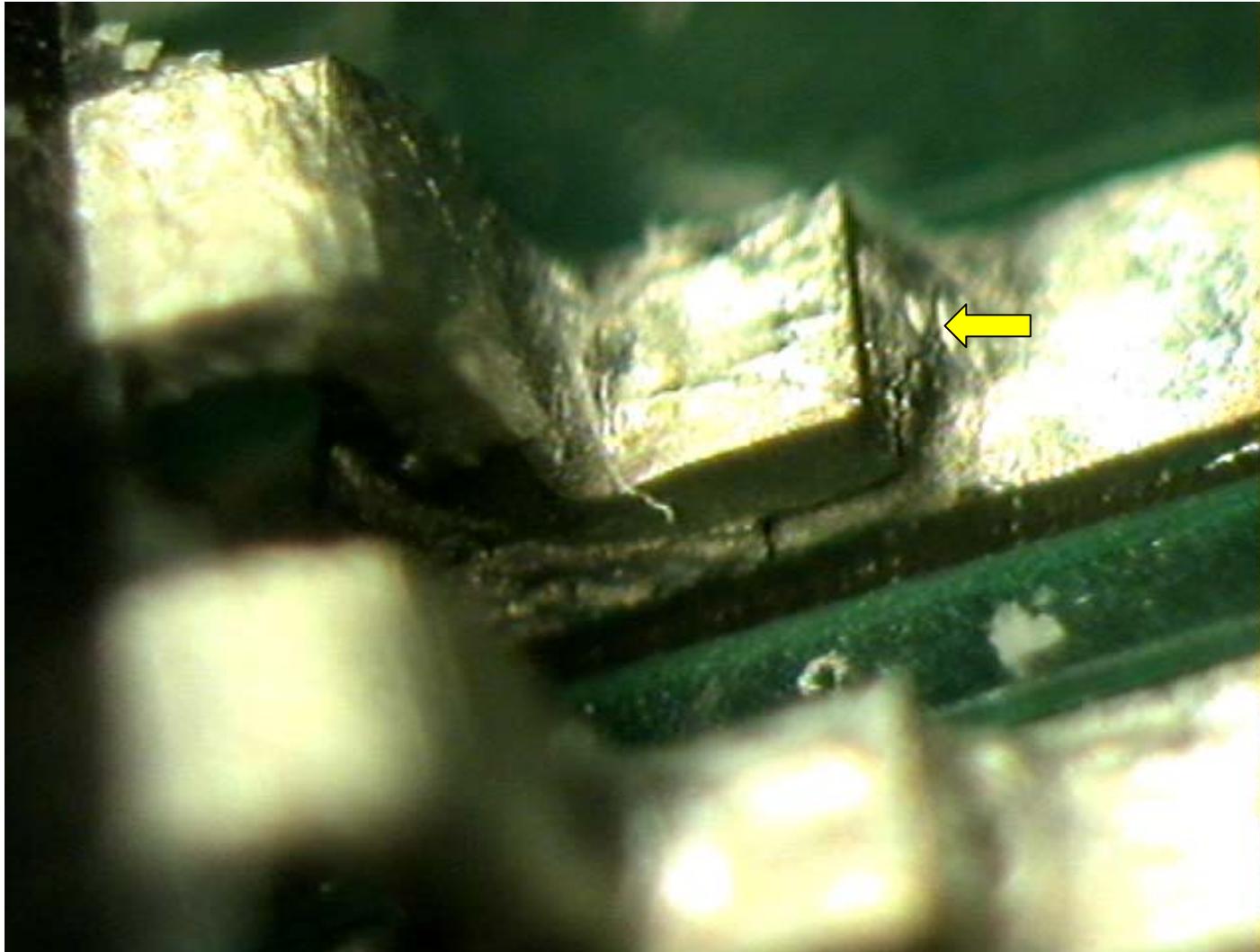


Figure 69. Test Vehicle 34 TSOP U61 (Cracked SnPb/SnPb Solder Joint)

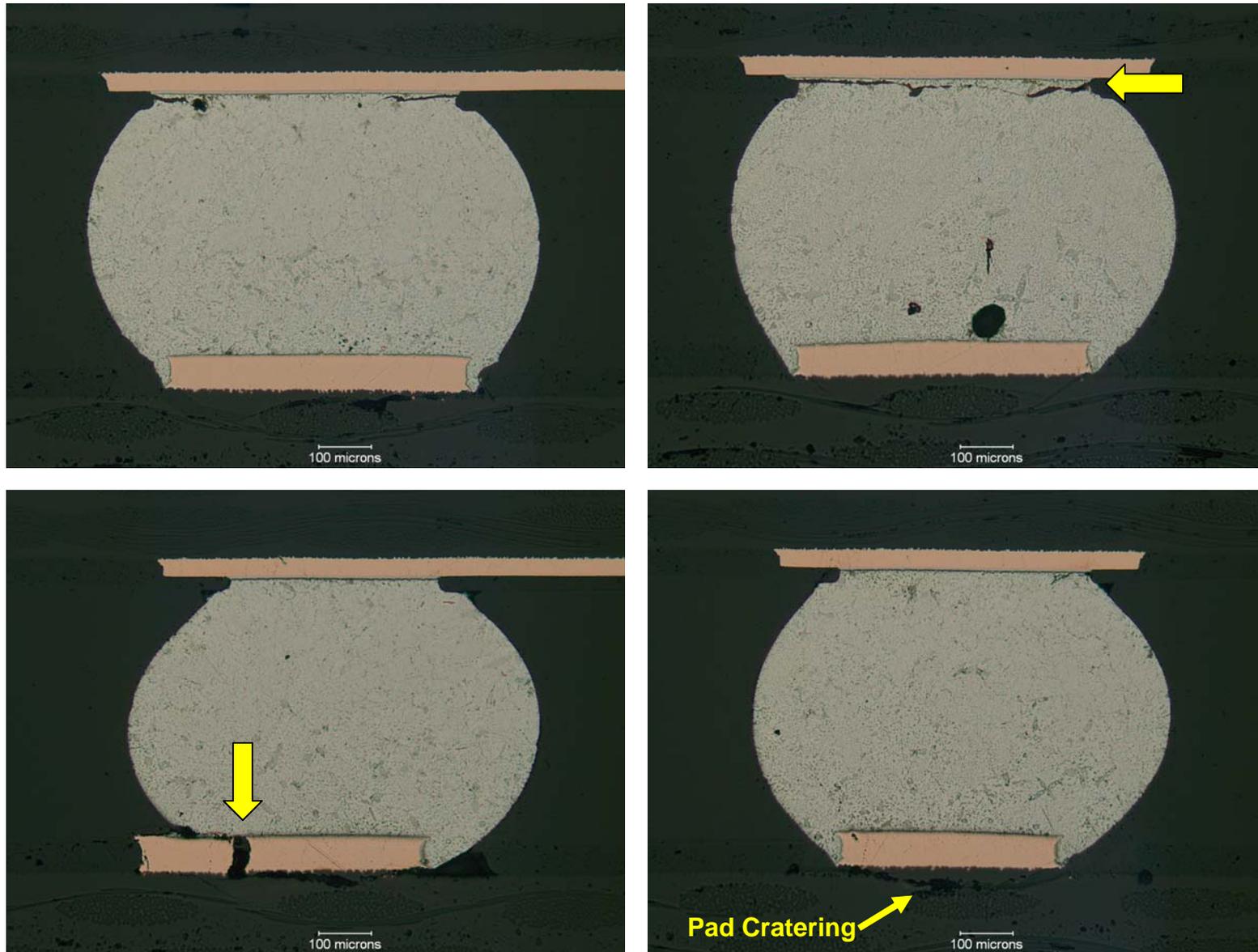


Figure 70. Test Vehicle 34 - Four Corner Balls of BGA U6 (SnPb Solder/SnPb Balls)

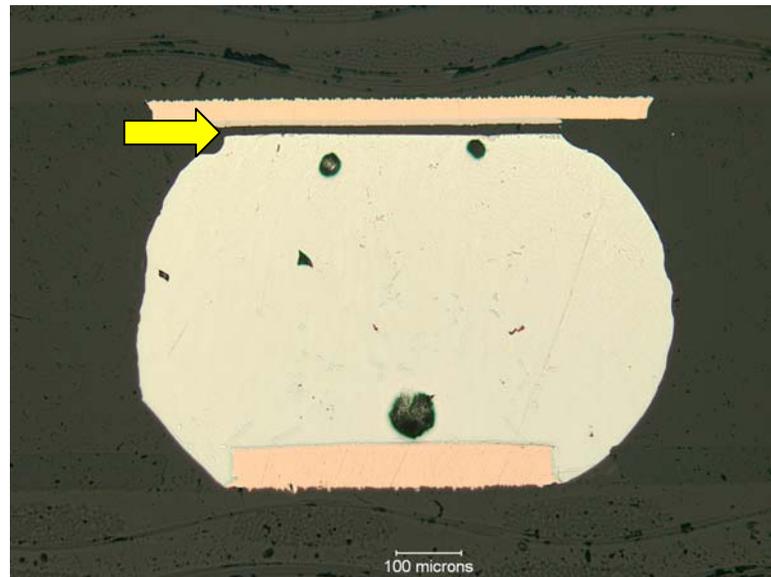
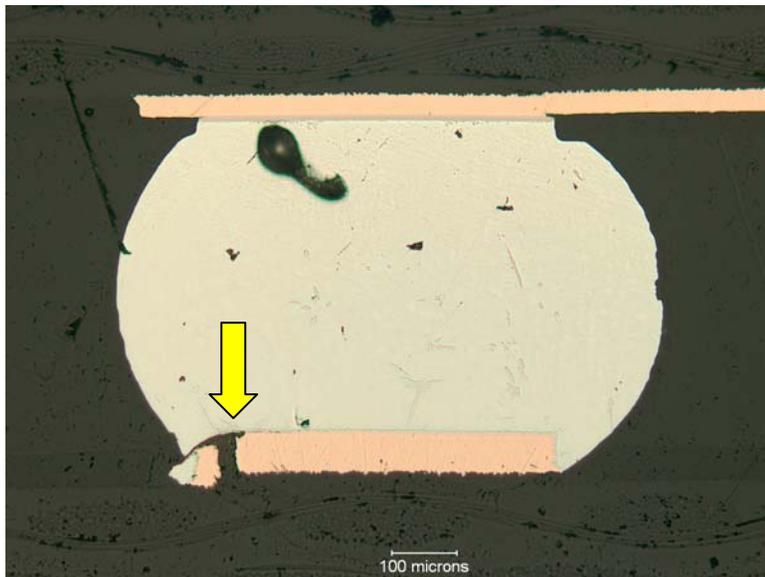
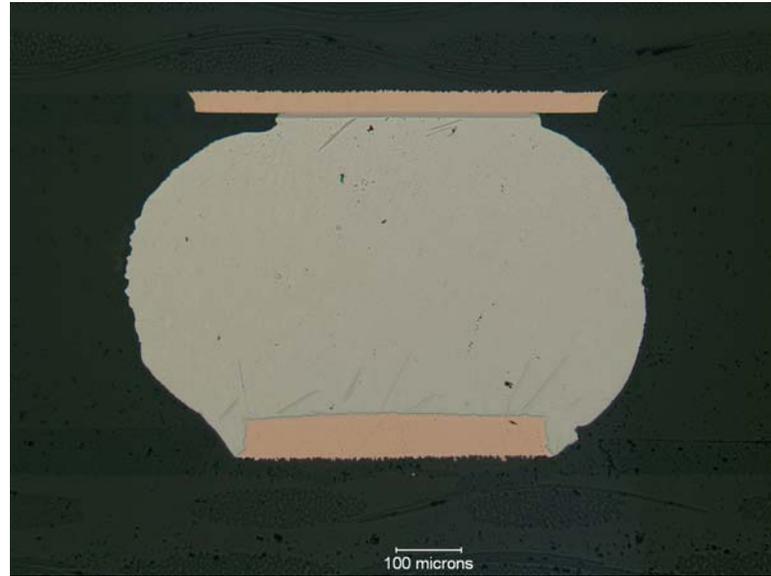
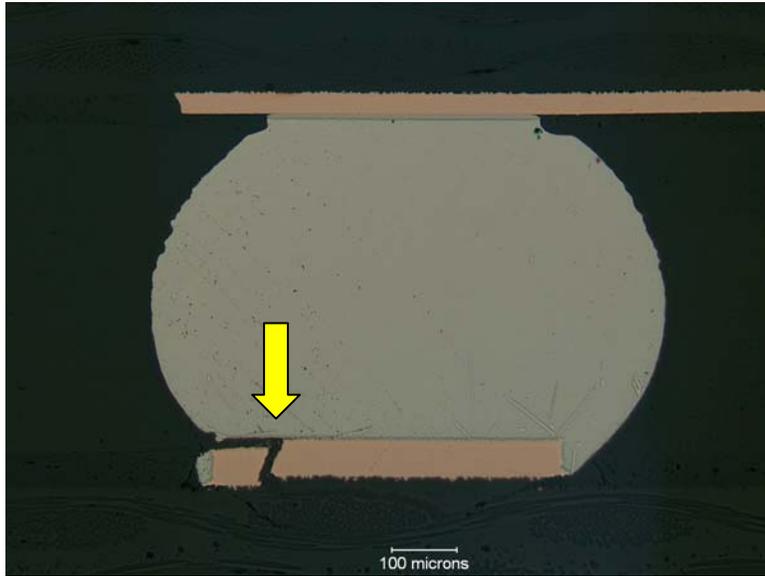


Figure 71. Test Vehicle 89 - Four Corner Balls of BGA U2 (SAC305 Solder/SAC405 Balls)

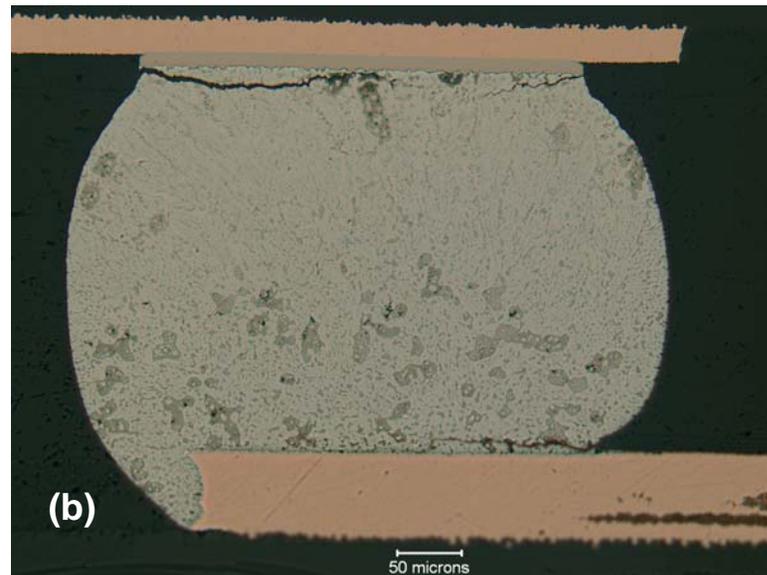
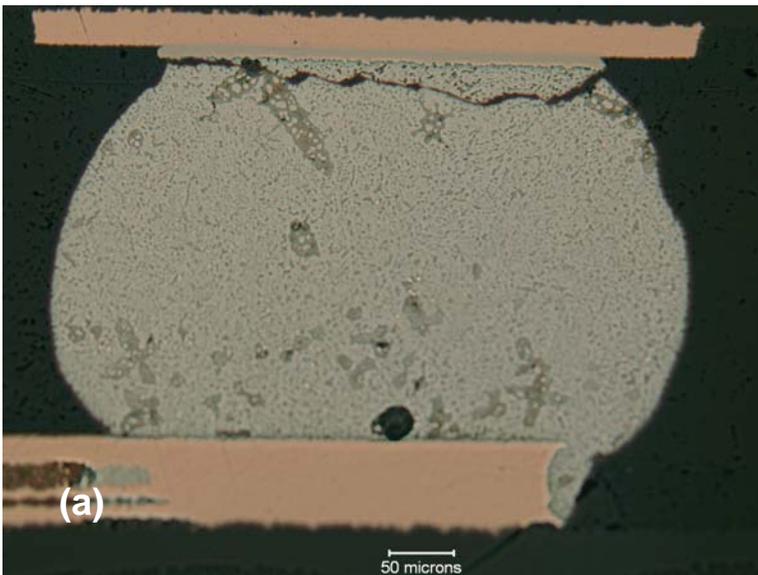
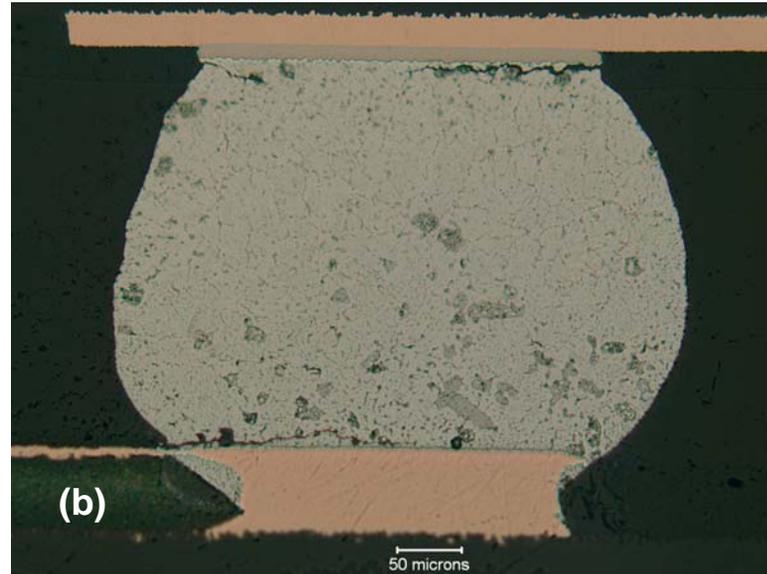
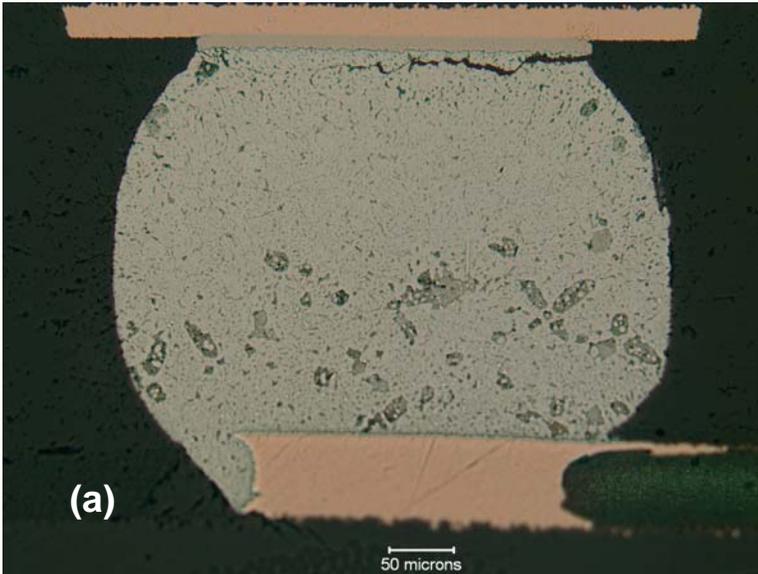


Figure 72. Test Vehicle 34 – CSP U33 (a) Corner Ball, (b) Ball Adjacent to Corner Ball (SnPb Solder/SnPb Balls)

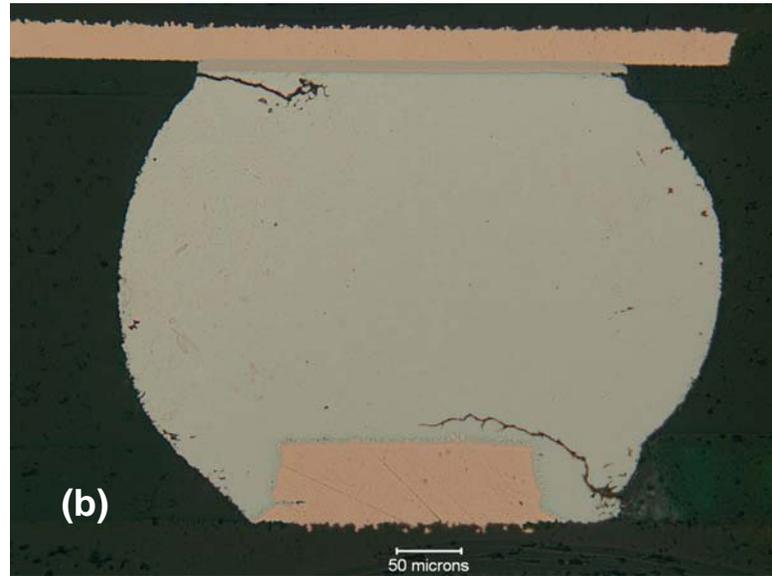
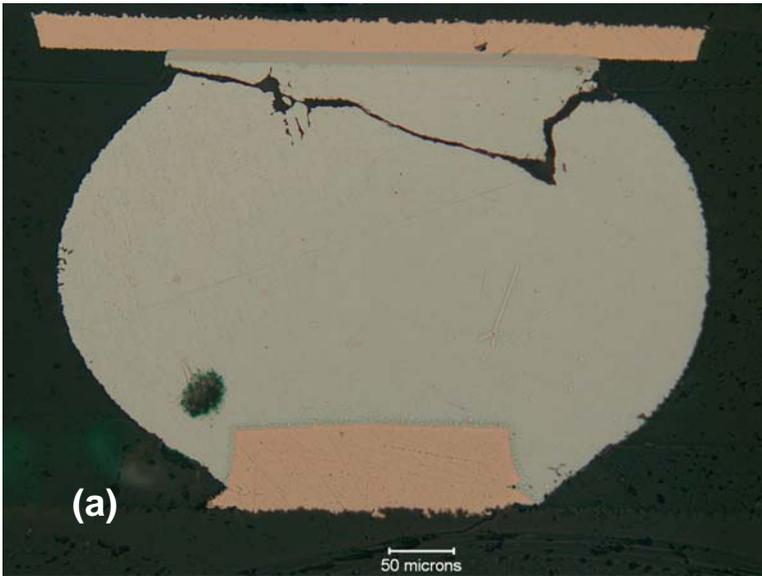
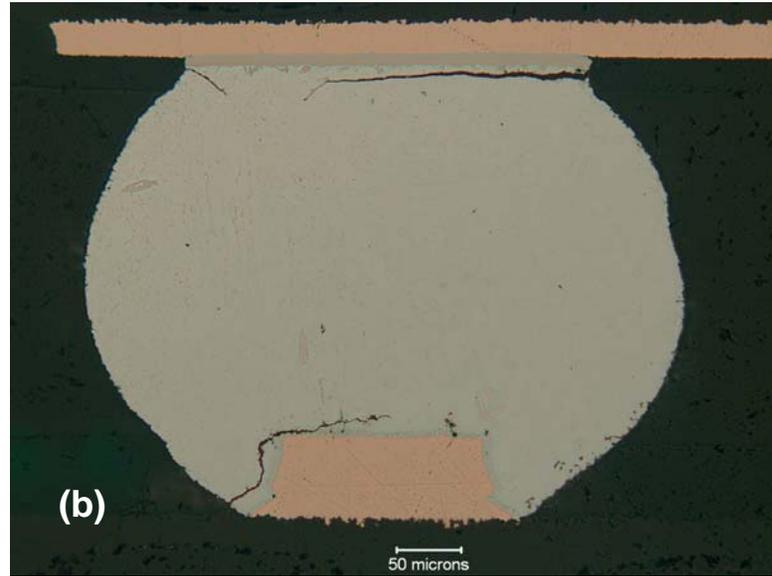
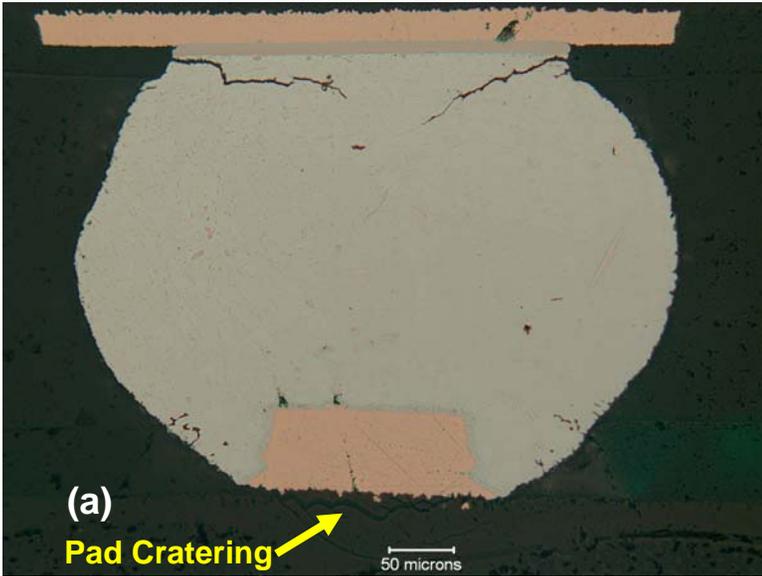


Figure 73. Test Vehicle 89 – CSP U33 (a) Corner Ball, (b) Ball Adjacent to Corner Ball (SAC305 Solder/SAC105 Balls)

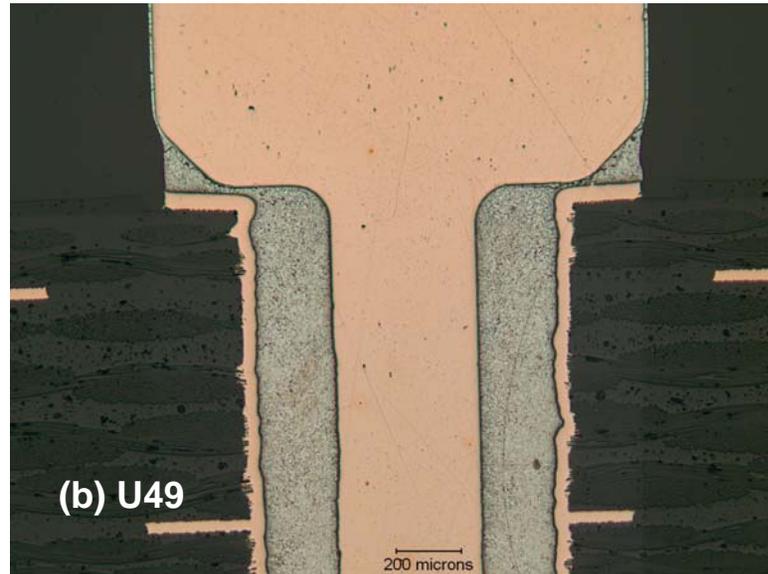
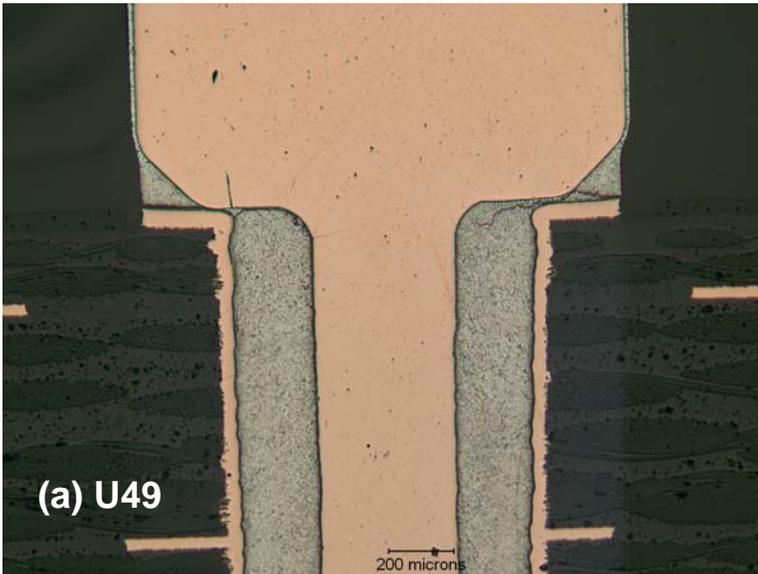
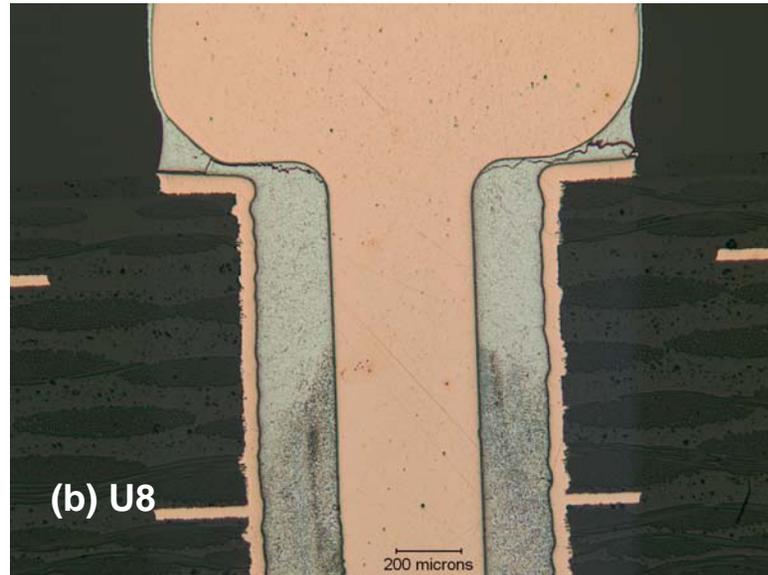
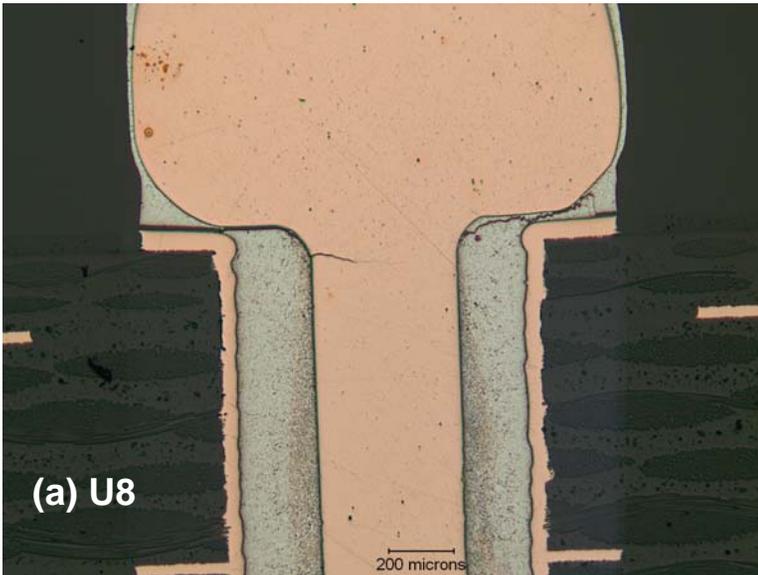


Figure 74. Test Vehicle 34 – PDIPs U8 and U49 (a) Corner Lead, (b) Lead Adjacent to Corner Lead (SnPb Solder/SnPb Finish)

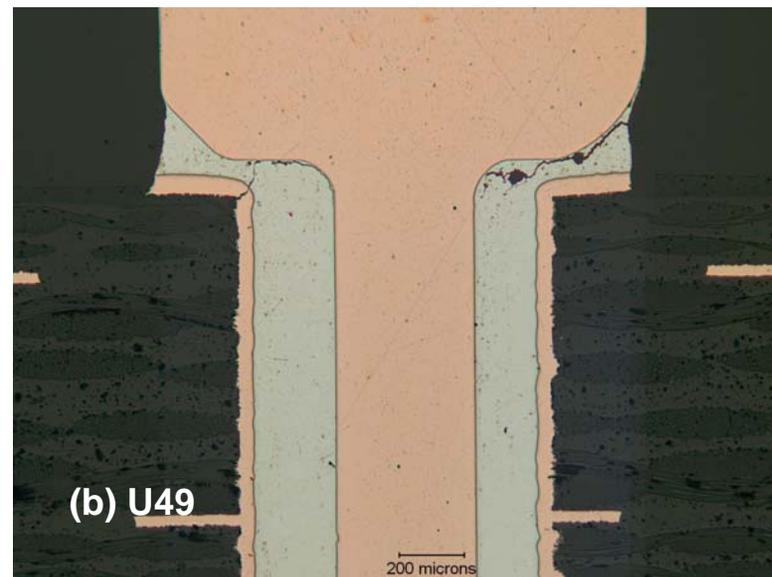
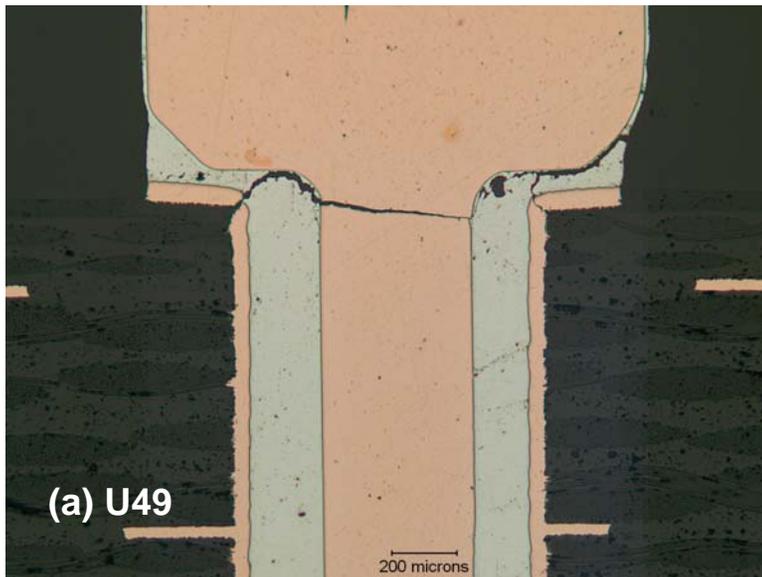
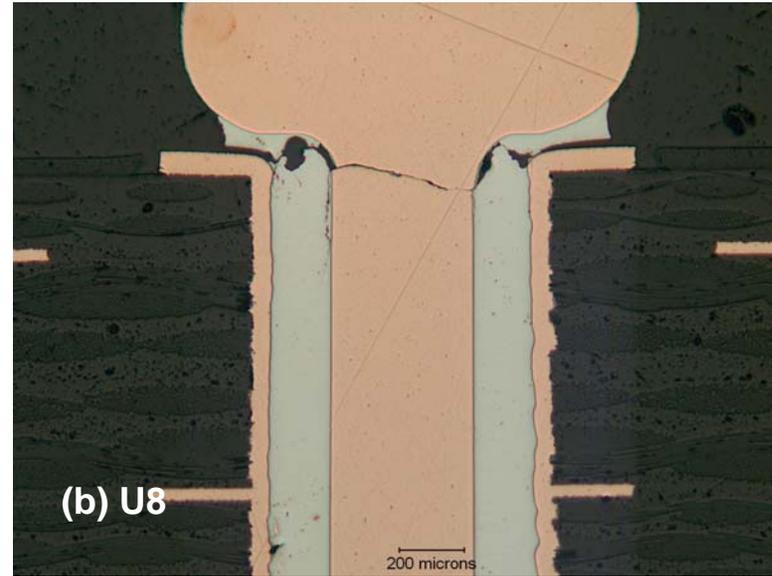
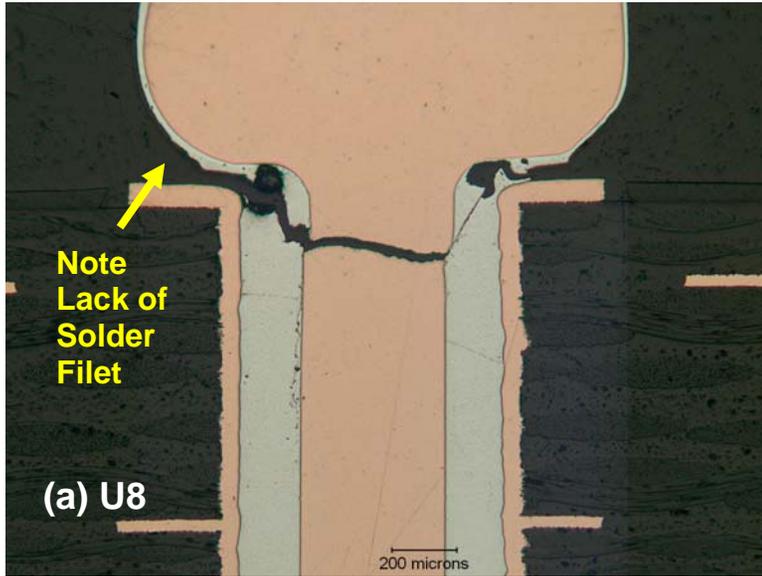


Figure 75. Test Vehicle 89 – PDIPs U8 and U49 (a) Corner Lead, (b) Lead Adjacent to Corner Lead (SN100C Solder/Sn Finish)

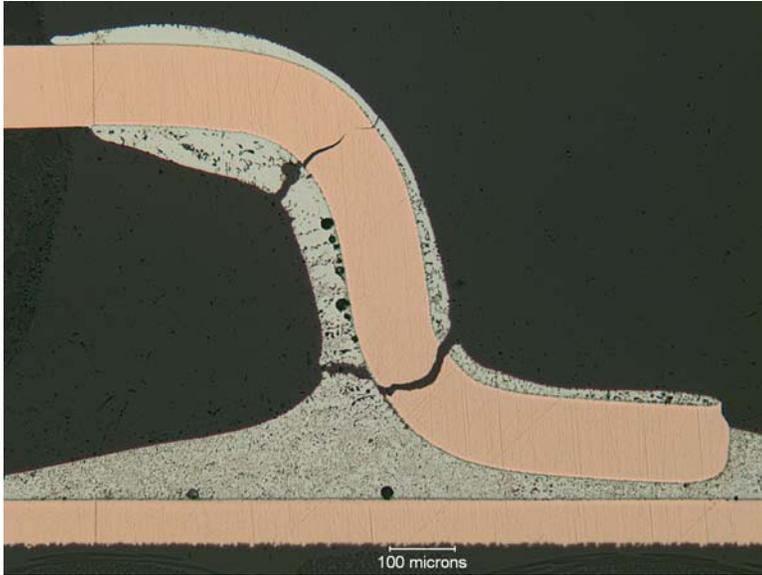


Figure 76. Test Vehicle 34 – TQFP U7, Corner Leads (SnPb Solder/Sn Finish)

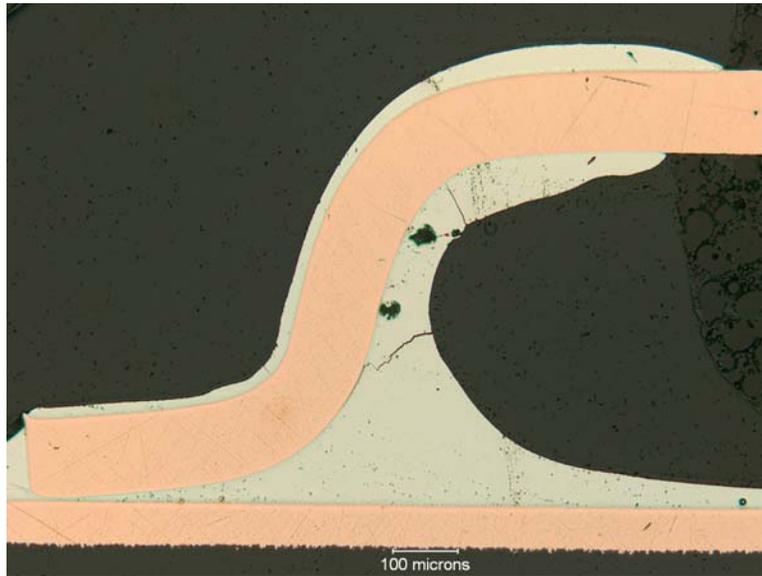


Figure 77. Test Vehicle 89 – TQFP U7, Four Corner Leads (SAC305 Solder/Sn Finish). This TQFP Had Not Failed at the End of the Test.

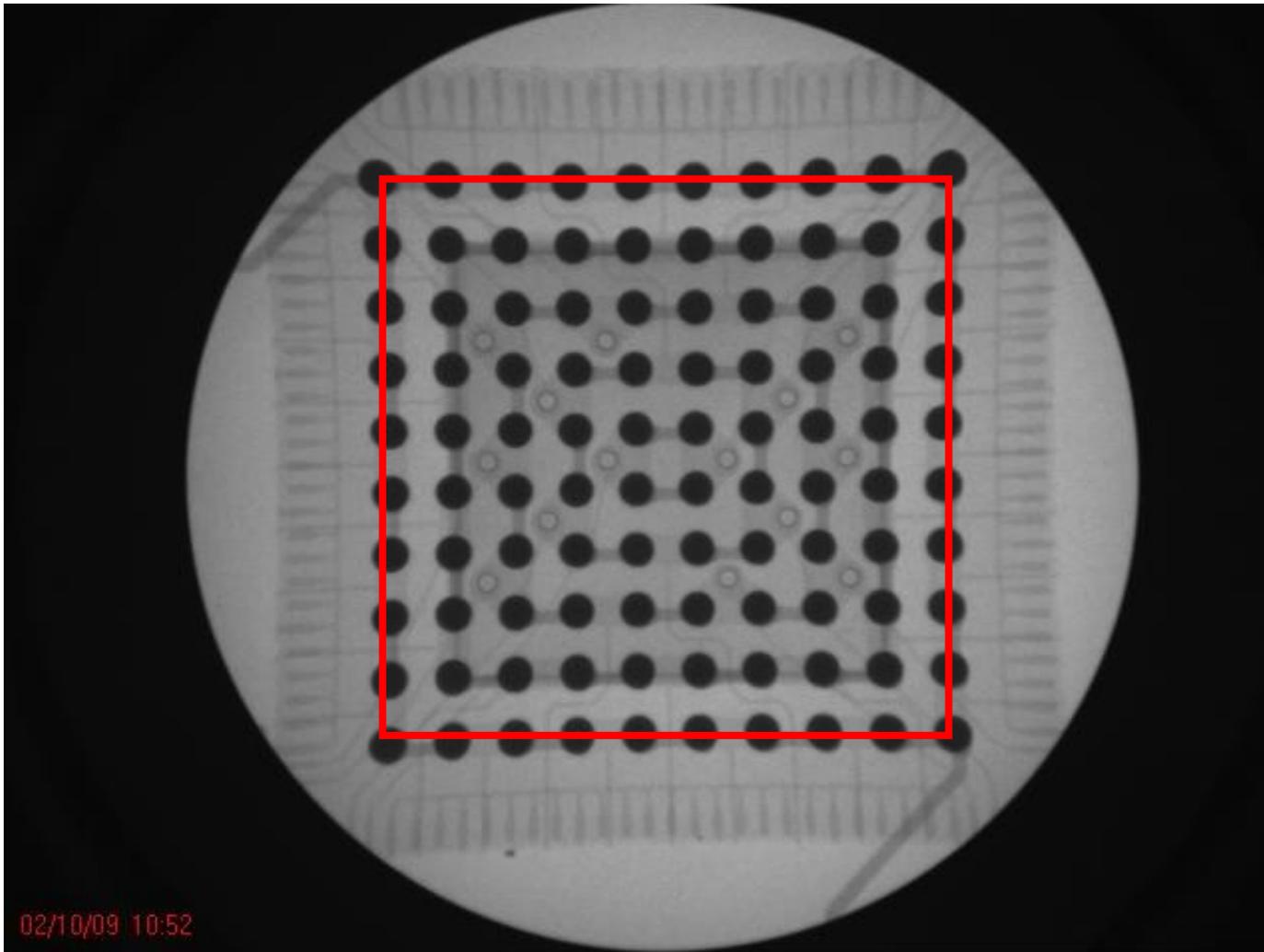


Figure 78. X-Ray of a CSP-100 Which Shows that Only the Outer Balls Form a Daisy-Chain (Red Lines)

Table 7. Ranking of Solder Alloy/Component Finish Combinations

Relative Ranking (Solder/Finish)										
Component	Sn37Pb/Sn37Pb	SAC305/SAC405	Sn37Pb/SAC405	SAC305/Sn37Pb	Rwk Flux Only/Sn37Pb	Rwk Flux Only/SAC405	Rwk Sn37Pb/SAC405 (SnPb Profile)	Rwk Sn37Pb/SAC405 (Pb-Free Profile)		
BGA-225	1	1	2	1	1	1	2	1		
Component	Sn37Pb/Sn37Pb	SAC305/SAC305	Sn37Pb/SAC305	SAC305/Sn37Pb						
CLCC-20	1	2	2	2						
Component	Sn37Pb/Sn37Pb	SAC305/SAC105	Sn37Pb/SAC105	SAC305/Sn37Pb	Rwk Flux Only/Sn37Pb	Rwk Flux Only/SAC105	Rwk Sn37Pb/SAC105 (SnPb Profile)	Rwk Sn37Pb/SAC105 (Pb-Free Profile)		
CSP-100	1	1	2	1	2	1	2	2		
Component	Sn37Pb/SnPb	SN100C/Sn	Sn37Pb/NiPdAu	Rwk Sn37Pb/Sn	Rwk SN100C/Sn					
PDIP-20	1	1	1	2	2					
Component	Sn37Pb/Sn37Pb	SAC305/Sn	Sn37Pb/Sn	SAC305/Sn37Pb						
QFN-20	Not enough failures to rank									
Component	Sn37Pb/Sn	SAC305/Sn	Sn37Pb/NiPdAu	SAC305/NiPdAu	Sn37Pb/Sn37Pb Dip	SAC305/SAC305 Dip				
TQFP-144	1	1	1	1	1	2				
Component	Sn37Pb/SnPb	Sn37Pb/Sn	Sn37Pb/SnBi	SAC305/Sn	SAC305/SnBi	SAC305/SnPb	Rwk Sn37Pb/SnPb	Rwk Sn37Pb/Sn (SnPb Profile)	Rwk Sn37Pb/Sn (Pb-Free Profile)	Rwk SAC305/SnBi
TSOP-50	Not enough failures to rank	2	2	2	2					

Key: Solder/Component Finish
Rwk = reworked

Appendix A. Post-Test Inspection for Broken Leads

Table A-1. Results of Visual Inspection

MECH SHOCK BOARDS	TV #	30	31	32	33	34	88	89	90	91	75	189	190	191	192	193	149	150	151	152	153	160
U1	TQFP-144	CL	CL,CSJ	CL			CL	CL	CL	CL,CSJ	CL	CL	CL	CSJ	CSJ,CL	CL	CL	CL	CL,CSJ	CL	CL	CL,CSJ
U2	BGA-225	MC																				
U3	TQFP-144	CL,ML	CL,CST	CL	CL	CL,ML	CL	CL,ML	CL,CSJ	CL	CL	CL,CSJ	CL	CL	CL,CSJ	CL,ML,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CSJ,CL	CL	CL,CSJ
U4	BGA-225	MC	MC													MC	MC		MC	MC	MC	MC
U5	BGA-225		MC													MC	MC		MC	MC		MC
U6	BGA-225		MC													MC			MC			MC
U7	TQFP-144	CL	CL	CL		CL	CL	CL		CL	CL	CL,CSJ	CL,ML	CL	CL,CSJ	CL,ML,CSJ	CL		CL,CSJ	CL	CL	CL,CSJ
U8	PDIP-20	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ,V?	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ,CL		CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U9	CLCC-20													Mlid	Mlid	Mlid						
U10	CLCC-20		MC					ML								CL						
U11	PDIP-20	CSJ	CSJ	CSJ	CSJ			CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U12	TSOP-50																					
U13	CLCC-20	MC										Mlid				Mlid	Mlid	Mlid			MC	
U14	CLCC-20	MC	MC	Mlid											Mlid	MC	Mlid	Mlid			MC	Mlid
U15	QFN-20																					
U16	TSOP-50																					
U17	CLCC-20													Mlid			Mlid					
U18	BGA-225																					
U19	CSP-100																					
U20	TQFP-144	CL	CL,CSJ	CL	CL,CSJ	CL	CL	CL	CL	CL,ML	CL	CL,CSJ	CL	CL	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,ML,CSJ	CL,CSJ	CL,ML	CL,CSJ
U21	BGA-225		MC													MC						
U22	CLCC-20		MC													Mlid	Mlid					Mlid
U23	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ	CSJ?	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U24	TSOP-50																					
U25	TSOP-50																					
U26	TSOP-50																					
U27	QFN-20																					
U28	QFN-20																					
U29	TSOP-50																					
U30	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ		CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U31	TQFP-144	CL,CSJ	CL,CSJ	CL	CL		CL	CL,ML	CL,ML	CL	CL	CL	CL		CSJ,CL	CL,CSJ	CL,CSJ	CL	CL	CL,CSJ	CL,CSJ	CL
U32	CSP-100																					
U33	CSP-100																					
U34	TQFP-144	ML,CL	CL,CSJ,ML	CSJ	CSJ	CL	CL		CL	CL	CL	CL,CSJ	CL	CL,CSJ	CL,CSJ	CL,ML,CSJ	CL,CSJ	CL	CL,CSJ	CL,CSJ	CL	CL,CSJ
U35	CSP-100																					
U36	CSP-100																					
U37	CSP-100																					
U38	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ		CSJ	CSJ	CSJ	CSJ	CSJ		CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U39	TSOP-50																					
U40	TSOP-50																					
U41	TQFP-144	CL	CL,CSJ	CSJ,CL	CSJ,CL	CL	CL		CL	CL	CL	CSJ	CL	CL	CL,CSJ	CL,CSJ	CL	CL	CL	CSJ	CL	CL,CSJ
U42	CSP-100																					
U43	BGA-225															MC					MC	MC
U44	BGA-225															MC						
U45	CLCC-20		Mlid									Mlid						Mlid				
U46	CLCC-20			Mlid					Mlid		Mlid					Mlid						
U47	QFN-20																					
U48	TQFP-144	CL	CL		CL	CL	CL			CL	CSJ	CL,CSJ?	CL,CSJ	CL	CL,CSJ	CSJ			CL,CSJ	CL,CSJ	CL	CL,CSJ
U49	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ		CSJ	CSJ	CSJ	CSJ	CSJ		CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U50	CSP-100																					
U51	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U52	CLCC-20		Mlid				Mlid									Mlid					Mlid	Mlid
U53	CLCC-20		MC													Mlid	Mlid					
U54	QFN-20																					
U55	BGA-225																					
U56	BGA-225																					
U57	TQFP-144	CL,CSJ	CL	CL	CL	CL	CL	CL	CL	CL,CSJ	CL	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CL,CSJ	CSJ,CL	CL,CSJ
U58	TQFP-144	CL,CSJ	CL,CSJ	CL	CL	CL	CL	CL	CL,CSJ	CL	CL	CL,CSJ	CL,CSJ	CL,ML	CL,CSJ	CL,CSJ	CL,CSJ	CL	CL,ML,CSJ	CL,CSJ	CL,CSJ	CL,CSJ,ML
U59	PDIP-20	CSJ	CSJ	CSJ	CSJ		CSJ		CSJ?	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ	CSJ
U60	CSP-100																					
U61	TSOP-50																					
U62	TSOP-50																					
U63	CSP-100																					

MC = missing component
 CL = cracked leads
 ML = missing leads
 CSJ = cracked solder joint
 Mlid = missing lid
 V = void

Appendix B. Test Data

Table B-1. BGA-225 U2

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SAC405	100	100	100	100	100	11				
89		SAC305/SAC405	100	100	100	100	100	29				
90		SAC305/SAC405	100	100	100	100	100	51				
91		SAC305/SAC405	100	100	100	100	100	78				
88		SAC305/SAC405	100	100	100	100	100	100	100	3		
30		SnPb/SnPb	100	100	100	100	100	7				
32		SnPb/SnPb	100	100	100	100	100	21				
33		SnPb/SnPb	100	100	100	100	100	71				
31		SnPb/SnPb	100	100	100	100	100	100	18			
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework										
"Rework" (ImAg)			These components were reworked									
192	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	32				
193	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	53				
189	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	100	20			
190	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	100	22			
191	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	100	26			
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	29				
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	35				
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	41				
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	61				
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	*				
"Rework" (ENIG)												
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	67			

Reworked 1X
Reworked 2X

*Removed from test on Shock Pulse 574

Table B-2. BGA-225 U4

Test Vehicle ID	Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
90	SAC305/SAC405	100	100	100	12					
75	SAC305/SAC405	100	100	100	54					
91	SAC305/SAC405	100	100	100	100	81				
88	SAC305/SAC405	100	100	100	100	86				
89	SAC305/SAC405	100	100	100	100	100	15			
30	SnPb/SnPb	100	100	100	96					
31	SnPb/SnPb	100	100	100	100	4				
32	SnPb/SnPb	100	100	100	100	17				
33	SnPb/SnPb	100	100	100	100	88				
34	SnPb/SnPb	100	100	100	100	100	15			
"Rework" (ImAg)										
These components were not reworked										
192	SAC305/SnPb	100	100	100	100	48				
191	SAC305/SnPb	100	100	100	100	64				
189	SAC305/SnPb	100	100	100	100	75				
193	SAC305/SnPb	100	100	100	100	82				
190	SAC305/SnPb	100	100	100	100	100	3			
149	SnPb/SAC405	100	100	77						
151	SnPb/SAC405	100	100	100	1					
152	SnPb/SAC405	100	100	100	100	5				
150	SnPb/SAC405	100	100	100	100	19				
153	SnPb/SAC405	100	100	100	100	26				
"Rework" (ENIG)										
160	SnPb/SAC405	100	100	100	100	44				

Table B-3. BGA-225 U5

Test Vehicle ID	Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC405	100	100	100	4					
89	SAC305/SAC405	100	100	100	100	100	1			
90	SAC305/SAC405	100	100	100	100	100	1			
91	SAC305/SAC405	100	100	100	100	100	2			
88	SAC305/SAC405	100	100	100	100	100	9			
30	SnPb/SnPb	100	100	100	100	8				
31	SnPb/SnPb	100	100	100	100	59				
32	SnPb/SnPb	100	100	100	100	64				
33	SnPb/SnPb	100	100	100	100	100	2			
34	SnPb/SnPb	100	100	100	100	100	41			
"Rework" (ImAg)		These components were not reworked								
192	SAC305/SnPb	100	100	100	100	49				
191	SAC305/SnPb	100	100	100	100	94				
193	SAC305/SnPb	100	100	100	100	100	1			
189	SAC305/SnPb	100	100	100	100	100	4			
190	SAC305/SnPb	100	100	100	100	100	18			
151	SnPb/SAC405	100	100	100	2					
149	SnPb/SAC405	100	100	100	9					
152	SnPb/SAC405	100	100	100	100	1				
153	SnPb/SAC405	100	100	100	100	33				
150	SnPb/SAC405	100	100	100	100	58				
"Rework" (ENIG)										
160	SnPb/SAC405	100	100	100	100	41				

Table B-4. BGA-225 U6

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)							
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75		SAC305/SAC405	100	100	100	100	33			
90		SAC305/SAC405	100	100	100	100	100	19		
89		SAC305/SAC405	100	100	100	100	100	41		
88		SAC305/SAC405	100	100	100	100	100	51		
91		SAC305/SAC405	100	100	100	100	100	67		
30		SnPb/SnPb	100	100	100	100	100	14		
31		SnPb/SnPb	100	100	100	100	100	14		
32		SnPb/SnPb	100	100	100	100	100	38		
33		SnPb/SnPb	100	100	100	100	100	45		
34		SnPb/SnPb	100	100	100	100	100	71		
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework								
"Rework" (ImAg)										
These components were reworked										
191	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	6		
193	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	9		
192	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	12		
190	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	13		
189	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	45		
152	SnPb/SnPb	SnPb/SAC405	Bad							
151	SnPb/SnPb	SnPb/SAC405	100	100	100	100	9			
149	SnPb/SnPb	SnPb/SAC405	100	100	100	100	91			
150	SnPb/SnPb	SnPb/SAC405	100	100	100	100	91			
153	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	6		
"Rework" (ENIG)										
160	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	11		

Reworked 1X
Reworked 2X

Table B-5. BGA-225 U18

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
75		SAC305/SAC405	100	100	100	100	100	19			
89		SAC305/SAC405	100	100	100	100	100	49			
90		SAC305/SAC405	100	100	100	100	100	52			
91		SAC305/SAC405	100	100	100	100	100	87			
88		SAC305/SAC405	100	100	100	100	100	100	100	100	100
30		SnPb/SnPb	100	100	100	100	100	10			
32		SnPb/SnPb	100	100	100	100	100	21			
33		SnPb/SnPb	100	100	100	100	100	76			
31		SnPb/SnPb	100	100	100	100	100	100	100	27	
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework									
"Rework" (ImAg)											
These components were reworked											
192	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	100	18		
189	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	100	20		
193	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	100	23		
191	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	100	100	59	
190	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	100	100	62	
153	SnPb/SnPb	SnPb/SAC405	1								
149	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	29			
150	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	41			
152	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	45			
151	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	94			
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/SAC405	100	100	100	100	100	100	6		

Reworked 1X
Reworked 2X

Table B-6. BGA-225 U21

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
75		SAC305/SAC405	100	100	100	100	100	1			
90		SAC305/SAC405	100	100	100	100	100	30			
89		SAC305/SAC405	100	100	100	100	100	55			
88		SAC305/SAC405	100	100	100	100	100	76			
91		SAC305/SAC405	100	100	100	100	100	78			
30		SnPb/SnPb	100	100	100	100	100	14			
31		SnPb/SnPb	100	100	100	100	100	14			
32		SnPb/SnPb	100	100	100	100	100	42			
33		SnPb/SnPb	100	100	100	100	100	51			
34		SnPb/SnPb	100	100	100	100	100	68			
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework									
"Rework" (ImAg)											
These components were reworked											
191	SAC305/SAC405	Flux Only/SAC405	Bad								
190	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	6			
193	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	7			
192	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	8			
189	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	24			
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	6			
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	11			
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	18			
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	18			
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	26			
"Rework" (ENIG)											
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	47			

Reworked 1X
Reworked 2X
Reworked 3X

Table B-7. BGA-225 U43

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SAC405	100	100	100	85						
91		SAC305/SAC405	100	100	100	100	56					
88		SAC305/SAC405	100	100	100	100	61					
90		SAC305/SAC405	100	100	100	100	100	4				
89		SAC305/SAC405	100	100	100	100	100	11				
30		SnPb/SnPb	100	100	100	100	6					
32		SnPb/SnPb	100	100	100	100	47					
31		SnPb/SnPb	100	100	100	100	87					
33		SnPb/SnPb	100	100	100	100	100	1				
34		SnPb/SnPb	100	100	100	100	100	33				
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework										
"Rework" (ImAg)			These components were reworked									
191	SAC305/SAC405	SnPb/SAC405	Bad									
190	SAC305/SAC405	SnPb/SAC405	100	100	100	100	9					
192	SAC305/SAC405	SnPb/SAC405	100	100	100	100	18					
189	SAC305/SAC405	SnPb/SAC405	100	100	100	100	28					
193	SAC305/SAC405	SnPb/SAC405	100	100	100	100	100	1				
153	SnPb/SnPb	SnPb/SAC405	Bad									
152	SnPb/SnPb	SnPb/SAC405	100	100	1							
151	SnPb/SnPb	SnPb/SAC405	100	100	100	1						
149	SnPb/SnPb	SnPb/SAC405	100	100	100	53						
150	SnPb/SnPb	SnPb/SAC405	100	100	100	100	26					
"Rework" (ENIG)												
160	SnPb/SnPb	SnPb/SAC405	100	100	100	100	27					

Reworked 1X
Reworked 2X

Table B-8. BGA-225 U44

Test Vehicle ID	Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC405	100	100	100	100	78				
90	SAC305/SAC405	100	100	100	100	100	16			
91	SAC305/SAC405	100	100	100	100	100	33			
88	SAC305/SAC405	100	100	100	100	100	36			
89	SAC305/SAC405	100	100	100	100	100	52			
30	SnPb/SnPb	100	100	100	100	100	4			
31	SnPb/SnPb	100	100	100	100	100	15			
32	SnPb/SnPb	100	100	100	100	100	28			
33	SnPb/SnPb	100	100	100	100	100	37			
34	SnPb/SnPb	100	100	100	100	100	69			
"Rework" (ImAg)										
These components were not reworked unless marked										
192	SAC305/SnPb	100	100	100	100	100	5			
191	SAC305/SnPb	100	100	100	100	100	10			
193	SAC305/SnPb	100	100	100	100	100	23			
190	SAC305/SnPb	100	100	100	100	100	49			
189	SAC305/SnPb	100	100	100	100	100	81			
151	SnPb/SAC405	100	100	100	100	60				
149	SnPb/SAC405	100	100	100	100	100	1			
152	SnPb/SAC405	100	100	100	100	100	6			
153	SnPb/SAC405	100	100	100	100	100	12			
150	SnPb/SAC405	100	100	100	100	100	13			
"Rework" (ENIG)										
160	SnPb/SAC405	100	100	100	100	100	18			

Reworked 1X

Table B-9. BGA-225 U55

Test Vehicle ID	Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC405	100	100	100	73					
91	SAC305/SAC405	100	100	100	100	88				
89	SAC305/SAC405	100	100	100	100	100	11			
90	SAC305/SAC405	100	100	100	100	100	30			
88	SAC305/SAC405	100	100	100	100	100	100	14		
30	SnPb/SnPb	100	100	100	100	2				
32	SnPb/SnPb	100	100	100	100	58				
31	SnPb/SnPb	100	100	100	100	92				
34	SnPb/SnPb	100	100	100	100	100	51			
33	SnPb/SnPb	100	100	100	100	100	100	100	26	
"Rework" (ImAg)										
These components were not reworked unless marked										
191	SAC305/SnPb	100	100	100	100	77				
192	SAC305/SnPb	100	100	100	100	100	4			
193	SAC305/SnPb	100	100	100	100	100	9			
189	SAC305/SnPb	100	100	100	100	100	51			
190	SAC305/SnPb	100	100	100	100	100	55			
151	SnPb/SAC405	100	100	100	9					
149	SnPb/SAC405	100	100	100	100	71				
153	SnPb/SAC405	100	100	100	100	100	1			
150	SnPb/SAC405	100	100	100	100	100	39			
152	SnPb/SAC405	100	100	100	100	100	100	28		
"Rework" (ENIG)										
160	SnPb/SAC405	100	100	100	100	100	8			

Reworked 2X

Table B-10. BGA-225 U56

Test Vehicle ID		Solder/BGA Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SAC405	100	100	100	100	100	17				
91		SAC305/SAC405	100	100	100	100	100	75				
89		SAC305/SAC405	100	100	100	100	100	76				
90		SAC305/SAC405	100	100	100	100	100	79				
88		SAC305/SAC405	100	100	100	100	100	100	100	100	100	100
30		SnPb/SnPb	100	100	100	100	100	14				
32		SnPb/SnPb	100	100	100	100	100	23				
33		SnPb/SnPb	100	100	100	100	100	73				
31		SnPb/SnPb	100	100	100	100	100	100	100	100	14	
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/BGA Ball Before Rework	Solder/BGA Ball After Rework										
"Rework" (ImAg)			These components were reworked									
191	SAC305/SAC405	Flux Only/SAC405	Bad									
190	SAC305/SAC405	Flux Only/SAC405	1									
193	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	60				
189	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	100	20			
192	SAC305/SAC405	Flux Only/SAC405	100	100	100	100	100	100	50			
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	40				
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	49				
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	56				
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	*				
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	1	
"Rework" (ENIG)												
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100

Reworked 1X
Reworked 2X

*Removed from test on Shock Pulse 574

Table B-11. CLCC-20 U9

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
91	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-12. CLCC-20 U10

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
91	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	100	91	
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	23	

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-13. CLCC-20 U13

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC305	100	100	100	100	100	43			
88	SAC305/SAC305	100	100	100	100	100	100	47		
89	SAC305/SAC305	100	100	100	100	100	100	100	100	7
90	SAC305/SAC305	100	100	100	100	100	100	100	100	39
75	SAC305/SAC305	100	100	100	100	100	100	100	100	74
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	43	
31	SnPb/SnPb	100	100	100	100	100	100	100	100	1
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
190	SAC305/SnPb	100	100	100	100	100	100	100	6	
193	SAC305/SnPb	100	100	100	100	100	100	100	51	
191	SAC305/SnPb	100	100	100	100	100	100	100	57	
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	67			
153	SnPb/SAC305	100	100	100	100	100	**			
152	SnPb/SAC305	100	100	100	100	100	100	39		
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	55		

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-14. CLCC-20 U14

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC305	100	100	100	100	100	14			
75	SAC305/SAC305	100	100	100	100	100	100	76		
89	SAC305/SAC305	100	100	100	100	100	100	78		
90	SAC305/SAC305	100	100	100	100	100	100	100	60	
88	SAC305/SAC305	100	100	100	100	100	100	100	100	
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	7		
33	SnPb/SnPb	100	100	100	100	100	100	96		
30	SnPb/SnPb	100	100	100	100	100	100	100	69	
34	SnPb/SnPb	100	100	100	100	100	100	100	95	
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	54			
192	SAC305/SnPb	100	100	100	100	100	90			
191	SAC305/SnPb	100	100	100	100	100	100	33		
189	SAC305/SnPb	100	100	100	100	100	100	40		
190	SAC305/SnPb	100	100	100	100	100	100	100	47	
152	SnPb/SAC305	100	100	100	100	100	62			
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
151	SnPb/SAC305	100	100	100	100	100	100	100	52	
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	32		

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-15. CLCC-20 U17

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
91	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-16. CLCC-20 U22

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
91	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	100	100	61
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	50	

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-17. CLCC-20 U45

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
91	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-18. CLCC-20 U46

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC305	100	100	100	100	100	100	63		
89	SAC305/SAC305	100	100	100	100	100	100	100	100	18
75	SAC305/SAC305	100	100	100	100	100	100	100	100	92
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
151	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-19. CLCC-20 U52

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC305	100	100	100	100	100	96			
75	SAC305/SAC305	100	100	100	100	100	100	100	100	100
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	100	84	
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	58		
192	SAC305/SnPb	100	100	100	100	100	100	100	30	
191	SAC305/SnPb	100	100	100	100	100	100	100	40	
190	SAC305/SnPb	100	100	100	100	100	100	100	45	
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
151	SnPb/SAC305	100	100	100	100	100	100	64		
149	SnPb/SAC305	100	100	100	100	100	100	100	100	30
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	81		

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-20. CLCC-20 U53

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC305	100	100	100	100	100	100	39		
75	SAC305/SAC305	100	100	100	100	100	100	100	28	
88	SAC305/SAC305	100	100	100	100	100	100	100	100	100
89	SAC305/SAC305	100	100	100	100	100	100	100	100	100
90	SAC305/SAC305	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	100	71	
34	SnPb/SnPb	100	100	100	100	100	100	100	100	54
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	85		
192	SAC305/SnPb	100	100	100	100	100	100	100	64	
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC305	100	100	100	100	100	**			
150	SnPb/SAC305	100	100	100	100	100	100	***		
151	SnPb/SAC305	100	100	100	100	100	100	100	54	
149	SnPb/SAC305	100	100	100	100	100	100	100	100	100
152	SnPb/SAC305	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC305	100	100	100	100	100	100	100	34	

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-21. CSP-100 U19

Test Vehicle ID		Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
89		SAC305/SAC105	100	100	100	100	100	100	100	100	40	
75		SAC305/SAC105	100	100	100	100	100	100	100	100	53	
88		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
90		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
91		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	100	*			
30		SnPb/SnPb	100	100	100	100	100	100	59			
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework										
"Rework" (ImAg)												
These components were reworked												
192	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	55		
189	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
190	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
191	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
193	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	**			
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	44		
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	92		
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	19	
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	72	
"Rework" (ENIG)												
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-22. CSP-100 U32

Test Vehicle ID	Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC105	100	100	100	100	100	100	27		
89	SAC305/SAC105	100	100	100	100	100	100	100	63	
88	SAC305/SAC105	100	100	100	100	100	100	100	100	100
90	SAC305/SAC105	100	100	100	100	100	100	100	100	100
91	SAC305/SAC105	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	93			
31	SnPb/SnPb	100	100	100	100	100	100	100	73	
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	21		
192	SAC305/SnPb	100	100	100	100	100	100	100	51	
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC105	100	100	100	100	100	**			
150	SnPb/SAC105	100	100	100	100	100	100	46		
152	SnPb/SAC105	100	100	100	100	100	100	100	29	
151	SnPb/SAC105	100	100	100	100	100	100	100	36	
149	SnPb/SAC105	100	100	100	100	100	100	100	100	36
"Rework" (ENIG)										
160	SnPb/SAC105	100	100	100	100	100	100	84		

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-23. CSP-100 U33

Test Vehicle ID		Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
91		SAC305/SAC105	100	100	100	100	100	100	42		
89		SAC305/SAC105	100	100	100	100	100	100	100	100	51
90		SAC305/SAC105	100	100	100	100	100	100	100	100	75
75		SAC305/SAC105	100	100	100	100	100	100	100	100	100
88		SAC305/SAC105	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*			
30		SnPb/SnPb	100	100	100	100	100	67			
31		SnPb/SnPb	100	100	100	100	100	100	14		
34		SnPb/SnPb	100	100	100	100	100	100	100	100	67
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework									
"Rework" (ImAg)											
These components were reworked											
192	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	50			
191	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	54		
193	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	57		
190	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	74		
189	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	11	
153	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	**			
149	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	49		
151	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	52		
150	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	***		
152	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	93		
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	21		

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-24. CSP-100 U35

Test Vehicle ID	Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/SAC105	100	100	100	100	100	100	100	36	
75	SAC305/SAC105	100	100	100	100	100	100	100	50	
88	SAC305/SAC105	100	100	100	100	100	100	100	100	100
89	SAC305/SAC105	100	100	100	100	100	100	100	100	100
90	SAC305/SAC105	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	72		
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC105	100	100	100	100	100	**			
150	SnPb/SAC105	100	100	100	100	100	100	***		
152	SnPb/SAC105	100	100	100	100	100	100	100	100	100
151	SnPb/SAC105	100	100	100	100	100	100	100	100	100
149	SnPb/SAC105	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC105	100	100	100	100	100	16			

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-25. CSP-100 U36

Test Vehicle ID	Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC105	100	100	100	100	100	100	100	100	100
89	SAC305/SAC105	100	100	100	100	100	100	100	100	100
88	SAC305/SAC105	100	100	100	100	100	100	100	100	100
90	SAC305/SAC105	100	100	100	100	100	100	100	100	100
91	SAC305/SAC105	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
31	SnPb/SnPb	100	100	100	100	100	100	100	100	28
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SAC105	100	100	100	100	100	100	100	100	100
190	SAC305/SAC105	100	100	100	100	100	100	100	100	100
191	SAC305/SAC105	100	100	100	100	100	100	100	100	100
192	SAC305/SAC105	100	100	100	100	100	100	100	100	100
193	SAC305/SAC105	100	100	100	100	100	100	100	100	100
153	SnPb/SAC105	100	100	100	100	100	**			
150	SnPb/SAC105	100	100	100	100	100	100	***		
149	SnPb/SAC105	100	100	100	100	100	100	100	100	100
151	SnPb/SAC105	100	100	100	100	100	100	100	100	100
152	SnPb/SAC105	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC105	100	100	100	100	100	100	100	44	

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-26. CSP-100 U37

Test Vehicle ID		Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
88		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
89		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
90		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
91		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*				
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100	14
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework										
"Rework" (ImAg)												
These components were reworked												
193	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	40	
189	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
190	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
191	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
192	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	**				
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	***			
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)												
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	100	100	100

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-27. CSP-100 U42

Test Vehicle ID	Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's				
"Manufactured" (ImAg)											
75	SAC305/SAC105	100	100	100	100	100	100	42			
88	SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
89	SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
90	SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
91	SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*				
30	SnPb/SnPb	100	100	100	100	100	100	30			
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100	14
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework									
"Rework" (ImAg)											
These components were reworked											
192	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	11		
193	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	36		
191	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	19
189	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	44
190	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	**			
150	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	18		
149	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	45		
151	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	17
152	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	76
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	18		

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-28. CSP-100 U50

Test Vehicle ID		Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
75		SAC305/SAC105	100	100	100	100	100	58			
90		SAC305/SAC105	100	100	100	100	100	100	100	31	
89		SAC305/SAC105	100	100	100	100	100	100	100	35	
88		SAC305/SAC105	100	100	100	100	100	100	100	100	100
91		SAC305/SAC105	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*			
30		SnPb/SnPb	100	100	100	100	100	100	43		
31		SnPb/SnPb	100	100	100	100	100	100	100	100	5
34		SnPb/SnPb	100	100	100	100	100	100	100	100	36
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework									
"Rework" (ImAg)											
These components were reworked											
191	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	45		
193	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	91		
189	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	74	
192	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	78	
190	SAC305/SAC105	Flux Only/SAC105	100	100	100	100	100	100	100	100	27
152	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	42			
153	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	**			
150	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	***		
151	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	23	
149	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	55	
"Rework" (ENIG)											
160	SnPb/SnPb	Flux Only/SnPb	100	100	100	100	100	100	100	34	

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-29. CSP-100 U60

Test Vehicle ID		Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
88		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
89		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
90		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
91		SAC305/SAC105	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*				
31		SnPb/SnPb	100	100	100	100	100	100	100	61		
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/CSP Ball Before Rework	Solder/CSP Ball After Rework										
"Rework" (ImAg)			These components were reworked									
193	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100	84
189	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
190	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
191	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
192	SAC305/SAC105	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	**				
150	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	***			
149	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
151	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)												
160	SnPb/SnPb	SnPb/SAC105	100	100	100	100	100	100	100	100	100	88

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-30. CSP-100 U63

Test Vehicle ID	Solder/CSP Ball	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SAC105	100	100	100	100	100	100	100	100	100
89	SAC305/SAC105	100	100	100	100	100	100	100	100	100
88	SAC305/SAC105	100	100	100	100	100	100	100	100	100
90	SAC305/SAC105	100	100	100	100	100	100	100	100	100
91	SAC305/SAC105	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	24
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SAC105	100	100	100	100	100	**			
150	SnPb/SAC105	100	100	100	100	100	100	***		
152	SnPb/SAC105	100	100	100	100	100	100	100	100	100
151	SnPb/SAC105	100	100	100	100	100	100	100	100	100
149	SnPb/SAC105	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SAC105	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-31. PDIP-20 U8

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
88	SN100C/Sn	100	100	100	100	100	16			
91	SN100C/Sn	100	100	100	100	100	22			
89	SN100C/Sn	100	100	100	100	100	53			
90	SN100C/Sn	100	100	100	100	100	100			
75	SN100C/NiPdAu	100	100	100	7					
32	SnPb/SnPb	100	100	100	100	1				
34	SnPb/SnPb	100	100	100	100	34				
30	SnPb/SnPb	100	100	100	100	100	15			
33	SnPb/SnPb	100	100	100	100	100	41			
31	SnPb/SnPb	100	100	100	100	100	54			
"Rework" (ImAg)										
These components were not reworked										
192	SN100C/Sn	100	100	71						
191	SN100C/Sn	100	100	100	56					
189	SN100C/Sn	100	100	100	100	100	8			
190	SN100C/Sn	100	100	100	100	100	44			
193	SN100C/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/NiPdAu	100	100	100	100	1				
150	SnPb/NiPdAu	100	100	100	100	46				
152	SnPb/NiPdAu	100	100	100	100	56				
149	SnPb/NiPdAu	100	100	100	100	67				
153	SnPb/NiPdAu	100	100	100	100	100	*			
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 574

Table B-32. PDIP-20 U11

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
88		SN100C/Sn	100	100	100	100	100	1			
91		SN100C/Sn	100	100	100	100	100	27			
89		SN100C/Sn	100	100	100	100	100	38			
90		SN100C/Sn	100	100	100	100	100	100	100	100	100
75		SN100C/NiPdAu	100	100	100	100	100	100	19		
32		SnPb/SnPb	100	100	100	100	100	28			
30		SnPb/SnPb	100	100	100	100	100	100	100	73	
33		SnPb/SnPb	100	100	100	100	100	100	100	100	21
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework									
"Rework" (ImAg)											
These components were reworked											
189	SN100C/Sn	SN100C/Sn	100	100	88						
193	SN100C/Sn	SN100C/Sn	100	100	100	20					
192	SN100C/Sn	SN100C/Sn	100	100	100	100	70				
190	SN100C/Sn	SN100C/Sn	100	100	100	100	100	100	100	100	100
191	SN100C/Sn	SN100C/Sn	100	100	100	100	100	100	100	100	100
149	SnPb/SnPb	SnPb/Sn	100	100	63						
153	SnPb/SnPb	SnPb/Sn	100	100	80						
151	SnPb/SnPb	SnPb/Sn	100	100	100	1					
150	SnPb/SnPb	SnPb/Sn	100	100	100	44					
152	SnPb/SnPb	SN100C/Sn	100	100	100	11					
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	33

Reworked 1X

Table B-33. PDIP-20 U23

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
88	SN100C/Sn	100	100	100	100	100	100	81		
89	SN100C/Sn	100	100	100	100	100	100	100	100	100
90	SN100C/Sn	100	100	100	100	100	100	100	100	100
91	SN100C/Sn	100	100	100	100	100	100	100	100	100
75	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
192	SN100C/Sn	100	100	100	100	100	100	27		
193	SN100C/Sn	100	100	100	100	100	100	100	100	4
189	SN100C/Sn	100	100	100	100	100	100	100	100	100
190	SN100C/Sn	100	100	100	100	100	100	100	100	100
191	SN100C/Sn	100	100	100	100	100	100	100	100	100
153	SnPb/NiPdAu	100	100	100	100	100	**			
150	SnPb/NiPdAu	100	100	100	100	100	100	***		
149	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100
151	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100
152	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-34. PDIP-20 U30

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
89	SN100C/Sn	100	100	100	49					
88	SN100C/Sn	100	100	100	100	55				
91	SN100C/Sn	100	100	100	100	60				
90	SN100C/Sn	100	100	100	100	100	100	97		
75	SN100C/NiPdAu	100	100	100	100	100	100	52		
30	SnPb/SnPb	100	100	100	100	100	46			
32	SnPb/SnPb	100	100	100	100	100	*			
33	SnPb/SnPb	100	100	100	100	100	81			
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SN100C/Sn	100	100	82						
191	SN100C/Sn	100	100	100	80					
192	SN100C/Sn	100	100	100	100	100	43			
190	SN100C/Sn	100	100	100	100	100	100	100	100	100
193	SN100C/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	1				
151	SnPb/Sn	100	100	100	100	41				
150	SnPb/Sn	100	100	100	100	45				
149	SnPb/Sn	100	100	100	100	100	39			
153	SnPb/Sn	100	100	100	100	100	**			
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	1	

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-35. PDIP-20 U38

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SN100C/Sn	100	100	93						
89	SN100C/Sn	100	100	100	100	6				
88	SN100C/Sn	100	100	100	100	100	100	65		
90	SN100C/Sn	100	100	100	100	100	100	100	100	100
75	SN100C/NiPdAu	100	100	100	100	100	100	72		
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	39		
33	SnPb/SnPb	100	100	100	100	100	100	100	100	94
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
191	SN100C/Sn	100	100	100	100	12				
189	SN100C/Sn	100	100	100	100	100	100	75		
190	SN100C/Sn	100	100	100	100	100	100	100	100	100
192	SN100C/Sn	100	100	100	100	100	100	100	100	100
193	SN100C/Sn	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-36. PDIP-20 U49

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
89	SN100C/Sn	100	100	77						
91	SN100C/Sn	100	100	100	1					
90	SN100C/Sn	100	100	100	100	33				
88	SN100C/Sn	100	100	100	100	34				
75	SN100C/NiPdAu	100	100	100	33					
30	SnPb/SnPb	100	100	100	72					
32	SnPb/SnPb	100	100	100	98					
31	SnPb/SnPb	100	100	100	100	11				
33	SnPb/SnPb	100	100	100	100	52				
34	SnPb/SnPb	100	100	100	100	100	8			
"Rework" (ImAg)										
These components were not reworked										
192	SN100C/Sn	100	100	100	15					
191	SN100C/Sn	100	100	100	23					
189	SN100C/Sn	100	100	100	100	30				
190	SN100C/Sn	100	100	100	100	100	100	100	100	100
193	SN100C/Sn	100	100	100	100	100	100	100	100	100
153	SnPb/NiPdAu	100	100	100	100	100	*			
150	SnPb/NiPdAu	100	100	100	100	100	83			
152	SnPb/NiPdAu	100	100	100	100	100	100	24		
149	SnPb/NiPdAu	100	100	100	100	100	100	83		
151	SnPb/NiPdAu	100	100	100	100	100	100	100	100	14
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	100	100	97

*Removed from test on Shock Pulse 574

Table B-37. PDIP-20 U51

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
91		SN100C/NiPdAu	100	100	100	69					
75		SN100C/NiPdAu	100	100	100	100	40				
88		SN100C/NiPdAu	100	100	100	100	100	47			
90		SN100C/NiPdAu	100	100	100	100	100	85			
89		SN100C/Sn	100	100	100	64					
32		SnPb/SnPb	100	100	100	100	100	35			
30		SnPb/SnPb	100	100	100	100	100	54			
33		SnPb/SnPb	100	100	100	100	100	100	100	16	
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework									
"Rework" (ImAg)											
These components were reworked											
191	SN100C/Sn	SN100C/Sn	100	100	100	23					
189	SN100C/Sn	SN100C/Sn	100	100	100	100	87				
190	SN100C/Sn	SN100C/Sn	100	100	100	100	100	100	23		
192	SN100C/Sn	SN100C/Sn	100	100	100	100	100	100	25		
193	SN100C/Sn	SN100C/Sn	100	100	100	100	100	100	100	100	36
149	SnPb/SnPb	SnPb/Sn	100	59							
151	SnPb/SnPb	SnPb/Sn	100	100	8						
153	SnPb/SnPb	SnPb/Sn	100	100	42						
150	SnPb/SnPb	SnPb/Sn	100	100	100	32					
152	SnPb/SnPb	SN100C/Sn	100	100	87						
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/Sn	100	100	100	100	2				

Reworked 1X

Table B-38. PDIP-20 U59

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
88	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
89	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
90	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
91	SN100C/NiPdAu	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	81	
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
192	SN100C/Sn	100	100	100	100	100	100	94		
189	SN100C/Sn	100	100	100	100	100	100	100	100	100
190	SN100C/Sn	100	100	100	100	100	100	100	100	100
191	SN100C/Sn	100	100	100	100	100	100	100	100	100
193	SN100C/Sn	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-39. QFN-20 U27

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-40. QFN-20 U28

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-41. QFN-20 U47

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
91	SAC305/Sn	100	100	100	100	100	100	100	100	27
89	SAC305/Sn	100	100	100	100	100	100	100	100	73
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-42. QFN-20 U54

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-43. TQFP-144 U1

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)											
75	SAC305/Sn	100	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100	100
32	SnPb/Sn	100	100	100	100	100	*				
31	SnPb/Sn	100	100	100	100	100	100	77			
30	SnPb/Sn	100	100	100	100	100	100	95			
34	SnPb/Sn	100	100	100	100	100	100	100	81		
33	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)											
These components were not reworked											
193	SAC305/SAC305 Dip	100	100	100	100	100	100	100	53		
189	SAC305/SAC305 Dip	100	100	100	100	100	100	100	100	100	100
190	SAC305/SAC305 Dip	100	100	100	100	100	100	100	100	100	100
191	SAC305/SAC305 Dip	100	100	100	100	100	100	100	100	100	100
192	SAC305/SAC305 Dip	100	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb Dip	100	100	100	100	100	**				
150	SnPb/SnPb Dip	100	100	100	100	100	100	***			
151	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100	58
149	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)											
160	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100	25

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Cracked Leads at End
of Test

Table B-44. TQFP-144 U3

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	1			
89	SAC305/Sn	100	100	100	100	100	24			
88	SAC305/Sn	100	100	100	100	100	29			
90	SAC305/Sn	100	100	100	100	100	38			
91	SAC305/Sn	100	100	100	100	100	58			
30	SnPb/Sn	100	100	100	100	100	9			
32	SnPb/Sn	100	100	100	100	100	10			
31	SnPb/Sn	100	100	100	100	100	28			
33	SnPb/Sn	100	100	100	100	100	54			
34	SnPb/Sn	100	100	100	100	100	80			
"Rework" (ImAg)		These components were not reworked								
191	SAC305/NiPdAu	100	100	100	100	100	19			
193	SAC305/NiPdAu	100	100	100	100	100	53			
192	SAC305/NiPdAu	100	100	100	100	100	55			
190	SAC305/NiPdAu	100	100	100	100	100	91			
189	SAC305/NiPdAu	100	100	100	100	100	100	13		
152	SnPb/NiPdAu	100	100	100	100	100	14			
151	SnPb/NiPdAu	100	100	100	100	100	18			
149	SnPb/NiPdAu	100	100	100	100	100	21			
150	SnPb/NiPdAu	100	100	100	100	100	30			
153	SnPb/NiPdAu	100	100	100	100	100	42			
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	35			

Cracked Leads at
End of Test

Table B-45. TQFP-144 U7

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	41	
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/Sn	100	100	100	100	100	*			
31	SnPb/Sn	100	100	100	100	100	98			
34	SnPb/Sn	100	100	100	100	100	100	100	100	15
30	SnPb/Sn	100	100	100	100	100	100	100	100	100
33	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
189	SAC305/SAC305 Dip	1								
193	SAC305/SAC305 Dip	100	100	100	100	100	100	23		
191	SAC305/SAC305 Dip	100	100	100	100	100	100	26		
192	SAC305/SAC305 Dip	100	100	100	100	100	100	64		
190	SAC305/SAC305 Dip	100	100	100	100	100	100	100	3	
153	SnPb/SnPb Dip	100	100	100	100	100	**			
151	SnPb/SnPb Dip	100	100	100	100	100	100	29		
150	SnPb/SnPb Dip	100	100	100	100	100	100	***		
149	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SnPb Dip	100	100	100	100	100	100	25		

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Cracked Leads at End
of Test

Table B-46. TQFP-144 U20

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	3			
90	SAC305/Sn	100	100	100	100	100	44			
91	SAC305/Sn	100	100	100	100	100	61			
88	SAC305/Sn	100	100	100	100	100	63			
89	SAC305/Sn	100	100	100	100	100	67			
30	SnPb/Sn	100	100	100	100	100	24			
31	SnPb/Sn	100	100	100	100	100	28			
32	SnPb/Sn	100	100	100	100	100	39			
33	SnPb/Sn	100	100	100	100	100	59			
34	SnPb/Sn	100	100	100	100	100	79			
"Rework" (ImAg)										
These components were not reworked										
192	SAC305/SAC305 Dip	100	100	90						
189	SAC305/SAC305 Dip	100	100	100	100	33				
191	SAC305/SAC305 Dip	100	100	100	100	100	25			
193	SAC305/SAC305 Dip	100	100	100	100	100	36			
190	SAC305/SAC305 Dip	100	100	100	100	100	60			
151	SnPb/SnPb Dip	100	100	100	100	100	22			
152	SnPb/SnPb Dip	100	100	100	100	100	27			
153	SnPb/SnPb Dip	100	100	100	100	100	29			
149	SnPb/SnPb Dip	100	100	100	100	100	31			
150	SnPb/SnPb Dip	100	100	100	100	100	41			
"Rework" (ENIG)										
160	SnPb/SnPb Dip	100	100	100	100	100	45			

Cracked Leads at End of Test

Table B-47. TQFP-144 U31

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
89	SAC305/Sn	100	100	100	100	100	100	41		
91	SAC305/Sn	100	100	100	100	100	100	100	82	
75	SAC305/Sn	100	100	100	100	100	100	100	100	17
90	SAC305/Sn	100	100	100	100	100	100	100	100	84
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/Sn	100	100	100	100	100	*			
30	SnPb/Sn	100	100	100	100	100	60			
33	SnPb/Sn	100	100	100	100	100	100	67		
31	SnPb/Sn	100	100	100	100	100	100	100	100	100
34	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/NiPdAu	100	100	100	100	100	100	100	100	88
189	SAC305/NiPdAu	100	100	100	100	100	100	100	100	100
190	SAC305/NiPdAu	100	100	100	100	100	100	100	100	100
191	SAC305/NiPdAu	100	100	100	100	100	100	100	100	100
192	SAC305/NiPdAu	100	100	100	100	100	100	100	100	100
153	SnPb/NiPdAu	100	100	100	100	100	**			
150	SnPb/NiPdAu	100	100	100	100	100	100	17		
152	SnPb/NiPdAu	100	100	100	100	100	100	17		
149	SnPb/NiPdAu	100	100	100	100	100	100	100	100	21
151	SnPb/NiPdAu	100	100	100	100	100	100	100	100	61
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Cracked Leads at
End of Test

Table B-48. TQFP-144 U34

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	66			
90	SAC305/Sn	100	100	100	100	100	100	66		
91	SAC305/Sn	100	100	100	100	100	100	100	37	
89	SAC305/Sn	100	100	100	100	100	100	100	84	
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
31	SnPb/Sn	100	100	100	100	100	41			
32	SnPb/Sn	100	100	100	100	100	*			
30	SnPb/Sn	100	100	100	100	100	100	38		
34	SnPb/Sn	100	100	100	100	100	100	39		
33	SnPb/Sn	100	100	100	100	100	100	100	54	
"Rework" (ImAg)										
These components were not reworked										
191	SAC305/NiPdAu	100	100	100	100	100	89			
193	SAC305/NiPdAu	100	100	100	100	100	100	41		
192	SAC305/NiPdAu	100	100	100	100	100	100	53		
190	SAC305/NiPdAu	100	100	100	100	100	100	60		
189	SAC305/NiPdAu	100	100	100	100	100	100	100	73	
153	SnPb/NiPdAu	100	100	100	100	100	52			
151	SnPb/NiPdAu	100	100	100	100	100	73			
152	SnPb/NiPdAu	100	100	100	100	100	100	33		
150	SnPb/NiPdAu	100	100	100	100	100	100	**		
149	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	34		

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 658

Cracked Leads at
End of Test

Table B-49. TQFP-144 U41

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	3		
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/Sn	100	100	100	100	100	*			
31	SnPb/Sn	100	100	100	100	100	100	7		
34	SnPb/Sn	100	100	100	100	100	100	60		
30	SnPb/Sn	100	100	100	100	100	100	100	100	100
33	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
191	SAC305/SAC305 Dip	100	100	100	100	100	100	49		
193	SAC305/SAC305 Dip	100	100	100	100	100	100	55		
190	SAC305/SAC305 Dip	100	100	100	100	100	100	59		
192	SAC305/SAC305 Dip	100	100	100	100	100	100	100	12	
189	SAC305/SAC305 Dip	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb Dip	100	100	100	100	100	**			
150	SnPb/SnPb Dip	100	100	100	100	100	100	***		
151	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	8
149	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb Dip	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SnPb Dip	100	100	100	100	100	100	20		

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Cracked Leads at End of Test

Table B-50. TQFP-144 U48

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	96			
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/Sn	100	100	100	100	100	*			
31	SnPb/Sn	100	100	100	100	100	84			
34	SnPb/Sn	100	100	100	100	100	100	100	41	
30	SnPb/Sn	100	100	100	100	100	100	100	100	100
33	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
191	SAC305/NiPdAu	100	100	100	100	100	100	53		
193	SAC305/NiPdAu	100	100	100	100	100	100	92		
190	SAC305/NiPdAu	100	100	100	100	100	100	100	22	
192	SAC305/NiPdAu	100	100	100	100	100	100	100	36	
189	SAC305/NiPdAu	100	100	100	100	100	100	100	100	100
153	SnPb/NiPdAu	100	100	100	100	100	**			
150	SnPb/NiPdAu	100	100	100	100	100	100	***		
151	SnPb/NiPdAu	100	100	100	100	100	100	86		
149	SnPb/NiPdAu	100	100	100	100	100	100	100	100	99
152	SnPb/NiPdAu	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	74		

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Cracked Leads at
End of Test

Table B-51. TQFP-144 U57

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	10			
89	SAC305/Sn	100	100	100	100	100	49			
90	SAC305/Sn	100	100	100	100	100	54			
91	SAC305/Sn	100	100	100	100	100	59			
88	SAC305/Sn	100	100	100	100	100	90			
30	SnPb/Sn	100	100	100	100	100	16			
32	SnPb/Sn	100	100	100	100	100	24			
33	SnPb/Sn	100	100	100	100	100	58			
31	SnPb/Sn	100	100	100	100	100	66			
34	SnPb/Sn	100	100	100	100	100	100	42		
"Rework" (ImAg)										
These components were not reworked										
191	SAC305/NiPdAu	100	100	100	100	100	96			
192	SAC305/NiPdAu	100	100	100	100	100	97			
193	SAC305/NiPdAu	100	100	100	100	100	100	22		
190	SAC305/NiPdAu	100	100	100	100	100	100	66		
189	SAC305/NiPdAu	100	100	100	100	100	100	82		
151	SnPb/NiPdAu	100	100	100	100	100	16			
152	SnPb/NiPdAu	100	100	100	100	100	18			
149	SnPb/NiPdAu	100	100	100	100	100	28			
150	SnPb/NiPdAu	100	100	100	100	100	38			
153	SnPb/NiPdAu	100	100	100	100	100	72			
"Rework" (ENIG)										
160	SnPb/NiPdAu	100	100	100	100	100	100	8		

Cracked Leads at
End of Test

Table B-52. TQFP-144 U58

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	58				
88	SAC305/Sn	100	100	100	100	100	9			
90	SAC305/Sn	100	100	100	100	100	13			
89	SAC305/Sn	100	100	100	100	100	27			
91	SAC305/Sn	100	100	100	100	100	41			
30	SnPb/Sn	100	100	100	100	100	5			
32	SnPb/Sn	100	100	100	100	100	10			
31	SnPb/Sn	100	100	100	100	100	15			
33	SnPb/Sn	100	100	100	100	100	24			
34	SnPb/Sn	100	100	100	100	100	66			
"Rework" (ImAg)		These components were not reworked								
189	SAC305/SAC305 Dip	100	100	100	100	65				
191	SAC305/SAC305 Dip	100	100	100	100	100	5			
193	SAC305/SAC305 Dip	100	100	100	100	100	26			
192	SAC305/SAC305 Dip	100	100	100	100	100	29			
190	SAC305/SAC305 Dip	100	100	100	100	100	41			
151	SnPb/SnPb Dip	100	100	100	100	93				
149	SnPb/SnPb Dip	100	100	100	100	100	1			
152	SnPb/SnPb Dip	100	100	100	100	100	10			
153	SnPb/SnPb Dip	100	100	100	100	100	16			
150	SnPb/SnPb Dip	100	100	100	100	100	17			
"Rework" (ENIG)										
160	SnPb/SnPb Dip	100	100	100	100	100	35			

Cracked Leads at End of Test

Table B-53. TSOP-50 U12

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/Sn	100	100	100	100	100	100	100	100	100	100
88		SAC305/Sn	100	100	100	100	100	100	100	100	100	100
89		SAC305/Sn	100	100	100	100	100	100	100	100	100	100
90		SAC305/Sn	100	100	100	100	100	100	100	100	100	100
91		SAC305/Sn	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*				
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100	39
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework										
"Rework" (ImAg)												
These components were reworked												
193	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	59	
189	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
190	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
191	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
192	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	**				
150	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100	16
149	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
151	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)												
160	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100	100

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-54. TSOP-50 U16

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SnBi	100	100	100	100	100	100	100	100	100
88	SAC305/SnBi	100	100	100	100	100	100	100	100	100
89	SAC305/SnBi	100	100	100	100	100	100	100	100	100
90	SAC305/SnBi	100	100	100	100	100	100	100	100	100
91	SAC305/SnBi	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
193	SAC305/SnPb	100	100	100	100	100	100	100	100	87
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SnBi	100	100	100	100	100	**			
150	SnPb/SnBi	100	100	100	100	100	100	***		
149	SnPb/SnBi	100	100	100	100	100	100	100	100	100
151	SnPb/SnBi	100	100	100	100	100	100	100	100	100
152	SnPb/SnBi	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SnBi	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-55. TSOP-50 U24

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
88		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
89		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
90		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
91		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	100	*			
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework										
"Rework" (ImAg)												
These components were reworked												
193	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	38	
191	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	51	
189	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
190	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
192	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	11			
150	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	69			
153	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	**			
149	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	92	
151	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)												
160	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	40			

Reworked 1X

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574

Table B-56. TSOP-50 U25

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)											
75		SAC305/Sn	100	100	100	100	100	100	100	100	100
88		SAC305/Sn	100	100	100	100	100	100	100	100	100
89		SAC305/Sn	100	100	100	100	100	100	100	100	100
90		SAC305/Sn	100	100	100	100	100	100	100	100	100
91		SAC305/Sn	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*			
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework									
"Rework" (ImAg)											
These components were reworked											
191	SAC305/Sn	SnPb/Sn	100	100	100	100	67				
190	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	22		
189	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	24		
193	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	53		
192	SAC305/Sn	SnPb/Sn	100	100	100	100	100	100	100	100	100
153	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	**			
150	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	50			
152	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	64	
149	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100
151	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)											
160	SnPb/SnPb	SnPb/SnPb	100	100	100	100	100	93			

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

Table B-57. TSOP-50 U26

Test Vehicle ID		Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)									
			20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's	
"Manufactured" (ImAg)												
75		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
88		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
89		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
90		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
91		SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
32		SnPb/SnPb	100	100	100	100	100	*				
30		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
31		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
33		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
34		SnPb/SnPb	100	100	100	100	100	100	100	100	100	100
	Solder/Finish Before Rework	Solder/Finish After Rework										
"Rework" (ImAg)			These components were reworked									
189	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
190	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
191	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
192	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
193	SAC305/SnBi	SAC305/SnBi	100	100	100	100	100	100	100	100	100	100
149	SnPb/SnPb	SnPb/Sn	Bad									
153	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	**				
150	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	***			
151	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
152	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)												
160	SnPb/SnPb	SnPb/Sn	100	100	100	100	100	100	100	100	100	100

Reworked 1X

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-58. TSOP-50 U29

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnBi	100	100	100	100	100	100	100	100	100
190	SAC305/SnBi	100	100	100	100	100	100	100	100	100
191	SAC305/SnBi	100	100	100	100	100	100	100	100	100
192	SAC305/SnBi	100	100	100	100	100	100	100	100	100
193	SAC305/SnBi	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	64

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-59. TSOP-50 U39

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnBi	100	100	100	100	100	100	100	100	100
190	SAC305/SnBi	100	100	100	100	100	100	100	100	100
191	SAC305/SnBi	100	100	100	100	100	100	100	100	100
192	SAC305/SnBi	100	100	100	100	100	100	100	100	100
193	SAC305/SnBi	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Table B-60. TSOP-50 U40

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SnBi	100	100	100	100	100	100	100	100	100
88	SAC305/SnBi	100	100	100	100	100	100	100	100	100
89	SAC305/SnBi	100	100	100	100	100	100	100	100	100
90	SAC305/SnBi	100	100	100	100	100	100	100	100	100
91	SAC305/SnBi	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
191	SAC305/SnPb	100	100	100	100	100	100	100	100	100
192	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SnBi	100	100	100	100	100	**			
150	SnPb/SnBi	100	100	100	100	100	100	***		
149	SnPb/SnBi	100	100	100	100	100	100	100	100	100
151	SnPb/SnBi	100	100	100	100	100	100	100	100	100
152	SnPb/SnBi	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SnBi	100	100	100	100	100	100	100	100	9

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-61. TSOP-50 U61

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/Sn	100	100	100	100	100	100	100	100	100
88	SAC305/Sn	100	100	100	100	100	100	100	100	100
89	SAC305/Sn	100	100	100	100	100	100	100	100	100
90	SAC305/Sn	100	100	100	100	100	100	100	100	100
91	SAC305/Sn	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
34	SnPb/SnPb	100	100	100	100	100	100	100	100	83
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SAC305/SnBi	100	100	100	100	100	100	100	100	100
190	SAC305/SnBi	100	100	100	100	100	100	100	100	100
191	SAC305/SnBi	100	100	100	100	100	100	100	100	100
192	SAC305/SnBi	100	100	100	100	100	100	100	100	100
193	SAC305/SnBi	100	100	100	100	100	100	100	100	100
153	SnPb/Sn	100	100	100	100	100	**			
150	SnPb/Sn	100	100	100	100	100	100	***		
149	SnPb/Sn	100	100	100	100	100	100	100	100	100
151	SnPb/Sn	100	100	100	100	100	100	100	100	100
152	SnPb/Sn	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/Sn	100	100	100	100	100	100	100	15	

*Removed from test on Shock Pulse 550

**Removed from test on Shock Pulse 574

***Removed from test on Shock Pulse 658

Table B-62. TSOP-50 U62

Test Vehicle ID	Solder/Finish	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SAC305/SnBi	100	100	100	100	100	100	100	100	100
88	SAC305/SnBi	100	100	100	100	100	100	100	100	100
89	SAC305/SnBi	100	100	100	100	100	100	100	100	100
90	SAC305/SnBi	100	100	100	100	100	100	100	100	100
91	SAC305/SnBi	100	100	100	100	100	100	100	100	100
32	SnPb/SnPb	100	100	100	100	100	*			
30	SnPb/SnPb	100	100	100	100	100	100	100	100	100
31	SnPb/SnPb	100	100	100	100	100	100	100	100	100
33	SnPb/SnPb	100	100	100	100	100	100	100	100	100
34	SnPb/SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)		These components were not reworked								
191	SAC305/SnPb	100	100	100	100	100	29			
192	SAC305/SnPb	100	100	100	100	100	100	100	33	
189	SAC305/SnPb	100	100	100	100	100	100	100	100	100
190	SAC305/SnPb	100	100	100	100	100	100	100	100	100
193	SAC305/SnPb	100	100	100	100	100	100	100	100	100
153	SnPb/SnBi	100	100	100	100	100	**			
150	SnPb/SnBi	100	100	100	100	100	100	***		
149	SnPb/SnBi	100	100	100	100	100	100	100	100	100
151	SnPb/SnBi	100	100	100	100	100	100	100	100	100
152	SnPb/SnBi	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb/SnBi	100	100	100	100	100	100	100	54	

Reworked 1X

- *Removed from test on Shock Pulse 550
- **Removed from test on Shock Pulse 574
- ***Removed from test on Shock Pulse 658

Table B-63. PTH

Test Vehicle ID	Wave Solder Alloy	Shocks Survived at Each Test Level (100 shocks per level in the Z-axis)								
		20 G's	40 G's	75 G's	100 G's	200 G's	300 G's	300 G's	300 G's	300 G's
"Manufactured" (ImAg)										
75	SN100C	100	100	100	100	100	100	100	100	100
88	SN100C	100	100	100	100	100	100	100	100	100
89	SN100C	100	100	100	100	100	100	100	100	100
90	SN100C	100	100	100	100	100	100	100	100	100
91	SN100C	100	100	100	100	100	100	100	100	100
32	SnPb	100	100	100	100	100	*			
30	SnPb	100	100	100	100	100	100	100	100	100
31	SnPb	100	100	100	100	100	100	100	100	100
33	SnPb	100	100	100	100	100	100	100	100	100
34	SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ImAg)										
These components were not reworked										
189	SN100C	100	100	100	100	100	100	100	100	100
190	SN100C	100	100	100	100	100	100	100	100	100
191	SN100C	100	100	100	100	100	100	100	100	100
192	SN100C	100	100	100	100	100	100	100	100	100
193	SN100C	100	100	100	100	100	100	100	100	100
153	SnPb	100	100	100	100	100	**			
150	SnPb	100	100	100	100	100	100	***		
149	SnPb	100	100	100	100	100	100	100	100	100
151	SnPb	100	100	100	100	100	100	100	100	100
152	SnPb	100	100	100	100	100	100	100	100	100
"Rework" (ENIG)										
160	SnPb	100	100	100	100	100	100	100	100	100

*Removed from test on Shock Pulse 550
 **Removed from test on Shock Pulse 574
 ***Removed from test on Shock Pulse 658

Appendix C. Selected Test Data in Graphical Format

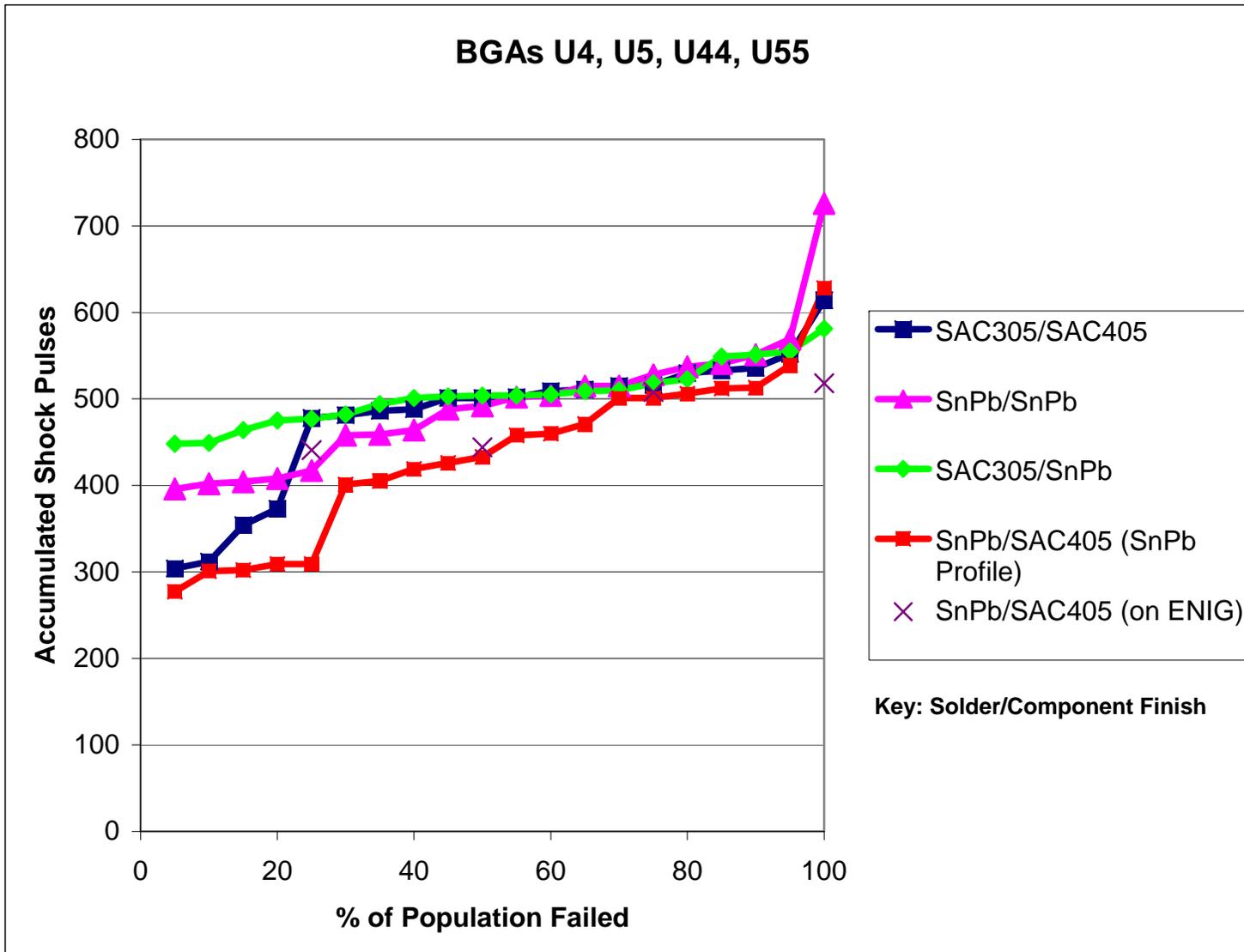


Figure C-1. Combined Data from BGA's U4, U5, U44, and U55

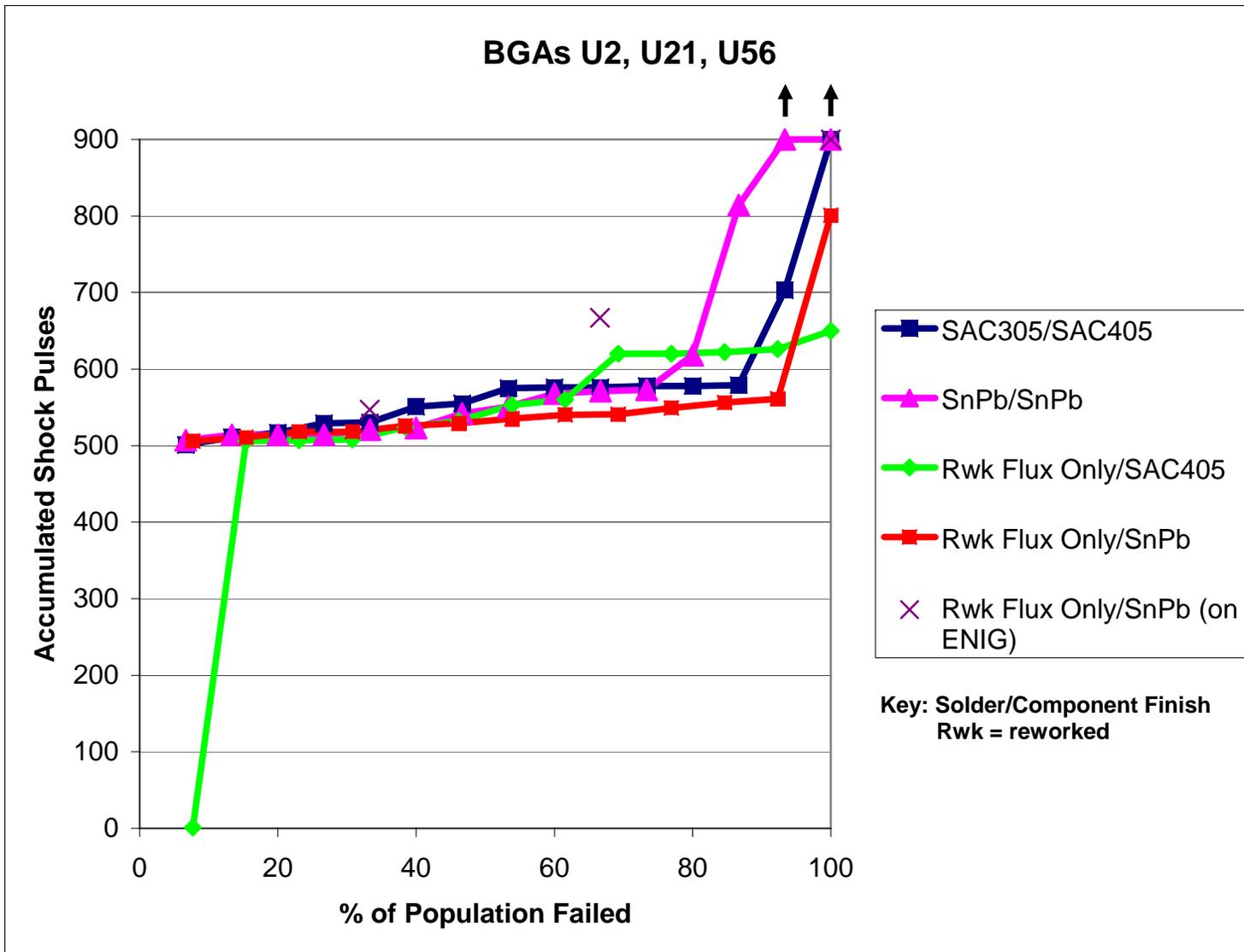


Figure C-2. Combined Data from BGA's U2, U21, and U56

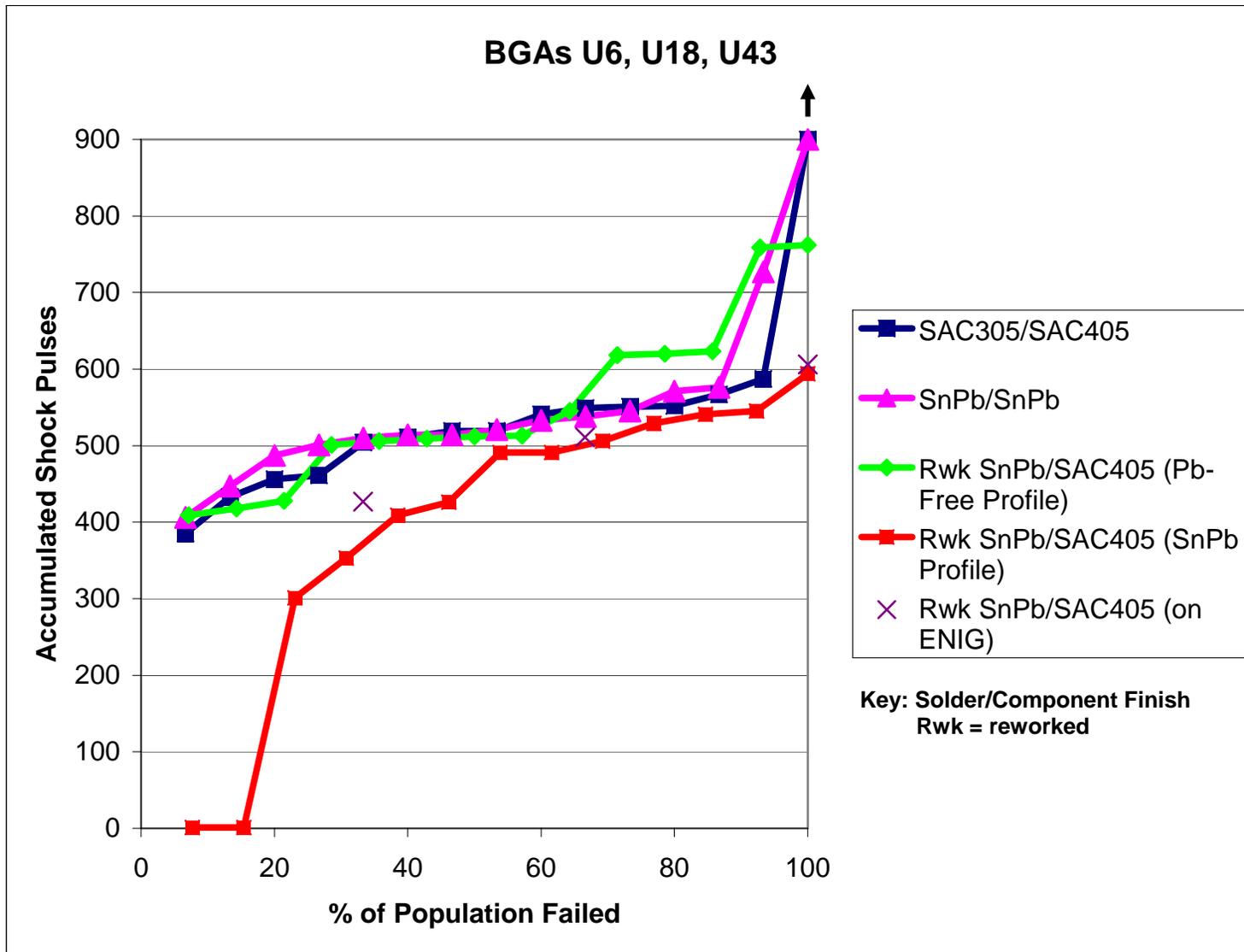


Figure C-3. Combined Data from BGA's U6, U18, and U43

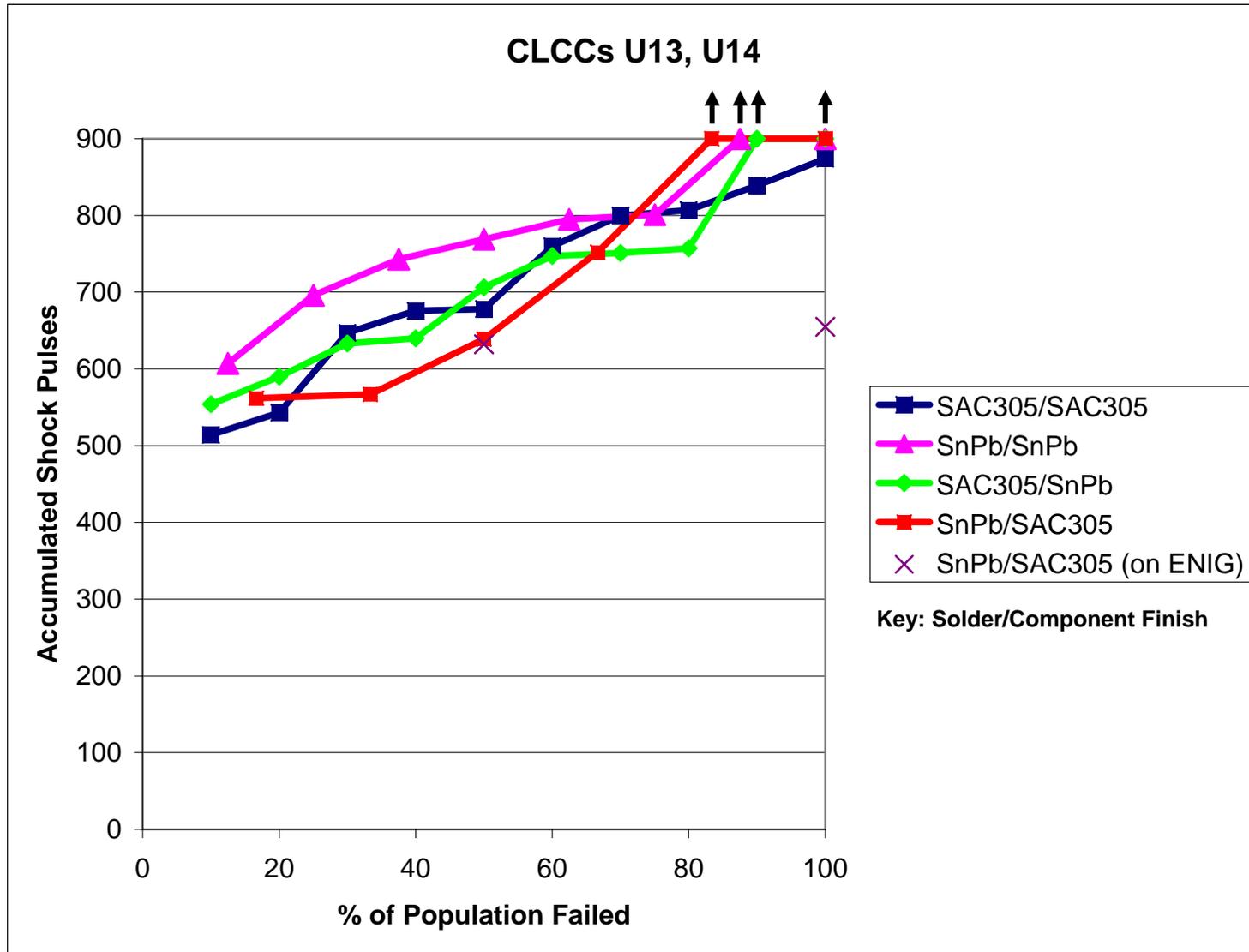


Figure C-4. Combined Data from CLCC's U13 and U14

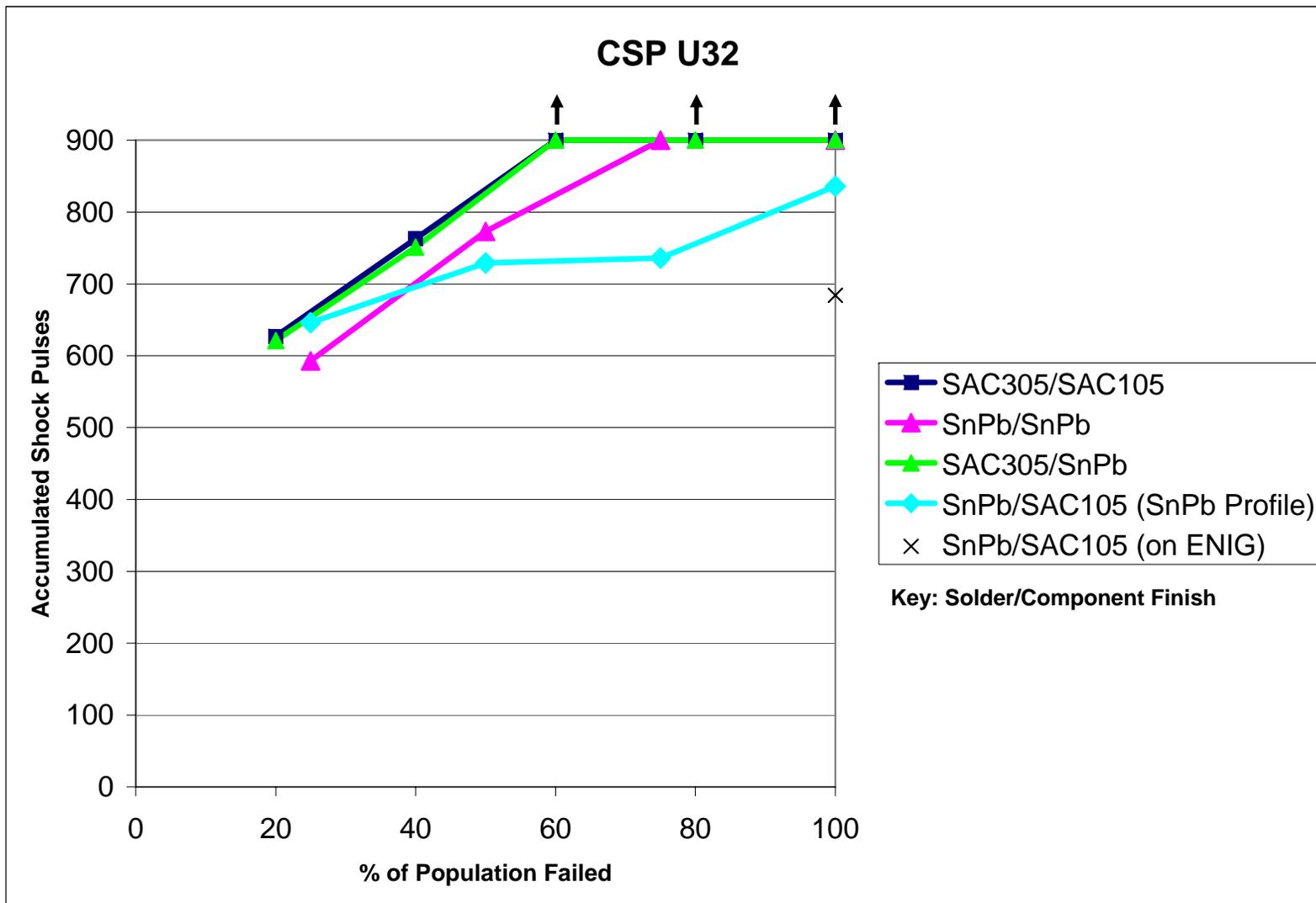


Figure C-5. CSP U32 Data

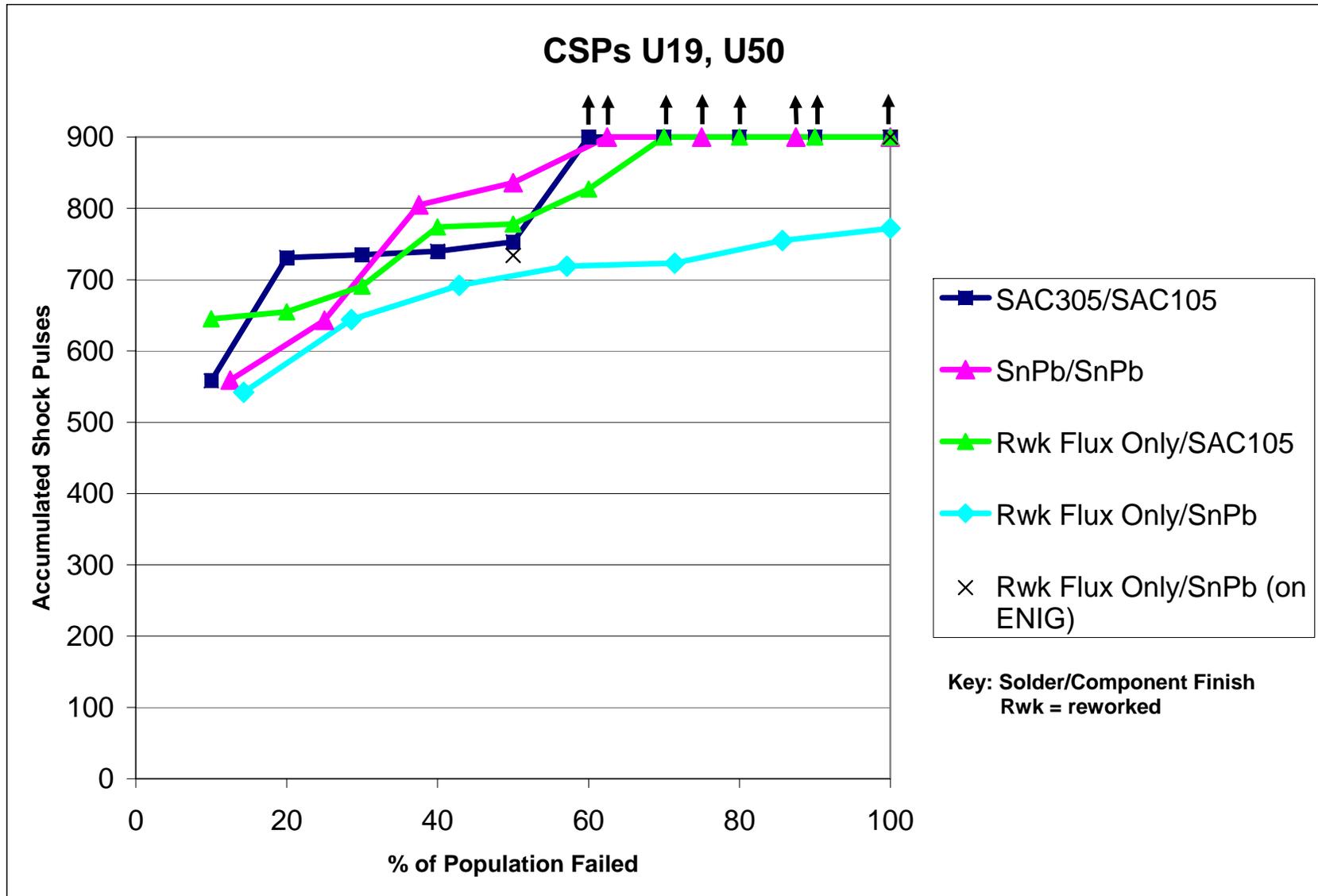


Figure C-6. Combined Data from CSP's U19 and U50

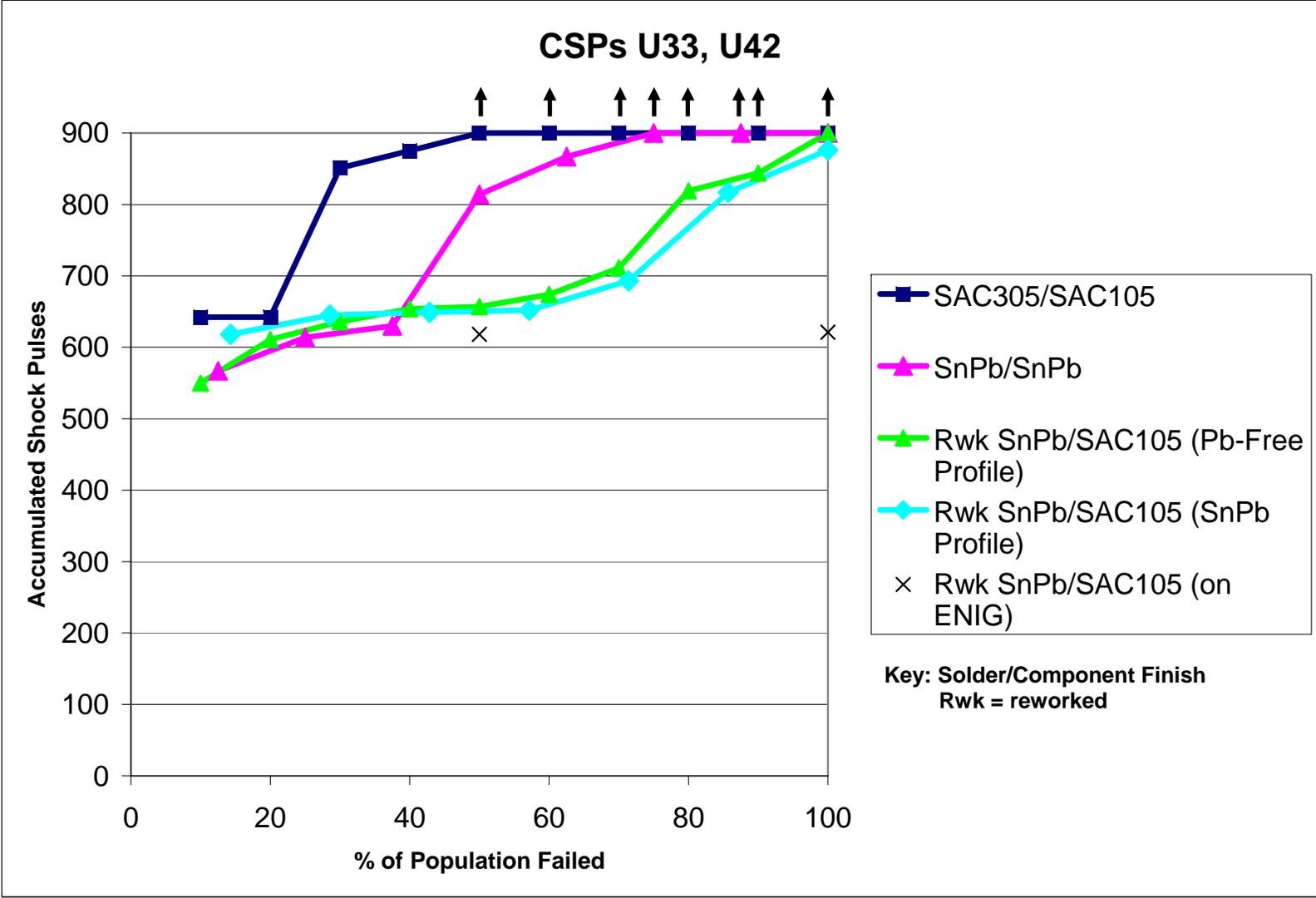


Figure C-7. Combined Data from CSP's U33 and U42

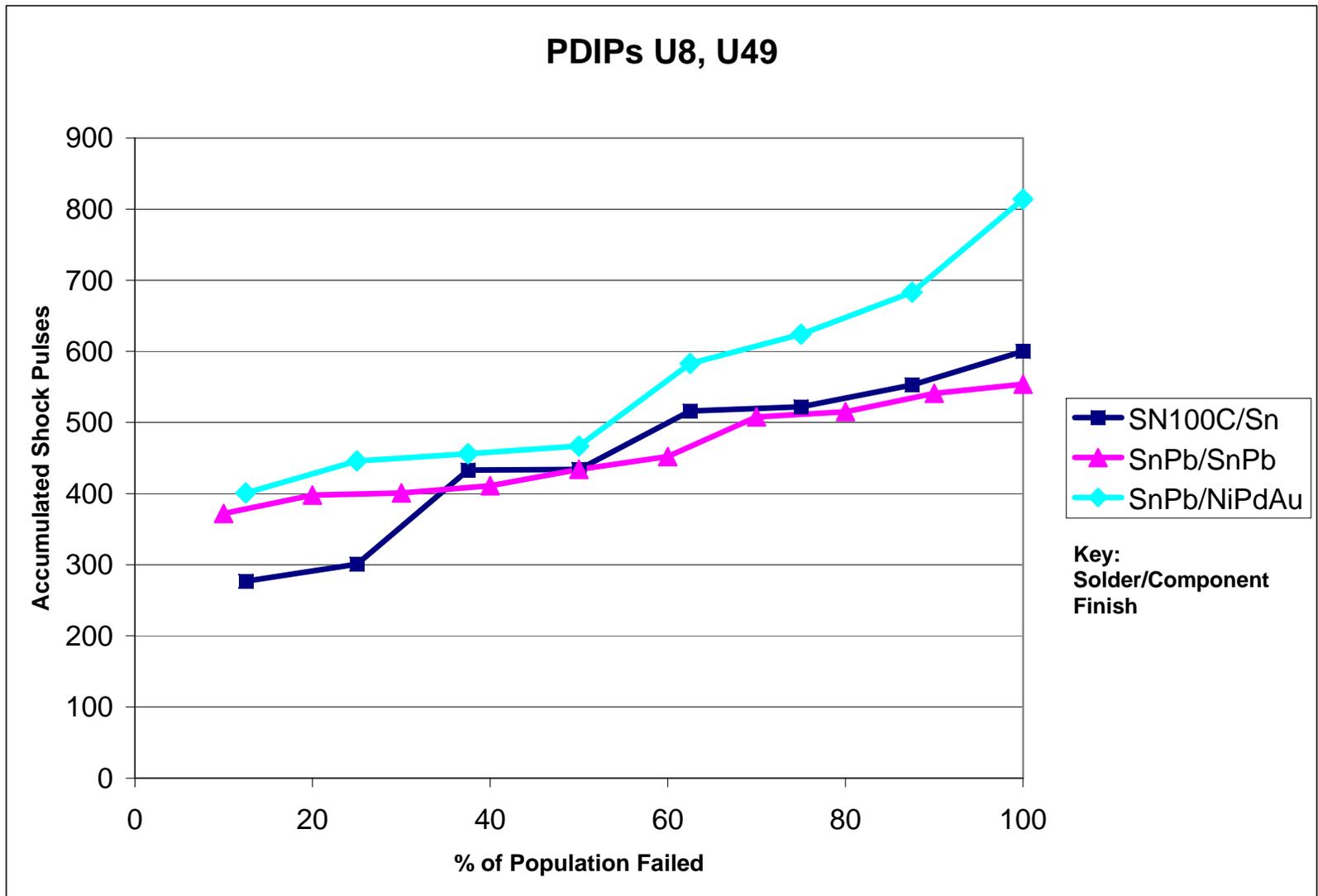


Figure C-8. Combined Data from PDIP's U8 and U49

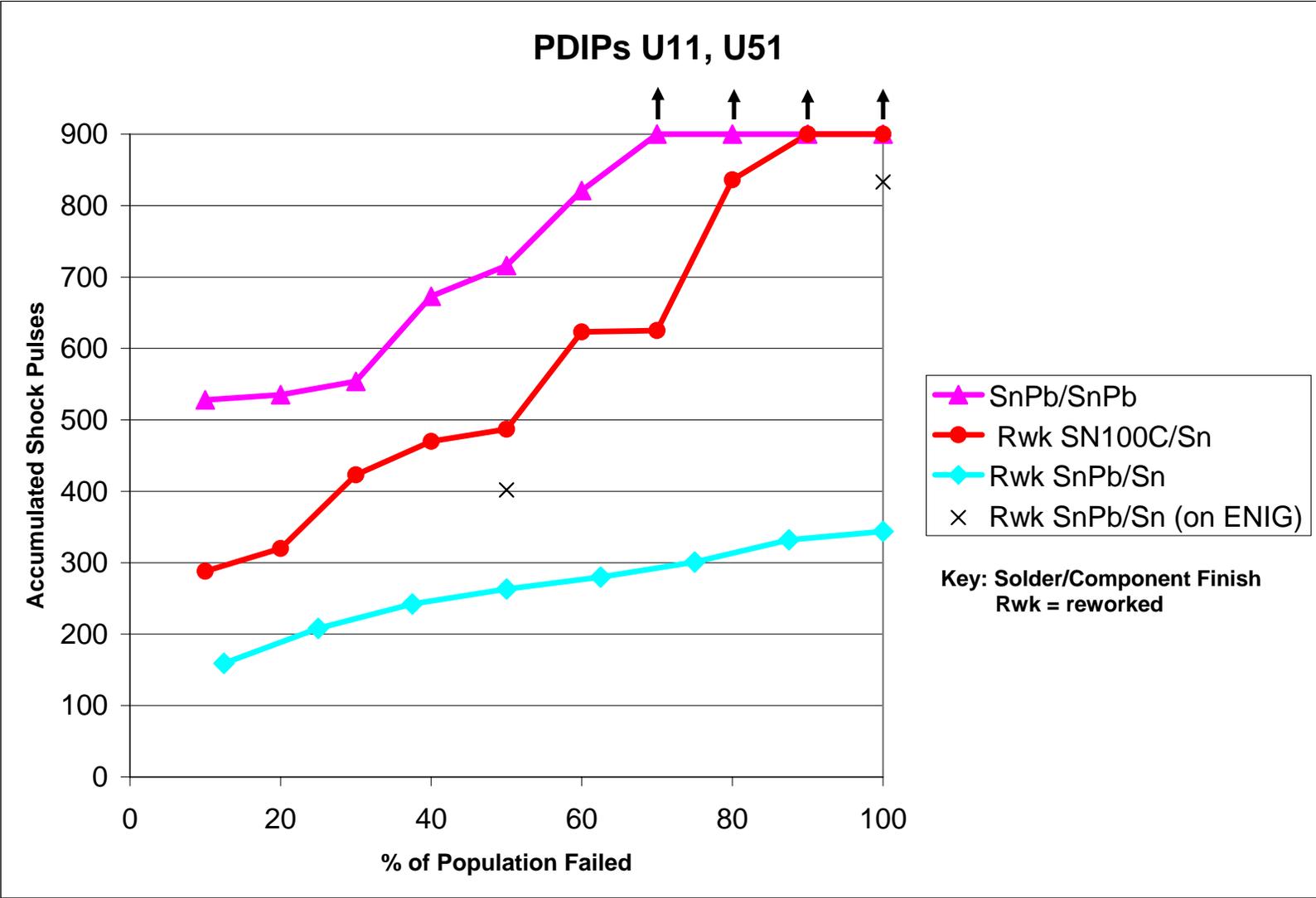


Figure C-9. Combined Data from PDIP's U11 and U51

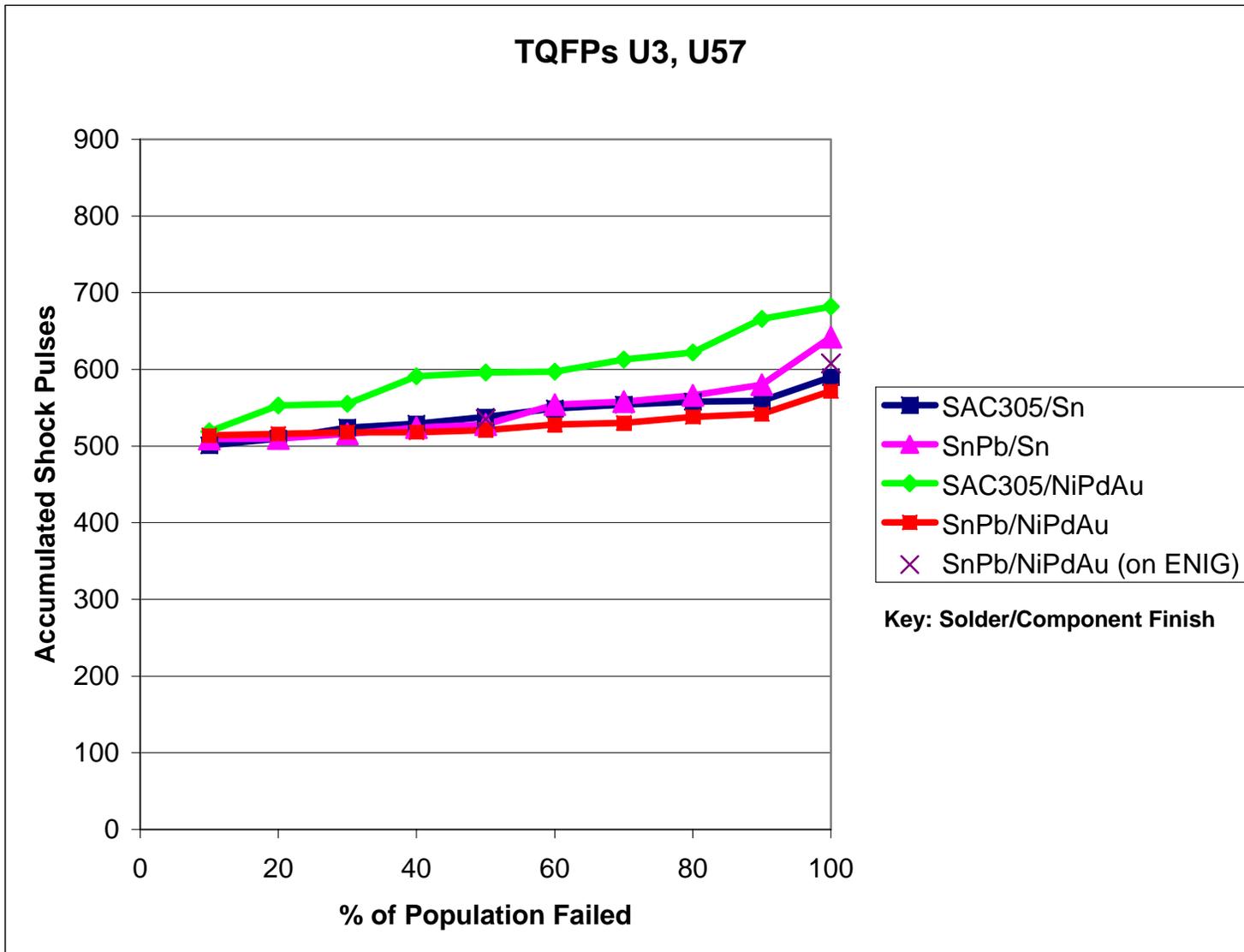


Figure C-10. Combined Data from TQFP's U3 and U57

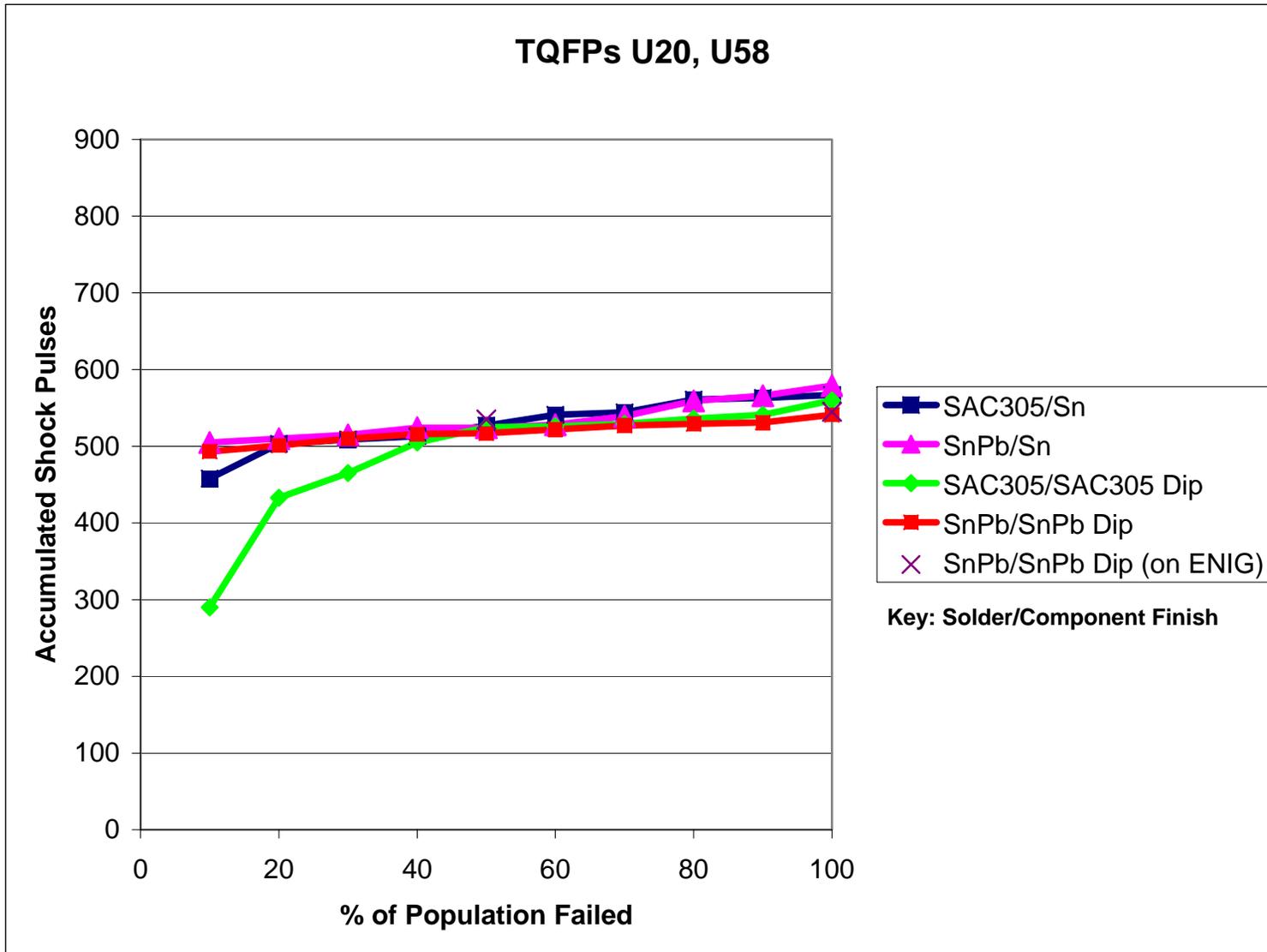


Figure C-11. Combined Data from TQFP's U20 and U58

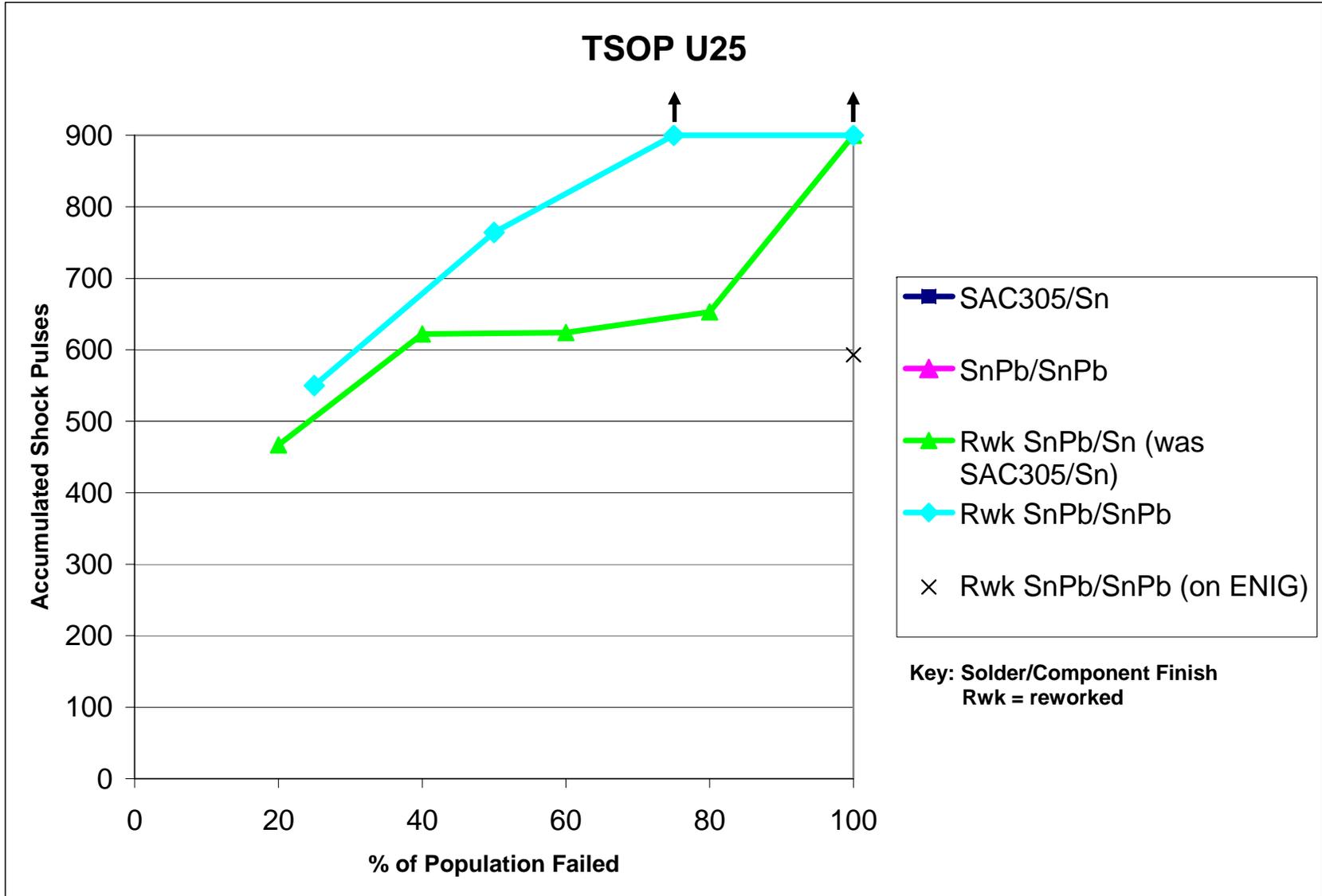


Figure C-12. TSOP U25 Data

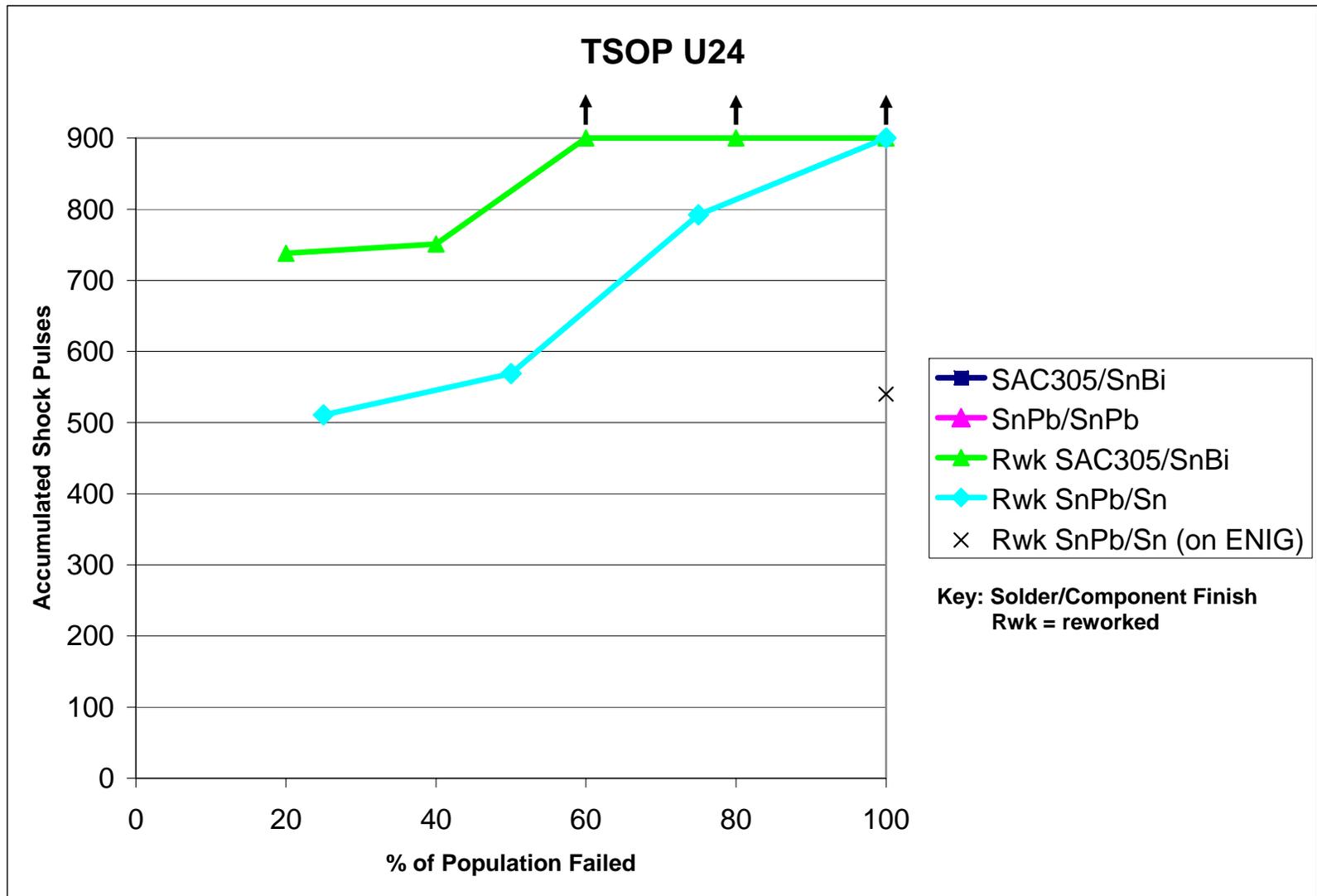


Figure C-13. TSOP U24 Data