FOURTH QUARTERLY REPORT
(Period: April 1 - June 30, 1966)

QUALIFICATION TESTING STUDY AND TEST PROGRAM FOR INTEGRATED CIRCUITS

To

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
George C. Marshall Space Flight Center
Huntsville, Alabama

Contract No. NAS8-20254

SPRAGUE ELECTRIC COMPANY
North Adams, Massachusetts
July 15, 1965

TABLE OF CONTENTS

SECTION 1

PURPOSE

The purpose of this program is as follows:

(1) Perform qualification testing necessary to qualify the microcircuits listed below to MSFC-SPEC-451 for the George C. Marshall Space Flight Center (MSFC), National Aeronautics and Space Administration, Huntsville, Alabama.

NASA Part No.	Sprague Part No.
SMN 511	US-261
SMN 513	US-263
SMN 514	US-264
SMN 515	US-265

(2) Deliver all test data and all microcircuits used to MSFC on completion of qualification testing.

(3) Prepare and submit to MSFC a histogram of each parameter listed in Table IV, Subgroup 4, of MSFC-SPEC-451 for Qualification Groups D and E. Plot these histograms using the data obtained at 100, 500, 1000, and 2000 hr.

(4) Conduct additional studies to determine the effectiveness of the screening methods and tests described in Paragraph 4.6 of MSFC-SPEC-451. In the course of these studies, test 13 samples of each of the four microcurcuit types. Upon completion of all screening and lot acceptance tests, subject all microcircuits to an additional 1000-hr operating life test using the conditions and measurements specified in Paragraph 4.7.4.4 of MSFC-SPEC-451.

(5) Prepare and submit quarterly progress reports to MSFC three months and six months after the effective date of the contract.

(6) Prepare and submit a final engineering report to MSFC at the conclusion of the work described above.

(7) To provide additional information, Sprague is including the following tests at no additional cost to the contractor.

Fifty additional units will be processed using the Sprague B-Pack to the environmental and life tests of Test Groups B, C, and E. Group D life tests will not be performed on the B-Pack since the test data derived from the Group D life test on the A-Pack units can be utilized because the same chip is involved.

SECTION 2

STATUS TO DATE INCLUDING FAILURE ANALYSIS

2.1 Prerequisites To Qualification

During this report period, the qualification units completed quality assurance and reliability screening. These units were selected and subjected to Test Groups B, C, D and E. Groups B and C experienced five failures. Group D has completed 1000 hours without a failure. The remaining good units from Groups B and C have been placed on Group E, Sequential Life Test, for informational purposes.

2.2 Failure Analysis

2.2.1 Status of Qualification

(a) Completed Tests

NASA qualification units (Part numbers SMN 511, 513, 514, and 515) have completed Group B, Sub-Groups I and II, and Group C tests.

(1) Group B, Subgroup I

Five SMN 511's were subjected to Dimensions, Solderability, and Solvent Resistance per Table II of MSFC-SPEC-451. There were 0 failures.

(2) Group B, Subgroup II

Ten SMN 511's and ten SMN 515's, for a total of twenty units, were subjected to Lead Fatigue, Thermal Shock, and Seal Test, per Table II of MSFC-SPEC-451. There were 0 failures.

(3) Group C

Ten SMN 513's, ten SMN 514's, and five SMN 515's for a total of twenty-five units, were subjected to Shock, Constant Acceleration, and Vibration Variable Frequency, per Table III of MSFC-SPEC-451. Five catastrophic failures were experienced: One SMN 513 with a broken external lead; two SMN 513's with the silicon chip lifted from the case; one SMN 514 and one SMN 515 both with the silicon chip lifted from the case.

Per Table I of MSFC-SPEC-451, two defectives were allowed for Test Groups B and C. Five failures were experienced.

(b) Tests in Process

Group D units have completed 1000 hours of life test without a failure. The good units remaining in Test Groups B and C total forty-five devices, three less than the minimum required for Group E sequential life testing. These forty-five good units were, however, placed on Group E Sequential Life Test for informational purposes.

2.2.2 Procedure of Analysis

Prior to any detailed failure analysis of the units, the screening and qualification specifications, and the process specifications, were reviewed to determine if the qualification units had been properly manufactured and had received the proper reliability and assurance testing and screening. After a thorough investigation, there was no evidence of any incorrect procedures.

In analyzing circumstances, Reliability Engineering pointed out we had only recently acquired the ability to centrifuge at levels greater than 20, 000 G's. New equipment had been purchased to provide conformance to the NASA qualification requirement of 30, 000 G's centrifuge. As a result of these qualification failures, experiments were initiated to determine what failure modes developed at various centrifuge levels.

(a) Determination of Failures

After completion of Test Group C, units were subjected to the electrical post test measurements per Table III of MSFC-SPEC-451. There were five catastrophic failures.

(b) Classification of Failures

There were two different failure modes: one unit had a broken external lead; four units had an internal failure mode. During visual examination this mode was determined to be the silicon chip separation from the bottom lid of the case.

(c) Visual Examination of Qualification Failures

The NASA qualification failures were delidded. examined and photographed (photographs are provided at the end of Section C). Following are the results of that examination. NOTE*

Unit #1 (SMN-513) - Observations

(1) Silicon chip was loose and broken into two pieces within the package.

(2) All bonding wires were sheared. The wire-to-chip bonds were acceptable. The wire-to-external lead bonds were acceptable.

(3) The gold bonding wires lay flat across the chip and then down the side, indicating the chip had lifted from the bottom of the case and held at the extent the bonding wires would allow. It is assumed that failure occurred during centrifuge in the Y_1 axis. Subsequent vibration broke the chip and sheared the bonding wires by chip movement within the package.

(4) The failure was caused by a lack of adhesion of the epoxy. The epoxy is used to secure the silicon chip to the gold-plated Kovar bottom lid of the package. Referring to Picture B of Unit #1, epoxy can be observed on one end of the package still adhering to the bottom lid. In the middle of the package there was an area in which the epoxy had adhered but was removed as the chip was removed. There was also an area void of epoxy as can be seen at the other end of the package. The silicon blank cracked over the area where the epoxy remained on the bottom lid. This can be seen in Pictures A and B of Unit #1. In Picture C, the back side of the silicon chip is shown. The crack extends across the blank separating the chip into two pieces, and the center of that area is free of epoxy; however, the edges do have some epoxy on them. On the larger broken portion of the chip, the void area can be seen and the area where the epoxy was left on the chip. This is a mirror image of the outline within the

*NOTE: The photographs are included only with the original copy sent to NASA package. It is also noteworthy that the gold-plated Kovar bottom lid still had all of the plating and the epoxy did not adhere to the gold plate. The gold plate was secure to the Kovar.

Unit #2 (SMN-514) - Observations

(1) The chip was loose within the package and was broken into four pieces.

(2) The chip-to-wire bond and the wire-to-external lead bonds were still intact on Pins 1 and 6. Each of these bonds were separately supporting a portion of the chip. The other bonding wires lay flat against the chip, and also had sheared off. Again it appeared that centrifuge in the Y_1 axis had caused the failure, and vibration had broken the chip and sheared the bonding wires.

(3) The silicon chip had separated from the bottom lid of the case, leaving epoxy on both the chip and the bottom lid. The majority of the epoxy was left on the silicon chip. In Picture B of Unit #2 the epoxy can be observed on the bottom lid of the case; however, there is an area in the center of the case where it appears the epoxy did not bond. The color of the gold is the same as the outside area, which would indicate there was no adhesion. There was a small periphery of adhesion around this void, quite noticeable in the lower end of the picture. In Picture C the epoxy can be observed on the back of the silicon chip.

Unit #3 (SMN-513) -Observations

(1) The chip was loose within the package and broken into three large pieces. There appeared to be a number of small pieces lost when the unit was delidded.

(2) All bonding wires lay flat against the top of the silicon chip and also extended down over the sides. The external lead-to-wire bonds and the chip-to-wire bonds were acceptable.

(3) The silicon chip had separated from the bottom lid of the case, leaving epoxy both on the silicon and the gold plate of the bottom lid. The gold plate was still secure to the Kovar. As can be seen from Pictures B and C of Unit #3, epoxy was under approximately two-thirds of the chip and on one end of the package. The broken

portion of the chip was over the area where epoxy was present. The void area contained no cracks or broken pieces.

Cracking of the chip over the area with the epoxy remaining on the bottom lid is consistent with Unit #1. It is theorized, with the epoxy adhering to the bottom lid, that the chip broke as the bottom lid flexed, before the chip and bottom lid separated.

Unit #4 (SMN-515) - Observations

(1) The silicon chip was loose within the package, however, still in one piece.

(2) All bonding wires had been sheared and had flattened against the top and along the sides of the chip. The external lead-to-wire bonds and the chip-to-wire bonds were acceptable. It appeared that centrifuge in the Y_1 axis had again lifted the chip causing the leads to flatten and the chip to move back and forth during vibration, causing the bonding wires to shear.

(3) The silicon chip had not remained secure to the bottom lid of the case. Epoxy again remained on both the silicon chip and the bottom lid. The area of adherence on the bottom lid can be observed in Picture B of Unit #4 by the dark shade of the gold. Within this area, also, there remained some epoxy. As can be seen on the picture, there are some scratch marks which were placed there during failure analysis to determine if there was gold plate and epoxy remaining on the bottom lid.

As can be seen by the scratches, epoxy was present. The gold plate was adhering to the lid, and a portion of this epoxy had been scraped off with the tweezers.

Unit #5 (SMN-513) - Observations

(1) External lead number 6 was broken at the glass-to-metal interface where the lead enters the package. Other leads of this package had been mangled badly.

(2) All bonds within the package were acceptable.

(3) The chip was secure within the package.

(4) There was no visual evidence of any internal failure.

(5) The cross sectional area of the lead did not appear

reduced. Failure appeared to be the result of mangling, bending, and restraightening, which caused excessive stressing and breaking of the lead.

(6) The broken portion of the lead was not observed. It was lost at the time the failure occurred.

(d) Explanation of Broken Lead

In preparing units for the Shock subgroup, they were molded in Carbowax 400. The Environmental Laboratory had failed to experiment with this Carbowax 400 to determine its setup time. The first time this wax was used was on this qualification subgroup. After the units were deposited in the wax, one unit still remained improperly potted. The operator attempted to push the unit deeper into the wax, however, the wax had already cooled and set, thus the lead was securely held and with the force of attempting to push it into the wax the lead was sharply bent, stressing it. In attempting to straighten this lead, it was again stressed. The unit was properly mounted by dissolving the wax and then remolding it. After completion of all the steps of Test Group C, an attempt was made to straighten the leads prior to electrical post test measurements. In loading the unit into the Augat test socket for these electrical tests, the lead fell off.

(e) Experimentation to Determine Cause of Chip Failures

Five experiments were run to isolate the cause of failure, and to determine the proper corrective action to prevent these failures.

EXPERIMENT #1

Title:

30,000 G CENTRIFUGE vs SHOCK AND A SUBSEQUENT 30,000 G CENTRIFUGE A-Pack RCTL

Purpose:

To determine if screening at 30,000 G's and subsequently running these devices to the qualification tests of Test Group C, Shock and a second 30,000 G Centrifuge, will screen out potential failures such that they will not occur during Test Group C.

Procedures:

1. Twenty-four units tested good electrically and were submitted to the following steps:

   (a) Centrifuged 30,000 G's, three seconds, Y_1 axis only, per MSFC-SPEC-451, Paragraph 4.5.8, Table III.

   (b) Tested electrically - three failures. Failures were delidded and visually examined. The silicon chip had separated from the bottom lid of the case in all three failures.

   (c) Tested twelve of the remaining good units to Shock per MSFC-SPEC-451, Paragraph 4.5.8, Table III.

   (d) Tested electrically - 0 failures.

   (e) Tested same twelve units as in Item "c", 30,000 G Centrifuge, 3 axes, per MSFC-SPEC-451, Paragraph 4.5.8, Table III.

   (f) Tested units electrically - 0 failures.

Conclusions:

This limited data revealed:

1. 30,000 G screening prior to qualification would eliminate qualification failures.

2. Shock was not the cause of the qualification failures.

3. Centrifuge in the Y_1 plane was sufficient to cause the failures.

4. Further experiments were necessary to assure that the 30,000G screening was the proper corrective action.

5. It would be necessary to determine if vibration contributed to the failures, or had any relation to the failures, experienced in Test Group C.

EXPERIMENT #2

Title:

30, 000 SCREENING vs SHOCK, VIBRATION, AND A SUBSEQUENT CENTRIFUGE AT 30, 000 G's
A-Pack

Purpose:

To determine if screening to 30, 000 G's, Y_1 axis, would eliminate failures experienced in Test Group C of MSFC-SPEC-451, Paragraph 4.5.8, Table III.

Procedures:

1. Nine of the remaining good units from Experiment #1, that were screened at 30, 000 G's, were processed as follows:

   (a) Shocked per MSFC-SPEC-451, Paragraph 4.5.8, Table III.

   (b) Tested electrically - 0 failures.

   (c) Vibration per MSFC-SPEC-451, Paragraph 4.5.8, Table III.

   (d) Tested electrically - 0 failures.

   (e) Centrifuged per MSFC-SPEC-451, Paragraph 4.5.8, Table III, 30, 000 G, three axes.

   (f) Tested electrically - one failure out of nine units. The failure indicated a short. The unit was delidded. All bonds were intact. The chip had lifted up from the bottom of the package, and was being held above the bottom of the package by the leads.

Conclusions:

This experiment revealed:

1. Again, shock was not the cause of the failure.

2. Vibration was not the cause of the failure.

3. One failure was experienced, indicating screening at 30, 000 G's did not eliminate all the failures when subjected to Test Group C, or to a second 30, 000 G Centrifuge. Effectively, there was one failure out of twenty-one units.

Noting that we did experience failures as a result of Experiment #2, the question arose: Was 30,000 G Centrifuge a critical point for failures, or were the units capable of much higher centrifuge G levels?

Experiment #3 was run to determine this.

EXPERIMENT #3

Title:

STEP-STRESS CENTRIFUGE
A-Pack

Purpose:

To determine if subsequent centrifuge step-stress levels would create catastrophic failures after an initial 30,000 G screening.

Procedures:

1. Centrifuge the eight remaining good units from Experiment #2 to 30,000 G, Y_1 axis.

2. Tested electrically - one failure. Silicon chip lifted.

3. Centrifuged the seven remaining electrically good units; 35,000 G Y_1 axis; one failure.

   Silicon chip lifted.

4. Centrifuged the six remaining to 40,000 G; Y_1 axis; 0 failures.

5. Centrifuged the six remaining to 50,000 G; Y_1 axis; 0 failures.

6. Centrifuged the six remaining to 75,000 G; Y_1 axis; 0 failures.

7. On all failures the chip had lifted from the bottom of the case.

Conclusions:

1. Subsequent centrifuging at 30,000 G continues to produce failures after previous screening at the same centrifuge level.

2. There appears to be a failure occurrence in the 30,000 G to 35,000 G centrifuge range, and the remaining units withstand the limit of our equipment.

EXPERIMENT #4

Title:

PROPOSED SCREENING PROCEDURE TO ELIMINATE 30,000 G CENTRIFUGE FAILURES
A-Pack

Purpose:

To determine if a 40,000 G centrifuge screening level would eliminate failures when subjected to subsequent 30,000 G centrifuge levels.

Procedures:

Forty-seven A-Pack units, good electrically, and not delidded, were subjected to the following:

1. 40,000 G; Y_1 axis and X_1 axis - two failures. Chip lifted from bottom of case on both failures.

2. 45 pieces; 30,000 G; Y_1 axis - 0 failures.

3. 45 pieces; 30,000 G; Y_1 axis - 0 failures.

4. 45 pieces; 40,000 G; Y_1 axis and X_1 axis - one failure. The failure was a chip-to-wire bond. The wire had broken just above the bond to the chip. There were no chip lifting failures.

5. Units were continued on step-stress. 45 pieces; 50,000 G; Y_1 axis; 0 failures.

6. 45 pieces; 75,000 G; Y_1 axis - one failure. The silicon chip had lifted from the bottom lid of case; unit was delidded and large area of the bottom lid was void of epoxy. Electrical failure resulted from the lead wire flattening against the aluminumization when the chip lifted causing an electrical short.

Conclusions:

1. Chip lifting did occur during the 40,000 G screening, substantiating the existence of failure mode up to and including that centrifuge G level.

2. This data indicates screening at 40,000 G, and then subjecting the units to three consecutive centrifuges at 30,000 G's, did not produce chip lifting failures; and subjecting the units to step-stress levels at 50,000 G's and 75,000 G's produced only one failure.

3. This procedure of screening, or preconditioning, at 40,000 G's, would eliminate any chip failures in the A-Pack, required by the NASA Qualification MSFC-SPEC-451.

EXPERIMENT #5

Title:

MECHANICAL STRESSING OF BOTTOM LID
A Pack

Purpose:

To determine if, by mechanically stressing the bottom lid of the A-Pack, failures of the type experienced in previous experiments would result.

Procedures:

1. Two A-Packs were delidded with heat and examined to determine if the chip was secure within the package.

2. These two units were then centrifuged in the Y_1 axis at 75, 000 G's.

3. The units were then visually examined and electrically tested. There were no failures.

4. Each unit was visually examined under a microscope while mechanical pressure with a tweezer was applied to the bottom lid area. The pressure was not measured, however with the use of the hands ten to twenty pounds were applied, causing the lid to depress and at the same time the chip cracked and separated from the bottom lid. The chip broke into two pieces, leaving epoxy both on the chip and on the lid. Both units exhibited the same type failure.

Conclusion:

It was possible by the use of mechanical stress on the bottom lid of the case to cause a failure mode similar to that experienced on centrifuge.

(f) Summary of Experiments

1. The A-Pack has a failure mode occurring up to 35,000 G's of centrifuge. The silicon chip lifts from the bottom lid of the A-Pack. This is the result of an epoxy separation between the chip and the bottom lid of the case. The majority of the epoxy remains on the silicon chip, leaving little on the bottom lid of the case. Separation of the epoxy from the bottom lid indicates three general possibilities, all of which have been investigated.

   (a) Poor cleaning of the bottom lid of the case.

   (b) Improper curing of the epoxy.

   (c) A flexing or bending of the bottom lid of the case under theforce of centrifuge such that the brittle epoxy separates from the expanding surface of the Kovar lid.

2. Initial experiments indicated 30,000 G screening was adequate, however, further evaluation indicated failures occurring between 30,000 G and 35,000 G.

3. Screening at 40,000 G's will eliminate failures occurring at lower centrifuge levels.

4. The results of the step-stress experiment of centrifuge levels up to 75,000 G's, with only one chip-lift failure, indicated 40,000 G screening does not produce undesirable secondary effects. It is Sprague's opinion that this screening will improve the reliability and will have no detrimental effect on the physical and electrical characteristics of the device.

5. Investigation and processing records indicated no incorrect procedures used in cleaning the case. No evidence can be found of any incorrect procedures in curing of the epoxy, and it is believed that there is no correlation between the failures and the epoxy curing.

6. Failure analysis indicated the catastrophic failures were caused by two general factors:

   (a) The inherent design of the A package. The bottom lid proved to be flexible and caused failure under mechanical stress. This flexibility is due to the thickness of the bottom lid: approximately .005 of an inch.

(b) To a lesser degree than Item (a), the epoxy did not adhere to the gold-plated metal surface. It appears the epoxy adheres better to the silicon and the glass of the B package than to the gold-plated Kovar surface of the A package.

6.2.3 Corrective Action

The following corrective action has been instituted to correct the chip lift-off failure mode.

(1) To Step 38, Production Screening Tests, of the NASA Microcircuit Process and Control Flow Chart, Figure 1, a 40,000 G Centrifuge in the Y_1 axis has been instituted.

(2) It is recommended that post measurement tests be conducted after each test within Test Group C, such that any failures may be isolated after the performance of such tests.

NOTE: Figure 1 is a copy of the Process and Control Flow Chart for NASA Microcircuits, Figure 2 shows the Sequence of Qualification, Figure 3 shows the Process Specifications for NASA Microcircuits and Figure 4 shows the Materials and Parts Specifications.

6.2.4 Relative Supplemental Data -- B-Pack

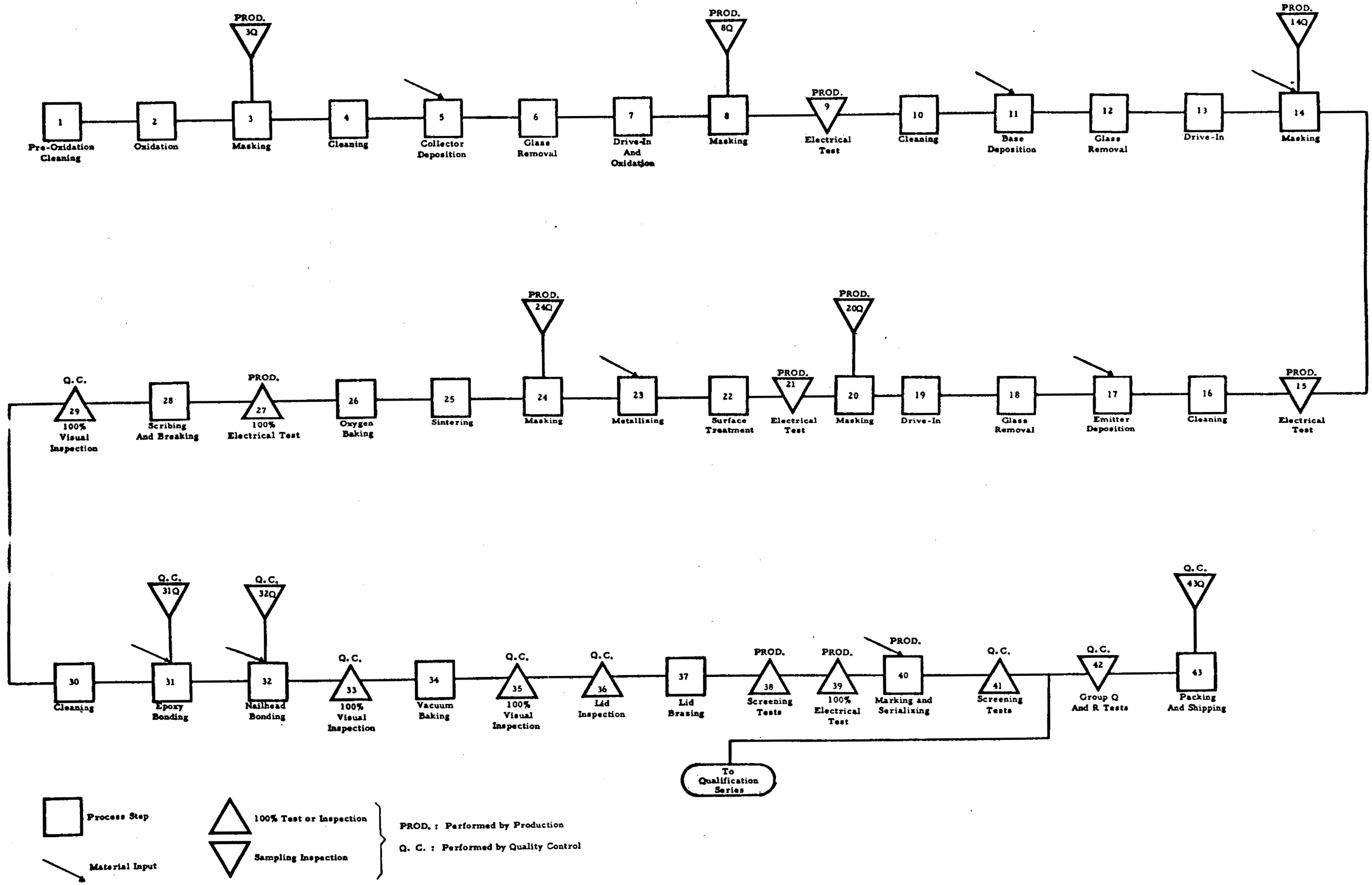
The Sprague Microcircuit B-Pack is being processed through the reliability and assurance screening tests of the MSFC-SPEC-451. These units have just completed the screening tests and samples are being picked for the qualification tests of Groups B, C, and E. During quality assurance and reliability screening, 140 pieces were subjected to 30,000 G centrifuge in the Y_1 axis, and no failures were experienced. From these 140 units, 50 units will be chosen for the qualification test groups. Fifty-two units will be submitted to the Q and R Tests for acceptance purposes.

As a result of experiencing chip lift-off with the A-Pack, a step-stress experiment was run on the B-Pack to determine if failures would occur under increasing levels of centrifuge. Fifty-six pieces were tested electrically and subjected to the following centrifuge levels:

After each centrifuge level the pieces were electrically tested.

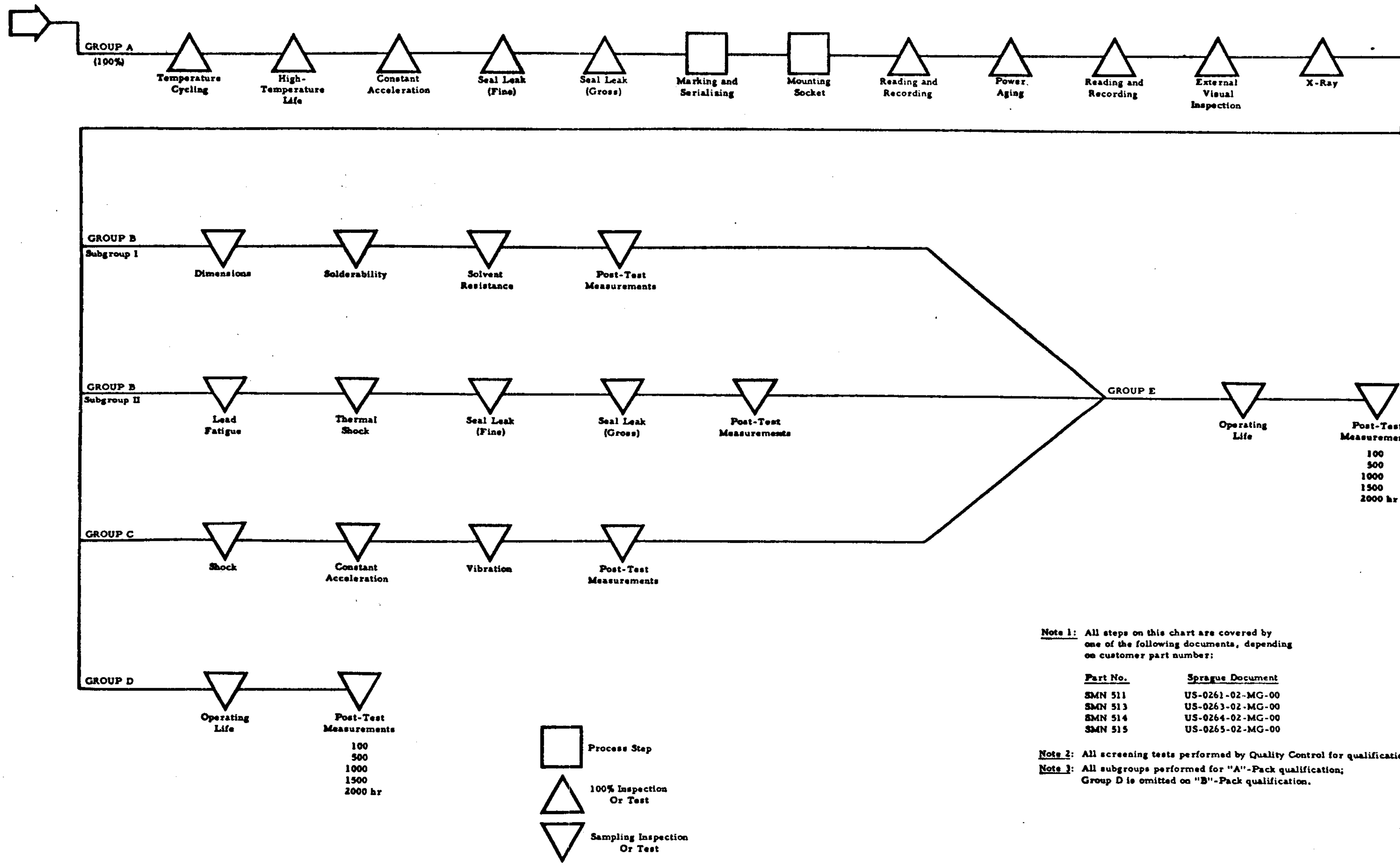
PROCESS AND CONTROL FLOW CHART -- NASA MICROCIRCUITS

FIGURE 1



SEQUENCE OF QUALIFICATION

FIGURE 2



Note 1: All steps on this chart are covered by one of the following documents, depending on customer part number:

Part No.	Sprague Document
SMN 511	US-0261-02-MG-00
SMN 513	US-0263-02-MG-00
SMN 514	US-0264-02-MG-00
SMN 515	US-0265-02-MG-00

Note 2: All screening tests performed by Quality Control for qualification.

Note 3: All subgroups performed for "A"-Pack qualification; Group D is omitted on "B"-Pack qualification.

FIGURE 3

PROCESS SPECIFICATIONS FOR NASA MICROCIRCUITS

Chart Reference	Title	Document No.	Revision No.	Original or Latest Rev. Date
1	Pre-oxidation cleaning	1-2-000-2001	1	5-6-65
2	Oxidation	1-2-000-2002	1	5-6-65
3	KMER processing - masking	1-2-000-2003	1	3-4-66
3Q	Mask alignment	32-00-505-00		
4	Pre-diffusion cleaning	1-2-000-2004	0	2-19-65
5	Collector deposition	1-2-000-2005	3	12-24-65
6	Glass removal	1-2-000-2006	4	1-6-66
7	Collector drive-in and oxidation	1-2-000-2007	2	9-17-65
8	KMER processing - masking	1-2-000-2003	1	3-4-66
8Q	Mask alignment	32-00-505-00		
9	Electrical tests	1-2-000-2008	0	2-18-65
10	Pre-diffusion cleaning	1-2-000-2004	0	2-19-65
11	Base deposition	1-2-000-2009	2	5-6-65
12	Glass removal	1-2-000-2006	4	1-6-66
13	Base drive-in	1-2-000-2010	1	9-17-65
14	KMER processing - masking	1-2-000-2003	1	3-4-66
14Q	Mask alignment	32-00-505-00		
15	Electrical tests	1-2-000-2011	0	2-23-65
16	Pre-diffusion cleaning	1-2-000-2004	0	2-19-65
17	Emitter deposition	1-2-000-2012	1	5-6-65
18	Glass removal	1-2-000-2006	4	1-6-66
19	Emitter drive-in	1-2-000-2013	2	9-17-65
20	KMER processing - masking	1-2-000-2003	1	3-4-66
20Q	Mask alignment	32-00-505-00		
21	Electrical tests	1-2-000-2014	0	2-18-65
22	Surface treatment	1-2-000-2026	1	9-23-65
23	Metallization	1-2-000-2015	1	5-11-65

FIGURE 3 - Page 2

PROCESS SPECIFICATIONS FOR NASA MICROCIRCUITS

Chart Reference	Title	Document No.	Revision No.	Original of Latest Rev. Date
24	KMER processing - masking	1-2-000-2003	1	3-4-66
24Q	Mask alignment	32-00-505-00		
25	Sintering	1-2-000-2027	2	3-30-66
26	Oxygen bake	1-2-000-2028	0	4-12-65
27	Electrical tests	1-2-000-2016		
28	Scribe and break	1-2-000-2017	0	2-19-65
29	100% visual inspection	Detail CAS (*Note)	0	8-11-65
		and		
		32-00-502-00	6	4-14-66
30	Chip cleaning	1-2-000-2018	0	2-19-65
31	Epoxy Bonding	1-2-000-2019	0	2-19-65
31Q	Visual Inspection at Epoxy bonding	32-00-501-00	1	3-14-66
32	Nailhead Bonding	1-2-000-2020	0	2-19-65
32Q	Visual Inspection at nailhead bonding	32-00-503-00	3	10-19-65
33	100% Visual Inspection	Detail CAS*		
		and		
		32-00-504-00	2	12-16-65
34	Vacuum Bake	1-2-000-2022	0	2-19-65
35	100% Visual Inspection	Detail CAS*		
		and		
		32-00-504-00	2	12-16-65
36	Visual Inspection of lids	32-00-506-00	2	11-5-65
37	Lid Brazing	1-2-000-2022	0	2-19-65
38	Screening Tests	Detail CAS*		
39	100% Electrical Test	Detail CAS*		
40	Marking and Serializing	Detail CAS*		
41	Screening Tests	Detail CAS*		

FIGURE 3 - Page 3

PROCESS SPECIFICATIONS FOR NASA MICROCIRCUITS

Chart Reference	Title	Document No.	Revision No.	Original or Latest Rev. Date
42	Group Q and R Tests	Detail CAS*		
43	Packing and Shipping	Detail CAS*		
43Q	Packing and Shipping Inspection	Detail CAS*		

* For Part No. SMN 511, see CAS No. US-0261-02-MG-00
For Part No. SMN 513, see CAS No. US-2063-02-MG-00
For Part No. SMN 514, see CAS No. US-0264-02-MG-00
For Part No. SMN 515, see CAS No. US-0265-02-MG-00

FIGURE 4

MATERIALS AND PARTS SPECIFICATIONS

Chart Reference	Title	Document No.	Revision No.	Original or Latest Rev. Date
1	Silicon slice	52-0620-0001	2	12-19-65
	Methanol	50-1301-0003	0	9-16-59
	Trichloroethylene	50-2002-0005	0	8-16-65
	Hydrofluoric acid	50-0802-0003	0	10-1-62
	Sulfuric acid	50-1907-0003	0	9-17-56
	Hydrogen peroxide	50-0803-0001	0	4-9-56
3	Trichloroethylene	50-2002-0005	0	8-16-65
	Methanol	50-1301-0003	0	9-16-59
	Nitrogen gas	50-1404-0001	0	9-3-57
	KMER	50-1105-0001	0	5-14-64
	KMER thinner	50-1106-0001	0	5-14-64
	KMER developer	50-1107-0001	0	5-14-64
	Xylene	50-2501-0001	0	6-27-63
	Hydrofluoric acid	50-0802-0003	0	10-1-62
	Sulfuric acid	50-1907-0003	0	9-17-56
	Hydrogen peroxide	50-0803-0001	0	4-9-56
4	Nitric acid	50-1402-0002	0	9-17-56
	Hydrofluoric acid	50-0802-0003	0	10-1-62
5	Phosphorous Oxychloride	50-1618-0001	0	5-14-64
6	Methanol	50-1301-0003	0	9-16-59
	Hydrofluoric acid	50-0802-0003	0	10-1-62
	Ammonium fluoride	50-0119-0001	0	3-22-65
8	Same as Step 3			

FIGURE 4 - Page 2

MATERIALS AND PARTS SPECIFICATIONS

Chart Reference	Title	Document No.	Revision No.	Original. or Latest Rev. Date
10	Same as Step 4			
11	Diborane	50-0406-0001	0	8-16-65
12	Same as Step 6			
16	Same as Step 4			
17	Phosphorous Oxychloride	50-1618-0001	0	5-14-64
18	Same as Step 6			
20	Same as Step 3			
22	Forming gas	50-0604-0001	0	8-16-65
23	Methanol	50-1301-0003	0	9-16-59
	Hydrofluoric acid	50-0802-0003	0	10-1-62
	Nitrogen, liquid	50-1404-0002	0	7-11-59
	Filament, tungsten/Al	51-0709-0001		
	Aluminum slug	50-0121-0001	1	12-16-65
	Acetic acid	50-0101-0002	1	6-27-66
24	KMER	50-1105-0001	0	5-14-64
	KMER thinner	50-1106-0001	0	5-14-64
	KMER developer	50-1107-0001	0	5-14-64
	Xylene	50-2501-0001	0	6-27-63
	Methanol	50-1301-0003	0	9-16-59
	Phosphoric acid	50-1613-0001	0	11-27-61

FIGURE 4 - Page 3

MATERIALS AND PARTS SPECIFICATIONS

Chart Reference	Title	Document No.	Revision No.	Original or Latest Rev. Date
	Nitric acid	50-1402-0002	0	9-17-56
	Hydrogen peroxide	50-0803-0001	0	4-9-56
	Sulfuric acid	50-1907-0003	0	9-17-56
30	Trichloroethylene	50-2002-0005	0	8-16-65
	Acetone	50-0102-0005	0	12-14-61
31	Resin, epoxy	4506-235		
	Hardener	1-4506-36		
32	Gold Wire	321-1		
37	Lid	62-0609-0001		
	Preform	62-0801-0001	3	10-6-65
	Forming gas	50-0604-0001	0	8-16-65
40	Marking ink	50-0908-0003	1	2-21-66

(a) 56 pieces; 20,000 G's; 0 failures

(b) 56 pieces; 30,000 G's; 0 failures

(c) 56 pieces; 30,000 G's; 0 failures

(d) 56 pieces; 40,000 G's; 0 failures

(e) 56 pieces; 50,000 G's; 0 failures

(f) 56 pieces; 75,000 G's; 1 failure

The silicon chip lifted from the bottom glass of the case. There was a large area void of epoxy under the chip.

It is concluded that the B-Pack can withstand 75,000 G's without preconditioning or screening at other than that prescribed by the screening of MSFC-SPEC-451, that is, 20,000 G's, Y axis. It appears there is no failuremode occurring in the 30,000 G to 35,000 G level range, as with the A-Pack. The B-Pack appears to be a much stronger and more rigid package.

SECTION 3

SCHEDULE FOR NEXT INTERVAL

A sequential schedule of qualification, projected as of June 30, 1966 is outlined below.

		Completion Dates SMN 511, 513, 514, 515
3.1	"A" Pack Schedule	
(1)	Quality Assurance Tests	
(a)	100% Chip Inspection at 100X Step 29 of Flow Chart Specification 32-00-502-00	complete
(b)	Sample Epoxy Bonding Inspection at 40X Step 31Q of Flow Chart Specification 32-00-501-00	complete
(c)	Sample Nail Head Bonding Inspection at 40X Step 32Q of Flow Chart Specification 32-00-503-00	complete
(d)	100% Visual Inspection at 40X Prior to Seal Step 33 of Flow Chart Specification 32-00-504-00	complete
(e)	Vacuum Bake Step 34 of Flow Chart	complete
(f)	100% Visual Inspection at 40X Prior to Seal Step 35 of Flow Chart Specification 32-00-504-00	complete
(g)	100% Visual Lid Inspection at 10X Step 36 of Flow Chart Specification 32-00-506-00	complete

	Completion Dates SMN 511, 513, 514, 515
(2) Quality Assurance and Reliability Screening	
(a) Temperature Cycle	complete
(b) Bake	complete
(c) Centrifuge	complete
(d) Fine Leak Test	complete
(e) Gross Leak Test	complete
(f) Stamp	complete
(g) Serialize	complete
(h) Read and Record plus 100% Electrical Test Group A Go/No Go	complete
(i) Burn-In, 96 hours	complete
(j) Read and Record plus 100% Electrical Test Group A Go/No Go	complete
(k) X-Ray and Visually Inspect	complete
(3) Qualification Testing	
(a) Select samples for Qualification Group, then read and record (Group A) Total sample size: 120 pieces	complete
(b) Environmental Tests (Group B and C) *1.	complete
(c) Life Test (Group D)	8/18/66
(d) Sequential Life Test (Group E)	9/19/66
(4) Acceptance Testing	
Completion of environmental tests, 2000 hour life, 2000-hour sequential life test, and end point testing	9/19/66
(5) Reporting	
(a) Final Report	10/7/66

*1. 25 units Subgroup C: 5 failures after 30,000 G Centrifuge. Only 45 units for Group E testing, started after notification of MSFC-NASA. Complete failure analysis will be provided in final report.

3.2 "B" Pack Schedule	Completion Dates SMN 511, 513, 514, 515
(1) Quality Assurance Tests	
(a) 100% Chip Inspection at 100X Step 29 of Flow Chart Specification 32-00-502-00	complete
(b) Sample Epoxy Bonding Inspection at 40X Step 31Q of Flow Chart Specification 32-00-501-00	complete
(c) Sample Nail Head Bonding Inspection at 40X Step 32Q of Flow Chart Specification 32-00-503-00	complete
(d) 100% Visual Inspection at 40X Prior to Seal Step 33 of Flow Chart Specification 32-00-504-00	complete
(e) Vacuum Bake Step 34 of Flow Chart	complete
(f) 100% Visual Inspection at 40X Prior to Seal Step 35 of Flow Chart Specification 32-00-504-00	complete
(g) 100% Visual Lid Inspection at 10X Step 36 of Flow Chart Specification 32-00-506-00	complete
(2) Quality Assurance and Reliability Screening	
(a) Temperature Cycle	complete
(b) Bake	complete
(c) Centrifuge	complete
(d) Fine Leak Test	complete
(e) Gross Leak Test	complete
(f) Stamp	complete
(g) Serialize	complete
(h) Read and Record plus 100% Electrical Test Group A Go/No Go	complete
(i) Burn-In, 96 hours	complete
(j) Read and Record plus 100% Electrical Test Group A Go/No Go	complete
(k) X-Ray and Visually Inspect	complete

		Completion Dates SMN 511, 513, 514, 515
(3)	Qualification Testing	
	(a) Select samples for Qualification Group, then read and record (Group A) Total sample size: 50 pieces *1.	In Process
	(b) Environmental Tests (Group B and C)	complete
	(c) Life Test (Group D) omitted	
	(d) Sequential Life Test (Group E)	10/14/66
(4)	Acceptance Testing	
	Completion of environmental tests, 2000-hour sequential life test, and end point testing	10/14/66
(5)	Reporting	
	(a) Final Report	11/1/66

*1. Lot size established by agreement with MSFC-NASA not to include units for Group D Life Test.

ADDENDUM

CONFERENCE REPORT

(Conference Held at NASA-Huntsville, July 6, 1966)

A conference between NASA personnel and representatives of the Sprague Electric Company took place at NASA-Huntsville on July 6, 1966. Sprague personnel included Messrs. J.E. Hearl, M. J. Mulvihill, C. R. Gray, and D. H. Yeaton. NASA personnel were Messrs. A. Davis, M. J. Nowakowski, and L. Hamiter. The purpose of the conference was to discuss the NASA-Huntsville RCTL qualification. Completion of the qualification contract was discussed because of difficulties experienced thus far such as unit availability, HREL processing, and unexpected failures. NASA was assured by Sprague that maximum effort will continue toward successful completion of the qualification. Further actions pertinent to the contract were agreed upon. These are as follows:

(a) Submission of the Fourth Quarterly Report including a failure analysis report.

(b) Submission of a reliability program plan as per MSFC-SPEC-451, Paragraph 4.1 inclusive. This program is due July 29, 1966 and will include:

  (a) Documentation on how Sprague complies to NPC-200-3.
  (b) Copies of the visual internal and external specifications with limits and pictures.
  (c) Show that Sprague complies to Paragraph 4.1.4.1. Data is not necessary.

(c) Request for extension of the present contract. This has been accomplished. (Letter dated 7/18/66) from Sprague's Mr. W. C. Donelan to NASA's T. Shoe). It was further agreed that the extension is contingent upon receipt of the Fourth Quarterly Report which includes a failure analysis report. A Program Plan must also be submitted.

(d) A-Pack qualification will continue, with the 70 units on Group D Life Test and the remaining 45 units on Group E, Sequential Life Test. NASA will advise us as to the acceptance of this qualification after review of the items of Step C.

(e) NASA will advise Sprague of the acceptability of the B-Pack proposal.

(f) NASA provided Jim Hearl with a copy of the electrical changes. These changes will be discussed and reviewed such that NASA will receive comments from Sprague by 8/1/66.

(g) NASA will advise Sprague on stamping of the acceptance units. Stamping of the qualification units is all right as is.

(h) NASA will also advise Sprague if the additional 52 units called out in the contract as our acceptance units may be in B Mech Pack with bent leads.

(i) Sprague will provide two X-Rays of the B-Pack acceptance units for qualification; one copy will be sent to NASA immediately; the second copy will be included in the final report. The X-Rays scheduled on 7/11 will be available for NASA approximately 7/15.

(j) Supply NASA the dimensions and tolerances Sprague can expect to hold on the B-Pack if they differ from the present specification.