STUDY OF FAILURE AND RELIABILITY OF MICROELECTRONIC DEVICES

13 QUARTERLY REPORT

14 February 1969

SINGER
LIBRASCOPE

STUDY OF FAILURE AND RELIABILITY OF MICROELECTRONIC DEVICES

13 QUARTERLY REPORT

14 February 1969

Prepared For

Electronics Research Center
National Aeronautics and Space Administration

Contract NAS 12-72

SINGER-GENERAL PRECISION, INC.
808 Western Avenue
Glendale, California 91201

2-0512

1.0 INTRODUCTION

This report is submitted to summarize work accomplished by Librascope on Contract NAS 12-72, Modification 2 during the calendar quarter ending 31 December 1968.

2.0 SUMMARY

In this reporting period, 1 October through 31 December, the following tests were completed in accordance with Test Procedure TR 1-1529 on 5 Groups of surface defect categories:

Vibration
Shock
Fine and Gross Leak
X-Ray Examination

The specimen defect categories tested were as follows:

Group II, Best Available
Group III, Surface Particles
Group IV, Surface Blemishes
Group V, Metalization Defects
Group VI, Bridging

The foregoing defect categories are defined in detail in Appendix A of Test Procedure TR 1-1529, submitted with the 11th Quarterly Report.

Without predicting the source or composition of the surface anomalies, or their possible effects, each category, without losing identification, was subjected to the foregoing environmental extremes and structural examinations. The intent is to accelerate any deleterious effects, especially those statistically identifiable with a surface defect category. Device performance is monitored by verifying selected d-c parameters following each environmental stress. The parameter measurement data has not thus far been statistically reduced but visual examination has revealed no catastrophic failures (open or shorted circuits). Two hundred fifty hours of the life test and measurement Point 11 have been completed.

3.0 ACCOMPLISHMENTS

3.1 Vibration All specimens of Groups II through VI were removed from their carriers and mounted in the fixture described in paragraph 3.2. The devices were subjected to 3 vibration cycles in each of their 3 major axes. Each cycle consisted of a logarithmic frequency sweep from 100 to 2000 to 100 at 30 g. Each sweep duration was 4 minutes. The purpose of the vibration exposure was to test structural integrity of the wire bonds and substrate and to induce migration of any contaminant particles. The specimens were examined for mechanical damage following the vibration exposures, and d-c parameters were measured asspecified in paragraph 4.2 of the Test Procedure (Measurement Point 8).

3.2 Shock Following post-vibration parameter measurements, all specimens of Groups II through VI were removed from their carriers and subjected to shock impacts in the Y_1 and Y_2 directions. The shock test was performed to verify integrity of wire bonds, substrate and substrate seal to the header. The shock pulse was calibrated at 1500 g with a duration of 1±1/2 millisecond and applied 5 times in each direction. For this test the specimens were installed in the mounting fixture depicted in Figure 3 of Test Procedure TR 1-1529. Compressibility of the 0.25-inch rubber pads was calibrated and spacers were fabricated to provide compression equivalent to or greater than the force exerted by the specimens at 1500 g. Thus an effectively rigid mounting was accomplished with the holding force uniformly distributed over the top and bottom surfaces of each device. Following the shock test the specimens were examined for mechanical damage and d-c parameters were verified as specified in paragraph 4.2, Test Procedure TR 1-1529 (Measurement Point 9).

3.3 Fine and Gross Leak All devices of Groups II through VII were tested for effectiveness of their seals following all previous environmental stresses. The test was performed by the Radiflo method, using Krypton 85 radioisotope, for dry gross leak and fine leak detection to

3.3 (Continued)

10^{-8} standard cc per second. The leak detection method was in accordance with Method 1014, Test Condition B, MIL-STD-883. Soak time was 30 minutes and activation pressure was 80 psia. One specimen serial number 613, indicated a leak rate of 1.7×10^{-8} standard cc per second while all others indicated less than 1×10^{-8}.

3.4 X-ray Examination All GroupsII through VII were x-rayed and the radiographs examined for defects within the case, foreign objects and seal anomalies. While the radiographic facilities used were capable of resolving .001-inch stainless steel they were unable to resolve the aluminum interconnect wires against the Kovar base-plate. The radiographs were examined at 5 X to 8 X magnification for observed voids or discontinuities at 4 locations; chip, seal, site and header. The results of this examination are summarized in the data sheets attached as Appendix A.

3.5 Post-Environmental Parameter Verification A subjective discussion of observed failures through the acceleration test (measurement Point 7) was included in the 12th Quarterly Report of 30 September 1968. Since completion of Measurement Point 7, 3 specimens of the Control Group have exhibited some parameter degradation without any environmental exposures. The following table summarizes, by device serial number, all failures observed by visual review of measurement data. The failure modes consist primarily of d-c parameter degradation with no trends identifiable with a surface defect category.

FAILURE SUMMARY- Devices displaying d-c parameter degradation at measurement point indicated	
Last Previous Environment	Serial Numbers
Acceleration MP-7	301
Vibration MP-8	102, 109 301
Shock MP-9	102 301 417
Initial Life Test MP-10	101, 102 301, 315 417, 450 537
Post 250 Hours MP-11	101, 102, 109 301, 315, 335, 417, 450, 531, 537, 620, 621, 648

3.5 (Continued)

The prevailing failure mode is excessive input load current (I_L) and failure of the output to go to a low state (V_{OL}).

The problem with V_{OL} is not related to the output circuit but results from an increase in the threshold level required to turn off the input transistor. Furthermore, the excessive input load current is caused by an apparent 70 to 80 -ohm leakage path in one direction, between emitters of the faulty input transistor. This failure mode is characteristic of a high leakage path between one emitter and the base of the input transistor under test. The failure mode described has occurred more than once in all groups except II (Best Available) and VI (Bridging) and, at this time, is not identifiable with a surface defect category.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Approximately 43,300 measurements have been compiled thus far and statistical reduction will be necessary to establish any meaningful trends or relationships. An accumulation of life test data should eventually identify the least desirable surface defect category.

The failure mode described in paragraph 3.4 is not identifiable with a defect category at this time, rather, it appears to be an infrequent occurrence among all the SG-140 specimens.

The marginal leak rate encountered on specimen number 613 is not considered significant.

The value of x-ray examination is limited by physical size and density of the specimen's internal structures and resolution of the x-ray equipment. The radiographs may prove useful however, in future failure analyses, when required.

Appendix A
Radiographic examination of SG-140 test specimens

GENERAL PRECISION SYSTEMS INC.
LIBRASCOPE GROUP

ENVIRONMENTAL LABORATORY DATA SHEET

TEST CONDITIONS: RADIOGRAPHIC EXAMINATION
IF RETEST CHECK ☐ OBSERVED VOIDS OR DISCONTINUITIES

S/N	CHIP	SEAL	SITE	HEADER					
204				X					
206	XXX								
301				X					
303		POOR							
304				XX					
305	POOR								
308	X								
312		P							
316	Lg X								
317		X							
318		XX							
324				XXX					
326		XX							
328				X					
331				X					
334	X			XX					
335		XX							
340		X							
342		BAD X							
344		Lg XX							
346	XX	X		X					

LEGEND:
X = EACH OCCURRENCE
Lg = LARGE
SM = SMALL
SL = SLIGHT
P = POROSITY

TEST CONDUCTED FOR		DATE 12-11-68
TEST	SAMPLE NUMBER	BAROM. PRESS. IN. HG.
PART NAME & NUMBER	TEST MEDIUM	WET BULB TEMP.
MANUFACTURER	TEST TEMP. C. ☐ F. ☐	DRY BULB TEMP.
ENGINEER [illegible] TECHNICIAN H. MONCHERYAN	INSPECTOR	
REF. SPEC.	DATA SHEET NUMBER 1 OF 4	

JOB NUMBER _____ PAGE OF TEST REPORT NO. _____

601-4
8/67

GENERAL PRECISION SYSTEMS INC.
LIBRASCOPE GROUP

ENVIRONMENTAL LABORATORY DATA SHEET

TEST CONDITIONS: RADIOGRAPHIC EXAMINATION
IF RETEST CHECK ☐ OBSERVED VOIDS OR DISCONTINUITIES

S/N	CHIP	SEAL	SITE	HEADER					
401		X		X					
403		Lg XX							
406	P								
407	Sm X								
408		Sm X							
412				P					
414				Smxx					
415				Sm xx					
419				SLP					
420				SLP					
422		X KOVAR							
428	Sm xx								
430			X						
432				SLP					
433				SLP					
438			P						
501	X			XX					
502	X	X	X	X					
506			Sm X						
507			Lg X						
509			Lg X						
511				SLP					
519	SL X	X							

TEST CONDUCTED FOR		DATE 12-11-68
TEST	SAMPLE NUMBER	BAROM. PRESS. IN. HG.
PART NAME & NUMBER	TEST MEDIUM	WET BULB TEMP.
MANUFACTURER	TEST TEMP. C. ☐ F. ☐	DRY BULB TEMP.
ENGINEER FGH / TECHNICIAN H. MUNCHERYAN	INSPECTOR	
REF. SPEC.	DATA SHEET NUMBER 2	

JOB NUMBER _____ PAGE OF TEST REPORT NO. _____

601-4
8/67

GENERAL PRECISION SYSTEMS INC.
LIBRASCOPE GROUP

ENVIRONMENTAL LABORATORY DATA SHEET

TEST CONDITIONS: RADIOGRAPHIC EXAMINATION
IF RETEST CHECK ☐ OBSERVED VOIDS OR DISCONTINUITIES

S/N	CHIP	SEAL	SITE	HEADER					
520				X					
523	BAD X								
528	X	Lg X							
530		X							
533	P	P	P	P					
534		Lg X							
535	P	P	P	P					
538	P								
545	P	P	P	P					
550	P								
601	SL X								
602	XX								
609	Lg X								
611		X							
612	P			P					
617		X							
618			X						
622	Sm X			Lg X					
627		X							
631	P	P	P	P					
632	P	P	P	P					
637			X						
639				X					

TEST CONDUCTED FOR		DATE 12-11-68
TEST	SAMPLE NUMBER	BAROM. PRESS. IN. HG.
PART NAME & NUMBER	TEST MEDIUM	WET BULB TEMP.
MANUFACTURER	TEST TEMP. C. ☐ F. ☐	DRY BULB TEMP.
ENGINEER [illegible]/H. MUNCHERYAN TECHNICIAN	INSPECTOR	
REF. SPEC.	DATA SHEET NUMBER 3	

JOB NUMBER _____ PAGE OF TEST REPORT NO. _____

601-4
8/67

GENERAL PRECISION SYSTEMS INC.
LIBRASCOPE GROUP

ENVIRONMENTAL LABORATORY DATA SHEET

TEST CONDITIONS: RADIOGRAPHIC EXAMINATION
IF RETEST CHECK ☐ OBSERVED VOIDS OR DISCONTINUITIES

S/N	CHIP	SEAL	SITE	HEADER					
642				X					
649	P								
650		X							

TEST CONDUCTED FOR			DATE 12-11-68
TEST		SAMPLE NUMBER	BAROM. PRESS IN. HG.
PART NAME & NUMBER		TEST MEDIUM	WET BULB TEMP.
MANUFACTURER		TEST TEMP. C. ☐ F. ☐	DRY BULB TEMP.
ENGINEER	TECHNICIAN FGH/H. MUNCHERYAN	INSPECTOR	
REF. SPEC.		DATA SHEET NUMBER 4	

JOB NUMBER _____ PAGE OF TEST REPORT NO. _____

601-4
8/67