On 14 July 1971 MSC issued an ALERT (MSC-71-04) on Texas Instruments 54L series integrated circuits. This ALERT indicated that devices manufactured prior to the second week of August 1971 may contain conductive particulate contaminants. Subsequently Bendix received LSPO letter EH2/10-8/L-505/B requesting a response as to the usage and the potential hardware impact on Array E. This ATM reviews the problem and summarizes the BxA response activities.

Revision A reflects the anticipated distribution of screened devices in Array E hardware, additional parts screening and failure analysis results, and a comparison of different logic devices and assembly areas at TI-Dallas.

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INTRODUCTION

The Texas Instruments Series 54L is a low power TTL (Transistor - Transistor) logic family. The nominal power consumption of these devices is one milliwatt per gate as opposed to 10 milliwatts per gate in standard power devices. They are available in three package configurations:

a) Metal Flatpack -- 0.26 x 0.15 x 0.05 inches
b) Ceramic Dual-In-Line -- 0.78 x 0.31 x 0.20 inches
c) Plastic Dual- In-Line -- 0.77 x 0.30 x 0.20 inches

with these metallizations:

a) Metal Flatpack: (F, H, R, S, T styles)	platinum - molybdenum - gold gold interconnecting wires no passivation
b) Cer. Dual-In-Line: (J style)	aluminum metalization aluminum interconnecting wires glass passivation
c) Plas. Dual-In-Line:	aluminum metalization gold interconnecting wires glass passivation

and with these reliability levels available:

a) SN 54L	- Commercial grade
b) SNM54L	- Class C per MIL-STD-883
c) SNA54L	- Not defined in MIL-STD-883
d) SNC54L	- Class B per MIL-STD-883
e) SNH54L	- Class A per MIL-STD-883
f) SM 54L	- per MSFC 85 MO 3766

(A summary of the screening requirements for these various reliability level devices is contained in Attachment A.)

The TTL-type integrated circuits offer many advantages over the DTL or Diode-Transistor type logic used in earlier ALSEP hardware. The TTL is faster then DTL, has a greater variety of circuit configurations available, and has more circuitry available in a given package, resulting in:

a) Higher Reliability
b) Simpler Design
c) Lower Weight
d) Smaller Volume
e) Lower susceptability to noise (in the zero input condition)

For the Array E ALSEP program, Bendix procurred 54 L devices from TI in accordance with the requirements of our SCD 2346201, Rev. B. The requirements of this SCD exceed those in the Marshall Specification MSFC 85 MO 3766. The flatpack package configuration was selected which has the platinum - molybdenum - gold metallization. Due to this complex metal system TI does not provide die surface passivation as is common with most aluminum metallization integrated circuits. Therefore, while this metal system does offer a number of advantages, the lack of passivation leaves the devices susceptible to particle induced failures.

ALERT NOTIFICATION

Bendix received MSC ALERT 71-04* on 14 October 1971 attached to LSPO letter EH2/10-8/L505/B requesting a response relative to the applicability and potential impacts on the ALSEP program. This ALERT states that Texas Instruments Series 54 L devices manufactured prior to the second week of August 1971 may have conductive, particulate contaminants which can cause internal shorting.

Subsequent to several failures on the Apollo J-Mission tape recorder data conditioner at Motorola G. E. D., which were attributed to conductive particles, a survey of the Texas Instruments Dallas facility was taken which confirmed that these devices were not assembled and inspected in a rated clean area. Since that survey, TI has instituted several process steps which were effective the first of August which significantly reduces the incidence of particles in the 54L devices.

The first evidence of the 54L conductive particle problem on the ALSEP program appeared in the Teledyne Telmetry transmitter. An SM 54LOOF device failed short during a Flight Acceptance test on 4 November 1971. Failure analysis was performed at TI's Dallas facility at the request of TTC's reliability department. The internal short which had appeared during a monitored vibration test was caused by a loose piece of gold preform found inside the device.

*see Attachment B for ALERT

The next failure occurred in the Command Decoder during an in-process test on 10 November 1971. The failed part was taken to the Goddard Space Flight Center for analysis by ALSEP Reliability personnel. The failure was caused by an iron particle which formed a "hard" short between metallization paths on the die. (see Attachment C for the detailed report).

Within the next few days, several 54L devices failed in-process tests at Bendix. At about this time ALSEP Reliability initiated a full--scale investigation, looking into the failure and part rejection history of the devices procured for the Array E program. In addition, a parts tracking and usage survey was prepared in order to account for each 54L part handled by Bendix for Array E hardware. (Attachment D contains a parts usage/tracking survey and a failure/rejection summary of the 54L devices).

A special NASA/BxA program review meeting on the impact of the 54L ALERT on the Array E program was held on 18 November. At this meeting, a summary of the TI 54L problem was presented, which included the ALERT history, the BxA failure experience, and Array D and Array E usages. A conductive particle screening method developed at North American's Autonetics Division was reviewed and discussed. Based on this discussion and those held on 19 November, MSC directed BxA as follows:

a) The ALSEP Array E program will continue by plan on all assemblies currently assembled containing 54L parts manufactured prior to the 32nd week of 1971.

b) Failure Analysis will be performed on the those failed chips now at BxA.

c) All 54L parts not in assemblies will be sent to Autonetics for prescribed screening.

d) All parts failed in Autonetics screening will be subjected to failure analysis.

e) Further action on items assembled in Qual and Flight hardware will be determined based on Autonetics testing of both the BxA parts and the lots provided from other users. BxA to collect data from Autonetics.

f) Specific attention to functional performance of all electronics assemblies using 54L parts will be made during operating vibration all failures will be processed in normal fashion.

g) All 54L parts found discrepant will be handled formally.

h) BxA will provide and update periodically a performance/failure Matrix.

A daily tracking of 54L parts failures at BxA, testing at Autonetics, failures at Autonetics, and other pertinent status of these devices was initiated on 22 November 1971. Throughout the rest of November and December of 1971 status meetings were held by Reliability each Monday, Wednesday, and Friday to co-ordinate the 54L IC tracking and parts availability with Manufacturing, Engineering, Quality and Material Control.

NAA SCREENING

There are several common screening tests oriented to detecting particles in electrical components: pre-cap visual inspection, monitored vibration, particle impact noise detection, and x-ray. Due to the close metallization paths, such as 0.3 mils on the Series 54L chip, particles large enough to cause failure are quite often small enough to escape these screens. However North American's Autonetics (NAA) division developed a monitored vibration/shock test for particle screening of integrated circuits on the Minutemen program.

The NAA screen consists of a conventional monitored vibration test with a mechanical shock impulse superimposed. The chips are vibrated in the "plane" of the die at 23 cps, and a 175 g shock pulse of 10 milliseconds duration is imparted normal to the plane of the die once every 7 seconds. It is intended that the vibration will move any particles around on the die surface, and the shock pulse will overcome electrostatic charges that build up after four or five impacts during vibration and cause the particles to "stick".

To evaluate the extent of TI Series 54L particle contamination and to evaluate the effectiveness of the Autonetics screens, MSFC and MSC personnel collected 120 devices and submitted them to NAA for screening. Of these 120 pieces 43 of them were manufactured after TI became particle conscious and began instituting corrective actions. Of the 120 devices tested, 8 failed, and it was noted that each of the failed parts was manufactured prior to May 1971. With the large number of failures experienced during the first test, it was decided to subject 65 of the "good" units to vibration again. There were no additional failures during the second run. These results provide a high degree of confidence that the Autonetics monitored vibration/shock test is highly effective in detecting particle contaminated devices.

A particularly important result of the tests performed for MSFC and MSC is the high failure rate of 54L95 devices; 4 of the 8 failures were 54L95. This high failure rate may be attributed to two major factors:

a) Increased complexity which requires more metallized paths that are also closer together.

b) Larger semiconductor die which requires a preform to be used during die mounting. This preform is a source for potentially loose slag.

There are two additional device-types that must be placed in the category of the 54L95 relative complexity and use of gold preforms. These are 54L91 and 54L93.

(A detailed discussion of this problem which was prepared at NAA is contained in Attachment E.)

RESULTS OF BXA SCREENING AT NAA

Following the program review meeting in late November 1971, all 54L series devices (BxA P/N 2346201-XX) were removed from bonded stores, incoming inspection, and PC board kits that were in-process or were awaiting fabrication. Altogether, 2196 parts, 1901 from BxA and 295 from subcontractors, were collected for shipment to NAA for the monitored vibration/shock screening test. Subsequent to these initial screening tests, 36 54L00 devices from Array D residual stock, and 220 devices from a 1972 rebuy were also sent to NAA.

28 Bendix and 3 subcontractor devices failed the vibration test. Each failed device was analyzed to determine failure mode and to verify the presence or absence of conductive particles. After a curve trace check was performed and anomalies noted, each device was decapped and examined for particles under a Scanning Electron Microscope. The contaminants found were then identified under the Microprobe as follows: Silicon, Silicon dioxide, Kovar, Gold, Gold slag, Copper, Aluminum, and organic materials. Attachment F contains a detailed summary of the vibration failures.

In addition to the monitored vibration screening given each device, a gross and a fine leak test were performed at NAA. These tests were added to the screening requirements to assure that handling and the vibration/shock testing did not degrade the hermetic seal of these devices.

Of the 2129 Bendix and 292 subcontractor parts that passed the monitored vibration test, 14 Bendix and 70 subcontractor parts failed the subsequent hermeticity test. However, it is believed that 61 of the subcontractor's parts which indicated a gross leak were not failures, and that the apparent leak can be attributed to either the double-sided tape on the bottom of the flatpack or a blue dot which is under the tape (see Attachment G for further discussion).

A detailed summary of the first 18 hermeticity failures has been published in BxA internal memorandum 9721-2706. This letter and a tracking summary showing all NAA hermeticity failures is contained in Attachment H.

Upon completion of the Autonetics screening, 10 pieces randomly selected from those which had successfully passed were returned to NAA for a screening effectiveness evaluation. Each device was examined with a curve tracer and then given a dye-penetrant leak test; the parts were then decapped, and given a thorough visual examination. (See Table I below)

Three devices exhibited soft knee breakdowns on the curve tracer, which should have been sharp; however, these devices do function normally. None of the 10 devices showed any evidence of a dye-penetrant leak, although three had poor lid welds due to uneven weld surfaces. Eight of the ten devices were contaminant-free, the other two contained conductive particles. Slag was found in varying degrees in the bottom of each package; this was due to oxidation of the silicon-gold eutectic when the die was "scrubbed-in".

TABLE I (10 Control Parts)

Type	Date Code	S/N	Curve Trace	Particle Anal.	Seal Anal.	Dye Pentetrant
54L04	7108A	150Z	lead 12 (+) to 11 (-) soft junction break down	good	Poor lid weld	Passed
54L04	7108A	121Z	lead 2 (+) of 6 (+) to 11 (-) soft junction break down	good	Poor lid weld	Passed
54L10	7112A	337Z	good	good	good	Passed
54L10	7113A	237Z	good	good	good	Passed
54L20	7114A	219Z	good	excessive gold slag. One 10 mil particle	good	Passed
54L20	7114A	069Z	good	good	good	Passed
54L93	7123A	333Z	good	good	Poor lid weld	Passed
54L73	7108A	133Z	good	good	good	Passed
54L95	7111A	039Z	good	2 Kovar particles & 1 glass	good	Passed
54L95	7111A	038Z	Pin 6 to VCC soft junction break down	good	good	Passed

PARTS REPLACEMENT

The ALERT MSC-71-04 recommends that for high reliability space applications, the 54L - Series devices ". . . should be subjected to an effective screening test for conductive particles." Subsequent to this ALERT, the MSFC ALERT (MSFC-71-21)* was issued which contained a more definitive recommendation:

"In all single failure point applications, all 54L91, 54L93, and 54L95 devices, regardless of date of manufacture, should be replaced with devices that have successfully passed the monitored vibration/shock test.

"In critical single failure point applications, all other TI 54L devices manufactured prior to 28 July 1971 should be replaced with devices that have successfully passed the monitored vibration/shock test."

(With the exception of a few 54L00, 54L04, and 54L93 devices, all 54L series integrated circuits in Array E hardware were manufactured prior to 28 July 1971).

To determine the effect of a 54L IC failure in the Array E ALSEP, the location and application of each IC was reviewed and a criticality assigned according to the following table:

Criticality	Effect of Device Failure
1	Loss of system
2	Loss of experiment
3	Data loss in Central Station degrading more than one experiment
4	Loss of redundancy
5	Partial science data loss within an individual experiment
6	Engineering data loss

*see Attachment I for ALERT

The results of this criticality analysis were issued on 3 December 1971 in the "ALSEP 54L Summary". This document has been periodically updated through revision H (BxA internal memorandum 9721-2780) and forwarded to MSC; see Attachment L for the results of the criticality analysis. Table 2 on page 10 summarizes the anticipated distribution of screened 54L devices in Array E hardware.

The criticality analysis revealed potential single-point failure modes in both the command decoder and data processor. These modes were removed by redesign of the D/P board 2349445 and C/D boards 2367625 and 2370075.

Based on the criticality analyses and the results of the NAA screening, BxA was directed by MSC to:

1) Use the existing Array E qual hardware with no 54L parts swap out.

2) Do no rework of already-build C/S flight hardware; these boards completed will be redesignated flight spare.

3) Build all C/S flight components using flight spare PC boards and NAA screened 54L parts.

4) Build/rework all LSG boards with NAA screened parts.

5) Make no 54L change outs in the LSP experiment.

6) Build LMS boards 2347540, 2347550, and 151-550 (UTD) with NAA screened parts; the one 54L00 device on board 2347555 will be a screened device.

7) Build a new 18 layer board for LEAM with NAA screened parts.

8) Replace all 54L parts that fail in Qual and Flight hardware with NAA screened parts.

9) Rework the Array D MUX spare with NAA screened parts.

Texas Instruments expects to introduce a modified low power 54 series device with quartz passivation sometime in late 1972. Until that time all new procurements and rebuys of 54L integrated circuits will require the NAA monitored vibration/shock screening.

TABLE 2

16 December 1971
Rev.(1) 24 January 1972
Rev.(2) 7 February 1972
(3) 28 March 1972

PLANNED ARRAY E 54L FLIGHT PART UTILIZATION
SHOWING PERCENT OF VIBRATION/HERMETIC SCREENED PARTS

Item	Board #	Crit 1 Parts	%	Crit 2 Parts	%	Crit 3 Parts	%	Crit 4 Parts	%	Crit 5 Parts	%	Crit 6 Parts	%
LSG	*BD#1	0	-	31	100	0	-	0	-	0	-	0	-
	*BD#2	0	-	13	100	0	-	0	-	4	100	0	-
	*BD#3	0	-	4	100	0	-	0	-	0	-	0	-
	*BD#4	0	-	23	100	0	-	0	-	0	-	0	-
	*BD#6	0	-	4	100	0	-	0	-	0	-	0	-
	*BD#8	0	-	1	100	0	-	0	-	2	100	0	-
	*14A1-A2	0	-	0	-	0	-	0	-	30	100	0	-
	*Subtotal	0	-	76	100	0	-	0	-	36	100	0	-
LMS	*2347550	0	-	0	-	0	-	0	-	75	100	0	-
	*2347540	0	-	21	100	0	-	0	-	2	100	11	100
	**2347555	0	-	1	100	0	-	0	-	0	-	22	0
	151-660(UTD)	0	-	0	-	0	-	0	-	4	0	1	0
	151-686(UTD)	0	-	26	0	0	-	0	-	2	0	0	-
	*151-550(UTD)	0	-	2	100	0	-	0	-	0	-	0	-
	Subtotal	0	-	50	48	0	-	0	-	83	93	34	33
LEAM	2 Dual Sensors	0	-	0	-	0	-	0	-	16	0	0	-
	Single Sensor	0	-	0	-	0	-	0	-	5	0	0	-
	BD#1 (Matrix)	0	-	2	0	0	-	0	-	0	0	0	-
	BD#2 (Matrix)	0	-	1	0	0	-	0	-	0	0	0	-
	*18 Layer Logic	0	-	3	100	0	-	0	-	64	100	0	-
	Power Supply	0	-	1	0	0	-	0	-	0	-	0	-
	Subtotal	0	-	7	43	0	-	0	-	85	75	0	-
LSPE	2347815(BD#1)	0	-	46	0	0	-	0	-	0	-	0	-
	2347825(BD#2)	0	-	22	0	0	-	0	-	0	-	0	-
	2347835(BD#3)	0	-	23	0	0	-	0	-	0	-	30	0
	8 EPA's	0	-	0	-	0	-	0	-	32	0	0	-
	2346710(MUX)	0	-	0	-	0	-	0	-	4	0	0	-
	2346720(A/D-A)	0	-	2	0	0	-	0	-	0	-	0	-
	2346725(A/D-D)	0	-	7	0	0	-	0	-	1	0	0	-
	Subtotal	0	-	100	0	0	-	0	-	37	0	30	0
CMD. DCDR.	*2367652(Demod)	0	-	0	-	0	-	22	100	0	-	0	-
	*2367625(Decode)	0	-	0	-	50	100	42	100	0	-	0	-
	*2370075(Contrl)	0	-	2	100	0	-	56	100	0	-	0	-
	*2367615(Seq)	0	-	6	100	0	-	33	100	0	-	0	-
	*Subtotal	0	-	8	100	50	100	153	100	0	-	0	-
Data Proc. (incl. 90 Chan. MUX)	*2349445(A/D)	0	-	0	-	0	-	24	100	0	-	0	-
	*2349455(INTFC)	0	-	10	100	0	-	0	-	0	-	0	-
	*2349450(T/CW)	0	-	0	-	0	-	90	100	0	-	0	-
	*2349415(Demand)	0	-	0	-	0	-	80	100	0	-	0	-
	*Subtotal	0	-	10	100	0	-	194	100	0	-	0	-
PCU	*2370060	0	-	0	-	0	-	2	100	0	-	0	-
PDU	*2362800	0	-	0	-	0	-	2	100	0	-	0	-
XMITTER	SYNTHESIZER	0	-	0	-	0	-	2	0	0	-	0	-
ALSEP Syst. (ARRAY E)	TOTAL	0	-	251	48%	50	100%	353	99%	241	73%	64	17%

*Indicates item will contain 100% screened parts for Flight.
**Indicates item will be reworked to use screened parts in most critial applications for Flight.

Note 1 - Criticality numbers: 1 = Loss of system, 2 = Loss of experiment, 3 = Data loss in C/S degrading more than one experiment, 4 = Loss of redundancy, 5 = Partial science data loss for an individual experiment, 6 = Engineering data loss.

Note 2 - The percentage of screened parts in the system for criticality 2 would increase from 48% to 60% if the system uses all screened parts except for LSPE.

Note 3 - In the event of part failure, vibration screened parts will be used for replacement on Flight (and Qual) regardless of this plan.

DEVICE DIFFERENCES/NEW PROCUREMENTS

In response to a MSC request for information on possible differences in the manufacture of logic devices for the Minuteman program and NASA programs, Bendix Reliability visited TI-Dallas to survey the assembly area and ascertain what differences exist. This survey/review revealed that different assembly areas do exist, due to differences in logic construction and specification requirements. The design differences are the primary reasons for the different assembly lines, and the MSFC 85 MO 3766 specification does not require clean room assembly areas.

Texas Instruments expects to introduce a modified low power, 54 series device in the second half of 72. A tungsten-titanium alloy will replace the molybdenum in the present moly-gold system, making quartz passivation feasible and thus eliminating the conductive particle problem. With the moly-gold system, quartz passivation is not feasible without an extra layer of molybdenum, which cannot be used because the etching of the added layer undercuts the original moly layer.

(The above mentioned differences are discussed in Bendix Letter #72-970-5365 to MSC; this letter can be found in Attachment K of this document).

Bendix recently procured additional quantities of several 54L devices to replenish the depleted supply available in ALSEP stores, which was caused by the replacement of many non-screened flatpacks and the rebuilding of several PC boards containing 54L devices. To facilitate timely deliveries of these replacement parts, the Bendix and GSI pre-cap inspection were waived. Therefore, to determine the acceptability of these devices for use in Array E hardware, Bendix Reliability visited TI-Dallas to review the in-process screening results, subsequent to capping, and to compare them with previously procured devices. The parts were found acceptable. A copy of the report to MSC has been included in this document as Attachment J.

SUMMARY

On 14 July 1971, MSC issued an ALERT on Texas Instruments 54L - series integrated circuits. This ALERT indicated that devices manufactured prior to the 2nd week of August 1971 may contain conductive, particulate contaminants. On 14 October 1971 Bendix received LSPO letter EH2/10-8/ L505/B requesting a response as to the usage and the potential hardware impact on Array E.

The first proof of this failure mode existing in ALSEP hardware appeared in the TTC transmitter on 4 November 1971. Subsequently several devices failed during assembly of central station components at Bendix. At this time ALSEP Reliability initiated a 54L parts usage and tracking survey to determine the exact status of all PC boards containing 54L parts, the number of rejected parts, the number of failed parts and the quantity of parts remaining in stores available for special screening.

Bendix was directed by MSC to stop work on all PC boards not complete and not yet started, and to send all available IC's to North American's Autonetics division for the monitored vibration/shock screening test, which had been developed for the Minuteman program. 1.3% of the 2452 devices screened failed the test, and another 3.4% failed gross and/or fine leak testing. All of the 31 vibration failures exhibited the failure mode defined in the MSC ALERT 71-04.

A Criticality analysis of the application of the each device in Array E hardware was performed to help provide a rational basis for swapping out or leaving each IC unchanged. This analysis also revealed several single point failure modes in both the command decoder and the data processor; these were removed with minor design changes on three PC boards. All critical parts in Flight hardware were replaced or the PC boards were rebuilt. In the qualification hardware, only devices that fail during in-process testing (and subsequent) are being replaced with screened parts.

Bendix Reliability visited TI-Dallas to ascertain the effect and/or possible impact of differences existing between the assembly lines for the MSFC 85 MO 3766 devices and those for the Minuteman program. The differences in the two lines reflect primarily the difference in logic construction and design of the two device types; in addition, the Minuteman devices are assembled in a clean room environment, a requirement which is not imposed in the MSFC spec.

Texas Instruments expects to introduce a modified 54L device having quarts passivation sometime in late 1972. Until such time that a qualified, passivated device is available, all rebuys, as well as new procurements, will require the monitored vibration/shock screening at NAA.

COMPARISON OF TEXAS INSTRUMENTS RELIABILITY LEVELS AVAILABLE FOR 54-SERIES DEVICES

SN54--	SNM54--	SNA54--	SNC54--	SNH54--
STANDARD FLAT PACK	CLASS C (LEVEL I, SNM)	CLASS C + (LEVEL II, SNA)	CLASS B (LEVEL III, SNC)	CLASS A (LEVEL IV, SNH)
40 X precap	40 X precap	40 X precap	40 X precap	40 X precap
	100 X precap Condition B	100 X precap Condition B	100 X precap Condition A	100 X precap Condition A
Final Seal	Final Seal	Final Seal	Final Seal	Final Seal
48 hour bake	48 hour bake	48 hour bake	48 hour bake	48 hour bake
				Thermal Shock
Temp Cycle	Temp Cycle	Temp Cycle	Temp Cycle	Temp Cycle
				Mech Shock 1500 G's
Centrifuge 20K G's	Centrifuge 30K G's	Centrifuge 30K G's	Centrifuge 30K G's	Centrifuge 30K G's 2 planes
Fine Leak 5 X 10^{-7}	Fine Leak 5 X 10^{-7}	Fine Leak 5 X 10^{-7}	Fine Leak 1 X 10^{-8}	Fine Leak 1 X 10^{-8}
Elect. Test DC @ -55°, 25°, 125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C
Gross Leak (Ethylene Glycol)	Gross Leak (883)	Gross Leak (883)	Gross Leak (883)	Gross Leak (883)
		Burn-in 168 hours	Burn-in 168 hours	Burn-in 240 hours
		Elect. Test DC @ -55° + 125°C	Elect. Test DC @ -55° +125°C	Elect. Test DC @ -55° & +125°C
Elect. Test AC (Sample bias)	Elect. Test AC @ +25°C	Elect. Test AC @ +25°C	Elect. Test AC @ 25°C	Elect. Test AC @ +25°C
				X Ray
Group A Lot Acceptance	Group A Lot Acceptance	Group A Lot Acceptance	Group A Lot Acceptance	Group A Lot Acceptance
Final Visual (Sample basis)	Final Visual	Final Visual	Final Visual	Final Visual
Pack	Pack	Pack	Pack	Pack
	Certificate of Compliance	Certificate of Compliance	Certificate of Compliance	Certificate of Compliance
Ship	Ship	Ship	Ship	Ship

This information applies to 54-series devices with date codes "prior to 7040."

NOTES: 1. Pre-cap conditions A & B per requirements of MIL-STD-883, Test Method 2010.

2. Circles denote changes in requirements at various reliability levels.

FROM: TI TTL Marketing News Letter, December 11, 1969.

Attachment A (Sheet 1 of 3)

SN54--	SNM54--	SNA54--	SNC54--	SNH54--
STANDARD FLAT PACK	CLASS C (LEVEL I, SNM)	CLASS C + (LEVEL II, SNA)	CLASS B (LEVEL III, SNC)	CLASS A (LEVEL IV, SNH)
40 X precap	40 X precap	40 X precap	40 X precap	40 X precap
	100 X precap Condition B	100 X precap Condition B	100 X precap Condition B	100 X precap Condition A
Final Seal	Final Seal	Final Seal	Final Seal	Final Seal
48 hour bake	48 hour bake	48 hour bake	48 hour bake	48 hour bake
				Thermal Shock
Temp Cycle	Temp Cycle	Temp Cycle	Temp Cycle	Temp Cycle
				Mech Shock 1500 G's
Centrifuge 20K G's	Centrifuge 30K G's	Centrifuge 30K G's	Centrifuge 30K G's	Centrifuge 30K G's 2 planes
Fine Leak 5×10^{-7}	Fine Leak 5×10^{-8}	Fine Leak 5×10^{-8}	Fine Leak 5×10^{-8}	Fine Leak 5×10^{-8}
Elect. Test DC @ -55°, 25°, 125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C	Elect. Test DC @ -55°, 25°, +125°C
Gross Leak (Ethylene Glycol)	Gross Leak (883)	Gross Leak (883)	Gross Leak (883)	Gross Leak (883)
		Burn-in 168 hours	Burn-in 168 hours	Burn-in 240 hours
		Elect. Test DC @ -55° + 125°C	Elect. Test DC @ -55° +125°C	Elect. Test DC @ -55° & +125°C
Elect. Test AC (Sample bias)	Elect. Test AC @ +25°C	Elect. Test AC @ +25°C	Elect. Test AC @ 25°C	Elect. Test AC @ +25°C
				X Ray
Group A Lot Acceptance	Group A Lot Acceptance	Group A Lot Acceptance*	Group A Lot Acceptance	Group A Lot Acceptance
Final Visual (Sample basis)	Final Visual	Final Visual	Final Visual	Final Visual
Pack	Pack	Pack	Pack	Pack
	Certificate of Compliance	Certificate of Compliance	Certificate of Compliance	Certificate of Compliance
Ship	Ship	Ship	Ship	Ship

This information applies to 54-series devices with date codes 7040 and later.

NOTES: 1. Pre-cap conditions A & B per requirements of MIL-STD-883, Test Method 2010.1

2. Circles denote changes in requirements at various reliability levels.

FROM: TI TTL Marketing Newsletter, Dec. 11, 1969; MACH IV Rev. A, Bulletin, September 28, 1970

Attachment A (Sheet 2 of 3)

MSFC 85MO3766
SCREENING REQUIREMENTS

1. Pre-cap visual inspection (per requirements of MIL-STD-883, Method 2010 A, Condidition A)
2. High temperature stabilization bake: 48 hours at 200°C
3. Temperature cycling: -65°C to +150°C, 10 cycles
4. Acceleration: 30,000 G, Y_1 Axis
5. Fine leak test: $< 1 \times 10^{-8}$ STD cc/sec
6. Gross leak test
7. Serialization
8. Electrical test: DC at 25°C
9. Burn-in: 240 hours at +125°C
10. Electrical test: DC at -55°C, 25°C, +125°C, AC at 25°C
11. Delta calculations at 25°C
12. X-ray: MSFC spec. 355B
13. QA lot acceptance: Electrical AQL 1% (if read and record data is not available at -55°C and +125°C)
14. External visual
15. QA preship inspection

Attachment A
(Sheet 3 of 3)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ALERT

(Reporting Parts and Materials Problems)

1. GENERIC CLASSIFICATION: Microelectronic Circuit Flatpack

2. ALERT NO.: MSC-71-04

3. DATE: DAY 14 MO. 7 YEAR 71

4. MANUFACTURER AND ADDRESS: Texas Instruments, Dallas, Texas

5. PROCUREMENT SPECIFICATION: Various (See 10.)

6. REFERENCE:

7. MANUFACTURER'S DESIGNATION: SN-54L-Series (See 10.)

8. LOT/DATE CODE OR SERIAL NO.: 7017, 7020, 7039

9. SPECIAL REQUIREMENTS OR ENVIRONMENT *(Requirements placed on or extreme environment to which item was exposed.)*

One failure occurred during equipment qualification vibration testing; two failures occurred during first energization of devices in equipment.

10. PROBLEM SITUATION AND CAUSE *(State facts of problem and cause – failure mode and mechanism – project and function)*

Investigation of 3 failures of 54L-Series integrated circuits used in the Apollo J-Mission tape recorder data conditioner revealed conductive metallic contamination in the devices. The parts involved are:

1. SN 54L04T-11 Date Code 7020A
2. SNC 54L73T Date Code 7017A
3. SM 54L95R-1 Date Code 7039A - (manufactured to the requirements of MSFC specification 85 MO 3766).

11. ACTIONS TAKEN *(State all actions taken to correct the problem situation.)*

Nine (9) devices, SNA 54L73T, Date Code 7017A, were opened and examined for metallic contamination. Conductive particles were found in 4 of these devices, however, the method used to open them is suspect of generating contamination.

A survey of the Texas Instruments Dallas facility confirmed that these devices were not assembled and inspected in a rated clean area, even though the production line was certified by NASA to the requirements of MSFC specifications 85M03766 and 85M03877. Texas Instruments has instituted several process steps to be effective the second week of August, 1971, intended to reduce the incidence of particles in series 54L devices.

CONTINUED ON NEXT PAGE

12. RECOMMENDATIONS FOR FURTHER ACTION *(Suggestions to prevent recurrence.)*

For high reliability space applications, 54L-Series devices should be procured, as a minimum, to the "H" level of Texas Instruments' MACH IV reliability specification, or equivalent, and should be subjected to an effective screening test for conductive particles (such as the screen developed by Autonetics for this type failure mechanism).

13. CONTACT POINTS FOR INFORMATION *(Name, affiliation, telephone)*

V. Schwab AC 602, 949-3865
Motorola Government Equipment Division, Scottsdale, AZ

14. MANUFACTURER NOTIFIED: DAY 4 MO. 5 YEAR 71

15. ALERT COORDINATOR *(Name, affiliation)*

B. M. Stewart, Reliability Division
Manned Spacecraft Center, Houston, Texas

16. SIGNATURE OF ALERT COORDINATOR: Billy M. Stewart

17. GENERIC CLASSIFICATION: Microelectronic Circuit, Flatpack

18. ALERT NO.: MSC-71-04

19. GIDEP INDEX NO.: [illegible]

11. ACTIONS TAKEN

MSFC has reinstated the certification of the facility through September, 1971, based on these process improvements. The effectiveness of these process changes has not yet been evaluated on the product.

Attachment B

Internal Memorandum

Bendix Aerospace Systems Division

Date 12-22-71 Letter No. 9721-2660 Ann Arbor, Michigan

To S. J. Ellison

From R. Dallaire

Subject Trip report to Goddard for 54L failure analysis, Nov. 10, 1971

Four 54L parts have failed in Array E. The first was the Teledyne Transmitter failure. Second and third, which failed in the C/S buildup, were electrically tested before opening at BxA. One had a broken bond wire, and the other cause of failure could not be determined.

Alert MSC-71-04 was received prior to the fourth failure being decapped. This part failed in the Command Decoder and had an apparent internal short. Since BxA has no facilities for opening these 54L parts without adding contamination, the fourth failed part was not opened at BxA. It was extensively tested electrically before being taken to Goddard Space Flight Center.

The failure analysis at Goddard went as follows:

1. The failed part was given a sine vibration sweep, 10Hz to 20KHz, 20 g's, for 15 minutes in the Z_1 Plane. If the failure was due to a loose particle contaminant, it would have shaken loose.

2. The part was electrically tested. The test verified that the failure mode was unchanged.

3. After testing the decapping method on a similar good part, the failed part was carefully decapped by grinding away the top edges and peeling off the lid. The contaminants that could be introduced (if any) would be Silicon Carbide or Kovar.

4. Both opened units were examined optically. The general appearance of both devices was good although the post bonds appeared to be slightly over bonded. One large (approx. 1.5 mils x .5 mils) particle contaminate was found in the failed part which could not be dislodged with a nitrogen blow. This particle was bridging two metal runs (see the attached photos).

5. The parts were then examined under a Scanning Electron Microscope (SEM) which confirmed the existence of the particle and did not reveal any others.

Attachment C
(Sheet 1 of 4)

9721-2660
12/22/71
Page 2

6. The failed part was then analysed under a Microprobe for X-ray spectral analysis. The contaminant was determined to be at least 95% pure iron. No traces of gold, nickel, cromium, or colbalt was found. Therefore the contaminant particle could not have been introduced by opening the part.

7. By tracing through the circuitry on the chip, the location of the short in the circuit on the circuit diagram was determined. The theoretical failure mode introduced by a short in this position exactly duplicated the observed failure mode. Figure 1 shows the location of the short in the circuit diagram.

8. A partial Autonetic vibration screen test was attempted in order to determine the effectiveness of the screen. Due to test equipment limitations, only the vibration at 23.5 Hz at 6 g's for 15 minutes was performed; the simultaneous solenoid shocks were not attempted. Optical examination after vibration showed the particle to be still lodged.

Conclusion

The cause of failure has been positively identified to be an iron particle contamination introduced at T.I. prior to capping. The contaminant is now lodged so firmly that vibration cannot shake it loose.

The contaminant caused failure demonstrates the applicability of the Alert MSC-71-04 to ALSEP hardware. Since the alert applies to all 54L parts prior to August, 1971, the Array D 90 and 16 CH. MUX's are also suspect since they also contain the same types of 54L parts. Disposition of Array D and E hardware is to be determined.

R. J. Dallaire

R. J. Dallaire
ALSEP Reliability P.E.

Attachments

cc: R. Roukas
A. Romans
T. Fox
J. Hendrickson
R. Hiebert

Attachment C
(Sheet 2 of 4)

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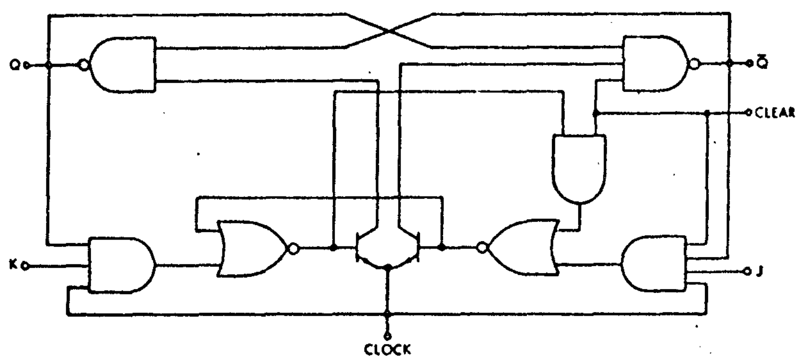
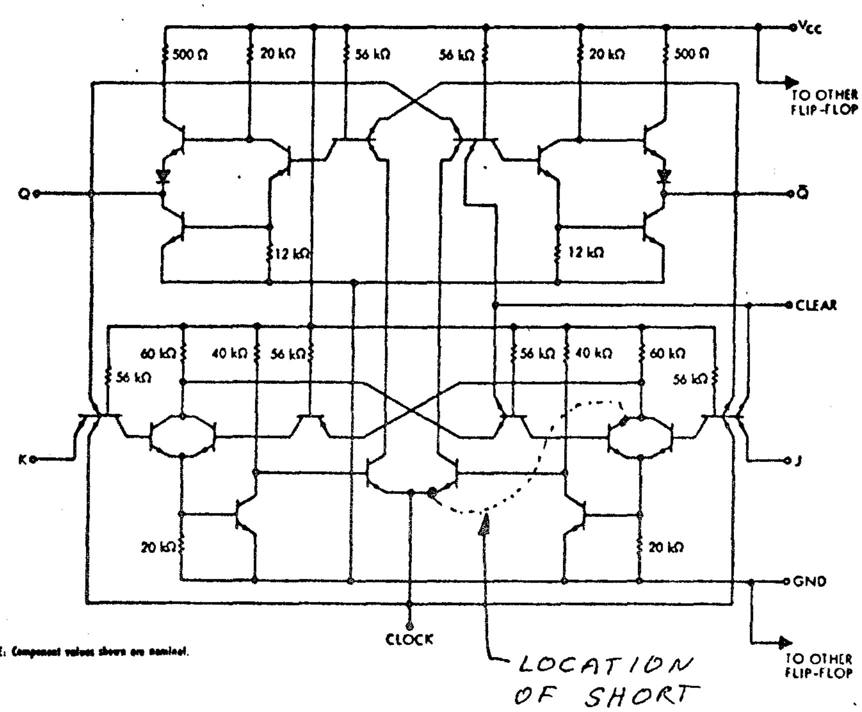
Page 3

CIRCUIT TYPES SN54L73, SN74L73
DUAL J-K MASTER-SLAVE FLIP-FLOPS

functional block diagram (each flip-flop)



schematic (each flip-flop)



NOTE: Component values shown are nominal.

— SEE ORDERING INSTRUCTIONS PAGE 1-1 —

4-20

Figure 1

Attachment C
(Sheet 3 of 4)

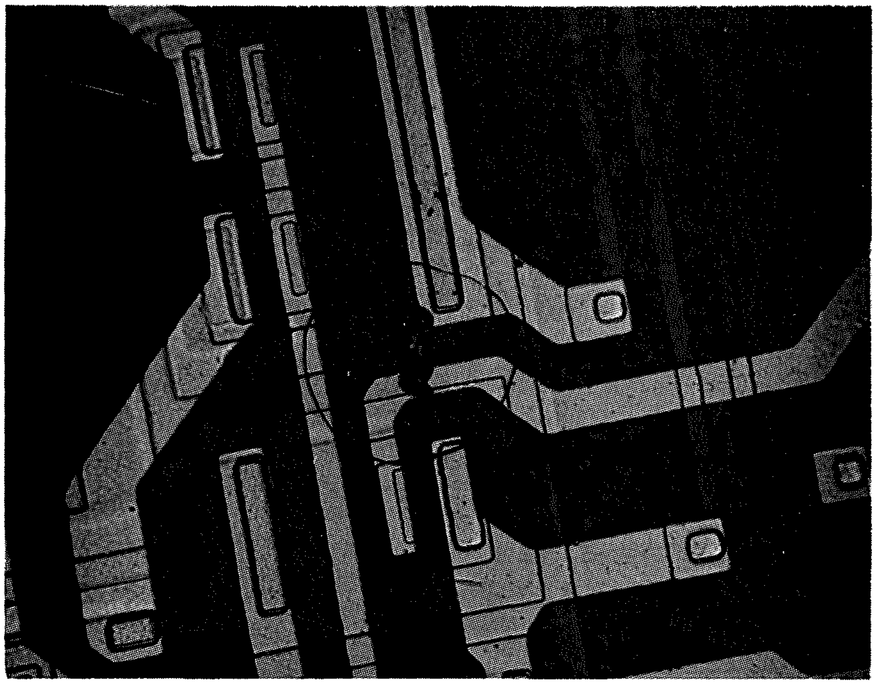


Figure 2 - Photo Micrograph of Iron Particle 320X

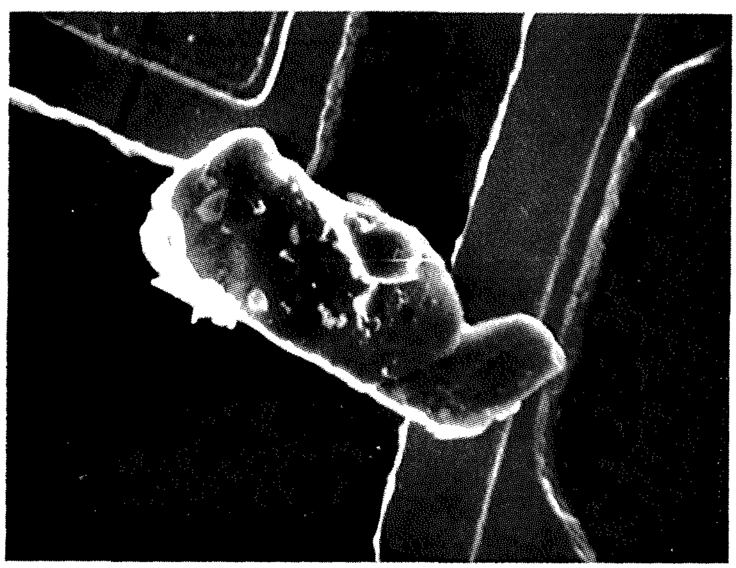


Figure 3 - SEM Photograph of Particle 1750X
Attachment C
(Sheet 4 of 4)

Bendix
Aerospace
Systems Division

54L ALERT
BxA Response Summary

ATM 1081 | A
PAGE 21 OF
DATE 30 March 1972

54 L PARTS TRACKING SUMMARY (BxA PARTS ONLY)

DATE 3-30-72

PART No. (TYPE)	QTY RCVD @ BxA	QTY REJECTED @ INC. INSP.	QTY SENT TO T-3	QTY TO FAB	QTY REJECTED IN-PROCESS	QTY FAILED @ BxA	QTY AVAILABLE FOR SCREEN	PARTS NOT ACCOUNTED FOR	QTY SENT TO NAA	QTY FAIL VIB @ NAA	QTY FAIL SEAL @ NAA	QTY RETURNED TO BxA	QTY REJECTED @ INC INSP	QTY RETURNED TO STORES
2346201-1 (54L00)	652	37	30	340	6	1	232	6	232	0	1	230	4	226
** 2346221-1 (L00)									150	3	0	147	4	143
2346201-2 (L04)	500	6	11	254	3	2	238	(-14)	238	4	3	214	1	213
** 2346221-2 (L04)									50	0	1	49	0	49
2346201-3 (L10)	400	0		184	2	1	211	2	211	2	0	206	2	204
-4 (L20)	400	15		147			233	5	233	4	2	231	4	227
-5 (L30)	150	4		22	3	(+5) 2	121	(-7)	121	1	2	118	0	122
-6 (L51)	150	0		54		1	95	1	95	0	0	96	1	95
-7 (L54)	60	1		36			23	0	23	0	0	23	0	23
-10 (L72)	72	0		22		1	49	0	49	1	0	48	0	48
-11 (L73)	441	20	16	177	6	(+5) 5	217	(-5)	217	1	3	213	3	210
-12 (L86)	25	0		2			23	0	23	0	0	23	0	23
-14 (L93)	144	0		75	1	1	66	1	66	2	1	63	0	63
-15 (L95)	139	9		62			68	0	88 +	7	0	81	2	75
-16 (L78)	216	0		86			128	2	128	1	0	133	0	127
-17 (L74)	150	5		46			98	1	95	0	0	98	0	98
-18 (L01)	134	0		66	3	1	65	(-1)	65	0	0	65	0	65
2346207-22 (54L121)	85	0		51			34	0	34	0	0	34	0	34
TOTALS	3718	97	57	1624	24	15	1901		2121	28	13	2072	21	2045
* 2346201-1 (L00)									36	0	1	35	-	35

* ARRAY D PARTS ; ** DLC SUBSEQUENT TO 7139 ; + INCLUDES 20 DEVICES FROM REBUY IN 1972 (DLC 7125)

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Attachment D
(Sheet 1 of 3)

54L ALERT
BxA Response Summary

T²L -- 54 L REJECT / FAILURE SUMMARY (NON-SCREENED PARTS) REV J DATE 3-22-72

ITEM	PART NUMBER (TYPE) REV A & UP	DATE CODE	SERIAL NUMBER	DR, SQ, FIAR No.	REJECTION / FAILURE OCCURED DURING: INSPECTION, ASSEMBLY, OR TEST?		REJECTION / FAILURE CAUSE; EVALUATION / ANALYSIS RESULTS		** FAILURE MODE CODE	REMARKS
1	7342201 -11 (54L73)	7125A	706	AC 3014	IN-PROCESS TEST (IPT)		@NAA	SILICON, KOVAR	A, F	ALERT VERIFIED
	-2 (L04)	7117A	643	AC 2249/2991			@NAA	GLASS PARTICLES	A, F	
	-16 (L01)	7112A	119	AC 2276	"		@NAA	DIE DAMAGED, Cl CONTAMINANTS	D, B, F	" "
	-11 (L73)	7112A	261	AC 3139	"		@NAA	Cl CONTAMINATION	B, F	"
5	-2 (L04)	7110A	316	AC 3261	"		@NAA	Si CHIPS + ELECT. SHORT	A, F	" "
	-2 (L04)	7110A	357	AC 3293	ASSEMBLY		@NAA	NO CONT. + LEAD DAMAGE	C	ALERT NOT VERIFIED
	-2 (L10)	?	529	AC 3268/2443	BOARD REWORK			LEAD DAMAGE	C	
	-2 (L04)	?	155	AC 1961	ASSEMBLY			LEAD DAMAGE	C	
	-1 (L00)	?	?	AC 2114	"		@NAA	LEAD DAMAGE	C	ALERT NOT VERIFIED
10	-2 (L10)	?	433	AC 2735	IPT		@BxA	BROKEN BOND WIRE	D, F	
	-11 (L72)	?	600	AC 2426/2726	FAILED COLD TEMP TEST			?	F	PART LOST
	-1 (L00)	?	83	AC 2456/2750	IPT		@BxA	OPEN EMITTER WINDOW	F	
	-10 (L72)	7112A	59	AC 3013	IPT			ELECTRICAL FAILURE	F	
	-11 (L73)	7112A	265	AC 3111	IPT		@GSFC	Fe PARTICLE, SHORT	A, F	ALERT VERIFIED
15	-14 (L93)	7123A	352	SR 0982	IPT		@BxA	ELECT FAIL	F	ALERT NOT VERIFIED
	-3 (L10)	?	?	SR 0681	REWORK		"	LEAD DAMAGE	C	PART LOST
	-1 (L00)	7108A	?	SR 1193	IPT			LEAD DAMAGE	C	PART LOST
	-13 (L01)	?	159	AC 3297	ASSEMBLY		@NAA	LEAD DAMAGE	C	ALERT NOT VERIFIED
	-2 (L04)	7112A	537	AC 3020/3295	"			TWISTED LEAD	C	
20	-14 (L93)	7123A	295	AC 3020/3300	"			TWISTED LEAD	C	
	-5 (L30)	7110A	073	AC 3502	"			TWISTED LEAD	C	
	-5 (L30)	7110A	79	AC 3502	"			LEAD BROKEN	C	
	-16 (L01)	7111A	204	AC 3411/3578	"			LEADS BENT	C	
	-11 (L73)	7108A	160	AC 3411/3577	"			LEADS BENT	C	
25	-1 (L00)	7108A	155	NO REPORT	"		@NAA	LEADS BENT	C	ALERT NOT VERIFIED
	-13 (L01)	7112A	136	NO REPORT	"		@NAA	LEADS BENT	C	ALERT NOT VERIFIED
	-5 (L30)	?	?	NO REPORT	"			LEADS BENT	C	PART LOST
	-5 (L30)	?	?	NO REPORT	"			FAILED ELECTRICALLY, BENT LEAD	C, F	PART LOST
	-1 (L00)	?	1061	AC 3441/3572	"			LEAD DAMAGE	C	
30	-1 (L00)	?	1178	AC 3441/3572	"			LEAD DAMAGE	C	
	-1 (L00)	7105A	110	AC 3551/3640	IPT			LEAD DAMAGE	C	
	-11 (L73)	7103A	155	–	CONTROL SAMPLE		@NAA	Si PARTICLES	A	ALERT VERIFIED
	-11 (L73)	7103A	55	–	CONTROL SAMPLE		@NAA	Si PARTICLES	A	ALERT VERIFIED
	-11 (L73)	7108A	?	–	CONTROL SAMPLE		@GSFC	CLEAN	SAS PART	ALERT NOT VERIFIED
35	-6 (L51)	7118A	177	AC 3969/4321	ASSEMBLY	(LSPE)	@NAA	LID DENT, LOOSE Si, FIXED UNK.	C, A, F	ALERT VERIFIED
	-11 (L73)	7116A	553	AC 4153	IPT	(LSG)		OPER. ERROR	D	PART NOT DISCREPANT
	-11 (L73)	7116A	611	AC 4153	IPT	(LSG)		OPER. ERROR	D	" " "
	-5 (L30)	7110A	175	AC 4148/4325	ASSEMBLY	(LMS)	@NAA	PART TESTS OK, NO PARTICLES	F	ALERT NOT VERIFIED
	-11 (L73)	7116A	599	AC 4327/4148	IPT	(LMS)	@NAA	2 MIL Ag, Cu & POTASSIUM, Fe, Co, Ni	A F	ALERT VERIFIED
40										

** A = PARTICLE CONTAMINANT, B = CHEMICAL CONTAMINANT, C = EXTERNAL DAMAGE, D = OTHER, F = ELECT. FAILURE

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T²L -- 54L REJECT / FAILURE SUMMARY (NON-SCREENED PARTS) Rev E Date 1-12-7[illegible]

Item	Part Number (Type) Rev A & up	Date Code	Serial Number	Dr. Sr. FIAR No.	Rejection / Failure Occured During: Inspection, Assembly, or Test		Rejection / Failure Cause; Evaluation / Analysis Results		** Failure Mode Code	Remarks		
44												
45												
50												
55												
60												
65												
70												
75												
*	SM54L04F	7127 A	56X	–	ASSEMBLY	/IPT	③ NAA	Oxide defects, excessive gold on die	F	ALERT NOT	VERIFIED	[illegible]
*	SM54L04F	7[illegible]5A	846	–	"	"	③ NAA	Elect overstress, excessive gold [illegible]	F	ALERT NOT	VERIFIED	[illegible]
*	SM54L00F	7101 A	384	–	"	"	⑥ NAA	Elect overstress, gold slag	A, F	ALERT	VERIFIED	[illegible]
*	SM54L00F	7108 A	635	–	"	"	③ NAA	Elect overstress, [illegible], gold [illegible]	A, D, F	ALERT	VERIFIED	[illegible]
* 80	151-367-01 (54L121)	7116 A	32	–	"	"	② NAA	Elect overstress, no particles	F	ALERT NOT	VERIFIED	[illegible]
*	151-367-01 (54L121)	7116 A	26	–	"	"	③ NAA	Elect overstress, no particles	F	ALERT NOT	VERIFIED	[illegible]
*	151-367-01 (54L121)	7116 A	10	–	"	"	② NAA	Elect fail, [illegible], gold particle.	A, F	ALERT	VERIFIED	[illegible]
*	151-367-01 (54L121)	7116 A	17	–	"	"	⑥ NAA	Elect overstress, [illegible] part	A, F	ALERT	VERIFIED	[illegible]
*	SM54L00F	7118 A	996	–	"	"	③ NAA	Elect overstress, loose gold [illegible]	A, F	ALERT	VERIFIED	[illegible]
* 85	SM54L00F	?	?	FIAR 108	FLIGHT	A.T.	⑥ TI	Gold preform	A, F	ALERT	VERIFIED	[illegible]

* SUBCONTRACTOR PARTS

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54L ALERT
BxA Response Summary

Attachment D
(Sheet 3 of 3)

NORTH AMERICAN ROCKWELL CORPORATION
SPACE DIVISION

EXPLAINED PROBLEM

PROBLEM REPORT NO. 4496-1

PAC CODE 4-536

DR/CAR NO.

RATIONALE:

PROBLEM:

During Qualification Test (Space Flight Vibration) of the Tape Recorder Data Conditioner (TRDC) S/N A102 on April 24, 1971, bit error overflow was observed after starting vibration in the X axis during the second Qual test vib phase. Subsequent failure analysis revealed that Integrated Circuit (I/C) P/N 51-P14494B051, Texas Instruments (TI) P/N SN54L95R-1, had an Emitter-Collector short caused by a metallic particle. This dev was from a lot coded 7039A (39th week of 1970). Total operating time recorded was 404 hours.

On May 11, 1971 during Qualification Test (high temperature - maximum voltage) of Tape Recorder Data Conditioner (TRDC) S/N A103, the 64KBS output was noted to be unstable at 135°F. The problem was intermittent and after completion of Qualification Test the suspect I/C (P/N SNC54L73; Data Code 7017A) was opened (June 16, 1971) and seven partic were found.

On May 13, 1971 during initial power up of module level tests (prior to ATP) of a Buffer Extension module of the TRDC another failure, subsequently traced to an I/C, occurred. This P/N was a 51-P10379B051, TI P/N SN54L73, date coded 7017A. This failure has also been determined to be due to an Emitter-Collector short caused by metallic particle contamination.

One other failure at the module level has also occurred involving P/N 51-P14488B031, TI P/N SN54L04T-11, date coded 7020A.

DISCUSSION:

Owing to the possible severity of this problem, the NR Reliability Manager accompanied Mr. C. Murphy of NASA-GE (R&QA) visisted Motorola and Texas Instruments Co. on 5/12/71 and 5/13/71 respectively, to investigate circumstances surrounding these failures.

EFFECTIVITY:

113 - 115

APPROVALS:

		DATE
SUPERVISOR/DEPT	[signature]	9/17/71
DESIGN ENG	[signature]	9/29/71
PRA	[signature]	9/30/71
REL PROJ		
CUSTOMER		

EXPLAINED PROBLEM 222*

PAC CODE 4-536 PROBLEM REPORT NO. 4496-1

DISCUSSION (cont.)

In examining Motorola's failure analysis, the procedures were considered satisfactory in that anomalies were isolated to a specific flat pack and further analyzed to a specific area of the IC circuitry, by the use of a curve tracer prior to opening the flat pack. Adequacy of the procedure was verified by finding the contaminates in the suspected areas. Magnification photographs were taken using a scanning electron microscope in each instance prior to proceeding with further investigations. Some criticism could be made concerning the first investigation when Motorola Lab personnel moved the particle with a camel hair brush and the particle (described as a flake approximately 0.8 mil (0.0008") was lost. On the subsequent investigations, microprobe was performed prior to any attempt to move the particle. All particles were less than 1 mil (0.001") in any dimension.

Microprobe data indicated the following:

SM54L 95 device - Ni - Fe - Cr

SN54L 73 device - Ni - Fe - Cr and AL

SN54L 04 device - particle lost - flake appearance - most likely source would be welding slag from eutectic bond of chip to header or cap bond stitch weld.

Cobalt or gold was not found, indicating that the material was foreign to the parent device materials. All radiography was performed at Motorola's Semiconductor Laboratories.

It should be noted, that following the microprobe operation, the attached particle in the SM54L95 device was foreshortened apparently by the radiographic bombardment. Subsequent powering of the circuit resulted in normal operation. This was also true of the SN54L04 and SN54L73 devices after the particles were moved. Replacement of the flat packs on the module boards provided normal module operation. Following discussions at Motorola, the NR Reliability and NASA/MSC representative were accompanied by Motorola to Texas Instruments in Dallas for discussions with Mr. R. Shankle, Program Manager, and E. Macaruso, Project Engineering, for these devices.

At TI, discussions were held on parts manufacturing, QA records were reviewed, and user and particle failure histories were obtained. The pertinent discussion points were as follows:

Manufacturing -

All 54L Series devices including those to the Huntsville spec are manufactured on the same production line using the same people. Differences in part classifications and designations in this report are effected by inspection criteria and testing performed in processing. All 54L Series parts are assembled in a good housekeeping environment designated as a Class 100 clean room atmosphere, i.e. normal building air filtration and temperature controls. The N_2 purge welding cabinet receives N_2 from a bulk station approximately 1 mile away. Filtration data for this system was unattainable and filters were not located at the units. Possible sources of stainless steel particles were parts transport trays, surgical tweezer, room air and GN_2 purge systems. All parts are transported in stainless steel trays face up and are open to the room while work is in progress. Covers are used when parts are in transit or stored.

EXPLAINED PROBLEM 222*

PAC CODE 4-536 PROBLEM REPORT NO. 4496-1

DISCUSSION (cont.)

Twenty-four to thirty-six hours can elapse following 100X visual inspections and final capping operations. The 40X visual precap examinations are normally performed immediately prior to 100X inspections. Parts are not vibrated. However, each is given a 20,000g acceleration test in shock, [illegible] temperature cycling, gross and fine leak tests, and at least 168 hours of burn-in. All parts are 100% inspected and tested by manufacturing and additionally sample tested by Quality Control.

Inspection x-rays for the SM54L95 lot in question were reviewed on a 22X viewer. The SM54L95 - S/N 550 records indicated this device to be clean. In viewing four devices that were rejected from the same lot for contamination it was noted that one mil particles were the smallest particles that could be screened by x-rays; i.e., the 1/2 mil circuit bond wire was not visible. In addition, the area of eutectic weld (chip to header) produced an x-ray density that could mask screening detection of small particles. Some 2 mil particles around the periphery of the chip were very apparent. TI stated that particles found in the failed devices were smaller than the screens required by inspection specifications and the capability of x-rays. Review of the inspection records verified this statement.

FAILURE HISTORY:

Inquiries by NR Reliability have established the following failure history of 54L devices:

Date Code	Reported By		Number of Failures	Approx. Total Devices	Contaminant
70-11	Langley	SM54L95	1	1,000	Weld Splatter
----	MSFC	----	0	30,000	----
----	GAEC	----	0	3,348	----
----	Leach Controls	----	0	84	----
70-20	Motorola ("J" Mission)	SN54L04 (Pre ATP)	1 }		Suspect Weld Splatter
70-39	Motorola ("J" Mission)	SM54L95	1 }	2,060	Stainless Steel
70-17	Motorola ("J" Mission)	SN54L73	1 }		Stainless Steel and Aluminum
70-17	Motorola ("J" Mission)	SN54L73	1 }		Gold, Silicon, Aluminum

TI would not provide the total number of parts manufactured since late 1966 but indicated delivery of 250,000 in 1970 and 85,000 up to May 1971. Conservatively this would project to approximately 1 million delivered devices from late 1966 to date.

EXPLAINED PROBLEM 222*

PAC CODE 4-530 PROBLEM REPORT NO. 4496-1

FAILURE HISTORY (cont.)

These statistics place the incidence rate optimistically at 1 in 200K units. Pessimistically, T.I. produced 250K units in 1970, and all failures occurred in units produced during the 29 week period between date codes 70-11 and 70-39. The later approach yields 1 in 28,000 units for this period. Metal particle contamination shorts have not been reported in other periods for this production line.

Known Test History on Failed Lots

Motorola records indicate that the following number of units were purchased from lot codes that were processed during or near the same week for failed parts and operated successfully during manufacturing and ATP testing:

Units	Date Codes
80 Devices	70-20
40 Devices	70-30
15 Devices	70-38 (Between 2 fail date weeks)
113 Devices	70-17
248 Devices Total	

The noted units satisfactorily completed Motorola manufacturing electrical checks that screened 2 of the Motorola failures.

Orientation of the units and devices within the units indicate that AVT should be an effective screening process. Sub MIL size particles, and the internal spacing of circuitry does indicate, that the particle must be placed exactly to produce results noted. To date, the Apollo program has experienced two failures that passed AVT, one due to a loose particle and one due to a particle attached at one end.

Apollo CSM 54L I/C usage is as follows:

End Item	Supplier	54L's Used	Vehicle Usage
Data Modulator	Motorola Scottsdale, Ariz.	18	113/114
TRDC	Motorola Scottsdale, Ariz.	150	113/114
DRR	Leach Azusa, Calif.	4	113/114
MLT	GAC Bethpage, N.Y.	98	ALL
Particle & Field Sub-Sat.	TRW Redondo Beach	16	113 ONLY
X-Ray Spec.	American Science & Engineering Cambridge, Mass	299	113 ONLY
Alpha Spec.		299	113 ONLY
3" Map Camera	Fairchild Syosset, N.Y.	51	ALL
UV [illegible]	[illegible]		[illegible]

EXPLAINED PROBLEM 222*

PAC CODE 4-536 PROBLEM REPORT NO. 4496-1

FAILURE HISTORY (cont.)

Other 54L Series device users are:

Contractor	Program
Motorola	Apollo Skylab
Singer Kearfott	LM MET
Lockheed	P-95 Classified
Hughes	Intelsat IV
T.R.W.	Advanced Pioneer
NASA	Various
JPL	Various
Collins Radio	Various
AIL (Airborne Instrument Lab)	Unknown
General Time	Unknown
Bendix	Unknown
Martin Denver	Evaluation for Viking

On June 10, 1971 NR directed Motorola to open and examine ten (10) I/C's date coded 7017 for conductive particles. This effort has been completed and the results are documented in Test Memorandum No. 1350 (attached). Motorola found loose conductive particles in four of the nine units examined, specimens 2, 4, 8 and 10. (Specimen 6 was accidently destroyed).

A summary of the conductive and non-conductive material found together with a possible source follows:

Al, Ca, Mg, Ti	Talc - Finger Cots
Na, Cl	Body salt
Al, Ca, K, Si	Grinding wheel
Al, K, Si	Cover glass
Cu	Electrodes/wire associated with welding process
Pb	Solder on tinned leads
Ba	Glass impurity
P	Glass impurity
S	Glass impurity
Fe	Glass impurity
Fe, Ni, Co	Cover (KOVAR)
Au, Si	Device - Eutectic
Zn	Solder on tinned leads
Pt	Device

EXPLAINED PROBLEM 222*

PAC CODE 4-536 PROBLEM REPORT NO. 4496-1

FAILURE HISTORY (cont.)

Of the four previous failures reported, two of the conductive particles were identified as stainless steel presumably introduced into the I/C's during the manufacturing cycle by transporting the uncapped chips on stainless steel trays. The other two failures were identified as a) probable weld splatter; and 2) due to particles consisting of gold, silicon and gold, and aluminum. No stainless steel particles were found in the nine samples and it is concluded that the particles in these samples were either introduced during the opening of the devices or can be traced to device materials.

CONCLUSIONS:

1. The manufacturing methods of all three device classes (SM54L, SN54L, SNC54L) expose the three classes equally to contamination.
2. The ultimate solution is a passivating layer on the chip surface.
3. X-ray and present pre-cap inspections are inadequate to preclude problems.
4. Present highest class (SM54L) tests will not provide a 100% screen.

Mission Effect Evaluation

1. The TRDC uses 150 of the 54L Series I/C's. Prior to release of E.O. No. 796690 effective S/C 112 thru 115, failure of any one of 115 devices would not actuate the TRDC to the fail safe mode. The noted E.O. modification allows switching the TRDC to the fail safe mode by ground command. Therefore the unit will automatically shift to fail safe as originally designed for any of 35 failures and can be commanded to switch if any of the remaining 115 54L Series devices fail.

   The two remaining DRR's assigned to "J" missions (S/N 7 - S/C 113 and S/N 23 - S/C 114) have measured flutter characteristics of 0.6% and 0.7% respectively. This degree of flutter would not seriously degrade reproduced data in the event it was necessary to use the by-pass mode of the TRDC.

2. The Data Recorder Reproducer (DRR) use 4 of these devices. Failure of any of these devices would cause loss of either of two data channels. Devices installed in these units were manufactured by TI in the 69-21 and 69-51 date coded periods.

3. The Data Modulator (DM) uses 18 of these devices. Two are used in the calibrate mode. The remaining 16 devices are associated with the three phase modulated sub carriers. These are 576KHz (64 KBS play back data), 768KHz (64 KBS real time data), and 1024KHz (51.2 KBS play back data). Any I/C failure occurring in any of these channels would result in the loss of that channel. 54L Series devices utilized in the DM were manufactured by TI in the 69-51 and 70-03 date code periods.

SUPPLEMENTAL INFORMATION

Representative samples of 54L I/C's were obtained from Motorola, Leach, Texas Instruments and MSFC and subjected to a special screening test developed by Autonetics. The test was specifically instituted to detect small conductive particles within the I/C package. The test subjects the I/C to an approximately 20 Hz continuous sine vibration, interspersed with an approximate 170g, 10 millisecond shock every 7 seconds. The inputs and outputs of the I/C are continuously monitored for duration of the test.

EXPLAINED PROBLEM 222*

PAC CODE 4-536 PROBLEM REPORT NO. 4496-1

SUPPLEMENTAL INFORMATION (cont.)

which lasts 30 minutes. Fifty-two (52) devices were submitted as "NR" supplied and sixty-eight (68) as "MSFC" supplied. Eight (8) failures were recorded of the 120 pieces tested.

The eight failed devices were hand carried to Texas Instruments, Dallas, Texas and analysis performed. Five of the eight devices were found to have loose particles within the package when the devices were opened. The results of the analysis are tabulated below.

P/N				
SN54L51	7045	TRDC	Nearly every impact-hard failure remained at test conclusion.	One loose particle - 3 x 4 mil - iron with trace of gold.
SN54L95 (S/N 557)	7039	TRDC	22 min. at 26 min. hard failure - remained at test conclusion.	One thin loose flake-oval 5 x 9 mil - gold with trace of iron. Two fixed particles.
SN54L95 (S/N 508)	7039	TRDC	2 min.,3 min. OK rest of test.	Three loose particles - 4 mil and two 1 mil - One gold and one silicon. One fixed particle.
SN54L95	7039	TRDC	17 min.,22 min. then random failures with impact-OK at conclusion.	One fixed particle 4 mils long.
SNC54L73	7017	TRDC	1 min.,17 min., 22 min. OK rest of test.	Two or three fixed particles 2 mils and one 1 x 7 mils.
SNC54L95	7050	TRDC	5 min. hard failure - remained at test conclusion	Two loose particles - 3 mil dia - cobalt with trace of gold. One fixed particle.
SN54L10	7016	TRDC	2-1/2 min. then OK rest of test.	One loose particle - 1 x 3 mil - gold with trace of silicon. One fixed particle.
SN54L00	7020	TRDC	Immediate - continuous with each impact - hard failure remained at test conclusion.	Two fixed particles.

Attachment E
(Sheet 7 of 7)

54L ALERT

BxA Response Summary

T²L -- NAA VIBRATION SCREEN TEST FAILURE SUMMARY

REV J DATE 3-22-72

ITEM	PART NUMBER (TYP.) REV A & UP	DATE CODE	SERIAL NUMBER	DR, SR, FIAR No.	REJECTION / FAILURE OCCURRED DURING: INSPECTION, ASSEMBLY, OR TEST	REJECTION / FAILURE CAUSE; EVALUATION / ANALYSIS RESULTS.	** FAILURE MODE CODE	REMARKS
	2246201-14 (L4.93)	7123 A	394	-	NAA VIBRATION SCREEN	@NAA SILICON, KOVAR	A, F	ALERT VERIFIED (MSC-71-04)
	-15 (L95)	7117 A	173	-	.. ..	@NAA SILICON, KOVAR	A, F	.. ..
	-5 (L30)	7110 A	134	-	.. ..	@NAA GOLD SLAG	A, F	.. ..
	-2 (L04)	7109 A	369	-	.. ..	@NAA COPPER PARTICLE	A, F	.. ..
5	-14 (L93)	7123 A	397	-	.. ..	@NAA GOLD FLAKE, KOVAR	A, F	.. ..
	-2 (L04)	7105 A	473	-	.. ..	@NAA GOLD SLAG, KOVAR	A, F	.. ..
	-3 (L10)	7112 A	412	-	.. ..	@NAA KOVAR	A, F	.. ..
	-3 (L10)	7112 A	296	-	.. ..	@NAA LIFTED DIE SURFACE	A, F	.. ..
	-16 (L78)	7118 A	235	-	.. ..	@NAA SEE F/A PHOTO # 13-1	A, F	..
10	-15 (L95)	7111 A	21	-	.. ..	@NAA SILICON	A, F	.. ..
	-10 (L71)	7112 A	95	-	.. ..	@NAA GOLD SLAG	A, F	— ..
	-15 (L95)	7112 A	115	-	.. ..	@NAA SILICON, KOVAR	A, F	.. ..
	-4 (L20)	7114 A	204	-	.. ..	@NAA SILICON, KOVAR	A, F	.. ..
	-15 (L95)	7112 A	121	-	.. ..	@NAA SILICON, KOVAR	A, F	— ..
15	-15 (L95)	7111 A	33	-	.. ..	@NAA Si, KOVAR, MANY PARTICLES	A, F	.. ..
	-15 (L95)	7111 A	37	-	.. ..	@NAA Si, GOLD FILAMENTS, GOLD SLAG	A, F	.. ..
	-4 (L20)	7114 A	21	-	.. ..	@NAA Si, PARTICLE ON DIE	A, F	.. ..
	-3 (L10)	7112 A	300	-	.. ..	@NAA Si, SiO_2, GOLD, KOVAR	A, F	.. ..
	-3 (L10)	7112 A	367	-	.. ..	@NAA 20 mil SQUARE Al PART, ORGANIC MAT'L	A, F	— ..
20	-15 (L95)	7111 A	34	-	— ..	@NAA Si, KOVAR, DIE CHIPS	A, F	— ..
	-2 (L04)	7110 A	364	-	.. ..	@NAA Si, GOLD SLAG	A, F	.. ..
	-4 (L20)	7113 A	345	-	..	@NAA Si, Au, GOLD SLAG, KOVAR	A, F	.. ..
	-4 (L20)	7113 A	671	-	.. ..	@NAA KOVAR, NON-LINEAR [illegible]	A, F	.. ..
	-2 (L04)	7110 A	390	-	.. ..	@NAA Si, KOVAR, GOLD SLAG, ORGANIC MAT'L	A, F	.. ..
25	-4 (L20)	7042 A	146	-	.. ..	@NAA Si CHIPS, [illegible] SUBSTRATE	A, F	.. .. S/C PART
	-4 (L20)	7029 A	383	-	.. ..	@NAA SiO_2, KOVAR, Al, MANY PARTICLES	A, F	.. .. S/C PART
	-4 (L20)	7029 A	403	-	.. ..	@NAA Si, Au, KOVAR, GOLD SLAG	A, F	.. S/C PART
	-11 (L71)	7125 A	790	-	.. ..	@NAA Lg Si CHIPS, [illegible], KOVAR, SLAG	A, F	.. ..
	* SM54L00	7144A	773	-	.. ..	@NAA BURNED TRANSISTOR	? A, F	POSSIBLE CONTAMINATE
30	* SM54L00	7145A	727	-	.. ..	@NAA Au, SiO_2	A, F	ALERT VERIFIED
	* SM54L00	7146A	684	-	.. ..	@NAA Cu PARTICLE SHORTS PIN 4 TO 11	A, F	.. ..

** A = PARTICLE CONTAMINANT, B = CHEMICAL CONTAMINANT, C = EXTERNAL DAMAGE, D = OTHER, F = ELECTRICAL FAILURE

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Attachment F

Internal
Memorandum

Bendix Aerospace Systems Division

Date 5 January 1972 Letter No. 9721-2663

To L. Deusterberg

From R. Hiebert

Subject 67 U.T.D. Gross Leak Flat Pack Rejects

Of the Flat Packs sent from UTD for the Autonetics screen, 67 parts were rejected at gross leak. (All 67 parts passed the fine leak test on the initial Autonetics screen). The gross leak appeared after five boxes of parts were tested without a failure. On the sixth box containing 16 parts, the first ten parts were all observed to have bubbles and the test was called off before the remaining parts could be run. All UTDs' devices had tape insulators on the back of the package.

The 67 parts were retested for fine and gross leak at Autonetics with BxA Quality and Reliability as well as DCAS observing the results. The results are tabulated in Table I for these parts. Of the 67 parts retested, three passed both fine and gross leak test with no evidence of bubbles on the part. One device (SM 54L 71 S/N 100) failed fine leak with a reading of 1.2×10^{-7}.

All of the remaining 63 parts had bubbles coming from the device. The devices were carefully observed and the bubbles were observed coming from the device in three different locations:

Type A: Bubbles were observed being emitted from the blue dot under the tape.

Type B: Small bubbles were observed coming from the periphery of the tape for about one second.

Type C: Bubbles appeared to be coming from one location at or near a given lead.

All eleven parts exhibiting a Type "C" bubble emission were retested after removing the tape from the back of the package. Two devices were rejected as gross leaker. (See Table II). One of the two rejects exhibited a short burst of bubbles. No visual anomalies could be seen under high

9721-2663
Page 2

magnification. The other unit had a stream of bubbles coming from lead number 7. Visual examination revealed a void in the glass seal for the lead seven feedthrough. These two devices as well as the fine leaker were retained by Autonetics for additional analysis.

All of the remaining 61 devices are not suspected as gross or fine leaker since the source of the bubbles is known not to be from the interior of the case or, as with nine of the eleven type C bubble emissions, when the tape was removed, no bubbles were observed. The parts should never be fine or gross leak tested with tape on the package.

R. Hiebert

RH:mc

Enclosures

cc: S. Ellison
J. Hendrickson
T. Fox
D. Cook
M. O'Mara

9721-2663
Page 3

TABLE I

SM 54L00

S/N	Emission Type	S/N	Emission Type
908	A	920	A + C (lead 7)
935	A	949	A
936	A	910	A
911	A	948	A
924	A	937	A
914	A	953	A
923	A	913	A
909	A	922	A

SM 54L73

S/N	Emission Type	S/N	Emission Type
231	A, B, C (lead 12)	253	B, C lead 7
215	B	256	B
244	B	229	B, C lead 14
233	B	258	B, C lead 9, 10
263	B	238	B
249	B, C (lead 2)	266	B
257	B	267	B
217	B	255	A, B
232	B	241	A, B
248	B	234	B
235	B	236	B
259	B, C (lead 11 & 12)	228	A, B, C (lead 6)
219	B, C 12	230	B
250	A, B	243	B
242	A, C (lead 8)	221	B
225	B	222	B

SM 54L71

S/N	Emission Type	S/N	Emission Type
016	passed	111	A
021	A, B	086	A
041	A	040	passed
127	C (lead 8)	091	A
100	(fine leak 1.2×10^{-7})	126	A
003	B	042	Passed
068	A, B	090	A, B
010	A	007	A, B
113	B	116	A, B
		125	A, B

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TABLE II

(Units retested with tape removed -- Type "C" Emission)

SM 54L73 S/N	Lead(s)	Retest results
231	12	No leakage
249	2	
259	11, 12	
219	12	
242	8	
253	7	
229	14	
258	9 and 10	
228	6	No leakage

SM 54L00		
920	7	Gross leak

SM 54L71		
127	8	Gross leak - minor indication

Internal Memorandum

Bendix Aerospace Systems Division
Ann Arbor, Michigan

Date 4 February 1972 Letter No. 9721-2706

To R. Dallaire

From R. Hiebert

Subject 18 Hermetic Seal Failures Sent to Autonetics for Failure Analysis

The devices all failed hermetic seal test as indicated in Table I. The units were all given the dye penetrate test and delidded for observations. The pictures are at Autonetics and have not been returned to BxA for these parts. Eleven parts had dye penetrant noted in the cases. Dye will, on occasion, not penetrate a leaker. In some cases, the gross leak test will seal the leakage which will inhibit the dye from penetrating the package. Two gross leakage paths were observed visually. One of these devices had a cracked glass eyelet seal and one device had a poor lid weld. One of the devices had excessive amounts of oil and dye in the case indicating a real gross leak. One device had an organic type of growth on the bar indicating the package was a gross leaker.

Four devices had curve traces with soft knee breakdowns, low breakdowns, and/or shunts. These four had no dye penetrate or visible evidence of leakage, although particles were observed in some of the four parts. These soft knee breakdowns can be associated with oxide defects.

Seven devices had particles in the case; two of the devices had unidentified particles and five had gold particles, two of which were loose. Gold slug is caused by oxygen present when the bar is scrubbed in.

Two devices had a chip from the bar which was loose in the case. These chips were caused by tweezers used to hold the bar during the scrub in operation.

Table I is a matrix of all the parts by S/N and observations.

Robert W. Hiebert
Robert W. Hiebert

S. Ellison
J. Hendrickson
T. Fox

Attachment H
(Sheet 1 of 3)

TABLE I

OBSERVATIONS ON 18 HERMETIC FAILURES

	Type	S/N	Leak	Dye	Observations	Particle Observations
1	L71	038	Fine	No	Oxide anomalies, C. T.(1) analysis indicates soft knee breakdowns	None
2	L20	065	Gross	Yes	C. T. analysis indicates soft knee breakdowns	None
3	L73	124	Fine	Yes	C. T. analysis indicates an unstable low resistance path. Organic growth noted in case on bar	Other than growth - None
4	L20	420	Gross	No	Chip out of dye loose in case	Gold slag attached to bottom of case + SILICON PARTICLE.
5	L121	150	Fine	No	C. T. analysis was good. Oxide anomalies observed but caused no electrical anomalies	Gold slag not loose
6	L73	769	Gross	Yes	C. T. analysis indicates soft knee breakdown. Chip out of bar	Gold slag loose in case (2) + SILICON PARTICLE.
7	L51	187	Gross	No	C. T. analysis was good	None
8	L00	1157	Gross	Yes	C. T. analysis indicated soft knee breakdown	3 small glass particles
9	L20	398	Gross	No	C. T. analysis indicates shunt path in circuit	Loose gold slag (2)
10	L93	300	Gross	Yes	Excessive dye and lots of oil in case. Lots of shunt paths. Unit has a real gross leak	None observed
11	L20	134	Gross	Yes	C. T. analysis indicates soft knee breakdown	Stationary unidentified particle on bar
12	L30	171	Gross	Yes	C. T. analysis good. Crack in glass seal (eyelets) in case	None
13	L30	010	Gross	Yes	C. T. analysis indicates low breakdown	None
14	L73	842	Gross	Yes	C. T. analysis indicates soft knee breakdown. Poor lid welds	None
15	L04	392	Gross	Yes	C. T. analysis indicates excessive shunt paths, excessive dye in case	None
16	L04	1291	Fine	No	C. T. analysis indicates shunt paths and low breakdowns. Contamination on edge of bar	None
17	L04	157	Gross	No	C. T. analysis indicates low breakdown in pin 2 observation. Diffusion fault, substrate to collector	Small gold colored particle on bar
18	L04	045	Gross	Yes	C. T. analysis good. Excessive dye in case	None

NOTE (1) C.T. = CURVE TRACE
NOTE (2) PARTICLE CONTAMINATION FOR THESE PARTS NOT PREVIOUSLY REPORTED SINCE THESE PARTS FAILED HERMETIC TEST AFTER PASSING VIBRATION TEST.

Attachment H
(Sheet 2 of 3)

54L ALERT
BxA Response Summary

T^2L -- NAA HERMETICITY SCREEN TEST FAILURE SUMMARY

REV J DATE 3-22-72

ITEM	PART NUMBER (TYPE) REV A & UP	DATE CODE	SERIAL NUMBER	DR, SR, FIAR No	REJECTION / FAILURE OCCURRED DURING: INSPECTION, ASSEMBLY, TEST?	REJECTION / FAILURE CAUSE; EVALUATION / ANALYSIS RESULTS.	** FAILURE MODE CODE		REMARKS	
1	2346201-4 (54L20)	7114 A	65	-	NAA GROSS LEAK	DYE PENETRANT INSIDE	D			
	-4 (L20)	7114 A	134	-	"	" " "	D			
	-5 (L30)	7110 A	10	-	"	" " "	D			
	-2 (L04)	7108 A	157	-	"	UNKNOWN	D			
5	-2 (L04)	7108 A	45	-	"	DYE PENETRANT INSIDE	D			
	-1 (L00)	7108 A	1157	-	"	" " "	D			
	-14 (L53)	7123 A	300	-	"	" " "	D			
	-5 (L30)	7110 A	171	-	"	CRACKED LEAD SEAL	D			
	-11 (L73)	?	124	-	NAA FINE LEAK	DYE PENETRANT IN CASE	D	MEASURED	6×10^{-5} cc/s	
10	-11 (L73)	?	769	-	NAA GROSS LEAK	" " " "	D			
	-11 (L73)	?	842	-	"	POOR LID WELD	D			
	-2 (L04)	?	392	-	"	DYE PENETRANT IN CASE	D			
	SM54L71	7033 A	38	-	NAA FINE LEAK	UNKNOWN	D			S/C PART
	SM54L04	7030 A	1291	-	"	UNKNOWN	D			S/C PART
15	151-342-01 (54L121)	7122 A	150	-	"	UNKNOWN	D			S/C PART
	SM54L20	7029 A	398	-	NAA GROSS LEAK	UNKNOWN	D			S/C PART
	SM54L51	7041 A	187	-	"	UNKNOWN	D			S/C PART
	SM54L20	7029 A	420	-	"	UNKNOWN	D			S/C PART
	SM54L71	7033 A	100	-	NAA FINE LEAK	UNKNOWN	D	MEASURED	1.2×10^{-7} cc/s	(UTD) NOTE
20	SM54L71	7033 A	127	-	NAA GROSS LEAK	UNKNOWN	D			(UTD) NOTE
	SM54L00	7118 A	920	-	"	UNKNOWN	D			(UTD) NOTE
	2346201-1 (L00)	7011 A	198	AC 3191	"	BAD CASE WELD	D	ARRAY D PART		
	SM54L04	7147 A	1916	AC 4753	"	UNKNOWN	D	1972 REBUY		
25										
30										
35										
40										

NOTE:
RETEST OF 70 S/C PARTS INDICATES THAT:
(1) 3 PARTS FAIL DEFINITE
(2) 6 PARTS PASS DEFINITE
(3) 61 PARTS QUESTIONABLE

** A = PARTICLE CONTAMINANT, B = CHEMICAL CONTAMINANT, C = EXTERNAL DAMAGE, D = OTHER, F = ELECTRICAL FAILURE

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(PLEASE TYPE ALL INFORMATION - SEE INSTRUCTIONS ON REVERSE)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ALERT
(Reporting Parts and Materials Problems)

1. GENERIC CLASSIFICATION
Microelectronic Circuit Flatpack

2. ALERT NO.
MSFC-71-21

3. DATE
16 Nov. 1971
DAY MO. YEAR

4. MANUFACTURER AND ADDRESS
Texas Instruments, Inc.
P. O. Box 5012
Dallas, TX 75222

5. PROCUREMENT SPECIFICATION
Various (See 10)

6. REFERENCE
MSC-71-04

7. MANUFACTURER'S DESIGNATION
SN-54L-Series

8. LOT/DATE CODE OR SERIAL NO.
Various

9. SPECIAL REQUIREMENTS OR ENVIRONMENT *(Requirements placed on or extreme environment to which item was exposed.)*
As stated in MSC-71-04 one failure occurred during equipment qualification vibration testing; two failures occurred during first energization of devices in equipment.

10. PROBLEM SITUATION AND CAUSE *(State facts of problem and cause — failure mode and mechanism — project and function)*
As stated in MSC-71-04 investigation of 3 failures of 54L-Series integrated circuits used in the Apollo J-Mission tape recorder data conditioner revealed conductive metallic contamination in the devices. The parts involved are:

1. SN 54L04T-11 Date Code 7020A
2. SNC 54L73T Date Code 7017A
3. SM 54L95R-1 Date Code 7039A - (Manufactured to the requirements of MSFC Specification 85M03766)

11. ACTIONS TAKEN *(State all actions taken to correct the problem situation.)*
Since one of the failed devices had been processed to MSFC Drawing 85M03766 and manufactured on a MSFC Certified Line, MSFC re-evaluated the Dallas line. This resulted in the certification being suspended on July 15, 1971. TI immediately instituted corrective actions: Laminar flow clean benches were installed in the precap visual inspection area; weld shields were added in the sealing chambers; visual inspection of device lids (prior to sealing) was initiated; and hard glass containers replaced aluminum containers for storage of package lids; spray wash after precap. prior to seal; and inverted storage of units after spray wash and prior to seal. The line certification was then reinstated effective July 28, 1971.
(Continued on page 2)

12. RECOMMENDATIONS FOR FURTHER ACTION *(Suggestions to prevent recurrence.)*
In critical single failure point applications, all 54L91, 54L93, 54L95 devices, regardless of date of manufacture, should be replaced with devices that have successfully passed the monitored vibration/shock test.

In critical single failure point applications, all other TI 54L devices manufactured prior to July 28, 1971, should be replaced with devices that have successfully passed the monitored vibration/shock test. At this time, Autonetics has
(Continued on page 2)

13. CONTACT POINTS FOR INFORMATION *(Name, affiliation, telephone)*
Ron Barlow, A.C. 205/453-3987
MSFC, S&E-QUAL-QT

14. MANUFACTURER NOTIFIED
8 Nov. 1971
DAY MO. YEAR

15. ALERT COORDINATOR *(Name, affiliation)*
Elizabeth G. Manning, S&E-QUAL-QRA
George C. Marshall Space Flight Center

16. SIGNATURE OF ALERT COORDINATOR
[signature]

17. GENERIC CLASSIFICATION
Microelectronic Circuit Flatpack

18. ALERT NO.
MSFC-71-21

19. GIDEP INDEX NO.
515.20.01.02-H1.01

NASA FORM 863 MARCH 1971 Previous Editions Are Obsolete.

2

11. ACTIONS TAKEN (CONT'D)

In addition, two other improvements are scheduled for the near future. A class 10,000 horizontal laminar flow clean room for chip inspection through package seal will be in operation by December 31, 1971. In first quarter of 72 a quartz protection system for chips will be available.

To determine the extent of particle contamination of the TI 54L devices, MSFC and MSC jointly arranged for monitored vibration/shock testing of 120 devices at Autonetics. Of these, 77 were manufactured prior to May 1971 and 43 subsequent to that time. (It was in May that TI became aware of the failures and instituted improved handling and storage procedures.) Eight devices manufactured prior to May failed the Autonetics test. There were no failures in the group manufactured after May 1971.

Of the eight failures, four were 54L95 type. All eight were opened and loose particles were found in five units including three of four 54L95. This high failure rate may be attributed to two major factors:

1. Increased complexity which requires more metallized paths that are also closer together.

2. Larger semiconductor die which requires a preform be used during die mounting. This preform is a source for potentially loose slag. (This applies to 54L91, 54L93, 54L95 devices.)

While no failures were experienced on 54L91 and 54L93, based on similarity in chip size and mounting method to 54L95, it is recommended they be categorized with 54L95.

In light of the large number of failures during the first test, it was decided to subject 65 of the good units to the monitored vibration/shock test again. There were no additional failures during the second run. These results provided a high degree of confidence that the monitored vibration/shock test is effective in detecting particle contaminated devices.

12. RECOMMENDATIONS FOR FURTHER ACTION (CONT'D)

the only known facility capable of performing the monitored vibration/shock test effectively. For information concerning the Autonetics test contact:

Mr. Jack Mann
North American Rockwell-Autonetics Division
3370 Miraloma Avenue
Anaheim, CA 92803
Telephone: 714/632-8777

Reference Autonetics Test Procedure IOD273/77, "Particle Contamination Screen."

Attachment I
(Sheet 2 of 2)

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BxP.O. 5069(TF)
72-970-5443

Mr. P. Donald Gerke, Manager
Lunar Surface Project Office
National Aeronautics and Space
Administration
Houston, Texas 77058

13 March 1972

Subject: Response to Action Item from the Array E Parts Status Meeting held at MSC on 7, 8 March 1972. (Review of TI-SM54Lxx Lot Test Data)

Attachment: Screening Results

Dear Mr. Gerke:

The subject action item requested Bendix to provide MSC with lot screening information for three types of 54L series integrated circuits. These devices were procured for use in Array E hardware without Bendix and without GSI pre-cap inspection.

Bendix Reliability and Quality Assurance visited TI-Dallas on 6 March 1972 and reviewed screening data for the following parts: (1) SM54L00 (DLC: 7144 A), (2) SM54L00 (DLC: 7145 A), and (3) SM54L04 (DLC: 7147 A). The results have been summarized and are included in the Attachment.

The review of screening results showed that lot yields were:

(1)	SM54L00	(7144 A) --	68%	(94 of 139)
(2)	SM54L00	(7145 A) --	51%	(106 of 207)
(3)	SM54L04	(7147 A) --	44%	(116 of 266)

and that the majority of the fallout was distributed among three tests: (a) the 40X and 100X pre-cap inspection, (b) an in-process electrical test equivalent

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to the EM2, but not required by 85MO3766, and (c) x-ray.

To determine the significance of the device fallout, each of the above screening tests was carefully evaluated for effectiveness. The .65% AQL sampling verified the effectiveness of the 100% pre-cap inspection in removing contaminated and visually defective devices. Similarly, the results of the EM2 screening indicate that the in-process electrical test, which was added to the screening sequence by TI, is effective in removing functionally marginal and defective devices. However, the initial reaction after reviewing the results of radiographic inspection (8%, 4%, 4% rejection) removes some of the confidence built up by the previous screening. A deeper examination of the x-ray rejection revealed that most devices rejected are not actually discrepant. Causes other than device defect are usually responsible; typically, only 5-10% of devices rejected for extraneous matter actually contain foreign materials. The remaining devices are rejected for apparent discrepancies which can generally be attributed to:

(1) contamination on the plastic trays which hold the devices during the x-ray exposure,
(2) x-ray film flaws,
(3) false images; e.g. scrub-up material, and
(4) gold plate sticking to the glass headers, etc.

Therefore, these apparently high x-ray rejection rates are not real and they do represent acceptable rejection levels (equivalent to approximately .6%, .3%, and .3% as opposed to 8%, 4%, and 4%).

Conclusions:

The review of the lot screening data, which has been summarized in the Attachment below, indicates the results are consistent with lots previously procured having Bendix and GSI pre-cap inspections. In addition, it must be noted that these devices were capped subsequent to "cleaning up the line" and

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line recertification by MSFC. Therefore, Bendix believes that referenced SM54Lxx devices are acceptable and should be approved for use in ALSEP Array E Qual, Flight, and Flight Spare hardware.

Very truly yours,

T. W. Fenske, Director
ALSEP Program

TWF:b
cc: P. Clyatt
J. Langford
E. Smith
A. Eckermann, MSC/Boeing

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ATTACHMENT

Contained herein is a summary of the lot screening test results for the following devices:

(1) SM 54L00 (DLC 7144A)

(2) SM 54L00 (DLC 7145A)

(3) SM 54L04 (DLC 7147A)

Upon reviewing the data tabulated below, it will be noted that "read and record" data at -55°C and +125°C is not available for the devices from DLC 7144A and 7145A. Texas Instruments did not have the on-line capability to identify the serial numbers at temperatures other than 25°C. MSFC waived this requirement and allowed TI to perform the EM2 tests at -55°C and +125°C on a GO/NO GO basis, provided that TI perform a 1% AQL sampling check. Subsequent to DLC7150, all devices have the "read and record" data for EM2 testing; a TV camera was added to the automatic test set-up which provides serial number identification for data correlation.

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SCREENING RESULTS

Device Type: SM54L04

Date Lot Code: 7147A

S/N Range: 1889 - 2019

	Screening Test		Start Qty.	End Qty.	% Fallout
1.	100X Pre-cap * (passed.65% AQL)		266	169	36%
2.	40X Pre-cap * (passed.65% AQL)		169	163	4%
3.	High temperature stabilization bake: 48 hours at 200°C				
4.	Temperature cycling: -65°C to +150°C (10 cycles)				
5.	Acceleration: 30,000 g's, Y_1 axis				
6.	Fine leak: <1 x 10^{-8} STD. cc/sec		163	148	9%
7.	TI performed an in-process electrical test (same as EM2 below) which is not required by 85MO3766 at this point				
8.	Gross leak:		131	131	0%
9.	TI serialized the devices at this point				
10.	Electrical Measurements (EM1), DC @ 25°C		131	130	1%
11.	Power Burn-in: 240 hours @ +125°C				
12.	EM 2:	DC @ +125°C	130	123**	2%
		DC @ +25°C	123	121	2%
		DC @ -55°C	121	121	0%
		AC @ +25°C	121	121	0%
	** four (4) devices rejected due to data loss on magnetic tape				
13.	X-ray: per MSFC-STD-355		121	116	4%

*100% inspection performed in-process, followed by QA sampling

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SCREENING RESULTS

Device Type: SM54L00

Date Lot Code: 7145A

S/N Range: 632 - 749

	Screening Test	Start Qty.	End Qty.	% Fallout
1.	100X Pre-cap* (passed .65% AQL)	207	154	26%
2.	40X Pre-cap * (failed .65% AQL)	154	138	10%
3.	40X Repeat (passed .65% AQL)	138	137	1%
4.	High temperature stabilization bake: 48 hours at 200°C			
5.	Temperature cycling: -65°C to +150°C (10 cycles)			
6.	Acceleration: 30,000 g's, Y_1 axis			
7.	Fine leak: $<1 \times 10^{-8}$ STD CC/SEC.	137	137	0%
8.	TI performed an in-process electrical test (same as EM2 below) which is not required by 85MO3766 at this point.			
9.	Gross leak	119	118	1%
10.	TI serialized the devices at this point; one part lost			
11.	Electrical Measurements (EM1), DC @ 25°C	117	117	0%
12.	Power Burn-in: 240 hours @ +125°C			
13.	EM2: DC @ 25°C	117	114**	2%
	DC @ 125°C } no read and	114	114	0%
	DC @ -55°C } record data	114	113	1%
	AC @ 25°C	113	113	0%
	** data lost for one device; two (2) devices failed test			
14.	X-ray: per MSFC-STD-355	113	108	4%
15.	1% AQL for EM2 resulted in no failures.			

*100% inspection performed in-process, followed by QA sampling

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SCREENING RESULTS

Device Type: SM54L00

Date Lot Code: 7144A

S/N Range: 750 - 856

	Screening Test	Start Qty.	End Qty.	% Fallout
1.	100X Pre-cap* (passed .65% AQL)	139	128	8%
2.	40X Pre-cap* (failed .65% AQL)	128	122	5%
3.	40X Pre-cap* (passed .65% AQL)	122	119	2%
4.	High temperature stabilization bake: 48 hours @ 200°C			
5.	Temperature cycling: -65°C to +150°C (10 cycles)			
6.	Acceleration: 30,000 g's, Y_1 axis			
7.	Fine leak: < 1 x 10^{-8} STD cc/sec	119	116	3%
8.	TI performed an in-process electrical test (same as EM2 below) which is not required by 85MO3766 at this point.			
9.	Gross leak	107	107	0%
10.	TI serialized the devices at this point			
11.	Electrical Measurements (EM1), DC @ 25°C	107	106	1%
12.	Power Burn-in: 240 hours @ +125°C			
13.	EM2: DC @ 25°C	106	104	2%
	DC @ 125°C } no read and	104	104	0%
	DC @ -55°C } record data	104	103	1%
	AC @ 25°C	103	103	0%
14.	X-ray: per MSFC-STD-355	103	95	8%
15.	1% AQL for EM2 resulted in one failure at -55°C -- final yield was 94 devices.			

*100% inspection performed in-process, followed by QA sampling

Attachment J
(Sheet 7 of 7)

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BxP. O. 4991(JH)
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Mr. P. D. Gerke, Manager
Lunar Surface Project Office
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

9 February 1972

Subject: Closeout of Action Item No. 590

Attachment: Table I: TI - Dallas, NASA Logic Design Comparison with Minuteman Logic Design

Dear Mr. Gerke:

The subject action item requested Bendix to provide MSC with information on the Texas Instruments assembly line for the manufacture of 54L series integrated circuits. It was suggested that there are different assembly lines for Apollo and other contracts (i. e., Minuteman).

In response to this action item Bendix Reliability visited TI-Dallas on 4 February 1972 to review differences in 54L "assembly lines" and to survey the assembly areas. The TI-Dallas review/survey revealed that there were (and still are) different assembly areas for NASA and Minuteman programs for the following reasons:

1. Logic construction and design is considerably different between NASA and Minuteman parts which is the primary reason for different assembly and manufacturing areas. (See attached Table I for differences)

2. NASA Spec. MSFC 85MO3766 specification did not require clean room assembly areas.

Attachment K

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Design Differences - The design difference details are presented in the attached Table I. Comparisons are made between NASA and Minuteman parts. Significant points are summarized below:

Item 1 - 54L (85MO3766) with flat pack package: This part is the low power TTL used for ALSEP and other Apollo electronics and is the only one that is not passivated. Lack of passivation is a problem when conductive particles are present. The reasons why passivation is not feasible on this present design are given in Table I. TI also indicated that MSFC is planning to have TI change the metallization system and add passivation under new contract.

Item 2 - 54L TTL in ceramic dual in-line package: This part uses a different metallization system than the flat pack and is passivated. The package size and the fact that the part can only be mounted on one side of a PC board is the main reason for using the smaller flatpack. The 54L TTL C-dip is built to 85MO3766 requirements for NASA and presently TI is completing baseline qualification to use this part for Minuteman ground installations.

Item 3 - 54 & 54H with either flatpack or C-dip package: This standard power and high speed (higher power) logic is made in Houston, is passivated, and uses different metallization system than 54L. ALSEP also uses 54 standard power logic (in flatpack case) but since the part is passivated, no particle contamination problems have been noted.

Item 4 - "Custom" logic in 10 lead flatpack: This item was made for Minuteman flight use starting in 1965. The logic is not TTL but is simple DTL logic. This part was originally unpassivated. Particle contamination became a problem in 1968 and the construction was modified to add passivation.

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Item 5 - RSN DTL & RSN TTL in "H" package: This item was developed by TI for Wright-Patterson in 1971 for radiation hardened requirements. The entire line has some "54L TTL functions" but design construction and number of logic functions available differs from the SM54L line. This line is to be marketed for Minuteman III flight use and other radiation hardened programs.

Clean Room Assembly - NASA TTL 85MO3766 assembly operations have been done in a class 10, 000 horizontal laminar flow clean room since January 1972. Prior to that, assembly operations were conducted in an open area about 100 feet from the present clean room. Also, in August 1971, several cleanliness procedures were instituted prior to moving into the clean room. These were:

1. Monitor particle count during weld operations.

2. Use of welder head shield to prevent weld splatter.

3. After packages are inspected they are inverted to keep foreign matter from falling into the package.

4. Package lids are now inspected for particles that may cling to lid.

The radiation hardened logic (e. g. Minuteman) has always been built in a clean room.

Recommendation

Particle contamination is due to both "foreign" particles induced in the package due to non-clean conditions and particles which may come from inside the package during non-operating environmental screen tests (such as acceleration and thermal cycling).

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The "foreign" particle problem is now resolved by TI's use of clean room and new cleanliness procedures. Particles of gold slag may possibly still be found in packages after environmental test. It should be noted that 85MO3766 requires a "eutectic" die bond (rather than cement or epon), which may produce gold slag particles which can continue to be a problem in the unpassivated 54L flatpack.

Therefore, BxA concurs with the MSC-LSPO that operating vibration screening (followed by hermetic seal tests) be continued for all unpassivated devices that use bonding systems capable of producing particles. This should be done regardless of clean room facilities used. That is to say, the SM 54L in the flatpack should be vibration screened to the Autonetics procedure regardless of Date Code. Also, this screen should be used until the die bond system is changed or until the device is modified to add passivation.

Very truly yours,

T. W. Fenske, Director
ALSEP Program

TWF:b
Attachment
cc: P. Clyatt
J. Langford
T. J. Nelson
D. J. Schwartz
A. Eckermann, MSC/Boeing
E. Smith

BxP.O. 4991(JH)
72-970-5365
9 February 1972

TABLE I

TI - DALLAS, NASA LOGIC DESIGN COMPARISON WITH MINUTEMAN LOGIC DESIGNS

Device Type (Spec.)	Package	Metallization System	Passivation	Wire Bond System	Die Attach	Remarks
54L SM54L (85M03766) 2346261 (85M03766) SNM54L (Mach IV) SNA54L (Mach IV) SNC54L (Mach IV) SNH54L (Mach IV)	14 Lead - Kovar Flatpack (.26 x .15 x .05 high)	Gold over Molybdenum	None (2) need new metal to passivate (3)	Gold Ball Bond to die	Hand scrub silicon to gold (L91, 93, 95 use preform, others do not) Note that bottom of silicon is not metallized, making die attach difficult and may be related to gold slag problem. Also, large preform for L90's is a source of gold slag (1)	(1) Autonetics vibration screen recommended because of lack of passivation. Also, gold slag particles will continue to be a problem regardless of elimination of "foreign" particle problem on line. (2) Quartz passivation not feasible without extra molybdenum layer. Extra moly layer not used because etch of this layer causes lateral etch undercut of original moly layer. (3) TI considering changing to Tungsten-Titanium instead of molybdenum under and over gold so quartz passivation can be used. Tungsten-Titanium 20 times less susceptible to lateral etch (undercut) than moly.
54L (85M03766) (BAC Minuteman Ground Spec-1972) (1)	14 Lead - Ceramic-Dip (.785 x .280 x .180 high) is 6 X area of F.P. & 24 X volume of F.P.	Aluminum over Titanium-Tungsten	Quartz	Aluminum ultrasonic bond	Ultrasonic die attach silicon to gold	(1) Early 1972 expect to complete baseline qual to use seven logic types for Minuteman ground equipment.
54 and 54H SM54 (85M03766) SM54H (85M03766) 2346.97 (85M03766)	Flatpack or C-dip described above	Aluminum over Titanium-Tungsten	Quartz (1)	Gold (2) Ball Bond	Depends on Package	(1) 54 & 54H dice manufactured and passivated in Houston. May be assembled in Houston or Dallas. (2) Gold bond to aluminum metal is weaker than gold to gold or aluminum to aluminum.
"Custom" DTL (NAA Minuteman Flight Spec-1965)	10 Lead - Kovar flatpack with dielectric isolation (ie, ceramic spacer in Header) Approx. same size & shape as 14 Lead Koval F.P.)	Gold over Molybdenum	Extra Moly layer over gold, then quartz (1), (2)	Gold	Bonded to ceramic spacer which is bonded to Kovar case (for radiation hardening)	(1) Originally designed with moly-gold unpassivated system. In 1968 switched to a moly-gold-moly-quartz system to obtain passivation and eliminate particle contamination problem. (2) Large line widths and very simple geometry with large spacing make etch of top moly layer feasible without severe undercut of first moly layer.
RSN DTL & RSN TTL (1) (Wright-Patterson AFB Spec 1971 Radiation Hardened Spec Requirements) (2)	"H" package is 14 Lead ceramic package approx. same size & shape as 14 Lead Kovar flatpack	Aluminum Metallization and chromium resistors (1)	Quartz	Aluminum Bond wires	Epon attach of silicon chip to ceramic package	(1) Several "54L TTL Functions" available but construction is different from ordinary 54LXX parts due to radiation hardening (ie, use of larger line widths and use of chromium resistors in addition to Dielectric isolation of header/case). (2) TI trying to sell for Minuteman III.

DATA PROCESSOR

CRITICALITY SUMMARY

TI P/N	1	2	3	4	5	6	Remarks
Data Processor A/D Conv. (Redundant) 2349445							
54L00	0	0	0	4	0	0	
54L04	0	0	0	2	0	0	
54L10	0	0	0	2	0	0	No comment
54L30	0	0	0	2	0	0	
54L93	0	0	0	4	0	0	
54L95	0	0	0	4	0	0	
54L74	0	0	0	6	0	0	
Data Processor Interface (Redundant) 2349455							
54L00	0	2	0	0	0	0	Lose experiments for criticality 2 due to loss of clock/demand to experiment. Outputs are wire/or. Each L00 or L04 pair loses 1 experiment (quantities shown are redundant).
54L04	0	8	0	0	0	0	
Data Processor - Timing + CW Gen (Redundant) 2349425 (Qual) 2349450 (Flight, Spare)							
54L00	0	0	0	22	0	0	
54L04	0	0	0	14	0	0	
54L10	0	0	0	16	0	0	
54L20	0	0	0	6	0	0	No comment
54L73	0	0	0	22	0	0	
54L93	0	0	0	2	0	0	
54L78	0	0	0	2	0	0	
54L74	0	0	0	6	0	0	
Data Processor - Demand Matrix (Redundant) 2349415							
54L00	0	0	0	10	0	0	
54L04	0	0	0	8	0	0	
54L10	0	0	0	12	0	0	
54L30	0	0	0	4	0	0	No comment
54L73	0	0	0	6	0	0	
54L74	0	0	0	8	0	0	
54L01	0	0	0	32	0	0	

COMMAND DECODER

CRITICALITY SUMMARY

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
			C/D Demodulator A, B 2367645 Qual 2367652 Flight				
54L00	0	0	0	2	0	0	
54L04	0	0	0	4	0	0	
54L10	0	0	0	2	0	0	
54L20	0	0	0	2	0	0	No comment
54L51	0	0	0	2	0	0	
54L72	0	0	0	2	0	0	
54L73	0	0	0	8	0	0	
			C/D Decode A, B BDS 2367625				
54L00	0	0	50	2	0	0	Will require complete rework if these parts are changed.
54L04	0	0	0	16	0	0	
54L20	0	0	0	24	0	0	
			C/D Sequencer 2367615				
54L00	0	0	0	8	0	0	Change of these parts will probably cause loss of board. Board contains long lead items (NH0001A op amps)
54L04	0	2	0	6	0	0	
54L10	0	0	0	5	0	0	
54L20	0	4	0	7	0	0	
54L74	0	0	0	3	0	0	Note: For criticality 2 lose experiments due to power shut down.
54L93	0	0	0	4	0	0	

COMMAND DECODER (continued)

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
				C/D Control Logic A, B 2370075, Qual, Spare, Flight			
54L00	0	0	0	20	0	0	This board was not yet built; therefore will get screened parts.
54L04	0	2	0	2	0	0	
54L10	0	0	0	8	0	0	
54L20	0	0	0	4	0	0	
54L30	0	0	0	2	0	0	
54L72	0	0	0	6	0	0	
54L73	0	0	0	12	0	0	
54L78	0	0	0	2	0	0	
				PCU (Redundant) 2370060			
54L04	0	0	0	2	0	0	No comment
				PDU (Redundant) 2362800			
54L30	0	0	0	2	0	0	No comment
				S-Band Transmitter (Redundant) Synthesizer			
54L00	0	0	0	2	0	0	Parts from DLC 7142, which is not particle suspect.

LSG

Criticality Summary

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
				LSG A/D Converter/Dig. Mux Board #1			
54L93	0	1	0	0	0	0	If 54L IC's have to be replaced then a board is necessary. Qual and flight PC boards have not been potted at this time. There is one spare PC board. Some parts have to be reprocured, other parts will be transferred from board to board.
54L04	0	3	0	0	0	0	
54L10	0	1	0	0	0	0	
54L20	0	1	0	0	0	0	
54L00	0	6	0	0	0	0	
54L95	0	3	0	0	0	0	
54L54	0	10	0	0	0	0	
54L73	0	6	0	0	0	0	
				LSG Digital Lines BFR/RCVR Commands Board #2			
54L73	0	0	0	0	1	0	If 54L IC's have to be replaced then new board is necessary. Signetics 8T80 & 8T90 can be replaced in this board. There is sufficient quantities of Signetic IC's in stores. Swap board to board on other parts; see memo 984-ME-165. Problem is transfer of parts. Replacement of more than 3 to 4 IC' s will require new PC board. At this time this PC board for qual or flight have not been potted. If the board is potted it is difficult to remove 54L IC's but can be done. This board has not been attached to the mother board. There is 1 PC board spare. Some parts have to be procured others can be transferred from board to board.
54L10	0	0	0	0	1	0	
54L72	0	0	0	0	1	0	
54L78	0	2	0	0	0	0	
54L86	0	0	0	0	1	0	
54L00	0	3	0	0	0	0	
54L04	0	8	0	0	0	0	
				LSG Analog Output Buffers/Analog Mux Board #3			
54L10	0	1	0	0	0	0	If 54L IC's have to be replaced, board can be reworked. Flight and qual PC boards have not been potted at this time. There is one spare PC board. There is one spare PC board. There are Philbrick op amp in this board.
54L04	0	3	0	0	0	0	

LSG (continued)

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
							LSG Tilt/Screw Servo Control Board #4
54L78	0	2	0	0	0	0	If 54L IC's have to be replaced new board is necessary. Flight PC board have not been potted at this time. Qual board is potted. There is one spare PC board. Replace Signetics 8T80 and 8T90. There are suggicient quantities of these IC's in B/S. Other parts can be swap from board to board or reprocured.
54L72	0	2	0	0	0	0	
54L20	0	1	0	0	0	0	
54L10	0	2	0	0	0	0	
54L00	0	10	0	0	0	0	
54L93	0	5	0	0	0	0	
2346207-22	0	1	0	0	0	0	
							LSG Mass Change Servo Board #6
54L78	0	1	0	0	0	0	If 54L IC's are to be replaced the PC board can be reworked. Qual and flight PC boards have not been potted at this time. There is a spare board.
54L73	0	2	0	0	0	0	
54L00	0	1	0	0	0	0	
							LSG Board #8
54L78	0	0	0	0	2	0	If 54L IC's have to be replaced PC board can be reworked. Flight PC board have not been potted at this time. Qual PC board is potted. There is one spare PC board.
54L30	0	1	0	0	0	0	
							LSG Shaft Encoder Board #14 A1 & A2
54L51	0	0	0	0	5	0	If 54L IC's are replaced new boards are necessary. Qual and flight PC board have not been potted at this time. There are spare PC boards. Some parts have to be reprocured other parts will be transferred from board to board. 54L IC's are criticality 5.
54L04	0	0	0	0	4	0	
54L10	0	0	0	0	19	0	
54L73	0	0	0	0	1	0	
54L78	0	0	0	0	1	0	

LSPE

CRITICALITY SUMMARY

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
LSPE C/S Electronics Digital Processor 2347815 (Board #1)							
54L00	0	7	0	0	0	0	If criticality 2 parts are changed old board must be scrapped. New board and all other parts on hand.
54L04	0	11	0	0	0	0	
54L10	0	5	0	0	0	0	
54L20	0	6	0	0	0	0	
54L30	0	1	0	0	0	0	
54L73	0	10	0	0	0	0	
54L78	0	3	0	0	0	0	
54L121 (2346207-22)	0	3	0	0	0	0	
LSPE C/S Electronics Digital Processor 2347825 (Board #2)							
54L00	0	2	0	0	0	0	If criticality 2 parts are changed old board must be scrapped. New board and all other parts on hand.
54L01	0	1	0	0	0	0	
54L04	0	4	0	0	0	0	
54L10	0	10	0	0	0	0	
54L54	0	2	0	0	0	0	
54L73	0	1	0	0	0	0	
54L121 (2346207-22)	0	2	0	0	0	0	
LSPE C/S Electronics Digital Processor 2347835 (Board #3)							
54L00	0	2	0	0	0	1	If criticality 2 parts are changed old board must be scrapped. New board and all other parts on hand.
54L04	0	7	0	0	0	7	
54L10	0	1	0	0	0	5	
54L20	0	0	0	0	0	1	
54L51	0	6	0	0	0	8	
54L54	0	2	0	0	0	4	
54L78	0	5	0	0	0	4	

LSPE (continued)

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
	LSPE - 16 Channel Mux						
	Board #2346710						
54L20	0	0	0	0	4	0	A/D digital board 2376725 must be scrapped. A/D analog board 2376720 and MUX board 2376710 are o.k.
	Board #2346720						
54L04	0	2	0	0	0	0	
	Board #2346725						
54L04	0	2	0	0	0	0	
54L10	0	2	0	0	0	0	
54L30	0	0	0	0	1	0	
54L93	0	3	0	0	0	0	
	LSPE Explosive Package Assembly Firing Circuit Assembly 2348393 Signal Processor 2348355 (8 boards req'd)						
54L73	0	0	0	0	2	0	There is no problem in replacing replacing these parts.
54L121 (2346207-22)	0	0	0	0	2	0	

Attachment L
(Sheet 7 of 12)

LMS

CRITICALITY SUMMARY

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
				Counting & Data Compressor (BxA) 2347550			
54L00	0	0	0	0	9	0	
54L04	0	0	0	0	6	0	
54L10	0	0	0	0	3	0	
54L20	0	0	0	0	6	0	PC is available for replacement
54L72	0	0	0	0	3	0	
54L73	0	0	0	0	6	0	
54L93	0	0	0	0	18	0	
54L95	0	0	0	0	24	0	
				Signal Conditioner & Command Decoder (BxA) 2347540			
54L00	0	3	0	0	0	0	ML-PCB
54L04	0	6	0	0	0	0	Not yet fab. for flight. 2 spare
54L20	0	6	0	0	1	2	blank boards on hand. 4 weeks to
54L30	0	0	0	0	0	3	fab/test. May have two weeks
54L73	0	1	0	0	0	0	delay due to "piggy-back" board fab.
54L78	0	4	0	0	1	5	All other parts believed to be
54L93	0	1	0	0	0	0	available. Will have flight fab.
54L121 (2346207-22)	0	0	0	0	0	1	with NAA screened parts.
				Emission Control Board (UTD) 151-550			
54L04	0	1	0	0	0	0	No comment
54L10	0	1	0	0	0	0	
				Housekeeping (BxA) 2347555			
54L00	0	1	0	0	0	0	One IC need to be removed from
54L010	0	0	0	0	0	1	this multilayer board. C.R.
54L51	0	0	0	0	0	6	rating of II due to 90th frame
54L78	0	0	0	0	0	15	marker through chip.

LMS (continued)

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
			Pre Amp/Discriminator (UTD) 151-660				
54L00	0	0	0	0	0	1	No comment
54L121	0	0	0	0	4	0	
			Sweep Hi-Voltage P/S (UTD) 151-686				
54L00	0	3	0	0	0	0	Assembly mounted to and wired to Emission Control Board. Unit must be disassembled for rework. New board not suggested since 50% of board is not flat pack circuit, also many parts are long lead items. Since board is polywire, IC may be removed with greater probability of success than with multilayer boards. IC's are soldered to feed through nickle studs; wire is welded to back side of stud.
54L04	0	3	0	0	0	0	
54L20	0	2	0	0	0	0	
54L30	0	3	0	0	0	0	
54L51	0	2	0	0	0	0	
54L71	0	3	0	0	0	0	
54L73	0	9	0	0	0	0	
54L121	0	1	0	0	2	0	

Attachment L
(Sheet 9 of 12)

LEAM

CRITICALITY SUMMARY

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
				LEAM Matrix - Board #1			
54L00	0	1	0	0	0	0	1 IC and a module in this board. Module 10126028. If module and IC is replaced board can be reworked. Parts have to be procured. Replacement module is easy. Module fab. by Time Zero.
	Module 10126028						
54L04	0	1	0	0	0	0	
				LEAM Matrix - Board #2			
	Module 10126007						1 module in this board. Module 10126007. Module has a Harris op amp. Spare module being fabricated and waiting for 54L00 IC from the 54L IC's screened at Autonetics. Replacement of module is easy.
54L00	0	1	0	0	0	0	
				LEAM Power Supply			
	OSC Module 10126001						If 10 KHZ OSC is replaced PC board can be reworked. Replace module is easy. Parts have to be procured. New module fab. by Time Zero. Fab. time 2 weeks + new parts.
54L72	0	1	0	0	0	0	
				LEAM Logic Board Assy. Central Electronics			
54L00	0	0	0	0	27	0	New MLB is being fabricated by Vostron. Parts will be assembled on the MLB by BxA. The only problem is the need of 54L IC's screened at Autonetics. No modules on this board.
54L04	0	2	0	0	14	0	
54L20	0	0	0	0	8	0	
54L30	0	1	0	0	2	0	
54L72	0	0	0	0	2	0	
54L73	0	0	0	0	11	0	

LEAM (continued)

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
							(1st) Microphone Board - Dual Sensor
54L00	0	0	0	0	1	0	There are 3 IC's and 5 modules in
54L04	0	0	0	0	1	0	this board. Modules 10126015 (1),
54L73	0	0	0	0	1	0	10126010 (4). Replacement of more
	Module 10126015						than one module new board is needed.
54L04	0	0	0	0	1	0	There are 6 Harris op amp in this
	Module 10126010 (4 req'd)						board. Parts have to be procured.
54L00	0	0	0	0	1	0	Replacement of module is easy.
							Module to be fab. by Time Zero.

(2nd) Microphone Board - Dual Sensor

Same as (1st) Microphone Board above

Microphone Board - Single Sensor

54L00	0	0	0	0	1	0	3 IC and 2 modules in this board.
54L04	0	0	0	0	1	0	Modules 10126015 and 10126010.
54L73	0	0	0	0	1	0	Replacement of more than one
	Module 10126015						module new board is needed. Parts
54L04	0	0	0	0	1	0	have to be reprocured. Replacement
	Module 10126010						of module is easy. Module to be fab.
54L00	0	0	0	0	1	0	by Time Zero.

ARRAY D

CRITICALITY SUMMARY

TI P/N	Criticality No. 1	2	3	4	5	6	Remarks
			90 Channel Mux (Redundant)				
54L04	0	0	0	0	0	4	
54L10	0	0	0	0	0	4	
54L30	0	0	0	0	0	2	No comment
54L72	0	0	0	0	0	2	
54L93	0	0	0	0	0	6	
			16 Channel Mux 2376710 Mux 2376720 A/D (Analog) 2376725 A/D Digital				
	Board 2346710						
54L20	0	0	0	0	4	0	
	Board 2346720						
54L04	0	2	0	0	0	0	
	Board 2346725						
54L04	0	2	0	0	0	0	If criticality 2 parts are to be replaced. 2376725 board should be scrapped. Other boards can be saved. All parts including board on hand.
54L10	0	2	0	0	0	0	
54L30	0	0	0	0	1	0	
54L93	0	3	0	0	0	0	