(NASA-CR-161152) TRANSISTER STEP STRESS TESTING PROGRAM FOR JANTX2N3811 Final Report (DCA Reliability Lab., Sunnyvale, Calif.) 44 p HC A03/MF A01 CSCI 09A

N79-18255

Unclas
G3/33 16133

TRANSISTOR

STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR
JANTX2N3811

JANUARY 1979

Prepared
For

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

DCA RELIABILITY LABORATORY
SPECIAL PRODUCTS DIVISION
975 BENICIA AVE
SUNNYVALE, CALIFORNIA 94086

DCA
RELIABILITY LABORATORY

FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION/SCOPE

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the dual transistor JANTX2N3811 manufactured by Motorola and National Semiconductor.

A total of 48 samples from Motorola and 47 from National Semiconductor were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The current was set by I_E and the voltage was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All remaining

devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The dual transistors were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of MRP for a total of 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-one units, 16 from Motorola and 15 from National Semiconductor, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at MRP in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at MRP in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of

the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Motorola. The Motorola sample lot completed the entire 2500-hour Group I Testing with no catastrophic failures. Typical characteristics for this sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 106.3pA from an initial mean of 489.4pA to a final mean of 383.1pA.
2) The mean value for $V_{CE(SAT)}$ changed 1.370mV from an initial mean of 69.00mV to a final mean of 67.63mV.
3) The mean value for h_{FE} changed 31.90 from an initial mean of 455.8 to a final mean of 487.7.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 175.8pA from an initial mean of 510.6pA to a final mean of 334.8pA.
2) The mean value for $V_{CE(SAT)}$ changed 8.37mV from an initial mean of 75.50mV to a final mean of 67.13mV.
3) The mean value for h_{FE} changed 36.30 from an initial mean of 450.0 to a final mean of 486.3.
4) The mean value for h_{FE} (matching) changed

.0070 from an initial value of 1.012 to a final value of 1.005.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 National Semiconductor. The National Semiconductor sample lot completed the entire 2500-hour Group I Testing with a total of three catastrophic failures. The first failure occurred 50 hours into the 50% MRP step. Serial Numbers 2547 (Sides A and B) failed the maximum $V_{CE(SAT)}$ limit and the minimum h_{FE} limit. Serial Number 2546 was removed from the testing 150 hours into the 50% MRP step as a visual reject due to handling. The next failure occurred 250 hours into the 50% MRP step. Serial Number 2548 (Side B) failed the maximum $V_{CE(SAT)}$ limit. The final failure occurred 150 hours into the 175% MRP step. Serial Number 2257 (Side B) failed the minimum h_{FE} limit. Typical characteristics of these sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 1.782nA from an initial mean of 817.5pA to a final mean of 2.399nA.
2) The mean value for $V_{CE(SAT)}$ changed 1.330mV from an initial mean of 47.75mV to a final mean of 46.42mV.
3) The mean value of h_{FE} changed 28.60 from an initial mean of 392.8 to a final mean of 364.2.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 88.30pA from an initial mean of 570.0pA to a final

mean of 481.7pA.

2) The mean value for $V_{CE(SAT)}$ changed 6.110mV from an initial mean of 52.44mV to a final mean of 46.33mV.

3) The mean value for h_{FE} changed 17.90 from an initial mean of 384.3 to a final mean of 366.4.

4) The mean value for hFE (matching) changed .0255 from an initial mean of 1.023 to a final mean of .9975.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for all of the specified electrical parameters and all measurement points for both Motorola and National Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Motorola. The Motorola sample lot completed 1280 hours of the Group II Testing with nine catastrophic failures. The lot continued processing through the entire 1600 hours of testing and accumulated five more failures. The first nine failures occurred 160 hours into the 250°C-temperature step. Serial Numbers 6322, 6323, 6326, 6328, 6331, 6333 and 6334 failed the maximum $V_{CE(SAT)}$ limit (Side B). Serial Number 6336 failed due to excessive I_{CBO} leakage (Side B). Serial Number 6327 failed the maximum $V_{CE(SAT)}$ limit (Sides A and B) and the minimum h_{FE} limit (Side A). The next failure occurred 160 hours into

the 275°C-temperature step. Serial Number 6332 (Side A) failed the maximum $V_{CE(SAT)}$ limit. The final four failures occurred 160 hours into the 300°C-temperature step. Serial Number 6324 (Side B) failed the maximum I_{CBO} and $V_{CE(SAT)}$ and the minimum h_{FE} limits. Serial Number 6325 (Side A) failed the maximum I_{CBO} and minimum h_{FE} limits. Serial Number 6329 failed the maximum I_{CBO} (Side A), and $V_{CE(SAT)}$ (Sides A and B) and minimum h_{FE} (Side B) limits. Serial Number 6335 failed the maximum I_{CBO} (Side A), $V_{CE(SAT)}$ (Sides A and B), and h_{FE} (matching) limits. Typical characteristics of this sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 4.163 A from an initial mean of 420.0pA to a final mean of 4.163 A.
2) The mean value for $V_{CE(SAT)}$ changed 2.933V from an initial mean of 7.000mV to a final mean of 3.003V.
3) The mean value for h_{FE} changed 287.5 from an initial mean of 477.6 to a final mean of 290.1.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 883.1nA from an initial mean of 435.0pA to a final mean of 833.5nA.
2) The mean value for $V_{CE(SAT)}$ changed 1.884V from an initial mean of 69.92mV to a final mean of 1.954V.
3) The mean value for h_{FE} changed 144.2 from an initial mean of 494.0 to a final mean of 352.3.
4) The mean value for h_{FE} (matching) changed

19.80 from an initial mean of .9688 to a final mean of 20.77.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 National Semiconductor. The National Semiconductor lot completed 1120 hours before the lot was stopped after six catastrophic failures. The first two failures occurred 160 hours into the 200°C-temperature step. Serial Number 2562 and 2573 failed the minimum h_{FE} (Side A) limit. The remaining failures occurred 160 hours into the 225°C-temperature step. Serial Numbers 2561 and 2575 failed the minimum h_{FE} (Side A) limit. Serial Number 2564 (Side B) failed the maximum $V_{CE(SAT)}$ and minimum h_{FE} limits. Serial Number 2565 (Side B) failed the maximum I_{CBO} and minimum h_{FE} limits. Serial Numbers 2566 and 2568 were removed from testing as MIL-S-19500 failures. Typical characteristics of this sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 20.34nA from an initial mean of 369.3pA to a final mean of 20.71nA.
2) The mean value for $V_{CE(SAT)}$ changed 10.36mV from an initial mean of 49.33 to a final mean of 59.69mV.
3) The mean value for h_{FE} changed 91.80 from an initial mean of 379.5 to a final mean of 287.7.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 224.7nA

from an initial mean of 338.7pA to a final mean of 225.0nA.

2) The mean value for VCE(SAT) changed 1.104V from an initial mean of 49.00mV to a final mean of 1.153V.

3) The mean value for h_{FE} changed 103.5 from an initial mean of 383.1 to a final mean of 279.6.

4) The mean value for h_{FE} (matching) changed .9439 from an initial mean of .9921 to a final mean of 1.936.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 outlines the results of Group II - Temperature Stress I Testing for all of the specified electrical parameters and all of the measurement points pertaining to both Motorola and National Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Motorola. The Motorola sample lot completed the entire 112-hour Group III Testing with no catastrophic failures. Typical characteristics of this sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 108.7pA from an initial mean of 531.2pA to a final mean of 422.5pA.

2) The mean value for $V_{CE(SAT)}$ changed 1.500mV from an initial mean of 71.00mV to a final mean of 69.50mV.

3) The mean value for h_{FE} changed 24.20 from

an initial mean of 509.0 to a final mean of 484.8.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 26.80pA from an initial mean of 376.2pA to a final mean of 349.4pa.
2) The mean value for $V_{CE(SAT)}$ changed 1.310mV from an initial mean of 70.31mV to a final mean of 69.00mV.
3) The mean value of h_{FE} changed 33.20 from an initial mean of 511.9 to a final mean of 478.7.
4) The mean value for h_{FE} (matching) changed .0164 from an initial mean of .9976 to a final mean of 1.014.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 National Semiconductor. The National Semiconductor sample lot completed the entire 112 hours of the Group III Testing with seven catastrophic failures. The first failures occurred 16 hours into the 225°C-temperature step. Serial Number 2579 failed the minimum h_{FE} (Side A) and maximum I_{CBO} (Side B) limits. Serial Number 2576 failed the maximum h_{FE} (matching) limit. The next failure occurred 16 hours into the 250°C-temperature step. Serial Number 2581 failed the maximum h_{FE} (matching) limit. The next failure occurred 16 hours into the 275°C-temperature step. Serial Number 2577 (Side B) failed the maximum $V_{CE(SAT)}$ and minimum h_{FE} limits. The final failures occurred 16 hours into the 300°C-temperature step.

Serial Number 2586 (Side B) failed the maximum $V_{CE(SAT)}$ and minimum h_{FE} limits. Serial Number 2587 (Side B) failed the maximum I_{CBO} and minimum h_{FE} limits. Serial Number 2590 (Side A) failed the minimum h_{FE} limits. Typical characteristics of this sample lot's performance (Side A) were:

1) The mean value for I_{CBO} changed 16.20pA from an initial mean of 336.9pA to a final mean of 320.7pA.
2) The mean value for $V_{CE(SAT)}$ changed 48.30mV from an initial mean of 47.13mV to a final mean of 95.43mV.
3) The mean value for h_{FE} changed 92.40 from an initial mean of 386.4 to a final mean of 294.0.

Typical characteristics of this sample lot's performance (Side B) were:

1) The mean value for I_{CBO} changed 135.4nA from an initial mean of 306.2pA to a final mean of 135.6nA.
2) The mean value for $V_{CE(SAT)}$ changed 103.8mV from an initial mean of 46.81mV to a final mean of 150.6mV.
3) The mean value for h_{FE} changed 130.3 from an initial mean of 381.6 to a final mean of 251.3.
4) The mean value for h_{FE} (matching) changed .0283 from an initial mean of 1.014 to a final mean of .9857.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results for Group III - Temperature Stress II Testing for each of the specified electrical parameters and all measurement points for both Motorola and National Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

Both manufacturers' sample lots held up well during the Group I - Power Stress Process.

The Group II Testing for National Semiconductor's stopped at the 225°C step and although Motorola showed a higher total number of rejects, the

majority of the failures occurred at the last step of the Group II testing.

Failure analysis shows that the National Semiconductor devices are constructed with gold ball bonded internal wires, while the Motorola devices have ultrasonically bonded aluminum internal wires. This difference in construction may be the reason for the difference of performance of the two sample lots. Hysteresis or leakage was common to a majority of the National Semiconductor parts. This pattern suggests the presence of contamination in (or on) the base diffusion. The flow of metal from the gold leads and the intermetallics, because of the stress, is one source of such contaminants. Possibly the National Semiconductor lot failures could have been postponed to higher stress levels if aluminum wires had been used instead of gold.

A plot showing cumulative failure distribution for Groups II and III was drawn for the National Semiconductor lot (Figures 4 and 5). A complete plot for the Motorola lot could not be drawn due to an absence of failure points in the Group III Testing (Figures 2 and 3). Figures 4 and 5 display the data for the National Semiconductor sample lot used to calculate an activation energy of 1.24eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

Because of defects caused by the extreme heat of the stress test (discovered in Failure Analysis), Serial Number 2577 was calculated as part of the regression line.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2}\right)\right]\left[\frac{8.63 \times 10^{-5}\ eV/^{o}K}{\left(\frac{1}{T_1+273}\right) - \left(\frac{1}{T_2+273}\right)}\right] eV$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in ^{o}C of 16% failure for Group II.

T_2 = temperature in ^{o}C of 16% failure for Group III.

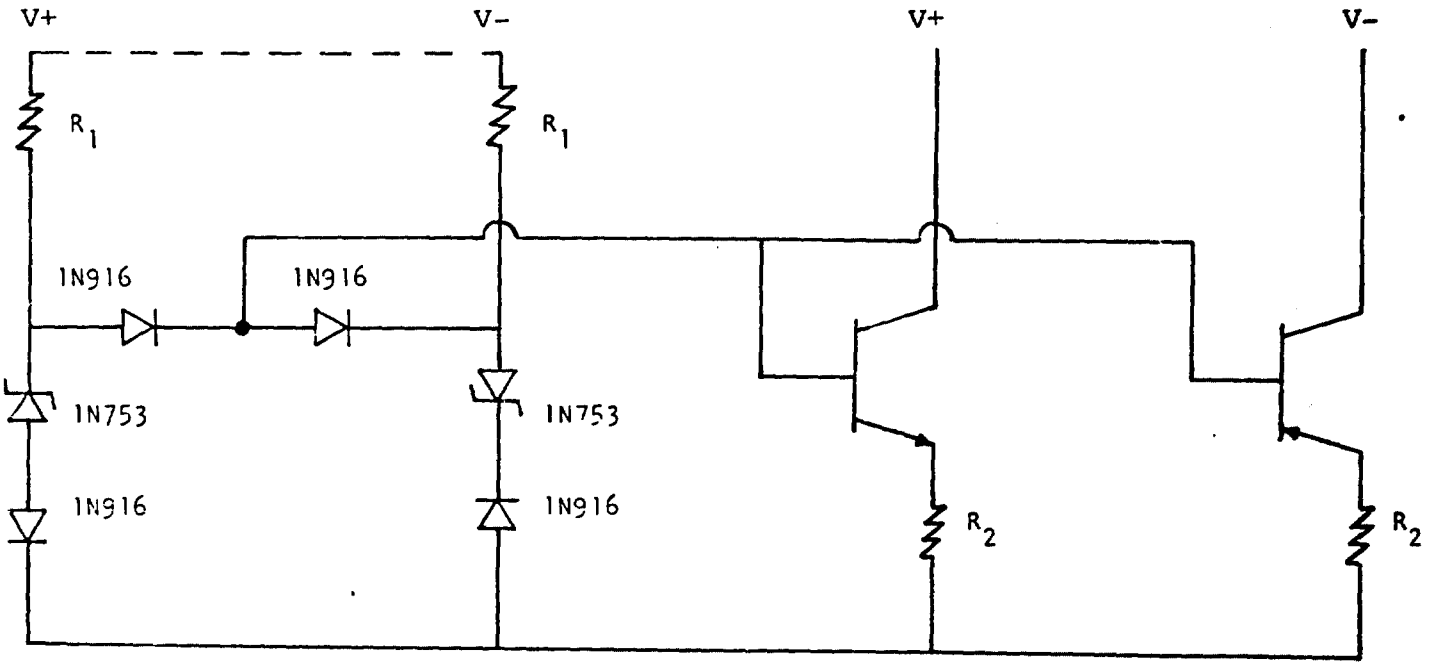
NOTE:

*Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times.

C) Other parameters exceed millimits by 50% or more.

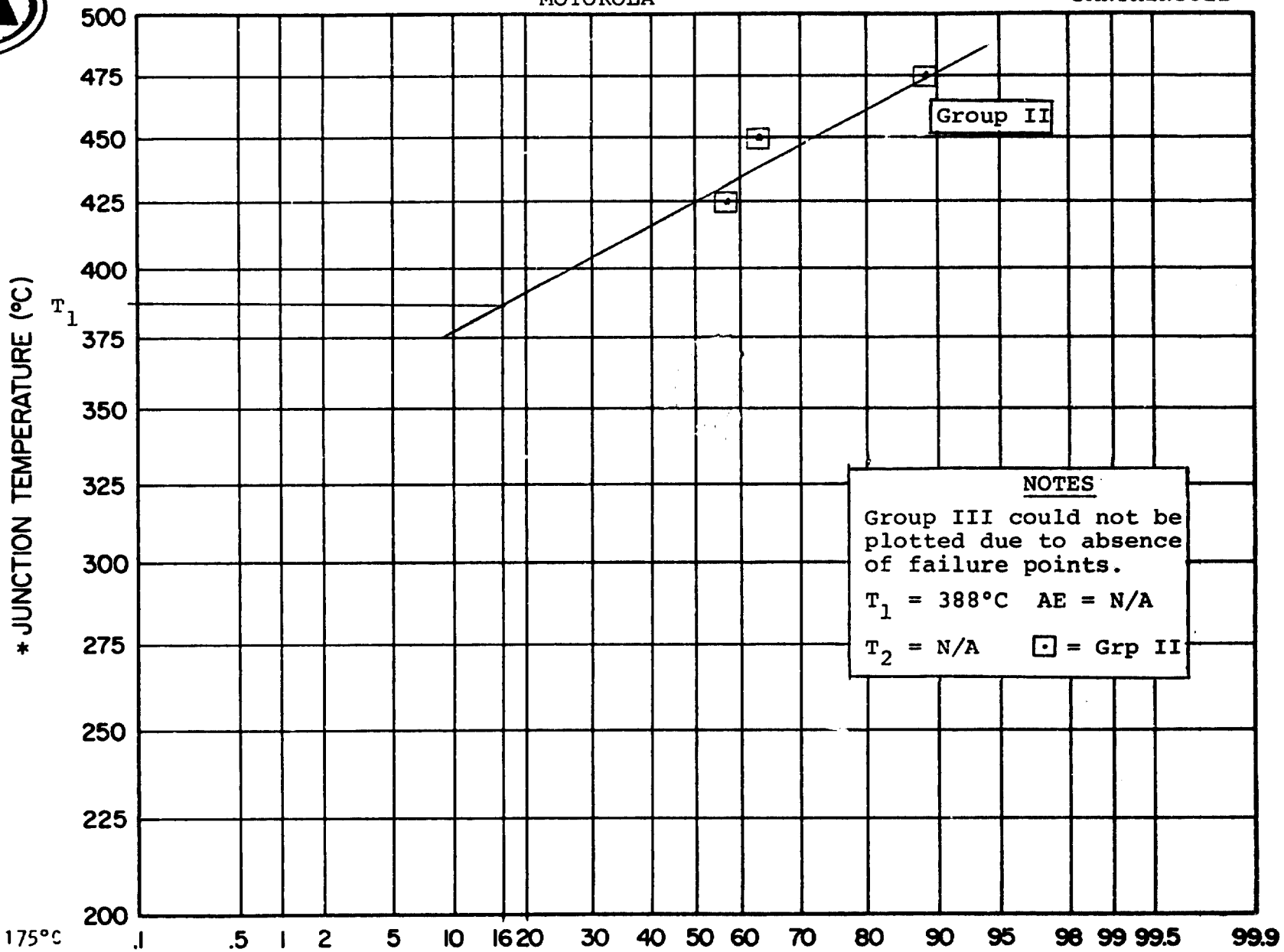


NOTES: R_1 = 800±5%, 2W. R_2 = 287Ω±1%½W

Use V+ for NPN Transistors; Use V- for PNP Transistors.

FIGURE 1

POWER AND TEMPERATURE STRESS CIRCUIT
FOR JANTX2N3811



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Motorola

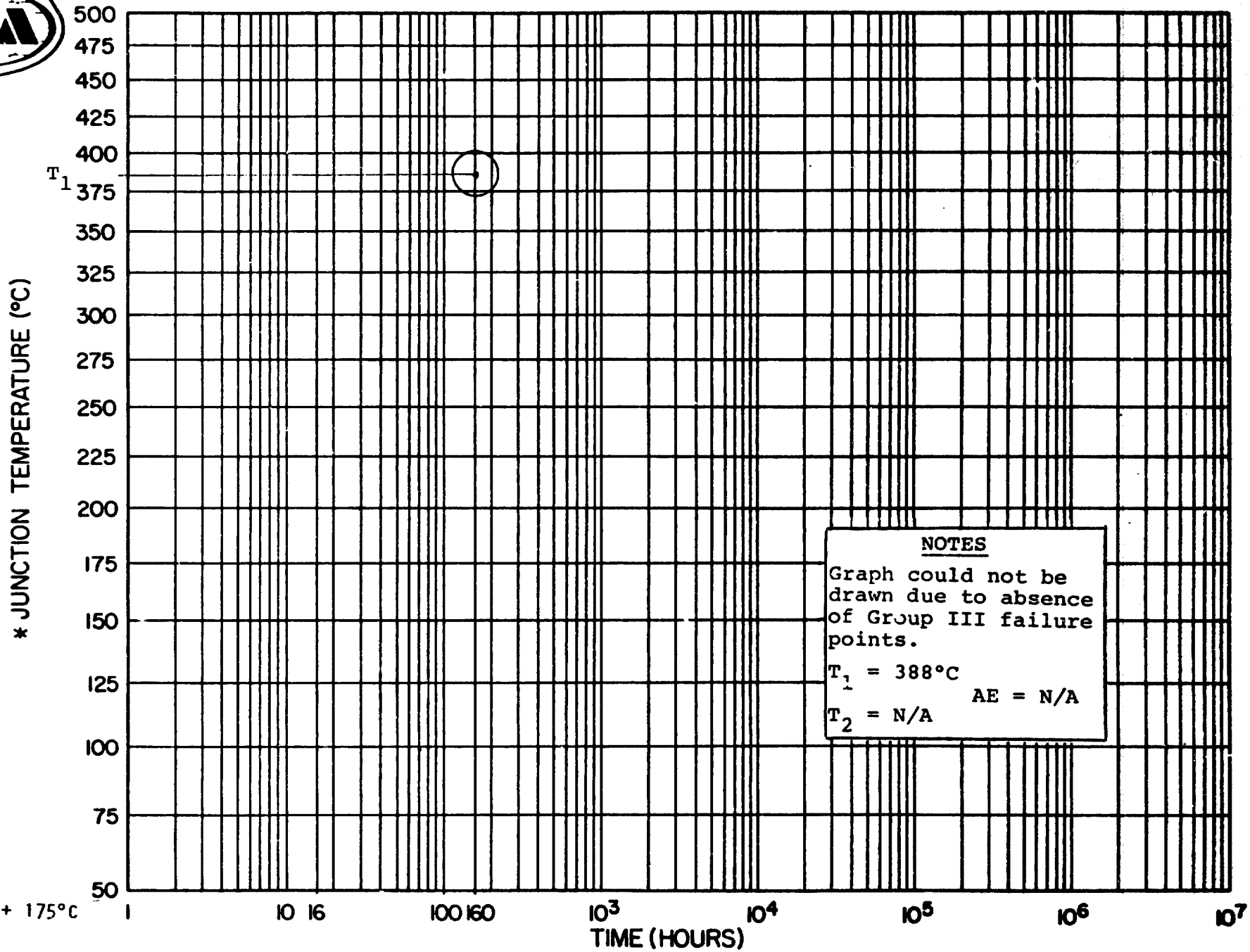
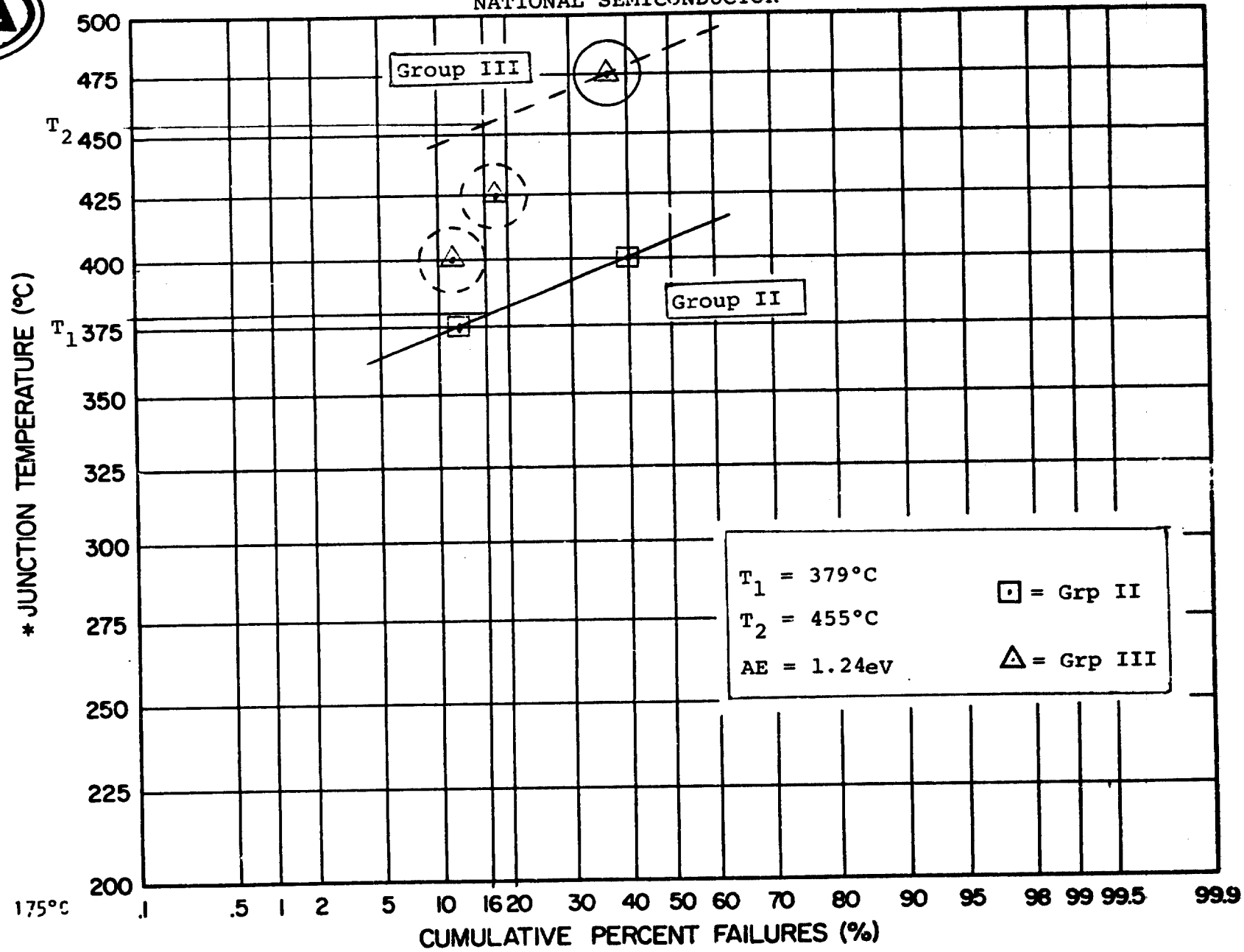


FIGURE 3
Time Steps Versus Junction Temperature, Motorola

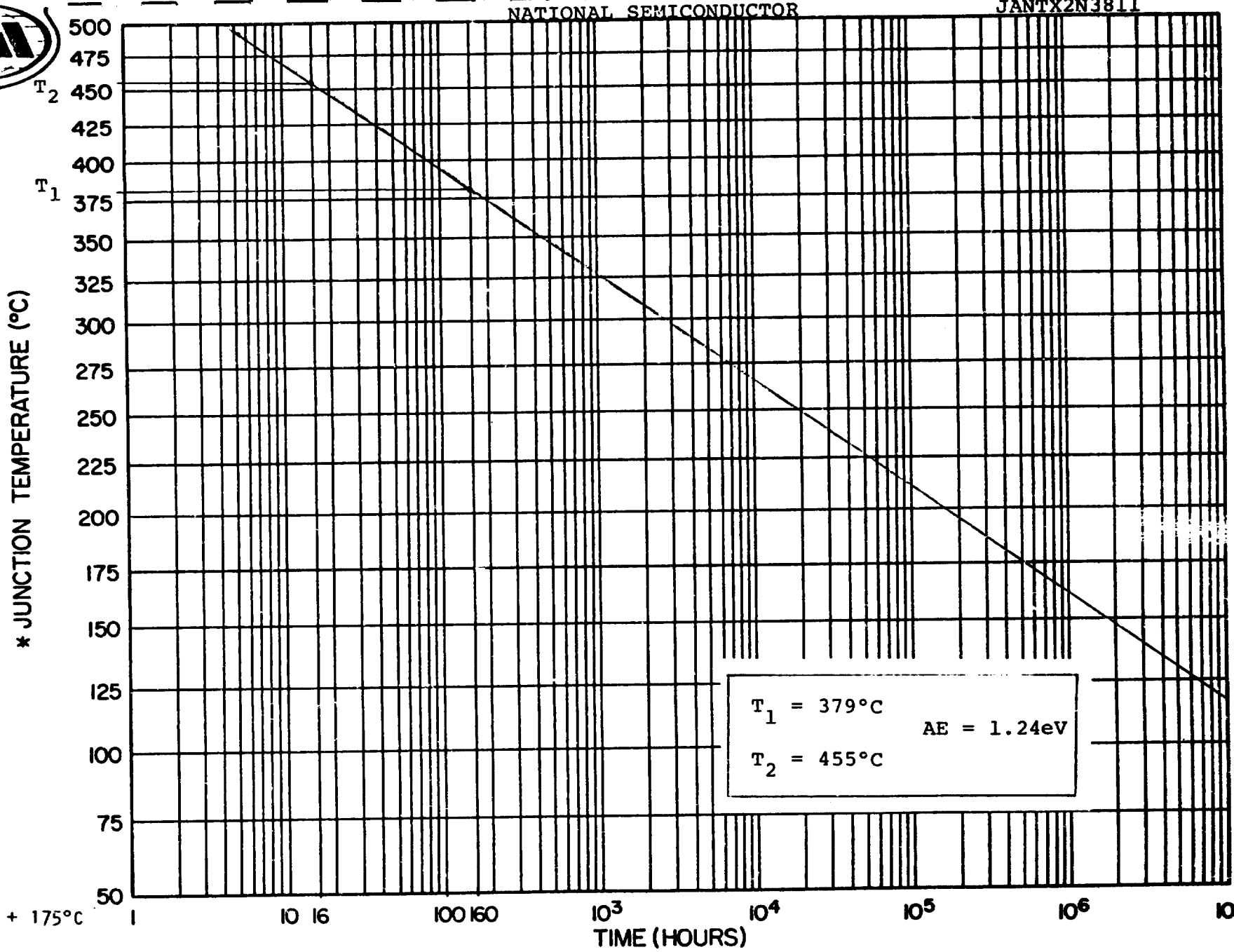


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, National Semiconductor



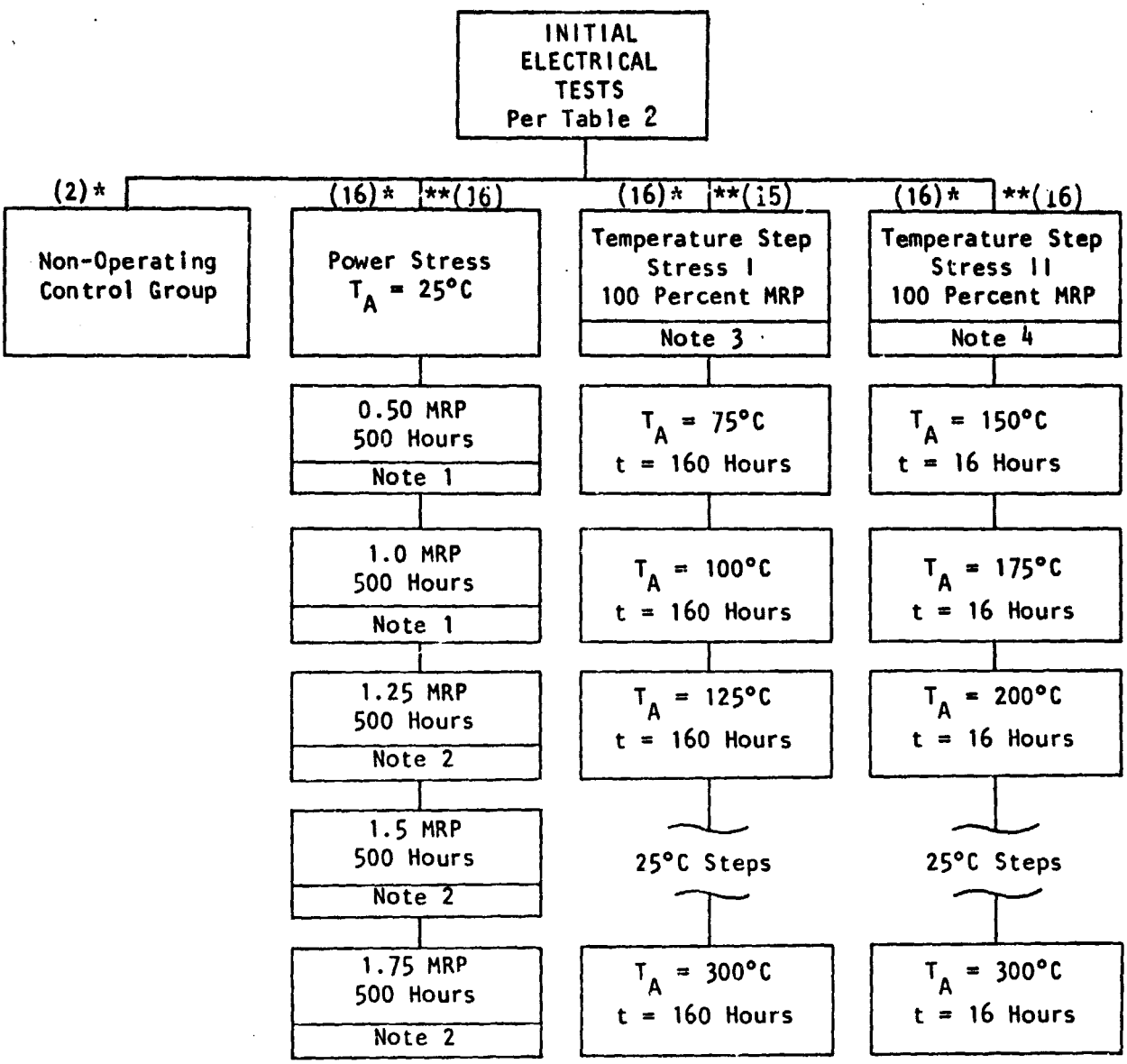
*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5
Time Steps Versus Junction Temperature, National Semiconductor

JANTX2N3811

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Motorola)
**Quantity per manufacturer (National Semiconductor)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_{CBO}	@ V_{CB} = -50V		-10		-1000	nA
$V_{CE(SAT)}$	@ I_C = -1.0mA, I_B = -100µA		.25		.375	V
h_{FE}	@ V_{CE} = -5.0V, I_C = -100µA	300	900	150	1350	-
h_{FE_1}/ h_{FE_2}	(h_{FE} matching) @ V_{CE} = -5.0V, I_C = -100µA	.9	1.1	.45	1.65	-

NOTES:

TABLE 3
POWER STRESS BURN-IN CONDITIONS

I_E = 19.6mA	
V_{CE} =	Percent P_D
7.5V	50
15.0V	100
18.75V	125
22.5V	150
26.25V	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I — POWER STRESS DATA SUMMARY
SIDE A

PARAMETER	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE_1} = 300(MIN) 900(MAX)			
CONDITIONS AND LIMIT	@ V_{CB} = -50V		@ I_C = -1mA I_B = -100µA		@ V_{CE} = -5V I_C = -100µA			
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS		
INITIAL DATA								
MIN VALUE	320.0pA	330.0pA	58.00mV	42.00mV	305.0	322.0		
MAX VALUE	440.0pA	3.390nA	86.00mV	54.00mV	600.0	458.0		
MEAN	489.4pA	617.5pA	69.00mV	47.75mV	455.8	392.8		
STD DEV	209.3pA	722.4pA	6.661mV	3.413mV	61.31	38.79		
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	14.30pA	-25.60pA	-.5600mV	621.0mV	8.800	-25.60		
150 HRS	96.60pA	23.90pA	-.5000mV	-.8200mV	9.000	-2.500		
250 HRS	-15.70pA	-49.60pA	1.880mV	.3200mV	32.90	7.100		
500 HRS	-55.70pA	-58.30pA	1.250mV	-.6000mV	29.00	-6.300		
100% POWER								
550 HRS	-63.20pA	-112.1pA	1.000mV	-.7500mV	27.30	-6.400		
650 HRS	-91.30pA	-106.7pA	1.060mV	-.6700mV	34.80	-4.100		
750 HRS	-94.40pA	-112.9pA	.6300mV	-.6000mV	33.50	-1.300		
1000 HRS	-125.0pA	-153.7pA	-.6900mV	-1.830mV	23.50	-14.70		
125% POWER								
1010 HRS	52.50pA	-53.70pA	.2500mV	-1.060mV	31.80	-8.100		
1025 HRS	68.10pA	12.50pA	.8100mV	-.6000mV	32.90	-5.300		
1050 HRS	78.70pA	59.40pA	.8800mV	-.3700mV	39.50	-2.600		
1150 HRS	73.70pA	163.3pA	.3800mV	-.6700mV	40.80	-6.100		
1250 HRS	88.70pA	342.5pA	.2500mV	-.6000mV	53.00	-3.800		
1500 HRS	68.10pA	291.7pA	-.4400mV	-1.060mV	41.70	-10.80		

(continued on second sheet)

TABLE 4 (Cont'd)

(continued from first sheet) GROUP I — POWER STRESS DATA SUMMARY (SIDE A)

PARAMETER	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE_1}=300 (MIN) 900(MAX)			
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA I_B = -100µA		@ V_{CE} = -5V I_C = -100µA			
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS		
INITIAL DATA								
MIN VALUE	320.0pA	330.0pA	58.00mV	42.00mV	305.0	322.0		
MAX VALUE	440.0pA	3.390nA	86.00mV	54.00mV	600.0	458.0		
MEAN	489.4pA	617.5pA	69.00mV	47.75mV	455.8	392.8		
STD DEV	209.3pA	722.4pA	6.661mV	3.419mV	61.31	38.79		
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	70.60pA	390.5pA	5600mV	-1.440mV	42.60	-6.600		
1525 HRS	68.10pA	472.5pA	-.5000mV	-.6700mV	45.30	-10.30		
1550 HRS	85.60pA	534.5pA	-.1200mV	-.9800mV	53.60	-7.600		
1650 HRS	66.20pA	1.010nA	-.5000mV	-1.210mV	46.40	-7.000		
1750 HRS	70.00pA	971.5pA	-.7500mV	-.210mV	47.50	-13.40		
2000 HRS	60.00pA	1.156nA	-1.440mV	-1.670mV	41.60	-15.90		
175% POWER								
2010 HRS	75.00pA	1.295nA	-.8100mV	-1.210mV	58.20	-10.60		
2025 HRS	62.50pA	6.152nA	-1.310mV	-.8300mV	54.00	-7.300		
2050 HRS	52.50pA	1.461nA	-1.690mV	-.9800mV	55.10	-11.60		
2150 HRS	60.60pA	1.495nA	-1.440mV	-.7500mV	53.90	-17.30		
2250 HRS	39.30pA	1.779nA	-1.940mV	.6700mV	40.10	-3.900		
2500 HRS	-106.3pA	1.782nA	-1.370mV	-1.330mV	31.90	-28.60		
FINAL DATA								
MIN VALUE	280.0pA	280.0pA	56.00mV	41.00mV	361.0	319.0		
MAX VALUE	1.010pA	25.00nA	87.00mV	52.00mV	610.0	431.0		
MEAN	383.1pA	2.399nA	67.63mV	46.42mV	487.7	364.2		
STD DEV	214.1pA	6.815 A	6.790mV	3.353mV	67.09	33.69		

NOTE: Catastrophic Rejects removed from data.

TABLE 4 (Cont'd)

(continued from prior sheet) GROUP I — POWER STRESS DATA SUMMARY (SIDE B)

PARAMETER	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE_1}=300(MIN) 900(MAX)		h_{FE_1}/h_{FE_2} = .9(MIN), 1.1(MAX)	
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA, I_B = -100µA		@ V_{CE} = -5V, I_C = -100µA		@ V_{CE} = -5V, I_C = -100µA	
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS	MOT	NS
INITIAL DATA								
MIN VALUE	390.0pA	400.0pA	57.00mV	42.00mV	312.0	318.0	.9450	.9500
MAX VALUE	910.0pA	1.460nA	129.0mV	107.0mV	569.0	467.0	1.083	1.090
MEAN	510.6pA	570.0pA	75.50mV	54.44mV	450.0	384.3	1.012	1.023
STD DEV	125.9pA	253.7pA	16.35mV	15.12mV	55.33	42.98	.0415	.0367
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	10.60pA	62.34nA	-7.190mV	616.2mV	-.3000	-24.00	.0210	-.0010
150 HRS	-103.7pA	-82.90pA	-6.870mV	-5.080mV	1.100	2.300	.0180	-.0130
250 HRS	-63.10pA	-128.6pA	-4.620mV	706.2mV	38.10	-16.70	-.0100	-.0253
500 HRS	-130.6pA	-142.2pA	-5.810mV	-5.290mV	27.70	-3.800	.0040	-.0050
100% POWER								
550 HRS	-110.6pA	-136.2pA	-5.690mV	-5.210mV	29.40	-1.100	-.0040	-.0140
650 HRS	-151.2pA	-169.2pA	-6.250mV	-5.210mV	25.40	-.000	.0220	-.0100
750 HRS	-176.2pA	-182.3pA	-6.690mV	-5.290mV	29.40	-.600	.0100	-.0010
1000 HRS	-171.9pA	-199.2pA	-6.940mV	-6.290mV	26.00	-8.100	-.0040	-.0180
125% POWER								
1010 HRS	15.00pA	-72.30pA	-6.500mV	-5.440mV	39.20	.3000	.0020	-.0230
1025 HRS	26.30pA	-3.100pA	-5.620mV	-5.210mV	40.00	.9000	-.0090	-.0160
1050 HRS	24.40pA	-4.600pA	-5.690mV	-5.290mV	44.00	2.500	-.0080	-.0150
1150 HRS	25.00pA	-2.300pA	-6.560mV	-5.440mV	41.20	-.3000	.0010	-.0150
1250 HRS	42.50pA	23.80pA	-6.440mV	-5.290mV	48.30	1.100	-.0030	-.0110
1500 HRS	22.50pA	-6.200pA	-7.000mV	-5.670mV	45.20	-2.800	-.0080	-.0210

NOTE: Catastrophic Rejects removed from data.

TABLE 4 (Cont'd)

(continued from prior sheet) GROUP I — POWER STRESS DATA SUMMARY (SIDE B)

PARAMETER	I_{CBO} = -10nA(MAX)		$V_{CE(SAT)}$ = .25V(MAX)		h_{FE_2} = 300(MIN) 900(MAX)		h_{FE_1}/h_{FE_2} = .9 (MIN), 1.1 (MAX)	
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA, I_B = -100µA		@ V_{CE} = -5V, I_C = -100µA		@ V_{CE} = -5V, I_C = -100µA	
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS	MOT	NS
INITIAL DATA								
MIN VALUE	390.0pA	400.0pA	57.00mV	42.00mV	312.0	318.0	.9450	.9500
MAX VALUE	910.0pA	1.460nA	129.0mV	107.0mV	569.0	467.0	1.083	1.090
MEAN	510.6pA	570.0pA	75.50mV	52.44mV	450.0	384.3	1.012	1.023
STD DEV	125.9pA	253.7pA	16.35mV	15.12mV	55.33	42.98	.0415	.0367
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	13.10pA	-10.00pA	-7.060mV	-6.210mV	50.60	-3.300	-.0182	-.0080
1525 HRS	24.40pA	-13.80pA	-6.940mV	-5.440mV	49.30	-5.500	-.0080	-.0120
1550 HRS	25.00pA	.8000pA	-6.940mV	-5.900mV	52.80	.400	.0030	-.0200
1650 HRS	15.60pA	-5.400pA	-7.060mV	-5.900mV	55.20	2.200	-.0080	-.0220
1750 HRS	25.60pA	40.00pA	-7.190mV	-4.900mV	54.00	-3.900	-.0110	-.0210
2000 HRS	4.400pA	2.300pA	-8.120mV	-6.360mV	63.10	-4.600	-.0207	-.0292
175% POWER								
2010 HRS	-16.20pA	20.00pA	-7.630mV	-6.210mV	55.00	-1.400	-.0139	-.0210
2025 HRS	-10.60pA	-16.20pA	-7.690mV	-6.210mV	63.90	1.500	-.0157	-.0210
2050 HRS	-3.100pA	28.50pA	-8.250mV	-6.290mV	55.80	-4.400	-.0010	-.0180
2150 HRS	-1.900pA	54.60pA	-8.130mV	-3.670mV	62.50	-27.60	-.0170	1.532
2250 HRS	22.50pA	47.50pA	-8.560mV	-6.190mV	48.80	-8.900	-.0164	.0160
2500 HRS	-175.8pA	-88.30pA	-8.370mV	-6.110mV	36.30	-17.90	-.0070	-.0255
FINAL DATA								
MIN VALUE	290.0pA	270.0pA	56.00mV	41.00mV	359.0	325.0	.9400	.9300
MAX VALUE	680.0pA	1.810nA	85.00mV	50.00mV	617.0	438.0	1.120	1.090
MEAN	334.8pA	481.7pA	67.13mV	46.33mV	486.3	366.4	1.005	.9975
STD DEV	97.16pA	440.8pA	6.888mV	2.867mV	71.87	37.28	.0369	.0415

NOTE: Catastrophic Rejects removed from data.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY (160 HRS) SIDE A

PARAMETERS	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE1} =300(MIN) 900(MAX)			
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA I_B = -100µA		@ V_{CE} = -5V I_C = -100µA			
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS		
INITIAL DATA								
MIN VALUE	290.0pA	290.0pA	57.00mV	43.00mV	345.0	300.0		
MAX VALUE	1.300nA	540.0pA	78.00mV	65.00mV	668.0	514.0		
MEAN	420.0pA	369.3pA	70.00mV	49.33mV	477.6	379.5		
STD DEV	253.6pA	62.13pA	5.948mV	4.975mV	82.15	60.09		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS TEMP(T_A)								
160 +75°C	152.5pA	139.4pA	-.5600mV	-.000mV	3.500	8.200		
320 +100°C	155.6pA	138.0pA	-.5600mV	-1.000mV	9.800	3.700		
480 +125°C	146.2pA	132.7pA	-1.870mV	-2.130mV	2.100	23.50		
640 +150°C	162.5pA	149.4pA	-1.190mV	-1.060mV	13.30	-1.800		
800 +175°C	124.4pA	158.7pA	-1.310mV	-1.000mV	6.300	-17.20		
960 +200°C	135.6pA	174.0pA	-1.000mV	3.600mV	-4.700	-62.50		
1120 +225°C	131.2pA	20.34nA	-1.250mV	10.36mV	-11.80	-91.80		
1280 +250°C	158.7pA	JOB STOPPED	36.60mV	JOB STOPPED	-39.60	JOB STOPPED		
1440 +275°C	200.5nA		1.336V		-28.10			
1600 +300°C	4.163µA		2.933V		-187.5			
FINAL DATA								
FINAL TEMP (T_A)	300°C	225°C	300°C	225°C	300°C	225°C		
MIN VALUE	70.00pA	480.0pA	67.00mV	46.00mV	0.000	3.400		
MAX VALUE	9.990µA	232.0nA	9.990V	147.0mV	999.0	474.0		
MEAN	4.163µA	20.71nA	3.003V	59.69mV	290.1	287.7		
STD DEV	4.925µA	61.46nA	4.120V	26.34mV	302.5	129.5		

*NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA AFTER THIS POINT.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY (160 HRS) SIDE B

PARAMETERS	I_{CBO} = -10nA(MAX)		$V_{CE(SAT)}$ = .25V(MAX)		h_{FE_2}=300(MIN) 900(MAX)		h_{FE_1}/h_{FE_2} = .9(MIN), 1.1(MAX)	
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ IC = -1mA I_B = -100µA		@ V_{CE} = -5V I_C = -100µA		@ V_{CE} = -5V I_C = -100µA	
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS	MOT	NS
INITIAL DATA								
MIN VALUE	280.0pA	290.0pA	58.00mV	43.00mV	367.0	302.0	.9000	.9500
MAX VALUE	1.360nA	470.0pA	79.00mV	64.00mV	682.0	500.0	1.110	1.030
MEAN	435.0pA	338.7pA	69.62mV	49.00mV	494.0	383.1	.9688	.9921
STD DEV	286.7pA	47.03pA	5.499mV	4.803mV	92.04	60.83	.0531	.0251
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS TEMP (T_A)								
160 +75°C	139.4pA	154.0pA	-.6200mV	70.00µV	-12.20	3.700	.0281	.0089
320 +100°C	165.6pA	160.6pA	-.5600mV	470µV	4.900	7.800	.0106	-.0114
480 +125°C	150.0pA	152.0pA	-1.490mV	-1.330mV	-2.500	-4.900	.0068	.0026
640 +150°C	161.2pA	174.0pA	-1.370mV	-800µV	3.400	-1.200	.0208	-.0028
800 +175°C	135.6pA	165.3pA	-1.180mV	-0.000mV	.7000	-12.00	.0118	-.0148
950 +200°C	115.0pA	166.6pA	-1.930mV	1.200mV	-27.60	-44.50	.0452	-.0361
1120 +225°C	148.7pA	224.7nA	-1.240mV	1.104	-24.30	-103.5	.0218	.9439
1280 +250°C	62.86nA	JOB STOPPED	1.170V	JOB STOPPED	-25.50	JOB STOPPED	-.0258	JOB STOPPED
1440 +275°C	448.3pA		1.285V		-25.90		.0922	
1600 +300°C	883.1nA		1.884V		-144.2		19.80	
FINAL DATA								
FINAL TEMP (T_A)	300°C	225°C	300°C	225°C	300°C	225°C	300°C	225°C
MIN VALUE	70.00pA	470.0pA	66.00mV	42.00mV	0.000	0.000	.0100	0.000
MAX VALUE	9.900µA	2.000µA	9.990V	9.990V	667.0	440.0	179.2	13.46
MEAN	833.5nA	225.0nA	1.954V	1.153V	352.3	279.6	20.77	1.936
STD DEV	2.761µA	627.6nA	2.761V	3.124V	180.0	150.3	56.01	3.663

*NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY (16 HRS) SIDE A

PARAMETERS	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE1} =300(MIN),900(MAX)			
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA, I_B = -100μA		@ V_{CE} = -5V, I_C = -100μA			
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS		
INITIAL DATA								
MIN VALUE	310.0pA	290.0pA	59.00mV	40.00mV	419.0	317.0		
MAX VALUE	1.580nA	620.0pA	78.00mV	65.00mV	645.0	496.0		
MEAN	531.2pA	336.9pA	71.00mV	47.13mV	509.0	386.4		
STD DEV	372.2pA	77.28pA	21.569mV	5.611mV	81.73	317.0		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
16 / +150°C	-41.20pA	-17.50pA	-.500mV	-1.25mV	-1.200	8.500		
32 / +175°C	-25.00pA	-3.200pA	-1.250mV	-1.320mV	11.30	10.10		
48 / +200°C	-55.60pA	-16.30pA	-1.060mV	-1.250mV	17.40	7.600		
64 / +225°C	-56.20pA	-6.30pA	-.560mV	-.750mV	19.10	-2.400		
80 / +250°C	-66.20pA	-13.30pA	-1.380mV	-2.630mV	19.90	12.70		
96 / +275°C	-81.80pA	-30.50pA	-1.000mV	-2.420mV	25.90	9.300		
112 / +300°C	-108.7pA	-16.20pA	-1.500mV	48.30mV	-24.20	-92.40		
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C	300°C	300°C		
MIN VALUE	300.0pA	290.0pA	57.00mV	40.00mV	373.0	0.000		
MAX VALUE	1.040nA	390.0pA	78.00mV	750.0mV	696.0	464.0		
MEAN	422.5pA	320.7pA	69.50mV	95.43mV	484.8	294.0		
STD DEV	222.7pA	29.87pA	4.796mV	181.5mV	91.24	102.4		

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY (16 HRS) SIDE B

PARAMETERS	I_{CBO} = -10nA (MAX)		$V_{CE(SAT)}$ = .25V (MAX)		h_{FE_2}=300(MIN) 900(MAX)		h_{FE_1}/h_{FE_2}=.9(MIN),1.1(MAX)	
CONDITIONS AND LIMITS	@ V_{CB} = -50V		@ I_C = -1mA I_B = -100μA		@ V_{CE} = -5V I_C = -100μA		@ V_{CE} = -5V I_C = -100μA	
IDENTIFICATION	MOT	NS	MOT	NS	MOT	NS	MOT	NS
INITIAL DATA								
MIN VALUE	300.0pA	290.0pA	56.00mV	40.00mV	399.0	303.0	.9140	.9700
MAX VALUE	670.0pA	340.0pA	80.00mV	62.00mV	692.0	484.0	1.057	1.077
MEAN	376.2pA	306.2pA	70.31mV	46.81mV	511.9	381.6	.9976	1.014
STD DEV	106.4pA	17.63pA	5.132mV	4.990mV	90.64	60.69	.0389	.0250
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS TEMP(T_A)								
16 +150°C	-7.500pA	-5.600pA	-.8100mV	-1.370mV	4.500	16.00	-.0110	-.0202
32 +175°C	-18.10pA	-3.100pA	-1.370mV	-1.560mV	-4.400	6.800	.0284	.0090
48 +200°C	-8.100pA	-6.200pA	-1.000mV	-1.560mV	3.300	7.600	.0254	.0050
64 +225°C	-13.10pA	62.41nA	-.7500mV	.750mV	10.30	.3000	.0154	.0070
80 +250°C	-8.100pA	1.700pA	-1.180mV	-2.450mV	19.30	5.900	-.0005	.0420
96 +275°C	-22.50pA	-8.300pA	-1.060mV	-2.170mV	14.50	19.20	.0234	-.0202
112 +300°C	-26.80pA	135.4nA	-1.310mV	103.8mV	-33.20	-130.3	.0164	-.0283
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C	300°C	300°C	300°C	300°C
MIN VALUE	270.0pA	280.0pA	53.00mV	40.00mV	364.0	0.000	.9450	.9000
MAX VALUE	540.0pA	999.0nA	78.00mV	891.0mV	655.0	443.0	1.103	1.136
MEAN	349.4pA	135.6nA	69.00mV	150.6mV	478.7	251.3	1.014	.9857
STD DEV	78.86pA	344.7nA	5.443mV	266.2mV	89.12	148.1	.0517	.0063

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 7
FINAL DATA SUMMARY

SIDE A

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			MOT	NS	MOT	NS	MOT	NS
I_{CBO}	-	-10	nA		+.02690	+.71999	+436.47	+3.0332	-.06210	-.01476
$V_{CE(SAT)}$	-	.25	V		-.00024	+.02312	+.42979	+.00125	+.00104	+.00553
h_{FE_1}	300	900	-		+38.796	-8.8692	-23.670	-19.700	+9.7429	-6.6571

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

DCA

TABLE 7
FINAL DATA SUMMARY
SIDE B

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			MOT	NS	MOT	NS	MOT	NS
I_{CBO}	-	-10	nA		-.03146	-.03781	+94.742	+32.239	-.01489	+28.256
$V_{CE(SAT)}$	-	.25	V		-.00692	+.04570	+.43306	+.15766	-.00107	+.01363
h_{FE_2}	300	900	-		+43.700	-4.7577	-25.320	-22.086	+2.0429	-10.463
h_{FE_1}/h_{FE_2}	.9	1.1	-		-.00135	-.00392	+2.0012	+.12719	+.01329	-.00081

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JANTX2N3811

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	1	A
100 hr.	0	–	0	–
100 hr.	0	–	1	B
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
150% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
175% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	1	C
100 hr.	0	–	0	–
250 hr.	0	–	0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125 °C	0	–	0	–
150 °C	0	–	0	–
175 °C	0	–	0	–
200 °C	0	–	2	C
225 °C	0	–	1 / 2 / 1	A / C / F
250 °C	1 / 7 / 1	A / B / D	JOB	STOP
275 °C	1	B		
300 °C	1 / 0 / 1	F / H / G		

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150 °C	0	–	0	–
175 °C	0	–	0	–
200 °C	0	–	0	–
225 °C	0	–	1 / 1	E / F
250 °C	0	–	1	E
275 °C	0	–	1	A
300 °C	0	–	1 / 1	A / C / F

MFR "A" = MOTOROLA
MFR "B" = NATIONAL SEMICONDUCTOR

NOTES:
A - V_{CE} >.375V and h_{FE} <150
B - V_{CE} >.375V
C - h_{FE} <150
D - I_{CBO} >1000nA
E - h_{FE} (MATCHING) >1.65
F - h_{FE} <150 and I_{CBO} >1000nA
G - SEE NOTES B, D & E
H - SEE NOTES A & D

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX2N3811

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	1	A	0	–
100 hr.	0	–	1	C
100 hr.	0	–	0	–
250 hr.	0	–	1	A
100% 50 hr	0	–	0	–
100 hr.	2	A	0	–
100 hr.	2 / 1	A / B	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	1	A
250 hr.	0	–	0	–
150% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	1	D
100 hr.	0	–	0	–
250 hr.	0	–	0	–
175% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	1	A
250 hr.	0	–	0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	1	A	0	–
100° C	0	–	0	–
125 °C	0	–	0	–
150 °C	0	–	1	B
175 °C	0	–	1 / 1	A / E
200 °C	0	–	1 / 1	E / F
225 °C	0	–	1 / 1	E / D
250 °C	0	–	1 / 2	B / G
275 °C	1	B	JOB	STOP
300 °C	–	–	↓	↓

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150 °C	0	–	1	A
175 °C	0	–	0	–
200 °C	2	A	1	E
225 °C	0	–	0	–
250 °C	1	B	1	B
275 °C	1	A	2	E
300 °C	1	A	3	E

MFR A = MOTOROLA
MFR B = NATIONAL SEMICONDUCTOR

NOTES:
A – $h_{FE(MATCHING)}$ MAXMMUM LIMIT FAILURE
B – $h_{FE(MATCHING}$ MINIMUM LIMIT FAILURE
C – SN 2546 REMOVED FROM TESTING AS VISUAL REJECT DUE TO HANDLING
D – I_{CBO} MAXIMUM LIMIT FAILURE
E – h_{FE} MINIMUM LIMIT FAILURE
F – SEE NOTES A AND E
G – SN 2566 AND 2568 REMOVED FROM TESTING AS MIL-S-19500 FAILURES

APPENDIX

FAILURE ANALYSIS

JANTX2N3811

FAILURE ANALYSIS

Date 4 April 1978

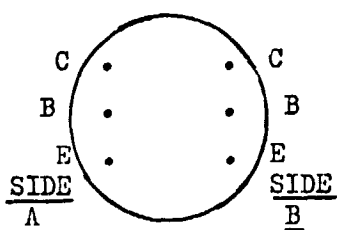
J/N 2CN242-08C P/N 2N3811(PNP) MFR NATIONAL SEMICONDUCTOR

FAILURE VERIFICATION:

S/N	BV_{CEO} -volts- A / B	BV_{CEO} -volts- A / B	I_{CBO} -μA- @ V_{CB} 50V A / B	BV_{EBO} -volts- A / B	A/B h_{FE} @ I_C = 100μA; V_{CE}= 5 V.	V_{BEO} -volts- A / B	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
2577	66S/52S	79/62S	<.2/<.2	10/10R	435/0.2R	0.8/0.8	15	I_{CBO}-h_{FE}
2588	88H/88H	114/114	<.2/<.2	10.5/10.6	222/238	0.8/0.8	15	h_{FE}
2591	78H/76H	90/90	<.2/<.2	10.6/10.8	270/312	0.8/0.8	09	h_{FE}MATCH

INTERNAL VISUAL INSPECTION:

All samples exhibit gold-aluminum intermatallics on base and emitter bonds. (See Figure A-1.)



*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

JANTX2N3811

FAILURE ANALYSIS

Date 4 April 1978

J/N 2CN242-08C P/N 2N3811 MFR MOTOROLA SEMICONDUCTOR

FAILURE VERIFICATION:

S/N	BV_{CEO} -volts- A / B	BV_{CEO} -volts- A / B	I_{CBO} -μA- @ V_{CB}= 50 V. A / B	BV_{EBO} -volts- A / B	A/B h_{FE} @ I_C= 100μA; V_{CE}= 5 V.	V_{BEO} -volts- @ I_{BEO}= 10 mA A / B	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6304	77H/78H	85/90	0.2/0.2	6.1/6.0	446/418	0.85/0.85	07	h_{FE}MATCH
6342	60H/68H	70/76	0.2/0.2	6.0/6.0	400/500	0.8/0.85	07	h_{FE}MATCH
6351	60H/60H	72/66	0.2/0.2	6.2/6.2	588/556	0.85/0.86	11	h_{FE}MATCH

INTERNAL VISUAL INSPECTION:

All Motorola samples were free of significant visual defects.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSIONS

These competitive parts were not of comparable construction since the National Semiconductor parts have gold ball bonded internal wires, while the Motorola parts have ultrasonically bonded aluminum wires. The failure modes reflect the differences in their construction.

NATIONAL SEMICONDUCTOR

The National parts all have "purple plague" around their emitter and base wire bonds. One of these samples (S/N 2577) has a partial emitter-base short which reduces the h_{FE} of Side "B" almost to zero. The other two National parts have low h_{FE} due to excessive leakage in BV_{CEO}. The leakage is believed to be due to contamination of the base region as a result of contamination by drifting ions during the thermal stress.

MOTOROLA SEMICONDUCTOR

The Motorola samples all have some hysteresis (leakage) in BV_{CEO}. S/N 6304 and 6351 fell within the failure criteria limits at the time of this failure analysis. S/N 6342 has an unacceptable h_{FE} ratio of 1.25:1. Since these devices contain separate dice rather than an integrated matched pair, processing geometry or a contamination difference could reasonably exist which would cause the h_{FE} to change unequally under stress.

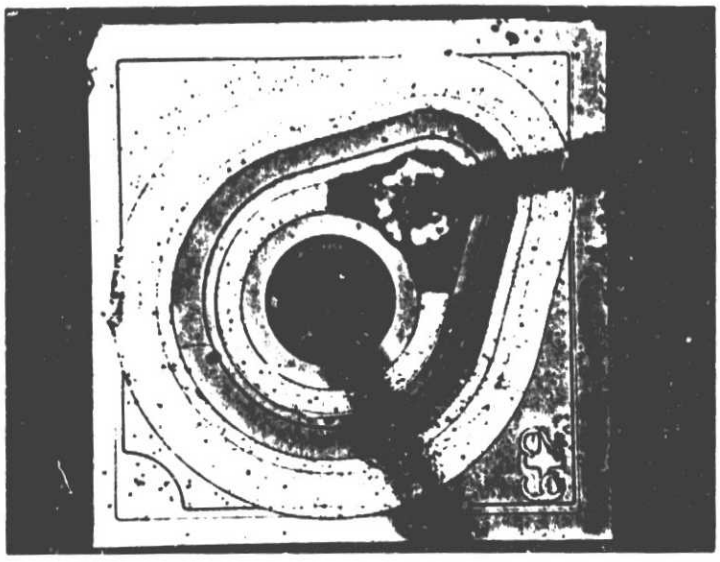


FIGURE A-1
S/N 2577. Typical National Semiconductor Die Geometry, 152X. Gold-aluminum intermetallics at base and emitter bonds.

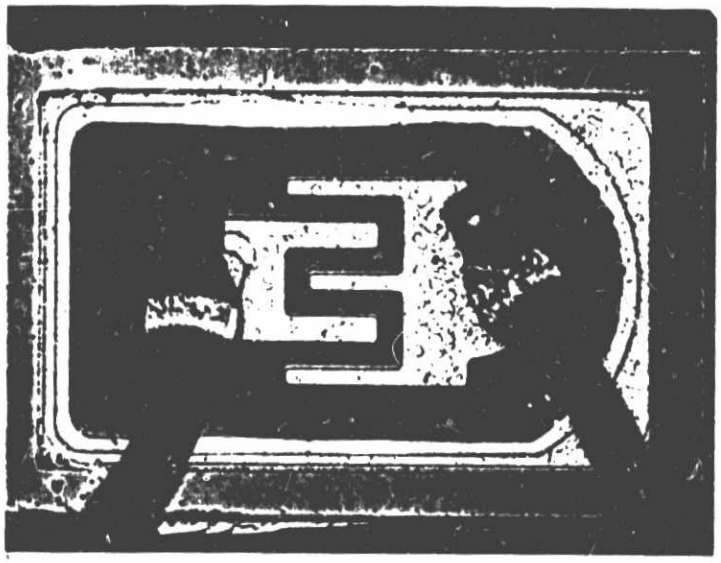


FIGURE A-2
S/N 6342. Typical Motorola Die Geometry, 256X.