

ELEVENTH QUARTERLY REPORT

on

A STUDY OF THE RELIABILITY OF
ELECTRONIC COMPONENTS IN A NUCLEAR-
RADIATION ENVIRONMENT

to

JET PROPULSION LABORATORY

October 15, 1965

by

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This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, pursuant to a sub-contract issued under Prime Contract NAS7-100 between the California Institute of Technology and the United States of America represented by the National Aeronautics and Space Administration.

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INTRODUCTION

This is the Eleventh Quarterly Report and the Thirty-Fourth Monthly Progress Report on Contract No. 950458 (File 2998) entitled "A Study of the Reliability of Electronic Components in a Nuclear-Radiation Environment". This report summarizes the project activity from July 1 to September 30, 1965, which has included approximately 1800 hours of additional radiation exposure for the electronic parts in Test Groups III, V, and VI. This makes a total of approximately 7250 hours of exposure since the radiation exposure was initiated. The parameter measurements after 6000 and 7000 hours of exposure were also completed during this period.

PROGRESS SUMMARY

Progress during this report interval has included the following project activities:

- (1) Completion of the 6000- and 7000-hour measurements on all component parts in the seven test groups. This is in addition to 100 hours of high-flux radiation for the parts in Test Group IV.

- (2) Conversion of the 6000-hour data cards as generated by the automatic data-recording system to the requirements of JPL Specification No. ZPP-2090-GEN. The 7000-hour measurements were completed at the end of this report period, and the conversion of the data cards is incomplete.

TECHNICAL DETAILS

Project effort during this report interim was directed toward the continuation of the life tests that include nuclear radiation as an environmental condition. As a part of this effort, parameter measurements were performed following the completion of 6000 and 7000 hours of radiation exposure.

This section presents various details concerning these activities and the progress that has been made.

Measurement Status

Parameter measurements were completed according to schedule on all test groups when the parts in Test Groups III, V, and VI had accumulated 6000 and 7000 hours of radiation exposure during this report interval. The data cards generated in the performance of the 6000-hour measurements by the automatic data-recording system were processed with a computer program to obtain data cards in accordance with the format requirements of JPL Specification No. ZPP-2090-GEN. The output cards from this program were shipped to the sponsor.

The measurements, after 7000 hours of radiation exposure, were performed during the last week of this report period; and the conversion of the data cards was not completed prior to the end of this quarter.

Results

Progress during this report interval has included the completion of 2208 additional hours of operational load for an accumulated total of approximately 8790 operational hours for all test groups. The component parts in Test Groups III, V, and VI have accumulated a total of 7250 hours of radiation exposure. The 8790 hours of operational load are in addition to 100 hours of operation and high-flux radiation exposure of the electronic parts in Test Group IV.

Table 1 is a listing of the additional component parts that have indicated failure during this report period. The 7000-hour failure data were not available for this report and will be included in the next monthly progress report. The environmental conditions for the various test groups listed in Table 1 are as follows:

Group	Test Conditions
I	100 C, 760 torr, operational
II	100 C, 10^{-5} torr, operational
III	100 C, 10^{-5} torr, operational ^(a)
IV	100 C, 10^{-5} torr, operational ^(b)
V	50 C, 10^{-5} torr, operational ^(a)
VI	100 C, 10^{-5} torr, static ^(a)
VII	100 C, 760 torr, static

(a) 10,000 hours at 3×10^5 n cm⁻² sec⁻¹
and 1×10^5 ergs g⁻¹ (C) hr⁻¹

(b) 100 hours at 3×10^7 n cm⁻² sec⁻¹
and 1×10^7 ergs g⁻¹ (C) hr⁻¹

The following table summarizes the radiation exposure of Test Groups III, V, and VI through 7209.1 hours of exposure. The exposure values listed are averages over the volumes of the capsules occupied by the test specimens. Neutron exposures listed are for fast neutrons only (i.e., $E > 0.1$ MeV). These values are based on neutron distributions measured in mockups of the irradiation capsules (see the Neutron Dosimetry Section of the Supplement to the First Quarterly Report, May 15, 1963, or the Revised Test Procedure for JPL Test No. 617, Phase II, January 25, 1965) and do not include perturbations due to test components or assembly or time-dependent distribution changes. Post-irradiation analysis of in-pile neutron dosimeters will provide more accurate determinations of actual doses received by individual components or groups of components.

APPROXIMATE NEUTRON AND GAMMA EXPOSURES

Irradiation Period, hours	Neutrons (n/cm^2)		Gamma [ergs/g(c)]	
	Test Group V	Test Groups III and VI	Test Group V	Test Groups III and VI
0 - 250	2.4×10^{11}	2.8×10^{11}	2.64×10^7	2.62×10^7
250 - 500	2.6×10^{11}	3.0×10^{11}	2.60×10^7	2.57×10^7
500 - 1000	3.9×10^{11}	4.6×10^{11}	5.31×10^7	5.29×10^7
1000 - 2000	7.4×10^{11}	9.3×10^{11}	1.04×10^8	1.04×10^8
2000 - 3000	7.5×10^{11}	8.8×10^{11}	1.12×10^8	1.12×10^8
3000 - 4000	7.4×10^{11}	8.8×10^{11}	1.03×10^8	1.02×10^8
4000 - 5000	7.5×10^{11}	8.8×10^{11}	9.81×10^7	9.76×10^7
5000 - 6000	7.4×10^{11}	8.8×10^{11}	1.06×10^8	1.05×10^8
6000 - 7000	7.5×10^{11}	8.8×10^{11}	1.02×10^8	1.02×10^8
Total In-Pile*	5.6×10^{12}	6.5×10^{12}	7.47×10^8	7.43×10^8

*Estimated integrated exposures from experiment startup through BRR (Battelle Research Reactor) Cycle 192, 7209.1 hours of accumulated irradiation.

FUTURE PLANS

The radiation exposure and operational life tests will continue throughout the next quarterly report interval. This should include completion of approximately 9000 hours of accumulated irradiation with parameter measurements of the various component parts at the 8000- and 9000-hour intervals. Data cards will be shipped to the Jet Propulsion Laboratory within one week following the completion of each set of measurements.

TABLE 1. IDENTIFICATION OF ADDITIONAL CATASTROPHIC FAILURES

Type of Component	Manufacturer's Part Number	Test Group	Specimen Number	Hours at Failure	Remarks
Capacitor	P323ZN2	III	15	6000	
"	"	II	42	6000	
"	"	II	46	6000	
"	"	IV	64	6000	
"	"	IV	65	6000	
"	"	IV	67	6000	
"	"	IV	69	6000	
"	"	IV	73	6000	
"	"	VI	110	6000	
"	"	VI	115	6000	
"	"	VI	116	6000	
Capacitor	HP56C50D1	I	23	6000	
Diode	FD643	II	59	6000	Open
Controlled Rectifier	3N58	VII	123	6000	I _H
Transistor	2N911	IV	78	6000	I _{CBO}
"	"	V	95	6000	h _{FE}
Transistor	2N914	III	05	6000	I _{CBO}
"	"	III	13	6000	I _{CBO}
Transistor	2N915	III	10	6000	
"	"	V	83	6000	h _{FE}
"	"	VI	114	6000	h _{FE}
Transistor	2N1050	V	95	6000	h _{FE}
"	"	VI	102	6000	
"	"	VI	107	6000	h _{FE}
"	"	VI	118	6000	h _{FE}
"	"	VI	119	6000	h _{FE}
"	"	VII	121	6000	h _{FE}
Transistor	2N2412	V	95	6000	h _{FE}

TABLE 1 (Continued)

Type of Component	Manufacturer's Part Number	Test Group	Specimen Number	Hours at Failure	Remarks
Transistor	2N861	III	01	6000	h _{FE}
"	"	III	19	6000	h _{FE}
"	"	I	27	6000	h _{FE}
"	"	VI	117	6000	h _{FE}
"	"	VI	119	6000	h _{FE}
"	"	VII	136	6000	h _{FE}
"	"	VII	138	6000	h _{FE}