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LIQUID ROCKET PLANT

MASTER

MECHANICAL IRRADIATION TEST NO. 4/L001

TURBINE POWER CONTROL VALVE
CONFIGURATION NO. 1

VOLUME III

Final Test Report No. 1.9.5-1E

February 1964

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MASTER

FINAL TEST REPORT NO. 1.9.5 - 1E

VOLUME III

MECHANICAL IRRADIATION TEST NO. 4/LOOL, Vol I, 20/7

TURBINE POWER CONTROL VALVE,

CONFIGURATION NO. 1

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MAY 5 1964

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I. ABSTRACT

This test was to provide preliminary information as to the suitability of the NERVA Turbine Power Control Valve (TPCV) for operation in a radiation environment. The TPCV tested was designed for use in the heated bleed cycle engine. The irradiation test, which lasted for 327 seconds, was conducted on 17 July 1963, on the Aerospace Systems Test Reactor (ASTR) at General Dynamics Corporation, Fort Worth, Texas.

The valve body and disc were exposed to ambient GH_2 at a low flow rate and a low pressure (115 psig). The valve was cycled once each 60 seconds and received a total integrated fast neutron dose of from 1.1×10^{13} n/cm² ($E > 2.9$ Mev) and a gamma dose of from 3.8×10^7 to 8.1×10^7 ergs/g(c).

The valve operating times were satisfactory and there was no apparent damage to valve, seat, or seals.

II. INTRODUCTION

The objective of the NERVA Radiation Effects Test Program is to provide preliminary information of the effects of radiation on NERVA non-nuclear engine components under expected engine operating conditions. The testing was originally planned as a coordination effort (side by side) with L.A.S.L. during KIWI-B testing at NNRDS. However, late in the fabrication stages of the pallet, the testing was shifted to the Aerospace Systems Test Reactor at General Dynamics, Fort Worth, Texas. The first test, reported herein, included components which were developed for the NERVA heated-bleed cycle engine. Although the engine design was changed to the hot-bleed cycle, it was desired to conduct the experiment for two reasons. First, valid technical information would be obtained that would permit the provisioning of more highly developed components to the first block of E-engines. Secondly, the experience to be gained in providing the test supporting equipment and in performing liaison with the test facility would be invaluable with regard to future testing.

III. EXPERIMENT IDENTIFICATION

A. Test Plan Reference -

4/LOO1 Turbine Power Control Valve, Configuration No. 1.

B. Sponsor -

NERVA Rocket Operations

Liquid Rocket Plant

Aerojet - General Corporation

C. Test Facilities -

1. Pre-Irradiation Tests - Liquid Rocket Plant

Aerojet - General Corporation

Sacramento, California

2. Irradiation Test - NARF - ASTR

General Dynamics

Fort Worth, Texas

3. Post-Irradiation Tests - Liquid Rocket Plant

Aerojet-General Corporation

Sacramento, California

D. Test Date

1. 17 July 1963

General Dynamics

Fort Worth, Texas

IV. PURPOSE OF THE EXPERIMENT

This experiment was designed to determine the effects of radiation on the operation of a Configuration No. 1 Turbine Power Control Valve (TPCV) and the associated position indicator. Although it was desired to operate the TPCV under typical engine operating conditions, funds and time (KIWI-B test schedule) prevented the provisioning of a hot gas supply that would approximate engine flow rates. For this reason, ambient hydrogen was to be used in the first test, and later tests would use

hot gas. GH_2 was flowed through the TPCV and was also used for valve actuation. The valve was to be actuated several times during the irradiation test. Pressures, temperatures, and valve positions would be monitored to provide operational information, and pre- and post-irradiation measurements would be compared to determine physical effects.

V. TEST DESCRIPTION

The TPCV (P/N 260563-29, S/N X-1), a gas operated rack-and-pinion actuator, and a rotary potentiometer (Figure A-1) were mounted on a test pallet (P/N 255802-19) for this test. A functional checkout of these components was conducted at TEST ZONE G-7 (Figure A-2) at the Liquid Rocket Plant on 13 March 1963.

During the 60-second checkout test at G-7, the TPCV was cycled (opened-closed-opened) twice, but an electrical malfunction prevented the recording of position data. Following this checkout test, the pallet and TPCV were packaged and shipped to General Dynamics, Fort Worth, Texas. The pallet was installed on the ASTR dolly (Figure A-3) and using the procedures covered in Section VI, leak checks, instrumentation calibration, and a functional check were performed. The TPCV was actuated twice during the coast-down period following the 10-second bearing tester check run (See Figures C-2 and C-3).

The irradiation test was then performed on 17 July 1963. The TPCV was cycled once every sixty seconds during the 327 second irradiation test (See Figure D-7).

The test pallet, used to control the fluid flow and the actuation of the TPCV, will be more completely described in Volume V of this report.

The test pallet consisted of an aluminum structural portion designed to support the test component in the desired position relative to the radiation field of the adjacent reactor (Figure A-4).

The pallet contained the necessary valves, regulator, filters, relief-systems and instrumentation to control the fluid and electrical supplies to the test component (Figure C-1). Liquid hydrogen pressure at the test pallet was controlled at

the liquid hydrogen storage dewar. This dewar with its pressurization, vent, and deluge system is shown in Figure A-5. A gas distribution system supplied gaseous helium to the pallet regulation system. Helium was used to purge the container housing the TPCV throughout the test.

Control of the test equipment was accomplished through the use of a master sequencer and associated control rack as shown in Figure A-5. The master sequencer checker contained switches for control of all manual control functions on the test pallet, the liquid hydrogen dewar, the motor generator set and the electrical control rack. This unit also contained run and emergency warning lights. The electrical control rack included a sequencer unit, power panel, event recorder, output amplifiers and a signal conditioning unit.

The data acquisition system for this test consisted of an analog magnetic tape system, video tape system, visual meter panels and four 4-channel Sanborn recorders. Critical parameters were monitored visually during the test by use of the meter panels. All critical and "kill" parameters were wired directly to the Sanborn recorders and all test measurement parameters were recorded on analog tape. The analog magnetic tape system had twenty-four tape channels and each tape channel had the capacity to record six separate parameters.

VI. TEST PROCEDURES

Report No. 9440-1SA, Test Procedure No. 1.9.5-1, Mechanical Irradiation Test No. 901 presents the data handling requirements and the detailed pre-test, irradiation test, and post-test operating procedures. Briefly, the following sequence of major events was adhered to: The test pallet and associated control equipment was set up and functionally tested prior to its installation of the reactor site. Once the test equipment was installed at ASTR, leak checks, functional tests and a liquid nitrogen flow test were performed to ascertain that all systems were operational. The liquid hydrogen dewar was loaded with LH₂, a cool-down sequence was followed, and a short control run was initiated. After the bearing tester motor was turned off (FS₂),

the TPCV was cycled twice ($FS_1 + 150$ sec. and $FS_1 + 170$ secs.). The test was then terminated and the LH_2 dewar was refilled. When ready for the irradiation test on the evening of 17 July, the cooldown sequence was repeated, the reactor was brought up to 10 MW and the 300 second test was begun.

A complete electrical checkout and calibration was made of all electrical controls and instrumentation when the test pallet was first placed in the irradiation position. At the conclusion of the irradiation test, all pressure transducers were recalibrated using the same Heise gage that was used for the original calibrations. All irradiation test parameters were plotted using the post-test calibration data because the conditions at this time more nearly simulated the conditions achieved during the test. Appendix E presents the calibration curves used in conjunction with the oscillograph charts.

VII. NUCLEAR MEASUREMENTS

A. Neutron

The neutron flux was monitored during the test at 19 locations. Neutron flux measurements were made with the threshold detectors-sulfur for energy > 2.9 Mev and aluminum for energy > 8.1 Mev; phosphorus pellets (bare and cadmium) were used to measure the thermal flux.

Detectors were mounted on $3 \frac{1}{2} \times 3$ inch aluminum holders, which in turn were mounted on or near the components. All foils were counted and the data reduced by an IBM 7090 digital computer program.

B. Gamma

The gamma dose measurements were made with nitrous oxide (N_2O) dosimeters, chemical dosimeters, and cobalt glass.

1. Nitrous Oxide Dosimeters

The nitrous oxide dosimeters used at GD/FW consist of a quartz shell forming a volume of about 24 cc which is filled with a measured quantity of N_2O gas before the dosimeter is flame-sealed. Upon

exposure to gamma radiation, the following reaction is produced in the gas:

The dose is determined by measuring the moles of $\text{N}_2 + \text{O}_2$ produced per mole of original N_2O , and relating this quantity to dose on a calibration curve.

Energy dependence of the N_2O system is air-equivalent (within 10%) from 150 kev to 5 Mev. The dosimeters are usable in the dose and temperature ranges of from 10^8 to 10^{12} ergs/gm(C) and -90° to $+120^\circ\text{C}$, respectively. The dosimeters have a reproducibility of 7% to 9%.

2. Chemical Dosimeters

The chemical dosimeters are the chlorinated hydrocarbon type developed originally by Taplin-Sigaloff and modified at GD/FW. They consist of 0.8 ml of tetrachloroethylene overlaid with 0.2 ml of water. The dosimeters, sensitive to gamma energies from 65 kev to 10 Mev, have a usable gamma dose range from 10^5 to 10^8 ergs/gm(C), a temperature range from 5 to 50°C , and a precision of 5 to 6% at the 95% confidence level.

3. Cobalt Glass Dosimeters

These dosimeters are cobalt-activated borosilicate glass plates, 15 by 6 by 1.5 mm, manufactured by Bausch and Lomb Inc. Exposure to ionizing radiation darkens the glass. The change in optical density measured at 390 nm versus dose was plotted and the plot was compared with similar plots of calibrated glass plates to obtain the dose. The recommended range of the dosimeters is from 10^6 to 2.6×10^8 ergs/gm(C).

These dosimeters were enclosed in a 1/16 inch-thick thermal

neutron shield of the following composition: 33% by weight $B_{10}C$ (92% enriched B^{10}), 33% Epon 828, and 33% Versamid 140.

VIII. TEST RESULTS

The TPCV (P/N 260563-29) used in this test was cycled five times (see Figure D-7) as indicated below:

Cycle	GH ₂ Temp. at TPCV Inlet	GH ₂ Pressure (PSIG) at TPCV Inlet (Used for Actuation)	Operating Time (Seconds)		Position Indicator Output (Volts) (5V Excitation)	Remarks
			Closing	Opening		
1	107° F	117	>1.0 <2.0	>1.0 <2.0	0.7 V	Normal
2	131° F	117→0	>1.0 <2.0	>.5 <2.0	1.1 V	Lost actuation gas due to GH ₂ pressure switch closure.
3	140° F	117	>1.0 <2.0	>1.0 <3.0	0.7 V	Normal
4	152° F	105	>1.0 <3.0	>1.0 <3.0	0.7 V	Normal
5	160° F	117	>2.0 <4.0	>2.0 <3.0	0.7 V	Normal

A slight increase (>0<1.0 Sec) in TPCV operating times may be noted in the above tabulation. This was accompanied by an increase in temperature of the GH₂ at TPCV inlet (see Figure D-5). Pre- and post-irradiation inspections (see Figure D-1) revealed no change in valve dimensions and no detectable change in the actuating shaft carbon O-rings which might have contributed to a friction increase. There was an apparent decrease from 6.65 to 6.55 inches in the free length of the actuator piston spring, but the spring rate did not vary (Figure 2).

Comparison of pre-and post-irradiation inspections of the rotary potentiometer used to provide valve position information revealed no change in starting torque, insulation resistance and dielectric withstanding voltage attributable to radiation effects. Variations of measurements of other electrical characteristics, such as peak noise and total resistance were within the allowable limits for normal

wear and instrumentation errors (see Figure D-3).

The integrated radiation received was:

Item	Gamma	Neutrons (E 2.9 Mev)
TPCV	3.8×10^7 to 8.1×10^7 ergs/gm (C)	1.1×10^{13} to 3.8×10^{13} n/cm ²
Actuator	2.2×10^7 to 7.4×10^7 ergs/gm (C)	1.0×10^{13} to 2.5×10^{13} n/cm ²

(Also, see Tables B-I and B-II)

These recorded values were interpreted and adjusted in Reference 6. A comparison of test results to estimated NERVA engine conditions is included.

IX. DISCUSSION OF TEST RESULTS

The data obtained during this test and the pre- and post-irradiation tests indicated that the valve operation was satisfactory in a radiation environment representative of NERVA operations when subjected to a low mass flow of ambient GH₂ at 115 psig. Pre- and post-test inspections revealed no change in dimensions or other physical characteristics of the valve.

In order to isolate possible radiation effects in the valve itself, the non-prototype actuator that was used was instrumented and a potentiometer was provided. Actuation pressure and temperature and valve position were monitored. Data from these measurements indicated increases in actuation times during the test and an increase in the temperature of the GH₂ in the valve. Since there were no visible evidences of valve deformation or galling, it is deduced that the increase in actuation times is attributable to actuator design rather than the TPCV. It is mentioned here only because of its general applicability to the radiation effects program. The Duncan Electronics 10,000 ohm potentiometer (P/N 1200-602) performed satisfactorily and exhibited negligible changes in electrical characteristics, which could

be attributed to radiation (See Figure D-3).

The recorded values of integrated radiation doses shown in Tables B-I and B-II and Reference 6 are representative of those expected in engine operations.

X. CONCLUSIONS AND RECOMMENDATIONS

A. It is concluded that:

1. The TPCV functioned satisfactorily under the combined test environments imposed.
2. The Duncan potentiometer operated satisfactorily under the test conditions imposed.
3. Additional irradiation testing of a TPCV without prototype actuator and at flow rate, pressure, and temperature other than rated NERVA engine conditions is not advisable.
4. Test planning improvements are necessary for future tests.
5. Further testing should be delayed until necessary instrumentation accuracies can be assured under the radiation environment at ASTR.

B. It is recommended that:

1. The Duncan potentiometer should be considered for use on NERVA valves and additional irradiation testing be conducted to further define operational capabilities.
2. A radiation effects test program should be designed for testing the prototype TPCV and actuator assembly at rated NERVA engine flow rate, pressure, and temperature.
3. The test planning for future tests should ensure consideration of all factors; including materials data, instrumentation capabilities, non-nuclear TPCV and actuator development, and analysis of NERVA engine radiation environment.
4. The development of test instrumentation of required accuracy in

a nuclear radiation environment should be expedited and additional TPCV testing should await demonstration of instrumentation adequacy.

XI. APPENDICES

APPENDIX A

PHOTOGRAPHS

LIST OF FIGURES

APPENDIX A

<u>Figure No.</u>	<u>Title</u>
A-1	Turbine Power Control Valve
A-2	Radiation Effects Test Pallet on Test Stand at G-7
A-3	Radiation Effects Test Pallet on ASTR Dolly
A-4	Radiation Effects Pallet, TPCV in Foreground

31-7273

Figure A-1

Turbine Power Control Valve

Figure A-2

Radiation Effects Test Pallet on Test Stand at G-7

31-7206

Radiation Effects Test Pallet on ASTR Dolly

Figure A-3

L1261 146

Figure A-4

Radiation Effects Pallet, TPCV in Foreground

APPENDIX B

DOSIMETRY

LIST OF TABLES AND FIGURES

APPENDIX B

<u>Table or Figure No.</u>	<u>Title</u>
B-I	Dosimetry Results
B-II	Dosimetry Locations

DOSIMETRY

Appendix B

Nineteen dosimetry packets were attached to the various components on the test pallet to measure the integrated dose received by each component. Table I contains the dose measured by each of the dosimetry packets. Table II contains the location description and number of the dosimetry packets for each of the components.

TABLE I

Dosimetry Results

Packet	Gamma ergs/gm(C)	Neutrons/cm ² E > 8.1 Mev	Neutrons/cm ² E > 2.9 Mev	Thermal Neutrons/cm ² E < 0.48 ev
1	8.1 (7)*	6.2 (11)	1.8 (13)	2.8 (12)
2	3.8 (7)	3.5 (11)	1.1 (13)	2.5 (12)
3	1.3 (7)	1.3 (12)	3.7 (13)	
4	1.4 (8)	2.3 (12)	8.3 (13)	
5	2.1 (6)	2.5 (12)	9.2 (13)	
6	3.8 (8)	2.4 (12)	8.1 (13)	
7	1.8 (8)	1.1 (12)	3.5 (13)	
8	1.7 (7)	1.8 (11)	5.2 (12)	3.2 (12)
9	1.4 (7)	1.8 (11)	5.2 (12)	3.1 (12)
10	1.7 (7)	1.0 (11)	3.6 (12)	2.7 (12)
11	8.1 (6)	6.0 (10)	1.7 (12)	2.1 (12)
12	5.4 (6)	1.3 (10)	6.0 (11)	1.6 (12)
13	7.4 (7)	7.9 (11)	2.5 (13)	
14	2.2 (7)	3.2 (11)	1.0 (13)	2.4 (12)
15	8.1 (7)	7.9 (11)	2.5 (13)	
17	5.4 (7)	8.0 (11)	2.8 (13)	
18	7.0 (6)	2.6 (11)	1.3 (12)	2.1 (12)
19	4.0 (7)	1.7 (11)	9.0 (12)	2.5 (12)
20	2.9 (7)	2.7 (11)	8.6 (12)	2.8 (12)

*8.1 (7) denotes 8.1×10^7

TABLE II

Appendix B

Dosimetry Locations

Static Flange Seal Assembly

Packet No. 1	On horizontal centerline, 6 inches from left end, on front face.
Packet No. 3	On horizontal centerline, 12 inches from left end, on front face.
Packet No. 19	On horizontal centerline, $8\frac{1}{2}$ inches from left end, on back face.

Tank Shut Off Valve

Packet No. 19	On vertical centerline, front face, directly behind Static Flange Seal Assembly.
Packet No. 20	Directly behind No. 19 on back face of TSOV.

Bearing Tester

Packet No. 4	On front face, vertical and horizontal centerlines.
Packet No. 17	Mounted on rear surface of flange at top.
Packet No. 18	Mounted on rear surface of Bearing Tester Motor.

Turbine Pump Control Valve Actuator

Packet No. 13	On front face
Packet No. 14	On rear face

Turbine Pump Control Valve

Packet No. 15	On front face
Packet No. 2	On rear face

Shroud (outside dosimetry 6 inches up from base)

Front face left to right distance from left side of shroud

$18\frac{1}{2}$ " 25" 34"

APPENDIX C

TEST DATA - 10 SECOND RUN

LIST OF FIGURES

APPENDIX C

<u>Figure No.</u>	<u>Title</u>
C-1	Flow Diagram MIT 901 Pallet
C-2	Voltage Output, Turbine Power Control Valve Position Indicator
C-3	Temperature, GH_2 , Turbine Power Control Valve Inlet

- NOTES: 1. SYMBOLS PER MIL-STD-10.
2. ALL SECONDARY LINES ARE 1/2 INCH DIA.
3. TO BE USED IN CONJUNCTION WITH A-1, GW, 255BUT, 255BUT-2.
4. FOR CONTROL SYSTEM SCHEMATIC SEE DRAWING 255BUT-1.
5. FOR AIR CONDITIONING EFFECTS PALLET SEE DRAWING 255BUT-2.
6. FOR AIR ELECTRICAL HARNESS INTERFACE SEE DRAWING 255BUT-3.
7. DENOTES NERVA ENGINE COMPONENT TO BE TESTED (NOT PART OF TEST PALLET).

Figure C-1, Sheet 2 of 2

SYSTEM COMPONENTS					
COMPONENT SYMBOL	DESCRIPTION	UNIT NO.	HYDRAULIC SYMBOL	QTY	LOC. NO.
1	PRESSURE LINE	TYPE 100-15	APRCH 25112	0-1000 PSIG	1
2	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	2
3	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	3
4	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	4
5	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	5
6	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	6
7	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	7
8	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	8
9	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	9
10	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	10
11	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	11
12	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	12
13	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	13
14	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	14
15	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	15
16	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	16
17	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	17
18	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	18
19	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	19
20	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	20
21	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	21
22	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	22
23	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	23
24	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	24
25	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	25
26	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	26
27	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	27
28	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	28
29	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	29
30	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	30
31	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	31
32	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	32
33	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	33
34	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	34
35	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	35
36	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	36
37	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	37
38	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	38
39	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	39
40	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	40
41	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	41
42	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	42
43	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	43
44	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	44
45	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	45
46	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	46
47	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	47
48	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	48
49	HAIRY LONDR	TYPE 100-15	APRCH 25112	0-1000 PSIG	49

HYDRAULIC DATA	
SYMBOL	DESCRIPTION
1	HAIRY LONDR
2	HAIRY LONDR
3	HAIRY LONDR
4	HAIRY LONDR
5	HAIRY LONDR
6	HAIRY LONDR
7	HAIRY LONDR
8	HAIRY LONDR
9	HAIRY LONDR
10	HAIRY LONDR
11	HAIRY LONDR
12	HAIRY LONDR
13	HAIRY LONDR
14	HAIRY LONDR
15	HAIRY LONDR
16	HAIRY LONDR
17	HAIRY LONDR
18	HAIRY LONDR
19	HAIRY LONDR
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21	HAIRY LONDR
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37	HAIRY LONDR
38	HAIRY LONDR
39	HAIRY LONDR
40	HAIRY LONDR
41	HAIRY LONDR
42	HAIRY LONDR
43	HAIRY LONDR
44	HAIRY LONDR
45	HAIRY LONDR
46	HAIRY LONDR
47	HAIRY LONDR
48	HAIRY LONDR
49	HAIRY LONDR

PARAMETRIC DATA		
SYMBOL	DESCRIPTION	FUNCTION
1	HAIRY LONDR	HAIRY LONDR
2	HAIRY LONDR	HAIRY LONDR
3	HAIRY LONDR	HAIRY LONDR
4	HAIRY LONDR	HAIRY LONDR
5	HAIRY LONDR	HAIRY LONDR
6	HAIRY LONDR	HAIRY LONDR
7	HAIRY LONDR	HAIRY LONDR
8	HAIRY LONDR	HAIRY LONDR
9	HAIRY LONDR	HAIRY LONDR
10	HAIRY LONDR	HAIRY LONDR
11	HAIRY LONDR	HAIRY LONDR
12	HAIRY LONDR	HAIRY LONDR
13	HAIRY LONDR	HAIRY LONDR
14	HAIRY LONDR	HAIRY LONDR
15	HAIRY LONDR	HAIRY LONDR
16	HAIRY LONDR	HAIRY LONDR
17	HAIRY LONDR	HAIRY LONDR
18	HAIRY LONDR	HAIRY LONDR
19	HAIRY LONDR	HAIRY LONDR
20	HAIRY LONDR	HAIRY LONDR
21	HAIRY LONDR	HAIRY LONDR
22	HAIRY LONDR	HAIRY LONDR
23	HAIRY LONDR	HAIRY LONDR
24	HAIRY LONDR	HAIRY LONDR
25	HAIRY LONDR	HAIRY LONDR
26	HAIRY LONDR	HAIRY LONDR
27	HAIRY LONDR	HAIRY LONDR
28	HAIRY LONDR	HAIRY LONDR
29	HAIRY LONDR	HAIRY LONDR
30	HAIRY LONDR	HAIRY LONDR
31	HAIRY LONDR	HAIRY LONDR
32	HAIRY LONDR	HAIRY LONDR
33	HAIRY LONDR	HAIRY LONDR
34	HAIRY LONDR	HAIRY LONDR
35	HAIRY LONDR	HAIRY LONDR
36	HAIRY LONDR	HAIRY LONDR
37	HAIRY LONDR	HAIRY LONDR
38	HAIRY LONDR	HAIRY LONDR
39	HAIRY LONDR	HAIRY LONDR
40	HAIRY LONDR	HAIRY LONDR
41	HAIRY LONDR	HAIRY LONDR
42	HAIRY LONDR	HAIRY LONDR
43	HAIRY LONDR	HAIRY LONDR
44	HAIRY LONDR	HAIRY LONDR
45	HAIRY LONDR	HAIRY LONDR
46	HAIRY LONDR	HAIRY LONDR
47	HAIRY LONDR	HAIRY LONDR
48	HAIRY LONDR	HAIRY LONDR
49	HAIRY LONDR	HAIRY LONDR

Flow Diagram MIT 901 Pallet

Figure C-2

Preirradiation Run: Voltage Output from Turbine Power Control Valve Position Indicator

Figure C-3

Preirradiation Run: Temperature of GH_2 at the Inlet to the Turbine Power Control Valve

APPENDIX D

TEST DATA - 300 SECOND TEST

LIST OF FIGURES

APPENDIX D

<u>Figure No.</u>	<u>Title</u>
D-1	Body Bore Measurements
D-2	Spring Deflection Curves
D-3	Electrical Characteristics of Type 1200-602 Duncan Electronics Rotary Potentiometer
D-4	Temperature Inside Pallet Shroud
D-5	Temperature GH_2 at the Inlet to the Turbine Power Control Valve
D-6	Pressure of GH_2 at the Inlet and Outlet of the Turbine Power Control Valve
D-7	Voltage Output from Turbine Power Control Valve Position Indicator

NOTE: P/N Inscription on
Body Identifies Front

	Before Radiation	After Radiation
Front Horizontal	2.873	2.873
Front Vertical	2.873	2.873
Rear Horizontal	2.875	2.872
Rear Vertical	2.870	2.870

Body Bore Measurements

Figure D-1

Figure D-2

Spring Deflection Curves

	<u>PRE-RADIATION</u>	<u>POST-RADIATION</u>
TOTAL RESISTANCE	10060 OHMS	10041 OHMS
MINIMUM RESISTANCE	PINS 2-1 40 OHMS PINS 2-3 25 OHMS	PINS 2-1 38 OHMS PINS 2-3 21 OHMS
PEAK NOISE	NEGLIGIBLE	40 OHMS
STARTING TORQUE	CLOCKWISE AND COUNTER-CLOCKWISE 0.24 INCH-OUNCE	UNCHANGED
INSULATION RESISTANCE	INFINITE	UNCHANGED
DIELECTRIC WITHSTANDING VOLTAGE	ZERO LEAKAGE CURRENT	UNCHANGED

Electrical Characteristics of Type 1200-602 Duncan
Electronics Rotary Potentiometer

Figure D-3

Figure D-4

Irradiation Run: Temperature Inside the Pallet Shroud

Figure D-5

Irradiation run: Temperature of $^3\text{H}_2$ at the Inlet to the Turbine Power Control Valve

Figure D-6

Irradiation Run: Pressure of GH₂ at the Inlet and Outlet of the Turbine
Power Control Valve

Figure D-7

Irradiation Run: Voltage Output from Turbine Power Control Valve Position Indicator

APPENDIX E

CALIBRATION DATA

LIST OF FIGURES

APPENDIX E

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E-2	Calibration Curve - Turbine Power Control Valve Inlet Pressure Transducer
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Figure E-1

Calibration Curve - Shroud Temperature Transducer

Figure E-2

Calibration Curve - Turbine Power Control Valve
Inlet Pressure Transducer

Figure E-3

Calibration Curve - Turbine Power Control Valve
Outlet Pressure Transducer

REFERENCES

APPENDIX F

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