TID/SNA -- 1397

KEYPUNCHED

PRELIMINARY REPORT

SNPO-C

ASTR-4

IRRADIATION TEST
4 MAY 1964

MASTER

NUCLEAR AEROSPACE RESEARCH FACILITY

operated by

GENERAL DYNAMICS | FORT WORTH

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T1D/SNA--1397

PRELIMINARY REPORT

SNPO-C

ASTR-4

IRRADIATION TEST

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FOREWORD

The test described in this document is designated SNPO-C, ASTR-4. It is the third in a series of tests of NERVA components being performed under Supplement 1 of Contract AF29(601)-6213 by the Nuclear Aerospace Research Facility (NARF) at General Dynamics/Fort Worth for the Space Nuclear Propulsion Office, Cleveland, Ohio (SNPO-C). The 3-Mw Ground Test Reactor (GTR) and the 10-Mw Aerospace Systems Test Reactor (ASTR) are being utilized for these tests.

Before the present series, eight tests on NERVA components were performed at NARF under Supplement 8 of Contract AF33(657)-7201. These may be found in the eight volumes constituting GD/FW Report FZK-170.

The results of the first 2 tests of the present series may be found in the documents listed below:

<u>Test</u>	<u>GD/FW Report No.</u>
GTR 11	FZK-184-1
GTR 12	FZK-184-2

TABLE OF CONTENTS

Foreword

List of Figures

List of Tables

I Introduction

II General Information

2.1 Test Summary

2.2 Nuclear Measurements

2.2.1 Neutron

2.2.2 Gamma

2.2.2.1 Nitrous Oxide Dosimeters

2.2.2.2 Chemical Dosimeters

III Test Results

3.1 Pre-irradiation Test

3.2 Irradiated Test

3.3 Post-irradiation Inspection

3.4 Dosimetry

Appendices

A. Reactor Log

B. Audio Comments from Magnetic Tape

LIST OF FIGURES

- Figure 1-1 Test Pallet with Bearing Tester Installed
- Figure 1-2 Closeup of Bearing Tester on Test Pallet
- Figure 1-3 ASTR Test Cell with Test Pallet Installed
- Figure 1-4 Digital Tape System
- Figure 1-5 Analog Tape System
- Figure 1-6 Sanborn Recorders
- Figure 1-7 Pallet and Dewar Control Panel, Load Control
Panel, and Gas Distribution System Pressure
Gages
- Figure 1-8 Event Recorder and Meter Panel No. 1
- Figure 1-9 Meter Panel No. 2
- Figure 1-10 Television Monitors and Explosive Mixture
Detectors
- Figure 1-11 ASTR Radiation Effects Testing System Console
- Figure 1-12 Video Tape Recorder
- Figure 2-1 Gas-Distribution and Cryogen-Supply Systems
- Figure 2-2 Cryogen Supply System
- Figure 2-3 Load Control Pallet
- Figure 2-4 Damaged Load Sleeve of Bearing Tester (S/N 005)
- Figure 2-5 Biological Shield Around ASTR Test Cell
- Figure 3-1 Pressures vs Time for Preirradiation Test
- Figure 3-2 Temperatures vs Time for Preirradiation Test
- Figure 3-3 Motor Speed and Current vs Time for
Preirradiation Test

LIST OF FIGURES
(cont'd)

- Figure 3-4 Pressures vs Time for Irradiated Run No. 6
- Figure 3-5 Temperatures vs Time for Irradiated Run No. 6
- Figure 3-6 Motor Speed and Current vs Time for
Irradiated Run No. 6
- Figure 3-7 Postirradiation View of Roller Bearing No. 2
with Motor Case Removed
- Figure 3-8 Postirradiation View of Roller Bearing No. 2
with Outer Bearing Race Retainer Removed
- Figure 3-9 Postirradiation View of Roller Bearing No. 2
Cage and Rollers
- Figure 3-10 Postirradiation View of Roller Bearing No. 2
Outer Race
- Figure 3-11 Postirradiation View of Roller Bearing No. 2
Inner Race
- Figure 3-12 Dosimetry Packet Locations on Bearing Tester:
Rear View
- Figure 3-13 Dosimetry Packet Locations on Bearing Tester:
Top View
- Figure 3-14 Dosimetry Packet Locations on Flowmatics
Valves: Rear View
- Figure 3-15 Dosimetry Paek Locations on Flowmatics
Valves: Front View
- Figure 3-16 Dosimetry Packet Locations on Pallet Shroud:
Rear View
- Figure 3-17 Dosimetry Packet Locations on Pallet Shroud:
Top View

LIST OF TABLES

Table	Title
1	Chronological Review of Events
2	Time and Event Correlation
3	Dosimetry Location
4	Dosimetry Data

I. INTRODUCTION

A series of tests is presently being conducted by General Dynamics/Fort Worth to evaluate the effects of nuclear radiation on various mechanical components which are to be used in the NERVA program. These tests are being accomplished using the Radiation Effects Testing System of the Nuclear Aerospace Research Facility. The test specimens and hardware are furnished by Aerojet-General Corporation.

The test covered in this report, which was the fourth in the present series, involved the irradiation of candidate turbo pump assembly bearings. These bearings were installed in an electric motor driven bearing tester which supplied mechanical loads and stresses similar to those encountered in the turbo pump assembly. The cryogenic environment in which the bearings must operate in the NERVA engine was simulated by flowing liquid hydrogen (LH_2) through the bearing tester. The radiation environment was provided by the Aerospace Test Reactor (ASTR).

The bearing tester was mounted on a test pallet which contained the valves, plumbing, transducers, etc., necessary for operation (Fig. 1-1 and 1-2). The pallet was then installed in the test facility (Fig. 1-3), where a complete checkout and calibration of all controls and instrumentation was made (Fig. 1-4 through 1-12). Following leak checks of all plumbing and hardware with

NPC 20,470
31-7848

Figure 1-1 Test Pallet with Bearing Tester Installed

Figure 1-2 Closeup of Bearing Tester on Test Pallet

NPc 20,471
31-7846

NPC 20, 472
31-7854

Figure 1-3 ASTR Test Cell with Test Pallet Installed

NPC 20,473
31-7856

Figure 1-4 Digital Tape System

NPC 20,474
31-7840

Figure 1-5 Analog Tape System

NFC 20,475
31-7857

Figure 1-6 Sanborn Recorders

NPC 20,476
31-7844

Figure 1-7 Pallet and Dewar Control Panel, Load Control Panel, and Gas Distribution System Pressure Gages

NPC 20,477
31-7839

Figure 1-8 Event Recorder and Meter Panel No. 1

Figure 1-9 Meter Panel No. 2

NPC 20,479
31-7360

Figure 1-10 Television Monitors and Explosive Mixture Detectors

Figure 1-11 ASTR Radiation Effects Testing System Console

NPC 20,480
31-7861

Figure 1-12 Video Tape Recorder

liquid nitrogen (LN_2), a 5-minute pre-irradiation control run was made with LH_2 to verify that all components and instrumentation were operating satisfactorily.

The bearing tester was then operated for a total of 333 seconds during which time the reactor was at a power level of 10 megawatts for 284 seconds. The test was terminated at this point because of a rapid increase in the temperature of one of the roller bearings.

After termination of the irradiation test, all the transducers were post calibrated, and the bearing tester was partially disassembled for inspection. The roller bearing which had experienced the rapid rise in temperature was found to have a cracked inner race and a damaged cage. The tester was then shipped to Aerojet-General Corp. for further analysis.

II. GENERAL INFORMATION

2.1 Test Summary

The test setup was begun on 17 February with the installation of the test pallet in the ASTR test cell and the instrumentation in the control room. The gas distribution, cryogen supply and load control systems (Fig. 2-1 through 2-3) were then integrated with the test pallet. At this time, the bearing tester on hand (S/N 005) was found to have a damaged load sleeve and it was necessary to return it to Aerojet-General Corporation (Fig. 2-4). A replacement tester (S/N 006) was received on 11 March and installed on the test pallet. After the plumbing was leak checked with gaseous helium and the instrumentation was checked out and calibrated, the entire liquid hydrogen system was chilled down with LN_2 . This was done to leak check the entire system in a non-hydrogen cryogenic environment.

After completion of the LN_2 runs, the reactor biological shield was installed (Fig. 2-5) and the cryogen supply dewar was filled with LH_2 . A 300-second pre-irradiation run was made using the same procedure to be followed during the irradiation test. This was done to obtain base line data and to verify satisfactory operation of the bearing tester and instrumentation.

A total of six runs were made during the irradiation portion of the test. Runs No. 1 and 2 were aborted prior

NPC 20,482
31-7836

Figure 2-1 Gas-Distribution and Cryogen-Supply Systems

NFC 20,483
31-7850

Figure 2-2 Cryogen Supply System

NPC 19,892
31-7480

Figure 2-3 Load-Control Pallet

Figure 2-4 Damaged Load Sleeve of Bearing Tester (S/N 005)

NPC 20,485
31-7695

NPC 20,486
31-7837

Figure 2-5 Biological Shield around ASTR Test Cell

to starting the bearing tester and bringing the reactor to power because of an inoperative bearing temperature thermocouple and a ruptured burst disc in the LH_2 supply system.

Run No. 3 proceeded satisfactorily through the point of bringing the reactor to a 10-megawatt power level and starting the bearing tester. Immediately upon achieving 10 megawatts, however, the reactor was shutdown by an automatic scram circuit. The bearing tester stop switch was activated immediately but the tester did not stop; therefore, the emergency shutdown switch was activated. Total bearing tester operating time for this run was 63 seconds.

In Run No. 4, 70 seconds of bearing tester operation and 71 seconds of reactor time at 10 megawatts were achieved at which time the run was terminated due to a hydrogen leak indication on one of the explosive mixture detectors located on the test pallet. Run No. 5 was aborted prior to bearing tester start due to an inoperative thermocouple.

Run No. 6 proceeded normally until approximately 180 seconds of bearing tester operation had been achieved. At this point, the motor current increased suddenly and the temperature of Roller Bearing No. 2 began a rapid rise which exceeded the kill limit and the test was terminated.

Immediately prior to termination of this run, another hydrogen leak was detected on one of the explosive mixture sensors. Reactor time at 10 megawatts was 198 seconds for this run.

Analysis of the data from Run No. 6 indicated possible damage to roller bearing No. 2; therefore, the bearing tester was removed from the test pallet and partially disassembled. This inspection revealed that the bearing had a cracked inner race and a damaged cage. The tester was then shipped to Aerojet-General Corporation for further analysis.

All transducers on the test pallet were recalibrated following Run No. 6 to determine any changes from the pre-test calibrations.

A chronological review of events is shown in Table 1.

TABLE 1

Chronological Review of Events

Run No.	Date	Time	Brg. Motor Run Time (Seconds)	Reactor Time at 10 Mw (Seconds)	Comments
LN ₂ -1	3/20	1700	---	---	TRB-2 sluggish
LN ₂ -2	3/20	2200	---	---	TRB-2 sluggish
LN ₂ -3	3/20	2330	---	---	
LN ₂ -4	3/24	0900	---	---	LN ₂ leak at Dewar
LN ₂ -5	3/26	0000	---	---	Cryogen Supply Line Leak
LN ₂ -6	3/27	0300	---	---	Run Satisfactory
LH ₂ Con- trol (300-sec control run)	3/30	0700	301	---	Run Satisfactory
LH ₂ -1 (Ifr.)	3/31	0700	---	---	TRB-1 thermo- couple inoper- ative
LH ₂ -2 (Ifr.)	3/31	1800	---	---	LH ₂ supply line burst disc rup- tured
LH ₂ -3 (Ifr.)	3/31	2100	63	15	Reactor scram immediately upon reaching 10 Mw power level
LH ₂ -4 (Ifr.)	4/1	0700	70	71	Hydrogen leak (alarm on de- tector 10)
LH ₂ -5 (Ifr.)	4/2	1220	---	---	TRB-2 inoperative
LH ₂ -6 (Ifr.)	4/2	2100	200	198	TRB-2 temperature change rate reach- ed kill limit; hydrogen leak (alarm on detector #8)

2.2 Nuclear Measurements

2.2.1 Neutron

The neutron flux was monitored during the test at 36 locations. These measurements were made with the following threshold detectors: sulfur ($E > 2.9$ Mev), aluminum ($E > 8.1$ Mev), and phosphorus (bare and cadmium covered) for the thermal flux. The detectors were mounted on 3-1/2 X 3 inch aluminum holders which were in turn mounted on or near the components on the test pallet. The detectors were counted and the data reduced by an IBM 7090 digital computer program (Ref. 1).

2.2.2 Gamma

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

2.2.2.1 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 and then flame sealed. Upon exposure to gamma radiation, the following reaction is produced in the gas:

The dose is determined by measuring the number of moles of N_2 and 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 10^8 to 10^{12} ergs/gm(C) and -90° to 120°C , respectively.

The dosimeters have a reproducibility of 7 to 9%.

2.2.2.2 Chemical Dosimeters

The chemical dosimeters are of 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. These dosimeters, sensitive to gamma energies from 65 Kev to 10 Mev, have a usable 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.

III. TEST RESULTS

The preliminary analog data from the five minute LH_2 control run and from the final irradiation attempt have been plotted vs time and are presented in Figures 3-1 through 3-6. Table 2 contains a time correlation between major events during each of the runs involving bearing tester operation. A transcript of the audio comments, as recorded on analog tape during these runs, is presented in Appendix A. Appendix B contains the reactor log for each irradiated run.

3.1 Preirradiation Control Run

The 5 minute LH_2 control run was made on 3/30/64. Figure 3-1 shows plots of the various pressures vs time. The temperatures are shown plotted vs time in Fig. 3-2. Current and motor speed are plotted vs time in Fig. 3-3. An examination of Fig. 3-2 shows the temperature of TRB-2 to increase rapidly after the motor is started. This occurrence was unusual since previous tests (ASTR 1,2,&3) failed to indicate such a rapid increase in this parameter. Throughout the control run, TRB-2 stayed well below the kill temperature of -50°F .

3.2 Irradiated Test

The six attempts to perform the first radiation test were all aborted short of their scheduled duration. The longest irradiation time (200 seconds) was logged during the sixth attempt. This attempt was aborted due to a rapid

increase in TRB-2. Data relating the pressures to time for Run No. 6 are shown in Fig. 3-4, temperature vs time in Fig. 3-5, and current and motor speed vs time in Fig. 3-6. The plot of TRB-2 (Fig. 3-5) showed signs of stabilizing after the motor was started, but after 200 seconds a rapid increase in TRB-2, which exceeded the kill limit, caused the test to be terminated.

Figure 3-1 Pressures vs Time for Preirradiation Test

Figure 3-2 Temperatures vs Time for Preirradiation Test

Figure 3-3 Motor Speed and Current vs Time for Preirradiation Test

Figure 3-4 Pressures vs Time for Irradiation Run No. 6

Figure 3-5 Pressures vs Time for Irradiated Run No. 6

Figure 3-6 Motor Speed and Current vs Time for Irradiation Run No. 6

TABLE 2

Time and Event CorrelationASTR-4 Pre-irradiation Control RunTime (sec.)

-3113	Started LH ₂ line cool down
-1017	Started Bearing Tester cool down
0	Bearing Tester start
+ 300	Bearing Tester off
+1986	Stopped LH ₂ flow

Irradiated Run No. 3

- 630	Started Bearing Tester cool down
- 84	Reactor at 1 Kw
- 48	Reactor at 100 Kw
- 27	Reactor at 1 Mw
0	Reactor at 10 Mw, Bearing Tester started
+ 15	Reactor SCRAM
+ 63	Bearing tester off
+ 117	LH ₂ flow stopped

Irradiated Run No. 4

- 948	Started LH ₂ line cool down
- 772	Started Bearing Tester cool down
- 90	Reactor at 1 Kw
- 53	Reactor at 100 Kw
- 30	Reactor at 1 Mw

TABLE 2
(cont'd)

Time (sec.)

0	Reactor at 10 Mw; Bearing Tester started
+ 54	Alarm on No. 10 hydrogen detector
+ 71	Bearing Tester stopped and Reactor shut down
+ 91	LH ₂ flow stopped

Irradiated Run No. 6

- 591	Started Bearing Tester cool down
- 95	Reactor at 1 Kw
- 59	Reactor at 100 Kw
- 46	Reactor at 1 Mw
0	Reactor at 10 Mw; Bearing Tester started
+ 181	Motor current increased suddenly
+ 185	TRB-2 increasing rapidly
+ 190	Alarm on hydrogen detector No. 8
+ 200	Bearing Tester stopped and Reactor shut down
+ 242	LH ₂ flow stopped

3.3 Post-irradiation Inspection

Approximately 24 hours after the final irradiated test, the bearing tester was removed from the test pallet and partially disassembled. As shown in Figures 3-7 through 3-11, roller bearing No. 2 had a longitudinal crack in the inner race and a damaged roller cage. The inner race was also galled in spots although the rollers and the outer race showed no signs of damage.

The tester was then crated and shipped to Aerojet-General Corp. for further disassembly and analysis. Inspection of the test pallet revealed several loose tube fittings. This was apparently the result of excessive vibration due to the damaged bearing.

3.4 Dosimetry

Thirty-six dosimetry packets were attached to the bearing tester and other components on the test pallet to measure the integrated dose incident upon each component. The packet locations are shown in Figures 3-12 through 3-17 and in Table 3. Table 4 contains the integrated doses measured for each packet. Data reduction is incomplete at this time therefore this data is considered as preliminary information and is subject to change.

NPC 20,487
31-7879

Figure 3-7 Postirradiation View of Roller Bearing No. 2 with Motor Case Removed

NFC 20,488
31-7877

Figure 3-8 Postirradiation View of Roller Bearing No. 2 with
Outer Bearing Race Retainer Removed

NPC 20,489
31-7380

Figure 3-9 Postirradiation View of Roller Bearing No. 2 Cage and Rollers

NPC 20,490
31-7867

Figure 3-10 Postirradiation View of Roller Bearing No. 2
Outer Race

Figure 3-11 Postirradiation View of Roller Bearing No. 2
Inner Race

NPC 20,491
31-7862

Figure 3-12 Dosimetry Packet Locations on Bearing Tester:
Rear View

NPC 20,492
31-7829

This figure will be included in the Final Report.

Figure 3-13

NPC 20,494
31-7834

Figure 3-14 Dosimetry Packet Locations on Flowmatics Valves:
Rear View

MPG 20,495
31-7835

Figure 3-15 Dosimetry Packet Locations on Flowmatics Valves:
Front View

MPC 20, 496
 31-7824

Figure 3-16 Dosimetry Packet Locations on Pallet Shroud:
 Rear View

NPC 20,497
31-7826

Figure 3-17 Dosimetry Packet Locations on Pallet Shroud:
Top View

TABLE 3

Dosimetry Location

Shroud (Outside)

Front (Reactor) face (distance from left side of
pallet-facing reactor)

		5 in.	17 in.	29 in.
Top	Packet No.	218	215	212
(15 1/2 in. above base)				
Middle		219	216	213
(10 in. above base)				
Bottom		220	217	214
(4 1/2 in. above base)				
Rear face				
Top		201	210	204
Middle		211	203	208
Bottom		202	209	205

Bearing Tester

Packet No.

Location

66	Front face, vertical and horizontal centerlines
62	Rear face of mounting flange-left side
63	Rear face of mounting flange-top
64	Rear face of mounting flange-right side
65	Rear face of mounting flange-bottom
71	Motor housing-bottom
72	Motor housing-left side
73	Motor housing-top
74	Motor housing-right side
75	Motor housing-rear face, vertical and horizontal centerlines

TABLE 3
(cont'd)

Orifice bypass valve

Packet No. 69 on front

LH₂ Filter

Packet No. 67 on front face

Packet No. 68 on rear face

Transducer bracket

Packet No. 70 on front face

Pilot Valves (OBPV)

Packet No. 60 on front valve

Packet No. 61 on rear valve

LH₂S Valve

Packet No. 206 on front face

Packet No. 202 on rear face

HeS Valve

Packet No. 859 on front face

Packet No. 868 on rear face

TABLE 4

Dosimetry Data

Packet No.	Neutron Flux ($E > 2.9$ Mev) n/cm^2	Gamma Dose ergs/gm-C
60	2.4(13)*	3.2(8)
61	1.2(13)	3.1(8)
62	1.5(13)	2.6(8)
63	1.3(13)	2.7(8)
64	1.7(13)	3.0(8)
65	1.9(13)	2.9(8)
66	6.5(13)	2.5(8)
67	5.6(12)	2.2(8)
68	3.2(12)	2.8(8)
69	1.6(13)	6.7(8)
70	2.1(13)	---
71	7.0(12)	2.0(8)
72	7.2(12)	2.6(8)
73	6.6(12)	2.5(8)
74	9.0(12)	2.5(8)
75	2.6(12)	2.3(8)
201	7.8(12)	3.0(7)
202	4.2(12)	3.9(7)
203	1.1(12)	9.2(6)
204	6.8(12)	2.8(7)
205	5.7(12)	2.5(7)
206	1.5(12)	1.1(7)
207	1.0(12)	8.7(6)
208	4.5(12)	2.6(7)
209	3.7(12)	6.0(7)
210	2.9(12)	2.0(7)
211	6.7(12)	4.0(7)
212	3.0(13)	1.9(8)
213	3.8(13)	2.3(8)
214	3.7(13)	2.2(8)
215	6.3(13)	3.2(8)
216	9.4(13)	3.7(8)
217	9.3(13)	3.7(8)
218	2.5(13)	1.9(8)
219	3.1(13)	1.9(8)
220	3.2(13)	6.2(7)
859	1.1(12)	1.4(7)
868	5.8(11)	8.5(6)

* 2.4(13) denotes 2.4×10^{13}

REFERENCES

1. Dungan, W. E., Specification of the Neutron Flux in the Radiation Effects Testing Facility, Convair-Fort Worth Report MR-N-270 (NARF-60-23T, July 1960).

APPENDIX B

Reactor Log

<u>Reactor Power Level</u>	<u>Time</u>	<u>Frame No.</u>
<u>Irradiated Run No. 3 - 3/31/64</u>		
100 watts	2124:24	2402
1 Kw	2129:48	2906
5 Kw	2130:02	2920
100 Kw	2130:24	2942
500 Kw	2130:40	2958
1 Mw	2130:45	2963
5 Mw	2130:55	2973
7-1/2 Mw	2131:05	2983
10 Mw	2131:12	2990
0 (Reactor SCRAM)	2131:27	3005
<u>Irradiated Run No. 4 - 4/1/64</u>		
100 watts	0725:27	2960
1 Kw	0732:00	3353
10 Kw	0732:17	3370
100 Kw	0732:37	3390
1 Mw	0733:00	3413
5 Mw	0733:16	3429
10 Mw	0733:30	3443
0 (SCRAM)	0734:39	3512
<u>Irradiated Run No. 6 - 4/2/64</u>		
100 watts	2103:00	0310
1 Kw	2113:04	0914
10 Kw	2113:25	0935
100 Kw	2113:40	0950
1 Mw	2113:53	0963
5 Mw	2114:23	0993
10 Mw	2114:39	1009
0 (SCRAM)	2117:57	1207

3/30/64 PRE IRR LH₂ CONTROL RUN

Frame No.

0938 SW#9 up
1174 SW#7 BLAS up
1185 SW#5 CDBP up
1208 Close GH₂ VV₁, SW#39, up
1213 Close GH₂ VV₂, SW#40, center
1222 Open LH₂ SV, SW#45, up
1229 Open GH₂ PRV, SW#44, up
1237 Increase dewar press. to 100 psig, SW#42
1243 Dewar press. coming up
1258 Starting Brown Recorder
1367 Holding at 100 psi for leak check.
1612 We have a meter off scale
1624 A whole rack of power supplies went out, but should be back in operation soon.
1640 Crabtree said he saw vapor coming out of the small stack.
1646 Tell him that we lost a 115 volt power supply; had to dump dewar press.
1671 PR -3 meter reading 1045 psi and creeping up
1674 Need to dump dewar press. again and go out and back off regulator.
1796 Dewar pressurized to 135 psi
1845 Hit SV3 on and off real quick to drop press.
1894 Try SV3 one more time like that

2025 We are getting liquid flow to the pallet, and
frost on the line.

2097 We lost our power again.

2108 John's working on it and press. is off dewar.

3025 Do you want to go to 150 psi and hold?

3027 Roger.

3084 We're at 150 psi on the dewar.

3277 Set 20 psi on PRL,

3392 Set 300 psi on PAL

3333 SW #8 hold down

3340 Close CDBP SW #5 center

3354 Increase press. to 225 psi

3358 TLSH coming in

3372 -300 on TLSH

3390 TRB-1 coming in

3392 TRB-2 coming in

3394 TLDH getting cold

3403 Press. 200 psi

3415 Good flame out of stack

3355 TLDH - -250°

3468 225 psi on dewar

3495 FO-D running about 12 or 13 psi

3531 B₁ light is on

3859 Running almost 14 psi across the orifice on ΔP

3879 225 psi on dewar.

3888 PLSH-2, 192 psi

3912 PLDH, 190 psi

3997 PO₁, 211 psi

4004 PO1R, 211 psi

4043 PLSH-2, 190psi

4061 Opened OBPV momentarily and then closed
4072 PLDH increased to over 200psi
4086 PO-D dropped to zero when OBPV was open
4115 KO-D 7 psi
4152 216 psi line press.
4160 PLSH 1 and 2 up slightly after opening OBPV
4185 Both back to 203 psi
4216 PO1, 210 psi
4221 1.1" water
4229 Getting low on LH₂
4270 1" water
4282 PLDH, 195 psi
4320 Will be starting bearing tester soon
4329 200psi PLDH
4340 10 second count down
4350 starting bearing tester
4353 RPM indication
4355 23000 RPM - 60 amps
4375 23850 PRM - 50 amps
4383 TLDH, -213°
4405 TLDH, -300°
4420 PRL, 600 psi, PAL 500 psi
4422 PLDH, 213 psi
4444 TRB1, -420°, TRB-2 -420°
4480 PLDH, 211 psi
4500 lost PO-D
4520 PBTLC 38 psi
4530 I(m), 50 amps; 23,750 RPM
4550 TRB-1 & 2 warming TRB-1, -390°, TRB-2, -360°
4558 1 minute to go

4600 50 seconds to go
4628 PLDH, 211 psi; TLDH, -260°
4649 0 minutes
4651 I(m) dropped off, PBTLIC down to zero
4662 Bleeding PAL & PRL
4666 TLDH getting colder
4668 Bearings Read -420°
4731 .9" water (230 gallons)
4947 Still emptying dewar
5000 TLDH, -375°
5030 PO1 slight increase
5250 .1" water in dewar (160 gal.)
5470 Flowing through bearing tester only
5492 PLDH, 211 psi
5520 TLDH, -375°
5709 TLSH, -400°, TRB-1 & 2, -400°, TLDH, -375°
5805 100 gallons left
5913 TLDH, -375°; TLSH, -400°
5933 Line temp still pegged (inoperative)
5969 205 psi PLDH
6052 ID-D coming back
6060 Both TLDH's warming up
6324 Close GH₂ PRV, SW #44, center
6330 Open GHe VV2, SW #38, up
6336 Open GH₂ VV2, SW #40, up
6350 Open GH₂ VV1 SW #39, center
6405 Bleeding PRL and PAL

FRAME No.

2544	Cal.
2613	Cal off.
6743	LH ₂ line frosting.
6747	225 dewar press.
6770	PLSH-2, 220 psi.
6775	TRB-1 and 2 coming off peg.
6795	60 cycle on TRB-1 again.
6820	Dewar press. creeping down, will try to raise.
6855	TRB-2, -180°
6867	100 watts.
6949	TRB-1 is still out
6987	TLDH almost to -423°
7005	PLDH 202 psi and dropping
7101	Going to stop flow and run a helium purge through pallet until we can get TRB-1 fixed.

0470	Cal on
0490	Cal off
2360	Little frost on LH ₂ line
2384	222 psi on dewar
2402	100 watts level
2476	PLSH-2, 220 psi
2485	TRB-1, -290°; TRB-2, -190°
2500	PLDH, 215 psi; TLDH, -282°

FRAME NO.

2517 PBTLC barely off peg
2607 TLSH, -400°
2685 Line temp, -415°
2705 PLSH steady
2722 Bearings temps are down enough to start
2766 225 psi on dewar
2772 PLSH-2, 220 psi
2780 TRB-1, -355°; TRB-2, -325°
2879 PLSH-2, 220 psi
2884 TRB-1, -365°; TRB-2, -330°
2906 1 kw
2920 5 kw
2942 100 kw
2958 500 kw
2963 1 meg
2973 5 meg
2983 7-1/2 meg
2990 10 meg
2993 Speed coming up
Alarm on
3005 Channel No. 5, scram reactor
3010 Stop bearing motor and bring loads down
3036 You haven't shut the motor off
3045 Stop switch won't drop out
3052 Try the emergency shut down
3056 Emergency shut down worked
3062 Close LH₂ S

FRAME NO.

3072	Sw No. 44 center
3077	Sw No. 38 up
3087	Sw No. 40 up
3092	Sw No. 39 center
3127	No. 3 hydrogen detector creeping up
3136	Down below 400 gallons in dewar
3160	5% on hydrogen detector
3224	Lets shut down , lower reactor and top off dewar

ASTR LH₂ Irr Attempt No. 4

4/1/64

0555 hrs.

3429	Cal on
3474	Cal off and at signal
2436	Sw No. 9 up, and Sw No. 7 up
2444	Set PRL to 20 psi Set PAL to 300 psi
2460	CDBP open
2468	Sw No. 45, up
2474	Sw No. 39 up
2487	Sw No. 40 center
2494	Sw No. 44 up
2495	Bring dewar press to 225 psi
2507	Burst disc light came on
2517	Reset it
2568	Turned line temp on
2583	Flame reported at stack
2630	Line temp -370° to -400°
2654	Liquid level at 2.3"
2664	Dewar press 225 psi
2671	Sw No. 20 up, Sw No. 8 hold down

FRAME NO.

2686	Line temp -420°
2690	Sw No. 5, center
2739	PLSH-2,210 psi
2744	TRB-1,-150° ;TRB-2,-50°
2792	TRB-1,-275°; TRB-2,-135°
2842	TRB-1,-290°; TRB-2,205°
2852	TLDH,-310°; TLSH,-400°
2875	PLDH,205 psi
2892	Exhaust manifold frosted over
2960	100 watts level
2966	TRB-1,-355°;TRB-2,-325°
3006	PLDH,195 psi
3353	1 kw
3370	10 kw
3390	100 kw
3413	1 meg
3429	5 meg
3443	10 meg
3450	Speed coming up
3467	TRB-2 is getting erratic
3487	I _m ,90 amps
3492	60 cycle pick up on TRB-1 and 2
3500	Alarm on No. 10 detector
3512	SCRAM
3514	Killing bearing tester
3515	Speed dropping to zero
3525	Unloading vents and bearing loads
3534	LH ₂ S closed
3541	Sw No. 44 center, reactor shut down

FRAME NO.

3556 SW #39, center, SW #40, up
3616 SW #38, center

	LH ₂ ASTR 4 IRR ATTEMPT #5	4/2/64	1220 hrs.
2242	Bringing dewar press. up to 225 psi		
2260	SW #20, up, and hold down SW #8		
2284	TLSH coming in and reading -175°		
2293	Line temp, -420°		
2298	TLSH, -275°		
2309	100 watts		
2322	PLSH-1, 215 psi; PLSH-2, 215 psi		
2340	TRB-1 coming in		
2394	Slight increase on #5 detector under bearing tester		
2426	TRB-2 hasn't come in yet		
2505	Liquid level, 2.15"		
2519	Line temp, -420°		
2524	PLDH came in; now it's out		
2540	Line press., 223 psi		
2557	223 psi, dewar press.		
2563	PLDH came in momentarily		
2628	PO-D was running a little high		
2648	PLDH meter is not calibrating		
2698	Dewar press. was dropped to 120 psi		
2802	#10 detector up a small amount, 1/2 of 1%		
3015	GH ₂ running 1000 psi		

FRAME NO.

3017 GHe running 1450 psi
3173 PLSH-1 had a sudden increase
3206 1.06", liquid level

LH₂ IRR ATTEMPT #6 4/2/64 2100 hrs.

0418 Open LH₂S, SW #20, up; SW #8, hold down
0442 PLSH is coming in
0464 TRB-1 coming in
0469 TLDH coming in
0474 TRB-2 moving up
0481 PBTLIC not reading yet
0490 TLSH, -380°
0518 Cal
0537 Cal off
0618 Close CDBP, SW #5, center
0628 225 psi, dewar press.
0633 PLSH-2, 207 psi
0641 TRB-1, -350°; TRB-2, -275°
0720 PLDH-1, 200 psi
0739 225 psi, dewar press.
0745 PLSH-2, 203 psi
0752 TRB-1, -375°; TRB-2, -290°
0877 TRB-1, -400°; TRB-2, -295°
0914 1 kw
0935 10 kw
0944 PLSH-2, 100 psi

FRAME NO.

0950	100 kw
0963	1 meg
0993	5 meg
1009	10 meg
1014	motor speed coming up
1027	TRB-2, noisy
1067	I(m), 90 amps
1094	TRB-1, -400° TRB-2, -150°
1153	TRB-1, -390° steady
1162	PO-D dropped to zero on motor start
1173	TRB-2 warming up a little
1180	TLDH, -210°
1190	PO-D, 0 psi
1192	I(m) went to 200 suddenly
1196	TRB-2 warming up fast
1201	hydrogen alarm on #8
1205	SCRAM
1213	SW #20, center; SW #8, center
1223	vent PAL, PRL
1239	SW #44, center
1248	SW #38, up
1251	SW #40, up
1255	SW #39, center
1360	SW #46, center
1375	SW #45, center