TID/SNA--~~XXXXXXXXXX~~
1815

~~XXXXXXXXXX~~

AEROJET-GENERAL CORPORATION

SACRAMENTO

•

CALIFORNIA

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TID/SNA - ~~1887~~ 1815

LRP #24

SNP-1SA3 CONTRACT

MASTER

MONTHLY LETTER REPORT

JUNE 1963

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

M E M O R A N D U M

8 July 1963
JVD:ljb

TO: W. L. Wheeler (25)

FROM: J. J. Peterson

SUBJECT: SNP-1SA3 Contract Monthly Letter Report for the
Period 27 May 1963 through 26 June 1963

DISTRIBUTION: Azusa: G L Ryland (5), D L Dewing (10 of Enclosure 2)

Sacto: R M Beattie, G Birdsell, G A Boeck (2),
W J Caress (2), V H Chang, J V Danek, R R Downey,
O I Ford, M B Grossman, W H Haase, G S Kaveney (2),
I L Odgers, J E Ogden, P W Rowe, K F Royer,
L R Shirley, L A Shurley, J L Smith (2), J J Sogorka,
R R Stewart, L A Holcomb, H A Yee, 8200 File (2)

SNPO-C Rep: M M Carness

Enclosure: (1) NERVA LRP-24 Monthly Letter Report, June 1963
(2) NERVA Reliability and Quality Assurance Status Report,
June 1963
(3) NERVA PERT Computer Run, By Subtask*
(*To the Addressee Only)

1. Enclosure (1) is the monthly letter report describing LRP effort on AEC-NASA Contract SNP-1SA3 in June 1963. Work accomplished in this period and work planned for July are presented in this report.

2. Enclosure (2) is the NERVA Reliability and Quality Assurance Monthly Status Report for June 1963. This report is being submitted under separate cover.

3. Enclosure (3) is the NERVA PERT Computer Run, by Subtask, depicting status as of 31 June 1963.

J. J. Peterson, Manager
NERVA Rocket Operations
Liquid Rocket Plant

ENCLOSURE (1)

NERVA LRP-24 MONTHLY LETTER REPORT

JUNE 1963

I. INTRODUCTION

This is the twenty-fourth monthly letter report describing LRP effort on the NERVA engine development program. It is submitted in partial fulfillment of AEC-NASA Contract SNP-1SA3.

II. SUMMARY

This report describes the progress of work on the CY 1963 program. Major accomplishments during June were:

1. Completion and submittal of NCS-309, Information Concerning the Cryogenic Facility at NARF for Testing the Propellant Feed System.
2. Completion of NCS-308, Program Plan for NRX-A Nozzles with Area Ratio 4, to be submitted to REON early in July.

In response to the TWX, from W D Stinnett / D Holzman to J J Peterson, dated 24 May 1963, a monthly instrumentation procurement report is submitted under subtask 2.4 with this report.

For this month only, the hardware demand and test schedules are not included in the monthly report, as requested by TWX from J J Peterson to W D Stinnett, dated 29 April 1963. These will be submitted at the 11 July Management Review Meeting to prevent duplication of effort.

Other accomplishments during June are summarized by subtask on the following pages.

ITEM 1.1 - ENGINE SYSTEM

A. Accomplished in June

Engineering and Fabrication

All NRX gage and match plate drawings were released and fabrication has started.

A preliminary non nuclear NERVA development engine basic parts list and abbreviated assembly guide was prepared.

Drawings of the CFDTs unique hardware were nearly completed except for the turbine inlet line which must be redesigned for diluent ducting from the pressure vessel closure. Fabrication orders were issued for standard hardware for the thrust structure assembly.

The study of the assembly, handling, and transportation of the CFDTs continued.

The CFDTs instrumentation list neared completion.

Agreement was reached with REON on a conceptual design for the control drum actuators manifold.

The NRX-A1 test specification is 60% complete and is scheduled for transmittal 8 July.

The new NRX-A1 assembly drawing (no. 299066-9) is 90% complete.

Forty-nine vendor packaging instruction procedures were prepared.

B. Planned for July

1. Engineering

The NRX-A gage designs will be reviewed and modified, as required, for the NRX-A2 design. These changes will be incorporated in the existing gages.

Non-nuclear development engine definition and coordination efforts will be continued.

NERVA LRP-24
MONTHLY LETTER REPORT

CFDTS unique hardware drawings will be released and fabrication will be initiated. Conceptual design of the propellant supply line from H-5 test stand to the TSOV and the LRP instrumentation list are scheduled for completion.

A new schedule and PERT network of LRP effort will be initiated for NRX-A2 to reflect the change in the A2 test schedule per AGC report no. 2560.

Input to the NRX-A test specification will be completed and the specification will be released on 8 July for review by REON.

The conceptual design study of the LRP test facilities planned for the NRX-A2 cold flow test will be completed.

LRP mileposts, based on changes indicated in AGC report 2560, will be incorporated in the existing PERT network. Design layout and fabrication drawings of the NRX nozzle camera assembly, to be used during flow testing at NRDS, will be completed.

2. Fabrication

Fabrication of unique hardware will be initiated for the LRP cold flow acceptance testing of NRX-A2 non nuclear assembly and, in addition, for the new NRX-A1 requirement of a remote TV, camera, and light mounting hardware (for use at NRDS).

3. Testing

No testing is programmed under this subtask during July.

ITEM 1.2 - PROPELLANT FEED SYSTEM

A. Accomplished in June

1. Engineering

Work was started on 3 June on the redirected Mark IV, Mod 2 TPA design per NCS-307 (Provision for a "wet" TPA). The associated PFS interface control drawing was also redirected to the new configuration. The turbine exhaust line design change to eliminate choked flow condition must await the determination of a final turbine exhaust configuration.

A report was issued delineating the results of the preliminary pump suction line water flow tests. (M/P 1211152, Report #1244001)

A redesign of the turbine inlet line was started in compliance with REON PD 189A.

The TPA bearing test plan was completed.

Design coordination on C-7 and H-6 facility systems continued.

Preparation of TSOV and TPCV acceptance test specifications was started.

2. Fabrication

Fabrication of lines, disconnects, valves, and TPA's continued. Many valve component parts were completed. Fabrication of the TPA turbine for the Milepost endurance demonstration was started.

3. Testing

Disconnect and seal testing continued.

Valve seal testing continued.

One TPA and four bearing development tests were completed.

B. Planned for July

1. Engineering

Work on the Mark IV, Model 2 TPA design will continue, the design concept will be frozen. Mapping of TPA performance parameters will continue.

Design coordination with the Test Division on C-7 and H-6 will continue.

The TPCV acceptance test specification will be completed.

2. Fabrication

Fabrication of one prototype suction line, one each TSOV, TPCV, and RCDV, and four assemblies and/or reassemblies of TPA's are scheduled.

3. Testing

LH₂ TSOV testing will be initiated and TPCV and RCDV seal development testing will be continued.

TPA and bearing development testing will continue in accordance with the program test schedule.

ITEM 1.4 - THRUST CHAMBER ASSEMBLY

A. Accomplished in June

1. Engineering

Hot bleed nozzle detail and assembly drawings were completed. Higher priority work delayed completion of the hot bleed port firings report until next month.

Analysis of preliminary data from the proof test of NRX-A pressure vessel S/N 0000002 indicates that the test was successful in satisfying its three objectives of (1) demonstrating the ability of the pressure vessel to withstand room temperature proof pressure, (2) providing data on stresses and flange rotations, and (3) demonstrating the structural integrity of structural nozzle simulator S/N 001S.

Drawings were prepared for the fabrication of a nozzle for NRX-A1 incorporating three camera ports in the jacket for observing the bottom of the reactor during the cold flow test.

2. Fabrication

The manufacture of metallic seals to be used with the pressure vessel and nozzle was delayed by a problem in acquiring approval for rent-free use of government owned facilities.

Hot bleed nozzle S/N 0000010 was converted for use in NRX-A1 by incorporating three camera ports in the convergent section of the nozzles.

The U-tube nozzle jacket forging for nozzle S/N 0000008 was received oversize at Marquardt and is being machined to size. This excess of material will delay fabrication completion 3 to 5 weeks.

NERVA LRP-24
MONTHLY LETTER REPORT

Fabrication of the lower thrust structure, S/N 0000001, was completed; the part is now being instrumented for structural testing.

The pressure vessel for criticality studies at WANL are completed but shipment is being withheld pending purchase order approval by SNPO-C.

The Material Review Board accepted pressure vessel S/N 0000002 (following its successful hydrotest) for use on NRX-A1.

Reactor Backup Nozzle S/N 002L was completed, hydrotested, and shipped to the test area for simulation firing.

3. Testing

The hydrostatic proof test of pressure vessel S/N 0000002 was completed successfully.

An injector with steel face plates was tested and severe face plate erosion occurred in the outermost channels.

Reactor Backup Nozzle S/N 002L was installed in the test stand in preparation for simulation firing.

B. Planned for July

1. Engineering

A feasibility study for cryogenic testing of pressure vessel seals will be completed.

2. Fabrication

The first set of pressure vessel metallic seals will be shipped from the vendor.

The jacket for hybrid nozzle S/N 001H will be cast at Howard Foundry.

NRX-A nozzle S/N 0000004 will be completed, and the jacket of three more NRX-A nozzles will be cast.

3. Testing

Four tests of reactor backup nozzle S/N 002L are planned at various chamber pressures to check heat transfer data and to demonstrate the structural integrity of the nozzle jacket.

The titanium pressure vessel will be hydrotested.

ITEM 1.5 - ENGINE CONTROLS

A. Accomplished in June

Engineering

Rough drafts of harness schematics and harness design requirements were completed.

Preliminary system integration studies and design concepts were completed.

A thermal analysis of a quartz insulated cable assembly was completed.

B. Planned for July

Engineering

Vendor capability study and harness design requirements will be completed.

ITEM 1.7 - PNEUMATIC SYSTEM

A. Accomplished in June

Engineering

Design study layouts and system schematic work continued on CFDTs and E engines.

Specification control drawings for the 1/2-in. and 1 1/4-in. filter, 3/4-in. regulator, and relief valve were released.

Specification control drawings for shutoff and check valves were sent to vendors for quotation.

B. Planned for July

Engineering

Design studies and system sizing and layouts will continue. CFDTs detail drawings will be started.

A relief valve specification will be released and a burst diaphragm specification completed.

Vendor quotations will be requested on filters, the regulator, and relief valves.

ITEM 1.9 - RADIATION EFFECTS

A. Accomplished in June

1. Engineering

Engineering design of the mechanical and electrical irradiation test pallets and fixtures for CY 1963 tests was continued.

The design of the GD/FW electrical system is complete.

The preliminary test plans for the control pallet, MIT #903, and MIT #905 have been completed and are being reproduced for transmittal to REON.

The preparation of preliminary test specifications for MIT #903 and #905 was continued.

The preliminary test specification for MIT #902 has been completed.

The EIT #501 system drawings were updated and the EIT #502 electrical schematic drawings were completed.

Preliminary design information was received from sub-subtask 2.4.3 for EIT #503.

Close liaison with GD/FW was maintained on the gas distribution system installation and the pre-checkout of MIT #901.

2. Fabrication

Long lead procurement for MIT #904, #906, and #910 continued.

Fabrication of EIT #501 is approximately 60% complete and fabrication of MIT #903 and #905 is approximately 15% complete.

Fabrication of EIT #502 was initiated.

3. Testing

The pre-irradiation checkout at GD/FW of MIT #901 is in process. Proof tests and leak checks of the gas distribution system at GD/FW were completed.

B. Planned for July

1. Engineering

The preliminary test plans for the control pallet, MIT #903, and MIT #905 will be transmitted to REON.

Detail design of the mechanical and electrical test systems will continue. Design of MIT #902 will be completed. The preliminary test specifications for MIT #903 and MIT #905 will be completed and transmitted to REON.

Liaison with GD/FW will continue.

EIT #501 final test specifications will be prepared and submitted to REON.

All EIT #502 drawings will be released and the EIT #503 design layout drawing will be completed.

The preliminary design layout for EIT #504 will be started.

2. Fabrication

Long lead procurement and fabrication for all CY 1963 mechanical and electrical pallets will continue.

EIT #501 fabrication will be completed.

EIT #502 fabrication will be continued.

Fabrication of the modification kit for MIT #902 will be completed.

3. Testing

Proof testing and leak checking of the LH₂ system at GD/FW will be completed.

MIT #901 will be tested at GD/FW.

The EIT #501 tests will be conducted at LRP cryogenics laboratory.

ITEM 2.1 - REMOTE HANDLING EQUIPMENT

A. Accomplished in June

1. NRX

Design effort on item N-23 (tool kit, rocket engine disassembly - remote) was discontinued.

Materials for item N-211 (fixture, lifting, rocket engine, forward closure - remote) have been ordered.

All Preliminary Performance Specifications for NRX remote handling equipment have been completed.

A preliminary study of the remote handling portion of the NRX-A2 operational support plan was started.

2. "E" Engine Equipment

Work was performed on preliminary flow diagrams in agreement with REON Report 2520.

B. Planned for July

1. NRX

Analysis for the remote handling portion of the NRX-A2 operational support plan will continue.

Interface control drawings for NRX GSE will be initiated.

2. "E" Engine Equipment

No further effort is planned on E-engine GSE support.

ITEM 2.2 - GROUND SUPPORT EQUIPMENT (CHECKOUT AND TEST SYSTEM)

A. Accomplished in June

1. NRX

Completion of fabrication of item N-430 is scheduled for 5 July.

Preliminary performance specifications for NRX checkout and test support equipment were completed.

2. "E" Engine Equipment

Systems engineering analysis of Block I, engine support equipment requirements continued.

B. Planned for July

1. NRX

An interface control drawing for NRX GSE will be initiated.

Proof testing and development of items N-430 and N-431 will be started.

2. "E" Engine Equipment

No further effort is planned on E-engine GSE support.

ITEM 2.3 - GROUND SUPPORT EQUIPMENT (HANDLING AND MAINTENANCE)

A. Accomplished in June

Engineering and fabrication effort is proceeding on all NRX GSE items. Items N-917 and N-918 were received.

Revisions to the support equipment plan based on revised NRX-A1 hardware flow and assembly procedures were initiated.

Preliminary performance specifications for the NRX support equipment were completed.

B. Planned for July

Revisions to the NRX-A1 support equipment plan and provisioning data list will be completed.

The NRX Block I support equipment plan and provisioning data sheets will be initiated.

Receipt of NRX GSE items N-801, N-803, N-914, N-915, and N-916 is scheduled to begin.

An interface control drawing for NRX GSE will be initiated.

ITEM 2.4 - INSTRUMENTATION

A. Accomplished in June

1. Engineering

Specification control drawings (SCD) were updated to incorporate the latest environmental requirements for the NRX-A-1 cold flow engine.

A tungsten-rhenium thermocouple was designed for the NRX-A-2 hot flow engine.

Input for the July quarterly revision to the NERVA instrumentation data book was prepared and submitted to REON.

Several design studies were performed which included a port adapter for the LASL NRX-A thrust chamber simulator furnace, a new cryostat for precise calibration of temperature sensors in the liquid hydrogen range, a temperature gradient analysis for the EIT-502 cryostat, and piezoelectric accelerometer shielding calculations.

Development of a miniature temperature sensor for cryogenic applications is in process.

2. Fabrication

Required material was ordered for tungsten-rhenium thermocouple fabrication.

Instrumentation components were ordered for the MIT #903, #904, #905, and two control pallets.

Miniature temperature sensors were ordered for evaluation.

Acceptance testing of EIT #501 and #502 instrumentation components is in process.

3. Testing

Evaluation vibration tests were performed on pressure transducers for the NRX-A-1 CF engine.

Evaluation testing of platinum resistance temperature sensors is in process.

B. Planned for July

1. Engineering

Preparation of design criteria, developmental plans, and specifications will continue in all areas of instrumentation development not yet completed.

Monthly data book input will be prepared.

2. Fabrication

Procurement of instrumentation components will continue for the NRX-A1 and NRX-A2 engines, special evaluation units, the EIT, and the MIT programs.

Fabrication of two RTT calibration sets will be completed, and eight tungsten-rhenium thermocouples will be built for evaluation at LASL.

3. Testing

Evaluation and acceptance testing of instrumentation components will continue as required.

INSTRUMENTATION HARDWARE STATUS REPORT FOR NRX-A-1

<u>Part Name/ Type</u>	<u>Use</u>	<u>Purchase Order Number</u>	<u>Spec. Number</u>	<u>Quantity Ordered Per Item</u>	<u>Estimated Unit Cost Per Item</u>	<u>Data Sheet # in Inst. Data Book</u>	<u>In Plant</u>
Transducer Press. Absolute	NRX-A-1 Cat. "B"	AE 174319	298973	24	695.00	P-51	21
Transducer Press. Diff. (Pm)	NRX-A-1 Cat. "B"	"	298951	6	865.00	P-53	6
Transducer Press. Diff. (Pm)	NRX-A-1 Cat. "B"	"	298953	6	865.00	P-53	2
Swivel Nut, Tee	NRX-A-1 Cat. "B"	A 176140		50	1.79		25
Cap Nut	NRX-A-1 Cat. "B"	"		50	0.44		25
Swivel Nut, Run Tee	NRX-A-1 Cat. "B"	"		25	0.25		25
Tubing 1/4" Cres. 304	NRX-A Cat. "B"	A 263005	MIL-T-8504	1000 ft.	per ft. .0521		1030 ft.
RTT - Plat. Res. Rosemount 134 EB	NRX-A Cat. "B"	A 176152		22	390.00	TT-51	22
T.C. Wire CEI-316-CT	NRX-A Cat. "B"	A 175363		120 ft.	per ft. 2.07	T-53	120 ft.
T.C. Wire CEI-316-DT	NRX-A Cat. "B"	"		1470 ft.	per ft. 2.07	T-51	1470 ft.
Accelerometer Clevite #25D21-X	NRX-A Cat. "E"	A 176159		24	470.00	G-54	24

INSTRUMENTATION HARDWARE STATUS REPORT FOR NRX-A-1

<u>Part Name/ Type</u>	<u>Use</u>	<u>Purchase Order Number</u>	<u>Spec. Number</u>	<u>Quantity Ordered Per Item</u>	<u>Estimated Unit Cost Per Item</u>	<u>Data Sheet # in Inst. Data Book</u>	<u>In Plant</u>
Transducer Dummy	NRX-A Cat. "B"	A 176126		27	125.00		27
Clamp	NRX-A Cat. "B"	A 265055	MS9025- 17	100	1.00		100
"	NRX-A Cat. "B"	"	MS9025- 03	100	1.00		100
Seal "K" 12100-PG-4	NRX-A Cat. "B"	A 265070		51	3.40		51
Cable 6/c Radiation Resist	NRX-A Cat. "B"	A 178682		1140 ft.	per ft. 7.00		1140 ft.
Cable 4/c Radiation Resist	NRX-A Cat. "B"	"		180 ft.	per ft. 6.00		180 ft.
Cable 2/c Radiation Resist	NRX-A Cat. "B"	"		280 ft.	per ft. 5.00		280 ft.
Thermocouple #T5283 - Rev. "B"	NRX-A Cat. "E"	A 177312		6	1915.00	T-54	0
Thermocouple #T5340	NRX-A Cat. "B"	"		12	1287.00	T-52	0
Strain Gages	NRX-A Cat. "A"	A 177327	248477	200	10.80	SS-53	20
Strain Gages	NRX-A Cat. "B"	A 180617	248476	64	34.00	SS-52	35

INSTRUMENTATION HARDWARE STATUS REPORT FOR NRX-A-1

<u>Part Name/ Type</u>	<u>Use</u>	<u>Purchase Order Number</u>	<u>Spec. Number</u>	<u>Quantity Ordered Per Item</u>	<u>Estimated Unit Cost Per Item</u>	<u>Data Sheet # in Inst. Data Book</u>	<u>In Plant</u>
Strain Gages	NRX-A Cat. "B"	A 180617	248475	128	23.50	SS-51	37
Connectors	NRX-A Cat. "E"	A 271444		5	17.00		5
"	NRX-A Cat. "E"	"		5	25.10		5
Connectors	NRX-A Cat. "E"	E 326605	AGC 235779-E	71	12.00		71
"	NRX-A Cat. "F"	"	AGC 235774-B	22	12.00		22
"	NRX-A Cat. "E"	"	AGC 235734-B	34	12.00		34
"	NRX-A Cat. "E"	"	AGC 235739-C	5	12.00		5
Thermocouple Probe (Electro- West)	NRX-A Cat. "F"	E 327080	AGC 248998	9	103.50	Not Assigned	0
Cable 4/c Radiation Resist	NRX-A Cat. "E"	A 180631		1500 ft.	per ft. 6.00		0
Transducer Press. Diff.	NRX-A Cat. "E"	A 180646		15	865.00		0
Transducer Press. Diff.	NRX-A Cat. "E"	"		6	865.00		0
130FJ Rev. "A" RTT Probe	NRX-A Cat. "E"	A 180645		7	846.00	TT-56	0

ITEM 4 - PROGRAM MANAGEMENT

A. ITEM 4.1 - PERT

1. Accomplished in June

All NCS-305, Revised CY 1963 Cost Study, LRP PERT networks for individual subtasks were reviewed and updated to reflect negotiated changes. The networks were run on the NASA PERT Program as an integrated LRP NERVA PERT program.

A new reporting technique involving information submittal directly from performing departments rather than from cognizant departments was initiated and a change control as it effects program plans is being prepared.

Two coordination meetings were held between REON and LRP personnel for the following purposes:

- a. Review and coordination of NCS-305 PERT networks.
- b. Improvement of the reporting system.

PERT biweekly reports were prepared and submitted to REON.

2. Planned for July

As a part of NCS-306, CY 1964 Cost Study, REON PERT demand charts will be reviewed.

New LRP PERT networks will be prepared and submitted to REON.

PERT input cards will be completed and a complete PERT computer run will be submitted to REON.

PERT biweekly reports will be prepared and submitted to REON.

B. ITEM 4.2 - FISCAL CONTROL

1. Accomplished in June

The computer programs used in the preparation of the budget variance report have been modified to attain greater efficiency. More detailed reports can be generated at 75% of the original cost.

2. Planned for July

Fiscal data for NCS-306 will be prepared for submittal to REON in accordance with REON PD 198.

Modifications will be incorporated into the budget preparation computer program to allow open commitments and incurred costs to be reported at desired levels.

C. ITEM 4.3 - TECHNICAL REPORTS

1. Accomplished in June

Work was started on NCS-308, Program Plan for NRX-A Nozzles With Area Ratio 4.

NCS-309, Information Concerning the Cryogenic Facility at NARF for Testing the Propellant Feed System, was prepared and submitted to REON.

In response to REON PD 177, the second monthly document listing report covering the SNP-1 contract period from program inception (11 July 1961) to 31 May 1963 was prepared and submitted to REON.

LRP NERVA weekly reports, biweekly PERT reports, and the monthly letter report were prepared and submitted to REON. A monthly Reliability and Quality Assurance Status Report, prepared by subtask 2.6, was assembled and submitted to REON.

A NERVA movie strip covering significant activities during the period of January through May was submitted to REON.

2. Planned for July

NCS-308, Program Plan for NRX-A Nozzles With Area Ratio 4, will be completed and submitted to REON.

NCS-311, Program Plan for Final CY 1963 Effort, will be completed and submitted to REON.

NERVA LRP-24
MONTHLY LETTER REPORT

Major emphasis will be placed on preparation and assembly of NCS-306, CY 1964 Cost Study, to be submitted to REON before the end of July.

LRP weekly reports, biweekly PERT reports, the monthly letter, and a NERVA movie strip will be prepared and submitted to REON.

D. ITEM 4.4 - CENTRAL DATA SYSTEM

1. Accomplished in June

Engineering documentation including drawing lists, drawing number control reports, and WANL specifications received from REON were distributed.

2. Planned for July

LRP PD 59E, Revised NERVA Engineering Data and Documentation Requirements, will be issued and implemented.

ITEM 5 - SPECIAL TEST EQUIPMENT

A. ITEM 5.1 - LRP (TEST ZONE "C")

1. Accomplished in June

Specifications and contract drawings covering the installation of the TSOV vessel and related piping were completed. Formal contractor quotations were requested during the latter part of the month. Included in the installation will be the relocation and extension of the test stand C-7 flare stack over to test stand C-6. This is being done to avoid the possibility of exhaust flame damage to C-6 during high pressure TPA testing on test stand C-7.

Design criteria for the installation of the test stand C-6 supersonic diffuser were prepared and transmitted to AETRON for final design preparation. Actual stand installation of the diffuser has been deferred until the early part of 1964 because of the revised testing program.

2. Planned for July

Bids will be received, evaluated, and awarded for the TSOV installation with active contractor work starting shortly afterwards.

B. ITEM 5.2 - LRP CRYOGENICS LABORATORY (TEST ZONE "A")

1. Accomplished in June

Bids covering the fabrication and installation of LN_2 transfer piping systems were received and means of securing additional contract funds were reviewed. With the securing of the required funding, contract award will be completed shortly. Completion of the contract is expected 90 days after award.

2. Planned for July

Procurement of the hydrogen leak measurement apparatus will be

initiated upon completion of review of design criteria by cognizant laboratory personnel.

C. ITEM 5.3 - LRP (TEST ZONE "H")

1. Accomplished in June

All necessary pieces of vacuum insulated piping were received in test zone "H", allowing on-stand piping installation work to proceed.

Effort was expended in the preparation of contractor-activation procedures. The work encompassed by the activation bid package was presented to the contractor for his price determination.

Completion of contractor-activation of test stands H-4, 5, & 6 is presently scheduled for 16 August. Activation by AGC personnel will be completed 16 September for TPA testing on test stand H-6.

Aetron began redesign of the hot hydrogen heat exchanger, as required by recently-imposed fabrication requirements of NASA. As directed by SNPO-C, the high temperature heater section must be redesigned to conform to latest ASME code requirements. It is not anticipated that the proposed delivery date of 15 November will be affected at this time.

Contractor fabrication of the ejector system for test stand H-3 was completed and preparations were made for shipment to AGC-LRP on 1 July.

2. Planned for July

Construction and fabrication efforts will be continued in test zone H. Both mechanical and electrical work will be actively pursued towards the scheduled activation date.

D. ITEM 5.8 - LRP (BUILDING 3308 - TEMPERATURE LABORATORY)

1. Accomplished during June

A decision was reached regarding the fabrication and procurement of the LH_2 -Neon cryogenic temperature calibration facility. Detailed design work and specification preparation has been initiated, and necessary items will be procured from outside vendors. Overall unit fabrication will be completed by LRP. It is expected that nine months will be required to complete the cryostat.

2. Planned for July

Design, procurement, and fabrication efforts will be continued.

E. ITEM 5.9 - LRP - CONTROLS AND CHEMICAL LAB (BUILDING 2002)

1. Accomplished during June

Design work associated with the special vibration equipment for TCA testing was completed. The control console and data acquisition system are essentially complete.

2. Planned for July

Installation of the vibration equipment will be completed during the early part of July (for vibration testing of the TCA under subtask 1.4).

III. DETAILED DISCUSSION

ITEM 1.1 - ENGINE SYSTEM

A. ITEM 1.1.0 - SYSTEM

1. Accomplished in June

Engineering and Fabrication

The following mileposts were completed or rescheduled.

Event No. 1101-450 (Complete the preliminary design and layout of the drum actuator manifold) was completed 4 June and submitted to REON.

Event No. 1101-475 (Start finalization of the preliminary design of the manifold) scheduled to start 4 June was rescheduled for 8 July, assuming an LRP-REON design review and agreement has been reached at that date.

Effort during the report period included the following:

a. Non-Nuclear E-Engine

Monitoring of the subsystem design and development efforts was continued. Liaison with engineers of subtasks 1.2, 1.4, 1.5, 1.7, and 2.4 resulted in establishment of the tentative configuration to be used for completing event no. 1101-465 (Non-nuclear, hot bleed, Block I E-Engine layout). Tentatively, the configuration will reflect the MK IV Mod 2 TPA, Mod 2B TSOV, aluminum cast hot bleed nozzle with 3-2 pass bolted skirt, plenum source cooled turbine inlet line to TPCV, a titanium pressure vessel, and the latest upper and lower thrust structure. Associated conceptual instrumentation will be shown and PFS configuration V pilot and cup flanges will be utilized.

NERVA LRP-24
MONTHLY LETTER REPORT

A preliminary assembly guide (abridged) for the NERVA E-Engine, based on LRP layout dwg. no. 284768, was prepared and transmitted informally to REON the first week of June. This effort is in partial support of event no. 1101-345, for the preparation of a remote assembly-disassembly procedure.

A preliminary NERVA development engine basic parts list was prepared in support of event no. 1101-485. Since its suitability for anything other than planning and costing is nebulous at this time, it is being withheld and will not be disseminated until it has been checked further and agrees with the August 1963 NERVA development engine.

b. NRX Gages

Fabrication of match plates T-603093A and T-603094A, as well as master gages T-603316A, T-603317A, and T-603318A was started.

Design drawings of LRP master gages T-603329 and T-603330 were completed and released. Transparencies of each design were sent to REON.

A fabrication request was initiated for LRP master gages T-603329 and T-603330.

A tool design revision request was issued for match plates T-603093A and T-603094A, as well as for master gages T-603316A, and T-603317A. Revisions are required due to a revision on the NRX-A pressure vessel.

c. Packaging and Materials Handling Engineering

A total of forty-two vendor packaging instructions which

NERVA LRP-24
MONTHLY LETTER REPORT

delineate methods and materials for the packaging of NERVA components purchased from outside sources was generated. A total of one hundred-nineteen component drawings was reviewed for the purpose of preparing definitive preservation and packaging instructions for components fabricated and processed in-plant. A complete analysis covering all stages of fabrication, handling, processing, and storage of the NRX-A chamber for the purpose of developing proper handling instructions was initiated and completed during the report period. As a result of the analysis, design was initiated and completed for one set of internal protective plugs, one set of external chamber covers, and a storage and shipping container. Additionally, all tooling and similar devices were analyzed for potential causes of hardware damage. Recommendations for the addition of pads were submitted and implemented.

2. Planned for July

Engineering and Fabrication

a. Non-Nuclear E-Engine

Event No. 1101-475 will be started on 8 July and work will continue on events nos. 1101-465, 1101-345, and 1101-485.

b. NRX Gages

Fabrication will continue on watch plates T-603093C, T-603094C as well as master gages T-603316B, T-603317D, and T-603318A.

Fabrication of master gages T-603329 and T-603330 will be started.

Inspection procedures for master gages T-603329 and T-603330 will be prepared and released to Q.C. and planning.

c. Packaging and Materials Handling Engineering

Reviewal of component designs and preparation of vendor packaging instructions will continue.

B. ITEM 1.1.2 - COLD FLOW DEVELOPMENT TLST SYSTEM

1. Accomplished in June
Engineering

Unique hardware drawings were nearly finished except for the turbine inlet line which must be redesigned for diluent extraction from the pressure vessel closure. Fabrication orders were issued for seals, couplings, and bellows for the thrust structure assembly.

Study of the assembly handling and transportation of the CFDTs continued.

Environmental vibration criteria for transducers were received from REON. The WANL instrumentation requirements were not finalized between WANL and REON, consequently, the LRP instrumentation list could not be finalized.

Work continued on the revision to the preliminary test plan.

The conceptual design of the control drum actuators manifold and closure instrumentation interface was presented to REON. Agreement was reached on a manifold concept. The acceptability of the instrumentation interface proposal rests upon further study of the feasibility of having electrical connectors within the reactor pressure vessel.

The design of the mechanical interface between the upper thrust

structure and the H-5 test stand was resumed only briefly before higher priority work interfered.

The conceptual design of the propellant supply line from the H-5 stand to the TSOV was studied again. It does not appear that the ideal solution is to have two Petter flowmeters in series to provide redundancy while covering the high and low flow ranges of interest.

2. Planned for July

Engineering

Drawings of unique hardware will be released and fabrication orders will be issued, except for the turbine-inlet line, (because of the diluent line change) and the mechanical interface between the upper thrust structure and the H-5 test stand.

The study of the assembly, handling, and transportation of the CFDTs will continue.

The LRP instrumentation list will be finalized if agreement can be reached on the requirements between WANL, REON, and LRP.

Work will continue on the revision of the preliminary test plan.

The instrumentation interface conceptual study will continue with special attention given to the feasibility of having electrical connectors within the reactor pressure vessel.

The conceptual design of the propellant supply line from the H-5 stand to the TSOV will be completed.

C. ITEM 1.1.6 - ENGINE SYSTEM ANALYSIS

1. Accomplished in June

Engineering

The programing on the data reduction package for the CFDTs was

completed and check out was started on 28 June. This package has been in work since 15 May and completion is expected by 7 July.

Modifications started in May to the heat transfer programs (8006 and 8015, old 806-LR) were completed; including axial conduction, internal heat generation, and compatibility with the data reduction package.

Work on the updating of the steady state analytical model continued with the addition of more exact models for the hot bleed port nozzle tubes.

Pre-test analyses were performed for the NRX-A1, CFDTS, and NRX-A2 in-house cold flow test systems.

A revised program plan, including new mileposts, was prepared and submitted.

2. Planned for July

Engineering

Emphasis in July will be placed on the completion and improvement of the CFDTS data analysis computer package. Modifications will also be started to make this program compatible with the NRX-A1 test data. Analytical support work will also be performed for CFDTS, NRX-A1, NRX-A2, and other programs.

Changes will be made in analytical models for both the hot bleed port and steady state computer programs, making them faster and more accurate. The new 8015 program (heat transfer model for reflector, shield, and core) will be completed and integration into the steady state engine model will begin. Modification of both 8015 and 8006 computer programs will be started to make them more useful in the two phase region.

Pneumatic transient analysis and accuracy improvements in the transient pump and turbine computer program will begin in July.

D. ITEM 1.1.7 - INTERFACE MOCKUPS

1. Accomplished in June

Engineering

Design of the closure-to-manifold and manifold-to-actuators interface mockups was not started due to a schedule slippage of REON layouts.

Final issue of the test plan for the pressure vessel closure interface mockup was postponed until July due to the addition of a pressure vessel shear lip design.

2. Planned for July

Engineering

Design of the closure-to-manifold and manifold-to-actuators interface mockups will commence upon receipt of REON layouts.

The test plan and test request for the pressure vessel closure interface mockups will be completed.

E. ITEM 1.1.8 - NRX-A INTEGRATION AND DOCUMENTATION

1. Accomplished in June

a. Engineering

The NRX-A1 test specification is 60% complete and is scheduled for transmittal to REON on 8 July.

The NRX-A1 structural acceptance test was deleted from the program because the new window nozzle will be completed in fabrication after the pressure vessel has been shipped to NRDS. A revised NRX-A1 Acceptance Test Plan will be prepared.

The new NRX-A1 assembly drawing (no. 299066-9) is 90% complete.

NERVA LRP-24
MONTHLY LETTER REPORT

Due to problem areas mentioned in the last monthly report, and in a TWX (dated 13 June, from J. J. Peterson to W. D. Stinnett) LRP will ship NRX-A1 components on the following dates:

- (1) P.V. cylinder, 1 August
- (2) P.V. closure, 15 August
- (3) Nozzle, propellant feed line, and instrumentation -
15 September

The conceptual design for NRX-A2 LRP cold flow test facilities has been completed.

Due to the change in the NRX-A2 schedule, the LRP cold flow acceptance test plan will not be completed until the next report period.

Due to the change in the NRX-A1 program concerning shipment of hardware, the following activities are no longer required in the PLRT system:

- (1) 1181-210 Start and complete NRX-A1
- (2) 1181-220 engine assembly at LRP.
- (3) 1181-180 Complete NRX-A1 Assy-Disassy Procedure

Events (1) and (2) may be removed due to shipping instructions transmitted by a TWX, dated 13 June 1963, from J. J. Peterson to W. D. Stinnett, subj. "Shipment of NRX-A1 Components".

Event (3) is no longer required due to the inclusion of the procedure in the NRX-A1 Test Specification.

The following events are related to the NRX-A2 and A3 units:

- (1) NRX-A2
 - (a) 1181-350 Start and Complete NRX-A2 Preliminary
1181-380 Assy-Disassy Procedure.

NERVA LRP-24
MONTHLY LETTER REPORT

- (b) 1181-390 Start and Complete NRX-A2 Final
1181-435 Assy-Disassy Procedures.
- (c) 1181-135 Start and Complete NRX-A2
1181-170 Test Specification.
- (d) 1181-140 Start NRX-A2 Test Plan.
- (2) NRX-A3
 - (a) 1181-400 Start Preliminary Assy-Disassy Procedure.
 - (b) 1181-405 Start NRX-A3 Test Plan.
 - (c) 1181-410 Start NRX-A3 Test Specification.
 - (d) 1181-415 Start NRX-A3 Parts List

These mileposts are presently undergoing reevaluation based on the schedule changes indicated in AGC Report 2560. It is anticipated that a revised schedule will be available in the next monthly report.

A new NRX-A2 schedule and PLRT network has been initiated.

b. Fabrication

Fabrication orders were initiated on long lead items for unique hardware for the NRX-A2 LRP cold flow acceptance test.

c. Testing

No testing was performed.

2. Planned for July

a. Engineering

The following items will be completed in July:

- (1) The NRX-A2 LRP cold flow acceptance test plan
- (2) NRX-A1 test specification
- (3) Reviewal of all NRX-A1 packaging and shipping requirements

NERVA LRP-24
MONTHLY LETTER REPORT

- (4) The required integration meetings for final NRX-A1 test specification coordination
- (5) The NRX-A2 test plan
- (6) The NRX-A2 schedule and PERT network (and transmittal of these items to REON)
- (7) The NRX-A2 assembly drawing and parts list
- (8) The detail fabrication and assembly drawing of NRX-A2 unique hardware for the LRP cold flow test
- (9) NRX-A1 acceptance test plans

b. Fabrication

Fabrication of all the NRX-A2 unique hardware for LRP's cold flow test will be initiated.

ITEM 1.2 - PROPELLANT FEED SYSTEM

A. ITEM 1.2.0 - SYSTEM ASSEMBLY

1. Accomplished in June

a. Engineering

The installation and interface control layout of the Mark IV TPA in the lower thrust structure was redirected to the Mark IV, Mod 2 TPA configuration upon customer acceptance of NCS-307. Completion was rescheduled to July.

Propellant inlet system design coordination for test stand C-7 has been completed; H-6 design coordination continues.

The NARF propellant feed system mechanical interface control drawing was started.

Sketches were completed presenting machining details, materials, proof pressures, proof temperatures, AGC part numbers, and vendor part numbers for the twenty-two remote conoseal joints in the propellant feed system.

Due to a lack of interest by the Gamah Corp., they will be eliminated as a backup to the Marman remote disconnects for the propellant feed system.

b. Fabrication

A 5-inch Marman remote joint test cell, representative of a pump discharge flange, was received.

The delivery of the Marman disconnect test cells for development testing has slipped to 23 July.

Fabrication orders were placed for Marman disconnect test cells for a 12 inch suction line flange, a five inch discharge line flange and a four inch turbine inlet line flange.

c. Testing

A 1500 psig hydrostatic proof test was successfully performed on the five inch Marman remote joint.

2. Planned for July

a. Engineering

The Mark IV, Mod 2 TPA installation and interface drawing will be completed and a current propellant feed system layout will be initiated.

Design coordination with the Liquid Rocket Plant Test Division will continue for the H-6 test stand propellant system.

The NARF propellant feed system mechanical interface control drawing will be completed.

b. Fabrication

Procurement of remote disconnects will continue.

c. Testing

Testing of Marman remote joint test cells will be continued and testing of Marman remote disconnect test cells will be initiated.

B. ITEM 1.2.1 - LINES AND DISCONNECTS

1. Accomplished in June

a. Engineering

CFDTS line drawings are being updated for release in July.

Analyses were started on the turbine inlet line redesign in compliance with REON PD-189A.

A report was issued on the results of the preliminary pump suction line water flow test. (M/P 1211152, Report #1244001)

b. Fabrication

Fabrication of the prototype pump suction line and the TPA test lines continued.

Fabrication of the component development turbine inlet lines was stopped pending completion of the turbine inlet line redesign requested by REON.

2. Planned for July

a. Engineering

The CFDTs line drawings will be released for fabrication.

Design analyses of the new turbine inlet line will be completed.

Redesign of the Mark IV TPA turbine exhaust line will be completed.

b. Fabrication

Fabrication of one prototype pump suction line will be completed.

Fabrication of TPA test lines will continue.

C. ITEM 1.2.2 - VALVES

1. Accomplished in June

a. Engineering

(1) Tank Shutoff Valve

In addition to the source control drawing of the Configuration II TSOV with a double seal with bellows shutoff seal design, now being prepared, a shutoff seal design incorporating the features of the flexible disc used on the cooldown valve is being prepared.

A specification is being prepared to outline the method for installing solid silver inserts into the valve body. The specification will be called out on the TSOVPV body print. Development testing has proven the solid silver

seats superior to the silver brazed or stainless seats.

Preparation of a TSOV acceptance test specification was started.

(2) Turbine Power Control Valve

Investigation of the indentation found in the body bore following the TPCV leak tests revealed that a significant thrust loading along the shaft axis occurs with a differential pressure across the gate in the closed position. As a result of this disclosure, the axle housing of the body will be redesigned to provide a thrust bearing to absorb the thrust normally transmitted to the body bore.

Preparation of the TPCV acceptance test specification was started.

(3) Reactor Cooldown Valve

REON has advised that the only power available on the NERVA engine for the CDV actuator will be 22 to 31 volt d-c and single phase 115 volt a-c of an unknown frequency. Based on this, a d-c hermetically sealed unit will be used as the primary configuration for the CDV. Prior to the purchase of future units, the specification will be revised incorporating this change.

b. Fabrication

(1) Tank Shutoff Valve

The first Configuration II TSOV kit is complete, except for the valve body, which is scheduled to arrive by 18 July. It was previously scheduled for completion in June, but had to be returned for rework.

NERVA LRP-24
MONTHLY LETTER REPORT

Four 347 CRES and four 17-4DH CRES rings were received and are being processed through receiving inspection. These rings will be used to fabricate seals and seats for Configuration I TSOV seal testing, which has seals identical to the Configuration II TSOV primary seals.

The TSOVPV solenoids from the G. W. Lisk Company are being processed through receiving inspection. Units from Allen Engineering and Anderson Controls were also ordered.

Eight TSOV disconnect actuator air motors were ordered from the ARO Corporation.

Two air motors sent back for rework were received from DK Products Inc. These units are presently being processed through receiving inspection.

The first of the TSOV potentiometers ordered to specification no. AGC 42233 and drawing no. 268951 will be received in September.

(2) Turbine Power Control Valve

The bore of the second stainless steel Configuration II TPCV body was chrome plated.

Fabrication of the first Inconel-X Configuration II TPCV kits continues.

Fabrication of the TPCV piston ring test fixture was completed. This fixture is being used to evaluate the effect of high temperature upon the spring characteristics of the TPCV piston rings.

(3) Reactor Cooldown Valve

Fabrication of the first CDV is complete except for the body, which is to be available next month.

Three stainless steel seats were fabricated for the initial CDV kits. These seals replace the aluminum seats originally ordered for the CDV kits.

The three phase a-c CDV motors ordered from Consolidated Controls Corp. are presently undergoing receiving inspection. Since three phase a-c power is no longer available, these units will be used primarily for valve development, however, limited evaluation will be performed.

The first of the CDV potentiometers ordered to specification no. AGC 42228 and drawing no. 268399 are scheduled for delivery in August.

(4) Propellant Feed System Check Valves

Three 2-inch purge check valves are on order from Consolidated Controls Corp. These are scheduled for delivery in August.

Five 5-inch discharge line check valves are on order from H. W. Loud Machine Works Inc. These are scheduled for delivery in September.

c. Testing

(1) Tank Shutoff Valve

One tank shutoff valve pilot valve with a solid silver insert seat underwent a 7000 cycle endurance test. Gaseous-helium 250-psig leak tests were conducted after every 500 cycles. The functional cycles were conducted at +160°F, -320°F and ambient temperature. Leakage during the ambient and high temperature cycles averaged less than one cc/min past either the supply or vent seats. Leakage during the

liquid nitrogen tests averaged 13 cc/min and 1.7 cc/min past the supply and vent seats, respectively.

A Configuration I TSOV was assembled, acceptance tested, and shipped to the Cryogenics Laboratory where it will undergo liquid hydrogen tests.

(2) Turbine Power Control Valve

Two TPCV piston rings fabricated from Hastelloy C were installed in the piston ring test fixture and placed in a 1400°F oven for five minutes. The piston rings were dimensionally inspected before installation and after removal from the test fixture. There was no evidence of any loss in spring rate or permanent deformation due to the elevated temperature.

The stainless steel Configuration II turbine power control valve with the chromium carbide coated bore underwent ambient temperature internal leakage tests. The valve gate was cycled open and closed 800 times. Leakage past the piston rings with 25 psig gaseous nitrogen applied to the inlet averaged 2.1 scfm during the test.

The valve was disassembled and a sealing compound was applied to the sides of the piston rings, limiting leakage to that which occurs between the piston ring and the body bore. The leak test was repeated. Leakage decreased to 1.5 scfm gaseous nitrogen.

The valve was disassembled and visually inspected. The shaft hub of the gate had caused some indentations on

the body bore although the chromium carbide coating was not broken.

(3) Reactor Cooldown Valve

The CDV test cell incorporating a stainless steel seat and primary seal was subjected to a liquid hydrogen leak check at the Cryogenics Laboratory. Prior to liquid hydrogen testing, a 50-psig ambient-temperature gaseous-helium leak test was conducted to demonstrate the bubble-tight seal of the primary poppet seal. The test cell was purged with warm dry gaseous nitrogen for two hours. Liquid hydrogen was then bled into the test cell until the temperature had stabilized at -420°F . The inlet pressure was raised to 20 psig with the poppet in the closed position. The primary seal remained bubble-tight throughout the test.

The 50-psig gaseous-helium leak test was repeated after the test cell had warmed to ambient temperature. The primary poppet seal remained bubble tight.

A stainless steel poppet seal and seat underwent a functional and leak test using the CDV test cell. The test was conducted using gaseous helium cooled to liquid nitrogen temperature. Fifty psig leak tests were conducted at various intervals during the 370 poppet actuations of the test cell. Leakage averaged less than 2 cc/min during the ten leak tests conducted. Previous tests showed the seal to be bubble tight at ambient temperature.

Inspection of the seat and seal following the test

disclosed no deterioration of either the seat or seal. Analysis of test results is continuing.

A position indicating potentiometer from Maurey Instruments Corp. was evaluated for use in the CDV. The potentiometer met specification requirements except for discontinuity during vibration in the frequency range of 120 to 140 cps at 10 g's and loss of the voltage trace during -302°F tests. The vendor will be informed of this deficiency so that corrective action can be taken.

Potentiometers from two other vendors have previously completed the preradiation evaluation tests satisfactorily.

Testing of the Globe d-c units revealed a wide variation in torque-current requirements, which indicates a degradation of gear box materials.

2. Planned for July

a. Engineering

Drawings of the TSOV Configuration II bellows type seal and flexible disc type seal will be released.

The solid silver insert installation specification on the TSOVPV will be completed.

The TPCV acceptance test specification will be completed.

b. Fabrication

The valve body will be received from the Fabrication Department for completion of the initial Configuration II TSOV kit.

The initial Configuration II TPCV kit will be received from the Fabrication Department.

NERVA LRP-24
MONTHLY LETTER REPORT

The initial CDV kit will be received from the Fabrication Department.

c. Testing

Liquid hydrogen testing of the Configuration I TSOV will be initiated.

Configuration II TPCV development testing will continue.

Testing of primary and secondary poppet seals with the CDV test cell will be continued.

D. ITEM: 1.2.3 - TURBOPUMP ASSEMBLY

1. Accomplished in June

a. Engineering

The design engineering effort on the Mark IV turbopump was redirected to conceptual design activity on the new wet feasibility Mod 2 concept. The Mark IV, Mod 2 concept includes provisions for a lift-off seal in the power transmission at the turbine interface and dual fluid seals on all external joints. The concepts that will meet the Mod 2 design objectives neared completion. The effects of the redirection were discussed at a recent meeting, and the following new milestone schedule was formulated:

<u>Mark IV Mod 2 Major Mileposts</u>	<u>Completion Date</u>
Preliminary Design Concept	8 July 1963
Final Conceptual Layout	8 August 1963
Last Detail Fabrication Drawing	
Released	22 October 1963
Assemble 1st TPA	8 April 1964
Testing Initiated	22 April 1964

NERVA LRP-24
MONTHLY LETTER REPORT

The basic test plan (memo 9646:0073) was brought up to date in amendments published during this report period. Test plan memo 9636:0100, dated 4 June 1963, detailed the new requirements evolving from the 2nd stage nozzle failure, which occurred during hot gas test 1.2-08-NNP-002. The memo also outlines interface definition and points out differences between turbopumps assigned to be tested in C-7 and the new H-6 facility. The second test plan memo 9636:0111, dated 14 June, outlined the necessary changes in design and testing that have resulted from the 2nd stage turbine rotor damage that occurred during 1.2-08-NNP-003. The basic test plan memo revision to include these and other considerations in carrying out the development of the NERVA TPA neared completion.

A bearing test plan (LRP No. 001) was completed. The first and backup choices of bearings for demonstration of the contract year mileposts were selected and presented in this test plan.

Also completed was a preliminary specification (Memo 9636:0121) which delineated turbopump assembly inspection instruction, disassembly inspection instruction, "new hardware" component dimensional record, and "final hardware" component dimensional records. Work progressed on other preliminary specifications concerning test procedures and instrumentation requirements, as they are applied to the development of the NERVA TPA.

Liaison, future planning, and review of test facility designs for future test activity on H-6 have continued. Recent changes in development plans and objectives have been integrated into the test facility requirements.

The specification and specification control drawing for the P/N 286627 turbine speed sensor were submitted to various vendors with requests for quotations.

b. Fabrication

Turbopump S/N 0000006 was reassembled to the same configuration (278000-89) as was tested on run 1.2-08-NNP-003 and was installed in test stand C-7. This second assembly required replacement of the second stage nozzle.

Assembly of TPA S/N 0000005 to P/N 278000-79) neared completion. This TPA employs the pinned 2nd stage nozzle, integral labyrinth, and Armalon bearing cages in all positions. Balancing operations have been completed and final assembly is continuing on the unit.

The second stage turbine nozzle configuration for use in the CY63 milepost endurance demonstration was selected and fabrication of two parts was commenced. A part machined from one piece of D-979 material will be used. As well as providing a part without braze or weld joints, this part will provide design data on the workability of D-979 which will be valuable in the Mark IV design. To maintain test schedules while continuing the development, interim nozzles are being reworked from existing hardware.

Interim turbine configurations in work are as follows:

- (1) Brazed-in configuration with the integral labyrinth which was tested successfully under conditions duplicating those which caused failure on S/N 0000007 (rework from MK III, Mod 1 third stage nozzles).

(2) Another configuration identical to that discussed in (1) above, except for a ring welded in place for the labyrinth (to permit salvage from MK III, Mod 3 initial parts prior to the failure during test 1.2-08-NNP-002). These parts were analyzed to be of the same integrity, once successfully fabricated.

(3) A two-piece design similar to the present concepts, but having the shroud ring welded in place by the electron beam process to permit salvage of parts unsuccessfully brazed. This configuration was found necessary due to the scrap rate of the brazed configurations (approximately 50%).

Fabrication of the second refined bearing tester, S/N 0000004, was completed and will be assembled with bearings of Milepost Choice #1 per LRP Test Plan #001.

Forgings for the redesigned pump impeller of the Mark IV Mod 2 configuration were ordered.

c. Testing

<u>Tests Conducted</u>	<u>This Period</u>	<u>CY 63 To Date</u>
Turbopump Development Tests	1	26
Bearing Development Tests	4	52

(Bearing Tester)

TPA test 1.2-08-NNP-003 (hot gas drive) was successfully accomplished on 6 June for a total duration of 71.4 seconds. The object of this test was to evaluate the turbine under hot turbine conditions, and this objective was satisfied. Post test disassembly revealed some melting of the leading edge near the tip of the second stage rotor buckets. Memo 9636:0119, dated

20 June, outlines preliminary test results, explores possible causes, and delineates test setup modifications to prevent a recurrence. These changes include addition of a plenum mixing chamber in the gas generation system and inclusion of an O₂ line purge to ensure elimination of any shutdown temperature spikes.

These necessary gas generation system changes have prompted gas generation system checkout testing. Two tests were conducted. The first was accomplished on 19 June with satisfactory steady state performance, but a temperature spike occurred at shutdown. The gas generation fuel manifold cover developed a crack during the test and the unit required replacement. The second gas generator checkout test was accomplished on 21 June without a temperature spike. On this test injector erosion occurred, and the unit was replaced. This second unit was slightly longer between the injector and the turbulence ring.

TPA testing will be resumed using the gas generator configuration of the first checkout test and the O₂ line purge of the second test.

Three bearing tests (1.2-04-NNW-016, -017, and -018) were conducted in the turbine tester during this report period. The first was aborted due to LH₂ line contamination from the test stand. The second was performed to evaluate a new ITI close clearance thrust bearing geometry with an Armalloy thin-line cage. Post test inspection of the bearing after 8.2 minutes of operation at 2000 pound load showed inner race distress due to a brittle fracture at the ball rolling track.

NERVA LRP-24
MONTHLY LETTER REPORT

The third test was performed primarily to evaluate a 16-roller thin-line Armalon caged roller bearing for the turbine end position. After 9.0 minutes of operation at 2000 lb load and 16,000 rpm, this bearing remained in excellent condition. The development of non-metallic caged roller bearings was previously considered very difficult due to low cage strength at the thin sections between the rollers. A 14-roller bearing with a similar Armalon thin-line cage was run in the slave (unloaded) position of this third test. The cage pockets of this bearing were moderately burned, and the surfaces of the rollers had a dull blue-stained appearance while the rollers of the loaded 16-roller bearing were bright. This indicates that an unloaded condition may be more severe than one with a 2000 lb load.

The electric motor tester was run at 3000 rpm for one minute in the Cryolab as a checkout of the electrical power supply system. Flow tests were made on the pneumatic bearing loading system. Difficulties in the pneumatic bearing loading encountered during this test are being defined and corrected prior to high speed testing.

The second stage turbine nozzle damaged in TPA S/N 0000006 during test 1.2-08-NNP-003 (Reference Memo 9636:0111) and the new nozzle installed in S/N 0000006 for test 1.2-08-NNP-004 were statically tested to 122% of the FX force. The room temperature-to-1800°R 0.2% offset yield stress ratio of the material (A-286) is 1.22.

d. Support

Nine specimens were forwarded to Azusa for stress-rupture tests of D979 alloy. A report was written covering the tensile test results of D979 alloy at room temperature, 500°F, 1150°F, 1350°F, 1550°F, and 1750°F.

Final machining of D979 alloy dilatometer specimens has been completed and expansion measurements will be started as soon as the dilatometer is in working order.

Stress-rupture testing of D979 specimens at Azusa is in progress.

Chemical analysis of the D979 alloy material is in progress.

2. Planned for July

a. Engineering

Design activity on the Mark IV, Mod 2 TPA will continue. The design concepts of this configuration will be finalized on 8 July and preparation of detail fabrication drawings will be started. Mapping of the basic pump and turbine performance parameters will continue.

Design coordination and liaison with the Test Division on the conversion of test stand C-7 will continue.

Vendor proposals for the P/N 286627 turbine speed sensor will be received and evaluated.

b. Fabrication

Four TPA's are scheduled to be reassembled and/or assembled. TPA S/N's 0000005, C6, and C7 are programmed to be used in the endurance studies. TPA S/N 0000008 is a gutted unit that is to be used for mock-up in test stand M-6. TPA S/N 000.004 parts

NERVA LRP-24
MONTHLY LETTER REPORT

will be used to reassemble S/N 0000003 for use in the C-7 unbled start and system NPSP tests. S/N 0000004 flanges were designed to fit the E-engine and H-6 which are different than the C-7 interfaces.

c. Testing

Hot gas testing will be continued on C-7 with emphasis on turbine endurance demonstration. Test stand conversion of C-7 will begin during July with scheduled down time of one month.

d. Support

A report will be issued covering the tensile test results of D979 alloy specimens.

Stress-rupture tests of D979 alloy specimens at Azusa will continue. Chemical analysis of D979 alloy material will continue. Expansion measurement of D979 alloy specimens will be started.

ITEM 1.4 - THRUST CHAMBER ASSEMBLY

A. ITEM 1.4.0 - ASSEMBLY

1. Accomplished in June

a. Engineering

A feasibility study for cryogenic seal testing in support of the NRX-A program was initiated. Coordination on the ambient temperature gas seal test program continued.

Based upon program management direction the TCA dynamic test has been postponed until the next contract year, however, planning will continue as required.

b. Fabrication

The first set of metallic seals has been inspected and will soon be plated. Delay in completion was primarily due to late confirmation of approval by SNPO-C of rent free use of government owned vendor facilities.

Materials for the mass core simulator for the TCA dynamic test were received and the fabrication was initiated.

c. Testing

No testing was performed.

d. Support

A rubber water bag and wood collar to take up pressure vessel internal volume during ambient temperature metallic seal helium leakage tests were designed and released for fabrication. The specification for these tests has been written and is ready for final typing.

In preparation for the TCA dynamic test the preliminary design of the low frequency drive unit and the final design of

the pressure vessel tooling and air bag are complete. Due to program slippage, work has been discontinued until the next contract year.

Dynamic analyses in support of the thrust structure resonance survey and the TCA dynamic test program are in progress.

2. Planned for July

a. Engineering

The cryogenic pressure vessel seal testing feasibility study is to be completed, establishing the general test setup, the basic method of leak detection, the type of test fluid, and the probable location for performing the tests. A preliminary test plan will be prepared in order to define hardware, tooling, facilities and instrumentation requirements, and the associated costs of the performing the tests.

Project coordination with the structures test laboratory will be provided on the ambient gas seal testing. Results of the initial tests planned will be evaluated.

b. Fabrication

The first sets of metallic seals are to be received and fabrication on additional sets will continue.

Fabrication of the mass core simulator will be completed.

c. Testing

Metallic seals tests are scheduled for July (see item d, Support).

d. Support

Test tooling for the ambient temperature metallic seals gaseous leakage tests will be completed. The test specification

will be completed and published.

One set of three seals each for the nozzle and forward closure ends of the pressure vessel will be tested for leakage with gaseous helium using pressure vessel S/N 0000002 and structural nozzle S/N 0000003.

B. ITEM 1.4.1 - NOZZLE AND EXTENSION (BOTH CYCLES)

1. Accomplished in June

a. Engineering

All assembly and detail drawings of the nozzle and hot bleed port have been completed. An analysis for determining chamber pressure, flow rates and mixture ratio for simulation of the part at reactor conditions have been completed. The final report for the six hot bleed port firings conducted earlier in this contract year utilizing the Titan modified XLR87 hardware was delayed by higher priority work. It is now complete and will be published next month.

Coordination of fabrication, brazing techniques, and tooling for the U-tube nozzle was accomplished. A brazing test sample was completed and is awaiting end closures (which are in fabrication). After the end closures are installed, the test sample will be subjected to proof and leak test and then to a failure test.

The finalized heat transfer report on the nozzle skirt is complete and in rough draft form; accompanying charts and figures are in progress. The final design report has been held up due to a re-design of several components of the skirt assembly. The initial reinforcing rings were shown to be inadequate and have since been redesigned with a larger cross-sectional area.

Drawings on the skirt-diffuser adapter were released on all final assembly components. All dynamic and stress analyses have been completed and design modifications have been made accordingly.

A flange heating study and a hydraulic analysis have been completed and are available in report form.

Drawings were made to convert the steel face injector S/N 241 to copper face plates and copper baffles. These drawings convert the injector to the same general configuration as the KIWI-B injector, S/N 1482.

b. Fabrication

Hot bleed nozzle S/N 0000010 has been converted to a NRX-A camera port chamber for the NRX-A1 cold flow test. All tubes for the hot bleed nozzles have been returned to the vendor for reworking the tube to aft adapter weld joint.

The Marquardt Corporation is progressing on the machining of the U-tube nozzle forging. AGC is scheduled to receive a forging from General Metals the first week in July. The machine for machining grooves in the forging is being shipped 24 June from the Downey plant; samples have been machined satisfactory.

All flanges for the nozzle-skirt joint have been first-cut machined.

Adapter S/N 001K was completed and assembled with the S/N 002L nozzle test assembly. Fabrication of adapter S/N 001N was completed but leaks were discovered during the proof and leak tests between the aluminum jacket and the adapter to injector flange. Action to locate and repair leaks has been

NERVA LRP-24
MONTHLY LETTER REPORT

initiated. Adapter S/N 002N will be completed except for installation of the overboard dump torus at the end of this report period. Adapter S/N 003N has undergone the first braze cycle and is presently waiting for rework of hydro tooling to proof and leak test the tube bundle. Adapter S/N 004N tube bundle is laid and is waiting for Pc tube holes to be drilled. The shop load is causing the completion date of this part to slip.

All parts for the skirt diffuser are on order; tooling has been ordered and will arrive on schedule.

Injector S/N 0241 with steel face plates is 90% completed. All final machining has been completed with the exception of drilling the orifice patterns. This injector will be converted to copper face plates. Installation of all weldable components for injectors S/A 0242 and 0260 have been started; these injectors are approximately 60% completed.

Completion of the fourth thrust support structure scheduled for this report period is rescheduled for 20 July because of the excessive shop load.

c. Testing

Injector S/N 0112 which was modified to incorporate an orifice pattern having a uniform mixture ratio distribution across the face of the injector was tested. This injector employed stainless steel face plates with like-on-like double rows of impinging orifice pairs for both the fuel and oxidizer pattern.

Post fire inspection revealed severe injector face plate erosion in the outermost channels.

NERVA LRP-24
MONTHLY LETTER REPORT

In light of the fact that this is the second time stainless steel face plates have eroded during the injector development program, it has been decided to convert all injectors which will be needed during this contract year to copper face plates and copper baffles.

d. Support

Stress analysis indicated the initial band reinforcement designs on the nozzle, skirt, and skirt extension to be inadequate. The bands have since been resized to obtain sufficient structural integrity. Stress analyses of the U-tube nozzle for chemical and nuclear firings are 70% complete. No work on the hot bleed nozzle for nuclear firing was accomplished during June due to the need for additional heat transfer data.

Application engineering assisted in the engineering evaluation of the jacket for NRX-A chamber 004, cast on 29 May. The scope of work included a review of X-ray films and results of chemical tests obtained during melt down at the foundry. The results of this evaluation, combined with information supplied by the materials laboratory concerning the mechanical properties of test coupons obtained from the jacket, formed the basis of Flash Report 63-279. This report recommended stopping work on the next scheduled jacket until the foundry problems encountered on NRX-A 004 are solved.

A review was made on the casting history of all jackets produced to date and the information was summarized for presentation to the customer.

A considerable increase in engineering input and coordination

NERVA LRP-24
MONTHLY LETTER REPORT

between this department and the AGC foundry has been directed as part of the work assigned the NERVA task force in resolving problems associated with the cast jacket program.

2. Planned for July

a. Engineering

Engineering will be devoted primarily to drawing maintenance and fabrication coordination for all hardware items of this subtask.

The heat transfer report for the nozzle skirt will be made available and the final design report will be completed. Design modifications will be completed and will be incorporated during fabrication.

b. Fabrication

Tubes for the first hot bleed nozzle (S/N 0000011) will be delivered to AGC during the second half of July.

Machining of the AGC U-tube nozzle forging will be initiated; component parts are being fabricated to the last incorporated change.

All parts for the nozzle skirt are on order and tube layup is expected in mid July if vendor delivery dates are adhered to. All tooling is on schedule.

Effort to locate and repair leaks in S/N 001N adapter will be accomplished; S/N 002N adapter will be completed. Casting of aluminum jacket of S/N 003N is scheduled at the AGC Foundry late in this period, and brazing and installation of lock wires in S/N 004N will be accomplished.

Tube layup for the skirt-diffuser adapter will begin near the end of the July report period.

Injector S/N 0241 will be converted to copper face plates and baffles. Injector S/N 0112, which was tested during June, will also be converted to copper face plates and baffles. Injectors S/N 0242 and 0260 will be 70% completed.

The fourth thrust support structure unit will be completed during this report period.

c. Testing

No hot bleed port nozzles are scheduled for testing during the current contract year. Also, no further injector development tests will be conducted during the current contract year.

d. Support

Upon receipt of temperature data, the NERVA nozzle will be analyzed for the nuclear firing condition and stress analysis on the U-tube nozzle will be continued.

C. ITEM 1.4.2 - THRUST STRUCTURE & GIMBAL

1. Accomplished in June

a. Engineering

Due to slippage of the estimated fabrication completion date of thrust structure assemblies S/N 0000006 and S/N 0000008, assembly S/N 0000001 will be modified for use in the initial phases of the TPA test. Redesign necessary for this modification has been initiated and will be completed by 5 July.

Lower thrust structure assembly drawings have been reviewed for ease of fabrication; necessary changes to these drawings are being made.

Layout of the electrical connector interface flange for the upper thrust structure (S/N 0000008) has been completed.

NERVA LRP-24
MONTHLY LETTER REPORT

b. Fabrication

Fabrication of the lower thrust structure assembly (S/N 0000001) is complete, and the unit is presently being tested.

Fabrication is continuing on the remaining upper and lower thrust structure assemblies for this contract year. Due to a design change in the gimbal housing, fabrication has been delayed and completion dates have been revised as follows:

<u>Use</u>	<u>P/N</u>	<u>S/N</u>	<u>Est. Completion Date</u>
<u>UTS</u>			
Comp. Devel.	296954	000007	4 October 1963
TPA	280200-19	000006	1 October 1963
CFDTS	296954	000008	20 November 1963
<u>LTS</u>			
Comp. Devel.	298223	000002	2 October 1963
TPA	291655	000008	27 September 1963
CFDTS	298223	000003	28 November 1963

Fabrication of the dummy gimbal actuators is continuing with an estimated fabrication completion date of 15 August.

The gimbal housing fairings for use on the TPA, TCA dynamics test, and CFDTS assembly are continuing in fabrication and the estimated fabrication completion date for this hardware is 1 August.

The upper and lower gimbal housing assemblies for use on the C-8 propellant feed system test is expected to be available in September.

Completion of the first gimbal on 15 June was not accomplished

because of shop load. All O. P. parts required for assembly of the first units are available with the exception of some bolts which were returned to the vendor for rework.

c. Testing

No tests were conducted.

d. Support

All tooling and instrumentation for the resonance survey of thrust structure assembly (S/N 0000001) has been completed and checked out. The reaction mass baseplate has been installed and grouted in place. The instrumentation assembly has been checked out and calibrated. The redirection of thrust structure S/N 0000001 to TPA testing has necessitated a rescheduling of the resonance survey to November. All work will stop on this test setup by 3 July.

The test specification was issued for the static structural test of lower thrust structure S/N 0000001 (Report No. 748N-TP). The test specification report was completed and is in final typing for the static structural test of the upper thrust structure S/N 0000001 (Report No. 749N-TP). Dimensional measurements were made of both the upper and lower thrust structures. All test tooling designs for thrust structure static tests were completed and all items of tooling were in fabrication.

The following thrust structure test tooling items were received:

- (1) T-417187 - Test Fixture

- (2) T-417192 - Gimbal Simulator
- (3) T-417193 - Pressure Vessel Closure Simulator
- (4) T-417198 - Gimbal Loading Fixtures (less load cell calibration adapters)
- (5) T-417200 - Gimbal Actuator Support Loading Fixtures (less jack pads)
- (6) T-417201 - Clamp, PV-LTS

Stress analysis of the RIFT joint was completed. All analyses of the thrust structure and gimbal, accomplished after the publication of the Phase II structural analysis report, have been revised to reflect current design criteria and structural loads. Expected strains, rotations, and deflections for the lower thrust structure tests have been provided.

Application engineering meetings were conducted with the design engineers to discuss the fabrication procedures and needed tooling to produce NERVA thrust structures P/N 280210, 280200, 298223, and 298954. The method of fabricating, welding, sizing, and repairing of these parts was outlined.

C. Planned for July

a. Engineering

Detail drawings of the electrical connector interface flange for the upper thrust structure (for use on the CFETS) will be completed.

The design will be completed and drawings will be released for attaching the lower thrust structure cylinder to S/N 0000008, presently being fabricated. Attachment of a cylinder to this unit will allow structural testing prior to use on the TPA test.

b. Fabrication

Fabrication of all upper and lower thrust structure assembly hardware will continue. Modification of lower thrust structure S/N 0000001, to permit use of this unit on the TPA test, will be initiated.

Assembly of the first gimbal will be completed and completion of units 2 and 3 will be delayed until 7 August and 7 September because of a heavy shop load.

c. Testing

Static testing of the lower thrust structure S/N 0000001 will be initiated and completed as noted in item d, Support. It is planned to complete all test objectives; however, if test objectives are not accomplished on schedule, the test will be discontinued in order to allow sufficient time for thrust structure modification prior to delivery for the TPA test. Static testing of the upper thrust structure assembly (S/N 0000001) will be initiated during the fourth week of July as reported in item d, Support.

d. Support

All work will stop on the thrust structure resonance survey on 3 July 1963. The test specification document will be completed by that date and published by 8 July 1963.

The test specifications for the upper thrust structure static test will be published (Report No. 749N-TP) and fabrication will be completed on all thrust structure test tooling.

Static structural testing of the lower thrust structure will be performed (test 748N) and the test of the upper thrust structure will be initiated (test no. 749N).

D. ITEM 1.4.3 - PRESSURE VESSEL

1. Accomplished in June

a. Engineering

The NRX-A2 interface control drawing was checked for discrepancies and comments were forwarded to REON. Work on the hydrotest assembly drawing for vendor acceptance proof testing was discontinued in favor of a test plan which has been initiated.

Analysis of preliminary data from test 808N, the instrumented proof test of pressure vessel S/N 0000002, is in process. Preliminary evaluation indicates that the test was successful in satisfying its three primary objectives of (1) demonstrating the ability of the pressure vessel to withstand room temperature proof pressure, (2) providing information on flange deflections and rotations and stresses in areas computed to have minimum margins of safety, and (3) demonstrating the ability of the structural nozzle simulator, S/N 0000001S, to withstand a proof pressure.

Revision B of the program plan for the titanium pressure vessel test was completed and project coordination with the test laboratory was continued.

b. Fabrication

Following the successful hydrotest and subsequent X-ray and liquid penetrant check of NRX-A pressure vessel S/N 0000002, it was tentatively accepted by the Material Review Board. However, final acceptance is withheld pending successful repair by the vendor of through wall liquid penetrant indications in two closure instrumentation ports.

NERVA LRP-24
MONTHLY LETTER REPORT

Fabrication of criticality pressure vessel S/N 0000001 was completed. The vessel is awaiting shipment pending SNPO-C action on approval of rent-free use of government owned vendor facilities.

Fabrication of pressure vessels S/N 0000003 and S/N 0000004 is in process. Closures for both assemblies are being machined and girth weld #1 on the cylinder of S/N 0000003 has been completed. The cylinder for S/N 0000002 is awaiting welding.

The shear lip of structural nozzle S/N 0000001 was modified to permit mating with the titanium pressure vessel and an "O" ring groove was machined.

c. Testing

Test 808N, the instrumented hydrostatic proof test of pressure vessel S/N 0000002, was completed. (See Support, item d.)

d. Support

The NRX-A pressure vessel, S/N 0000002, was successfully tested to 100% of laboratory ambient temperature proof pressure (test no. 808N).

The test specification for the hydrostatic pressure test of NERVA pressure vessel, PV 001T, was published (Report No. 280N-TP). All tooling required for the hydrostatic pressure test of PV 001T was completed and on-hand. Tooling required for applying an 81.5 kip axial tension load to the PV 001T pressure vessel was designed, and drawings were sent out for fabrication cost estimates. The PV 001T pressure vessel was instrumented in preparation for the hydrostatic pressure test (test no. 280N).

Stress analysis of the aluminum pressure vessel test assembly for the proof pressure condition was completed and assistance

NERVA LRP-24
MONTHLY LETTER REPORT

was provided during the test. Test data is being reduced and evaluated.

2. Planned for July

a. Engineering

Analysis of test results from test 808N will be completed and a report will be initiated.

Project coordination of the titanium pressure vessel structural development program will continue. Results of the hydrostatic tests will be analyzed as data are available.

b. Fabrication

Repair of the closure instrumentation ports of pressure vessel S/N 0000002 will be completed at the vendor's facilities. The unit will then be returned to LRP. The cylinder is to have four additional instrumentation holes machined for new NRX-A1 requirements.

Fabrication of pressure vessels S/N 0000003 and 0000004 will be continued. Fabrication of pressure vessel S/N 0000005 will be initiated.

c. Testing

The first three phases of test 280N on the titanium pressure vessel will be completed. (See item d, Support.)

d. Support

The hydrostatic pressure testing of the titanium pressure vessel will be performed. The test data report for the hydrostatic test of NRX-A pressure vessel S/N 0000002 will be completed and published.

Structural analysis of the titanium pressure vessel for the test 280N condition will be revised for the two pressure system.

E. ITEM: 1.4.5 - KIWI "B" & HYBRID NOZZLES

1. Accomplished in June

a. Engineering

Efforts were made to resolve the problem of choking of LH_2 flow through the adapter to injector flange into the overboard dump torus.

b. Fabrication

Hybrid nozzle S/N 001H was made ready for casting and was shipped to Howard Foundry during the second week of this report period.

The tube and chamber of adapter S/N 002K were proof and leak tested to determine if any leakage around the aluminum jacket occurred as in adapter S/N 001N. No leakage was found. Fabrication of this adapter is temporarily suspended due to excessive shop load.

c. Testing

No testing was scheduled.

d. Support

The failure investigation of KIWI "B" nozzle S/N 001K is complete except for final writeup. The definite cause of failure could not be determined; however, all but two possible causes can be judged invalid. The first possibility is that an instantaneous explosion occurred in the combustion chamber. The second, which is only valid for a brittle material, is that stresses (due to a thermal shock condition) and geometrical discontinuities combined with low stresses (due to internal pressure) to cause a condition which exceeded the fracture strength of the material. The

mechanical properties evaluation indicated the jacket to have a low average elongation of 1.65%.

2. Planned for July

a. Engineering

Effort will be directed toward design changes to improve LH_2 flow through the adapter to injector flange.

b. Fabrication

Nozzle S/N 001H will be cast at Howard Foundry. Nozzle S/N 002H will be installed on the casting fixture during the first week of this report period and during the second week this nozzle will be cast and radiographically inspected. The remainder of this report period will be spent on preliminary machining of the nozzle prior to heat treatment.

Rework of manifold bosses and installation of 90 degree tube bypasses to the overboard dump torres will be completed. Completion of this part is planned for August.

c. Testing

No testing is scheduled.

F. ITEM 1.4.6 - APPLIED RESEARCH PROGRAM

1. Accomplished in June

a. Cast Aluminum Jacket Development

The mechanical properties, chemistry, and microstructure of KIWI-B nozzle jacket, S/N 001K, were established. Results were reported in flash report 63-362 of 5 June 1963 and flash report 63-278 of 12 June 1963. Average room temperature properties were 29.2 ksi ultimate, 27.4 ksi 0.2% yield, and 1.65% elongation (in4D). Chemistry was found satisfactory except for high copper content.

NERVA LRP-24
MONTHLY LETTER REPORT

The tensile fractures were indicative of a low-toughness material. Undesirable properties are attributed to the coarse needle-like structure of the primary alpha phase in the matrix, gas-porosity, and microshrinkage cracks. Notched-tensile properties are being determined at room temperature and -320°F. Thermal shock characteristics of the cast A-256 alloy are being established.

The mechanical properties and complete chemistry of experimental test bars having four levels of magnesium, in section thicknesses of 1/4-, 1/2-, 1-, 2-, and 3-inch, have been determined. Micro-examination of 20 samples has been completed. Test results are being subjected to data reduction and are being cross-plotted versus magnesium levels. Increases in the magnesium content were found to generally increase the strength level of sodium inoculated samples, whereas the effect of ductility was found inconclusive due to the masking effects of casting defects. The investigation also revealed that samples inoculated with sodium generally had a smaller volume of the coarse needle-like alpha phase, however, the volume of alpha phase was found to increase with increasing section thickness for both non-inoculated and inoculated samples. The final report is being issued.

The mechanical properties of NRX-A nozzle S/N 0000004 were established. A final report was written and is being issued. Mechanical properties of reactor back-up S/N 002L nozzle flange material, heat-treated with the reactor back-up nozzle, were established and results were reported in flash report 63-372 of 6 June 1963. Analysis of NERVA nozzle S/N 001N cast aluminum alloy jacket microstructure was completed and results were reported

NERVA LRP-24
MONTHLY LETTER REPORT

in flash report 63-261 of 29 May 1963. The mechanical properties of the HYBRID I nozzle jacket, S/N 001H, were established. A final report was written and is being issued.

The mechanical properties of separately cast test bars produced by the Howard Foundry, Chicago, Ill., were established and the results were transmitted to the NERVA Project Group. The final report has been written and is being issued. The microstructure was also examined and found to consist of primary alpha phase and a sodium modified eutectic.

b. Braze Alloy Development

A tentative brazing procedure for the "U-Tube" nozzle design was prepared and presented to AGC personnel at Azusa on 14 June and to NACA personnel at Washington DC on 18 June. NIOBO (82% Au-18% Ni) 2T shear specimens were prepared and tested at room temperature. Parent metal failure occurred for all specimens.

Fabrication of the first simulated throat specimen A-1 (ref: flash report 63-210, dated 11 March 1963) was completed and submitted to the Hydro Lab for proof-testing. X-rays for this specimen were interpreted and standards are being developed.

c. TCA Materials Development

A report on the tensile testing of stainless maraging steel from Special Metals, Inc. is being written. The testing was previously reported.

A quotation was solicited from Voi-Shan Inc. for tensile specimens of cold drawn and aged Inconel 718 bolt material. Procurement was initiated and delivery is estimated at six weeks.

NERVA LRP-24
MONTHLY LETTER REPORT

A-286 bolt material received from Standard Pressed Steel was submitted to the Model Shop for machining of tensile specimens. Metallographic examination of this material was started.

d. Pressure Vessel Materials Development

Flash report 63-313 was issued covering tensile tests on specimens taken from a forward closure, several cylinders, and an aft-adapter of OOI TPV. A report is being issued covering tensile tests of 6AL-4V ELI titanium alloy forged plate at room temperature, -100°F, -320°F, and -423°F. Welding of the 6AL-4V ELI titanium alloy plates was completed.

2. Planned for July

a. Cast Aluminum Jacket Development

The KIWI-B nozzle jacket S/N OOLK failure analysis will be completed and a report will be issued. The final reports mentioned in the work for June will be issued. Metallurgical work in support of the NERVA Project Group will continue.

b. Braze Alloy Development

Specimens A-2, B-1, and C-1 are scheduled for completion.

c. TCA Materials Development

The report on the stainless maraging steel from Special Metals will be published.

A report on 18% Nickel maraging steel will be written as soon as the results of the tests at -423°F arrive from Azusa.

Testing of the A-286 bolt material from Standard Pressed Steel will be started as soon as the specimens are prepared. A-286 bolt material from Camcar Screw & Manufacturing Co. will be submitted to the Model Shop for machining into tensile specimens as soon as it is received.

d. Pressure Vessel Materials Development

Material from a welded titanium test ring will be submitted for pre-cracked impact tests.

A report will be issued on the tensile tests of 6AL-4V ELI titanium alloy specimens at room temperature, -100°F , -320°F , and -423°F . Heat-treating of the welded 6AL-4V ELI titanium alloy forged plate material, to obtain maximum crack-propagation resistance, will be started as soon as the optimum heat-treating cycle (stress relieving) has been established.

G. ITEM 1.4.7 - NRX-A AND REACTOR BACKUP NOZZLES

1. Accomplished in June

a. Engineering

NRX-A drawings were refined. Details were redimensioned to clarify callouts and further assure quality.

The NRX-A drawings were modified to build a nozzle for the NRX-A1 cold flow test which incorporates three camera windows. The drawing of the tube layup, with the holes cut and prior to casting, was released.

It was found that the tube vendor's weld joint between the coolant tube and the cast tube adapter was not adequate. More rigid controls over the welding procedure will eliminate the problem and more rigorous quality control will assure top quality. Effort was expended in resolving the problem (inadequate weld penetration) discovered in the coolant tube to tube adapter weld joint, although this joint has withstood the proof pressure on three NRX-A nozzles which have been brazed. This area will be reinforced by TIG brazing on tube bundles which are already brazed, and welding on

NERVA LRP-24
MONTHLY LETTER REPORT

tube bundles which are not. Tubes not yet laid up in a tube bundle were returned to the vendor.

Engineering surveillance of NRX-A nozzle fabrication processes has been continued on a round-the-clock basis.

Engineering effort on the reactor backup nozzle consisted of shop liaison, preparation of a test request, preparation of instrumentation drawings and calculation of a systems balance data for the coming reactor backup nozzle test.

Required drawing maintenance of the NRX-A propellant feed line was performed. Engineering and fabrication liaison was continued.

b. Fabrication

Five NRX-A nozzles are in fabrication. Two of these carry the highest priority in the Aerojet shop. Because of the request that a three-port nozzle be used for NRX-A1, nozzle S/N 0000010 (originally a hot-bleed nozzle) has been made an NRX-A nozzle. During the second week of June the holes were cut into the tube bundle. The bypass manifolds were then welded into the ports. The tubes were swaged to obtain the proper joint clearance for brazing and the nozzle was brazed. The cast aluminum jacket was poured on NRX-A nozzle S/N 0000004 during the last week of May. It was X-ray inspected and shows marked improvement over previous castings. Machining and drilling of the bolt coolant circuit are complete and bolt coolant manifold installation is presently in progress. Nozzle S/N 0000005 has been completed to the point of preparation for casting the jacket. The wire interlocks were brazed to nozzle S/N 0000006 during the first week of June. Following the inspections of this operation, the nozzle was leak

NERVA LRP-24
MONTHLY LETTER REPORT

checked in the hydrotest laboratory. Several leaks were noted, at present are the discrepant coolant tube to tube adapter weld joints. Premabrazed 250 is being TIG brazed to these areas.

Casting of reactor backup nozzle S/N 001L has been deferred until after the casting of nozzle S/N 0000010 at AGC and of nozzle S/N 001H at Howard Foundry.

Fabrication of reactor backup nozzle S/N 002L was completed. The nozzle, injector, and adapter were assembled into a test assembly, hydro tested, and delivered to the test area for testing.

NERVA nozzle S/N 001N has been cleaned, hydro tested, and shipped to Howard Foundry for casting.

Fabrication of the first NRX-A propellant feed line continued and is scheduled for completion 30 August.

c. Testing

The reactor backup nozzle S/N 002L test assembly was installed in the test stand and is being instrumented for a test firing scheduled to take place before the end of the month.

d. Support

An analysis of the NRX-A nozzle for the chemical firing conditions (except temperature effects) was completed.

2. Planned for July

a. Engineering

Final drawings on the three-port nozzle will be released. Close engineering followup in the shop will be maintained to assure top quality. Constant drawing maintenance will be continued on the NRX-A nozzle drawings. Weld procedures on the coolant tube-to-adapter joint will be improved to give a satisfactory weld. Round-the-clock engineering surveillance of all

NERVA LRP-24
MONTHLY LETTER REPORT

fabrication processes will be continued.

Engineering effort on the reactor backup nozzles will be devoted to test liaison, analyzing test data, and reporting test results on nozzle S/N 002L firing.

b. Fabrication

NRX-A nozzle S/N 0000.04 will be completed, so that it may be simulation fired, during the first week of August. This will require the elimination of the machining of some instrumentation bosses until after simulation firing. It will be heat treated by the first of July. NRX-A nozzle S/N 0000006 will be ready for casting of the aluminum jacket by the second week of July. During the first week of July, the wire interlocks will be attached to nozzle S/N 0000010. It will have the aluminum jacket casting completed during the third week and be preliminary machined by the end of the month.

The fuel inlet lines for the first NRX-A nozzle will be completed and the test assembly will be built up and delivered to the test area.

The decision as to where and when to cast nozzle S/N 001L will be made. This nozzle is currently available for casting of the aluminum jacket. This will be performed at AGC foundry during the last week of July.

Fabrication of NERVA nozzle S/N 001N will be limited to casting pattern preparation and activities associated with preparation of foundry facilities for casting the aluminum jacket on this nozzle.

c. Testing

Four tests on reactor backup nozzle S/N 002L are planned for July. Tests will be performed at various chamber pressures to check heat transfer data and determine the structural integrity of the nozzle.

ITEM 1.5 - ENGINE CONTROLS

A. ITEM 1.5.0 - CONTROLS SYSTEM

1. Accomplished in June

Liaison and technical management work was performed.

2. Planned for July

Liaison and technical management work will continue.

B. ITEM 1.5.4 - HARNESS

1. Accomplished in June

Engineering

The first rough drafts of the harness schematics were completed.

The rough drafts of the electrical harness design requirement sheets were completed.

Preliminary system integration study was completed.

The preliminary design concept of the engine harness was established. Discussion with 8200 (Projects) and REON will follow to obtain approval of the concept.

2. Planned for July

Engineering

The vendor capability study will be completed.

Electrical harness design requirement sheets will be continued.

Harness design studies, engine layout and schematic work will be continued.

A wiring diagram for CFDTs will be started.

ITEM 1.7 - PNEUMATIC SYSTEM

A. ITEM 1.7.0 - PNEUMATIC SYSTEM

1. Accomplished in June
Engineering

Discussions were held with L. Favero of REON to establish firm agreements on the pneumatic system schematics for engine blocks E-I, E-II, E-III, and FX. The discussed changes were made to the schematic drawings and the drawings are now in reproduction.

The duty cycle for the NERVA FX engine pneumatic system was received from REON. The gas flow rates are shown, but no time scale is defined.

The CFDTS lines were sized by first approximation methods. The lines were then resized based on experience, handling requirements, and standard tubing sizes of 321 stainless steel. The wall thickness of the tubing was calculated, based on a proof pressure of 2 x design pressure and burst pressure of 4 x design pressure (as is the standard design criteria of LRP for hydraulic or pneumatic system lines of less than 1 1/2-in. OD). All the wall thicknesses were increased to be compatible with tubing that is in stock.

From the CFDTS pneumatic system (PS) layout drawing line lengths were scaled and the system was sketched for calculating the state points at various locations in the system.

Review of PS component design criteria from REON was continued.

Survey of advanced valve technology was continued.

Filters were discussed with Mr. H. G. Preyer of Purelator Products Inc. on 18 June. He will send AGC an estimated cost for filters for the CFDTS. The vendor stated that the 10 micron size requirement,

which is a requirement imposed by REON design criteria, will be very difficult to attain.

2. Planned for July

Engineering

CFDTS state points will be calculated and line sizes will be checked for choked flow.

The survey and study of advanced valve technology will be continued.

Review of REON design criteria for the PS and components will be continued.

The system operating sequence for engine blocks E-I, E-II, E-III, and FX will be rewritten.

The system operating sequence and corrected schematics will be sent to REON.

B. ITEM 1.7.1 - PNEUMATIC SYSTEM LINES

1. Accomplished in June

Engineering

The layout drawing of the pneumatic system for the CFDTS is 90% complete. Specification of instrumentation requirements and selection of a back pressure regulator will permit completion of the layout drawings.

The layout of the pneumatic system for Block E-1 engine was initiated, but was stopped because the configuration of components such as TSOV, control drum actuator manifold, etc., have not been defined.

Design of the gland (seal area) of the test stand pneumatic connector has been initiated and should be complete early next month. This design and a component specification (being prepared) will be used to obtain vendor proposals.

2. Planned for July

The CFETS layout and start detail drawings will be completed.

The test stand pneumatic connector specification will be completed.

Preliminary layout of the storage tank will be started.

Work on the layout of a pneumatic system for the FX engine will be continued.

Hardware design and development program work will be continued.

C. ITEM 1.7.2 - PNEUMATIC SYSTEM VALVES

1. Accomplished in June

Engineering

Preparation of the burst diaphragm specification was initiated.

The relief valve specification is being released.

Preparation of specification control drawings continued. The following drawings were released:

<u>Drawing No.</u>	<u>Title</u>	<u>Classification</u>
291624	Filter, Fluid Pressure 1 1/4-inch tube	Confidential
291625	Filter, Fluid Pressure 1/2-inch tube	Confidential
298638	Regulator Fluid Pressure 3/4-inch	Confidential
298639	Valve, Relief, Pressure	Confidential

Further effort on the 2 1/2-in. regulator specification control drawing is delayed, pending additional design information from REON.

The specification and specification control drawing for the following components were sent to vendors, with requests for quotation:

a. 1/2-in. shutoff valve.

NERVA LRP-24
MONTHLY LITTER REPORT

- b. 3/4-in. shutoff valve.
- c. 3/4-in. check valve.
- d. 1 1/4-in. check valve.

2. Planned for July

Engineering

The relief valve specification will be released.

Preparation of the burst diaphragm specification will be completed.

Requests for quotation on the filters, regulator, and relief valve will be initiated.

ITEM 1.9 - RADIATION EFFECTS

A. ITEM 1.9.5 - LRP COMPONENT RADIATION EFFECTS

1. Accomplished in June

a. Engineering

Detail design of the Control Pallet, MIT #902, MIT #903, and #905 continued. Preliminary test plans for the control pallet, MIT #903, and #905 have been prepared, reviewed, and are being reproduced. The preliminary test specifications for MIT #903 and #905 are being reviewed. The preliminary test specification for MIT #902 has been completed.

Redesign of the Modification kit for MIT #902 continued.

Liaison with GD/FW for the checkout and installation of MIT #901 continued.

EIT #501 system drawings were updated.

EIT #502 electrical schematic drawings were completed.

EIT #503 preliminary design requirements were received from sub-subtask 2.4.3 and are being reviewed.

b. Fabrication

Long lead procurement and fabrication for all CY 1963 pallets and for MIT #905 and #906 continued.

Mating electrical connectors required at GD/FW for EIT #501 were shipped.

Fabrication of EIT #501 is approximately 60% complete.

Fabrication of EIT #502 was initiated.

c. Testing

The pre-irradiation checkout tests of MIT #901 are in progress.

2. Planned for July

a. Engineering

Liaison with GD/FW for the checkout, test, and post-irradiation inspections will continue. Redesign of the Modification kit for MIT #902 will be completed. Preliminary test plans for the control pallet, MIT #903, and #905 will be submitted to REON. Preparation of preliminary test specifications for MIT #903 and #905 will be completed and transmitted to REON. The preliminary test specification for MIT #902 will be submitted to REON. Detailed design of the control pallet and pallets for MIT #903 and #905 will continue.

EIT #501 final test specifications will be prepared and submitted to REON.

All EIT #502 drawings will be completed and released and the checkout test procedure will be written.

The design layout for EIT #503 will be completed and long lead parts will be ordered.

The preliminary design layout for EIT #504 will be started.

b. Fabrication

Long lead procurement and fabrication for all CY 1963 mechanical pallets will continue.

EIT #501 fabrication will be completed.

Fabrication of EIT #502 will be continued.

MIT #902 fabrication will be completed.

c. Testing

The irradiation test of MIT #901 will be completed.

The testing of MIT #501 will be conducted at the LRP Cryogenics Laboratory.

B. ITEM 1.9.7 - LRP RADIATION EFFECTS STE

1. Accomplished in June

a. Engineering

Liaison between GD/FW and LRP continued.

The design of the GD/FW gas distribution and electrical systems was completed.

b. Fabrication

The LH_2 piping, the two control racks for the gas distribution system, the Dewar, the electrical system, and the flex lines have been installed at GD/FW.

c. Testing

Checkout of the gas distribution and electrical systems was completed for MIT #901 tests. Inspection and tests revealed that improvements in the gas distribution system are necessary for future tests.

2. Planned for July

a. Engineering

Liaison between GD/FW and LRP will continue until completion of the necessary gas distribution system modifications for tests after MIT #901.

b. Fabrication

Fabrication and procurement will be necessary to modify the gas distribution system to ensure that it is adequate for future tests.

c. Testing

The modified gas distribution system will be completely checked out prior to additional tests after MIT #901.

ITEM 2.1 - REMOTE HANDLING EQUIPMENT

A. ITEM 2.1.3 - NRX

1. Accomplished in June

Design effort on NRX Item N-25 (tool kit, rocket engine disassembly - remote) was discontinued on 19 June by verbal direction from the NERVA Operations Office. The item will be deleted from the LRP Provisioning Data List.

Raw stock and commercial hardware for NRX Item N-211 (fixture, lifting, rocket engine, forward closure) have been ordered. Fabrication is scheduled for completion on 13 September.

Preliminary performance specifications for NRX remote handling equipment have been completed.

A preliminary study of the remote handling portion of the NRX-A2 Operational Support Plan was initiated.

2. Planned for July

Study of the remote handling portion of the NRX-A2 Operational Support Plan will continue and preliminary input will be prepared.

B. ITEM 2.1.5 - "E" ENGINE EQUIPMENT

1. Accomplished in June

Work was performed on preliminary flow diagrams in agreement with REON Report 2520.

2. Planned for July

No further effort is planned on E engine GSE support.

ITEM 2.2 - GROUND SUPPORT EQUIPMENT (CHECKOUT & TEST SYSTEM)

A. ITEM 2.2.3 - NRX

1. Accomplished in June

NRX Item N-450, Closure Kit, Pressure Testing, Rocket Engine.

This item is now in Fabrication. Scheduled completion date is 5 July 1963.

NRX Item N-451, Closure Kit, Pressure Testing, Nozzle Throat - Rocket Engine. Hydro-Test fixtures for development testing of N-450 are being made and will be available for checkout of N-450 by 15 July.

Preliminary Performance Specifications for NRX checkout and test support equipment were completed.

2. Planned for July

Design of additional leak test closures to be included in Item 450 will be initiated, based on new requirements established by design changes to the pressure cylinder and nozzle assembly.

Proof testing and development of Items N-450 and N-451 will be started.

B. ITEM 2.2.5 - "E" ENGINE EQUIPMENT

1. Accomplished in June

Systems engineering analysis of Block I, engine support equipment requirements was continued.

2. Planned for July

No further effort is planned on E-engine GSE support.

ITEM 2.3 - GROUND SUPPORT EQUIPMENT (HANDLING & MAINTENANCE)

A. ITEM 2.3.3 - NRX

1. Accomplished in June

Engineering

The NRX-A1 support equipment plan and associated provisioning data sheets were completed. Revisions to the plan, based on revised NRX-A1 hardware flow and assembly procedures, were started.

The preliminary performance specifications for the NRX support equipment were completed. Design of NRX item 813 (beam, hoisting, nozzle - rocket engine) was initiated in accordance with direction received from the LRP Projects Office. Engineering and fabrication effort is proceeding on all NRX GSE items. The following list presents the status of these items.

<u>ITEM NO.</u>	<u>NOMENCLATURE</u>	<u>STATUS OF NRX GSE ITEMS</u>
N-211	Fixture, lifting, rocket engine forward closure - remote	Completion scheduled for 13 September.
N-450	Closure kit, pressure testing rocket engine	Fabrication complete with exception of container. Completion should be 12 July.
N-451	Closure kit, pressure testing, nozzle throat - rocket engine	Procurement problems have delayed completion of this unit. Estimated completion now in early August.
N-704	Shipping and storage container, rocket engine nozzle	Current planned availability is during the last week in August.

NERVA LRP-24
MONTHLY LETTER REPORT

<u>ITEM NO.</u>	<u>NOMENCLATURE</u>	<u>STATUS OF NRX GSE ITEMS</u>
N-724	Semitrailer, rocket engine	Expected delivery of first unit is during the first week in August.
N-801	Sling, multiple leg - multiple purpose, 3000 pounds capacity	Some delay due to discontinuance of a standard hardware item, however, completion will be by 3 July.
N-803	Fixture, lifting, rocket engine forward closure	Delivery scheduled by 12 July.
N-809	Sling, beam type	Stress requirements dictated design changes. Delivery date to LRP is now 6 August.
N-813	Beam, hoisting, nozzle - rocket engine	Design completion expected 10 July.
N-817A	Sling, multiple leg - 12,000 pounds capacity	Fabrication completion expected 9 August.
N-914	Adapter, handling, rocket engine	Vendor delivery problems have caused a slip with delivery of first unit expected late in August.
N-915	Stand, rocket engine	A material change on the stand unit has caused some design changes. A new fabrication completion date is not available at this time.

NERVA LRP-24
MONTHLY LETTER REPORT

<u>ITEM NO.</u>	<u>NOMENCLATURE</u>	<u>STATUS OF NRX GSE ITEMS</u>
N-916	Maintenance platform, rocket engine	All parts received at lrp. Assembly will be completed by 26 July.
N-917	Stand, nozzle, rocket engine	This item was completed and received at LRP.
N-918	Stand, nozzle, rocket engine	This item was completed and received at LRP.

The fabrication order for the engine suspension system was issued on 24 June.

2. Planned for July
Engineering

Revision A to the NRX-A1 support equipment system plan and associated provisioning data sheets will be completed.

The NRX Block I support equipment plan and associated provisioning data sheets will be initiated.

NRX GSE items N-801, N-803, N-914, N-915, and N-916 are scheduled to be received.

B. ITEM 2.3.5 - "E" ENGINE EQUIPMENT

1. Accomplished in June

A review of E Mad building facility and remote handling equipment was initiated. This was requested by REON so that long lead items could be delineated for future procurement.

2. Planned for July

No further major efforts are planned in this sub-subtask.

ITEM 2.4 - INSTRUMENTATION

A. ITEM 2.4.1 - LRP ENGINE INSTRUMENTATION COMPONENTS

1. Accomplished in June

a. Engineering

(1) NRX-A-1 Cold Flow

Specification control drawings (SCD) for the NRX-A-1 cold flow engine were updated to incorporate the latest environmental requirements. The SCD's were photographed and reduced to 8½ x 11-in. for incorporation into the instrumentation data book. The SCD contains the applicable component specification on the face of the drawing and is used as the sole document for solicitation of vendor quotations and procurement of hardware.

(2) NRX-A Hot Firings

A tungsten-rhenium thermocouple was designed for the NRX-A-2 HF engine. One element consists of W-5%Re, by weight, and the other W-26%Re. Thoria will be used as the thermocouple wire insulating material, and the thermocouple will be sheathed in a tantalum inner sheath and a W-26%Re outer sheath. The fabrication drawing for this thermocouple is in preparation.

The design of a port adapter for the LASL NRX-A thrust chamber simulator furnace was completed and fabrication drawings are in preparation. The drawings will be submitted to LASL for review and comment.

Proposal drawings were submitted by the Aero Research Instrument Division of Advanced Technology Laboratories,

Chicago, Illinois, for a high temperature exhaust thermocouple assembly for use on the initial NRX-A hot flow engines. The drawings were reviewed and returned to the vendor with approval of the design, contingent upon receipt of updated drawings from the vendor incorporating the latest required revisions.

A summary of reactor instrumentation development work done since the KIVI-B-4A hot run was received from LASL. The information in this report is being incorporated into the developmental plans and design criteria for NRX-A hot flow engine instrumentation and transducer development activity.

(3) Thermocouple Calibration

The proposed modifications to the AGC hyperthermal environmental simulator are still under consideration. Dynamic calibration of the tungsten-rhenium thermocouples will be conducted at LASL on an interim basis. Static calibrations will be conducted using the resistance furnace and GH_2 in the Aerophysics Lab at AGC.

b. Fabrication

NRX-A Hot Firings

Purchase orders were submitted for thermocouple extension lead wires and special connectors. The connectors ordered will produce a negligible emf at connector temperatures of up to 500°F.

Purchase orders were also submitted for W-5%Re and W-26%Re thermocouple material. Upon notification that this would not be immediately available, an order was placed for W/W-26%Re

material. This order was filled and notice was received that the W-5%Re type will be available early in July. Techniques for joining the W-26%Re outer sheath to the tantalum inner sheath are being studied.

2. Planned for July

a. Engineering

Preparation of design criteria, developmental plans, and specifications will continue, based on the best available environmental information.

Specification preparation for the NRX-A-2 HF engine will be continued.

b. Fabrication

Procurement of NRX-A1 and NRX-A2 engine instrumentation components will be continued.

Fabrication of both W-W26%Re and W-5%Re/W-26%Re thermocouples will be completed for further evaluation.

Eight units of the final tungsten-rhenium thermocouple configuration will be produced for delivery to LASL for dynamic calibration.

Written process procedures will be prepared for fabrication of the tungsten-rhenium thermocouples.

c. Testing

Static calibrations will be performed in hot hydrogen gas and the data obtained will be evaluated for the tungsten-rhenium thermocouples.

B. ITEM 2.4.3 - LRP INSTRUMENTATION COMPONENT EVALUATION

1. Accomplished in June

a. Engineering

(1) NERVA Instrumentation Data Book

The final sections of the instrumentation data book were completed and transmitted to REON for inclusion in the July quarterly revision.

(2) Instrumentation Supplier Seminar Follow-up

Component design proposals were received from vendors and the response is expected to continue into July. The proposals received were evaluated using an evaluation report form that will be used in the final selection of vendors. Vendor response to the NERVA design specifications has presented several new design approaches that appear promising in the severe nuclear environment. Design analysis studies are being conducted to appraise the various design proposals.

(3) Specifications

Environmental test specifications were prepared for the testing of the NRX-A-1 CF instrumentation. Based on the specifications, proposals were received from two independent environmental testing laboratories. The laboratories were visited and the plant testing facilities were reviewed. Both laboratories were found to be capable of performing the required tests commensurate with the AGC schedule requirements. A purchase order is being generated and testing will begin during the first week of July.

An evaluation of the existing LRP and SRP environmental

test facilities was conducted. Additional facilities required for support of the Item 2.4.3 component environmental test program include vibration equipment with temperature controls from -300 to +600°F, a shock test machine, a temperature altitude chamber, an acoustical system, and an acceleration system.

(4) Design Studies

(a) Calibration Cryostat

A concept for a cryostat to be used for precise calibrations of temperature sensors in the liquid hydrogen temperature region was evaluated. The primary design consideration was the achievement of stable temperature gradients by use of a central core of solid aluminum as a thermal moderator. Use of the same cryostat for calibration of pressure transducers is considered to be entirely feasible.

(b) EIT-502 Cryostat

An analysis was made to determine the temperature gradients in the gas above the cryostat fluid in the EIT-502 cryostat (for reference purposes in locating test components in that volume).

(c) Piezoelectric Accelerometer Shielding

Shielding calculations were performed for a typical piezoelectric accelerometer mounted in the NERVA environment to investigate methods of extending the useful life in a radiation environment. Calculations indicated that with minimal shielding the useful life of the crystal

could be extended to encompass the anticipated NERVA radiation doses.

b. Fabrication

There was no new fabrication activity on Item 2.4.3.

Acceptance testing of components scheduled for EIT #501 and EIT #502 continued during this period. Several components damaged during the tests were returned to the vendor for repairs. Acceptance testing of the repaired units will be conducted during the next report period. The Statham A515 accelerometer is the only unit for use in EIT #501 which has not been subjected to the acceptance testing. Eight of these units will be tested when received from the vendor.

c. Testing

Evaluation vibration tests were performed on two Statham PA732 TC pressure transducers to provide backup environmental data for similar units being used on the NRX-A1 engine. The test data indicated that these units were suitable for use on the NRX-A1 engine.

2. Planned for July

a. Engineering

NERVA instrumentation data book input will be prepared and submitted on a monthly basis for incorporation by REON into their quarterly revisions.

Evaluation of vendor component proposals will be continued. An agency will be selected to conduct the required environmental testing.

b. Fabrication

No fabrication activity is planned.

c. Testing

Acceptance testing of components for use in the EIT program will be continued, and environmental testing will be started in support of NRX-A1 instrumentation components.

C. ITEM 2.4.4 - MECHANICAL COMPONENT RADIATION TEST INSTRUMENTATION

1. Accomplished in June

a. Engineering

RTT length requirements have been determined and the new and changed parameters for MIT #903, #904, #905, and the control pallet have been listed. The wattmeter, voltmeter, current transformer, and speed probe have been deleted from test pallets #903 and #904.

The details for mounting resistance temperature transmitters on one-inch jacketed lines have been determined.

b. Fabrication

A fabrication order (Ref. APS 158631, Doc. No. 335052) was released to procure instrumentation components for MIT #903, #904, #905, and two control pallets. Manufacturing spares were included in the order. Close interdepartment coordination will be maintained to expedite receipt of all components. The radiation resistant pressure switches may become a pacing item. Specification control drawings for the pressure switches are being processed by AGC personnel, and drawing release is expected around 15 July.

Fabrication of two calibration sets for use in the Cryogenics

Laboratories at AGC and General Dynamics will not be completed until 5 July. Completion was originally scheduled for 15 June.

c. Testing

Acceptance testing for MIT #902 will be delayed because vendor specifications are not yet available for the Dynisco APT 25 pressure transducers. The final shipment of Dynisco APT 25 transducers is scheduled for 17 June.

2. Planned for July

a. Engineering

Specification control drawings will be released for pressure switches, flowmeters, and vibration transducers.

b. Fabrication

Fabrication orders will be prepared for pressure switches, flowmeters, and vibration transducers. Fabrication of two MIT calibration sets will be completed.

Fabrication orders for MIT #906 instrumentation components will be initiated.

c. Testing

Acceptance testing of MIT #902 instrumentation will be completed.

D. ITEM 2.4.8 - LRP ENGINE INSTRUMENTATION INSTALLATION

1. Accomplished in June

Effort continued toward completion of the NREX-A1 instrumentation installation drawing.

The instrumentation schematic was submitted for release. The anticipated date of final release is 8 July.

2. Planned for July

The NRX-A1 instrumentation installation drawing will be released. The drawing will be submitted for check about 3 July.

Work will be initiated on NRX-A2 instrumentation installation and schematic drawings.

E. ITEM 2.4.9 - TPA CRYOGENIC TEMPERATURE SENSOR DEVELOPMENT

1. Accomplished in June

a. Engineering

Detailed information was prepared for procurement, installation, and data reduction procedures for the Model 134CT cryogenic temperature sensors used in the LRP test area. The details include a summary of sensor development for high-accuracy liquid hydrogen temperature measurement systems, sensor calibration procedures, sensor selection criteria, data reduction curves, sensor installation procedures, metallic seal recommendations, specification control drawing requirements, procurement specifications, cost and delivery dates, and a program completion plan.

The calibration procedure for platinum sensors has been completed and submitted to Transducer Laboratory management for suggestions and approval.

A study which establishes the requirements for a cryogenic temperature calibration facility has been completed.

A technical review has been completed on the miniature sensor proposal, No. 6638, submitted by Rosemount Engineering Company. The proposal, entitled "Technical Proposal for a Specially Designed Platinum Resistance Temperature Sensor for Shallow Immersion Applications", covers units designed to be

completely interchangeable (within 0.5°F, including manufacturing tolerances, calibration accuracy, and repeatability). The sensors will have a maximum diameter of 0.15 inches, and the sensing element will be in the last 0.10 inch of the probe.

A hardware demand schedule for miniature temperature sensors was completed and submitted to the NERVA Project Office.

Preliminary calculations have been made to study the feasibility of standardizing the Electro-Optical Systems temperature sensors by adding a shunt resistor to the silicon sensing element.

b. Fabrication

A technical review was completed on the Winsco and Electro-west quotations for five platinum resistance temperature sensors manufactured to AGC specification control drawing no. 248059. Winsco was the low bidder, but their bid was based on an unacceptable deviation from the specification. This was a deviation from the resistance-temperature curve in the LH_2 temperature region which would necessitate new data reduction procedures and associated costs of reprogramming the computer and revamping the data acquisition equipment. Winsco will be asked to resubmit their bid without deviations from the specification, and the successful bidder will then be evaluated as a potential second source of supply.

A purchase requisition was initiated for 20 miniature sensors manufactured by Rosemount Engineering Company. Five units each of four different stem lengths will be evaluated.

The Microdot Corporation was asked to provide a specification control drawing for a platinum film temperature sensor which is

mechanically interchangeable with the Rosemount Model 134CT. The Microdot sensor is also electrically compatible with the constant-current system in the LRP test area.

c. Testing

An evaluation of the thermal emf induced in Rosemount Model 134CT platinum resistance temperature sensors has been initiated. Tests in liquid neon are being conducted.

A Rosemount Model 134LB cryogenic temperature sensor (radiation resistant design) was removed from LRP test service. This unit was used in dynamic temperature measurements in liquid hydrogen on more than 15 engine component tests. It will be recalibrated to verify the vendor's claim of a repeatability of 0.02°F throughout the range of -400 to -415°F .

Reduction of data from the calibration of two Electro-Optical Systems, Model 3370, and from the recalibration of a Rosemount sensor, Model 134CT, (after dynamic testing) was started during this report period.

2. Planned for July

a. Engineering

The calibration procedure for platinum resistance temperature sensors will be released.

The development program plan for a miniature cryogenic temperature sensor will be prepared.

The cryogenic temperature measurement system error analysis will be continued.

The hydrogen quality detection system development will be continued.

Techniques for standardizing the resistance-temperature characteristics of Electro-Optical Systems silicon temperature sensors will be investigated.

b. Fabrication

Procurement negotiations for five platinum resistance temperature sensors (either Winsco or Electrowest) will be completed.

c. Testing

Reduction of data from two evaluation units of the Electro-Optical Systems Model 3370 silicon temperature sensors will be completed.

Calibration data from an evaluation unit of the Rosemount Model 134LB cryogenic temperature sensor (radiation resistant design) will be reduced.

Reduction and evaluation of recalibration data from the Rosemount Model 134CT unit will continue.

ITEM 2.6 - RELIABILITY AND QUALITY ASSURANCE

The monthly letter report for subtask 2.6 will be forwarded for distribution under separate cover.

NERVA LRP-24
MONTHLY LETTER REPORT

ITEM 2.7 - SAFETY PROGRAM

No significant activity was performed on this subtask.

ITEM 2.8 - TRAINING

A. ITEM 2.8.1 - TRAINING ANALYSIS

1. Accomplished in June

NERVA orientation lectures were conducted and training aids such as schematics were prepared.

2. Planned for July

NERVA orientation lectures will be conducted for the Reliability Division. The development of training material will continue.

ITEM 4 - PROGRAM MANAGEMENT

A. ITEM 4.1 - PERT

1. Accomplished in June

All NCS-305, Revised CY 1963 Cost Study, LRP PERT networks for individual subtasks were reviewed and updated to reflect negotiated changes. The networks were run on the NASA PERT Program as an integrated LRP NERVA PERT program.

A new reporting technique involving information submittal directly from performing departments rather than from cognizant departments was initiated and a change control as it effects program plans is being prepared.

Two coordination meetings were held between REON and LRP personnel for the following purposes:

- a. Review and coordination of NCS-305 PERT networks
- b. Improvement of the reporting system

PERT biweekly reports were prepared and submitted to REON.

2. Planned for July

As a part of NCS-306, CY 1964 Cost Study, REON PERT demand charts will be reviewed.

New LRP PERT networks will be prepared and submitted to REON.

PERT input cards will be completed and a complete PERT computer run will be submitted to REON.

PERT biweekly reports will be prepared and submitted to REON.

B. ITEM 4.2 - FISCAL CONTROL

1. Accomplished in June

The computer programs used in the preparation of the budget variance report have been modified to attain greater efficiency. More detailed reports can be generated at 75% of the original cost.

2. Planned for July

Fiscal data for NCS-306 will be prepared for submittal to REON in accordance with REON PD 198.

Modifications will be incorporated into the budget preparation computer program to allow open commitments and incurred costs to be reported at desired levels.

C. ITEM 4.3 - TECHNICAL REPORTS

1. Accomplished in June

Work was started on NCS-308, Program Plan for NRX-A Nozzles With Area Ratio 4.

NCS-309, Information Concerning the Cryogenic Facility at NARF for Testing the Propellant Feed System, was prepared and submitted to REON.

In response to REON PD 177, the second monthly document listing report covering the SNP-1 contract period from program inception (11 July 1961) to 31 May 1963 was prepared and submitted to REON.

LRP NERVA weekly reports, biweekly PLRT reports, and the monthly letter report were prepared and submitted to REON. A monthly Reliability and Quality Assurance Status Report, prepared by subtask 2.6, was assembled and submitted to REON.

A NERVA movie strip covering significant activities during the period of January through May was submitted to REON.

2. Planned for July

NCS-308, Program Plan for NRX-A Nozzles With Area Ratio 4, will be completed and submitted to REON.

NCS-311, Program Plan for Final CY 1963 Effort, will be completed and submitted to REON.

NERVA LRP-24
MONTHLY LETTER REPORT

Major emphasis will be placed on preparation and assembly of NCS-306, CY 1964 Cost Study, to be submitted to REON before the end of July.

LRP weekly reports, biweekly PERT reports, the Monthly letter, and a NERVA movie strip will be prepared and submitted to REON.

D. ITEM 4.4 - CENTRAL DATA SYSTEM

1. Accomplished in June

Engineering documentation including drawing lists, drawing number control reports, and WANL specifications received from REON were distributed.

2. Planned for July

LRP PD 59E, Revised NERVA Engineering Data and Documentation Requirements, will be issued and implemented.

ITEM 5 - SPECIAL TEST EQUIPMENT

A. ITEM 5.1 - LRP (TEST ZONE "C")

1. Accomplished in June

Fabrication of the TSOV vessel for test stand C-7 is proceeding according to agreements reached during the month in Cleveland by NASA, AETRON, and AGC. These agreements concerned detailed welding callouts, non-destructive testing, and quality assurance controls.

Specifications and contract drawings covering the installation of the TSOV vessel and related piping were completed. Formal contractor quotations were requested during the latter part of the month. Included in the installation will be the relocation and extension of the test stand C-7 flare stack over to test stand C-6. This is being done to avoid the possibility of exhaust flame damage to C-6 during high pressure TPA testing on test stand C-7.

Design criteria for the installation of the test stand C-6 supersonic diffuser were prepared and transmitted to AETRON for final design preparation. Actual stand installation of the diffuser has been deferred until the early part of 1964 because of the revised testing program.

Design work progressed on test stand C-6 modifications to accommodate NRX-A nozzle testing scheduled for September. Design work associated with TPCV testing on test stand C-7 was initiated.

2. Planned for July

Design work on NRX-A and TPCV testing will be completed with drawings and specifications prepared preparatory to contractor bidding.

Bids will be received, evaluated, and awarded for the TSOV installation with active contractor work starting shortly afterwards.

B. ITEM 5.2 - LRP CRYOGENICS LABORATORY (TEST ZONE "A")

1. Accomplished in June

Design effort associated with TPCV testing was completed and fabrication of the required STE hardware was initiated.

Bids covering the fabrication and installation of LH_2 transfer piping systems were received and means of securing additional contract funds were reviewed. With the securing of the required funding, contract award will be completed shortly. Completion of the contract is expected 90 days after award.

A delay in the completion of the TPCV test setup was caused by late receipt of necessary components from vendor suppliers. Portions of items are enroute to AGC at this time.

2. Planned for July

Procurement of the hydrogen leak measurement apparatus will be initiated upon completion of review of design criteria by cognizant laboratory personnel.

Formal contract approval will be sought from NASA for the fabrication and installation of the LH_2 piping systems.

Fabrication of the TSOV test system will be completed.

C. ITEM 5.3 - LRP (TEST ZONE "H")

1. Accomplished in June

All necessary pieces of vacuum insulated piping were received in test zone "H", allowing on-stand piping installation work to proceed.

Contractor installation of the mechanical STE continued throughout the month with considerable progress noted on GH_2 , LN_2 , GN_2 , LO_2 , and GO_2 piping systems. Overall percentage completion is approximately 90% as of the end of the month.

NERVA LRP-24
MONTHLY LETTER REPORT

Effort was expended in the preparation of contractor-activation procedures. The work encompassed by the activation bid package was presented to the contractor for his price determination.

A second-shift operation has been put into effect by the electrical contractor as part of an accelerated effort to complete instrumentation and control STE installation in test zone "H".

Completion of contractor-activation of test stands H-4, 5, & 6 is presently scheduled for 16 August. Activation by AGC personnel will be completed 16 September for TPA testing on test stand H-6.

Aetron began redesign of the hot hydrogen heat exchanger, as required by recently-imposed fabrication requirements of NASA. As directed by SNFO-C, the high temperature heater section must be redesigned to conform to latest ASME code requirements. It is not anticipated that the proposed delivery date of 15 November will be affected at this time.

Contractor fabrication of the ejector system for test stand H-5 was completed and preparations were made for shipment to AGC-LRP on 1 July.

Fabrication of the gas generator for TPA testing was started along with the initiation of design of the electrical controls for the TPA test setup.

Design work associated with the LH_2 TSOV support systems and modifications to H-4, 5, & 6 for blast effects was completed by test planning engineers.

2. Planned for July

Construction and fabrication efforts will be continued in test zone H. Both mechanical and electrical work will be actively pursued towards the scheduled activation date.

D. ITEM 5.8 - LRP (BUILDING 3508 - TEMPERATURE LABORATORY)

1. Accomplished During June

A decision was reached regarding the fabrication and procurement of the LH_2 -Neon cryogenic temperature calibration facility. Detailed design work and specification preparation has been initiated, and necessary items will be procured from outside vendors. Overall unit fabrication will be completed by LRP. It is expected that nine months will be required to complete the cryostat.

2. Planned for July

Design, procurement, and fabrication efforts will be continued.

E. ITEM 5.9 - LRP - CONTROLS AND CHEMICAL LAB (BUILDING 2002)

1. Accomplished during June

Design work associated with the special vibration equipment for TCA testing was completed. The control console and data acquisition system are essentially complete.

2. Planned for July

Installation of the vibration equipment will be completed during the early part of July (for vibration testing of the TCA under subtask 1.4).

TASK 6 - GOVERNMENT PROPERTY

A. ITEM 6.2 - AGC (LRP "A")

1. Accomplished in June

Procurement of the hydrogen leak measurement apparatus has been temporarily delayed pending review of submitted bids by NASA. Effort on other items of CY 1963 work was continued throughout the month.

2. Planned for July

Effort will continue, as required, to support scheduled completion of zone "H" test facilities.

IV. WEIGHT AND BALANCE CHANGE REPORT

There have been no weight and balance changes during the month of June. If any changes occur, they will be reported in separate documents.

ENCLOSURE (2)

NERVA
RELIABILITY AND QUALITY ASSURANCE
STATUS REPORT
JUNE 1963

This Enclosure is being submitted
for distribution under separate cover.

ENCLOSURE (3)*

NERVA
PERT COMPUTER RUN
BY SUBTASK

AS OF
28 JUNE 1963

- a. By Successor Event Number and
Predecessor Event Number
- b. By Paths of Criticality
- c. By Expected Date and Successor
Event Number
- d. By Scheduled or Latest Allowable
Date and Successor Event Number
- e. By Department, Expected Date,
and Successor Event
- f. Master Schedule, by Subtask
and Level

*This Enclosure sent to the addressee only.