NERVA TEST OPERATIONS

Nuclear Rocket Development Station

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Attached is the second quarterly progress report input to WANL for CY 1968. The inputs received here have, in some cases, been edited to eliminate redundant material.

W. D. Wayne, Manager
NERVA Test Operations

Enclosure

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PROJECT 2517 - GROUND OPERATIONS SAFETY

GENERAL

During this report period, there have been no lost time accidents and no radiation exposures exceeding the AEC guides.

Two NTO technicians were forced to jump from the LASL L-2 Locomotive when it lost traction on the downgrade north of E-MAD. The technicians were operating the L-2 during a LASL transfer. They were not seriously injured although the engine was subsequently derailed.

The annual summary of radiation exposures (AEC-190) and accidents and injuries (AEC-13) were prepared and sent to WANL and Aerojet.

Health and Safety personnel participated in an investigation of inappropriate beryllium handling.

The quarterly inventory of all SS materials on site was conducted and the balance report was submitted to SNPO-C.

CRITICALITY

Peripheral poison wires were removed from the XE-1. The measured 1/M curve closely followed the predicted curve.

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Preparations necessary at E-MAD for receipt of NRX-A6 fuel elements were discussed with E-MAD management. Lockable valves are being installed on water lines to the Disassembly Bay and the Post-op cells.

A fourth RIDL system for the neutron multiplication monitor was received and checked out. This provides a backup unit to the three units used for poison wire removal operations, and is also useful as a data channel.

NTO-SOP-0017, "NTO Standard Operating Procedure for Neutron Multiplication Detection," was revised and transmitted for review.

E-MAD water lines to the hot bay and hot cells were inspected for compliance with criticality requirements prior to receipt of the first shipment of fuel from R-MAD.

The results of a WANL nuclear safety analysis for the E-MAD Post Ops metallurgical specimen storage rack were received and transmitted to the Manager, Post Ops Examinations.

Following a discussion with E-MAD and R-MAD Disassembly and Post Ops Examinations management, a new Crit Zone Limit of 32 fuel elements in a planar array was approved. Management stated that this would result in a 15% to 20% increase in efficiency based on real work time for the hot cells by allowing more elements

to be transferred together, thus reducing down time during transfers.

A copy of the nuclear safety analysis performed by WANL for the E-MAD Poisoned Fuel Element Library was received and reviewed. Based on this analysis, the Library was approved for use at E-MAD.

A proposal by Pan Am to SNPO-N for reprocessing spent Rover fuel elements was reviewed at the request of SNPO-N. Conclusions of Pan Am relating to criticality safety of proposed new shipping containers were found to be satisfactory.

Standards were written for handling "crit-safe" vacuum cleaner canisters at the E-MAD.

E-MAD

An audit of liquid storage in the warm lab at E-MAD indicates that new purchases of chemicals and combustibles were in containers compatible with the "Aerojet-Genral Red Target" and "Westinghouse Safe Practice Data Sheets." Storage is congested but much improved from NTO R-MAD storage.

The initial shipment of irradiated fuel elements was received at the E-MAD.

Health and Safety:

- a. Made recommendations to E-MAD engineering for safeguards on the high voltage power supply for the F.E.P.S. photo flash unit.
- b. Prepared a statement of NTO Health and Safety criteria for use of the E-MAD hot hold tank and drain field.
- c. Assisted E-MAD management in the modification to improve the criticality alarm.
- d. Reviewed numerous safe work permits for toxic and radioactive materials handling at E-MAD.
- e. Aided E-MAD management in the proper methods of proof load testing miscellaneous lifting equipment.
- f. Reviewed and commented on the E-MAD Radiological Support Plan Procedure.
- g. Transferred NRX-A6 fuel from R-MAD to E-MAD.

The heater in the high pressure gas system was reviewed with NRO and SNPO-C safety representatives. It was determined that extension of the exclusion area would satisfy safety requirements.

ETS-1

Health and Safety made a standby on the duct vault and pipe chase inerting test and reviewed the procedures for the test.

Health and Safety directed the installation of emergency oxygen unit cabinets.

A meeting between Pan Am Health and Safety and ETO management was called to discuss proposed contamination control at ETS-1. Possible control measures were discussed and a plan of action was devised.

An inspection of the contractor's area at ETS-1 resulted in SNPO-N recommendations for immediate removal of scaffolds not in use and re-rigging of several being used.

Continuing emphasis has been placed on cleaning up the general ETS-1 area. ETS-1 management is establishing special "clean-up times" to aid in solving the problem.

Health and Safety reviewed and concurred with procedures to proof pressure test the water lines from the 2.5 million gallon water tank.

Health and Safety assisted NRO and SNPO-C in follow-up assessment of ETS-1 readiness for XECF testing.

A follow-up audit on the scaffolds in facility indicates that all existing and future scaffolds will be maintained to meet the ASA for Building Construction, A10.2-1944. Unscheduled inspections will continue during NTO Health and Safety daily surveillance.

A meeting was held with PAA Health and Safety to discuss NRDS scaffold and lift standards and establish agreement for ETS-1 requirements.

A second noise survey was made during ETS-1 CP operations to determine if there were any speech interference levels (SIL) during operations. Maximum readings (A, B, C) were 62 to 64 db during test and (A, B, C) of 74 db upon termination of test with five people speaking simultaneously to persons across the CP room. No SIL problems were detected at any console.

The service of O₂ analyzers, explosimeters and gas detection equipment at ETS-1 has been transferred from NTO Health and Safety to Operations. NTO Health and Safety made a pre-NEP-HE-1 audit of operating equipment and current service requirements.

ETS-1 lighting has improved in areas where B-systems maintenance personnel make daylight checks for non-functioning lighting. A light survey will be performed again by NTO Health and Safety when the supplementary lighting package is completed.

R-MAD

Inspection of a crane requested for R-MAD support from PAA resulted in the crane being rejected by PAA and NTO safety. Another crane was checked out and accepted. The slipping clutch on the rejected crane will be repaired and load tested before return to service.

Health and Safety arranged for a shipment of NRX irradiated fuel to LASL.

TEST CELL "C"

The WANL accident prevention administrator was conducted on a tour of facilities. No major safety discrepancies were indicated.

PROJECT 2637 - PRODUCT ASSURANCE

GENERAL

A new NTO Administrative Procedure defining Product Assurance activities at E-MAD was completed and released.

A proposed format for the experimental engine (XE) logs was prepared and is currently being coordinated.

The NTO procedures governing the control of nonconforming material at NRDS have been revised and transmitted to NRO, WANL and SNPO-C for review and comments.

The proposed revision to the QRDR form has been completed and is currently being coordinated.

The following Quality Reliability Instructions (QRIs) have been initiated and approved for NTO use:

- a. 3.3B "Quality Reliability Instructions"
- b. 5.1D "Receiving Inspection"
- c. 5.8 "Supplier Source Control"
- d. 6.1 "Control of Government Furnished Property"
- e. 7.13 "Product Assurance Audit of Preventative Maintenance"
- f. 9.2B "Calibration of Inspection Measuring Equipment"
- g. 9.5A "Control of Electronic Instrumentation at ETS-1"

ETS-1 OPERATIONS

During a checkout of the fire protection system a substantial leak was discovered in that portion of the line that services valve pit Nos. 1 and 2. An examination revealed that a Victaulic coupling had failed with the resulting leakage. The entire line was examined and suspected couplings were replaced with welded steel bands. In order to more clearly define this problem, NTO Product Assurance has sent the failed coupling to NRO for a detailed failure analysis.

NTO Product Assurance witnessed the final checkouts and adjustments of all the modifications to the shield latch system.

NTO Product Assurance monitored all Steam Generator system checkouts in preparation for the NEP-He-1 test. Discrepancies discovered in the Steam Generator Pressure Switches were documented on QRDRs. These switches were sent to the Pan Am Valve Shop for disassembly, cleaning, re-assembly, and test. These problems were resolved and the generator tests successfully completed.

A dye penetrant inspection revealed cracks in the S-1 trough. Product Assurance monitored all work required to correct this problem.

The hydro-tests for V-3901 through 3905 were satisfactorily completed.

MAD OPERATIONS

The Actuator Checker High Pressure System was inspected by Product Assurance and all discrepancies discovered during this inspection were resolved.

All lifting equipment at E-MAD was inspected by Product Assurance and those items not meeting with specification requirements were identified and are currently awaiting disposition.

Calibration of equipment at E-MAD has been progressing at a satisfactory rate.

Product Assurance provided inspection during XE-1 cable routing, instrumentation installation and checkout in accordance with XE-1-P4 and data log sheets requirements.

The XE-1 Pneumatic Actuators were inspected in accordance with the requirements of XE-1-P3. Discrepancies recorded during this inspection are being satisfactorily resolved.

RELIABILITY

In order to help prevent the degradation of reliability within critical facility systems, a procedure governing the age control of elastomeric or synthetic rubber parts was initiated. This procedure has been approved for NTO use.

Reliability personnel have been participating in the establishment of a preventive maintenance program for the ETS-1 facility. The responsibility for this task has been delegated to NTO Engineering, however, Quality Control and Reliability personnel have been requested to contribute to this program in the areas of discrepancy/failure history, operating time/cycle data, storage life data, and component evaluation data.

A reliability procedure governing the review of, or initiation of, a Failure Mode Analysis by NTO personnel was prepared and has been approved for NTO use.

PROJECT 7017 - NRDS GENERAL SUPPORT

NRDS GENERAL SUPPORT

This section reports the activities of Program Controls, Documentation and Reporting, and Engineering and Technical Support. These groups provided assistance to NTO facilities and administrative coordination with other NRDS organizations.

Program Controls

Participated in conferences with representatives from SNPO-C, SNPO-N, EG&G, PAA and LASL to determine ways and means of accomplishing the existing test schedules within existing funds. PRD dollar limitations were established in all work and procurement categories. Pertinent costs by category will be reported by the Support Services Contractors in a monthly Cost Versus Bank Report.

Prepared and submitted PRD cost analysis information to NRO fiscal control for monthly publication of incurred PRD category bank expenditures in graphic/numeric display form.

Prepared detailed information regarding PRD cost to complete FY 1968. FY 1969, FY 1970 and FY 1971 manpower and material requirements formalized for inclusion in the 6th annual edition of Report 2578 (PRD) tentatively scheduled for April 1968 publication.

Provided the SNP-1 NTO CY 1968, 1969 and 1970 Program Planning Documents and reviewed the NP-1 NTO Work Statements and cost data. Prepared and issued monthly management control documents such as Manpower Ceiling reports, Department Rosters, etc. Revised the

existing computer program of NTO personnel reports and related summary forms. Performed SNP-1 NTO budget analysis on a continuing basis. Prepared and issued monthly overtime estimates and CY 1968 work authorization documents.

Scheduled the procurement of propellants and pressurants commensurate with requirements dictated by test activities and facility testing at ETS-1 and prepared quarterly and 36 month propellant forecasts by commodity for testing XECF, XE-1, XE-2, Pewee 1, 2 and R1 at Test Cell "C" and ETS-1, and submitted to NRO Sacramento.

Documentation and Reporting

General

The NTO Documentation Manual, NTO-A-0001, was issued. This manual provides instructions for generating, processing and distributing documents issued by NTO.

A total of 10 SOP's were published. Three administrative procedures were revised. Two standards were revised. One SOP was transmitted off-site for review. Two instructions were approved and reproduced.

NRX-A6

The NRX-A6 Site Test Report was published.

Work was initiated on the NRX-A6 Post Test Report. This report will be published in two parts. Part I will deal with Disassembly

and Part II with Post-Operative Examination. The draft for Part I is complete and effort on the draft for Part II was initiated.

The "NRX-A6 Dosimetry Data Report", NTO-R-0136, was published.

XECF

The XECF Pre-Test Report was completed and submitted for approval.

Three (3) XECF procedures were transmitted off-site for review. Proposed final issues were issued for four (4) procedures. One procedure was revised. One procedure was submitted for internal review.

XE-1

One XE-1 procedure was submitted for internal review. One XE-1 instruction was revised.

Site Engineering

ETS-1

Piping Stress Analyses were completed to verify existing designs as to determine the acceptability of required system modifications.

Engineering Packages, drawings, and/or specifications were completed in support of ETS-1. This effort included:

- Actuator Check Out System

- Survey of Lateral Pipe Supports

- PM Cells Drive Modification

- CSA Fixture Adapter

- XE-1 Throat Plug Retention Device

Test Cell "C" General Support

Provided general support to LASL/J-5 for the scrubber development and test program. The primary effort during this period was the design and fabrication of the 2 lb/min. scrubber system.

NTO Counting Laboratory

The Counting Laboratory supported NTO/LASL Test Operations, E-MAD, and ETS-1 with:

NRX-A6 Dosimetry Report

XE-1 Dosimetry Packets preparation

XE-1 Gridwork for fall out study

General

Supported Project Staff Group and included work on the following:

ETS-1 Modification 75K Thrust Engine

Cooldown Recirculation Vent System

Interface Gas Systems

Propellant Line modification

Side Shield evaluation

Scrubber

PROJECT 7107 - TEST CELL "C" OPERATIONS

GENERAL

NTO personnel provided support to LASL/JTO Group for the post-NRX-A6 data analysis effort; the extensive Test Cell "C" modifications for the Phoebus-2A test series; and the Phoebus-2A Shutdown Studies, EP-II, EP-IIA, EP-IIB and EP-III. The significant work accomplished or in progress during this reporting period is described in the following sections:

TEST CELL "C" FACILITY CONSTRUCTION AND MODIFICATIONS

Control and Neutronics Systems

Post NRX-A6 Activity

When the Control Room was no longer needed for the testing and post-test cooldown of NRX-A6, previously planned Control Room modifications were begun in preparation for the Phoebus-2A reactor test. These activities encompassed elimination of the NRX-A6 power and temperature limiters, rescaling the liquid hydrogen flow rate, turbine speed mixing chamber, high pressure dewar, and liquid nitrogen control systems to the values appropriate for Phoebus-2A testing. The modification of the consoles in the Test Monitoring Room to be used for Phoebus-2A testing has been started. At present, physical relocation of the consoles has been completed and the electronic portions of the work are in the checkout phase.

Phoebus-2A Shutdown Studies

Before the Phoebus-2A reactor can be tested, a safe means for performing an emergency shutdown from intermediate and full power conditions must be demonstrated with the systems at Test Cell "C". These shutdown studies involve Control Room activity in two important ways: First, the basic problem of controlling the pressure profiles, which in turn supply the flow rates to the reactor and tie tube systems, may be resolved to one of control. Second, the proper simulation of the impedances of the reactor and tie tubes must be performed with sufficient accuracy during the conduct of the test to properly assess the validity of various shutdown systems under test. Modifications associated with control of facility components have involved the installation of a 4.5 gpm servo valve on H-60, the turbine control valve, in order to slow its maximum velocity to 120%/sec., and the installation of a hydraulic orifice in the H-60 override hydraulic system to slow its maximum velocity to 160%/sec. Additional modifications have required changing the shutdown mode for the turbine energy source control valves so that they close rather than open on shutdown; the incorporation of H-101, the turbine energy source chillover valve to the shutdown chain, and causing it to open to 16% on shutdown to prevent trapping liquid hydrogen between the closed control valves and the check valve in the turbine energy source inlet line.

Two methods have been provided to give real time simulation of the changing reactor and tie tube impedance during the first second after shutdown: The first and simplest was a reinstallation of the exponential decay circuits which demand B-15 and B-215, the test cart simulation valves, from their positions at shutdown to a new level

adjustable from the Control Room on an exponential curve whose time constant may be determined in advance by the selection of circuit **components**. A second and hopefully more accurate method involves the use of a small analog computer which solves simplified differential equations which describe the dynamics of hydrogen flow in the various reactor and tie tube plena. This computer takes as its inputs the measured pressures to the nozzle and tie tube inlet and, from the differential equations, calculates the proper position of the cart valves to simulate the system impedances.

In preparation for the resumption of Phoebus-2 reactor studies, it has been necessary to reinstall and check the operation of the tie tube control circuits. Also during this report period, the DDP-116 with some associated Control Room hardware has been used to replace the Data Trak profile generators. For all experimental plans conducted after NRX-A6, programmed profiles have been generated by a digital program written for the DDP-116.

Neutronics System

Three of the six neutronic detectors to be evaluated during the Phoebus-2A reactor test have been delivered to the Test Site and have undergone preliminary inspection and qualification tests. These detectors will be mounted on the Phoebus-2A nozzle in a continuing attempt to find a suitable detector and mounting scheme to use this desirable location for the detectors used in reactor control and protection. A continuing effort has been maintained in the neutronics area to correct deficiencies found during the NRX-A6 testing and redesign those portions of the system in which improvement is felt necessary or desirable in preparation for Phoebus-2A. These areas

have included the modification to the Control Room scalers, temperature compensation to minimize drift in the logarithmic amplifiers, expanding the useful control range of the logarithmic circuits, and the use of improved preamplifiers in the startup system.

Miscellaneous

Operational experience with the process water boiler system has revealed some unanticipated controls problems. Work with J-5 is progressing to solve these problems, but the system is not yet operational from the Control Point.

Progress has been made in improving the simulation capability in the Test Cell "C" Control Room. Necessary reactor heat exchanger rescaling has been accomplished for the Phoebus-2A reactor. Now in progress is a modification to the tie tube system simulation, which will allow it to operate in conjunction with the main reactor heat exchanger model.

Data Systems

NRX-A6 Activity

As a part of the NRX-A6 test series, the following data reduction was accomplished:

Cal-comp originals	40,000 plots
Sanborn strip charts	600 sheets
Wide-band reduction	As requested

This data reduction effort was interrupted and impeded several times due to the inoperability of the IBM 704 computer.

Test Cell "C" Data Systems

At the conclusion of the NRX-A6 test series, a set of previously planned modifications to the Test Cell "C" data systems was undertaken. The calibrator for the wide-band system, a part of the original Test Cell "C" data system installation, had been redesigned. This new system was installed and its checkout completed. Also in the category of reworking old and marginally operable equipment was a redesign of the photo timing system which provides the binary coded decimal light system and timer operation on the test pad. This system has been installed and its qualification tests completed. The Control Room communications system has been modified by the installation of amplifiers previously used in the Test Cell "A" Control Room communications system. It is hoped that this modification will provide a better quality run day communication net for the operating team.

The installation of eleven 50-pair cables, forty shielded two-conductor cables, and one television coaxial cable between the Control Point and test cell was completed and continuity testing performed. The remainder of the complement of 100 Neff amplifiers for the high level data system was installed. Wiring was completed from the test cell to the Control Point patch rack for all existing high level data channels. An additional 50 channels were installed in the Motorola time-shared binary data system used for transmission of valve limit indications between the test cell and Control Point.

Gas Scrubber

Thirty-two permanently assigned data channels were installed for the gas scrubber experiment. These channels are identical to

normal Test Cell "C" high level channels and use the same equipment located in the Electronics Room of Test Cell "C" as is used by the normal test cell data system. These channels are simply routed and assigned for the exclusive use in the gas scrubber experimental program. The additional control systems required for the modified gas scrubber have been installed and are now operational.

DDP-116

The completion of hardware testing for the DDP-116 modifications was continued and is now completed. The modifications were principally in the area of the disc memory storage unit and required the assistance of a factory representative. Utility programs to transfer information between the core memory, disc memory, and the CRT have been undertaken and programming is still in progress. A modification to the multiplexer and ana-log-to-digital converter unit is presently in progress to increase its transfer rate from 10 kHz to 20 kHz.

The definition of the application programs to be used for the Phoebus-2A reactor test is essentially completed, and the programming effort has been initiated. A new time history code is being written which will allow for three modes of operation.

In the first mode, the most recent 2500 seconds of data for each of the time histories will be capable of display in the TMR. In the second mode, to be used during a run phase, the time history will be initiated by a sense switch and will display time history data in real time up to 2500 seconds. In the third mode, data during the most recent 24-hour period can be displayed by selecting the

first two digits of the Control Room time period of interest, and the time history program will display 2500 seconds of data after the time selected.

Channel Requests and Data Reduction

The NRX-A6 channels have been cancelled and the wiring removed. Additional channels have been installed for the Phoebus-2 Shutdown Test Series and dual mode turbopump operation. The bulk of the Phoebus-2A reactor channel requests have been initiated through J-17 and are now being processed by EG&G channel engineering. The following is a list of channel requests processed during the report period:

NRX-A6

Cancelled	500 channels
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Facility

New	86 channels
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Cancelled	115 channels
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Revised	301 channels
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Phoebus-2A

New	754 channels
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Revised	84 channels
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In support of the Phoebus-2 Shutdown Test Series, data has been reduced in the following quantities:

Cal-comp originals	8,000 plots
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Sanborn strip charts	150 sheets
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TEST OPERATIONS

Experimental Plans

Experimental Plan II, Phoebus-2 Shutdown Studies

Experimental Plan I of this series was conducted during the last report period, and the objectives and results of the test are contained in the last quarterly report. After NRX-A6 and in preparation for future shutdown studies in this series, it was necessary to perform some rather extensive modifications and repairs to Test Cell "C". A review of the changes is contained in the next section. The principal objective of this test series is to find a method by which the pressure and, hence, flow rate profiles to the reactor and tie tube systems can be made consistent with the requirements to provide adequate cooling to the nozzle tubes on the one hand and cool the reactor core slowly enough to prevent damage to certain critical components in the reactor.

Experimental Plan II was planned to provide a test of two possible modes of shutdown. Analyses in other groups had shown that these two methods held promise in meeting the above requirements. The first method uses a 10-cubic foot gas accumulator to augment the energy stored in the main propellant line by virtue of the compressibility of the hydrogen which it contains. This accumulator would, upon shutdown, produce gas expansion into the main propellant line, thus forcing flow rate into the reactor and tie tubes in sufficient quantities, and at the proper rate, to protect the nozzle and reactor until the high pressure dewar could assume the cooldown function. The accumulator has the additional property

of suppressing acoustic pressure waves in the main propellant line. A second method proposed to supply the additional energy requirements for shutdown was to slow the operation of the turbine control valve so that energy is derived from the turbopump. Additional objectives included the investigation of the effects of system behavior due to the failure of certain critical valves in the facility: open and closed failures of the turbine control valve, open failure of the pump bypass valve, and the failure of the facility throttle valve to close on command. It was also necessary on this test to reevaluate, in light of the higher flow rate requirements of Phoebus-2A, the high pressure dewar, mixing chamber, and liquid nitrogen flow systems both from the fluid dynamic and control aspects.

These shutdown studies were conducted on February 19, 1968. After a "green" run had been performed on the new turbomachinery and no problems uncovered, dynamic response data were obtained on the newly installed dual turbopump speed and flow rate control systems. The next test was an emergency shutdown from the Phoebus-2A intermediate hold conditions at which the flow rate to the reactor and tie tubes is 195 lbs/sec. Upon examination of the data obtained from this shutdown, it was discovered that abnormal operation of the liquid hydrogen pump bypass valves had occurred which rendered the data of little use in evaluating the characteristics of such a shutdown. Mechanical and electrical tests on the valve indicated that the control and indication potentiometers on one of the valves had rotated with respect to the shaft to which it is attached. Hence the valve could not be properly positioned, nor its position accurately determined. The initial failure was found to have occurred in a heater in the valve housing which had allowed

the accumulation of frozen water vapor and nitrogen deposits which caused the malfunctions described. Because this failure required extensive repair and subsequent test procedures, no further turbo-pump operation was performed and the objectives relating to reactor shutdown were postponed. However, it was possible to demonstrate the flow rate and control characteristics of the high pressure dewar system, the mixing chamber system, and the liquid nitrogen system using the Reactor Cooldown Vaporizer. Previous analysis which had shown that sufficient flow rate from these systems could be achieved was confirmed; flow elements in these systems were calibrated and system pressure drops measured. The control systems associated with these cooldown systems were shown to be operable over the range required for the Phoebus-2A cooldown profile.

The next attempt to complete the objectives of Experimental Plan II was performed on February 21, 1968. After all cryogenic systems required for the test had been chilled, DDP-116 generated profiles to the Phoebus-2A design conditions were accomplished. During the ramp to full power hold conditions, a rather substantial leak developed in the Flow Control Room which required an abbreviated list of experiments to be performed at this point. When the shutdown was initiated, control of the test cart valves used to simulate the reactor and tie tube systems was switched to a small analog computer described in a previous section. In an attempt to adjust the reactor simulating valve to account for the rapidly changing reactor impedance immediately after shutdown, the valve was commanded to operate with great rapidity. This valve operation caused a failure of a flare fitting on the valve actuator hydraulic line which

resulted in a massive hydraulic leak on the test cart. The hydraulic fluid was ignited by the propellant flare but the fire caused only minimal damage to a support member on the test cart. The liquid hydrogen leak and hydraulic failure caused a termination of test activity for that run day.

Experimental Plan II-B, Phoebus-2A Shutdown Studies

Experimental Plan II-B, Phoebus 2A Shutdown Studies, was conducted on March 6, 1968, at Test Cell "C". The primary objective of this experimental plan was to continue the investigation of the capability of the facility flow systems to satisfy reactor and nozzle requirements for an Emergency Shutdown at Phoebus-2A operating conditions. The specific objectives were as follows:

Objectives

- a. To gather additional information on the operating characteristics of the High Pressure Dewar and the Mixing Chamber.
- b. To investigate the acceptability of a new method for establishing and maintaining a satisfactory chill of the Dewar 3 discharge.
- c. To perform controls experiments on the Speed and Flow Loops at Phoebus-2A operating conditions.
- d. To evaluate two procedures for maintaining satisfactory coolant flow to the reactor and tie-tube systems following an Emergency Shutdown initiated either by the CTO or by simulating a valve failure which would cause a parameter change sufficient to trip the shutdown chain.

Test Description and Results

The experimental plan consisted of three types of runs: Dewar 3 blowdown and mixing chamber operation; shutdown studies with and without the gas accumulator for various probable types of failures at full power; and shutdown studies at the intermediate power hold.

To understand the significance of performing the first run, methods of "X" system chilldown used for Phoebus-1B and NRX-A6 reactors were discussed. When these methods were used on previous Phoebus-2A tests, line chilldown was inadequate. The proposed chilldown technique was to use X-103 to chill the line initially and use a trickle flow through X-223 to maintain the line chilldown. The line between X-3 and the downstream check valve would remain unchilled since that gas volume is small and it would probably mix well with LH_2 before arriving at the reactor. The results of this successful test from a preliminary analysis of the data, indicated that the size of a bubble in the LH_2 from Dewar 3 line into the main propellant line was trivial.

During the first and second runs, the performance of the "X" systems on blowdown and the changeover from Dewar 3 to Dewars 4 and 5 flow was examined. The result of the Dewar 3 blowdown on the first test was unsatisfactory. It was determined that the ullage volume pressure decayed more rapidly than desired because ullage gas was flowing out through X-171. For the next test X-171 was closed. In the second run, the "X" system performed as expected, and a smooth transition from Dewar 3 to Dewars 4 and 5 occurred. Mixing chamber operation was conducted to gain frequency response measurements on the system and to provide additional operator training.

The next set of runs were investigations of methods of shutting down the Pheobus-2A reactor from full power operating conditions. A flow of LH_2 through the nozzle tubes must be maintained at all times to prevent nozzle burn-up. Upon shutdown, the change in pressure at the nozzle inlet manifold from 1300 to 500 psig must be controlled during a 0.2-second interval after initiating shutdown. Inlet manifold pressure should be greater than the reactor plenum pressure so that LH_2 continues to flow through the nozzle tubes.

The first run of this series of tests was an H-60 closure shutdown from full power hold with GH_2 accumulator and Dewar 3 on-line. Valve B-15 and B-215 were ramped to final shutdown positions using exponential controller output signals rather than being controlled by the analog computer TR-10. System behavior upon shutdown, when turbine control valve H-60 suddenly fails closed, followed the expected performance. The closing rate on H-60 has been reduced by changing the Moog servo actuator and installing an orifice in the hydraulic line to the Shutdown servo valve. The results of this run showed that the drop in pressure at the nozzle inlet manifold (BP-15) was satisfactory.

During another run, the performance of the turbopump system when H-60 fails open was investigated. As H-60 opened to 55%, system parameters did not exceed any trip input valves, and a manual shutdown was ordered by the TGL. During this run, L-11 was not on the shutdown chain and did not close on shutdown command. The experimental data indicated that the bubble of gas did not travel through L-11.

The last shutdown from full power with the accumulator on-line was accomplished by stepping the LHBV, L-109 to 35%. The shutdown

chain was tripped by the tie tube delta flow input. It was expected that the nozzle delta flow input to the shutdown chain would have caused the shutdown. Investigation of this unexpected event is in progress.

Two additional runs were made to further investigate the system behavior during a shutdown from the intermediate power hold. The first was an emergency shutdown initiated by the CTO and the second was caused by an H-60 closed failure. Both runs were successful in that systems behaved as expected. A reentry followed in order to tighten up the packing bolts of L-21 and X-103 and eliminate the LH_2 leaks.

Two additional full power shutdowns were performed to evaluate an alternate method for preventing unacceptable reactor and tie tube flow rate transients. This method utilizes the available turbopump rotational energy to maintain the nozzle supply pressure at a level acceptable for reactor shutdown. The opening rate of L-109 and L-209 was selected to keep line pressure up while preventing the pumps from stalling during a shutdown. The H-60 rate limit was the same as for previous shutdown tests, but the gas accumulator was not used. The preliminary investigation of the data disclosed that for the CTO manual Emergency Shutdown and the H-60 closed failure the shutdowns were satisfactory.

Experimental Plan III, Phoebus-2A Shutdown Studies

Experimental Plan III, Phoebus-2A Shutdown Studies, was conducted on March 20, 1968, at Test Cell "C". It consisted of two major parts:

(1) a "green run" on the newly installed Mark 25 turbines and (2) a checkout of all flow systems that are required for Phoebus-2A testing. In addition, the operation of the emergency shutdown systems and procedures were verified to assure that they are adequate to protect the reactor in the event that an unplanned Emergency Shutdown is required.

Objectives

- a. To verify the test cell systems' integrity for performing the Phoebus-2A Test Series.
- b. To perform a "green run" on the dual Mark 25 turbines in RPM Control to 30,000 rpm to verify the turbopumps' operation.
- c. To perform a full power Phoebus-2A programmed profile run on the LH_2 flow systems including a simulated reactor cooldown using Dewar 3, the mixing chamber, and RCV LN_2 cooldown systems.
- d. To obtain frequency response data on the LH_2 flow control system and to perform step and pseudorandom response tests on the LH_2 flow and tie tube systems.
- e. To verify further the adequacy of the GH_2 accumulator and Dewar 3 for providing protection of the reactor and pumping system during ESD's and turbopump malfunctions.
- f. To perform main system and tie tube system tests simulating flow requirements in performing the Phoebus-2A Experimental Plan III checkout tests.
- g. To perform a program shutdown during a flow ramp to the full power hold.

- h. To verify the emergency operation of the reactor cooldown system using emergency electrical power and hydraulic accumulators.
- j. To verify the failure mode of critical cooldown valves with flow through the systems.

Test Description and Results

The reactor test car located at the test cell face and equipped with programmable valves B-15 and B-215, was used to simulate the reactor and tie tube flow systems' impedances. The facility flow systems were of the configuration to be used for the Phoebus-2A Test Series.

Simulated reactor profiles were programmed, using the DDP-116 computer to generate the required profiles of each programmed variable during the test runs. These included profiles to operate the flow systems to be used during the Phoebus-2A Experimental Plan IV Full Power Run; a test that included the reactor cooldown systems operation in which the accumulator, Dewar 3, mixing chamber, and the Reactor Cooldown Vaporizer (RCV) systems were verified en suite. At the full power hold, a frequency response measurement was performed on the LH_2 flow control system. A simulated Phoebus-2A Experimental Plan III checkout run was performed to verify the program profiles and to use the procedure required for the reactor tests; step and pseudo-random responses were performed on the main LH_2 and tie tube flow systems. In addition, test runs were performed that verified the system adequacy during an Emergency Shutdown from the full power hold; turbopump malfunction shutdown; and a program shutdown during a ramp up to the full power hold.

Operation of the reactor cooldown system was performed with the critical AC power switched off-line to determine if the emergency electrical power and hydraulic accumulator system can be used to shut down the reactor safely; this test was satisfactory. Failure mode tests of the critical cooldown valves required for reactor cooldown were performed to verify the proper position on loss of actuation pressures; the failure mode positions were recorded for future reference.

A tie tube flow test was performed to simulate the tie tube hydrogen reactivity experiment required for Experimental Plan III of the Phoebus-2A Test Series. During the flow tests, GH_2 was supplied to the simulated reactor impedance valve B-15, while tie tube LH_2 flow was being varied to obtain the hydrogen reactivity effects.

Turbine Testing

The effort to identify the cause of turbine blade failures reported during the last report period continued. Two tests were conducted to determine whether the vibrations observed using an accelerometer mounted on the turbine case were attributable to mechanical vibration of the turbine blades or to acoustically associated phenomena within the turbine stages. The approach taken in both tests was to change the gas used to drive the turbine on the hypothesis that a change in the sound velocity in the gas would shift the vibration frequency or turbine speed at which the acoustically generated vibrations appear, but leave unaffected those vibrations which were due to mechanical blade resonances.

The first such test used nitrogen as the turbine drive fluid and was performed without the pump attached to the turbine. Nitrogen was supplied to the turbine from a tube trailer and controlled by temporarily installed pressure regulating and hand valves. The turbine was operated at speeds up to 23,000 rpm on this local test. The amplitude of turbine vibrations during this test, if present at all, were of such low level that analysis was impossible.

A second test in this program was conducted on February 18, 1968 in conjunction with Experimental Plan II. For this test, the pump load was attached to the turbine, and a speed of 14,000 rpm was achieved using nitrogen gas as the turbine drive fluid. Another test was performed using helium to drive the turbine to a speed of 24,000 rpm. For comparison, gaseous hydrogen from the tank farm was used to power the turbine to a speed of 24,000 rpm. The nitrogen testing showed little case vibration up to 14,000 rpm. This result suggests that the vibrations observed during hydrogen operation are not predominately acoustic in nature. Had this been the case, the vibrations would have been observable in the 8,000 to 12,000 rpm speed range. When the helium and hydrogen vibration data were compared, it appeared that some vibration resonant peaks remained unaffected by the change in gas while others were shifted by an amount predicted by the difference in sound velocities in the two cases. The preliminary conclusion from this testing is that some of the resonant phenomena observed during hydrogen tests are associated with mechanical effects within the turbine while others are generated by an acoustic driving function.

FACILITY PLANNING AND REPORTING

NRX-A6 Activity

At the conclusion of the NRX-A6 test, a significant fraction of the group effort was devoted to assisting the DRAGON Team in the analysis of facility and reactor data. A preliminary test report was issued by the Joint Test Organization, and a final NRX-A6 test report, which included the evaluation and analysis of the performance of facility systems during the NRX-A6 test series, was issued.

Summary Test Plan

The Summary Test Plan is a document which responds to the Reactor Test Requirements document to show the capability of the test facility to perform the tests as outlined and meet the functional requirements for the Phoebus-2A power test. Extensive work was begun on this document in early January 1968. For a period of approximately three weeks, about one-half of the JTO effort was devoted to the detailed description and analysis of the test facility required in the preparation of the Summary Test Plan. All sections of the report are now in semi-final form except for the section dealing with detailed facility malfunctions.

Several problem areas, unforeseen in the preliminary planning stages, developed in the preparation of the document. From the facility side, it has not been appreciated fully the extent to which a detailed analysis of virtually every system in the test cell would have to be carried out in order to assure adequate flow rates, pressures, and

inventories for the Phoebus-2A reactor test. In the original facility design, it appeared that the sizing of major systems contained an adequate safety factor for testing a 5000 Mw reactor but subsequent data relating to facility performance and a more detailed understanding of the Phoebus-2A requirements have led to an erosion of the previously assumed safety factors. On the reactor side, it has been necessary, because of facility constraints recognized in the preparation of the Summary Test Plan, to modify procedures outlined in the RTR. This has been an iterative process with the reactor design division. Also on the reactor side, the complications in the main liquid hydrogen system, the high pressure dewar system, and the mixing chamber system introduced by the tie tubes, both in the analysis and malfunction areas, has resulted in larger than anticipated effort.

Test Cell "C" Acoustic Studies

During the conduct of the Phoebus-1B and NRX-A6 full power runs some minor damage was sustained on light metal structures at Test Cell "C" which seemed to be explicable only by the acoustic sound field generated by full power operation of a reactor. Among these effects were a failure of the Pump Room blowout shear pins and opening of the doors of the Propellant Pump Room during the Phoebus-1B test, and damage to corrugated metal structures used as thermal radiation protection for critical facility components during the NRX-A6 full power run. Previous acoustic studies by Douglas Aircraft Corporation had pointed out the difficulties and dangers in extrapolating sound pressure level data to higher powered engine operation and the ap-

parent sensitivity of the sound pressure field to the details of nozzle geometry. Possessing no expertise in these areas at NRDS, it was felt that expert aid should be solicited in order to predict the acoustic effects during the Phoebus-2A full power run. To this end, the services of the acoustic and structural groups at Marshall Space Flight Center were obtained on a consulting basis. Test Site effort to date in this area has been limited to a few man-weeks. The effort has consisted in producing available sound pressure data using the power spectral density analyzer available at NRDS to provide inputs for Marshall Space Flight Center digital computer analysis and predictions. Two Marshall Space Flight Center representatives visited NRDS to discuss the particular problems associated with the Phoebus-2A run and inspect Test Cell "C" to gain a feeling for those areas which may present problems or require detailed analysis. A preliminary effort has been initiated to redesign some structures to withstand the acoustic loads expected. These include principally the thermal shields on components on the tops of Dewars 1, 2, and 3, and the bracing of Dewars 1 and 2 flare stack. These proposed designing modifications will be transmitted to Marshall Space Flight Center for their review and analysis.

Facility Modification and Investigations

"X" System and "K" System Check Valves

Analysis of data from previous facility and reactor tests had shown that the check valves separating the high pressure dewar and mixing chamber systems from the main propellant line were susceptible to leaks which allowed hydrogen from the main propellant line

to enter these critical cooldown systems. This leakage had two adverse effects: First, it caused operational problems in that the flow measuring venturi is upstream of these leak sources and hence required the adjusting of reactor flow rate to design conditions at the intermediate and full power holds. Second, and perhaps more important, is that this unpredictable leak rate into the cooldown systems affects the calculated cooldown flow rates and requires undesirable operational manipulations of valves in crucial systems during reactor operation. An improved check valve had been ordered and, in cooperation with the manufacturer, redesigned by J-5. At the conclusion of the NRX-A6 test series, two such check valves were available for installation. For the reasons stated, it was decided that these check valves should be installed before Experimental Plan II. This installation has been completed and some available data obtained during Experimental Plan II. The valves appear to provide superior performance to those previously used.

Mixing Chamber Flow Control Venturi

A detailed analysis of the capability of the mixing chamber system to provide the flow rates required during the cooldown of Phoebus-2A revealed that the flow venturi which had been used on previous reactor tests was too small and provided a serious flow impedance in this system. It was, therefore, necessary to request that J-5 install a venturi in this position which was located in the discharge leg of the Cryogenic Engineering Laboratory flow loop. This installation was completed, and the flow capability of the system was demonstrated to be adequate during Experimental Plan II.

Process Water Heater

Immediately after the NRX-A6 testing was completed, work was begun on the installation of a 21M Btu/hour process water heater. This system is capable to raising the temperature of 300 gpm of water from ambient temperature to 200°F in a single pass. This additional capability is required for Phoebus-2A testing because of the increased requirements of the turbine energy source and the long time useage of the Reactor Cooldown Vaporizer during liquid nitrogen cooling. The 225,000 gallon water storage tank is not adequate to store all the water needed for the planned reactor operation and subsequent cooldown.

Critical Power System

Several major deficiencies in the critical power system at Test Cell "C" have been recognized at least since the Phoebus-1A test. First, the 700 kw dewar generator was not capable of delivering sufficient power to allow operation of the privy and shield water cooling pumps on the critical power system. Second, the system contained an overhead power line and power distribution system from the generator in the Control Point area to Test Cell "C". This led to the possibility of a single failure which could result in the loss of critical power at Test Cell "C". While acceptable protection was supplied by a battery powered inverter system, this single malfunction feature of the critical power system was felt to be a serious defect. To remedy the situation, two new diesel generator systems have been installed, one at the Control Point to supply all control building power needs during a test, and a second at Test Cell "C" which is capable of supplying all essential power requirements at the test cell, including the operation of the borated water pumps. Appropriate

switch-gear is also provided with the modification so that commercial power and diesel generators serve as redundant systems during the test period. This system has been installed and is operational with the exception of complete remote control capability for the test cell generator.

Test Cell "C" Thermal Spray Requirements

An analysis has been performed to determine the required amounts of water which must be supplied to various parts of the test cell, including the pad, to protect major structures and vessels during the Phoebus-2A test. An investigation in conjunction with J-5 has been completed to determine the adequacy of the existing flow nozzles in the thermal spray system to meet Phoebus-2A requirements operating the process water tank at an elevated pressure. A final determination of this system's adequacy for Phoebus-2A has not yet been made pending an analysis of data obtained during Experimental Plan II.

Radiation Damage Investigation

In coordination with EG&G, a radiation history of all critical electronic components at Test Cell "C" has been undertaken. Preliminary analysis has shown that the integrated radiation dose sustained by some electronic components may have reached a value which would cause failure during the Phoebus-2A full power run. While this survey is not yet complete, it has already been determined that some 20 power supplies associated with valves outside shielding structures were approaching the failure limit. Replacements for these power supplies have been ordered through EG&G.

Thermocouple Reference Junctions

A large number of facility and reactor thermocouples require a reference junction near room temperature. Before NRX-A6, these thermocouples had been referenced to a junction in an earth well located in the basement of Test Cell "C". During the NRX-A6 tests it was found that an appreciable fraction of these junctions had deteriorated and relatively low impedances to ground and between thermocouple junctions could be measured. Because of the uncertain reliability of these earth reference junctions, all thermocouples requiring a room temperature reference were supplied from a Pace reference oven. This system, however, has its own set of shortcomings. These are principally associated with the malfunctions of the oven thermocouples which regulate the temperatures of two thermostatically controlled temperature reference blocks. At present, an investigation, in cooperation with EG&G, is underway to determine the best and most practical reference source for Phoebus-2A measurements.

Decontamination

The decontamination of Test Cell "C" began at 0800 hours on December 27, 1967, and was completed at 1600 hours on December 29, 1967. The maximum contamination was found on the reactor pad; a swipe of an effective area of one square foot measured 50/mr/hr (open window). The principal methods used for decontamination included operation of the deluge system and localized water flushing with fire hoses. The amount of water used has been estimated at approximately 275,000 gallons. Radiation exposure of decontamination and monitoring personnel were 210 mrem and 155mrem, respectively. There were no incidents of contaminated skin, hair, or personal clothing for these personnel.

The general test cell area was released from anti-contamination protective clothing requirements by 1600 hours on December 26, 1967. The area around Dewars 1 and 2 were released by 1500 hours on December 27. The flow control room roof and reactor pad were released by 1500 hours on January 2, 1968. Protective clothing is currently required for work performed on the test cell face, reactor shield stand, and the FROG exhaust duct.

Prior to the release of the areas from protective clothing entry requirements, 689 personnel were surveyed for contamination. Seven (7) persons were found to have spot contamination on their skin, and 34 were found to have contaminated personal clothing. The maximum skin contamination was 200 mR/hr (open window). In all instances of skin contamination, decontamination of the affected area(s) was successful. The principal item of contaminated clothing was shoes. The maximum level of clothing contamination was 360 mR/hr (open window).

Two individuals had nasal contamination. The maximum level indicated on a nasal swab was 2.07×10^4 disintegrations per minute. Both individuals were sent to the NRDS Medical Facility for nasal irrigation and then to the Radiation Laboratory for whole body counting.

PROJECT 7317 - REACTOR OPERATIONS

MAD Operations effort during this report period resulted in continuation of remote disassembly and post operative examination of NRX-A6. Support was also provided for the assembly and cold flow testing of Phoebus 2A in preparation for a May full power test.

NRX-A6

The NRX-A6 disassembly effort was completed during this report period. Post operative examinations are still in progress. The hardware condition as noted during the disassembly and initial post operative examinations confirms the capability of the assembly to operate at rated power for a sixty minute period without severe degradation of the core components.

Major items noted during disassembly included:

Visual inspection of the core components showed very little sign of degradation.

The reflector contained a large number of cracks throughout the center ring. Cracks were observed at drum positions 3, 6, 9, 10 and 12. These cracks were on the outside diameter of the reflector and in some cases extended to the ring edges.

Some debris was noted on the periphery of the cluster plates and on both sides of the "O" ring after removal of the core support plate. Samples of this debris were collected for chemical analysis.

Examination of the grafoil wrapper in the region covered by tiles 1-06 through 6-13 showed axial corrosion patterns corresponding to the tile joints. The corrosion pattern was more pronounced toward the aft end.

A major portion of the fuel elements were bonded together and could not be separated with the existing remote GSE. A special fuel element removal tool was designed and fabricated to accomplish the fuel element separation with an acceptable breakage level. The tool pressed out the center element and then was expanded in the cavity, thereby separating the bonded elements.

Detailed results of the disassembly operations are contained in the NRX-A6 Disassembly Report, NTO-R-0141, to be published April 15, 1968.

The following post-operative examination efforts have been completed:

- Inspection of reflector sections.

- Examination and recording of data for nozzle braze patches.

- Examination of core support ring.

- Examination of aft end support ring.

- Examination of tungsten-rhenium nozzle temperature probes.

- Visual examination and photography of major test article subassemblies and components during disassembly operations.

- Fuel element weighing.

- Fuel element photography.

The post operative efforts presently in progress are as follows:

- Support block inspection including BAT.

- Hot end cluster examination.

MULE operations.

Whole body ionization operations.

Reading of thermal capsule temperatures.

Dye penetrant checking, visual and photographic examination of parted reflector segments.

Visual examination of nozzle.

Corrosion depth measurements.

WIPES.

Uranium analysis.

Center element radiography.

Air flow impedance testing.

Incremental weight measurement.

In-cell post test instrumentation calibration.

A report describing the results of the post operative inspection is scheduled to be published on May 1, 1968.

The following Radiochemistry tasks have been completed on NRX-A6 fuel:

Cutting and shipment of fuel slices to WANL Safeguards Engineering Laboratory.

Gross ion measurement.

Two point gamma measurement.

Analysis of reflector piece for activated isotopes.

Work is continuing on the following NRX-A6 items:

Axial gamma scanning.

U, Nb and X coat analysis of fuel slices.

Radiochemical determination of total core fissions.

Comparison of radial fission distribution as measured by gross ion and 2 point gamma techniques.

Completed installation of the mock-up defuser line in preparation for checking backup tool operations.

Phoebus 2A

Technician support was provided to LASL for the continuance of assembly operations and for the instrumentation of the reactor for the T-21 test car and shield buildup, for the preparation of disassembly and postmortem tooling and electrical modifications and for the preparation and checkout of Test Cell "C" for testing of the Phoebus 2A test article.

PROJECT 7327 - ENGINE OPERATIONS

Assembly, transport, integration and checkout was accomplished for the engine assemblies and preparations were continued for the recovery, maintenance, disassembly and performance of postmortem operations on the test article hardware.

XECF

The installation and checkout of the XECF test article in ETS-1 were continued and included modifications to update XECF UTSM to the XE-1 configuration; checkout of engine valve response times; leak checks and calibration testing; and cryoshock tests.

MAD Operations support of ETS-1 in preparation for XECF testing was completed and the NEP-He-1 test was completed on 8 March 1968 in preparation for XECF EP-s.

XE-1

The disassembly, cleanup and reassembly operations of XE-1 were continued and included the removal, cleaning and replacement of the central poison wires. The peripheral poison wires were removed, cleaned and returned to WANL.

Installation of the nozzle was completed on 25 January 1968.

Modification and checkout of the actuator checker gas supply system was completed.

Installation and leak check of plumbing for the actuator drive gas manifold was completed.

The alignment and leveling of the four (4) UTSM on-marks at the eighteen (18) inch interface were completed.

The pump discharge line and the turbine inlet line installation was completed on the lower engine assembly.

The UTSM modification was completed and the eighteen (18) inch interface modification for the control drum actuator overhead vent is in process.

The actuator checker reassembly and acceptance was completed.

The installation of the diluent line on the lower engine assembly was completed and purging of the core through the nozzle torus is continuing.

The fit and adjustment of the nozzle throat plug and the poison wire retention hardware was completed.

RADA/WEMU

Completed modification of the engine disassembly stand to support RADA during remote UTSM replacement checkout.

Initiated upgrading of RADA eighteen (18) inch interface to simulate XE-1 conditions.

Rough draft reports were completed summarizing the results of the two (2) WEMU remote tests conducted in the Hot Bay per procedures NTO-I-0335 ("WEMU Leak Test") and NTO-I-0336 ("WEMU Electrical Checkout").

RADA was transferred to the engine reassembly stand in the Cold Bay to allow realignment of the lower line alignment clamps to fit the RADA configuration for recalibration of the UTSM/Shield nut tool for repair of a damaged Marman clamp and 90° rotation of TEL Marman clamps.

Facilities, System and Equipment

The high pressure air system installation and testing was completed and checked out 15 January 1968. This high pressure air system was required for the operation of special tooling in the Hot Bay.

Modifications to the Motor Control Center #9 were completed on 26 January 1968. Modifications were required for the acceptance of the FEPS Gross Gamma Scanner.

The installation of radioactive drain filters in the Core Disassembly and Examination (CDAE) Cell was continued.

The preparation for the construction of an access road to the Engine Transport System Maintenance Building (ETSMB) was completed.

The sampling of air for particulate matter in the controlled assembly area was continued during the assembly of XE-1.

Completed modification of helium system for checkout of XE-1 actuators.

Cranes/Hoists/Manipulators

Ultrasonic testing of all crane hooks in the E-MAD Facility was completed on 25 January 1968.

Completed work package for installation of new remote controller on V-1 crane.

Continued engineering study of ETSMB crane work scaffold.

Heating, Ventilating and Air Conditioning System

The installation and checkout of acid tanks for the heating, ventilating and air conditioning (HVAC) system was continued.

The HVAC system preheat and chill coils were repaired and a hydrostatic test was successfully completed.

In an effort to upgrade the performance of the HVAC system, ninety-eight percent of the system controllers were cleaned and recalibrated. All of the remotely operated dampers and valves were checked and/or reworked where required to restore proper operation.

The design and fabrication of a new panel for the criticality alarm system were completed. This panel provides for the use of the regular Klaxon for broadcast over the PA system rather than taped Klaxon now installed.

Postmortem/GSE/CDAE

Retrofit and modifications to existing GSE, to be used on the XECF Remote UTSM replacement operation, have been initiated.

The Engine Reassembly Stand (ERS) was transferred from the Hot Bay to the Cold Bay and modifications to the Stand were initiated as a result of the 90-degree rotation of the TEL line clamps.

Three (3) one-inch shims were installed on the ERS pads in preparation for use with the XECF Remote Operations.

Final installation of controlled electrical outlets and regulated plant air disconnects were completed for NRX-A6 Disassembly Operations at windows E-1 through E-5.

Support Stands for the two (2) large air saws in the Hot Bay were designed and fabricated and 3/4-inch hose was installed on the saws.

Ten (10) brackets to support quartz iodide lights were designed, fabricated, installed, and the lamps adjusted for disassembly operations. Variac controls for the lamps were connected to the lamps and checkout completed.

Modifications to the nozzle disassembly stand clamps were completed in the E-MAD Shop per FCO from NRO.

The control drum disassembly stand was overhauled and checked out using a dummy control drum assembly. Electrical and pneumatic disconnects were installed to assist in remote removal of stand as required.

Twelve (12) wooden pallets for use in the Hot Bay were fabricated and delivered to the Hot Bay for NRX-A6 Disassembly use.

The RTV potting machine in Cell #171 has been cleaned, new seals installed, and is now operational.

The vacuum potting fixture in Cell #164 was completed, checked out and is operational.

The installation of the lifting fixture to raise the delta furnace and the transducer shaker has been completed.

The access port into the CDAE has been completed.

The actuator gas piping system engineering package has been completed.

A modification was initiated to provide failsafe operation of the alignment fixtures during power or plant air losses.

The external shielding blister is complete in Cell #8 except for the transport conveyor and guide tray inside the hot cell.

Fabrication of the Linear Variable Displacement Transducer micrometer test unit is 98% complete.

A Hot Bay probe has been designed, fabricated and is operational for testing seals on the reflector.

RTS-MCC/EIV/LOCO

Completed repair of EIV manipulators

Conducted preventative maintenance on the EIV, MCC and L-3 Locomotive.

Layout drawings were completed for installation of the MCC/EIV remote CCTV connector.

Construction Packages

The installation, checkout and final inspection of the Fire and Smoke Detection System were completed on 26 January 1968.

Completed construction of radioactive materials storage and transport area.

The construction contract and installation of shield door guide supports are constrained by the unavailability of the hot bay due to NRX-A6 disassembly schedule.

Contract has been awarded for roof repair at E-MAD.

Design efforts and drafting support were provided for the following:

Mechanical drawings for intercell gate modifications were completed.

An engineering package was initiated for the radiation monitoring.

Postmortem GSE

The design for the CDAE/Cell No. 160 intercell gate drive modifications was completed for fabrication.

The design of a postmortem cell HOCMTS car emergency removal fixture was completed.

A modification of the HOCMTS car control system was completed to permit capability as a backup for the FMHS.

The design was completed and fabrication was initiated for the AP-502, AP-504 and AP-772 pressure transducer bombs for Postmortem Cell No. 8 at E-MAD.

The designs for the AD-701, 702 and 703 linear variable differential transformer micrometer tests (LVDT) and for the AD 301 thru AD 306 lateral displacement micrometer test were continued.

The design and fabrication of a mold die and wire conductor and a conductor mount and clamp were completed for the mercury electrical contactor.

The fabrication, installation and checkout of a torsion balance for one (1) inch incremental weights were completed for Postmortem Cell No. 162.

An element cross-cut fixture for metallography, radiochemistry and cup sectioning was received and checked out for use.

Modifications to the Semkit vacuum potting fixture were continued. A new relief valve has been requisitioned and redesign effort to add adapter plates to cast mold for met. mount casting in Cell No. 164 was continued.

Completed drawing changes for gas actuator system schematic.

Completed drawings for polishing discs.

Initiated mechanical as-built drawings for reactor purge system.

Designed modification to standard connectors to facilitate use of remotely operated manipulator in connecting and disconnecting the CCTV cable connector in the CDAE.

The Radiation Monitoring System electrical schematic drawings were updated to include the relay for incorporation of the new Klaxon alarm panel.

Support Services Contract Activities

Pan American

Work orders were prepared for such items as:

Power receptacle and plug for EIV Car, repair Stokes Vacuum Pump, complete HVAC acid tank installation, completed installation of 208 volt 3 phase power outlet, completed radioactive drain filter in CDAE, clean and seal stack monitor detection pits, perform ultrasonic test of crane hooks, install air supply for metallograph manipulator, supply regulated plant air to Hot Bay.

The following items of work were completed:

Calibration of Fluke AC/DC differential voltmeters, HP null meter, Micro combustion Furnace, charge amplifiers, L&N Bridge, digital voltmeters, Cu/constant thermocouples.

Provide maintenance of Axial Scanner System, E-MAD Facility Radiation Monitoring System.

PROJECT 7407 - ENGINE TEST OPERATIONS

GENERAL

Experimental Plans NEP-He-I and NEP-He-II were conducted on the Nuclear Exhaust System. Facility modifications and subsystem checkout tests were in progress in support of the ETO scheduled program plan leading up to and including XE-1 power tests.

FACILITY CHECKOUT AND ACTIVATION

Nuclear Exhaust System

NEP-He-I was initiated on 1 March 1968. Three (3) of the scheduled nine (9) helium flow tests were satisfactorily conducted. These tests did not require steam generator operation. Subsequent helium flow tests were postponed due to difficulties with the steam generator.

The nine (9) mechanical discrepancies found in the steam generator following NEP-He-I were corrected and NEP-He-II was conducted on 8 March 1968. All of the primary test objectives were met. The helium emergency supply system was successful in preventing backflow of air into the engine test compartment via the NES duct exit during steam generator malfunction simulation.

Post-test inspection of the steam generator revealed two cracked injectors and cracks in the water jackets of

two ignitors. Deformation of the steam line was also noted. For further details, refer to System Performance Evaluation Analysis Report (SPEAR) NTO-R-0139 dated 14 March 1968.

XECF

The remaining portion of the XECF vibration test was completed 20 January 1968 in accordance with Change No. 4 to procedure NTO-I-0399. Large deflections were observed in the turbine inlet line at frequencies of 12 and 16.5 cps.

A second leak test on the installed XECF assembly was accomplished in accordance with procedure P-16 to verify system integrity following completion of the vibration test.

Activities preparatory to the initiation of XECF EP-I included the completion of XECF pre-test inspection and the refurbishment of the steam generator, steam line, main propellant supply line, engine test compartment and various subsystems.

A second steam generator test was conducted to evaluate system repairs made after NEP-He-II. Module No. 1 had a low propane manifold pressure shutdown during

full steam operation. Subsequent investigation revealed a cracked weld at the periphery of the injector face.

Facility Modifications

The following facility modifications were completed or in progress in support of the scheduled Experimental Plans. The Experimental Plans are listed in the existing planned sequence leading up to the XE-1 test program.

Required for NEP-He-I and -II

Reactivation of the steam generator system included replacement of propellant filters, refurbishment of pressure switches, leak testing of the hot gas system and electro-mechanical functional system checkouts. The steam line supports were modified and an anti-vortex dam was installed in an effort to reduce shock loads within the line during startup of the steam generator system.

Completed modifications associated with the engine test compartment (ETC) consisted of replacing the ETC purge line to prevent overpressurization and improve flow control; installation of the PCV-449 emergency helium supply system to prevent air intrusion into the NES duct in the event of a steam generator failure; and repair of the ETC top trough to eliminate leakage of molten eutectic alloy into the cavity between the trough bottom and top of the side shields.

Leaks in the aluminum bellows of the intermediate shield coolant water return line were corrected by replacing the bellows with aluminum pipe.

A redesigned ETC latching mechanism was installed which would withstand pressures developed within the ETC. During functional checkout tests, excessive gaseous nitrogen leaked around the latch actuation cylinder piston rods when the pistons were in the operating position. This deficiency necessitated incorporation of a temporary fix to permit latching of the side shields during NEP-He-I, NEP-He-II and XECF tests.

A GN₂ purge heater was installed to maintain transducer temperatures within the upper thrust structure (UTS) above 40 degrees F. to prevent erratic data recording.

Required for XECF Cold Flow Tests

Modifications which were completed consisted of the engine shield fill and drain system to provide borated coolant water to the engine external shield; LSE console modifications to provide correct indications and control for the safety systems; installation of the test stand equipment room (TSER) inerting system to provide a GN₂ atmosphere during test operations; shrouding of flanges and valves in the hydrogen system between LH₂ run vessel V-5001 and the ETC top shield for controlling possible external leaks at piping and valve

joints; installation of zipper tubing around the electrical control cabling above the ETC top shield to exclude water originating from the fire protection system; the addition of propane flares as a backup NES duct ignition source; and modification of the steam line suspension following the completion of NEP-He-II.

The duct vault and pipe chase GN₂ inerting system was installed and checked out. However, the completion of this modification is pending installation of the duct vault door/pipe chase inflatable seal following the completion of FEP-V.

After conducting NEP-He-II, the existing main propellant line screen filter was removed to permit installation of a stronger filter screen. When the propellant line was disassembled, a cup of fine sand was found between LH₂ run vessel V-5001 and the main propellant shut-off valve. This necessitated performing GN₂ blowdown tests on V-5001, after which the main propellant line was re-assembled and subjected to a cryoshock and leak test.

The repair and reinforcement of defective welds in the fire protection valve pits and underground water piping system serving the valve pits was accomplished. Work remaining consisted of replacing the EIV track at the test stand. It was at this location that a defective coupling

in the 24-inch diameter fire protection water supply line caused a loss of 417,000 gallons of demineralized water in a 25-minute period.

Modifications to the data acquisition system to assure proper system operation were completed except for computer channelization checkout. The system channelization was performed manually preparatory to XECF tests.

Checkout tests were conducted on the Test Diagnostic Center/Data Link System in an effort to correct problems experienced with the Data Link/Computer interface.

Required for NEP-VI

The requirement for NEP-VI was verbally cancelled by SNPO-C on 11 January 1968 per NRO recommendations.

Required for FEP-V

Fabrication of piping and supports was in progress for installation of a cryo-trap to remove all condensible elements from the hydrogen gas supplied to the engine system actuators. Piping fabrication was also underway for the XE-1 cooldown simulator system, which will simulate the engine flow and engine check valves during checkout of the emergency cooldown system in FEP-V.

Design work was initiated for providing an additional vent line from the GH_2 cooldown system relief valve 50-RV-77 into the FS-5001 flare stack.

Required for XE-1 Installation and Checkout

Completed modifications included the flush mounted transducer signal conditioning system; the control room stereo system consisting of dual channel console headsets; the facility kitchen and restroom addition; the propane vaporizer system to eliminate all ignition sources near the hydrogen and propane storage areas; and structural strengthening of supports for the LH_2 storage dewar and tank farm to withstand the seismic shocks expected during future AEC underground experiments.

Modifications which were in progress consisted of installing relief valves for overpressure protection of the helium cooldown line, helium engine purge and GN_2 engine disconnect; backup actuation for critical components in the cooldown system; post ETC checkout punch list items; facility supplementary lighting to aid night operations; and reinforcement of the test stand heat shield to withstand anticipated wind and/or thermal loads.

Other modifications which were initiated but cannot be installed until after the completion of XECF tests included remote operation of the 42-inch diameter main

water supply valve; inch mode of operation for the ETC side shields and the S-3 shield as they approach their parking stops and test position stops respectively; an auxiliary steam heating system as a backup for melting the eutectic alloy ETC trough seals; and means for flushing the NES duct with demineralized water following test operations in order to prevent mineral scale deposits.

Required for XE-1 Test Program

The completed modifications included installation of the Test Stand Control System (TSCS) backup power supplies; the source drive system for checking all ETC S-2 side shield mounted neutron channels end-to-end prior to unlocking the reactor drums; the fast fission channel system required for XE-1 power calibration; control room TV camera for display of control room activities at the A&E Building; and installation of water drains and curbing to control contaminated water runoff from the test stand to specific locations.

Installation of a water deluge system in the test stand and vault areas to provide cooling and decontamination water was continued.

Other modifications which were initiated but cannot be completed until after the completion of XECF or FEP-V consisted of the TSCS experimental controls; TSCS AC

power rearrangement; ATD console modifications; remote control of the LN₂ vaporizer; and surface treatment of concrete for ease of decontamination.

Six GN₂ trailers and associated piping to provide additional gas storage capacity were installed. Completion of this modification is pending receipt of six (6) additional GN₂ trailers.

Computer Programs and Data Handling

Programming of the CDC 3200 computer for Real Time data processing for display in the ETS-1 Test Diagnostic Center and A7E Building visitor's room was continued. Difficulties encountered during program checkout necessitated significant program revisions.

A new calibration program covering "average," "slope," "noise," "non-linearity" and drift" data for each digital data system channel was initiated.

A final master type format was prepared for the Valve Inventory Computerized System.

Data processing was completed for the XECF pre-test inspection (procedure P-16), duct vault and pipe chase inerting system tests and NEP-He-I and-II.

Channel Engineering

Testing of the computer directed patching system and updating of the patching system drawing was accomplished.

Recording Display Requirements (RDR) and Control Requirements were published for the various scheduled test programs leading up to XE-1.

Other Channel Engineering functions which were performed included updating of the Unit List and Transducer Inventory List, preparation of Data Logs, Master Channel Lists and XECF events patch audit.

Other Activities

Operator Training

Operator training was directed primarily towards meeting XECF requirements. The preparation of console manuals was continued.

Documentation

Documentation required for the conduct of NEP-He-I and II was issued. The Test Operating Procedure (TOP) for XECF EP-I was released as was the R-14 issue for EP-II. Procedure P-18 for post-test checkout of XECF at ETS-1 was prepared and submitted for internal and external review.

Due to a change in the cooldown concept for FEP-V, the existing Test Description which was issued for external review will require revisions.

Preparation of XE-1 procedure P-9 for the installation and checkout of XE-1 and ETS-1 was initiated. Internal review of the RDR and Control Requirements for XE-1 was completed. Work was in progress preparing the Support Operations Requirement Document (SORD) for the XE-1 test program.

Operations Analysis

System Performance Evaluation Analysis Review (SPEAR) report NTO-R-1039 for NEO-He-I and -II was issued.

Report NTO-R-0137 related to the checkout of the engine binary valves, TPCV and the TPA bearing purge system checkouts conducted as a part of the XECF pretest inspection (procedure P-16) was issued.

Reports NTO-M-16896 and NTO-M-21076 covering results of the Duct Vault and Pipe Chase inerting test were issued.

Coordination was provided for the FEP-V analog studies and for the functional requirements (FR-132) of the FEP-V permanent control system.

Relief valve settings for FEP-V and XE-1 were evaluated. An analysis was also provided in support of flushing the main propellant supply line with LN₂.

Planning

Configuration control of the ETS-1 facility was maintained and support information was provided for administrative and contractual obligations.

Detailed working schedules, based on the required daily activities in support of NEP-He-I, NEP-He-II and XECF experimental plans, were prepared and utilized as a tool for meeting scheduled test dates.

The ETS-1 Activation and Test Schedules were revised as necessary to circumvent problem areas having an adverse impact on the initiation of XE-1 power tests.