449

Record Copy,

SNPO-C
Ordin

WANL-TME-947

TEST CELL "A" EQUIPMENT ACQUISITION - CY 1965, CY 1966

(Title Unclassified)

MASTER

**Astronuclear Laboratory
Westinghouse Electric Corporation**

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.

WANL - TME - 947

TITLE: TEST CELL "A" EQUIPMENT ACQUISITION - CY 1965, CY 1966

Date: September 22, 1964

Author(s): J. Kutilek, Test Systems Design
M. Vuckovich, Instrument Systems Engineering

Approved by:

R. F. Roller, Supervisor
Instrument Systems Engineering

R. W. Kaisner, Manager
Instrumentation Systems & Facilities Support

H. S. Kirschbaum, Manager
Instrumentation and Control

W. B. Henderson, Manager
Equipment & Facilities Engineering

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, 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.

INFORMATION CATEGORY

UNCLASSIFIED

10-9-64
Authorized Classifier Date

TABLE OF CONTENTS TEST CELL "A" EQUIPMENT ACQUISITION - CY 1965, 1966

	<u>Page</u>
<u>INTRODUCTION</u>	1
<u>REQUIREMENT CRITERIA</u>	2
Contract Year 1965	2
Contract Year 1966	2
<u>EQUIPMENT REQUIRED IN FISCAL 1965 and 1966</u>	4
Recording	4
Data Tape Recorders	4
Tape Center Equipment	4
Oscillograph Recorder	5
Timing System	5
Test Cell "A" Equipment	6
VCO Calibrator	6
Quick-Look Facilities	6
Time Code Reader	6
Decommutator	6
TV System	6
Cameras	7
Heads	7
Lenses	7
Test Equipment	7
CP Power Monitor	7
Film Camera Equipment	7
Kalvar Multi-Mode Reproducer	7
70 mm Hulcher Camera	7
16 mm Camera, Mitchell	7
16 mm Camera, Milliken	8
Cables	8

	<u>Page</u>
<u>EXPANSION AND UPDATING OF TEST CELL "A"</u>	8
Multiplexers	8
Data Amplifiers	8
Signal Conditioning Equipment	8
Voice Tape Recorders	8
Low-Signal Amplifiers	9
Cryogenic Reference Wall	9
Digital System	9
<u>SUMMARY OF DATA ACQUISITION SYSTEM</u>	9
<u>MECHANICAL SYSTEM EQUIPMENT REQUIRED</u>	10
<u>CY 65</u>	
LN ₂ Dewar Modification	13
Tank Farm Modification	14
LH ₂ Pump and Vaporizer	14
Replacement of JBV 1, 2 and 3	15
Mark IX Turbine	16
Removal of Mixing Chamber	16
Emergency Cooling - PCV-18	16
FCR Concrete Wall Shield	16
CY 65 Modifications for NRX/EST	17
Propellant Line Modifications	17
EST Auxiliary Gas System	18
<u>CY 66</u>	18
Table of CY 66 Modifications	19
<u>MISCELLANEOUS EQUIPMENT AND CONTINGENCIES</u>	20
<u>STATUS OF CY 64 REQUIREMENTS</u>	20
<u>SUMMARY OF COST DATA</u>	21
<u>EQUIPMENT COSTS AND REQUESTED FUNDING</u>	21

LIST OF TABLES

Table 1:	EQUIPMENT AND COST FOR CY 65 AND CY 66		22
			23
			24

TEST CELL "A" EQUIPMENT ACQUISITION - CY-65, CY-66

INTRODUCTION

Operational testing of nuclear reactors for rocket propulsion is carried out in two complexes at the Nuclear Rocket Development Site. Test Cell "A" is the older of these testing areas, and is to be associated with NERVA system testing; Test Cell "C" has been used for KIWI and will be used for Phoebus reactors. Presently, both test cell complexes share equipment in the control point and use the same maintenance and assembly (R-MAD Building) capability. Such combined operation presents certain operational difficulties:

1. It is impossible to completely check out and operate the data acquisition system in one test cell while the other cell is in operation.
2. Certain control point equipment is shared and must be moved or repatched to provide operation with the other test cell.
3. Conflicting operations exist in the R-MAD Building which cannot be resolved until the E-MAD Building is operational. It is estimated that six (6) weeks are required between hot test reactors for disassembly, scrubbing of facilities, and preparation for the next reactor.

Originally it was not intended that the test cells be operated or checked out simultaneously. However, with the entrance of the NERVA team, certain simultaneous operations became necessary to avoid unacceptable delays between reactor tests. Realizing this, Aerojet General Corporation initiated studies toward the eventual goal of separate operation in January, 1962¹. A further study by Westinghouse and Aerojet General Corporation² recommended certain modifications that were agreed to by LASL, SNPO, AGC and WANL. WANL-TME-340³ and WANL-TME-631⁴ covered certain modifications which not only tended to separate the test cell operations, but attempted to outline certain expansions of Test Cell "A" to cover additional data acquisition requirements.

The present document is written to delineate the equipment to be provided in Contract Year 1965 and 1966 to provide the degree of operation required by the following criteria and for the expansion and updating of Test Cell "A".

-
- 1 "Study of Modifications for an Operationally Independent Test Cell 'A' ", EG&G, March 16, 1962, EG&G Report No. L-568
 - 2 Aerojet General Corporation, Report No. 2317
 - 3 "Requests for Test Cell 'A' Modifications," WANL-TME-340, May 6, 1963
 - 4 "Test Cell 'A' Equipment for CY 1964, CY 1965," WANL-TME-631, December 16, 1963

REQUIREMENT CRITERIA

Contract Year 1965

During 1965 the criteria for operation are:

1. Capability for simultaneous cold flow and/or reactor power test in both cells is not required. This lack of capability dictates a potential testing interference of about six (6) weeks from initial testing to disassembly.
2. Capability for simultaneous end-to-end instrumentation checkout is required (shared tape recorders must be rechecked after being placed back on line).
3. Equipment shared by both test cells must not require physical movement from one cell to another.
4. Equipment shared by both test cells must have the capability of supplying both cells in parallel during pre-test checkouts on both facility and test articles.
5. NERVA Test Operations must have access as required for user facilities such as instrument, electronics laboratories, channel engineering, etc.
6. Test Cell "A" shall be capable of supporting a full power reactor test which utilizes all the LH₂ presently available (including dewar C). This amounts to a full power test of 15 minutes duration.

Contract Year 1966

During Contract Year 1966 the criteria are as follows:

1. Capability for simultaneous reactor power test operations is not required.
2. Capability for end-to-end instrumentation checkout is required in one cell with the other operating on a cold flow test, except for the usage of tape recorders, which will remain shared in the future. End-to-end instrumentation checkout or cold flow testing in one test cell may be carried out while the other cell is preparing for a power test, up to R-3.
3. Equipment being shared by both cells must have the capability of supplying both cells in parallel during pre-test checkouts of both facility and test articles, with the exception of tape recorders.

4. NERVA Test Operations must have access as required for user facilities such as instruments, electronics and neutronics laboratories, channel engineering, etc.
5. Test Cell "A" shall be capable of supporting a full power reactor test of 30 minutes duration. (Full power equal to two (2) times NRX-A)

Specifically, the criteria above makes it necessary to operate with shared tape center facilities.

It should be noted that the R-MAD Building capability limits the time between hot reactor tests. Approximately six (6) weeks are required from the time of entrance of a "hot" reactor into the disassembly area until another can be brought in for disassembly. With the completion of the E-MAD Facility sometime in 1965, the frequency of testing could be increased with the utilization of both MAD Facilities. However, with the program outlined for Contract Year 1966, simultaneous cold-flow testing could be performed with no delays because of a lack of facility capacity, except where full tape recorder utilization is required.

At the conclusion of the work recommended for Contract Year 1966 certain equipment would still be shared by both test cells:

1. Time Code Generator - this unit would be shared, but the distribution systems would be separated. Trouble in one distribution system would not influence the remaining system. A back-up time code generator would be ready in case of failure of the main unit.
2. Public Address System - only a single public address system, used for both cells, would be available.
3. Laboratory Facilities - the electronics laboratory and calibration laboratory would be shared by both test cell operating groups. Problems here would be mainly those of detailed scheduling and can be minimized by the full cooperation of the user organizations.
4. Data Reduction Area - the computer center and the data reduction facilities located therein would be shared by all operating groups. Detailed scheduling should eliminate major interference difficulties.
5. The portable gas storage trailers are used by both test cells.
6. Tape recorders and tape control equipment would remain shared.

In addition to the equipment requirements, the proposed modifications provide for an increased and modernized capability for Test Cell "A". Items in this category are specifically called out in Table I. Insofar as possible, equipment purchased must be flexible, so that it may continue in service once the future uses of the Test Cell have been determined.

EQUIPMENT REQUIRED IN FISCAL 1965 and 1966

Recording System

Within the data recording center, certain equipment is necessary to achieve the goals indicated above.

Data Tape Recorders

Data tape recorders are magnetic tape machines to record PAM/FM and FM/FM data and time signals. Presently, there are ten (10) FR-600 data tape recorders and one (1) FR-100 data tape recorder modified with FR-600 electronics in the tape center. Allocation of these recorders is as follows:

<u>Test Cell "A"</u>	<u>Test Cell "C"</u>	<u>Shared</u>
4-FR-600	4-FR-600	1 (neutronics) 1 FM Record 1 Direct Record (FR-100)

All recorders must be located in the same area in the Control Point to permit sharing of recorders. Through a patching scheme it is possible to use the recorders assigned for one test cell as back-up recorders while the other cell is operating. Channels assigned to the neutronics recorder are essentially hand-wired to the recorder. In order that the FM record unit may be utilized for neutronics measurements, a patching system and associated electronics will have to be purchased so that both FM recorders may be used. In addition to the eleven (11) recorders in the recorder room, two (2) shared recorders are provided in the Data Processing Center for playback of quick-look data.

It must be pointed out that the recorder allocation as given for Test Cells "A" and "C" does not allow for any spares nor backup of recorders for the criteria as listed.

Tape Center Equipment

Tape center equipment includes test equipment used for tape machine trouble shooting and calibration. Such equipment is rack-mounted in close proximity to the tape machines,

and is interconnected with machines using patchboards. Most of the equipment required has been installed during Contract Year 1964. However, the following equipment has not yet been installed and should be completed during CY 66.

1. Voltage Reference for Calibration
2. Wow and Flutter Meter
3. Wave Analyzer, Distortion
4. True RMS Meter
5. Tape Degausser

Oscillographic Recorder

Present allocation of oscillographic capabilities are:

- 2 Test Cell "A" Quick Look
- 1 Test Cell "C" Quick Look
- 1 Neutronics (shared by "A" and "C")
- 1 Quick Look (Data Processing Center)

Acquisition of another recorder in 1966 will permit the sharing of neutronic recorders to end. Allocation will then be:

- 2 Test Cell "A" Quick-Look
- 1 Test Cell "A" Neutronics
- 1 Test Cell "C" Quick-Look
- 1 Test Cell "C" Neutronics
- 1 Quick-Look (Data Processing Center)

Timing System

The timing system is used to furnish time signals to all test locations for simultaneous recording with the data. No plans exist for separation of timing systems. However, the present timing system has no backup, and in case of failure extreme loss of data could be anticipated. The timing system is essentially serial in nature, and loss of one essential component could result in loss of all timing signals. A duplicate timing system is proposed to permit redundant or separate operation as required. Because this spare timing system is not essential to present operations, it has been included in the CY 1966 portion of the cost estimate.

Test Cell "A" Equipment

VCO Calibrator

Presently, only high level commutator signals are routed through the VCO calibrator. Since it is requested that the outmoded Bendix commutators be replaced by more advanced units, the present VCO calibrator should be redesigned to handle all the commutators used in Test Cell "A", or another VCO calibrator purchased to handle the replacements for the Bendix units.

Quick-Look Facilities

Quick-look facilities are those facilities (excluding recorders) used either for checking data in real time during a test, or for checking data in the brief time period between tests or phases of a test. Present quick-look facilities are inadequate to perform the required functions for both narrow and wide band data.

Time Code Reader

The ROVER time code consists of a group of digital signals representing elapsed time in seconds. A digital translation device is needed to recover the time signals, thus permitting correlation of data with data or data with time, in the quick-look facility of the Data Processing Center. The time code reader may be similar to that being used to read the 1KC modulated time code in the data recorder room.

Decommutator

PAM/FM data is commutated with a minimum of 42 channels available on each composite signal. While it is true that such data can be viewed using an alternate Offner amplifier output, long lines are required to transmit this data to the control point and an insufficient number of Sanborn recorders exists for real-time viewing of low-priority signals. Since two (2) decommutators exist in the quick-look facilities (Data Processing Center), these low-priority signals may be separated and viewed between tests or phases of tests. Since no additional recorders are anticipated, it must be pointed out that only two (2) Sanborn and one (1) CEC recorders exist at this facility, therefore limiting the number of channels to those that can be handled by these recorders.

TV System

The present shared television system is inadequate for simultaneous checkout of equipment or for simultaneous operation. Camera equipment is shared by both test cells, as are most other TV System items. During CY 64 LASL had requested and budgeted most items required to provide adequate operation of both test cells. These items have been received and are waiting scheduling for installation.

Additional equipment requested above the LASL budget includes:

Cameras. Three radiation-resistant cameras for installation in close proximity to the test article. LASL has purchased three (3) radiation-resistant cameras to be used on KIWI B4E. These should be available for NERVA in CY 65. However, two (2) additional non-resistant TV cameras are requested to provide sufficient back-up.

Heads. Two (2) additional pan and tilt heads are requested plus a single tripod for camera mounting and control for the two requested cameras.

Lenses. Two (2) additional lenses are requested for the television cameras.

Test Equipment. Laboratory test equipment for use with the television system is requested for CY 1965. Equipment includes a scope, signal generators, etc.

CP Power Monitor

A power line level monitor for the control point is necessary to monitor voltage levels at the Control Point.

Film Camera Equipment

The following photographic equipment is needed to permit NTO to meet commitments for photographic records, both microfilm and movies, which will be taken during NRX tests. This equipment is needed to provide the facilities for making microfilm records, backup capability for present equipment, and to cover special requirements.

1. Kalvar Multi-Mode Reproducer: This will replace the present obsolete equipment now being used to make microfilm records. The present equipment is extremely difficult to use and requires a great deal of trial and error adjustments before microfilm copies of the proper densities are made. Being quite old, the machine is down for repairs quite frequently.
2. 70mm Hulcher Camera. This camera can be operated at slow frame rates and will provide excellent resolution for documentary type pictures which would be photographed from the South Tower. Large size photographs can be made from single frames; the camera would also serve as a photographic chronometer of tests performed on the test article.
3. 16mm Camera, Mitchell. This is needed to provide a spare camera for this group. Four (4) of these now exist, but there is no spare for use in case of a 16mm camera failure.

4. 16 mm Camera, Milliken: This camera has adjustable frame rates up to 400 fps and would be used to provide high speed movies of the test article during portions of an Experimental Plan. It would also serve as a backup camera for the 16mm group when not being used in high-speed work.

In addition, certain modifications must be made to present bunkers.

Cables. Because of a shortage of cabling on NRX-A2, and in view of the number of measurements anticipated in the future, a minimum of 10 new triplex cables should be installed between Test Cell "A" and the Control Point. Presently there are 200 wide-band channels at Test Cell "A" which utilize 40 triplex cables for transmission to the Control Point. Ten (10) of these cables are being used for the neutronics system; therefore, reducing the wide-band channel capacity to 150 channels (five (5) channels per cable by means of linear mixing). Whereas this quantity is deemed necessary, fifteen (15) additional cables for a total of twenty-five (25) cables should be installed in order to obviate opening the cable trench in the future.

EXPANSION AND UPDATING OF TEST CELL "A"

In addition to those equipment additions necessary, certain items should be acquired to update and expand present capabilities in the Test Cell "A".

Multiplexers. The Bendix rotary switch multiplexers used in Test Cell "A" do not give sufficient sampling speed to yield data of higher frequencies than 1 cycle per second. Modern low-level, differential input multiplexers give a higher sampling rate and have lower noise characteristics. Three (3) such multiplexers (made by Systems Engineering Laboratories) will be loaned for NRX-A3 by LASL. It is suggested that LASL be requested to furnish four (4) such multiplexers until CY 1965, and eight (8) such units be purchased in CY 1965, completely replacing the outmoded Bendix units.

Data Amplifiers. Narrow band DC amplifiers will be needed to replace the present Offner amplifiers within several years, and to extend present capabilities. Frequency responses of forty (40) cycles per second or less are sufficient in this application.

Signal Conditioning Equipment. An additional eighty (80) channels of bridge-type signal conditioning equipment, similar to the recently purchased EG&G equipment, should be added to the fifty-eight (58) currently installed.

Voice Tape Recorders. Four (4) additional voice tape recorders are required for CY 1965 to record voice information during testing and checkout.

Low-Signal Amplifiers. To insure greater accuracies in cryogenic environments, it is requested that amplifiers having extremely low noise and very high gain be purchased for use with thermocouple measurements. Approximately 20 channels should circumvent present difficulties.

Cryogenic Reference Well. As a result of gross temperature measurement errors experienced during NRX-A1, it is requested that a cryogenic reference well, similar to that installed in Test Cell "C", be provided to insure good temperature readings in the cryogenic regions.

Digital System. An attempt should be made to increase the overall data system accuracy of Test Cell "A". Difficulties with temperature measurements on NRX-A1 and NRX-A2 have indicated a need for greater accuracies.

Presently, signals from transducers are routed through signal conditioners, amplifiers, voltage controlled oscillators (wideband system) or commutators and voltage controlled oscillators (narrow band system), over long lines and to analog tape recorders. During processing signals must then be digitized and stored on digital tape for future use. However, if a digital system (similar to that being installed at ETS-1) were provided, data system accuracy would be improved over the analog techniques now being used and conversion would not be necessary. With the digital data in IBM format, data would be put directly on digital tape, thus removing many errors which exist in an analog system. Reduction time of data would be reduced and less tape recorders would be required for the system. With the digital system, data could be accurately recovered even with high system noise levels.

Change-over from the analog system to digital could be made gradually at a rate of approximately 50 channels at a time and should be made consistent with the future test requirements and usage of Test Cell "A".

SUMMARY OF DATA ACQUISITION SYSTEM

The equipment described within this report represents that which is required to meet the criteria for CY 65 and CY 66. Equipment for expansion and updating should be installed during the requested times in order that increased flexibility and accuracy of the data system may be realized.

MECHANICAL SYSTEM EQUIPMENT REQUIRED

The following mechanical system additions are necessary in Test Cell "A" to expand and update the cell for reactor testing in CY 65 and CY 66.

For CY 65, it is proposed to operate reactors and NRX/EST for up to 15 minutes at full power. This can be accomplished by modifications which can be performed in time for NRX-A3 and NRX-A4. It will not sacrifice fluid storage for emergency contingencies. This capability is based on:

1. Initial tank farm pressure - 3350 psig at 80°F at start of run.
(50°F will give a slightly more optimistic amount of gas available if a winter test is contemplated.)
2. Initial GH₂ purge (flare, etc.) - 250 lb.
3. Dewar pressurization - 85 psig.
4. Mark IX turbine requirement - 6.5 lb/sec. (Flow rate required for full flow, full power operation - estimated flow rate to be used until experimental data is available. 5.5 lb/sec is also forecast as the full flow, full power turbine drive requirement.)
5. Minimum GH₂ turbine pressure (tank farm) - 1000 psig.
6. Emergency ambient GH₂ cooldown requirements from a scram at full power. (Initial flow rate independent of time at full power)
 - A. Reactor restart - Flow through normal flow path.

Initial flow rate	21 lb/sec.
Final flow rate	3.5 lb/sec @ 600 sec.
 - B. No reactor restart - Flow through dome.

Initial flow rate	25 lb/sec 0 - 30 sec.
Final flow rate	5 lb/sec @ 600 sec.

(GH₂ is not necessarily used for full 600 sec.)

7. Minimum GH_2 tank farm pressure to flow 25 lb/sec - 1150 psig.

8. Emergency ambient GHe cooldown requirements.

A. No reactor restart - Flow through normal flow path.

Initial flow rate 40 lb/sec.

(Initiating flow after first reducing chamber temperature)

Final flow rate (Switch to LN_2 as yet not determined. By increasing flow rate capability of LN_2 system, can determine switch over which will provide complete inert cooling capability.

9. Minimum tank farm pressure 300 psig.

To meet the stated requirements and ground rules above, it is proposed that the tank farm be arranged as follows:

STORAGE DESIGNATION OR BOTTLE NUMBER	FLUID	USAGE
1, 6, 7, 8, 9	GH_2	Turbine Drive
3, 5	GH_2	Initial purge, dewar pressurization, turbine drive, emergency cooldown
2A, 2B, and 4	GHe	Emergency cooldown, purge
Six (6) trailers	$\text{GN}_2(500^\circ\text{R})$	Purging, inerting, LN_2 dewar pressurization
LN_2 dewar	LN_2	Reactor cooling
LH_2 dewars	LH_2	Propellant

With this proposed arrangement of fluid storage, the following tabulation of uses is available:

FLUID	SERVICE	SOURCE	FLUID AVAILABLE LB.
GH ₂	Initial purge	Banks 3 & 5	250 lb.
GH ₂	Initial dewar pressure	Banks 3 & 5	210 lb.
GH ₂	Turbine	Banks 1,6,7,8,9,3 & 5	6480 lb.
GH ₂	Run dewar pressure	Banks 3 & 5	550 lb.
GH ₂	Emergency cooldown	Banks 3 & 5	770 lb.
GH ₂	Normal cooldown and emergency cooldown	Banks 1,6,7,8,9,3 & 5	3740 lb.
GHe	Emergency cooldown and purge	Banks 2A, 2B & 4	5750 lb.
GN ₂	Purge, inerting and LN ₂ dewar pressure	Trailers (H.P. Gas) (4000 lb/60,000 SCF Trailer)	24,000 lb.
LN ₂	Reactor cooling	LN ₂ dewar facility	87,700 lb.

The above table is the result of optimization of existing tank farm storage capabilities (plus minor system modifications). Usage flow rate demands versus storage pressure levels at various times during typical test result in more than one use for each bottle and in some cases saving a bottle at high pressure (keeping remote valve at outlet of bottle closed).

To perform full power reactor tests of up to 15 minutes duration in CY 65 with the arrangement just discussed, the following modifications are proposed: (A special section is devoted to the proposed NRX/EST modifications for the latter part of CY 65)

CY 65 MODIFICATIONSLN₂ Dewar Modification

A LN₂ dewar (13,000 gallon) and a vaporizer have been installed at Test Cell "A". Associated piping connects this equipment into the Flow Control Room. The vaporizer is capable of an output of 5 lb/sec of 200°R GN₂.

The fuel element temperature and the level of decay heat set the earliest time in cooldown when 5 lb/sec of cold nitrogen can be used. After a long duration full power test (15 minutes), the level of decay heat is the primary factor in determining the earliest time when 5 lb/sec of cold nitrogen can be used. Two factors in favor of using nitrogen cooling earlier in the cooldown are:

1. It is the cheapest coolant available at the test site.
2. The inert qualities are useful in emergency situations.

It is proposed that capability be provided for higher flow rates of cold nitrogen at Test Cell "A". Higher flow rates will make nitrogen available sooner in the cooldown sequence.

The objective can be accomplished by supplying LN₂ directly from the existing dewar and bypassing the existing vaporizer section and mixing system. It is proposed to pressurize the dewar by means of GN₂ supplied from trailers. To provide for this system the following modifications are necessary:

1. Provide a gas trailer connection line to the existing pressurizing coil outlet pipe. Install a pressure control valve in the gas trailer line.
2. Increase the size of the LN₂ pipe downstream of dewar liquid discharge valve to a point where a new tee can be installed.
3. From the new tee install a full size line to connect with the existing cold gas outlet pipe. Provide a relief valve and flow control valve and flow measurement in this line.
4. Insulate dewar LN₂ outlet pipe, liquid discharge valve, and new bypass line and components all the way to the existing cold gas outlet flange to meet existing insulated cold gas main run.

These modifications will not interfere with the present operating features of the vaporizer installation. It is estimated that the modifications proposed will cost \$25,000.

Tank Farm Modifications

The proposed tank farm arrangement requires that Bank No. 1 be switched from helium to hydrogen. The modification consists of paralleling Bank No. 1 with No. 6, No. 7, No. 8 and No. 9 for use in turbine drive. This is accomplished by installing a 4" spool piece and blind flange on the outlet of Bank No. 1.

The proposed use of six (6) trailers for high pressure GN_2 storage to satisfy the requirements for GN_2 for inerting, purging and other low flow services imposes a need for modification of the existing piping around Bank No. 2.

A summary of the proposed modifications (Reference Drawing No. WANL-NT0 715J004 Flow Diagram Test Cell "A" September 10, 1964) is as follows:

1. Supply trailer park for six (6) trailers.
2. Connect a 3" manifold pipe, equipped with trailer connections.
3. Disconnect pipe between OBV-15 and the 3" OBV-6 line, and install 3" pipe from OBV-15 to the 3" OBV-6 line downstream of check valve 34. In the new pipe install a check valve (flow direction away from OBV-15) and a bleed valve between the newly installed check valve and OBV-15.
4. Connect the room inerting header to the purge header immediately downstream of BV-34 by means of a new 1- $\frac{1}{2}$ " pipe and manual valve.
5. Close valves BV-20 and BV-34.

These modifications are estimated to cost \$45,000.

High Pressure LH_2 Pump and Vaporizer

Presently the high pressure gaseous hydrogen is transferred to the tank farm bottles from the stationary pump and vaporizer located at the tank farm fill station. This stationary high pressure pump and vaporizer at the fill station takes liquid hydrogen at low pressure from the contractor's trailer, boosts the pressure to 3500 psi and vaporizes the liquid to ambient

high pressure gas. The contractor's trailers are normally kept at the fill station for 20 hours to unload 7800 gallons. The demurrage charge for the trailer and driver is \$15.00 per hour after four (4) hours. In addition, there is an hourly overtime charge for two (2) technicians of \$4.10/hour for the last twelve (12) hours of the unloading operation.

It is recommended that a new pump and vaporizer be purchased and installed to handle liquid hydrogen from the Test Cell dewars and transfer high pressure gas to the tank farm. By this method the contractor's trailers can quickly dump liquid hydrogen into the existing dewars. The transfer operation of gas to the tank farm can be performed during normal working hours, thus saving the overtime and demurrage charges. Equally important is the capability to top off the tank farm bottles when necessary without trailer scheduling problems. The run time on NRX-A2 was limited by tank farm pressure because of the one day weather delay and the resultant lower initial bottle pressures due to purging and pressurization operations. This modification will also provide for faster transfer operations before a reactor restart and it gives a much needed backup for the existing stationary pump unit at the tank farm fill station.

On prior reactor tests, around the clock effort was required to keep the present pump operating.

The estimated savings from demurrage and overtime based on three (3) trailer loads per tank farm fill and eighteen (18) tank farm fills per year would be \$30,000. The estimated cost of this modification is \$60,000.

Replacement of JBV-1, 2 and 3

The main dewar shutoff valves JBV-1, 2 and 3 are 8" ball valves. Over the past two (2) years, there has been a continual problem of leaking associated with all three (3) valves. Recently the valves were overhauled, but the leaking was not corrected. The valves have been maintained to the limit of their effectiveness.

The two problems associated with the valves leaking are the wasting of gaseous helium and the increased boiloff of dewars. Both of these problems are a result of helium leaking past the valves and bubbling through LH_2 in the dewars. It is proposed that three butterfly valves such as has been supplied with the new dewar "C" be procured and installed as replacements for the present ball valves. This modification is estimated to cost \$42,000.

Mark IX Turbine

The new Mark IX turbine and spares are needed early in CY 65 to provide the necessary increased reliability for longer run times. No additional funds are shown for this item since it is supplied under a separate contract. Only minimal modifications to the Test Cell are necessary to accept the new turbo-pump package.

Removal of Mixing Chamber

A meeting was held on November 20, 1964, at WANL to determine the future usefulness of the mixing chamber. The decision was made to remove the mixing chamber from the Flow Control Room before NRX-A3. It was agreed that complete physical removal is preferable. The estimated cost is \$500.00 for removal.

Emergency Cooling - PCV-18

Dome end cooling is to be provided through a proposed larger size line and valve. The older 3" system requires a high bank pressure to obtain required flows. By replacing this system with a 6" system, a significant increase in usability of the stored gas is obtained. Although the initial flow rate is independent of the time at full power, the integrated amount of coolant is proportional to the length of run. With the higher impedance of the 3" control valve and piping, the system will not be able to follow the flow rate demand with time.

The estimated cost of the proposed new control valve and piping is \$20,200.

FCR Concrete Wall Shield

A requirement exists for a heat shield to protect the FCR concrete wall during long duration full power tests. Since tests are contemplated which involve restarts to full power for long duration, it is imperative that serious spalling and ultimate structural weakening of the concrete be avoided. It is proposed to install a light weight shield to protect the wall from both the flame radiation and attenuate the gamma radiation. The shield is estimated to cost \$15,000.

CY 65 Modifications for NRX/ESTPropellant Line Modification

The existing 8" propellant system will require modifications for performance of NRX/EST. It is proposed that installation of a facility bypass be made to provide a direct, controlled flow path from the dewars to the 8" penetration in the test car plug leading to the suction of the EST turbopump. The FE-4 venturi will be relocated to allow room for two (2) spool pieces to be installed on its downstream flange. One will connect the dewar line directly into the suction side of the facility turbopump. The EST spool piece will direct dewar flow into an analog control valve and filter located parallel to the existing ACV-3 line. An additional spool piece will be required to direct the flow into the 8" penetration on the test car. After NRX-A3 and NRX-A4, a spool piece will be required to redirect the ACV-3 flow from the 8" plug penetration to the 6" plug penetration.

Cost Estimate Breakdown for Propellant Line Modification

Spool Pieces

FE-4 to ACV	\$5700.
FE-4 to facility turbopump	3000.
JBV-3 to FE-4	6100.
(ACV) filter to plug	6000.
(ACV-3) filter to plug	6000.
Filter (vacuum jacketed)	2600.
ACV valve	15000.
OBV valve	2000.
Safety relief	750.
Check valve	100.

\$47,250.

EST Auxiliary Gas System

The requirement exists to provide purge gas to various lines and components in the engine system located on the test car. Some of the requirements are:

1. Continuous vent line purge.
2. Initial pump and propellant line purge.
3. Pneumatic actuation of the TPCV with low pressure helium.
4. Pneumatic actuation of all other valves on test car with high pressure helium.
5. Hot, dry gaseous N_2 and gaseous He for purging, inerting, drying and heating the transmission of the TPA.

It is proposed that a valve panel be supplied for providing gas at the required pressures, temperatures, and flow rates. This panel is estimated to cost \$5000.

CY 66 MODIFICATIONS

It is proposed for CY 66 that funding be made available for reactor testing to power levels twice that of present NRX-A for thirty (30) continuous minutes. In order to estimate the additional costs attendant to this testing, the primary factors considered were:

1. LH_2 flow rate - 145 lb/sec.
2. Facility LH_2 pump discharge pressure - > 1500 psi @ 145 lb/sec.

The table below summarizes the proposed modifications for CY 66.

ITEM	DESCRIPTION	QUANTITY	COST
Dewar System	LH ₂ - 300,000 gal.	1	\$1,000,000.
Gas Bottles	GH ₂ - 1750 ft ³ - 3500 psi	14	2,100,000.
Gas Bottles	GHe - 1750 ft ³ - 3500 psi	3	450,000.
Dewar System	LN ₂ - 45,000 gal.	1	300,000.
Piping and Valves	LH ₂ , GH ₂ , GHe, LN ₂		500,000.
Auxiliary Systems	Hydraulic, Neutronics, Water, Electrical		425,000.
(Turbopump not included)		TOTAL	\$4,775,000.
(The systems include I & C)			

The present piping is not adequate for the flows and pressures given. The primary feed lines from dewars and bottles are satisfactory; however, new headers will be required in some cases. There are alternate methods for obtaining the required increased gas storage. These have not been factored into the above estimate.

1. A tie line between Test Cell "A" and "C".
2. Additional gas trailers.
3. Surplus gas bottles.

MISCELLANEOUS EQUIPMENT AND CONTINGENCIES

This estimate provides for minor systems checkout equipment, general mechanical, instrumentation and electrical hardware including spares. It is requested that this equipment be provided in CY 65.

STATUS OF CY 64 REQUIREMENTS

The following paragraphs show the status of the equipment which was to be installed during CY 64 (see WANL-TME-631, "Test Cell "A" Equipment for CY 1964, CY 1965").

1. Three recorders were requested. No additional tape recorders were installed. Because of the criteria now set forth, tape recorder requirements have been deleted.
2. Some of the tape center equipment has been installed; however, those equipments which have not been installed have been resubmitted in CY 66 as shown in Table I.
3. The Sanborn Checker has not been installed, although it was requested for CY 1964. The present Sanborn Checker is being shared by Test Cells "A" and "C".
4. The TV system has been purchased and is waiting for scheduling of the installation. It is felt that the additional TV system will be installed and checked out before the end of the year. TV camera equipment requirements have been revised and resubmitted as shown in Table I.
5. The Neutronics system requirements have not been fulfilled during CY 64; therefore, they are resubmitted in Table I for CY 65.
6. The CP power monitor has not been installed and is being resubmitted for CY 65.
7. Requests for film camera equipment have been revised in CY 65.
8. Requests for equipment for updating and expansion of Test Cell "A" have been revised in areas of multiplexers, data amplifiers, demodulators and signal conditioners. Presently, none of the CY 64 requests have been carried out except for some of the demodulators. Additional high gain amplifiers have also been requested in this revised section of Table I.

9. Additional Neutronics Laboratory facilities have been provided in a trailer near the water tower at the CP area thereby eliminating sharing of the Neutronics Laboratory by both Test Cell operating groups.
10. All other CY 64 requirements have been fulfilled.

SUMMARY OF COST DATA

The program outlined in Table I is designed to increase the full power run duration time and bring about a degree of separation between test cells necessary to meet the criteria for CY 65 and CY 66.

EQUIPMENT COSTS AND REQUESTED FUNDING

A cost analysis for the items covered above including requested times for funding are given in Table I.

TABLE 1 EQUIPMENT AND COSTS FOR CY 65 AND CY 66

[illegible]

TABLE 1 EQUIPMENT AND COST FOR CY 65 AND CY 66

		CY 65					CY 66					Remarks
	EQUIPMENT	No. Req'd	No. Fr. LASL	Unit Cost	LASL Cost	Add'l. Cost	No. Req'd.	No. Fr. LASL	Unit Cost	LASL Cost	Add'l. Cost	
E.	NEUTRONICS SYSTEM											
1.	Power Integrator	2	2	4,000	8,000							
2.	Wide Band Neutronics	1	1	16,000	16,000							
F.	CP POWER MONITOR	1		1,000		1,000						
G.	FILM CAMERA EQUIPMENT											
1.	Multi-Mode Reproduc	1		4,000		4,000						
2.	70 mm	1		5,000		5,000						
3.	16 mm	4		5,000		20,000						
4.	16 mm (Adj. Frame Rate)	1		5,000		5,000						
5.	Bunker Modification	2		20,000		40,000						
H.	CABLING											
1.	Triplex Cables	25				35,000						
I.	EXPANSION AND UPDATING OF TEST CELL "A"											
1.	Commutators	8		12,000		96,000						LASL will be requested to furnish 4 multiplexers thru 1965
2.	Data Amplifiers	100		425		42,500	150		425		63,750	100 additional data amplifiers will be needed in 1967 to increase the total to 350
3.	Signal Conditioners	80		200		16,000						
4.	Voice Tape Recorders	4		600		2,400						
5.	Racks	5		350		1,750						
6.	High Gain Amplifiers	50		800		40,000						
7.	Cryogenic Reference Well	1		1,000		1,000						
8.	Digital System	*										
J.	MECHANICAL EQUIPMENT											
1.	LN ₂ Dewar Modification	1		25,000		25,000						

TABLE 1 EQUIPMENT AND COST FOR CY 65 AND CY 66

CY 65

CY 66

[illegible]