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Subcontract NP-1

WANL-TME-2779
March 1971

Westinghouse Astronuclear Laboratory

WESTINGHOUSE ASTRONUCLEAR EXPERIMENTAL FACILITY

WANEF ANNUAL OPERATIONS REPORT

January 1970 - March 1971

MASTER

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WANL-TME-1927, "WANEF Annual Operations Report - 1968", May 1969
WANL-TME-2694, "WANEF Annual Operations Report - 1969," May 1970

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1.0 INTRODUCTION

This report is submitted in accordance with one of the requirements of Section 7.4.4 of WANL-TNR-099, Rev. D., "Safety Report for the Westinghouse Astronuclear Experimental Facility," which specifies that Westinghouse will submit to ANSC/SNSO an annual report of operating experience and activities for each calendar year. The report shall include:

- a) A description and hazards evaluation of each series of tests or experiments
- b) Matters referred to, material submitted to, and actions taken by the WANL Nuclear Safety Committee
- c) Operational history of the facility indicating the number of experimental runs, integrated power, number of unscheduled shutdowns and their causes.

This report includes the operations of the facility through January, 1971. As noted herein the experimental program at WANEF was terminated in early February, 1971, and the Facility was placed on a "standby" basis, thereby permitting future startup capability when required.

This document represents the final annual report that will be issued by WANEF in this series. These reports will be resumed when WANEF reactor operations are resumed.

1.1 SITE DESCRIPTION

The WANEF facility is located on an 850 acre tract owned by the Westinghouse Electric Corporation. The site is approximately 20 miles southeast of Pittsburgh, Pennsylvania, and is the headquarters of the Advanced Reactors Division with the associated engineering support activities including analytical chemistry laboratories. In addition to the WANEF, the site also contains the PWR Systems Division Nuclear Training Facility, the Astronuclear Hydrogen Experimental Site and a High Voltage Test Facility of the Power Systems Planning Department of the East Pittsburgh Advanced Systems Technology group. Figure 1 shows the Waltz Mill Site layout.

A small staff of the PWR-Systems Division have conducted a training program for customer personnel on the Critical Experiment Station (CES-NTC) Nuclear Training Center through February, 1971. The training facility is being relocated to Zion, Illinois, in the

Figure 1. Waltz Mill Site Map

spring of 1971. Figure 2 shows the WANEF-WNTC facility layout.

1.2 PAX AND FCX REACTORS

During calendar year 1970 and through January 1971, critical experiments were performed in support of the development phase of the NERVA program. These experiments were conducted in the PAX/R-1 assembly which is a graphite-moderated beryllium-reflected reactor using fully enriched U^{235} as fuel. The PAX/R-1 reactor assembly was used to obtain data in support of the Nuclear Subsystem Preliminary Design Review (NSS PDR), and various Engineering Critical Component (ECC) designs.

1.3 FACILITY SHUTDOWN

A decision was made by Westinghouse management in early February 1971 to place the Experimental Facility on a standby basis. This decision was reached as a result of the overall reduction in funds for the NERVA program. The experimental effort on PAX was terminated in January 1971, and the PAX core was disassembled on March 8, 1971, and the fuel clusters stored in the fuel storage vault. The reflector was not disassembled.

The FCX reactor was disassembled in February 1971, and the fuel has been declared excess to the program needs. It is expected to be released for reprocessing in the near future.

1.4 WANEF STAFF

The WANEF Staff experienced a net reduction of personnel during the year through the loss of one Experimentalist, one Reactor Operator-in-Training, and one Fuel Handler. The entire staff was either furloughed or reassigned during March 1971 as a result of the facility being shut down.

Two engineers were designated as Experimentalists-in-Charge in July 1970.

The WANEF Staff is comprised of the Experimental Physics Group and the Reactor Operations Group. The Operations Group has the prime responsibility of safe operation and maintenance of the reactors, with overall responsibility for facility maintenance and assistance with experimental mockups. The Experimental Physics Group has the responsibility for planning, performance, and analysis of the experiments conducted at the facility. The organizational structure of WANEF is listed in Figure 3; the relationship of WANEF to Westinghouse is shown in Figure 4.

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Figure 2. WANEF-WNTC Layout

Figure 3. WANEF Organizational Chart

Figure 4 - WANEF - Westinghouse Organizational Relationship

2.0 SUMMARY OF ACTIVITIES

The types of experiments performed at WANEF on the PAX reactor included control drum worths, reactivity shimming, power distributions, reactivity coefficients of core and reflector materials, dosimetry measurements and reactor shutdown measurements.

Hazards analyses were performed on all experiments prior to initiation of the measurements. Experiments not specifically covered by WANEF controlling documentation or falling within the intent of this documentation are submitted to the WANL Nuclear Safety Committee with the request for concurrence by the Committee and approval by the Aerojet Nuclear Systems Company and the Space Nuclear Systems Office before the experiments are performed. No experiments were conducted during the year that required this action. During the year some operational problems were experienced with the three R-1 mockup drive mechanisms. These problems were resolved and the expanded aluminum cover shown in Figure 5 was installed to prevent the recurrence of these problems.

Revised documentation was issued: that indicated the recent changes to the facility and the Waltz Mill Site, for the operation of PAX with fuel loaded as high as code 630, and for the storage of up to seven fully loaded fuel shipping containers in crit zone 10. There were also corrections to some typographical errors and the description of the vacuum cleaner was changed to agree with the current machine in use.

To reduce the overall fuel inventory 950 low-loaded NERVA fuel elements, no longer required at WANEF, were shipped out during 1970 for disposition as scrap. The entire KIWI fuel element inventory was packaged in March of 1971 for eventual scrapping, and most NERVA elements not required for use in PAX experiments are in the process of being packed for reprocessing at the time of this report.

The new Waltz Mill Site alarm system was integrated into the facilities' emergency procedures. This alarm system annunciates fire, process and radiation alarms to the site health physics office as well as the guard station. The alarm is in the form of a printout which indicates the time of day, the date, type of alarm and the location of the alarm. WANEF is coded as zone 7.

Figure 5

PAX-G3A Reactor Showing Radially-Displaced
Reflector Segment and R-1 Mockup Drum Drives

3.0 OPERATIONAL EXPERIENCE

3.1 REACTOR OPERATIONS

During calendar year 1970 and including January 1971, a total of 355 reactor startups were made while producing a total of 9.94 Kw-hrs of integrated power. During operations 11 inadvertent reactor scrams occurred. All of these unscheduled scrams occurred as a result of noise transients in the linear and logarithmic picoammeters actuating the electronic trips. There were five scrams caused by the armature current trip and five scrams caused by line noise; the remaining scram was activated by the scaling of the range switch on the controlling linear channel. There were no scrams attributed to operator error. The breakdown of operating history is given in Table 1.

Personnel radiation exposures in the critical facility for the year were under the permissible level with an average of 12.7 mrem/wk/man. No person received an exposure in excess of the quarterly limit of 3 rem and the highest exposure for the year was 2.6 rem, which is well under the yearly limit of 5 rem.

3.2 FACILITY SHUTDOWN

As a result of decreased funding in the NERVA program, the facility has been placed on a "standby" basis. This "standby" condition is defined as follows: fuel from the PAX reactor is stored in the fuel storage vault--in cluster form, all instrumentation systems, reactor control console, etc., remain intact, as is the equipment required in the counting room that is necessary to conduct post irradiation analysis. All capital equipment has been secured in specific locations throughout the facility.

The WARD plant services personnel in conjunction with WANL Industrial Hygiene and Safety and with the cognizance of the Manager of Nuclear and Radiation Design (who will serve as Acting Manager, WANEF) will enter the WANEF building at periodic intervals to perform maintenance and health physics functions on the equipment that requires servicing and maintenance (e.g., the several sump pumps, the gamma monitoring system and the secured areas of the facility).

TABLE 1. WANEF SUMMARY OF OPERATIONS

January 1970 - March 1971

<u>Date</u>	<u>Cause</u>	<u>Type</u>	<u>Power Level</u> <u>Watts</u>	<u>Remarks</u>
1-14-70	Armature Current Overload	---	< 1	High current on drum No. 7 Drive
1-16-70	Armature Current Overload	---	< 1	High current on drum No. 7 Drive
1-16-70	Log Channel No. 1	Pd.	~ 0	Electronic Noise Transient
5-18-70	Armature Current Overload	---	~ 0	High current on drum No. 7 Drive
7-24-70	Log Channel No. 2	Pd.	~ 0	Electronic Noise Transient
7-24-70	Log Channel No. 2	Pd.	~ 0	Electronic Noise Transient
7-27-70	Log Channel No. 2	Pd.	~ 0	Electronic Noise Transient
7-30-70	Armature Current Overload	---	~ 0	High current on drum No. 6 Drive
8-6-70	Log Channel No. 1	Pd.	~ 0	Electronic Noise Transient
9-17-70	Armature Current Overload	---	~ 0	High Current on drum No. 5 Drive
12-29-70	Linear Channel No. 2	Lvl	~ 0	Switching Noise Transient

Total Number of Startups: 1970--333 1971--22 Total--355

Total Number of Unintentional Shutdowns: 11

Total Integrated Power: 9.94 Kw-hr

Corrective Action on Unintentional Shutdowns:

Electronic Noise--Instruments were repaired as necessary

Armature Overload--Drum drive mechanisms repaired as necessary

3.3 PERSONNEL TRAINING

3.3.1 Reactor Operator Training

Prior to becoming a reactor operator, personnel are instructed in the areas of: (1) basic nuclear physics, (2) health physics, (3) the electrical system associated with the reactor and (4) the mechanical systems including a thorough understanding of the reactor itself. These instructions are conducted by the Reactor Operations Engineer at WANEF. An outline of a formal training program to maintain operator and supervisory proficiency as required by the AEC IAD-8401-6 was prepared and discussed with ANSC/SNSO-C Health and Safety monitors.

In addition, experience and familiarity with procedures is gained by simulated operation of the reactor followed by a period in which a candidate is designated Operator-in-Training and performs daily operations under the supervision of the Experimentalist-in-Charge. Emergency exercises in the areas of radiological and industrial safety are also conducted to maintain staff proficiency.

A reactor operator's test, equivalent to an AEC examination, is given which includes all aspects covered in the training. Upon successful completion of this test, the staff member becomes a qualified reactor operator.

Two staff members were designated as Experimentalist-in-Charge by the Scientist-in-Charge (SIC) after meeting all qualification requirements including an oral examination by a group consisting of the Nuclear Safety Committee Chairman, the Manager of Systems Safety, and the SIC. One Experimentalist and two Fuel Handlers were lost to the staff as a result of a reduction in force and an internal transfer by WANL in 1970. The staff was completely phased out during March, 1971.

3.3.2 Fuel Handling and Emergency Procedures

A training program is conducted on a continuous basis to: (1) train new employees in the proper care and handling of NERVA type fuel and (2) review, with the entire staff, fuel handling procedures as revisions are made to the "WANEF Nuclear Safety Manual," WANL-TME-646. This year special sessions were conducted in the special handling procedures and

considerations required in the handling of the KIWI fuel because it has a much higher airborne contamination potential than NERVA fuel.

The Staff regularly participates in simulated emergency drills so that existing procedures may be revised, if necessary. These drills are then critiqued by members of WANEF Management, Industrial Hygiene and Safety, as well as members of the WANEF staff. Two such drills, one in conjunction with WNTC and WARD, were conducted this year.

3.4 GENERAL SITE EMERGENCY ALARM SYSTEM

A new site-wide emergency alarm system was installed this year. This alarm system, a Minneapolis Honeywell "balanced loop" used in conjunction with a Gray Sound Public Address system, automatically "senses" fire, process and radiation level abnormalities throughout the site. The alarm is annunciated by printout devices, in addition to an audible panel alarm, in both the Health Physics office and in the Security Control Center (guard house). An alarm is also actuated in the local area in which the emergency condition exists. If the emergency condition requires general site cognizance, the public address system is used in conjunction with the ALERT signal. The ALERT signal is a high pitched, rapid warbler sound. The "ALL CLEAR" signal is a steady tone over the public address system.

The annunciation of an alarm condition in the health physics office and guard house is in the form of a printout which indicates the date, time of day, type of alarm, and the location in which the alarm originated.

The alarm signals that are included in the system from WANEF are:

- Fire Alarm: A fire alarm will be annunciated upon actuation of any of the following:
1. Manual pull boxes located at each exit doorway of the facility.
 2. Automatic signals triggered from ion chamber smoke detectors and thermal detectors located in the experimental areas throughout the building.
- Process Alarms: A "process" alarm is annunciated upon actuation of any of the following:
1. The doors to the North or South Test Cells (personnel or truck) and the fuel assembly room.

2. High water in either the North or South Test Cells.
3. Loss of electric power to the facility.

Radiation Alarms: A radiation alarm is annunciated upon the actuation of gamma detectors at any of the following locations:

1. Fuel Storage Vault
2. Reactor Monitor
3. Fuel Assembly Room
4. Test Cell Fuel Storage

During the shutdown phase, the test cell doors and assembly room door alarms have been disconnected, and the doors have been padlocked with combination locks. The fuel assembly room and reactor monitor radiation alarms have been disconnected because no fuel is located in these areas.

3.5 FACILITY INSPECTIONS

Periodic inspections by members of the Industrial Hygiene and Safety Group have been conducted throughout the year. Security inspections have been conducted as well as compliance investigations by members of SNSO, ANSC and AEC. Internal operational audits by technically competent Westinghouse personnel have also been made.

There have been no nuclear safety violations. The industrial safety recommendations were implemented as required.

During the shutdown period, inspections will be conducted throughout the facility to verify the proper operation and condition of the following system(s):

- 1) Sump pump in North Test Cell and Labyrinth and South Test Cell
- 2) Gamma monitoring system on the South Test Cell Shelf and Fuel Storage Vault
- 3) The several secured equipment storage areas throughout the facility.

4.0 REACTOR EXPERIMENTAL PROGRAM

4.1 INTRODUCTION

Tests at WANEF are performed on critical assemblies termed Permanent Assembly Experiment (PAX) and Flexible Critical Experiment (FCX). The PAX assembly, shown in Figure 5 and described in detail in WANL-TNR-099, "Safety Report for the Westinghouse Astronuclear Experiment Facility," is a nuclear and mechanical mockup of the NERVA reactor. The FCX reactor has a mechanical design that is different from the PAX and NERVA assemblies even though the fuel material concentrations and element shape are similar. This characteristic provides the flexibility required for the variation of core materials, carbon/uranium rates, reflector materials and reflector thickness. The design also permits clean experiments unperturbed by extraneous materials found in NERVA reactors.

The FCX reactor was activated in early January, 1970, for the annual control rod inspection and maintenance. The FCX reactor was secured per Standard Operating Procedures after the inspection was completed.

The FCX reactor was dismantled on February 16, 1971. The fuel clusters from this reactor build were stored in the fuel storage racks on the South Test Cell shelf until they can be processed as excess to the needs of the NERVA program.

Six PAX configurations were designated during the year. These configurations were:

January 12, 1970--G1B	CaB ¹⁰ Control vanes installed on three R-1 mockup drums in place of AIB ¹⁰ vanes used originally
February 12, 1970--G2	Reshimmed Core--added TaC elements and pencils to maintain θ_{DC} of $115^\circ \pm 1^\circ$.
February 16, 1970--G2A	Reshimmed Core: removed "X" material and added Nb wire to maintain θ_{DC} of $115^\circ \pm 1^\circ$.
August 28, 1970--G2B	Removed Pressure Vessel; Installed 60° R-1 reflector mockup
September 9, 1970--G3	Reshimmed Core
September 30, 1970--G3A	Reshimmed Core (See Figure 5)

The PAX-G1 build and subsequent builds through G3-A incorporated the 60° R-1 reflector mockup with the use of three R-1 mockup drums.

On March 8, 1971, the fuel clusters were removed from the PAX reactor and stored in the Fuel Storage Vault for future disposition.

Hazards analyses were made for each type of experiment before its initiation. The Operating Limits Document (WANL-TME-1295) imposes restrictions on the design specifications, the operating variables and procedures and the administrative procedures which are necessary for the safety of the facility.

4.2 PAX EXPERIMENTS

The experiments performed at WANEF during Calendar Year 1970 and through January 1971 consisted of measurements of control drum worths, reactivity worths of core and reflector materials, fission flux distributions, the radiation environment in a support plate and shield mockup and the heating rate in the control vanes, using several configurations of cluster hardware, reflector materials, and variations of fuel element composition. In all of these experiments, the reactivity changes were below the .50\$ maximum, and no unevaluated safety conditions were encountered during the conduct of these experiments.

4.2.1 Control Drum Spans

Measurements of control drum spans in the G2 build were performed by measuring the reactivity change resulting from the movement of individual control drums from their most reactive position (180°) to their least reactive position (0°). These measurements were made by an analog computer programmed to solve the inverse of the standard point reactor kinetics equations. The integral control drum worth curve for each drum is obtained by continuously recording the output of the computer on an X-Y or strip chart recorder. By differentiating this curve, a differential drum worth curve is obtained. The integral and differential drum bank worth curves may be obtained by adding the individual differential worths. This procedure assumes no interaction between drums. (Refer to WANL-TME-2703).

The same type of control drum worth determinations were made on the G-3 build. This series of experiments differed from those conducted on the G-2 build only in the method of data acquisition. Instead of using the X-Y recorder, the Packard Bell-250 computer in

conjunction with the WANEF reactivity computer were utilized to comprise a system referred to as MIDAS. The G-3 control drum worths are reported in detail in DRM-53568.

4.2.2 Reactivity Coefficient Measurements

The reactivity coefficients of several in-core materials (carbon, uranium, iron, nickel, niobium, "X" and "Q" material) were determined by measuring the change in reactivity when the amount of material under investigation was perturbed. The reactivity coefficient is determined by dividing the measured reactivity change by the associated change in mass. These data are reported in DRMs 53570, 53565, 53572, 53575. Reactivity coefficients and the effect upon the span of control drums were measured by perturbing materials in the lateral support and reflector region. These measurements are reported in DRM 53904.

4.2.3 Power Distribution Measurements

These experiments provided gross and detailed radial fission density distributions in the PAX-G reactor builds for use in power distribution analysis calculations. The experimental procedure utilized U-Al wires located at the core midplane to determine the radial fission distributions. WANL-TME-2692 is the formal report of these experiments in PAX-G2, and DRM-52735 of those in PAX-G3.

4.2.4 On-Reactor Support Plate Streaming Measurements

A support plate mockup test similar to the shield mockup tests conducted in CY '68 and CY '69, as reported in WANL-TME reports 1852 and 1912, was performed. The purpose of these tests was to obtain neutron and photon radiation levels as a function of position external to and within a support plate segment and BATH (Boral, Aluminum, Titanium Hydride) shield mockup placed upon the support plate. The 60° support plate sector used was an exact mockup of the present R-1 design. The BATH shield mockup was made up of circular 52" OD laminated sheets of polyethylene, Boral, titanium, and aluminum.

The test was performed on the PAX-G2 reactor. The R-1 drum drive units were removed to permit installation of the shield adapter ring used to support the materials in position above PAX. Special hardware was installed so that the three R-1 drums were locked in the $115^\circ \pm 1.0^\circ$ position for the conduct of the tests. The reactor was shimmed with shipping

poison wires so that the delayed critical drum angle was $115^\circ \pm 1.0$ for the remaining drums. A 60° sector of the support plate was placed on a solid 1-1/2-inch thick 52" x 52" aluminum plate which firmly rests on the aluminum adapter ring. A mockup for the remaining (300°) area of the reactor consisted of laminations of aluminum sheet and void preserving the mass and volume of the support plate.

The radiation environment associated with this configuration was determined by the use of passive dosimeters. These dosimeters consisted of bare and Cd covered Dy foils, TLDs, Phylatrons, U-238 foils and S pellets. DRMs 53911, 52729, 52727, 52726, and 52724 report these data.

4.2.5 Control Vane Heating Measurements

The PAX-G2A reactor build was used to obtain radiation measurements on the surfaces of an early R-1 Cu^{10}B prototype control vane. To determine the neutron heating rate in the vane, measurements of the activation of ^{164}Dy were made as a function of position on the vane surface. The photon heating rate was determined using data obtained with ^7LiF thermoluminescent dosimeters. This experiment is reported in WANL-TME-1913.

4.2.6 Reactivity Worth of In-Place Shimming Adjustment (ISA)

Reactivity worths of various materials which are under consideration for use in the In-Place Shimming Adjustments (ISA) of the R-1 reactor were measured by using stainless steel tubes coated with these materials and inserting them in the central axial hole in central elements at selected core radii. This experiment is reported in WANL-TME-2719.

4.3 FCX OPERATIONS

The operations of the FCX facility were conducted early January, 1970, and again in February, 1971. The January, 1970, operations were concerned with the physical inspection of a control rod in the assembly and annual maintenance checkouts. The February, 1971, activity involved the dismantling of the assembly and placing the fuel clusters in storage on the South Test Cell Shelf. The graphite clusters that comprised the reflector are stored in the non-fuel storage rack in the Test Cell.

5. NUCLEAR SAFETY COMMITTEE

The function of the WANL Nuclear Safety Committee (NSC) is to review and consult on all major problems concerned with the nuclear safety of the WANEF facility. It is the responsibility of the committee to review and recommend for approval all experimental programs, operational procedures and proposed modifications to system or facility designs which may affect or change the safety of the facility operation and to provide assurance that boundaries of operational approvals will not be exceeded.

Items which must be reviewed by the NSC include:

- 1) Changes and addenda to the Operating Limits documents and the supporting changes and additions to the Safety Report.
- 2) Changes to the Reactor Operations Manual.
- 3) Experimental Details Checklists (EDC) which are not clearly: (a) within the limits of the Operating Limits document, or (b) consistent with portions of one or more standard operating procedure (SOP), or (c) involve unevaluated questions of safety*, or (d) operations which are expected to exceed the radiation exposure limits (AEC Manual, chapter 0524).
- 4) Proposed changes to WANL-TME-646, WANEF Nuclear Safety Manual, which do not fall within its present intent or the ground rules of the Safety Manual.
- 5) Changes to a reactor, the test stands or the facility (a) which are not clearly within the limits of the Operating Limits document, or (b) may constitute an unevaluated safety question.

Items in categories 2, 3 and 5, which the Safety Committee decides are within the scope of the Operating Limits document and framework of the WANEF Safety Report and its supplements, may be recommended for approval to the General Manager; otherwise, they require modifications to the controlling documents and must be handled as an item in category 1. Items in category 1 may be recommended to ANSC/SNSO for approval by the Safety Committee.

* Unevaluated questions of safety exist if (1) there is a possibility of an accident occurring which has not been analyzed in the WANEF Safety Report or its supplements, or if (2) there is an increase in either the probability of an accident previously analyzed, or (3) if there is an increase in the consequences of an accident previously analyzed.

MATTERS REFERRED TO AND RECOMMENDED FOR APPROVAL BY THE NUCLEAR SAFETY COMMITTEE DURING 1970

Meeting of April 17, 1970

1. Review of six-month experimental plan which included the simplified design of the R-1 drum pinning hardware.
2. Review of proposed changes to the Safety Analysis Report (WANL-TNR-099) that reflect the expanded facility and site, and provide for the use of fuel loaded to Code 630 in PAX and updating and editing of the OLD (WANL-TME-1295)

Meeting of September 30, 1970

1. Review of six-month experimental plan.
2. Review of proposed changes to the Nuclear Safety Manual that would permit the storage of fuel loaded to Code 630 and the permission to store up to seven fully loaded ORNL shipping containers in crit-zone 10.

TITLE Westinghouse Astronuclear Experimental Facility, WANEF Annual Operations Report, January, 1970 - January, 1970 - March 1971	
	DOCUMENT NO. WANL-TME-2779	DATE March 1971
ABSTRACT Capsule descriptions of the reactor operations carried out on PAX and FCX during the period 1/70 to 3/71 are given with references to documents on the experimental results. Also included is a description of the new site alarm system, revised safety documentation, fuel handling activities and training of personnel.		
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