ENRICO FERMI ATOMIC POWER PLANT

CURRENT EXPERIENCE SERIES

COMPILATION OF CURRENT TECHNICAL EXPERIENCE AT ENRICO FERMI ATOMIC POWER PLANT MAY 1969

R.E. Mueller
Assistant Project Engineer

United States Atomic Energy Commission
Contract No. AT (11-1)-865
Project Agreement No. 15

APPROVED

Charles E. Branyan

C. E. Branyan
Fermi Project Engineer
APDA

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States nor the Commission nor any person acting on behalf of the Commission makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report or that the use of any information, apparatus, method or process disclosed in this report may not infringe privately owned rights, or

B. Assumes any liability with respect to the use of, or for damages resulting from the use of any information, apparatus, method or process disclosed in this report.

As used in the above, person acting on behalf of the Commission includes any employee or contractor of the Commission or employee of such contractor, to the extent that such employee or contractor of the Commission or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission or his employment with such contractor.

PREPARED BY
Atomic Power Development Associates, Inc.
with the Cooperation of
Power Reactor Development Company
and
The Detroit Edison Company

ISSUED: October 1969

NOTICE

This report was received under the provisions of the *Atomic Energy Act of 1954* arrangement and is subject to the terms thereof.

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.

1
2
3

4
5
6

7

8

9

10

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
LIST OF ILLUSTRATIONS.....	iv
LIST OF TABLES	v
PREFACE.....	1
I. CURRENT EXPERIENCE SUMMARY.....	3
II. OPERATIONS	5
A. STATUS OF REACTOR SODIUM AND GAS SYSTEMS.....	5
B. STEAM GENERATOR PERFORMANCE	5
C. GAS SYSTEMS PERFORMANCE	7
D. FUEL AND REPAIR BUILDING SODIUM SYSTEM.....	7
E. RADIOACTIVE WASTE DISPOSAL	7
III. PHOTOGRAPHIC SURVEY OF HOLDDOWN MECHANISM	11
A. EQUIPMENT INSTALLATION.....	11
B. DIFFICULTIES ENCOUNTERED	13
C. HOLDDOWN PHOTOGRAPHS	20
IV. STATUS OF PLANT MODIFICATIONS UNDER CONSTRUCTION	23
A. FUEL TRANSFER FACILITY.....	23
B. AUXILIARY FUEL STORAGE FACILITY	23
C. MALFUNCTION DETECTION ANALYZER	25
D. PRIMARY SYSTEM COLD TRAP ROOM MODIFICATIONS	27
E. DELAYED NEUTRON DETECTOR	29
V. PLANT MAINTENANCE	35
A. PRIMARY SHIELD TANK BOOT SEAL REPLACEMENT COMPLETED	35
B. REPAIR OF NO. 1 PRIMARY SODIUM PUMP	38
C. NEUTRON DETECTOR CHANNEL MALFUNCTION	38
D. REPAIR OF DEW POINT HYDROMETER IN STEAM CLEANING CHAMBER	39
VI. SPECIAL INVESTIGATIONS	41
A. USE OF FLOWGUARDS IN SUBASSEMBLIES BEING STUDIED	41
B. POWER RANGE SIGNAL AMPLIFIER NOISE	41
C. NOISY LOOP-3 FLOWMETER	41

LIST OF ILLUSTRATIONS

<u>Fig. No.</u>		<u>Page</u>
1	Holddown Inspection Tool Prior to Insertion in Reactor	12
2	Borescopes, Camera, and Light in Access Penetration No. 5	12
3	Defective Keyway Slots in Service Hose Collar	15
4	Separation of Service Hose Joints Near Collar	15
5	Bowed Quartzline Lamp Bulbs	15
6	Blackened Pyrex Envelope for Lamps	15
7	Copper Tube Connection for Purge Gas Line at Top of Motor Compartment	17
8	Copper Tube Extension Through Bottom of Motor Compartment	17
9	Holddown Inspection Tool in Reactor During Light Test	18
10	View of Southeast Sector of Holddown Plate	21
11	View of Northwest Sector of Holddown Plate	22
12	Insulating Underside of Decay Tank Shield Plug	24
13	Stepped Steel Liner in Loading Port	24
14	Heater Stack During Construction	24
15	Heater Stack Assembled on Bottom of Storage Rotor	24
16	Close-Up of Heater Stack Assembly Under Storage Rotor	26
17	Storage Rotor in Place Inside Decay Tank	26
18	Rotor Shaft Penetration Through Inner Shield Plug	26
19	Inner Plug Cover Plate Being Lowered Over Rotor Shaft	26

LIST OF ILLUSTRATIONS (Continued)

<u>Fig. No.</u>		<u>Page</u>
20	Location of New Electromagnetic Pump for Primary System Plugging Indicator	28
21	Location of Flowmeter for Primary Sodium Hydrogen Detector	28
22	Moderator-Shield Assembly Box for Delayed Neutron Detector	32
23	Moderator-Shield Assembly Box Partially Filled	32
24	Cable Leads Out Top of Assembly Box	32
25	Cable Leads Through Penetration in Operating Floor	32
26	Primary Shield Tank Boot Seal Partially Installed	36
27	Mating Surfaces for Boot Seal Closure Splice	36
28	Clamping of Closure Splice after Gluing	36
29	Stitching of Closure Splice	37
30	Completed Boot Seal Installation	37
31	Two Views of Spalled Bearing Races — Thrust Bearing Assembly of the No. 1 Pump Shaft	40

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
1	Primary System Cover Gas Activity	7
2	Primary System Cover Gas Analysis	8

PREFACE

PURPOSE

The purpose of this monthly report is to make available to the fast reactor program the current experience being gained from the Enrico Fermi Atomic Power Plant.

SCOPE

The scope of this report includes all phases of current operations and maintenance experience concerning the nuclear portion and related systems of the Enrico Fermi Atomic Power Plant.

Earlier Fermi experience in certain selected areas was recorded in a series of technical reports completed by Atomic Power Development Associates, Inc., for the U. S. Atomic Energy Commission under AEC Contracts No. AT (11-1)-865, Project Agreement 15. This series of reports provides detailed information on the nuclear testing, machinery dome, steam generators, pumps, flowmeters, level detectors, sodium sampling and development of the primary sodium system.

Items in the sections of this report are selected on the basis of their special significance during the month. Other items may be found in the monthly report submitted to the Atomic Energy Commission by Power Reactor Development Company in compliance with the requirements of Provisional Operating License No. DPR-9, as amended.

BACKGROUND

The Fermi reactor achieved initial criticality on August 23, 1963. An extensive series of nuclear tests was conducted at power levels below 1 Mwt, through 1965. A high power (200 Mwt) license was issued on December 17, 1965, and operation in excess of 1 Mwt was initiated on December 29, 1965.

In January 1966, the power was raised in a series of steps to 20 Mwt. On April 1, 1966, power was first raised to 67 Mwt and on July 8, 1966 operation at 100 Mwt was initiated. On October 5, 1966, fuel damage occurred during an approach to power. Since that time the reactor has been shut down while the cause of damage is being eliminated and the reactor restored to the operating condition.

It is assumed that those reading this report have a general familiarity with the plant. As an aid to the reader, a perspective drawing of the plant was included at the back of APDA-CFE-1. In addition, a topical index appears at the end of APDA-CFE-28.

Since this report is intended to follow closely the current proceedings at the Fermi plant, it must necessarily be treated as preliminary information, subject to supersedence in the light of subsequent experience.

I. CURRENT EXPERIENCE SUMMARY

The reactor vessel remained partially drained of sodium during May while a photographic survey of the holddown mechanism was conducted. The mirror and other equipment needed to photograph the holddown fingers were utilized in the reactor four times during the month to obtain the required pictures. The quality of some of the pictures taken was not as good as had been expected because of recurring difficulties encountered with poor lighting; however, the pictures were found to be satisfactory for analysis. Very good pictures were obtained in the area where subassembly melting occurred, which is the area of principal interest. A preliminary evaluation of the photographs shows no evidence of misaligned holddown fingers.

Feedwater pressure drop tests were conducted on the No. 1 and No. 2 steam generators to determine whether the poppet-type orifices in the water tubes had reseated following the recent isolation tests. The test results indicate that some of the poppets did not reseat in the No. 1 unit. The unit will be opened next month to determine the cause and extent of the problem. The No. 3 steam generator developed a leak at the steam manifold cover plate when it was filled with water and feedwater flow tests on it were postponed until the cover plate bolts are retorqued.

Checkout of the new fuel transport facility erected in the reactor building was begun and is about 50% complete. All of the drives were energized and the controls tested. However, the jackscrew used to raise and lower the plug cask was damaged. This has delayed the final checkout somewhat.

Erection of the auxiliary fuel storage facility in the No. 2 equipment decay tank is about 75% complete. This month insulation was installed on the underside of the shield plugs, and steel liners were installed in the loading port and shaft penetrations through the shield plugs. The storage rotor, heater stack, and thermocouples were also installed inside the tank and the shield plugs placed in their final position.

Work has continued on installation of the malfunction detection analyzer (MDA) in the reactor control room. The cable racks for the signal cables to the analyzer were erected in the relay room and pulling, rerouting, and interconnecting of the signal cables was begun. Construction of a temporary simulator for use in checking out the system was also begun.

Erection of a delayed neutron detector system for the reactor at a location below the reactor building operating floor was completed except for

the final cable connections. The detector is positioned outside the secondary shield wall between the primary sodium outlet pipe vertical runs of loops 1 and 2.

Replacement of the boot seal for the primary shield tank was completed. The primary shield tank atmosphere was subsequently purged with dry nitrogen; by the end of the month the dew point of the shield tank atmosphere had been reduced from +35 F to -40 F. Preliminary leak testing of the new seal, made at a pressure of 8 inches WCG, showed no significant primary shield tank leakage.

The rotor for the No. 1 primary sodium pump motor, which last month was sent out for machining of the slip rings, was returned and reinstalled. Further inspection of the No. 1 pump revealed that the bearing races of the pump shaft thrust bearing assembly have an irregular wear pattern and they are being polished for reuse.

II. OPERATIONS

A. STATUS OF REACTOR SODIUM AND GAS SYSTEMS

The primary system remained partially drained of sodium throughout the month to conduct the holddown photographic survey. During this time the temperature of the primary system was maintained between 350 F and 380 F by the pipe and vessel induction and resistance heaters.

All three loops of the secondary sodium system remained filled with sodium at approximately 350 F. Feedwater pressure drop tests on the water sides of the No. 1 and No. 2 steam generators were conducted; when water was added to the No. 3 unit, a leak developed at the steam manifold and the unit had to be vented before hydraulic tests could be performed.

No cold-trapping of the primary, secondary, or fuel and repair building transfer tank sodium systems was performed. No movement of subassemblies was made during the month.

The below-floor area of the containment building and the primary cold trap room atmosphere remained purged with air throughout the month. This was necessary to allow erection of the delayed neutron detector system in the containment building and make modifications to the primary sodium plugging indicator circuit in the cold trap room. The primary shield tank atmosphere was purged with dry nitrogen following replacement of the primary shield tank boot seal.

B. STEAM GENERATOR PERFORMANCE

Thermal shock tests were performed on the No. 1 steam generator by isolating and venting last month (see APDA-CFE-32, Sec. II. C), and on the No. 2 and No. 3 units late in 1968 (see APDA-CFE-26, Sec. III. C. 1 and APDA-CFE-28, Sec. III. B. 1). Feedwater flow pressure drop tests were scheduled on the units this month to determine whether all the poppet-type pressure drop orifices recently installed in the water tubes (see APDA-CFE-32, p 27) had reseated following the isolation tests.

During the second week in May, the three steam generators were filled with water using water obtained from the No. 4 heater, where plant condensate was heated under pressure to 350 F. Circulation at a pressure of 600 psig was established by a plant boiler feed pump through the steam generator and main steam bypass line back to the No. 4 heater.

The feedwater-flow - versus - pressure-drop tests were conducted on the No. 1 unit on May 14 and on the No. 2 unit on May 16. Water flows of 120,000 to 210,000 lb/hr were used,* the latter flow being the nominal value for 200 Mwt operating conditions. The system temperature was isothermal at 350 F and the water pressure was 600 psig. The measured pressure drop across the No. 1 steam generator varied from 5.9 psi to 16.16 psi at the two flow extremes. These values are smaller than the 6.8 psi and 19.8 psi pressure drops measured at the same flow rates for the No. 1 unit last month before the isolation tests (see APDA-CFE-32, Sec. II. C). On this basis, it is believed that several of the poppet-type pressure drop orifices in the water tubes were lifted during the isolation tests and have remained in the up position. Preliminary estimates indicate that between five and ten orifices out of a total of 1200 could be stuck in the up position. It is thought that they might be hung up on the special test thermocouples installed in the water tubes of this unit. The water side of the No. 1 unit has been vented, purged, filled with nitrogen, and capped. Sodium will be drained from the unit prior to removal of the water inlet manifold cover to determine the cause and extent of the reduced pressure drop.

The measured pressure drops across the No. 2 steam generator at the two flow extremes were 6.1 psi and 19.2 psi, respectively. Although pressure drop data are not available for this unit prior to the isolation tests last year, the measured values are only about 4% smaller than predicted; they are also in close agreement with the pressure drops measured across the No. 1 unit before its isolation tests (see above). It has been concluded, therefore, that all orifices in this unit did reseal following the isolation tests. The water side of the unit has been vented, purged, filled with nitrogen, and capped.

A leak developed at the steam manifold cover plate of the No. 3 steam generator when it was filled with water at 600 psig in preparation for feedwater flow tests. The water side of the unit subsequently was vented, purged, filled with nitrogen, and capped. An attempt was made to seal the leak by retorquing the head bolts of the steam manifold cover plate, which was completed by the end of the month. The unit will be refilled with water to determine whether the steam leakage has been eliminated.

No cold-trapping was performed on any of the secondary sodium loops during May. The plugging temperature in the three loops fluctuated between

---

* Actually, flows as low as 10,000 lb/hr were used. However, reliable pressure drop data could not be obtained at flows less than 60,000 lb/hr. Only the data for the 120,000 to 210,000 lb/hr flows are given here because they are the only data which can be directly compared with the pre-isolation test data given in APDA-CFE-32.

260 F and 280 F with only minor variations between loops; the bulk sodium temperature was maintained at approximately 350 F throughout the month.

C. GAS SYSTEMS PERFORMANCE

Since the last reported data (see APDA-CFE-32), the following primary system cover gas activity and gas analysis information have been obtained.

TABLE 1 - PRIMARY SYSTEM COVER GAS ACTIVITY

<u>Location</u>	<u>Sample Date</u>	<u>Gross Beta Activity, $\mu\text{Ci}/\text{cm}^3$</u>
Reactor Cover Gas	5-8-69	1.36×10^{-6}
Reactor Cover Gas	5-14-69	7.45×10^{-7}
Reactor Cover Gas	5-21-69	2.11×10^{-6}
Reactor Cover Gas	5-29-69	1.49×10^{-6}
Primary Shield Tank	5-8-69	2.66×10^{-8}
Primary Shield Tank	5-19-69	6.30×10^{-8}
Primary Shield Tank	5-21-69	2.99×10^{-8}
Primary Shield Tank	5-29-69	3.49×10^{-8}

D. FUEL AND REPAIR BUILDING SODIUM SYSTEM

No fuel-handling or steam-cleaning operations were performed in the fuel and repair building during the month of May. No cold-trapping of the transfer tank sodium system was conducted. The sodium plugging temperature was 265 F at the beginning of the month and slowly rose to 272 F by the end of the month. The bulk sodium temperature in the system was maintained at approximately 450 F throughout the month.

E. RADIOACTIVE WASTE DISPOSAL

During May, 9,203 gallons of liquid waste was discharged through the metering pump to the north lagoon. The maximum specific activity measured in the liquid waste tanks in the fuel and repair building was approximately $5.25 \times 10^{-5} \mu\text{Ci}/\text{cm}^3$. The total activity discharged to the lagoon was approximately 16.2 millicuries. All effluent released after dilution with the circulating pump discharge was below maximum permissible concentration (MPC). Approximately 1×10^9 cubic feet of gaseous effluent was discharged through the plant waste gas stack during May. The concentration of activity was very small and well below MPC after dilution in the stack blower and in the atmosphere.

TABLE 2 - PRIMARY SYSTEM COVER GAS ANALYSIS

<u>Item</u>	<u>Reactor Cover Gas (Argon), ppm by volume</u>		<u>Primary Shield Tank Atmosphere (Nitrogen), ppm by volume</u>	
	<u>First Measurement*</u>	<u>Second Measurement**</u>	<u>During Boot Seal Repair*</u>	<u>During Shield Tank Purge**</u>
Oxygen	Below 25	Below 25	15.8% ⁺	40 ⁺
Carbon Monoxide	Below 10	Below 10	Below 10	Below 10
Carbon Dioxide	30	25	345 ⁺	25 ⁺
Hydrogen	Below 4 ⁺	Below 4 ⁺⁺	Below 2.5	15
Helium	Below 4	Below 4	Below 4	Below 4
Methane	Below 10	Below 10	Below 10	Below 10
Nitrous Oxide	←———— Not Measured —————→			
Nitrogen	350	650	←———— Remainder —————→	
Argon	←———— Remainder —————→		Not Measured	0.05%
Dew Point	←———— Not Measured —————→		+35 F ⁺⁺⁺	-40 F ⁺⁺⁺
Shield Graphite Temperature	315 F	308 F	315 F	308 F

* Sample taken May 7, 1969

** Sample taken May 28, 1969. The primary shield tank had been purged continuously for 14 days with dry nitrogen at this time (see Sec. V.A)

+ Technical Specifications state 1000 ppm maximum during reactor operation and during shutdown whenever primary system temperatures exceed 400 F

++ The recommended maximum for reactor operation is 10 ppm

+++ Technical Specifications state less than -35 F except during maintenance, when values as large as +80 F are allowed if primary system temperatures are less than 400 F

Data are available from an environmental radiation survey made during the four-week period from February 20 through March 20, 1969. A total of 81 environmental samples was collected and analyzed during this period and a summary of the activity levels found is as follows:

- The gross alpha and gross beta activity levels of airborne dust samples obtained from the reactor site area and from areas away from the reactor (to indicate the vicinity background) were found to be the same in both locations — approximately $3 \times 10^{-15} \mu\text{Ci}/\text{cm}^3$ for the alpha activity in both cases and $14 \times 10^{-14} \mu\text{Ci}/\text{cm}^3$ for the beta activity, thus indicating no airborne activity levels above background on the plant site. The activity levels also were essentially identical to those obtained in similar measurements made in 1967.
- Measurements of precipitation samples taken from the reactor site area and from locations away from the reactor site also indicated no activity levels above background on site, the gross alpha and gross beta activity levels in both locations being approximately $0.2 \text{ mCi}/\text{mile}^2$ and $3.5 \text{ mCi}/\text{mile}^2$, respectively. These values also correspond to the 1967 values.
- The specific activity of water samples taken from lakes and creeks near the plant site and from the drinking water supply of neighboring cities showed no significant change in gross beta activity from similar measurements made in 1967, the activity levels in all cases being approximately $4 \times 10^{-9} \mu\text{Ci}/\text{ml}$.

III. PHOTOGRAPHIC SURVEY OF HOLDDOWN MECHANISM

The holddown inspection tool (see APDA-CFE-30, Sec. III) and other equipment needed to photograph the fingers of the holddown mechanism were used in the reactor four times in May as part of the program to obtain the required series of pictures for use in determining alignment of the holddown fingers. Photographs were taken at each of the three azimuth positions of the reactor vessel rotating shield plug which were determined in the mock-up tests (see APDA-CFE-30, Sec. III. C) to be required to view all four quadrants of the holddown finger array. A fifth insertion of the inspection tool into the reactor lattice was made without plug rotation or photography to perform an environmental test of the integrated lighting system used. By the end of the month, the survey of the holddown finger array had been completed.

Because of recurring difficulties, principally with the integrated lighting system, the quality of some of the pictures obtained was not as good as had been expected. However, they were found to be satisfactory for analysis. Very good photographs were obtained in the area where subassembly melting had occurred, the principal area of interest. Preliminary evaluation of the photographs shows no evidence of misaligned fingers.

A. EQUIPMENT INSTALLATION

The holddown mechanism inspection tool was installed in the reactor on May 7 in outer radial blanket lattice position N07-P00. It was inserted from above the reactor, through a plastic bag, in the No. 3 access penetration in the rotating shield plug, as shown in Figure 1. The Mark II borescope with camera attachment, the Sunscope, and one articulated viewing light were installed in the adjacent No. 5 access penetration as shown in Figure 2 (see also APDA-CFE-9, p 19; APDA-CFE-16, p 5; and APDA-CFE-18, p 21). The Sunscope and articulated viewing light were used to view the inspection tool during its insertion in the reactor and subsequently to view the layout of the flexible umbilical cord (service hose) during plug rotation. Photographs were taken through the Mark II borescope, which focused on the spherical mirror set on top of the inspection tool. Varying exposure times were used, depending on the lighting conditions. An automatic exposure calculator was attached to the camera to aid in determining the exposure times.

The equipment arrangement remained essentially unchanged from that described above during subsequent insertions and photographic surveys on May 9, May 22, and May 29, except for minor variations made in the equipment locations in the plug access penetrations to gain greater versatility

Inspection Tool
in Plastic Bag

105569

**FIG. 1 HOLDDOWN INSPECTION TOOL PRIOR T
INSERTION IN REACTOR**

105669

**FIG. 2 BORESCOPES, CAMERA, AND LIGHT IN ACCESS
PENETRATION NO. 5**

in viewing and lighting. For the third and fourth insertions, the Mark III borescope (see APDA-CFE-9, p 19) containing a new modified objective lens was substituted for the Mark II borescope to take advantage of its three-times-larger light gathering capability. An additional articulated light, together with the Mark II borescope, also was installed in the remaining rotating plug access penetration for the fourth survey. This was done to provide better lighting and more versatility for viewing the inspection tool during its insertion in the reactor and subsequent service hose layout in the core cavity. It was found that although insertion of the inspection tool was aided by the added equipment, the best quality photographs of the holddown fingers were obtained when the two articulated lights were not used. The articulated lights resulted in undesirable shadows on the fingers due to light blockage from the upper safety rod guide tubes, which extend below the holddown plate. Their use also resulted in photographs of very high contrast and harsh highlights which made accurate analysis more difficult than for photographs taken in the soft diffused light of the integrated lighting system.

B. DIFFICULTIES ENCOUNTERED

A number of equipment difficulties were encountered during the attempts to photograph the holddown fingers. Four separate insertions of the inspection tool were required to complete the survey because of the need to remove the tool for repeated repairs and modifications. Each time the inspection tool was removed, it was necessary to also remove, dismantle, and clean accumulated sodium vapor deposits off each of the borescopes, in addition to cleaning the inspection tool mirror.

The most serious difficulty encountered was repeated failure of the four 1500-watt Quartzline lamps located on the mirror post. In three of the four surveys, the argon purge flow (3 cfm) to the integral light cluster, intended to remove sodium vapor from the vicinity of the lights, was lost before any photographs could be taken. This resulted in sodium deposition on the lights, progressive loss of light intensity during subsequent photography, and eventual overheating and failure of the lights. In the other survey, contamination of the lamp purge gas caused deposition of foreign deposits on the lamps, which also resulted in the fading of the illumination intensity during the photography.

The lack of adequate lighting caused difficulties in focusing the camera on the mirror and resulted in long exposure times (of the order of several minutes in many cases) during the picture taking. This, in turn, resulted in pictures of less than maximum resolution with picture fuzziness caused by small movements of the borescope during the exposure. Borecope flutter could not be eliminated entirely even though a rigid support cinch for the borescope was installed at the top of the rotating plug.

A brief chronological summary of the difficulties encountered during the holddown finger photographic surveys in May is given below:

1. First Survey

Following the first insertion of the holddown inspection tool on May 7, difficulty was experienced in disengaging the bail located at the top of the tool required to lay down the service hose in the core cavity. The locking keys located on either side of the bail, for use in holding the tool steady when it is lowered into the reactor, could not be disengaged from the keyway slots in the service hose collar connection to the bail (see Figure 3). Disengagement was eventually made, but resulted in disconnection of the silicone rubber argon purge line at the point where it enters the housing compartment for the mirror drive motor. During subsequent rotation of the reactor vessel shield plug to lay out the service hose, the hose contorted and the flex joints separated near the connection to the bail (see Figure 4). During the subsequent photography, as a result of the loss of purge gas, viewing and photography became progressively more difficult because of the diminishing illumination resulting from lamp blackening. Using an on-off mode of lamp operation, the total useful life of the lamps was about twenty minutes, with about twenty additional minutes of extremely dim light. Most photographs had to be taken with one-minute exposure times; in some cases exposure times as long as 1-1/2 minutes were used. The major portion of the lamp lifetime was required for orientation and focusing adjustments of the borescope.

Following removal of the inspection tool from the reactor, the separated portion of the service hose was repaired by silver soldering. The keyway slots for the bail pivots were filled with weld material so that the pivot lugs were free to pivot at all positions and the argon purge line was reconnected. The four Quartzline lamp bulbs which had blackened and bowed from overheating were replaced, together with the Pyrex envelope around them, which also was blackened and distorted (see Figures 5 and 6).

2. Second Survey

In the second survey, made on May 9, initial exposure times twice as long as those used in the first survey (two minutes versus one minute) were found to be required. Also, the light intensity from the lamps on the post began to fade noticeably after only eight minutes of total lamp usage. By the time the lamp usage totaled thirty-five minutes, exposure times of four minutes were required.

When the inspection tool was removed from the reactor for examination, the argon purge line to the lamp cluster was found to be intact; however, the lamps and Pyrex envelope were again blackened and distorted with a maximum temperature of at least 3,000 F indicated by the softening of the

105769
**FIG. 3 DEFECTIVE KEYWAY SLOTS
 IN SERVICE HOSE COLLAR**

105869
**FIG. 4 SEPARATION OF
 SERVICE HOSE
 JOINTS NEAR COLLAR**

105969
**FIG. 5 BOWED QUARTZLINE LAMP
 BULBS**

106069
**FIG. 6 BLACKENED PYREX ENVELOPE
 FOR LAMPS**

quartz lamps. The spherical Mirror also contained a stain that could not be removed, and a replacement mirror had to be installed. Investigation revealed that the probable cause of the lamp blackening was offgassing of low-volatile (less than 500 F) lubricants used in the mirror motor located in the motor compartment directly above the light cluster. In the original tool design, the silicone rubber argon purge line was connected to a copper tube entering the top of the motor compartment. The purge gas spilled first into the motor compartment, after which it was directed out of the motor compartment through small holes located in the bottom of the compartment to the light chamber below. Any offgassing of organic material in the motor compartment would therefore be carried into the light chamber and collect (hot-trap) on the light bulbs.

On this assumption, a design modification was made to the tool in which the copper tube purge line connection at the top of the motor compartment was extended completely through and out the bottom of the motor compartment. All remaining holes between the motor and light compartments were blocked except the one used by the new purge tube, thus allowing the purge gas to be carried directly to the light chamber. These modifications are shown in Figures 7 and 8. Purge flow to the motor compartment could be eliminated, since it served no useful purpose. High-temperature operation of the mirror drive motor had been previously demonstrated.

3. Light Test in Reactor

Following the purge line modifications and replacement of the damaged lights, blackened Pyrex envelope, and stained mirror, the inspection tool was returned to the reactor on May 20 for environmental testing of the lights to check out the modifications. Figure 9 is a photograph taken of the inspection tool through the Sunscoop during the lighting test in the reactor in which the lights were operated on a six-minute-off, six-minute-on cycle continuously for three hours, accumulating a total lamp usage of 90 minutes. Light intensity measurements were made using the camera and its exposure calculator. The measurements showed that the lamps operated for approximately one hour before any noticeable change in light output occurred. The calculated exposure times varied from 3 to 5 seconds at the beginning of the test to 8 to 10 seconds near the end of the test. These times compared favorably with the 15 to 30 second maximum allowable exposure times for high resolution found to be required in the mock-up tests of the inspection tool (see APDA-CFE-30, Sec. III.C). No deposits were found on the outer surface of the lamps or Pyrex envelope when the tool was removed from the reactor at the conclusion of the test, verifying the adequacy of the design modifications made in the argon purge system.

106169

**FIG. 7 COPPER TUBE CONNECTION FOR PURGE GAS LINE
AT TOP OF MOTOR COMPARTMENT**

106269

**FIG. 8 COPPER TUBE EXTENSION THROUGH BOTTOM
OF MOTOR COMPARTMENT**

106369

FIG. 9 HOLDDOWN INSPECTION TOOL IN REACTOR DURING LIGHT TEST

4. Third Survey

Shortly after the third insertion of the tool on May 22, an electrical short developed in the wiring to the rotating mirror motor winding which controlled clockwise rotation of the mirror. Attempts at clockwise rotation resulted in a succession of blown fuses; consequently, all subsequent picture taking was restricted to counterclockwise mirror rotation, which also eliminated control of the tilt of the mirror.

The initial pictures were taken with exposure times ranging from 80 to 120 seconds, which were substantially longer than estimated in the lighting test. Within a short time, the lighting began to fade even more rapidly, and the survey was soon forced to a halt due to a lack of sufficient lighting.

When the inspection tool was removed from the reactor, it was found that the purge hose was again severed near the top of the bail. The lamps were blackened but not bulged or warped. They were replaced with new lamps. The Pyrex envelope was clean and in good condition and did not require replacement. A new rubber hose was installed to replace the broken hose and the new hose rerouted on the bail in an attempt to minimize the possibility that loose sections of hose could snag in the top of the bail during tool insertion and subsequent service hose layout.

No cause for the partial failure of the mirror drive motor was found. Disassembly of the motor revealed no defects. In bench tests the motor operated normally in both directions; however, as a precautionary measure before the motor was reinstalled on the inspection tool post, the electrical leads were wrapped with glass tape and fastened securely to the bail.

5. Fourth Survey

When the inspection tool was inserted in the reactor for the fourth survey on May 28, the initial effort to rotate the mirror after service hose layout resulted in an electrical short in the wiring of the motor drive near the top of the rotating shield plug. Fuses were blown in the motor control box. Following repair of the short, visual observations made through the Sunscope and Mark II borescope revealed that the argon purge hose was again broken off. As previously, the lighting available for picture taking began to fade rapidly as the photography progressed. Within two hours, the exposure time per picture had risen from 68 seconds to 4 minutes, causing termination of the survey.

The inspection tool was once more removed from the reactor, and repair work is now in progress to replace the damaged argon supply hose with a new hose and to locate the hose on an altered route over the bail.

Consideration was given to replacing the silicone rubber hose, which is very flexible but has little strength, with a high-temperature substitute; but none could be found. All of the electrical wiring for the lights and for the mirror drive motor is also being replaced; the four Quartzline lamps will be changed. Finally, the lighting system is being converted from a grounded system to an isolated system to minimize the possibility that the lights can short in the event the lighting circuit becomes grounded.

C. HOLDDOWN PHOTOGRAPHS

During May, photographs were taken of all four quadrants of the hold-down finger plate. The individual areas covered in each of the four surveys were (1) the northwest and southwest quadrants; (2) southeast quadrant (the location where melted and bent subassemblies were found); (3) northeast and southeast quadrants; and (4) the southeast quadrant (see APDA-CFE-28, Figure 10). Typical photographs of the southeast quadrant and the northwest quadrant are shown in Figures 10 and 11. Although the quality of some of the pictures was not as good as that of others, most appear to have adequate clarity and resolution to allow analysis for evidence of holddown finger distortion and misalignment. In only a few cases is it believed the pictures cannot be accurately analyzed because of darkness or fuzziness. Pictures of portions of the northeast and southeast quadrants near the core edge are in this category. Also, no pictures of the holddown fingers were obtained near the core edge in the southwest quadrant. However, very good photographs were obtained in the area of the southeast sector where subassembly melting and distortion had occurred. This is the area of principal interest; the other areas are of lesser interest because there is no evidence that abnormal forces on subassemblies occurred outside the southeast sector during the October 5, 1966 incident.

Preliminary analysis of the photographs to date shows no evidence of misalignment of the holddown fingers. Detailed analyses are now being made to verify this fact and also to verify that the pictures of lesser quality (clarity) have adequate resolution for accurate graphical analysis. Following these analyses and repair of the inspection tool, it is planned that the tool will be reinserted in the reactor to rephotograph any areas where definitive analysis of the present photographs is doubtful, and to photograph that portion of the southwest sector missed in the earlier survey.

106469

FIG. 10 VIEW OF SOUTHEAST SECTOR OF HOLDDOWN PLATE

106569

FIG. 11 VIEW OF NORTHWEST SECTOR OF HOLDDOWN PLATE

IV. STATUS OF PLANT MODIFICATIONS UNDER CONSTRUCTION

A. FUEL TRANSFER FACILITY

Last month erection of the new fuel transport facility in the reactor building was completed (see APDA-CFE-32, Sec. IV.A); this month checkout of the facility was approximately 50% complete with all drives being energized and the controls tested. Painting of the facility is also nearly complete. However, the jackscrew used to raise and lower the plug cask on the bridge and trolley structure was damaged. The jackscrew is mounted on the bridge and trolley structure and extends downward from the structure into the top of the plug cask. A drive motor mounted on top of the plug cask is used to turn the screw to raise and lower the cask. The damage occurred when in order to calibrate the facility the interlocks were defeated. The plug cask was accidentally lowered too far, hitting the floor and bending the jackscrew. A new jackscrew has been ordered. Final alignment and checkout of the transport equipment will be delayed somewhat until the jackscrew is replaced. The exit port floor valve must also be installed.

B. AUXILIARY FUEL STORAGE FACILITY

Progress last month on converting equipment decay tank No. 2 in the reactor building to an auxiliary fuel storage facility (see APDA-CFE-30, Figure 19) consisted of insulating the bottom and sides of the tank and installing the false floor and drip pan inside the tank (see APDA-CFE-32, Sec. IV.B). This month the undersides of the shield plugs were insulated, steel liner tubes were installed in the plug access ports and rotor shaft penetration, the fuel storage rotor was installed in the tank together with the heater stack and thermocouple leads, and the shield plugs were returned and set in their final position in the tank. The auxiliary fuel storage facility is now about 75% complete.

Figure 12 shows the insulation being installed on the underside of the decay tank inner shield plug. The inner and outer shield plugs were both removed from the tank and set on support brackets on the reactor building operating floor adjacent to the decay tank for this purpose. The 4-inch-thick blocks of Johns-Manville Fiberfrax insulation were held in place by brackets welded to the bottom of the shield plugs, and the insulation was covered with a 5-mil thickness of corrugated aluminum protective lagging. Figure 13 is a photograph of a stepped steel liner tube grouted in place in one of the two fuel loading access port penetrations through the tank shield plugs. A similar liner was installed in the second access port and in the vertical penetration for the shaft of the fuel storage rotor. Solid carbon steel shield plugs will be located in the access ports when they are not being used for

106669

**FIG. 12 INSULATING UNDERSIDE OF
DECAY TANK SHIELD PLUG**

106769

**FIG. 13 STEPPED STEEL LINER IN
LOADING PORT**

106869

**FIG. 14 HEATER STACK DURING
CONSTRUCTION**

106969

**FIG. 15 HEATER STACK
ASSEMBLED ON
BOTTOM OF
STORAGE ROTOR**

fuel loading. A bushing is located in the bottom of the liner for the rotor shaft penetration to facilitate centering the rotor shaft in the penetration.

Figure 14 is a photograph taken during the construction of the heater stack for the auxiliary fuel storage facility. The heater stack will maintain the argon atmosphere of the storage facility at approximately 360 F. The heater stack, which was later centered and mounted on the underside of the storage rotor, consists of 15 Chromalox electrical resistance heaters located in the lower end of a 2-foot-square, 8-foot-long stack assembly. The heaters will be operated at 110 volts or one-half of their rated voltage (220 volts) for increased reliability and at this derated condition will provide a maximum capability of 15 kw. Since this is considerably more heat than necessary to maintain the storage area temperature desired, only about half of the circuits will be energized at one time during facility use. When installed, the stack extends to within 8 inches of the bottom of the sodium drip pan located on top of the false floor. This allows argon to enter the bottom of the stack and pass over the heaters. Circulation of the heated argon will be by natural convection up the stack and out openings located at the top.

Figures 15 and 16 show the heater stack mounted beneath the storage rotor prior to installation of the storage rotor in the decay tank. The electrical heater wire leads, thermocouples leads, and a gas sampling line were all brought up from the fuel storage area through the center of the hollow rotor shaft. They will be connected to a terminal junction box located at the top of the shaft. Lead shot will then be poured down the shaft around the leads to provide shielding against radiation streaming up the shaft.

Figure 17 is a photograph of the storage rotor with attached heater stack installed on the temporary support brackets located inside the decay tank. The installation of sodium leak detectors on the drip pan and thermocouples in various areas inside the tank had already been completed. Figures 18 and 19 show the facility following the reinsertion of the insulated shield plugs in the tank. The remaining work on the facility involves completion of the electrical, thermocouple, purge, and sample gas line connections at the junction box and argon station installation of the hand-operated worm gear drive and indexing equipment at the top of the rotor shaft above the shield plug, and conduct of mechanical tests of the facility.

C. MALFUNCTION DETECTION ANALYZER

During May, work continued on the installation of the MDA (see APDA-CFE-31, Sec. IV.C). The cable racks for the many signal cables to the computer are presently being installed in the relay room directly below the computer. After completion of the cable rack installation and cutting of the penetrations in the control room floor for the thermocouple and other signal cable leads, work will begin on pulling and installing the cable feeds to the computer.

Thermocouple and
Heater Leads Entering
Hollow Rotor Shaft

107069

**FIG. 16 CLOSE-UP OF HEATER STACK
ASSEMBLY UNDER
STORAGE ROTOR**

107169

**FIG. 17 STORAGE ROTOR IN PLACE
INSIDE DECAY TANK**

107269

**FIG. 18 ROTOR SHAFT PENETRATION
THROUGH INNER SHIELD PLUG**

107369

**FIG. 19 INNER PLUG COVER PLATE
BEING LOWERED OVER
ROTOR SHAFT**

In preparation for rerouting the thermocouple cables to the junction boxes, two criteria thermocouples were rerouted so that they can be read in the reactor control room during the rewiring. The equipment enclosure for the temporary simulator to be used in checking the operation of the malfunction detection analyzer has arrived and is being installed.

D. PRIMARY SYSTEM COLD-TRAP ROOM MODIFICATIONS

Last month a temporary lead shadow shield was erected part way around the primary cold trap in the primary sodium service building cold-trap room to allow personnel access for planned modifications to the sodium purity monitoring system (see APDA-CFE-32, Sec. IV.D). This month the piping in the primary cold-trap room was prepared for the necessary cutting, rerouting, and new equipment installation.

The primary sodium service system modifications are being made to improve the accuracy, repeatability, and sampling capability of the present primary sodium plugging indicator system and to allow the addition of a developmental sodium hydrogen detector which laboratory tests show has the potential capability of continuously monitoring sodium hydrogen content during reactor operation.

The modifications to the plugging indicator circuit consist essentially of changing the present system to a constant pressure system which is no longer in parallel with the primary cold trap. This should eliminate the perturbing effect which cold-trap operation previously was thought to have on operation of the plugging indicator. The system is also being changed so that the small flow required through the plugging indicator can be controlled by an automatically operated electromagnetic pump added upstream from the present plugging indicator and its flowmeter, rather than by the manually-operated throttle valve used in the present system. The throttle valve proved to be sensitive and difficult to adjust at the small flows required.

Figure 20 shows the bared piping upstream from the present plugging indicator and flowmeter at the location where the new electromagnetic pump will be added. To change the system so that it is independent of cold-trap operation, the outlet piping from the plugging indicator will be rerouted so that both it and the plugging indicator inlet line are connected close to each other, with no intervening components, on the main sodium service line feed from the reactor building, thus forming a loop independent from the cold-trap. Prior to baring the pipes for cutting, the service lines to the primary cold-trap room were heated and blown clear of sodium (back to the No. 1 IHX), the valves were closed to isolate the system, and the line heaters were de-energized to freeze any sodium remaining in the piping. The line heaters, insulation, and lagging were then removed from the section to be cut, and freeze boxes were put around each section of pipe in preparation for cutting.

107469

**FIG. 20 LOCATION OF NEW ELECTROMAGNETIC PUMP
FOR PRIMARY SYSTEM PLUGGING INDICATOR**

107569

**FIG. 21 LOCATION OF FLOWMETER FOR PRIMARY SYSTEM
HYDROGEN DETECTOR**

The hydrogen detector is scheduled to be added later in the inlet of the bypass loop (in parallel with the cold trap) used for the sodium sample coil. The present modifications consist of installing the magnetic flowmeter for the hydrogen detector in the inlet line upstream from the proposed hydrogen detector location. Figure 21 shows the inlet line bared for the flowmeter installation.

Prior to installing the electromagnetic pump in the modified plugging indicator loop, the pump was tested to determine the maximum safe voltage which could be applied to the pump with no sodium in the pump tube, without causing excessive overheating of the tube. The pump is designed for a maximum temperature of 450 F. It was found that 95 volts produced a maximum 290 F temperature rise above the nominal 150 F ambient temperature after two hours of operation. This is considerably more voltage than needed to produce starting flow in the plugging indicator. It was concluded, therefore, that by limiting the applied voltage to 95 volts or less, there will be sufficient power to produce flow, plus adequate protection against burnout during empty tube conditions. Installation of the new electromagnetic pump and flowmeter and rerouting of the piping in the cold trap room will begin next month.

E. DELAYED NEUTRON DETECTOR

1. Background

A delayed neutron detector system (DND) is being added to the plant for possible connection later to the new malfunction detection system (see APDA-CFE-31, Sec. IV. C). The moderator-shield portion of the system was installed this month below the reactor building operating floor on a platform set on the equipment compartment floor. The purpose of the DND is to detect either fuel pin cladding failure or melting by means of the delayed neutrons given off by the halogen fission products released to the sodium coolant. Although the detection sensitivity of the DND is not expected to be as great as that of the cover gas fission product monitor presently installed at the plant, its response time should be much faster. It also can be used in conjunction with the cover gas fission product detector during the forthcoming fuel testing program to facilitate identification of a noble fission gas release from test pin failure, as opposed to failure resulting in fuel melting.

2. Design of the Delayed Neutron Detector

The DND system consists of four Reuter-Stokes boron-10 lined proportional detectors mounted inside a combination moderator-shield assembly box located below the reactor building operating floor on the equipment compartment floor. The box is positioned between the vertical runs of the 30-inch primary sodium outlet lines of loops 1 and 2, just outside the secondary shield wall, at a point where the lines rise from the equipment compartment

floor after passing underneath the secondary shield wall to enter the intermediate heat exchanger tanks of each loop.

The vertical pipe runs are only approximately 6 feet apart at this location. Two detectors will be located adjacent to each of the 30-inch primary sodium pipes, although only one of the two detectors will be used to monitor each pipe and provide a signal to the electronic counting system at any given time. The spare detector is being provided at each pipe because the area where the detectors are located will be inaccessible once irradiated fuel is stored below floor in the auxiliary fuel storage facility, or when reactor operation is resumed. Two of the three primary loops are being monitored to assure that at least one counting channel will be available at all times during periods of anticipated two-loop operation. Also, the monitoring of two loops provides redundancy during three-loop operation, and during two-loop operation on loops 1 and 2. The detectors have an upper temperature limit of 400 F; no forced cooling will be required for them, since the below-floor atmosphere temperature in this area is not expected to exceed 130 F during 200 Mwt operation.

The detectors are mounted parallel to the sodium pipe in the moderator-shield assembly box, which in turn sits on a heavy steel platform raised three feet above the lower equipment compartment floor between loops 1 and 2. The box has the shape of a rectangle 70 inches long, 39 inches high, and 33 inches wide. The space around the detectors in the box is filled with lead, graphite, and sheets of Boral* shielding material. The Boral and lead are used to absorb and filter out the high-level neutron and gamma-ray background radiation in the area, which would otherwise adversely affect the operation of the detectors. The background radiation consists of low-energy neutron leakage from the secondary shield wall and high-energy gamma radiation from radioactive sodium in nearby pipes and components. The graphite is used to moderate the low-level, high-energy delayed neutrons resulting from the decay of the Br-87 and I-137 fission product isotopes in the sodium, and thereby increase the detector efficiency by improving sensitivity. Br-87 and I-137 are the only two fission product halogen isotopes of importance in the six delayed neutron groups released to the coolant upon fuel failure, since all others have half-lives which are short compared to the estimated 70 second sodium transport time from the core to the detector location.

The geometrical arrangement of the shielding and moderating material inside the detector assembly box is rather complex; in general, the arrangement is as follows:

At the two ends of the assembly, adjacent to and facing the primary sodium pipes, the space in the box between the pipe and detectors is filled from the outside inward with a 1/4-inch thickness of Boral, four inches of

---

* Natural boron carbide in an aluminum matrix clad with aluminum.

lead, and six inches of graphite. The remaining two sides of the assembly and its top and bottom contain a 3/4-inch thickness of Boral, six inches of graphite, four inches of lead, and finally three inches of graphite surrounding the detectors. Rectangular openings 13 inches by 1-1/4 inch by 1-1/4 inch are provided in the graphite at each end of the assembly for the detectors. The two detectors at each end are placed side-by-side facing the pipe with the two-inch space between the detectors being filled with graphite. The space in the middle of the box between the two sets of detectors is also filled with graphite.

With this arrangement of shielding and moderating material, the background radiation entering the two sides, top, and bottom of the box is effectively shielded to negligible levels at the location of the detectors. In addition, the design assures that the major portion of the background radiation entering the two ends of the box is also removed before it reaches the detectors, but it allows the major portion of the high-energy delayed neutron radiation entering the ends to filter through and be moderated at the detector location, thus resulting in an optimized signal-to-noise ratio.*

The detectors are mounted so that their weight is supported on the graphite at the bottom of the rectangular detector spaces located in the graphite cubes at each end of the assembly box. Each detector has a 1/2-inch-diameter triaxial cable integrally attached to it. The four cables are routed upward through the graphite and lead shielding material and are brought out of the box together at a centrally located fitting in the top of the box. The cables are then routed up through the reactor building operating floor by means of an existing 24-inch floor penetration located on the north side of the containment building. Rigid support for the cables to keep cable vibration at minimum is provided from the point where they emerge from the top of the moderator-shield assembly box to the bottom of the operating floor. This support is provided by a special structure attached to existing beams in the below-floor area, the cables being clamped at regular intervals along the support structure.

3. Erection of Delayed Neutron Detector

Assembly of the DND below the operating floor was essentially complete by the end of May. The construction sequences is summarized in Figures 22 through 25. Figure 22 shows the empty moderator-shield assembly box mounted on its steel support platform outside the secondary shield wall between the vertical pipe runs of primary loops 1 and 2. Figure 23 is a photograph of the box approximately half filled with graphite, lead, and Boral

---

* The background resulting from the fissioning of uranium impurities in the sodium coolant and from the uranium contamination on the surface of the fuel pins is negligible.

Secondary Shield Wall

Loop 2

Loop 1

107669

**FIG. 22 MODERATOR-SHIELD ASSEMBLY
BOX FOR DELAYED NEUTRON
DETECTOR**

Holes in Graphite
for Detectors

107769

**FIG. 23 MODERATOR-SHIELD ASSEMBLY
BOX PARTIALLY FILLED**

107869

**FIG. 24 CABLE LEADS OUT TOP
OF ASSEMBLY BOX**

107969

**FIG. 25 CABLE LEADS THROUGH
PENETRATION IN
OPERATING FLOOR**

shielding and moderating material. The total weight of the assembly when completely filled was approximately six tons; all six tons of material had to be hand-carried below-floor through a 24-inch-diameter manhole in the operating floor. Figure 24 shows the completed assembly box with the cables for the four detectors emerging from the top. Figure 25 is a photograph of the detector cables at their penetration through the reactor building operating floor. The remaining work on the DND involves connecting the detector leads to the preamplifiers, which will be located adjacent to the floor penetration, and making the connections to the readout equipment. The floor penetration will be filled with lead shot to prevent radiation leakage during reactor operation.

V. PLANT MAINTENANCE

A. PRIMARY SHIELD TANK BOOT SEAL REPLACEMENT COMPLETED

Installation of the new primary shield tank boot seal, which was begun last month (see APDA-CFE-32, Section IV. E), was completed on May 16. Figure 26 is a photograph taken during the installation showing the new upper clamp ring and new boot seal partially in place. After clamping most of the boot seal in place in this manner, a 10-foot-long section was left exposed on the reactor vessel machinery deck to allow the final closure splice to be made. The ends of the boot seal were cut so that about 2 inches of material from each end could be overlapped at the top and bottom, as shown in Figure 27. The mating surfaces of the boot ends were then cleaned with dye penetrant cleaner and coated with Silastic adhesive. After the prescribed drying time, the mating surfaces were bonded together and clamped for a 24-hour cure, as shown in Figure 28. Following removal of the clamps, the central body of the seal was hand-sewn with two vertical rows of nylon stitches, and the upper and lower overlapping sections were sewn with four horizontal rows of stitches, as shown in Figure 29. The entire joint was then coated on both sides with silicone rubber cement; after the cement had cured the remaining 10-foot section of boot seal was installed in the seal annulus and clamped in place to complete the installation, as shown in Figure 30.

Following completion of the boot seal installation the nitrogen pressure control systems for the primary shield tank, which had been converted to a flow-through system for the past year, were returned to service. A dry nitrogen purge flow of 5 cfm was then established through the lower sweep header in order to purge the shield tank of the air atmosphere introduced during the boot seal replacement program. The nitrogen flow was later increased to 20 cfm and maintained at that level until the gas purity and dew point levels of the primary shield tank atmosphere had reached acceptable values. By the end of May, the dew point of the shield tank atmosphere had been reduced from +35 F to -40 F, and the gas purity levels given in Table 2 had been attained.

On May 27, preliminary leak rate test was conducted on the shield tank to check for gross leakage and determine the general integrity of the new boot seal. The test was conducted over an 8-hour period with a pressure of 8 inches WCG in the lower primary shield tank. The measured leak rate was 18 scfh, which indicated that no significant leakage was occurring. Purging of the shield tank atmosphere will be continued until the dew point is lowered to -45 F. Following this, the annual 2-psig leak rate test will be conducted to make a final check on the integrity of the new deck ring boot seals.

108069

**FIG. 26 PRIMARY SHIELD TANK BOOT
SEAL PARTIALLY INSTALLED**

108169

**FIG. 27 MATING SURFACES FOR BOOT
SEAL CLOSURE SPLICE**

108269

**FIG. 28 CLAMPING OF CLOSURE SPLICE
AFTER GLUING**

108369

FIG. 29 STITCHING OF CLOSURE SPLICE

108469

FIG. 30 COMPLETED BOOT SEAL INSTALLATION

B. REPAIR OF NO. 1 PRIMARY SODIUM PUMP

The rotor for the No. 1 primary sodium pump motor, which was shipped off site last month (see APDA-CFE-32, Section V. C) for machining of slip rings found grooved from arc-over, was returned and reinstalled in the motor housing. In the meantime, the thrust bearing assembly for the pump shaft was disassembled for inspection. Inspection revealed an irregular wear pattern in the bearing races (see Figure 31). The spalled bearing races will be polished for reuse. The seal faces in the No. 1 pump are also being replaced to correct the oil leakage difficulty found last month, which was thought to be the cause of the arc-over and subsequent slip ring damage. The reason for the high torque observed several months ago on the No. 1 pump (see APDA-CFE-31, Section III. C) is still under investigation. Although no cause for it has been found yet, it is known that the No. 1 pump, which is of a slightly different design than the other two primary pumps, has always had higher torque than the other pumps.

C. NEUTRON DETECTOR CHANNEL MALFUNCTION

On May 13, during the daily logging of neutron detector signals taken with the reactor shut down, the shutdown count rate on the low-sensitivity source range channel 2 detector (a Westinghouse U-235 fission counter) was observed to have increased by approximately a factor of six above the count rate logged the previous day. No change occurred in the count rate on low-sensitivity source range channel 1 detector, also a Westinghouse U-235 fission counter, located in the same neutron detector tube at the same position as source range channel 2. The count rate on source rate channel 2 was monitored for several additional days, during which time it remained at the high level of May 13.

Preliminary inspection of the channel indicated that a change in gain has occurred somewhere between the detector, located inside neutron detector tube No. 3 in the primary graphite shield, and the discriminator, located in the relay room beneath the main reactor control room. This reduced the source of the trouble to either the preamplifier located in the neutron detector box set on the reactor building operating floor above the detector tube or to the pulse amplifier located in the relay room.

To determine whether the preamplifier or pulse amplifier was the source of the unexplained gain, the supplementary high-sensitivity source range channel 2 detector circuit* was energized and count rate ratios between the

---

* The high-sensitivity source range channel 2 detector is located in neutron detector tube No. 4, which is adjacent to neutron detector tube No. 3. The high-sensitivity detector is also a Westinghouse fission counter, but it is canned inside zirconium hydride to increase its sensitivity so that it can be used in extending the life of the antimony-beryllium neutron source used for reactor

low-sensitivity and high-sensitivity channel 2 detectors were compared. The count rate ratio of the two channels was first obtained at the output of each preamplifier. The ratio there was the same as that obtained in previous measurements made over the past several years, indicating that the gain shift was not in the preamplifier of low-sensitivity source range channel 2 (excluding the unlikely possibility that both preamplifiers had changed in an identical manner). This reduced the location of the gain shift to the pulse amplifier of source range channel 2. This conclusion was confirmed by connecting an oscilloscope and a Hamner amplifier at the output of the pulse amplifier for channel 2 and running comparative discriminator curves on both the low-and high-sensitivity channels. When these data were compared with earlier data, it was evident that the gain shift had occurred in the pulse amplifier, since the fixed discriminator for channel 2 was bypassed when the discriminator curves were obtained.

The gain setting of the pulse amplifier was subsequently adjusted to bring channel 2 into calibration with previously established data, i. e., the gain was adjusted so that the shutdown count rate on channel 2 returned to its normal value. The daily log of shutdown count rate on source range channel 2 will be reviewed periodically in the future for any further sign of change.

D. REPAIR OF DEW POINT HYDROMETER IN STEAM CLEANING CHAMBER

The dew point hydrometer for the steam cleaning equipment in the fuel and repair building was checked and various minor repairs made. The cooling water supply to the hydrometer was also changed from general service water to demineralized water to minimize the plugging of the filter which has occurred in the past. Initial checkout of the device indicates that it is operating satisfactorily and that accurate dew point measurements are being obtained. Future process cycles during fuel handling will establish the reliability of the instrument.

---

* start-up. The high-sensitivity source range channel 2 detector has its own preamplifier, but a mixer circuit allows the same pulse amplifier and discriminator to be used for it as are used for the low-sensitivity source range channel 2 detector, i. e., the low-sensitivity detector count rate can either be obtained separately or the low-sensitivity plus high-sensitivity detector responses can be obtained together.

108569

108669

FIG. 31 TWO VIEWS OF SPALLED BEARING RACES IN THRUST BEARING ASSEMBLY OF NO.1 PUMP SHAFT

VI. SPECIAL INVESTIGATIONS

A. USE OF FLOWGUARDS IN SUBASSEMBLIES BEING STUDIED

Consideration is being given to the possibility of installing flowguards in the core and inner radial blanket subassemblies of the new fuel loading. The flowguards would consist of extensions of the subassembly nozzles which would project below the lower core support plate when the subassemblies are in position in the reactor.

The purpose of the flowguards would be to prevent coolant blockage to subassemblies from foreign objects, such as occurred in the October 5, 1966, incident. Various models of flowguards have been designed, built, and are presently being tested; no decision has yet been made of the type to be used if flowguards are adopted. However, until the studies are completed, the installation of flow orifices in the nozzles of the new inner radial blanket subassemblies begun last month (see APDA-CFE-32, Section VII. A), is being delayed because the type of orifice used may depend upon the flowguard design adopted. A dimensional survey of the inner nozzle diameters of the new core and inner radial blanket subassemblies has also been completed for use in the flowguard design studies.

B. POWER RANGE SIGNAL AMPLIFIER NOISE

Tests were made on the dn/dt (rate of change of power) power range signal amplifiers in the reactor control system to determine their sensitivity to power line voltage fluctuations. In separate tests, step changes of 2 volts a-c were made in the power feeds to the four power range amplifier modules in the dn/dt circuit. The test results showed that deflections as large as 1/4 volt occurred at the output of the amplifiers, corresponding to power changes as large as 1/2 Mwt per minute. Some of the amplifiers were found to be more sensitive to power line fluctuations than others.

A voltage regulating transformer has therefore been ordered for use in supplying power to all four amplifiers. It is expected that this modification will eliminate future random fluctuations in the dn/dt meters during approach to power.

C. NOISY LOOP-3 FLOWMETER

A review was made of the operational history of the noisy flowmeter in the 14-inch inlet sodium line of loop 3 (see APDA-CFE-1, p20, and APDA-CFE-26, p20). Noise levels as high as $\pm 14\%$ at 1/2 cps have been observed over a number of years in this flowmeter. The noise apparently starts or stops when a significant change in flow is made. A review of all flow changes made, dating back to 1963, shows that in general the noise level has increased

in two distinct steps (1) in July 1965 a definite increase in noise level occurred and (2) in January 1966 another definite step increase occurred.

The loop-3 flowmeter was noted to be particularly noisy during the period August 3 to 5, 1966, at which time a 3-day, 100-Mwt, power-demonstration run was conducted. This is also the time when it is believed at least one of the loose zirconium segments was lodged beneath the lower core support plate. Subsequent data show that the meter was still noisy after the first loose zirconium segment was removed from the reactor last year. It is not known whether the noise still persists now that the second loose segment has been removed, since sodium has been circulated only at pony motor flow on loop 3 since removal of the second segment and a check cannot be made at low flow.

Various theories have been postulated to account for the noisy flowmeter on loop 3, but the cause is still not understood. It does not appear to be due to approach conditions (the pipe configuration downstream from the flowmeter), since it has been observed when the loop was shut down and reverse flow due to loop 1 and loop 2 existed in loop 3. Adjustment of the amplifier settings for the flowmeter do not eliminate the noise. It has been theorized that the noise could be the result of pipe vibrations.

DISTRIBUTION LIST

USAEC - Chicago Operations Office

Director, Contracts Division (2)
G. H. Lee

USAEC - Washington

Director, RDT
Asst. Dir., Program Management, RDT
Asst. Dir., Reactor Engineering, RDT
Asst. Dir., Reactor Technology, RDT
Asst. Dir., Plant Engineering, RDT
Asst. Dir., Nuclear Safety, RDT
Project Manager, LMEC, RDT
Project Manager, FFTF, RDT
Program Manager, LMBFR, RDT
Liquid Metal Projects Branch, RDT
Chem. & Chem. Separations Branch, RDT
Reactor Physics Branch, RDT
Fuels and Materials Branch, RDT
Applications and Facilities Branch, RDT
Components Branch, RDT (2)
Instrumentation and Control Branch, RDT
Systems Engineering Branch, RDT
Core Design Branch, RDT
Fuel Handling Branch, RDT
Special Technology Branch, RDT
Reactor Vessels Branch, RDT

USAEC-RDT Site Representatives

Site Representative, APDA
Senior Site Representative, ANL
Sensor Site Representative, AI
Acting Senior Site Representative, IdOO
Site Representative, CE
Site Representative, GA
Site Representative, GE
Site Representative, ORNL
Site Representative, PNL
Site Representative, SR
Site Representative, UNC

USAEC-DTIE

R. L. Shannon (3)

USAEC-New York Operations Office

J. Dissler

USAEC-San Francisco Operations Office

J. Holliday

Director, LMFBR Program Office, ANL

A. Amorosi

Director, LMEC, AI

R. W. Dickinson

Aerojet - General Corporation

H. Derow

Argonne National Laboratory

R. Bane
L. W. Fromm
S. Greenberg
L. J. Koch
S. Lawroski
M. Novick
F. Smith

Atomics International

R. Balent (2)
S. Golan

Babcock & Wilcox Company

(Box 1260, Lynchburg, Va 24505)
M. W. Croft

Babcock & Wilcox Company

(Barberton, Ohio)
P. B. Probert

Baldwin-Lima-Hamilton Corp.

(Industrial Equip. Div., Eddystone, Pa)
J. G. Gaydos
R. A. Tidball

Battelle Memorial Institute

(Columbus, Ohio)
AEC Library

Brookhaven National Laboratory

O. E. Dwyer
D. Gurinsky (2)
K. Hoffman
C. Klamut
L. Newman
A. Romano

Combustion Engineering, Inc.

(Box 500, Windsor, Conn)
W. P. Staker
W. H. Zinn

Detroit Edison Company

W. R. Olson
H. A. Wagner

General Electric Company

(175 Curtner, San Jose, Calif 93125)
K. P. Cohen (3)

General Electric Company

(310 DeGuigne, Sunnyvale, Calif 94086)
A. Gibson

Gulf General Atomic, Div. of Gulf Oil Co.
(San Diego, California)
P. Fortescue

M. W. Kellogg Company
(711 Third, New York, New York)
E. W. Jesser

Lewis Flight Prop. Lab., NASA
(21000 Brookpark, Cleveland, Ohio)
C. A. Barrett

Los Alamos Scientific Laboratory
D. B. Hall (2)
G. Waterbury
W. R. Wykoff

MSA Research Corp.
(Callery, Pa 14024)
C. H. Staub

Nuclear Materials & Equipment Corp.
(Apollo, Pennsylvania)
Z. M. Shapiro

Nuclear Safety Information Center
(ORNL, Box Y, Oak Ridge, Tenn)
Director

Oak Ridge National Laboratory
(Box X, Oak Ridge, Tennessee)
F. L. Culler
J. H. Devan
D. Gardiner
J. White

Oak Ridge National Laboratory
(Box Y, Oak Ridge, Tennessee)
R. E. MacPherson, Jr.

Pacific Northwest Laboratory, BMI
E. Astley (5)

Power Reactor Development Company
(1911 First Street, Detroit, Mich. 48226)
A. S. Griswold

Southwest Atomic Energy Associates
(Box 1106, Shreveport, La 71102)
J. R. Welsh

United Nuclear Corporation
(Box 1583, New Haven, Conn)
A. Strasser (2)

Westinghouse Electric Corporation
(Box 158, Madison, Pa 15663)
J. C. R. Kelly, Jr. (2)

Westinghouse Electric Corporation
(Box 158, Madison, Pa 15663)
C. A. Anderson

USAEC-UKAEA Exchange
UKAEA
Reactor Group Headquarters
Risley, Warrington, Lancashire
England

J. Stephenson (12)

USAEC-EURATOM Exchange
EURATOM
53, Rue Belliard
Brussels 4, Belgium
A. deStordeur (10)

CNEN
Via Mazzini 2
Bologna, Italy
F. Pierantoni (4)

CEN Saclay
Boite Postale 2
Gif-Sur-Yvette (Set 0) France
G. Vendryes (10)

Kernforschungszentrum Karlsruhe
7500 Karlsruhe, Germany
W. Haefele (10)

Oak Ridge National Laboratory
(RDT Library, 1000 Building)
M. Bender