ENRICO FERMI ATOMIC POWER PLANT

CURRENT EXPERIENCE SERIES

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

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and

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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 is being recorded in a series of technical reports completed or in preparation 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

Both the primary and secondary systems remained drained of sodium in January because of repair and maintenance work in progress. The principal work activities involved completing the lower plenum restoration operations undertaken after removal of the zirconium segments.

The welding of the zirconium screw shanks to the flow cone was completed. Photographs show all shanks satisfactorily welded in place. A scraper tool was used to remove any remaining loose weld material from the surface of the cone.

A new vacuum cleaner has been designed and built for use in removing debris created in the lower plenum during the segment removal program. The new design, required because of the difficulties uncovered earlier during mockup testing of the inlet line vacuum cleaner, was made by removing the internals from the arc-melt tool housing and inserting a vacuum tube. The converted arc-melt tool vacuum cleaner is inserted into the inlet plenum through one of the rotating shield plug penetrations, instead of through the 14-inch line penetration. Tests in the mockup proved satisfactory and the vacuum cleaner was inserted in the reactor near the end of the month. Very little debris has been encountered to date in the cleaning operations in the first of the six sectors.

The zirconium segments have been cleaned and appear in good condition, with no visible surface deterioration. The zirconium screw removed intact from the cone has been matched with the second zirconium segment found loose in the reactor, thus positively identifying it as having come from the south sector. Radioactivity measurements made of the six segments show a wide variation over the plate surfaces. The activity consists mainly of zirconium-niobium-95 and cobalt-60, with some hafnium background. The cobalt-60 activity is thought to be from melted stainless steel from the cone in the area of the zirconium screws. No definite pattern in segment activities is apparent at this time which would allow unqualified prediction of the migration history of the two loose segments in the lower plenum prior to the accident. Uniform samples are to be removed from each segment and etched to remove surface contamination for a more accurate quantitative analysis.

Modifications were made to the neutron detector tubes located in the graphite shield to allow more efficient detector cooling. The tube seal design was found to be inadequate, allowing the cooling gas to bypass the detectors.

Replacement of the steam generator water manifold cover gaskets was begun. The gaskets were observed to be leaking water to the atmosphere during the September steam generator testing.

Efforts were continued to re-establish sodium flow through the plugging indicator loop of the transfer tank located in the fuel and repair building. Although initial efforts at re-establishing flow were not successful, it is believed that modifications now in progress will solve the problem.

II. INVESTIGATION OF ZIRCONIUM SEGMENTS

A. BACKGROUND*

The last of the zirconium segments was removed from the reactor during the third week in December 1968. During the last week of December, the zirconium screw shanks on the south half of the conical flow guide were welded in place using the arc-melt tool, and the cone was scraped to remove any loose metal from the weld areas on this half of the cone. Also during the last week in December, the loose zirconium screw on the south sector of the cone was unscrewed from its hole using the arc-melt tool. It was subsequently recovered from the floor of the plenum and withdrawn from the reactor, using the spine-type manipulator tool.

B. WELDING OF REMAINING ZIRCONIUM SCREW SHANKS

During the first week in January 1969, the remaining zirconium screw shanks on the north half of the conical flow guide (Sectors 4, 5, and 6)** were welded permanently in place using the arc-melt tool. Photographs taken through the borescope before and after each welding operation confirmed that the welds had been made successfully and that the shanks were firmly attached in place. The photographs taken before welding showed that several of the screw shanks had already been welded in place during the prior screwhead removal operations, and no further welding was performed on them. Four screw shanks out of a total of sixteen were found in this condition. The photographs taken after welding showed that two of the screws still had their heads partially intact. These were later scraped off. Photographs of a typical screw shank before and after welding are shown in Figures 1 and 2.

After completion of welding and photographing, the scraper tool was inserted through one of the rotating plug penetrations, and the remaining loose weld material was scraped from the cone surface. The small amount of weld splatter material observed on the cone was generally found to be securely welded to the cone in the vicinity of the screw holes.

C. MATCH-UP OF REMOVED SCREW WITH SEGMENT NO. 2

As reported in APDA-CFE-28, Sec. II. F., the zirconium screw in the lower west corner of the south sector of the flow cone, found to be loose

* APDA-CFE-28.

** See Figure 10 of APDA-CFE-28.

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FIG. 1 TYPICAL SCREW SHANK BEFORE WELDING

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FIG. 2 TYPICAL SCREW SHANK AFTER WELDING

in its hole, was unscrewed and removed from the reactor. This sector was one of the two found with a segment missing; therefore it was known that the removed screw must have been originally located in the lower left-hand hole of one of the two bent segments found loose and recovered from the floor of the plenum. It had been decided to remove the screw intact in the hope of being able to identify the two tack weld marks on the screwhead with those on one of the two loose segments to identify the original location of the segments.

A definitive matching of the weld marks was possible because the corresponding tack welds on the two segments had not been made with the same angle between welds. It was clearly evident that the screw had been originally attached to the second bent segment removed from the reactor, i. e., the one found lodged under the support plates. The weld matchings for the two segments are shown in Figures 3 and 4.

The conclusion, therefore, is that the second bent segment recovered came from the No. 2 cone position (south sector), and the first bent segment recovered came from the No. 6 cone position (northeast sector).*

D. CONDITION OF ZIRCONIUM SEGMENTS

1. Cleaning the Segments

Early in January, following the recovery of the last of the zirconium segments, all six segments were cleaned to remove surface contamination. They were steam-cleaned, alcohol-cleaned, scrubbed with a wire brush, and finally cleaned in an ultrasonic bath. After the ultrasonic cleaning, they were coated with Krylon spray to prevent transfer of any remaining contamination.

The condition of the six segments after cleaning appears excellent. No visible surface erosion or corrosion is apparent after eight years in the reactor sodium environment. Photographs of two of the segments taken before and after cleaning are shown in Figures 5 and 6. Figure 7 shows all six segments after cleaning and arranged in their original positions on the conical flow guide.

Inspection of the segments does reveal, however, that the tops of the screw holes in the two bent segments appear to be worn away and enlarged. The screw holes are all elongated in a direction pointing toward the apex of the flow cone. The elongation is more pronounced for some holes than others, as can be seen in Figure 6. The elongation is apparently due to either vibration of the segments on the cone during operation, and/or

* APDA-CFE-28, Figure 10.

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**FIG. 3 MISMATCH OF WELD MARKS ON
REMOVED SCREW WITH THOSE ON
SEGMENT NO. 6**

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**FIG. 4 MATCH OF WELD MARKS ON
REMOVED SCREW WITH THOSE OF
SEGMENT NO. 2**

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FIG. 5 ZIRCONIUM SEGMENT FROM NORTHWEST SECTOR BEFORE AND AFTER CLEANING

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FIG. 6 ZIRCONIUM SEGMENT FROM SOUTH SECTOR BEFORE AND AFTER CLEANING

FIG. 7 CLEANED ZIRCONIUM SEGMENTS ARRANGED IN ORIGINAL POSITION ON THE CONE

forces resulting from differential thermal expansion of the steel cone and zirconium segments. Any evidence of similar screw hole elongation in the four segments found intact on the cone, if it existed, was destroyed by the hole enlargement caused by arc-melting. However, the hole from which the screw was found to be missing on the southwest segment* showed little or no evidence of distortion. In the case of both loose zirconium segments, the attaching zirconium screws remained in the cone. The indicated fretting and fatigue cracking found around the screw holes apparently allowed the segments to become free of the screwheads while leaving the screws intact and in position.

2. Radioactivity Measurements

Radioactivity measurements of the zirconium segments were made immediately after their removal from the reactor, while they were still in the glove box at the 14-inch pipe penetration (see APDA-CFE-28, Sec. II. D). They were also made after each step in the segment-cleaning procedure. It was hoped that the measurements would give some indication of the location of the two loose segments in the lower plenum prior to and during the October 5, 1966 incident. It is believed that at least one loose segment was lodged under the fuel support plates, partially blocking flow to several subassemblies during the time of the 3-day, 100 Mw sustained power run made in August of 1966 (see APDA-CFE-1, page 14). Higher than normal outlet temperature readings were obtained from several subassemblies at that time. Approximately half of the reactor's total integrated power was generated during this run; therefore, since a segment under the support plates during this time would have been approximately 35 inches closer to the core and in a higher neutron flux than segments on the flow cone, it is expected that such a segment would have a higher induced activity than the other segments.

Most of the activity measurements were gross gamma and beta measurements over the segment surface made using ionization and Geiger counters. The gamma ray spectra were also analyzed using a multichannel analyzer (MCA) after the final ultrasonic cleaning. The measurements are summarized in Table 1, which shows that considerable surface contamination was removed in the cleaning process. Cs-137 was the principal isotope detected in the steam-cleaning effluent and alcohol wash. The gross gamma and beta dose rate measurements after the final ultrasonic cleaning represent maximum values over the segment surface. The surface activity of a segment varied by a factor of 2 or 3, with the maximum activity in almost all cases being found in the vicinity of the screw holes.

* APDA-CFE-20, page 22.

TABLE 1 - RADIOACTIVITY MEASUREMENTS OF ZIRCONIUM SEGMENTS

Location on Flow Cone	Segment Number					
	1 SE Sector	2 South Sector*	3 SW Sector	4 NW Sector	5 North Sector	6 NE Sector**
Activity in Glove Box at 14-inch Line Penetration, mr/hr						
Beta	150	>200	120	190	160	200
Gamma	—	—	—	—	—	15
Activity after Steam-Cleaning in Plastic Bag, mr/hr						
Beta	—	700	—	—	—	—
Gamma	—	70	—	—	—	—
Activity after Alcohol Cleaning in Plastic Bag, mr/hr						
Beta	—	360	—	—	—	—
Gamma	—	—	—	—	—	—
Activity after Wire Brush Scrub- bing in Plastic Bag, mr/hr						
Beta	—	—	~ 5	—	—	—
Gamma	—	—	~ 1	—	—	—
Activity after Ultrasonic Cleaning and Krylon Spray, mr/hr						
Beta	35	12	5	14	6	12
Gamma	7	0.08	0.10	1.7	1.8	3
MCA Analysis						
Zr-Nb-95, μ Ci/segment	~ 0.018	~ 0.018	~0.018	~0.018	~0.018	~0.376
Co-60, μ Ci/segment	~ 0.22	~ 0.02	~0.09	~ 0.15	~0.11	~0.15

* Location of the second bent segment found loose in plenum

** Location of the first bent segment found loose in plenum

It was difficult to obtain a high degree of accuracy in the multi-channel analyzer spectrum measurements. The sodium iodide crystal used for the measurements was centered over each plate and a geometrical conversion made to convert the measured values to microcuries per segment. Uncertainty in the conversion to obtain the integrated effect over the segment surface arises because of the irregular segment geometry and the variation in surface activity. An additional uncertainty exists in the case of the measurements made of the two bent segments, No. 2 and No. 6, since they were bent over in a double layer thickness and required additional self-shielding and geometrical corrections.

The source of the combined zirconium-niobium-95 activity is clearly the (n, γ) reaction with zirconium-94, the predominant zirconium isotope. Zirconium-95 decays with a 65 day half-life to niobium-95, which in turn decays with a half-life of 35 days to stable molybdenum-95.

The source of the 5.3 year half-life Co-60 activity is not as obvious. Co-60 could have resulted from an (n, γ) reaction with cobalt-59 present as an impurity in the zirconium plates.* However, zirconium normally does not have cobalt as an impurity. No impurity analysis has been found for the zirconium used in the fabrication of the segments. The Co-60 activity may have resulted from an (n, p) reaction in nickel, a common impurity in zirconium. In addition, contamination of the segments by the radioactive products of the melted fuel and stainless steel wrapper cans could have occurred. These two possibilities are considered unlikely, however. It is possible too that the zirconium segments could have become contaminated with the Co-60 activity present in the stainless steel flow cone by means of diffusion of weld material generated during the arc-melting removal of the zirconium screwheads. The hypothesis of weld material contamination is supported by the fact that the highest gross segment surface activity occurs around the screw holes; however, no measurements have been made as yet to verify that the cobalt-60 activity is also concentrated in the area of the screw holes. Also, it is difficult to explain contamination during the arc-melting process of segments No. 2 and No. 6, since they were off the cone at that time.

To aid in clarifying these questions, small samples will be punched out of each segment, weighed, measured, and their γ -ray spectra analyzed on the MCA before and after a series of surface machinings. This should tell whether surface contamination is the source of the Co-60 activity. It will also aid in eliminating some of the uncertainty in the geometrical conversion used to obtain quantitative activity values.

* It is not unreasonable that an impurity activity like Co-60 could now (2-1/2 years after the accident) be as large as the zirconium activity, considering the difference in half-lives.

Hafnium activity was also seen in the spectrum analysis of the segments; but this is to be expected, since hafnium is a normally occurring impurity in zirconium. The zirconium screw removed intact from the cone had the same activity spectrum as the zirconium segments. Its activity could not be quantitatively compared with the segment activities, however, because of the large difference in geometry.

The measurements clearly indicate that the zirconium-niobium-95 activity of segment No. 6 is considerably larger than that of the other segments. Segment No. 6, the first bent segment found loose in the plenum, is the segment determined to be originally from the northeast sector of the cone. On this basis, the tentative conclusion has been made that it was located up against the underside of the lower support plate, partially blocking flow during the 3-day 100 Mwt sustained power run.

III. VACUUMING THE LOWER PLENUM

A. BACKGROUND

Development of a vacuum cleaner to sweep the floor of the lower plenum following removal of the zirconium segments has been underway for four months.* The purpose of the cleaner is to remove any debris which might have resulted from arc-melting the screwheads, welding the screw shanks to the cone, and subsequently scraping the cone surface.** Most of the weld slag from the arc-melting was found adhered to the edges of the screw holes of the removed segments, as expected from earlier test results.***

The small amount of debris observed to have resulted from these operations is small in size and concentrated in the vicinity of the flow cone. Some of it consists of weld splatters and some consists of spherical weld globules the size of bird shot. A considerable amount of sodium also can be seen on the plenum floor in the form of droplets. Since it is difficult to distinguish weld splatter from sodium, both sodium and weld splatter will be picked up by the vacuum cleaner.

Until this month, vacuum cleaner development efforts were devoted solely to a vacuum cleaner intended for insertion through the penetration in the 14-inch line; however, testing in the mockup facility has revealed several deficiencies in this device.**** Concern over its ability to pick up debris exists, because the nozzle lies horizontally on the plenum floor and inefficiently directs the suction flow parallel to the floor. Only debris directly in front of the nozzle can be picked up. Furthermore, the mock-up tests had shown that the vacuum cleaner was limited in its extent of coverage in the lower plenum. Concern was also expressed over the difficulty of its control and mobility in the plenum. It was found awkward to manipulate the nozzle from the below-floor penetration through the 14-inch line. The rubber vacuum hose had a tendency to twist and form knots in the lower plenum unless its movements were carefully controlled through continual viewing from the top of the rotating plug. Finally, precise positioning of the nozzle was difficult, a large number of turns on the control cable being required to make a single 360-degree rotation of the nozzle, as a result of windup in

* APDA-CFE-26, 27 and 28, pp. 16, 13, and 15 respectively.

** Larger debris detected in earlier surveys of the lower plenum had been previously removed with the spine tool device (APDA-CFE-21, page 19).

*** APDA-CFE-26, Sec. II. B. 1.

**** APDA-CFE-28, Sec. II. G. 1.

the control cable. This difficulty was solved in January, however, by the installation of a stiffer speedometer-type cable. With it, a one-to-one movement ratio between the nozzle and control cable was achieved.

For these reasons, an alternate vacuum cleaning system for cleaning the lower plenum was developed and tested in January. It is designated as the converted arc-melt tool vacuum cleaner, since it was constructed from the old arc-melt tool (see APDA-CFE-22, page 6 and APDA-CFE-23, page 6) by removing the internals from the tool housing and inserting a vacuum tube. The converted arc-melt tool vacuum cleaner will be installed in the reactor through one of the rotating plug penetrations and gain entrance to the lower plenum through the holes in the core support plate structure, as was done with the arc-melt tool.

Although lateral movement of this device is restricted by the limited 10-degree articulation available in the elbow of the lower arm, sufficient movement exists to fully cover an area extending to 10 inches beyond the flow cone. It also allows the area under the skirt of the cone to be vacuumed. Since the vacuum nozzle of the arc-melt tool vacuum cleaner can be centered vertically over the debris, an effective pressure difference is obtained. Because of the good direct control which this vacuum cleaner offers, it is the preferred cleaner and the one inserted in the reactor during the last week in January.

The 14-inch line vacuum cleaner has also been qualified for use in the reactor. If needed, it will be used later for cleaning the outer plenum regions which are beyond the reach of the arc-melt tool vacuum cleaner. This will only be done if surveys indicate that debris exists in these regions.

B. CONVERTED ARC-MELT TOOL VACUUM CLEANER

Conversion of the arc-melt tool to a vacuum cleaner was logical after difficulties were encountered in the development of the 14-inch line vacuum cleaner. The arc-melt tool design, which consists essentially of only a long housing tube having an articulated arm at its lower end inside of which are located the tool internals, was readily adaptable. Also, direct access to the lower plenum area near the flow cone had already been demonstrated in the use of this tool for screwhead removal.

The first attempt at converting the arc-melt tool to a vacuum cleaner consisted merely of removing the tool internals and attaching a hose fitting on top of the housing to accommodate a vacuum hose. The 38-foot-long upper section of the arc-melt tool housing was left intact. This section, which fits in the support plate holes, consists of two concentric tubes of 1-1/8 inches OD and 2.6 inches OD, respectively. However, the 2-foot-long, 3/4-inch-OD lower section of the old housing was lengthened to 34 inches. This is the articulated portion of the tool positioned in the lower plenum below the support plates when the tool is in the reactor; it was

lengthened for greater reach. By manually rotating the inner tube of the upper section through 180 degrees, a maximum 10-degree articulation of the lower arm from the vertical could be achieved.

Mockup tests of the first arc-melt tool vacuum cleaner design showed that it was not fully adequate. In spite of the extension made in the lower articulated arm, the arm lacked flexibility to perform vacuuming in the entire area underneath the flow cone. Tests made with large size (No. 4) lead shot showed that inadequate suction existed to draw it up the full length of the tube. This resulted in the shot dropping back into the plenum when the vacuum was turned off.

An improved design was developed to overcome these difficulties. First, the 34-inch-long articulated arm was replaced with a somewhat shorter arm (24 inches long) and a flexible metal vacuum hose 17 inches in length was added inside the arm. The hose can be extended out of the arm about 12 inches. A 1/4-inch-diameter stiff cable attached to the hose controls extension and retraction. Mockup tests on the design showed that the combination of hose extension and arm articulation would allow the vacuum nozzle to be positioned underneath the flow cone. An area extending to 10 inches beyond the cone could be covered in a similar manner. Movement of the device along the floor of the plenum is achieved by rotating the tool with the hose extended against the cone (or flow baffle structure) to exert a lateral force on the hose. To gain access to the entire area around the cone, vacuum cleaner positionings in all three reactor plug penetrations will be necessary. A photograph of the converted arc-melt tool vacuum cleaner installed in the mock-up facility is shown in Figure 8.

The design was further modified by adding a debris trap located immediately above the flexible metal hose portion of the vacuum tube in the lower articulated arm. Its function is to trap large pieces of debris which might otherwise fall back into the plenum when the vacuum is turned off. The debris trap, shown in Figure 9, is based on the same principle as the trap installed in the 14-inch line vacuum cleaner,* consisting of a catcher cup attached to the flexible hose and a gas flow deflector above the cup. Gas flow through the flexible hose is directed to the deflector. The gas stream is then diverted around the deflector in such a manner that if particles are not carried completely up the tube, the direction change results in their dropping back into the catcher cup.

Mockup tests of the final vacuum cleaner design using different sized lead shot (No. 4 to No. 12) showed that all shot was readily picked up, the fine shot passing directly to the top of the vacuum tube and the larger lead

* APDA-CFE-27, Figure 6.

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FIG. 8 CONVERTED ARC-MELT TOOL VACUUM CLEANER IN MOCKUP—BORESCOPE AT RIGHT

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FIG. 9 DEBRIS TRAP OF CONVERTED VACUUM CLEANER

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FIG. 10 CONVERTED VACUUM CLEANER INSTALLATION IN REACTOR—BORESCOPE AT RIGHT

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FIG. 11 CLOSE-UP OF VACUUM CLEANER INSTALLATION IN REACTOR—BORESCOPE ON RIGHT

shot being caught in the trap. No shot was observed to fall back into the lower plenum. It is anticipated that the trap will also retain some of the sodium which is picked up during the vacuuming in the reactor. The vacuum cleaner, required lighting, and borescope for viewing will be installed together in the reactor through the 6-inch penetrations in the rotating plug. Debris carried up the tube will be retained in a filter tank containing a fiber glass filter located on the operating floor. Although an industrial vacuuming system was used in the mockup tests, the suction during reactor vacuuming will be drawn from the reactor waste gas vacuum system, which it is anticipated will be more powerful than the industrial vacuum system.

C. VACUUMING EXPERIENCE TO DATE

The converted arc-melt tool vacuum cleaner was installed in the reactor and vacuuming operations begun during the last week of January. Photographs of the vacuum installation in the reactor are shown in Figures 10 and 11. The vacuum hose connection to the reactor waste gas system was made to an auxiliary waste gas line below the operating floor through an instrument penetration hole. Measurements indicated that continuous steady-state argon flow rates of 65 cfm through the vacuum cleaner could be maintained. Manual operation of a valve located at the hose connection to the vacuum cleaner gave instantaneous surge capacities of 110 cfm. The mockup tests had indicated that surge capacity would be useful in picking up any larger pieces of debris which might be encountered.

Vacuuming was begun in the northwest sector of the lower plenum opposite the No. 4 cone surface (see APDA-CFE-28, Fig. 10). When the vacuum cleaner was first used, flow restrictions were encountered in the section of vacuum line between the filter tank and the vacuum cleaner. The flow interruption, caused by collapse of the Teflon lining of the metal-sheathed vacuum hose, was corrected by replacing this section of hose with another having a thicker lining. An octagonal shaped scraper was also added to the nozzle of the vacuum cleaner at this time to aid in dislodging any particles found to be adhering to the pan.

During vacuuming operation, a black stain having no appreciable thickness (estimated at less than 0.0020 inch) was observed near the periphery of the flow cone. The stain can be seen in Figure 12, which is a photograph of the northwest sector taken prior to vacuuming. The discoloration had an irregular shape and appeared to be about 1-1/2 inches wide and 6 inches long. Scratches could be made through it with the scraper attachment, but it did not have sufficient substance to allow complete removal. Stains such as this have been observed previously in the lower plenum; their origin is unknown.

The vacuuming of the northwest sector was completed by the end of the month. As seen in Figure 13, the vacuuming operation did not signifi-

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FIG. 12 NORTHWEST SECTOR OF LOWER PLENUM BEFORE VACUUMING

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FIG. 13 NORTHWEST SECTOR AFTER VACUUMING

cantly alter the appearance of this sector, because there was so little material to be found. The only debris seen during the vacuuming was a few birdshot-sized pieces of weld slag. Inspection of the filter tank after vacuuming revealed only approximately 1 gram of weld material (about enough to fit in a thimble) and sodium. The trap in the vacuum cleaner was not inspected.

On the whole, the converted arc-melt tool vacuum cleaner appears to be working well. The detailed photographic survey has been found to be time-consuming, however, because of the difficulty in positioning the light and borescope for good-contrast pictures.

IV. OPERATIONS

A. STATUS OF REACTOR SODIUM AND GAS SYSTEMS

The primary system remained drained of sodium throughout the month to allow continuation of work inside the reactor vessel. The temperature of the primary system was maintained at approximately 350 F by the pipe and vessel induction and resistance heaters. The secondary system also remained drained and at ambient temperature (~100 F) to allow steam generator repairs to be made. No cold-trapping or subassembly movements were made during the month.

B. COVER GAS ACTIVITY *

<u>Location</u>	<u>Sample Date</u>	<u>Gross Beta Activity, $\mu\text{Ci}/\text{cm}^3$</u>
Reactor Cover Gas	1-3-69	1.24×10^{-6}
Reactor Cover Gas	1-16-69	1.6×10^{-6}
Reactor Cover Gas	1-30-69	1.12×10^{-6}
Primary Shield Tank	1-3-69	4.66×10^{-8}
Primary Shield Tank	1-16-69	3.33×10^{-8}
Primary Shield Tank	1-30-69	3.16×10^{-8}
Fuel and Repair Building (Receiving Station)	1-17-69	1.24×10^{-6}

C. PRIMARY SYSTEM COVER GAS ANALYSIS **

	<u>Reactor Cover Gas (Argon), ppm by volume</u>	<u>Primary Shield Tank Atmosphere (Nitrogen), ppm by volume</u>
Oxygen	Below 25	115***
Carbon Monoxide	Below 10	Below 10
Carbon Dioxide	15	10
Hydrogen	Below 4****	Below 2.5
Helium	Below 4	Below 4

* The last reported data on cover gas activity appear in APDA-CFE-28

** The last reported cover gas analysis data appear in APDA-CFE-28. The new data reported here were obtained from a sample taken January 16, 1969

*** Technical specifications state 1000 ppm maximum

**** The recommended maximum for reactor operation is 10 ppm

Methane	Below 10		Below 10
Nitrous Oxide	←	Not Measured	→
Nitrogen	680		Remainder
Argon	Remainder		Not Measured
Dew Point	Not Measured		-55 F

D. PRIMARY SODIUM SYSTEM ACTIVITY

The last reported data on the primary sodium system activity appear in APDA-CFE-25. The data below are from a previously unreported measurement.

<u>Location</u>	<u>Sample Date</u>	<u>Analysis Date</u>	<u>Specific Activity, μCi/g</u>
Sample Coil (No. 48) from Sampling Station	11-23-68	12-10-68	5.85×10^{-3}

V. PLANT MAINTENANCE

A. NEUTRON DETECTOR TUBE COOLING MODIFICATIONS

1. Description of Neutron Detector Tubes

The nuclear instrumentation for the reactor is enclosed inside six neutron detector tubes (NDTs) located on the south side of the reactor. The six-inch-diameter NDTs (see Figure 14) penetrate the operating floor at angles of 6 to 8 degrees from vertical; they have a short run in the below-floor region between the primary shield tank and secondary shield walls and enter the primary shield tank at the conical section just below the bottom of the operating floor. They then extend downward through the graphite shield to an elevation slightly below the core midplane. The neutron detectors are mounted on racks at varying elevations inside the NDTs. The rack assembly is attached to a concrete shield plug located in the operating floor penetration. The coaxial cables from the detectors spiral through the shield plug to an instrument box containing preamplifiers located on the operating floor above each tube. The detector rack has an alignment seal collar which seals the rack inside the NDT; the NDT sleeve through the operating floor is sealed by a bolted cover inside the instrument box.

2. Background of Problem

Fission counters are used for source range detection and ion chambers for the intermediate and power ranges. Prior to plant startup, it was believed that the detectors and cables would operate satisfactorily at the temperatures existing at the detector locations during full power operation. However, cooling to the detectors was provided in the plant design in the event it might be required. Data now indicate that detector cooling may be needed at some future date. Other data show that the installed detector cooling system is operating far below its design capacity. Investigations to determine the cause of the cooling deficiency have been made this month and corrective measures taken.

3. Detector Temperature Limitations

Measurements of the decrease in cable insulation resistance with temperature indicate that the mineral-insulated coaxial cables to the ion chambers have a lower maximum temperature limitation than originally anticipated. At temperatures above 350 F current losses became excessive. However, the high-temperature, vacuum-beaded insulated cables used for the fission chambers are not similarly affected.

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FIG. 14 NEUTRON DETECTOR TUBE SEALS BELOW FLOOR

Unsatisfactory operation of the intermediate range ion chambers due to cable current leakage at temperatures above 350 F would occur when the reactor had been operating at full power, is scrammed, and startup is attempted again shortly thereafter. For this mode of operation, high graphite temperatures exist at the time of the new startup. Leakage losses would be excessive during startup at a power level corresponding to the lower end of the overlap region between the source range detectors and intermediate range detectors. At this power level, leakage would be a large fraction (25%) of the ion chamber signal and overlap detection could conceivably be lost. No problem exists during cold startup or at higher power levels, since with a high signal the leakage losses can be tolerated.

4. Measured Temperatures

Temperature measurements have been made at 100 Mwt with the detector cooling system turned off and on. With no cooling, graphite temperatures of approximately 325 F were measured in the vicinity of the detector tubes. Temperatures inside the detector tubes were around 300 F. With the detector cooling system turned on, no appreciable cooling of the detectors could be seen, indicating that the cooling system was operating far below design capacity.

Extrapolation of the 100 Mwt temperature data to anticipated future operation at 200 Mwt indicates that equilibrium graphite temperatures in the vicinity of the detectors will be of the order of 350 F. This is the range where the need for detector cooling must be considered.

5. Reason for Cooling Deficiency

A schematic representation of the neutron detector cooling system is shown in Figure 15. Nitrogen used to cool the NDTs enters the reactor building in a 4-inch line via the normal below-floor atmosphere cooling system. The 4-inch coolant supply line connects with a 4-inch ring inlet header located around the periphery of the conical section of the primary shield tanks. From the header, 2-inch feed lines supply gas into the top of each neutron detector tube (Figure 16). The gas then passes downward through the tubes to the detectors and out the bottom, where it is collected in an outlet ring header. The gas exhausts from the primary shield tank through a common riser at a point about halfway up the primary shield tank wall. The temperature of the gas entering the NDTs is about 100 F, varying somewhat between winter and summer.

Pressure head tests of the detector tube coolant piping were made early this month in an attempt to reveal the reason for the loss of cooling efficiency. The extent of the loss was determined in a test where the discharge pipe from the outlet header was capped off outside the primary shield tank and fitted with a water manometer (See Figure 15). A measured

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FIG. 15 NEUTRON DETECTOR TUBE COOLING

FIG. 16 TYPICAL NDT BEFORE AND AFTER CLEANING

FIG. 17 GENERAL VIEW OF NDT AREA

discharge pressure of 50 inches water column gauge (WCG) at the discharge of the cooling fan was found to be reduced to only 4 inches at the capped outlet header, indicating a severe loss. To determine whether the loss was occurring between the fan and inlet header, the coolant supply line to the inlet header was disconnected and capped at the header and the measurement repeated. Forty-seven inches WCG was obtained, indicating that the leakage was not in this line but somewhere in the connections between the inlet header and neutron detector tubes. An additional measurement was also made at the inlet header with the supply line open and a pressure of 4 inches WCG was obtained.

A subsequent inspection of the detector tubes in the space between the primary and secondary shield walls revealed the source of the excessive leakage of cooling gas from the tubes. A poor alignment collar seal (Figure 14) was allowing most of the gas to leak upward past the seal, rather than flow down the tubes to the detectors. The gas was then leaking into the below-floor region at the three welded joints shown in Figure 14, which had not been designed gastight and were only stitch welded, with large gaps existing between welds. Gas leakage was also occurring through the porous asbestos dust covers around the slip-fit expansion joints, which similarly were not designed for gastightness. A photograph of a typical NDT in this area, taken before repair work was initiated, is shown in Figure 16.

6. Neutron Detector Tube Modifications

The leaks in the neutron detector tubes were repaired by seal-welding the three stitched welded pipe sections on each of the six detector tubes. The porous asbestos dust seals around the expansion joints were replaced by glass-reinforced silicone rubber band seals.

Access to the detector tubes for repairs was obtained through a manhole in the operating floor between the primary and secondary shield walls. A steel grating welded in the annulus between the two shield walls provided access between the manhole and detector tubes. Nevertheless, access was very difficult because of the many piping and instrumentation obstructions in this particular area. The work was performed in a 130 F ambient atmosphere. A photograph of a typical NDT after repairs is shown in Figure 16.

Pressure tests and temperature monitoring are planned to confirm that increased cooling capacity has been gained by the repair work.

B. REPLACEMENT OF STEAM GENERATOR WATER MANIFOLD GASKETS

An earlier report (APDA-CFE-25, page 21) described the difficulties which have been encountered with water leakage from the water manifold

covers of the three steam generators. The original soft iron gaskets had not been properly annealed and were found to be hard and inflexible. The decision was made to replace the gaskets on all three steam generators with copper gaskets. The new copper gaskets for the water manifold covers have now been received. Prior to replacement of the gaskets, the manifold covers have been removed from the No. 2 and No. 3 steam generator units.

Inspection has shown all the poppet-type orifice tubes to be in their proper positions, indicating that the orifice tubes did reseat following the isolation tests made several months ago.* There had been some concern that the orifice tubes might not reseat following the isolation and venting tests.

Replacement of the gaskets and reassembly of the steam generators has begun. Work on unit 1 is nearly complete; reassembly of units 2 and 3 is expected to be completed by the middle of February.

C. FUEL AND REPAIR BUILDING MAINTENANCE WORK

1. Replacement of Damaged Floor Valve Seal in Steam Cleaning Chamber

In September 1968, three fuel and 31 inner radial blanket sub-assemblies were transferred from the reactor to the fuel and repair building for steam-cleaning and temporary storage in the decay pool.** Difficulties were encountered at that time in the operation of the gripper for the steam-cleaning chamber machine. This led to the discovery of a damaged and deteriorated Buna rubber seal in the gate valve leading from the cleaning chamber to the cut-up pool.*** Since no replacement seal was immediately available, the valve was temporarily left in the open position to allow completion of the deposit of cleaned subassemblies in the cut-up pool.

Shipment has now been received of the new Buna rubber seal which seals the edges of the sliding valve plate. The cut-up pool valve has been removed from the floor of the steam-cleaning chamber room and the seal replaced. The background radiation level in the steam cleaning chamber room ranged from 50 to 200 mr/hr. The surface radiation level of the valve body was initially 200 mr/hr, but ultrasonic cleaning and decontamination reduced the value to 15 mr/hr. The contamination was identified as long-lived fission products from subassemblies previously washed in the steam-cleaning chamber.

* APDA-CFE-26, pg. 21 and APDA-CFE-28 Sec. III. B. 1.

** APDA-CFE-25, pg. 12.

*** APDA-CFE-25, pg. 29 and Figure 11.

The floor valve has not yet been reinstalled in the steam-cleaning chamber. This valve and an identical valve located in the new fuel dry loading tunnel have suffered similar seal deterioration before; therefore, consideration is being given to a possible new valve design for use in both areas.

2. Efforts to Establish Flow Through Transfer Tank Plugging Indicator

a. Background

As reported earlier (see APDA-CFE-25, page 20), the subassembly transfer operations during September 1968 made with the BMI multipurpose cask resulted in excessive leakage of air into the transfer tank sodium system in the fuel and repair building. The sodium plugging temperature rose from 210 F to 430 F, after which flow through the plugging indicator circuit stopped and could not be re-established. Excessive oxide buildup in the transfer tank sodium had apparently caused plugging somewhere in the 3/4-inch-diameter sodium piping of the plugging indicator circuit. This occurred in spite of continuous cold-trap operation during the fuel transfer. The subassembly transfers from the BMI cask to the transfer tank were completed, however, with this circuit out of service. Following this, subassembly steam-cleaning was interrupted for one week while cold-trapping was conducted at elevated temperatures (500 to 600 F) to clean up the transfer tank sodium. After sodium clean-up and temperature reduction to 400 F, the subassembly steam-cleaning and transfer to the decay pool was completed.

The transfer tank room was then opened up for inspection of the plugging indicator circuit (see APDA-CFE-28, Sec. V.A). The plugging indicator orifice was heated and a vacuum drawn on the line, but no sodium could be moved. Argon was blown down both the inlet and outlet sodium lines to the orifice. These tests indicated that the line upstream of the orifice was clear, but the line downstream to the electromagnetic pump was plugged. The downstream line was cut and flushed clean with alcohol to remove an oxide plug found in the suspected area. Further investigation also revealed that a section of 3/4-inch inlet pipe passing through the pump was twisted and pinched nearly closed. It appeared that this was probably the main cause of the line blockage rather than oxide accumulation. The pinched-off line was repaired and reinstalled in the pump. The cause of the line damage is not known.

b. Recent Investigations

Subsequent attempts in January to establish sodium flow through the plugging indicator circuit, using the electromagnetic pump, have proved unsuccessful. Although the sodium lines were again drained,

pressurized with argon, evacuated, and refilled with sodium a number of times, sodium flow could not be established through the plugging meter. During these attempts, a small sodium leak developed at a swaged fitting in the vacuum test line. In attempting to secure the fitting, a line break occurred, resulting in a small sodium fire. It was extinguished by shutting down the pump and smothering the area with argon. The maximum radiation level measured in the work area was 1.5 mr/hr.

To investigate the problem further, the transfer tank plugging indicator orifice was cut out of the circuit for inspection and cleaning. The small pinholes in the orifice flow plate were found to be completely plugged with unidentified foreign deposits. Alcohol and ultrasonic cleaning removed the restrictions. Prior to reinstallation of the orifice, the orifice inlet and outlet lines were retested for blockage by blowing argon down each line from their points of entry and exit from the orifice. The tests showed very little gas was being passed through the sodium outlet line upstream from the orifice. The line was flushed with alcohol, which resulted in dislodging unidentified black deposits, until clear. Following removal of the restrictions, both orifice sodium lines were again purged and tested with argon. New test lines were then installed near the orifice location to permit independent vacuum and pressure testing of each line after the orifice is reinstalled. To accomplish this, the line from the test gas supply tank was fitted with a tee and each leg of the tee was connected to the inlet and outlet lines on either side of the orifice location. Shut-off valves allow shunting of the test flow in the desired direction. It is now planned to reinstall the orifice and test the lines in both directions with the orifice installed. The system will then be filled with sodium and flow established to verify that the circuit is clear of all obstructions.