MONTHLY REPORT No. 13 - AUGUST 1967

COMPILATION OF CURRENT TECHNICAL EXPERIENCE AT ENRICO FERMI ATOMIC POWER PLANT

AEC CONTRACT No. AT (11-1)-865
PROJECT AGREEMENT No. 15

SPONSOR: DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY, UNITED STATES ATOMIC ENERGY COMMISSION

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DISCLAIMER

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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 nuclear operating and maintenance experience at 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 US Atomic Energy Commission under AEC Contract 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 one megawatt thermal, 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 this time the reactor has been shut down while the cause and extent of the damage are being investigated.

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 Report No. 1. In addition, a topical index appears at the end of the June 1967 report. Revisions to the index are planned at six-month intervals.

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.

SECTION I

CURRENT EXPERIENCE SUMMARY

Twenty-three subassemblies were relocated in the reactor lattice to open up a space to permit viewing of the hold-down fingers to determine if any are bent and to permit installing viewing and lighting equipment in the inlet plenum at the bottom of the reactor vessel. The inlet plenum inspection is to determine if some loose object may be present which could have plugged the inlet nozzles of the subassemblies which melted on October 5, 1966.

After the primary sodium had been cleaned up by cold trapping, the reactor vessel was drained below the level of the meltdown pan in the inlet plenum. Inspection of the interior, down to the support plates, was performed with a borescope borrowed from the Sun Oil Company. Good results with this instrument during the month prompted the decision to extend its length for viewing in the inlet plenum. The corescope is also being extended for inlet plenum viewing.

The core section of subassembly M127 was cut longitudinally with an abrasive wheel at the Battelle Memorial Institute hot lab. Examination of the halves showed that melting had taken place throughout the entire length and had formed an almost continuous void along the axial center of the section. One to three rows of pins at the outer edges near the can walls remained intact except in the areas adjacent to subassembly M098 where can wall penetration took place.

SECTION II

PLANT OPERATIONS

A. Reactor Subassembly Movements

The diagram on the following page shows that twenty core and blanket subassemblies were moved to different positions in the reactor lattice during August. In addition, three outer radial blanket (ORB) subassemblies were moved from the transfer rotor container (TRC) to the reactor lattice and were replaced by three core subassemblies from the reactor lattice. Most of the subassemblies were relocated to open up an area of the reactor lattice where a spherical mirror will be inserted to permit viewing of the fingers of the hold-down mechanism through a corescope. The other subassemblies were shifted to make openings in the reactor lattice where the corescope and light source will be inserted for viewing the reactor lower plenum. See Page 11 for additional details on the planned corescope viewing of the hold-down fingers and lower plenum.

The following listing summarizes the subassembly relocations made during August:

Subassy No.	Type	From Position	To Position	Reason for Move
S733	ORB	TRC	N09-P09	(Provide TRC space for
M942	ORB	TRC	N08-P09	core and IRB sub-
M972	ORB	TRC	N07-P09	assemblies)
M079	Core	N01-N03	TRC	(Clean an area for view-
M357	IRB*	N06-P02	TRC	ing of hold-down
M326	IRB*	N06-P01	TRC	fingers)
M898	ORB	N08-P01	N09-P04	Same
M914	ORB	N08-P00	N08-P04	Same
M973	ORB	N08-N01	N09-P05	Same
S735	ORB	N08-N02	N06-P05	Same
M982	ORB	N07-P02	N07-P04	(Clean an area for view-
M902	ORB	N07-P01	N06-P04	ing of hold-down
M909	ORB	N07-P00	N08-P05	fingers)
M869	ORB	N07-N01	N07-P05	Same
M115	Core	N04-N02	N05-P04	Same
M082	Core	N03-N02	N04-P05	Same
M153	Core	N03-N03	N05-P03	Same
M094	Core	N02-N03	N03-P01	Same
M124	Core	N04-N03	P09-P11	Same
M116	Core	P04-P02	N06-P03	(Provide spaces
M133	Core	P05-P01	N02-P03	for inspection
M136	Core	P05-N01	N02-P04	of east segments
M143	Core	P05-N02	N05-P05	of lower plenum

* IRB = Inner Radial Blanket Subassembly

KEY:

CR Control Rod No. 430169-
SR Safety Rod No. 430192-
OR Oscillator Rod
CS Core Shim Subassembly
CF Core Foil Subassembly
BF Blanket Foil Subassembly
CT Coarse Filter, Take-apart, Dummy Core Subassembly
NOTE: Dummy Core subassemblies in the reactor meet "Core A" core subassembly specification, and bear the suffix "CF"

NA Sodium Worth Subassembly
NS Neutron Source
TIT Temporary Instrument Thimble
MS APDA Materials Surveillance Subassembly
M Subassembly Manufactured by D.E. Makepeace Co.
S Subassembly Manufactured by Sylcor Division, Sylvania Electric Products Co.

M 001 - M 206 Core Subassemblies
M 301 - M 400 Inner Radial Blanket Subassemblies
S 500 - S 798 Outer Radial Blanket Subassemblies
M 801 - M 1000 Outer Radial Blanket Subassemblies

Units shown without prefix are dummy outer radial blanket subassemblies.

Oversize Nozzle Unit

"F" Subassembly (Contains fuel pins with high iron plus nickel, high carbon or Zirconium content.)

"W" Subassembly (Contains fuel pins with high iron plus nickel content.)

Blanket slugs have high carbon content. (APDA Surveillance Program Unit)

Stringering in Blanket Slugs

Large Grain Blanket Material (Hash)

Larger Than Normal Spacing Between the Blanket Elements and the Support Grid

Type 347 Stainless Steel Wrapper Tube

Handling Head Short

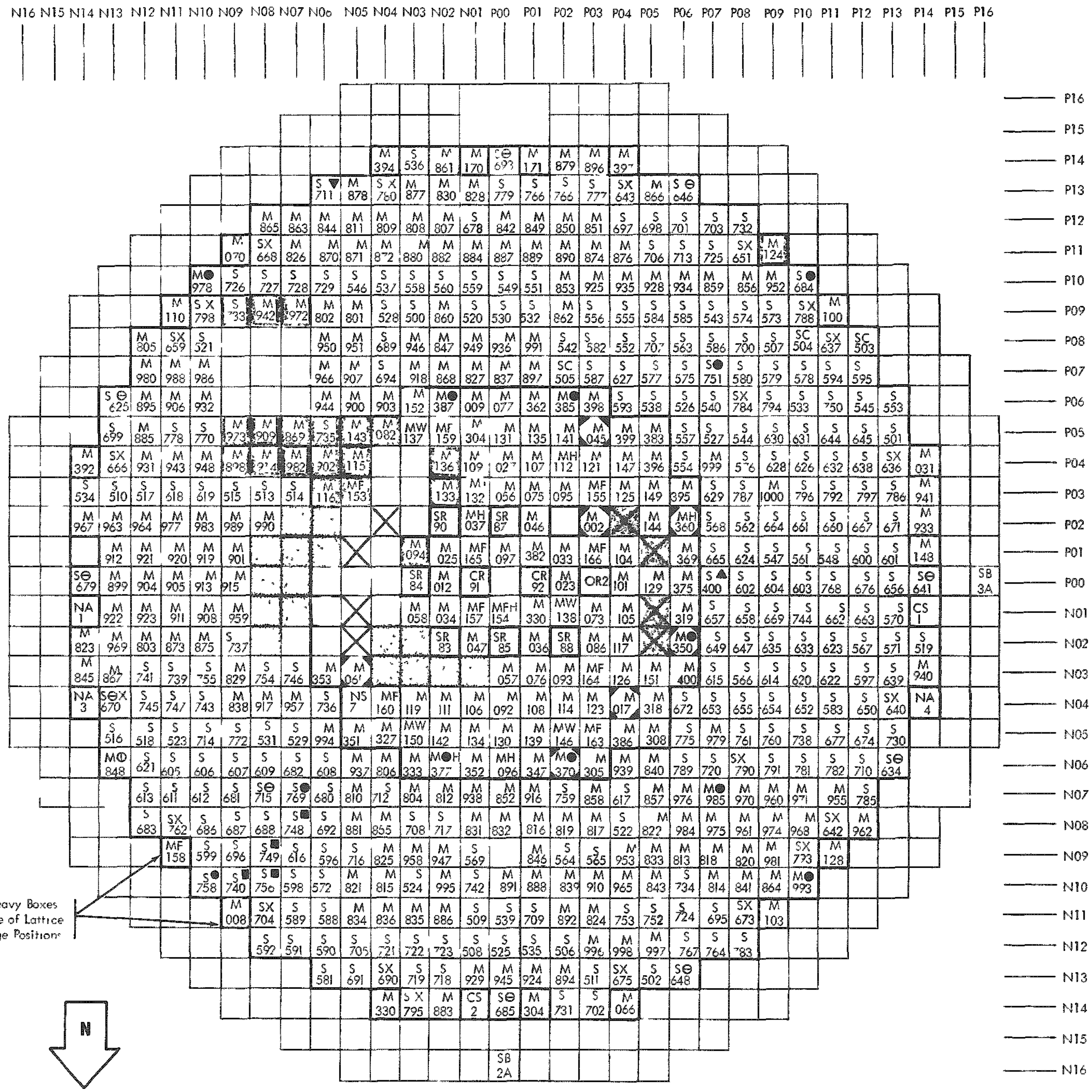
Test Flow Subassembly (S-400)

Slugs Previously Used in a Test Subassembly

"CP" Slugs

Locations Where Changes Were Made

Locations For Viewing Inlet Plenum



REACTOR LOADING 8-31-67

The offset handling mechanism (OHM) was converted to the automatic mode of operation to facilitate the fuel handling program. The OHM had been manually operated during July for the removal operation of subassemblies M127 and M098 (see Page 8 of Report No. 12). The rotating plug was also converted back to automatic operation; the plug dirve had been removed in June during the sodium drain operation so that the rotating plug Klozure seal back-up gasket could be installed for the sodium drain operation. No difficulty was experienced with fuel movements at the transfer rotor, although the rotor plate had been distorted somewhat in July when subassembly M098 was dropped (Page 12 of Report No. 12).

Most of the lattice positions into which subassemblies were inserted had only two adjacent surfaces available for camming against the sides of the subassembly being lowered into position. The square subassembly may have any orientation of its wrapper can sides when carried by the OHM, and the camming rotates the subassembly to make its sides parallel to its neighbors. Camming with only two adjacent surfaces available was in some cases so difficult that alternate insertion positions had to be selected. Precamming in other positions where more camming surfaces were available was frequently employed to aid in the final insertion.

B. Primary Sodium Cleanup

The reactor vessel was refilled with sodium at the end of July after subassembly M098 had been removed. The system temperature was raised to 500 F; a sodium sample was taken (see Page 20) and the sodium was cold trapped for 288 hours. The plugging temperature was observed to be 220 F after the cold trapping and the surface of the sodium, which previously had exhibited a cloudy appearance, appeared to be very clean when viewed through the shield glass window in the reactor rotating shield plug.

C. Reactor Vessel Drain

The sodium was transferred from the reactor vessel to the storage tanks on August 23 and 24. Essentially all the sodium in the vessel was removed so that the inlet plenum at the bottom could be inspected. Except as noted below, the drain procedure was the same as the procedure used in June to lower the sodium to a level one-inch below the upper support plate. See Pages 6-11 of Report No. 11 for details of the drain procedure.

On August 23 the initial drain to elevation 575 feet was made using the overflow pump and the IHX drains. The following day the syphon drain operation took place at a flow rate of 22 gpm and required eleven hours to lower the sodium level below the zirconium liner of the meltdown pan which is at the bottom of the inlet plenum at elevation 556 feet. Approximately 3100 cubic feet of sodium were transferred using the overflow pumps and the syphon drain line. An argon pressure of 10 psig was maintained in the reactor vessel during the syphon drain operation.

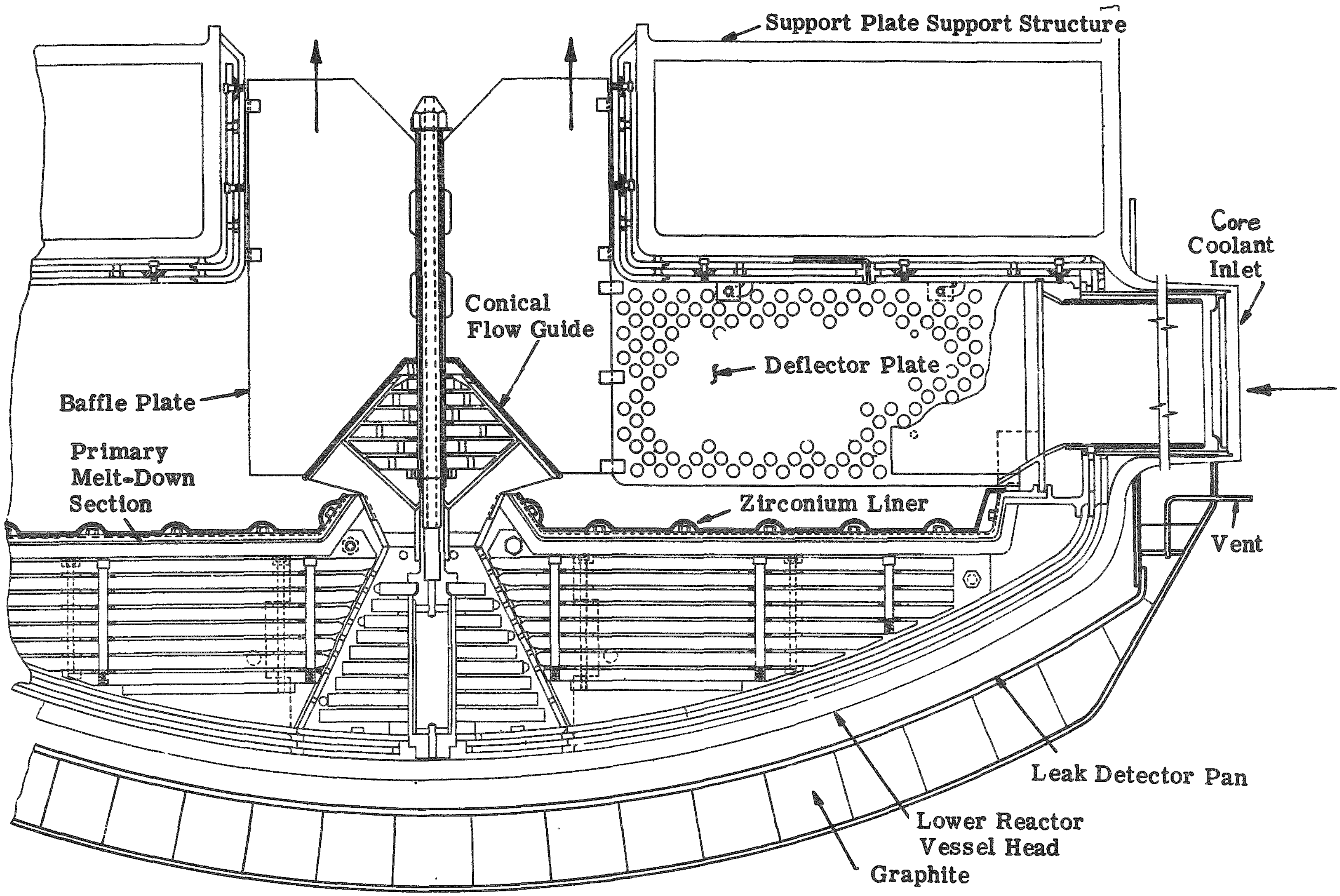
A hollow central column is permanently installed in the lower plenum to assist in making the complete drain as shown on the drawing on Page 10. The column is at the center of the reactor (position P00-P00) and its top is below the lower support plate. An extension with a copper nozzle was added to the syphon riser pipe used for the partial drain in June. The modified pipe was lowered into the vessel and butted against the top of the hollow column so as to make a leak-tight joint. The same technique had been used in 1962 when the vessel was completely drained for OHM, hold-down finger and support plate repairs.

Viewing through the window in the reactor rotating plug with a monocular confirmed the fact that the sodium had been drained below the zirconium liner of the meltdown pan. The pan liner could be sighted through the empty subassembly positions in the support plates. A portion of a batten strip and its mounting nut and washer were observed - all surfaces were clean and bright.

D. Inspection of the Reactor Vessel Interior

1. Use of the Sun Oil Co. Borescope

In addition to the USAEC-owned borescope and corescope previously used for viewing inside the reactor vessel (see description on Page 18 of Report No. 9), a borescope was on hand which had been borrowed from the Sun Oil Company in Toledo, Ohio. This borescope, nicknamed the Sunscope, had been used in 1962 during the reactor repair program. It had not been used during the recent investigations because of a question as to whether it would function properly in the higher ambient temperature. Modifications had, however, been made since its previous use to improve its ability to withstand elevated temperatures. Fibre lens locating sleeves were replaced with aluminum sleeves and air spaces were substituted for organic cement between the lenses.



MELT-DOWN SECTION IN LOWER REACTOR VESSEL

The Sunscope was used in August for viewing inside the vessel after the sodium was drained. It was selected because of the limitations of the other borescope and because the corescope was being modified, as described on Page 21. The east face of the safety rod Nos. 1, 4 and 6 lower guide tubes were inspected. The only marks of significance noted were a light scratch on the No. 4 L.G.T. and several small dark stains on the upper portion of the No. 1 L.G.T. It was also noted that subassembly M094, in position N03-P01, had many discolorations on its wrapper can exterior, some of which appeared to have appreciable thickness. The remaining subassemblies observed were all clean.

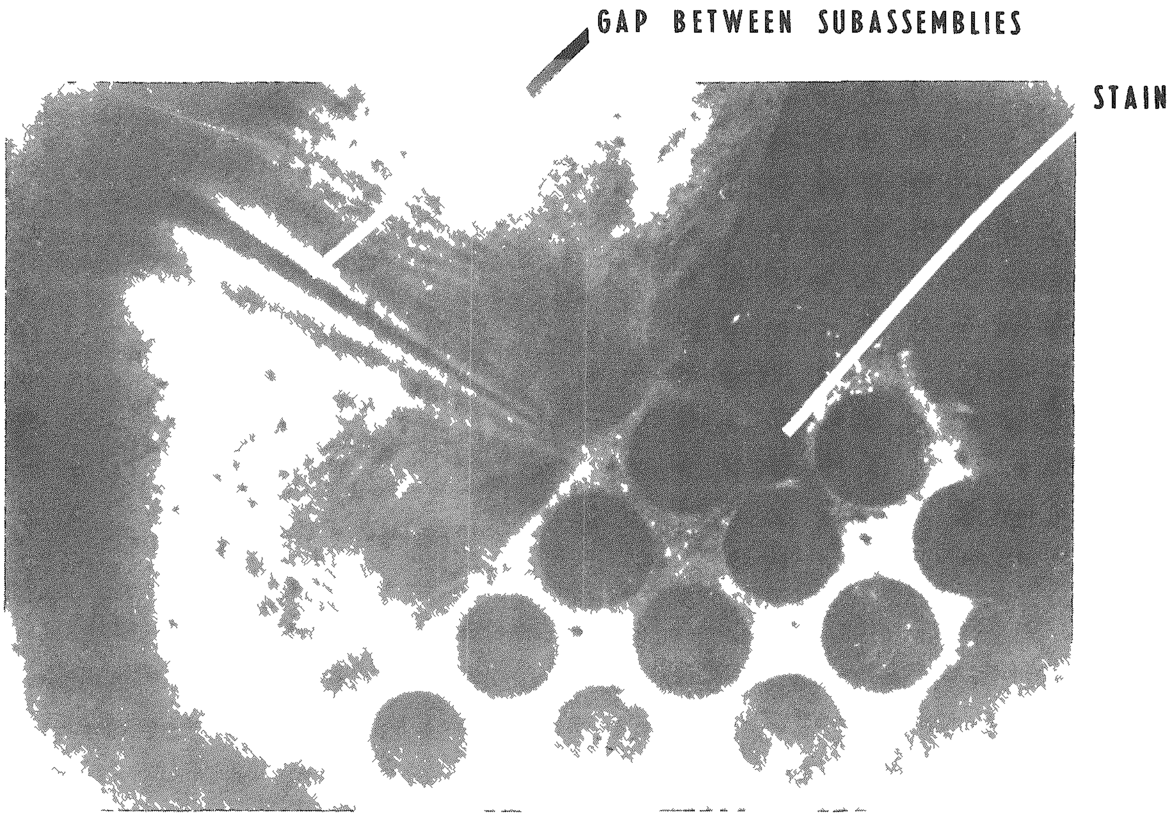
The upper support plate was observed with the Sunscope in the area around N05-P00. The upper photograph on Page 12 shows one black stain which was observed; otherwise, the surfaces in general were clean. The lower support plate top surface was also observed by lowering the light source between the support plates. The surface appeared to be in good condition; however, a close visual check was not possible because the Sunscope in its full down position is still 18-inches above the upper support plate.

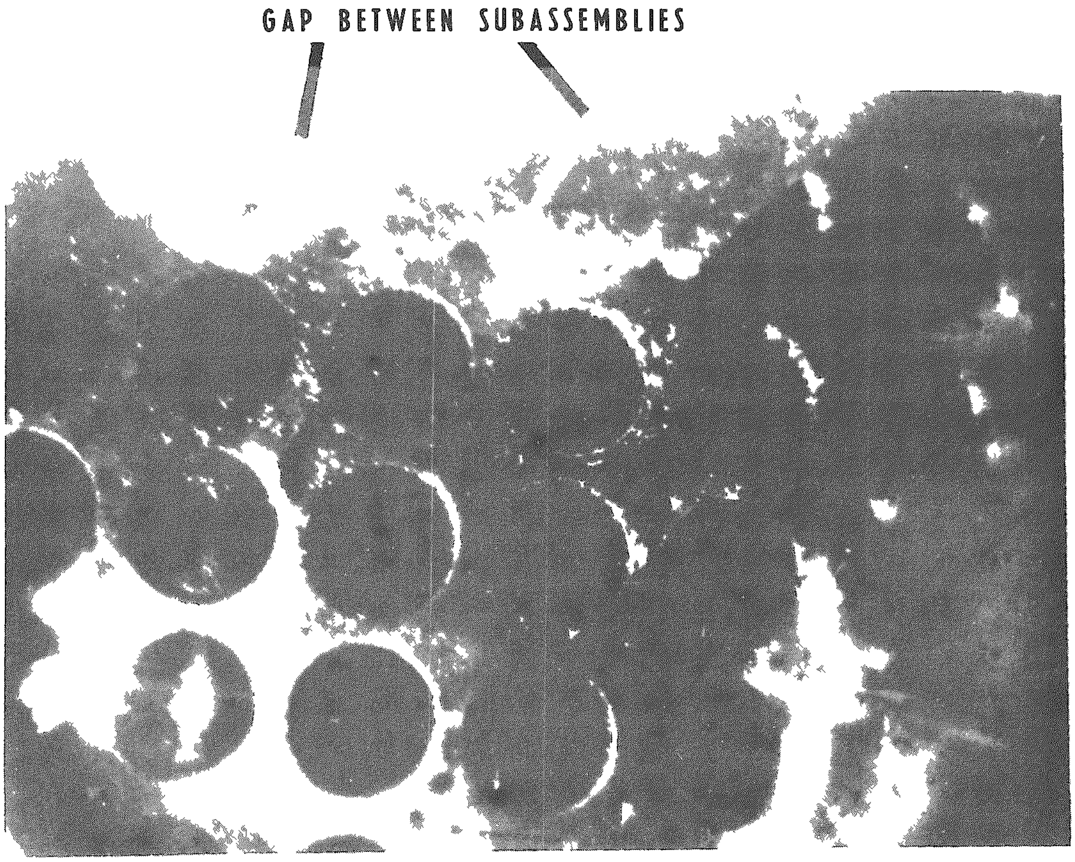
The 350 F ambient temperature in the reactor vessel did not adversely affect the Sunscope even though a cooling gas sheath was not provided. The view through the 1-3/4-inch diameter Sunscope was better than that obtained with the 2-1/2-inch diameter corescope or with the 1-inch diameter borescope.

2. Preparations for Inlet Plenum Inspection

Section IIA describes the subassembly moves which were made to provide openings in the reactor lattice for insertion of lighting and viewing equipment through the support plates into the inlet plenum. Flow deflector plates at each of the three 14-inch inlet nozzles divide the inlet plenum into 120 degree segments, so at least three locations in the reactor lattice are needed for complete inspection of the inlet plenum and one extra location has been made available. The main purpose of the inspection is to determine if some object might be in the plenum which could have been swept up by the sodium flow and held against the inlet nozzles of the subassemblies which melted on October 5, 1966.

It was originally planned that the borescope would be used for the plenum inspection, but it has been found to be unsatisfactory for this purpose. The corescope and Sunscope are being modified, as reported on Page 21, for inlet plenum viewing.





SUNSCOPE VIEWS OF THE UPPER SUPPORT PLATE

3. Preparations for Hold-Down Finger Inspection

It is remotely possible that some of the hold-down fingers may be bent since the upper portions of several of the subassemblies removed from the reactor were found to be badly warped. The decision has been made to inspect the hold-down fingers at least in the vicinity of the core where subassemblies M140, M127 and M098 were located.

A spherical mirror will be positioned 14-inches below the bottom of the hold-down fingers at location N07-P00. The SiO_2-coated quartz mirror will be fastened by means of a ball joint to a special stand which will rest in the holes in the upper and lower support plates. The mirror and stand will be inserted and removed through one of the 6-inch diameter lower guide tube access ports in the reactor rotating plug with a special handling tool.

The view of the fingers will be reflected by the mirror into the corescope which will be inserted, together with the light source, through the rotating plug access ports. Photographs of the hold-down fingers will be taken through the corescope. The spherical shape is necessary on the mirror to obtain a wide field of view from a location close to the hold-down fingers.

Many of the subassemblies surrounding the mirror location have been removed to provide a viewing angle from the mirror, located below the level of the tops of the subassemblies, to the corescope and fingers which are above the subassemblies. Four mirror and hold-down mechanism orientations can be used if it is found desirable to view all the fingers. At the end of August the mirror was on order and the design of the other items was nearing completion.

E. Reactor Building Decontamination

Decontamination of the reactor building was completed in early August. See Page 14 of Report No. 12 for further details on this operation. Page 15 of Report No. 12 describes the new health physics anticontamination building. The building was completed and placed in service in early August.

The tool used to separate subassemblies M127 and M098 in July had been temporarily stored in the reactor building in the No. 4 decay tank. Radioactivity from the tool had contaminated the reactor building as reported on Page 8 of Report No. 12. The tool was removed from the decay tank and the lower end was placed in a 55-gallon drum where a pipe cutter was used to separate the chisel section from the 30-foot handle. A plastic anticontamination enclosure was formed over the open end of the drum to prevent the release of radioactive particulates during the cutting operation. The drum was stored in the Fuel and Repair Building shielded ion-exchange pit. The radiation level at the side of the drum containing the chisel was 6 mr/hr; the radiation level of the chisel enclosed in a plastic bag was greater than 200 mr/hr (detector contacting chisel).

SECTION III

EXIT PORT INSPECTION FACILITY

The inspection facility was reinstalled at the exit port. The facility had been set aside in July to permit the removal and shipment of subassemblies M127 and M098. The lead brick shielding has been installed on all four walls. Installation, testing and adjustment of the inspection equipment is continuing and, at the end of August, was almost completed.

SECTION IV

SPECIAL INVESTIGATIONS

A. Inspection of Subassembly M127

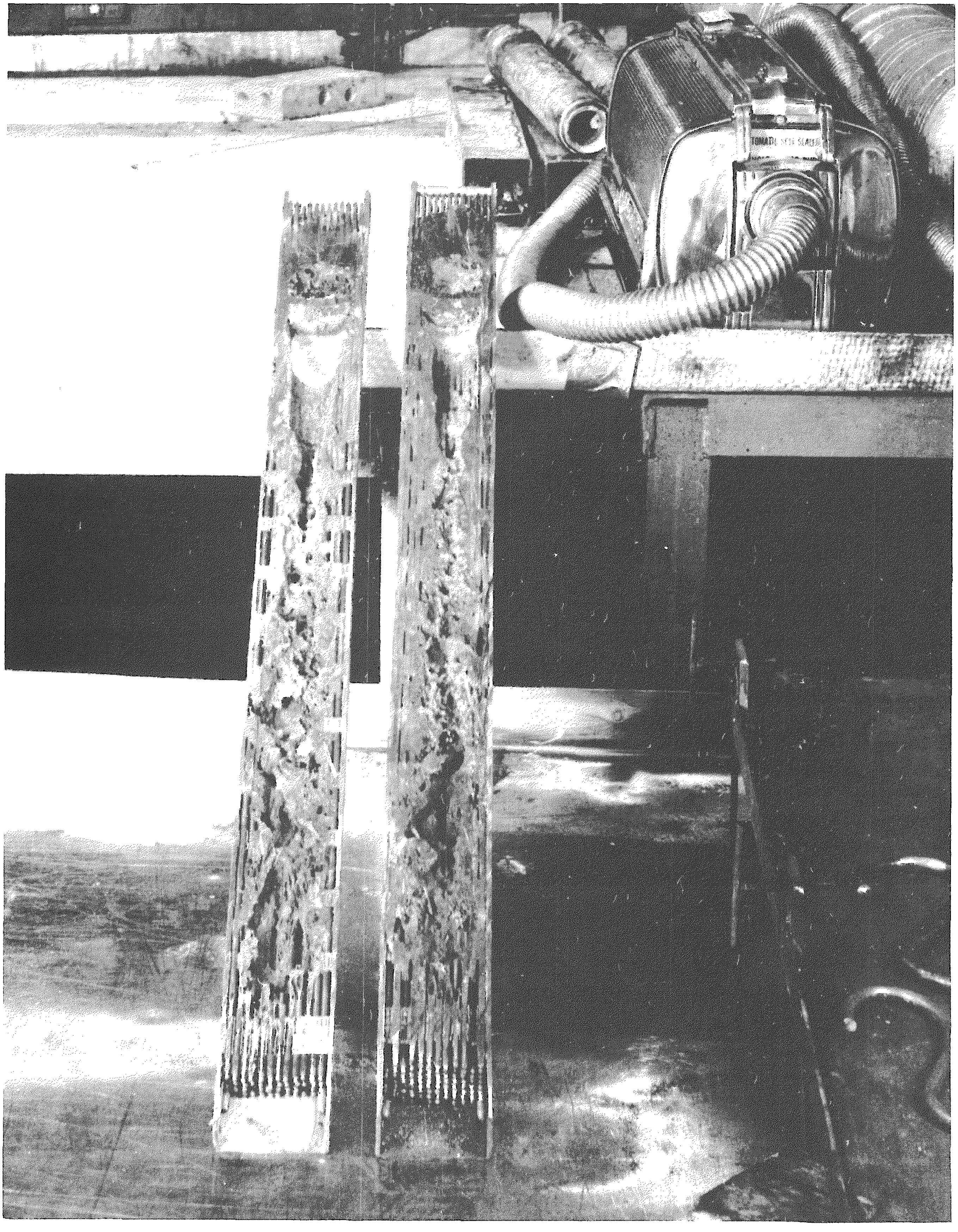
Inspection of M127 was started in July at the Battelle Memorial Institute hot lab, as described on Pages 16-20 of Report No. 12. Twenty days were required in August to make a longitudinal cut through the core section by means of a motor driven grinding wheel held in a special jig. The core section was positioned in a special trough so that very little grinding material was dispersed into the hot cell. The cutting was delayed by a failure of the grinder motor and shaft. They were replaced.

The photographs on Pages 17 and 18 show the results of the cutting operation. Melting of fuel occurred throughout the length of the core section and had formed a continuous void through most of the length of the section. One to three rows of fuel pins can be observed to be in a relatively undamaged condition adjacent to the wrapper can walls. The upper photograph on Page 18 shows an enlarged view of the longitudinal section, emphasizing the end caps and fuel pins at the top end of the core section. The swaged end caps were tight and the zirconium clad was intact. At one given axial location spherical voids were present in several fuel pins, as shown in the lower photo on Page 18. This type of voids was not evident at other axial locations. The explanation for the voids is not known at this time.

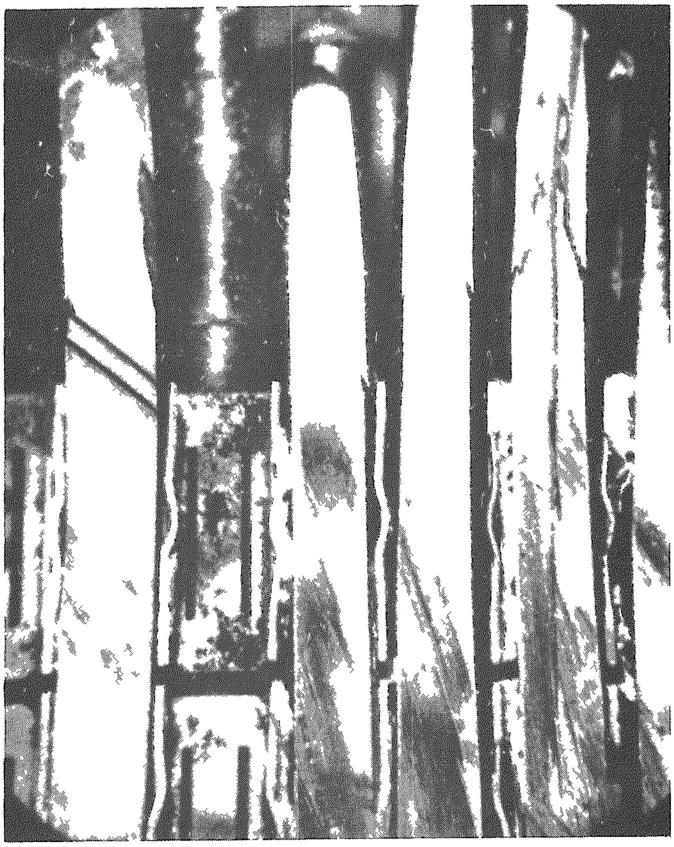
Six fuel pin sections have been removed for analysis from the top end of the core section. They were not welded to the melted section and hence were easily removed. Several loose samples of fuel pin cladding were also removed for analysis.

Measurements of the melted portion of each of the two longitudinal segments were made at two-inch intervals with a profile template. Weight measurements were made on each segment and the combined weight was 59.0 lb plus or minus 0.1 lb. This indicates little or no fuel was lost from the core section. Center of gravity measurements are to be made on each segment.

It is planned to make transverse cuts on each of the segments at the spacer pads. One or both of the sections to be cut will be polished for metallographic examination.

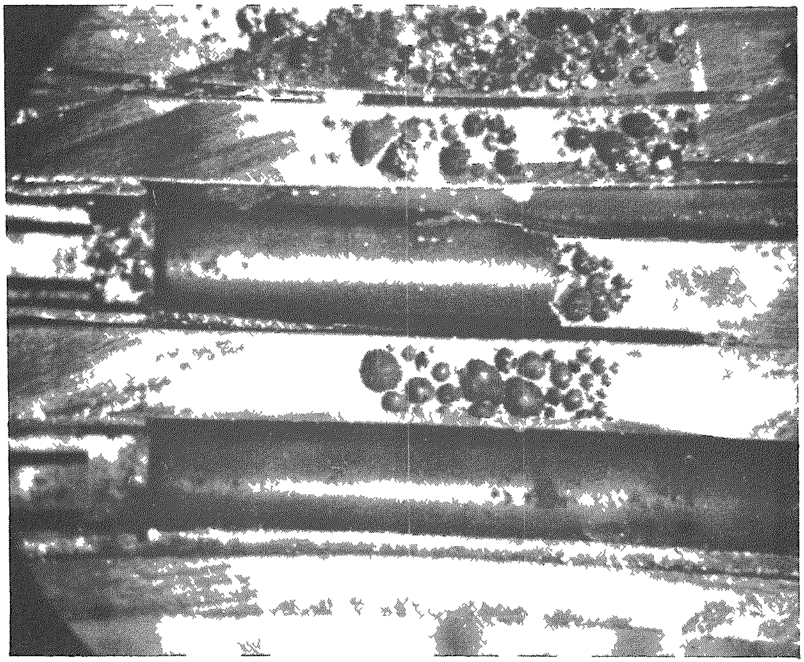


LONGITUDINAL SECTION THROUGH M127 CORE



TOP

END CAP AREA CUT THROUGH PINS,TOP END



TOP

UPPER END BETWEEN 2ND AND 3RD GRIDS FROM TOP

CLOSE-UPS OF M127 LONGITUDINAL SECTION

B. Inspection of Subassembly M098

Inspection of M098 was started in July at the Battelle Memorial Institute hot lab as described on Pages 20-25 of Report No. 12. The upper axial blanket and the inlet nozzle were cut off in August and the center section was cut through transversely at the large hole in the wrapper can. Weight measurements indicated a 7-1/2 lb decrease in weight above the hole and a 9 lb increase below the hole, apparently from fuel which had melted out of the core and frozen in the lower axial blanket.

The time required for sectioning M127, and equipment modifications necessary to enable better transverse cuts to be made in the hot cell, prevented further sectioning of M098 during August. It is planned to make transverse cuts on the M098 core section at various axial locations and to make longitudinal cuts only at the upper and lower ends of the core section. One segment will be selected for metallographic examination and all segments will be checked for weight and center of gravity location. These measurements will aid in estimating the reactivity loss attributable to this subassembly.

C. Analysis of Primary Sodium Samples

The following are the most recent chemical analyses made of the primary system sodium:

Sample Date Type Sample	May 30 Coil	August 2 Coil	June 22 Pot**
Carbon	19,23,26,32,34 39,40,50,62,72	46,68,74,76	92,92,146,185
Oxygen	5,6,6	8,8,9	9,8,9,6
*Non-Hydroxide Hydrogen	.2,.2,.3,.4	.3,.3,.3	.4,.4
*Hydroxide Hydrogen	.7,.7,.8,.8	1.1,1.3,1.5	1.5,1.9,2.5
Iron	.6,.6,1.3,3.4	.8,1.0,1.0,3.0	1.4,3.1
Nickel	.2,.2,.3,.4	.2,.3,.4,.4	.03,.05
Chromium	.5,.9, below .6	below .5,.9 1.0,1.6	0.6, below .1

*1.3 ppm recommended maximum for total hydrogen.
**Taken directly from reactor sodium during the vessel drain.

Note: Values are in ppm by weight. Samples analyzed at several different points to provide the separate readings indicated.

In addition to the chemical analysis on the June 22 sample direct from the reactor vessel, a particulate analysis was also made on this sodium. The analysis technique involves filtering and is described on Page 18 of Report No. 8. The filter residue was primarily carbon and less was detected than in previous samples. A sodium sample was taken during the second reactor vessel drain on August 24. This sample will be analyzed and the results reported when available.

D. Erratum - Report No. 11

The note at the bottom of the table on Page 20 should read, "Probably dust stirred up. The Kr-85 was an important constituent but was not detected as such by the gamma ray spectrometer."

SECTION V

MAINTENANCE

A. Preparations for Tube-to-Tube Sheet Weld Repairs on the No. 2 Steam Generator

Plans for steam generator modifications are described on Page 27 of Report No. 12. Flow restrictor tubes are to be added to increase the pressure drop from the water manifold to the steam manifold. The tube-to-tube sheet joints on the No. 2 and 3 steam generators will be rewelded using the internal bore weld technique that was used on the No. 1 steam generator. Page 28 of Report No. 10 reported that stress relieving of the tube sheet after the welding was under consideration. It has since been determined that stress relieving will not be necessary (it could produce undesirable distortions) since the sleeves which will be installed in the tube inlets, as part of the restrictor arrangement, will serve as thermal barriers to protect the welds from thermal shocks.

The water and sodium have been removed from the No. 2 steam generator and the ends of the tubes are being counter-bored in preparation for the welding operation.

B. Modifications to Viewing and Lighting Equipment

Light transmission through the borescope was very poor - somewhat like looking through a welder's eye shield. For this reason the planned use of this instrument for viewing the inlet plenum has been cancelled. The decision has been made to extend the corescope so that it will reach into the inlet plenum, replacing the borescope. The extension to the corescope is being assembled at the plant. The Sunscope is also being modified by adding an extension for viewing of the inlet plenum. The initial plan was to extend the corescope--followed by the more recent decision to do the same with the Sunscope, based on the recent favorable experience with the Sunscope.

As reported on Page 12 of Report No. 11, the 1000 watt lamps which provide the light source for viewing have failed prematurely. Preliminary results have shown improved performance with 1500 watt lamps operated at reduced voltage.

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1	AEC Library