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QUARTERLY PROJECT REPORT

ELK RIVER REACTOR

Contract No. AT(11-1)-654

AEC Research And Development Report

June - July - August, 1959

Prepared by

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DISCLAIMER

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FUEL ELEMENT MATERIAL DEVELOPMENT PROGRAM

Summary

This report will summarize the work which has been completed to date on the irradiation of the Elk River Reactor fuel samples. In summary, the following items are of significant interest:

A. Capsule I, instrumented, was completed and installed in General Electric Test Reactor during the June shutdown.

B. Capsules II, III, IV, and V, were completed and installed in the General Electric Test Reactor during the July shutdown.

C. The fuel pellets used for the five capsules were obtained from the following sources:

Capsule No.	Density	Source	Length	Densifier
I	95%	Davison Chemical	.375"	TiO_2
II	95%	APED	.500	CaO
III	95%	APED	.500	CaO
IV	90%	Davison Chemical	.500	TiO_2
V	97%	APED	.500	CaO_2

D. The temperatures sensed by the thermocouples in the fuel are within the expected ranges, but do not vary as widely throughout the operating cycle as had been originally predicted.

E. The temperatures sensed by the cladding thermocouples are in error because of crossed T. C. lead wires.

F. The temperatures sensed by the thermocouple in the NaK are within the predicted ranges.

G. The time required to achieve the requested burnups have not been calculated. This calculation cannot be completed until the U-233 buildup has been completed.

Pellet Fabrication

The fuel pellets used in the five (5) irradiation capsules were obtained from two sources. Pellets obtained from Davison Chemical were used in Capsules I and IV. The remaining fuel pellets were obtained from the Fuels and Materials Engineering Group of General Electric's Atomic Power Equipment Department.

The procurement of the fuel pellets for the irradiation capsules proved to be considerably more difficult than had originally been expected. The events related to the pellet procurement will be summarized below.

Initially the Fuels and Materials Engineering Group in San Jose was requested to make the pellets. The backlog of orders and the immediate pressure of work was such that they could not do the work. The Metals and Ceramics Group at the Vallecitos Laboratory then undertook the pellet fabrication and was initially very confident of their ability to make the pellets of the required size and density. However, the work was attempted using a non-ceramic grade UO_2. A supply of the ceramic grade UO_2 was not available at that time. The pellets fabricated by the VAL group did not meet the density specifications, and a decision was made in mid April to secure the entire batch of pellets from Davison Chemical Company at Erwin, Tennessee. Davison Chemical Company had expressed their confidence that the ThO_2 - UO_2 pellets, using a TiO_2 densifier, could be fabricated to the required density and size requirements, with delivery promised by mid May. On May 22, Davison Chemical advised that the pellets with the exception of the ones in the 90% theoretical density range, were shorter than the 0.500" requested (.3725" for the 95% and .3652" for the 97%), the pellet shortness due to a shortness in the die cavity. This last minute announcement created a severe problem, and the Fuels and Materials Engineering Group in APED, San Jose was again contacted and agreed to try to make the 95 and 97% pellets. A supply of ceramic grade UO_2 powder was available at that time at the Vallecitos Laboratory and was made available for their use. Pellets of the 95 and 97% density were successfully pressed, fired, and ground, with delivery to VAL made after the completion of Capsule I. The time insertion of Capsule I required the use of the short Davison Chemical Company pellets (95% density) in that capsule. The pellets fabricated in the APED shops in San Jose were used in Capsules II, III, and IV.

The table on page 3 summarizes the pertinent information on the pellets used in the irradiation capsules. It will be noted that the densities of the pellets in Capsules I and IV vary, and do not fall within the $\pm$ 1% variation which was requested. Timing did not permit the replacement of these pellets.

Mechanical Design

Capsule I - Instrumented

This capsule contained the Davison Chemical Company fuel elements-95% theoretical density-that were approximately 0.3725" in length. The pellets were within tolerances in diameter.

Some difficulties were experienced in drilling these pellets. The drilling procedure, using diamond dust and olive oil, did not prove to be satisfactory. However diamond drills were successfully used. The holes in the pellets were drilled 0.128" from the pellet center, with the diameter of the holes in the end pellets 50 mils, and the diameter of the holes in the pellets in which the thermocouples terminated 40 mils. As was expected, several of the pellets which were drilled had small chips of oxide fuel break away due to residual pellet stresses. The two end pellets in Capsule I had small chips break off near the holes. Photographs have been taken of these pellets.

The fuel tubes, part 20 on the capsule drawing, were all ground to give the required I. D. of 0.410" $^{+\ 0.0015"}_{-\ 0.0000"}$.

PELLET INFORMATION

Capsule No.	Fuel Source	Pellet No.	Calculated Density % Theoretical	Pellet Weight	Fuel Length	Fuel Diameter	Remarks	Pellet Tube I.D.	Pellet Tube O.D.
	Davison	1	93.3	7.646gms	.3950"	.4055"	Chipped during drilling		
		2	95.2	7.199gms	.3623"	.4053"	Drilled		
I	Chemical	3	93.7	7.135gms	.3616"	.4054"	Not Drilled	.411"	.451"
		4	94.3	7.349gms	.3730"	.4055"	Drilled		
	95%	5	93.6	6.935gms	.3572"	.4054"	Chipped and Drilled		
		1	96.3	10.170gms	.5010"	.4055"			
II	GE - APED 95%	2	96.6	10.199gms	.5010"	.4055"		.411"	.449"
		3	96.1	10.129gms	.5000"	.4055"			
		1	96.3	10.149gms	.5000"	.4055"			
III	GE - APED 95%	2	96.2	10.138gms	.5000"	.4055"		.411"	.450"
		3	96.1	10.129gms	.5000"	.4055"			
		1	88.6	9.321gms	.5005"	.4050"			
IV	Davison Chemical 90%	2	88.7	9.324gms	.5005"	.4050"		.4105"	.450"
		3	88.0	9.043gms	.4890"	.4050"			
		1	97.7	10.307gms	.5005"	.4055"			
V	GE - APED 97%	2	97.6	10.279gms	.5000"	.4055"		.411"	.451"
		3	97.6	10.285gms	.5000"	.4055"	Chipped at Edge		

The platinum thermocouples have proven to be very satisfactory to date. The design permitted the platinum thermocouples to be joined to the less expensive copper alloy thermocouples in the end plugs. The junction cavity was filled with insulating cement. The platinum thermocouples have a platinum-13% rhoduim sheath which gives a better control on the melting of the sheath during brazing operations. These thermocouples have special insulated junctions at the tips to preclude the possibility of a gradual change in the theromocouple characteristics (which could occur with an integral beaded junction at the tip), due to the condensation of uranium vapors on the ends of the thermocouple.

The two thermocouples which sense the fuel capsule wall temperatures are not functioning. Although readings have been obtained, they are not correct. Resistance measurements indicate the possibility of crossed T.C. leads within the lead tube. The thermocouple sensing the NaK temperature is functioning satisfactorily.

Capsules II-V - Non-Instrumented

The experiences gained in the fabrication of Capsule I resulted in several design simplifications which made the fabrication of the four remaining capsules camparatively easy. The table on page 6 has summarized the information on the four non-instrumented capsules. These capsules were completed in the last week of June.

Irradiation

Capsule I was inserted in the Test Reactor during the week of June 8, in pool capsule facility Z-16. The other four capsules were inserted in the reactor during the July shutdown, (week of July 7). All capsules were inserted so as to give a maximum unperturbed flux of 3.5×10^{13}nv.

The maximum flux in the capsule will occur at the end of the operating cycle, with the control rods withdrawn approximately 35 inches. The neutron flux shifts upward throughout the cycle, and above the core centerline is a minimum at the beginning of the operating cycle. The Table below summarizes the information regarding the capsule positions:

Capsule	Exposure	Perturbed Thermal Flux	Insertion Date
I	6700 MWD/Ton	3.5×10^{13}	June 59 Shutdown
II	13000 MWD/Ton	3.5×10^{13}	July 59 Shutdown
III	20000 MWD/Ton	3.5×10^{13}	July 59 Shutdown
IV	13000 MWD/Ton	3.5×10^{13}	July 59 Shutdown
V	13000 MWD/Ton	3.5×10^{13}	July 59 Shutdown

The irradiation period will be computed on a 650 computer using a code which has been developed to determine the U-233 build-up as a function of the irradiation time. This work has been held up because of lack of information on the shape of the flux curve at the end of the irriation cycle.

The table below summarizes the information with regard to the exposure time to date for each capsule.

	June 1959 Cycle 2	July 1959 Cycle
Capsule I	604	459
Capsule II		459
Capsule III		459
Capsule IV		459
Capsule V		459

Operating Information

The table on page 6 will summarize the expected operating conditions for the five capsules throughout the initial operating cycle. No attempts have been made to calculate for each cycle the changes in the temperatures as a result of the simultaneous burnup of U-235 and the buildup of U-233. However, the trend will be for the temperatures to progressively decrease. As explained earlier, the capsule temperatures will increase throughout any operating cycle for capsules located above the centerline of the core. The maximum predicted temperatures in Capsule I have not yet been achieved due to the fact that the reactor has not yet operated for a full cycle with an accompanying 35" rod withdrawal.

CONTROL ROD AND CONTROL ROD DRIVES

Control Rod Drive Mechanism

Engineering and drafting for the mechanisms at the vendors plant is 100% complete. Some work continues on tooling, instruction manuals, etc. Approximately 10% of material required has been received while 98% has been ordered. Fabrication has not yet begun, however at this time the vendor doesn't anticipate any delays as a result of the steel strike.

REACTOR VESSEL AND INTERNAL COMPONENTS

Reactor Vessel

Fabrication drawings have been approved and the vendors engineering and drafting has been completed. 97% of the material has been received at the plant. Prior to the strike at the Pacific Coast Engineering Company, fabrication was approximately 26% completed with an estimated completion date of December 24, 1959. This date will slip because of the strike. The vendor will re-schedule delivery after settlement of the strike and will do everything possible to expedite delivery of the equipment.

ESTIMATED OPERATING CONDITIONS FOR THE 5 CAPSULES DURING INITIAL CYCLE

	Predicted Temperature		Observed Temperature Cycle 2		Observed Temperature Cycle 3		Observed Temperature Cycle 4	
	Beginning of Cycle	End of Cycle	Beginning of Cycle	End of Cycle	Beginning of Cycle	End of Cycle	Beginning of Cycle	End of Cycle
T.C. #1-Bottom Fuel	1100°F	2400°F	1419	1914	1333	1647	1333	
T.C. #2-Top Fuel	1000°F	2200°F	589	666	447	459		
T.C. #3-Bottom Cladding	220°F	520°F	T.C.	INOPERATIVE				
T.C. #4-Top Cladding	188°F	210°F	T.C.	INOPERATIVE				
T.C. #5-Nak Ambient	130°F	340°F	173	265	173	238	186	
T.C. #6-Reference T.C.	115°F	115°F	T.C.	INOPERATIVE				

Core Support Assembly

The vendors engineering and drafting is complete and 97% of the material has been received at the plant. Prior to the strike at the Pacific Coast Engineering Company, fabrication had just commenced and was approximately 2% complete with an estimated completion date of December 28, 1959. This date will slip because of the strike.

Control Rod Guide & Shroud Assembly

Revised drawings were approved and forwarded to the vendor and the purchase order has been changed accordingly. This revision re-scheduled the delivery date from November 1, 1959 to December 1, 1959. The old shroud was 82% complete at time of cancellation. Follow is the current fabrication status.

1. All stainless angles bent and legs and ends machined to size. (includes outer shroudpieces.)
2. The stainless steel section is 75% complete.
3. All spot welded zirc angles machined to size on legs and ends.
4. All ½" zirc bars spot welded together have been machined prior to welding, ready for pickling and autoclaving.
5. Master control rod gage 90% complete.
6. Remaining 20% of zirc material on order due to be shipped complete by September 11, 1959.
7. Perforated stainless steel and bar stock for shroud extension ordered and promised for shipment complete by September 9, 1959.

SHIELDING

The vendor for the outer thermal shield reports engineering and drafting as 100% complete. Approximately 50% of all the material has been received. Fabrication has commenced and is approximately 8% completed. The steel strike has lengthened procurement and delayed fabrication 2 to 5 weeks. An estimated completion date is December 7, 1959.

Specification W-1645, Thermal Insulation, was submitted to the Allis-Chalmers Manufacturing Company for comments.

PROCESS

It has been deemed advisable to purchase two half-size makeup injection pumps instead of one full-size pump. This change will affect the piping design drawings. A pump location survey will be developed.

The piping design drawings were revised and released on August 28, 1959 so that the Maxon Construction Company could obtain a revised contract price from piping contractors.

Work continues on the checking of manufacturer's shop prints received for approval.

The production of the evaporators and evaporator sub-coolers has not been affected by the steel strike. Final delivery of this equipment is scheduled for October 1, 1959. The vendors engineering and drafting is 100% completed with over 95% of all the material on hand for fabrication. 70% of fabrication of the evaporators is completed while the sub-coolers are 45% completed.

Fabrication drawings for the heat exchangers, were approved and returned to the vendor. The vendors engineering and drafting is now 100% complete and all materials are on hand. Overall fabrication has progressed to where it is between 50% to 60% complete and shipment is scheduled for November 1, 1959 as required.

Fabrication drawings for the storage well cooler were approved and returned to the vendor. The vendors engineering and drafting is now 100% complete. All materials have been ordered and all have been received except the tubes. The tubes are on the supplier's schedule for shipment the week of September 14, 1959. Fabrication has not been started. The steel strike is not affecting the order and the vendor expects to complete fabrication about November 1, 1959.

Fabrication drawings for the recombiner cooler have been approved and returned to the vendor. Engineering and drafting is now 100% completed. All materials have been ordered and all received except the tubes. The tubes, purchased from B & W, are held up because of the steel strike. The vendor has released the job to their plant and fabrication will proceed up to the point of installation of the tubes. A completion date cannot be established until after delivery schedules have been received for the tubes from B & W at a time when they return to work.

The steel strike has not affected the progress of the emergency and test condenser. The vendor reports engineering and drafting is now 100% complete. 90% of all materials is on hand and only accessories such as valves and a gage glass are outstanding. Approximately 30% of fabrication is completed with final completion expected by the end of September, 1959. Inspection and final shell hydrostatic tests are currently being scheduled.

Revised prints have been received for the filters and are being checked. Upon final approval of these prints, engineering and drafting will be 100% complete. None of the material has been received, however, the vendor expects to fabricate and ship the equipment by November 20, 1959.

Proposals to provide the miscellaneous tanks, ion exchanger, makeup injection pumps and the storage well circulating and shield cooling pumps have been received and are currently being reviewed for an early placement of the purchase orders.

The High Pressure Boric Acid Compressor and Central Air Compressor, Specifications W-1628 and W-1626, have been awarded to the Ingersoll-Rand Company on the basis of satisfactory proposal and low bid.

Specification W-1644, Erection of Mechanical Equipment, was received for comments. Comments were forwarded September 11, 1959, and upon incorporation, the specification will be issued to the Maxon Construction Company for obtaining quotations.

Proposals for Specification W-1633, Stainless Steel Valves, were reviewed and comments were sent to the Maxon Construction Company on August 4, 1959.

Revised prints of the purification and decay heat cooling pumps have been approved and returned to the vendor on August 26, 1959.

Prints of the retention tanks have been noted with comments and returned to the Maxon Construction Company on August 31, 1959.

Prints of the sump pumps have been noted with comments and returned to the vendor on September 2, 1959.

INSTRUMENTATION

Engineering and drafting for the relay cabinets is not 100% completed. 60% of the material is on hand and the control relays are scheduled for delivery on September 21, 1959. At this time, 50% of the fabrication has been completed. The steel strike has not affected production materially. The estimated completion date is October 23, 1959.

The vendor for the annunciators advises that engineering and drafting is approximately 60% completed. 80% of the material required is on hand. Fabrication has started and is approximately 10% completed. The steel strike has not affected production materially. Fabrication will be completed about 8 weeks after final print approval.

Engineering and drafting for radiation monitors is approximately 90% completed by the vendor. 85% of the material is on hand and 33% of the fabrication is completed. The steel strike has not affected production on this order. The estimated completion date is January 1, 1960.

The vendor for neutron detectors advises that engineering and drafting is now 100% completed. 20% of the required material has been received and fabrication is approximately 10% complete. The steel strike has not affected the production and the job is scheduled for completion by January 1, 1960.

Master Instrument List, SL-1576, revised August 7, 1959 was received on August 13, 1959.

REACTOR BUILDING, PLANT FACILITIES, ETC.

Specification W-1641, Ventilating and Air Conditioning Systems, was released to Maxon Construction Company for obtaining quotations on July 5, 1959.

Specification W-1625, Building Work, was released for comments, on August 29, 1959. Comments were forwarded by telephone on September 8, 1959. This specification will be released for construction on or before September 11, 1959.

Power and Control Cable quantities, Specification W-1642, have been rechecked and released for construction to Maxon Construction Company on August 11, 1959.

Thermocouple Cable, Specification W-1646, was received for approval on August 26, 1959.

Addendum to Cable Specification W-1642 was received for approval on August 24, 1959.

The foundation details for the filters have been checked and will be released for construction. Check and release of the foundations for the miscellaneous pumps will be delayed until purchase of equipment and receipt of certified prints. Cerified prints of the Boric Acid and Control Air Compressors has been requested for approval.

Structural and architectural drawings are complete except for final drafting work on the biological shield.

Electrical Construction Drawings 12E-11809 and 12E-11810 were received for approval on August 24, 1959.

Cable routine Drawing 12E-11815 was received for approval on September 1, 1959.

Prints of the superheater flues and ducts system have been received from the Fuel Economy Engineering Company on August 26, 1959. The prints are being checked.

Reinforcing steel fabrication drawings have returned to the fabricator as follows:

Basement floor - approved August 14, 1959
Fuel storage well to El. 934'-0" - approved August 28, 1959
Emergency air lock shielding - approved August 28, 1959
Passageway - approved as noted for construction August 28, 1959

Structural steel drawings have been returned to the fabricator as follows:

Col. 9A alterations - approved August 28, 1959
Passageway structural steel with comments - August 25, 1959
Reactor support structure - approved August 28, 1959

Miscellaneous iron and steel drawings have been returned to the fabricator with comments on August 18, 1959.

Thermocouple installation drawings were returned with comments on August 27, 1959.

Information on full load current of motors was submitted to the vendor for the motor control centers on August 25, 1959.

CONSTRUCTION AT SITE

Sandblasting and waterproofing on the containment vessel were completed during this report period.

The 3/8 inch nuts for supporting the forms for the shadow shield were installed up to the elevation covered by the waterproofing point. Maxon will weld the additional nuts required as erection of the forms progresses.

Temporary wiring of the crane has been completed.

Prior to pouring of the concrete, samples were taken by the contractor and the A-C field engineer. The first pour of approximately 200 cubic yards of concrete was made under the containment vessel on June 19, 1959 and the average slump was 4½ inches. Test cylinders were made and forwarded to the test laboratory. As of the end of August, 1959, a total of approximately 1900 cubic yards of concrete has been poured. Work is progressing on forming and placing the reinforcing steel for the second lift of the superheater building walls. Forming and placing of reinforcing steel is also being made for pours #8, 10 and 11. In the last two weeks of August, the number of iron workers on the job was increased and erection has progressed rapidly. As the bulk of the reinforcing steel on hand is placed, the future demands for iron workers will be reduced and therefore the number of iron workers was reduced as of August 28, 1959.

Delivery of reinforcing steel to the site has been seriously delayed by the steel strike.

The vacuum breakers were tested at the Chicago Bridge and Iron Company in Chicago on July 31, 1959. The tests were witnessed by Allis-Chalmers, Sargent and Lundy and AEC-COO representatives. The breakers were given an overload test of 27 pounds. The diaphragm had been redesigned prior to this test so that it wouldn't rupture. Both vacuum breakers opened at between 9¼ and 9½ inches of vacuum. The vacuum breakers satisfactorily passed the test and were accepted.