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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

PROGRAM 4700

JULY 1958

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C-85 Reactors - Aircraft
Nuclear Propulsion Systems

ORNL-2580

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

PROGRAM 4700

July 1958

Date Issued: AUG 1958

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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UNION CARBIDE CORPORATION
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U.S. ATOMIC ENERGY COMMISSION

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

July 1958

This monthly report covers those AEC activities which fall under program 4700, categories C-84 and C-85, classified SECRET. Some of the topics are reported every month, but the majority are reported bimonthly.

PROGRAM 4700 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT

Shielding Theory and Design

The Monte Carlo code being developed for deep-penetration shielding calculations is now undergoing preliminary tests. The test case is a calculation of the spectrum resulting from isotropic scattering in an infinite medium in the laboratory system of the neutrons from a mono-energetic isotropic point source. Calculations made for a separation distance of 20 mean free paths and a ratio of the scattering cross section to the total cross section of 1/2 yielded fairly encouraging answers in comparison with those obtained from transport theory calculations.

Tower Shielding Facility (TSF) Experiments

The final measurements of the Convair-TSF experiment were completed July 3 with gamma-ray spectral measurements taken inside the compartmentalized crew shield as a function of the side shield water thickness. The high-energy portion of the spectra did not appear to result from neutron interaction in the air but, rather, from neutron capture in the structural materials in the crew shield and its support.

The Convair reactor and its associated equipment were removed and packed for shipping, and the TSR-I was reinstalled. Measurements were taken of the variation of the dose rate 4200 ft from the reactor as a function of the angle of emission of a highly collimated beam of radiation. The measured dose rate was reduced by a factor of 10 when the beam was pointed in the opposite direction from the measured point. The TSR-I reactor was then installed in a 2π shield in preparation for additional measurements now being made at the request of GE-ANPD.

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Tower Shielding Reactor-II (TSR-II) Development and Fabrication

The four lower fuel elements and two of the upper fuel elements in the central cylinder region were assembled. Fuel plates for the annular elements are being fabricated.

The lower section of the central cylinder which will support most of the fuel elements was formed and is ready for machining. The 1/4-in.-thick aluminum hemispherical shells which were to support the lead-boral shield were received from the fabricator, but they did not meet the tolerance specifications. Negotiations for new shells are under way. The 3/4-in.-thick hemispherical shell for the reactor tank and the 1/8-in.-thick hemispherical shells for the lead-boral shield, which were fabricated by another vendor, were shipped to ORNL, but they have not yet been received.

The life-test of the control mechanism was terminated at 5500 cycles (accepted lifetime is 2000 cycles). The lead screw nut was the only part which showed evidence of wear, and it probably would have operated satisfactorily for a few thousand more cycles. Design changes reduced the travel time of the control plates to 120 msec, which is satisfactory, but the bleed-down time of the line after the electrohydraulic transducer reduces the pressure is 50 msec. An effort is being made to reduce the bleed-down time by reducing the pressure at the control mechanism with a diaphragm-operated valve.

Kinetic studies of the TSR-II on the analog computer of the Reactor Controls Group indicated that there can be no credible accident with the proposed excess reactivity loading. For these studies, the response times of the control mechanism given above and values from the nuclear calculations were used. The studies included (1) cold slugging the reactor from the design temperature of 160°F to 32°F and (2) step inputs of 0.9% $\Delta k/k$ with the reactor at the design power of 5 Mw. However, it would be desirable to be able to control larger step inputs of $\Delta k/k$, and this can be done if the bleed-down time of the control mechanism is reduced.

Preliminary design work on the reactor shield and methods of positioning the beam holes was started. A hydraulic torque booster is being bench-tested to determine whether it is capable of positioning the shield satisfactorily.

An investigation was made of the stresses in the tower structure that will result from the additional electrical cables and water lines suspended from the tower structure to the reactor. The investigation revealed that the towers would not be overstressed in a fully loaded condition if some of the cables and water lines were suspended from tower leg I and others from tower leg II to the reactor, even though no effort was made to minimize the horizontal load. But the tower would be overstressed if all cables and water lines were suspended from tower leg I.

The water lines will be suspended from both towers. In addition, the suspension of the lines and cables from each of the tower legs will be designed to minimize horizontal loading.

The completion date on the 5-Mw cooling system was extended by labor difficulties and by additional work, but the contractor still hopes to complete his work the first week of October.

Columbium Fabrication

Additional seamless columbium tubing was received that included 59 ft of material clad with type 446 stainless steel and 45 ft of unclad material drawn by Superior Tube Company and 125 ft of unclad material prepared by Fansteel Metallurgical Corporation. The two-ply tubing is 0.620 in. OD with a 0.090-in. wall made up of 0.030 in. of columbium clad with 0.060 in. of type 446 stainless steel. The unclad tubing is 0.500 in. OD with a 0.030-in. wall. These shipments brought the inventory of seamless columbium tubing to about 100 ft of clad material and about 194 ft of unclad material. After nondestructive inspection, this material will be used in the construction of corrosion-testing loops.

Five more columbium billets were received. Four were from Wah Chang Corporation and one was from Temescal. The Temescal ingot, which was a remelt of turnings and other scrap from previous extrusions, represents the saving of approximately 9 lb of columbium. Five more extrusions were completed and were shipped to Superior Tube Company for tube reducing. Construction work is continuing on the high-temperature vacuum-annealing furnace described previously (ORNL report 2564).

Mechanical Property Tests of Molybdenum

The development of a small furnace that provides variable heating along the vertical axis and a controlled gaseous atmosphere was successfully completed. Molybdenum specimens were heated to 2500°F, and the temperature variation along the 2-in. gage of the specimen was controlled to ±3°F, as monitored by platinum-rhodium thermocouples positioned close to the specimen along the gage. The 3/8-in. specimens were heated to temperature and pulled to fracture within 1 hr. Ductile failures were observed.

Columbium and Molybdenum Welding and Brazing

Investigations of high-melting alloys for potential use as brazing alloys for joining columbium and molybdenum for service in lithium were continued. T-joints of molybdenum and columbium were brazed with the following brazing alloys and are to be examined metallographically: 72% Ti-28% Co, 69% Ti-31% Fe, and 84% Zr-16% Fe. Buttons of the following brazing alloys are being exposed to lithium at 1700°F and will be examined after 500 hr of exposure:

70% Zr-20% V-10% Cb
63% Zr-27% V-10% Cr
63% Zr-27% Fe-10% Mo
63% Zr-27% Fe-10% V
63% Ti-27% Fe-10% Mo
76% Ti-14% Fe-10% V
76% Ti-14% Fe-10% Mo

Corrosion of Columbium and Molybdenum in Lithium

Specimens of two types of columbium were tested in static lithium for 100 hr at 1600°F. Duplicate specimens were prepared from sintered rod and from arc-cast plate. The plate was prepared at Battelle Memorial Institute by arc-melting the sintered rod as a consumable electrode. Chemical analyses of the two types of columbium indicated the following impurities:

Impurity	Quantity Found (wt %)	
	In Sintered Specimen	In Arc-Cast Specimen
Oxygen	0.096	0.062
Nitrogen	0.032	0.036
Carbon	0.02	0.04
Zirconium	(not analyzed for)	0.15

Metallographic examinations showed the sintered material to have considerable amounts of nonmetallic inclusions, whereas there were very few such inclusions in the arc-cast material. The inclusions appeared to be globular and noncontinuous. Neither type of material was attacked to a significant extent by the lithium. Both types of specimens were covered with a 0.0002-in.-thick layer of columbium nitride, and all four specimens showed slight weight gains. Even though the impurity levels were high, the resulting globular nonmetallic inclusions did not provide paths for attack by the lithium.

Three seesaw-furnace tests of molybdenum in lithium were completed. Weighed, tabular-type specimens were suspended in both the hot and the cold zones of the apparatus in order to accurately determine the weight changes and attack in each zone. The first test was for a 500-hr period with a hot-zone temperature of 1700°F and cold-zone temperature of 1300°F. The second and third tests were for 100-hr periods each with hot- and cold-zone temperatures of 1800 and 1000°F and 1900 and 1000°F. The specimens used in the first test were hand polished, and less than 0.5 mil

of the surface was removed. The surfaces of the specimens used for the second and third tests were ground and about 5 mils of the surface was removed. Preliminary results show definite attack and mass transfer in the first test and neither attack nor mass transfer in the second and third tests. It therefore appears that the attack and mass transfer are related to the condition of the surface.

Yttrium Production and Lithium Purification

Studies of the purification of liquid lithium by extraction of impurities with molten salt were continued. In successive experiments the oxygen content of the lithium metal was reduced fivefold by a single salt extraction, as determined by analysis of the salt phase. Considerable difficulty was encountered with a bismuth extraction step used to remove metallic lithium from the salt phase. This difficulty appears to be caused by contamination of the bismuth. Consequently, and in view of recent improvements in direct analysis of oxygen and nitrogen in lithium, the salt analysis will be omitted and samples of the salt-extracted lithium will be taken for direct analysis. Apparatus with which to produce such samples and to emulsify them in petroleum oil was designed and is being constructed.

Installation of equipment for the yttrium-production pilot plant is nearing completion. Three weeks time was lost because of a strike by H. K. Ferguson Company craftsmen. A shipment of 1000 lb of Y_2O_3 was received and is to be converted to YF_3, the basic starting material for the process. An acceptable grade of MgF_2 was found to be available commercially and was ordered.

Analytical Chemistry - Yttrium Production Process

Analytical methods were devised to permit thorough evaluation of the chemical and metallurgical processes involved in the production of yttrium. A rapid, yet precise, titration method was adopted for the determination of yttrium and magnesium in the fused salt $LiF-MgF_2-YF_3$. Both yttrium and magnesium are titrated successively with ethylenediaminetetraacetic acid, the respective end points being determined with a mercury indicator. An improvised automatic titrator was devised particularly for this application. By using appropriate buffer solutions, no prior separations are required. The precision of the method is 1% for each element.

A fluorination method, involving the mixed fluoride salt $KBrF_4$, was evaluated for the determinations of oxides in $LiF-MgF_2-YF_3$ and in YF_3. Recovery of oxygen from additions of pure Y_2O_3 and MgO was 98% complete. The precision of the method on replicate samples of fluoride salts is 6%.

Bearing and Seal Tests

The centrifugal pump rotary assembly that is being operated under gamma irradiation in the MTR canal continued to function satisfactorily. The region of the oil-lubricated lower seal and journal bearing had accumulated, on July 26, 1958, a gamma-ray dosage of 7.5×10^9 roentgens during 3330 hr of operation.

A bellows-mounted seal installed in a centrifugal pump has accumulated 6750 hr of operation with NaK at 1200°F, a shaft speed of 2500 rpm, and a flow rate of 1200 gpm. Operation continues to be satisfactory.

Thermal-Stability of Thin Metal Shells

The thermal cycling test of the welded thin-shell model was terminated after 602 thermal cycles because of a leak in the hot sodium inlet to the shell housing. There was no indication that this leak was in any way associated with the test shell. Since the shell had been exposed to over twice the number of cycles originally programed, it is being removed from the test system for examination and dimensional analysis.

Edited by A. W. Savolainen

Approved by Alvin M. Weinberg, Director

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