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# OAK RIDGE NATIONAL LABORATORY

## STATUS AND PROGRESS REPORT

## PROGRAM 4700

## JANUARY 1959

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C-85 Reactors - Aircraft
Nuclear Propulsion Systems

ORNL-2692

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# OAK RIDGE NATIONAL LABORATORY
# STATUS AND PROGRESS REPORT
# PROGRAM 4700

January 1959

Date Issued: FEB 5 1959

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January 1959

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

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

Experiments with the bare TSR-II fuel elements at the Critical Experiments Facility have shown that excess reactivity on the order of 10% $\Delta k/k$ can be realized by introducing an aluminum ball in the internal reflector region to displace water and thereby reduce the neutron absorption. In such a reactor the water flow passage between the aluminum and the fuel would have to be kept small to limit the possibility of bubble formation which would cause sudden increases in reactivity. Experiments are continuing to determine the optimum spacing which will provide sufficient excess reactivity, adequate control, and no hazard from bubble formation.

The effect of a large sphere on the flow distribution in the central cylinder region is being studied. Wooden spheres 16.5 and 17 in. in diameter have been fabricated, and the 17-in.-dia sphere is being installed in the hydraulic flow test stand, together with four dummy aluminum fuel elements.

Designs were completed for the sling bar at the reactor to support the aerial cables and water lines and for the messenger cables and support rings for the water hose. Fabrication of the reactor support platform has been started. The reactor support bearing has been shipped. The reactor tank flange is being machined, and the coaxial water swivel has been fabricated.

The four upper lead-and-boral shield sections are being machined, and about one-half the lead has been placed on the lower lead-and-boral hemisphere. The control mechanism and pressure switches which have been

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assembled have been tested. Tests have been run on two stainless steel gears for driving the mechanism, and after 2000 cycles no wear or galling was apparent. Bids have been requested for construction of the lead-and-water beam shield.

Fabrication of the Pratt & Whitney shield mockup is in progress. Final design of the LiH blocks for the various shield sections is being made, and the template for casting the uranium shadow shield is on hand. Calculations of the heating in the shield during a 5-Mw reactor operation indicates that the maximum temperature will be 370°F, which is a safe operating temperature for LiH.

## Tower Shielding Facility (TSF) Experiments

The last phase of the second series of the GE 2π experiments was completed, and all the data have been forwarded to GE for final analysis.

## Welding of Columbium

Braze welds have been made on arc-cast columbium sheet with the alloys 85% Zr-15% Cb, 85% Cb-15% Zr, 100% Zr, 60% Cb-40% Ti, and 80% Zr-15% Nb-5% Mo, as the filler materials. The joints were made in an inert-atmosphere chamber under argon. All welds were quite ductile, and metallographic examinations showed no cracks. Further, there was less grain coarsening than in straight fusion welds or welds made with columbium filler metal.

Tungsten arc-fusion welds on columbium sheet have been machine-made in air with argon cover gas and helium backup gas. Complete penetration was achieved, and the weld surface was excellent in appearance. The lack of hardness increase along the weld and heat-affected zones indicated that weld contamination was minimized. No cracks developed during a longitudinal bend test, and only slight cracks were observed after a severe transverse bend test.

Aircomatic welding tests on columbium plate have been very promising. A small bead-on-plate type of weld had excellent surface appearance, and no hardness increase was detected in the weld zone.

## Effect of Nitrogen and Oxygen in Lithium on the Corrosion of Columbium

A series of tests have been performed to determine the effect of oxygen and nitrogen additions to lithium on the corrosion of columbium. Columbium specimens cut from the same piece of metal were tested in pure lithium, lithium with 5000 ppm oxygen added as lithium oxide, and lithium with 5000 ppm nitrogen added as lithium nitride. Preliminary metallographic examinations after 100 hr of exposure at 1500°F indicated no attack of the specimens despite the impurity additions.

## Yttrium Preparation Research

The yttrium "sponge" which was prepared by vacuum distilling relatively large pieces of Y-Mg alloy was found to be dense enough to arc melt by the consumable-electrode process without pressing. Two ingots have been prepared by arc melting under reduced pressure of argon. The first, which weighed approximately 4 1/2 lb, contained approximately 980 ppm oxygen according to analysis by the Leco method. The second, a 9-lb ingot, has not yet been analyzed.

Leco oxygen analyses of two sets of four yttrium specimens each which were vacuum annealed for 66 hr at 1000°C have indicated significant decreases in oxygen content of all the specimens. For the first set of specimens, the average oxygen content was 800 ppm before heat treating and 635 ppm after. The corresponding values for the second set of specimens were 820 and 545 ppm. Weight-loss measurements indicate that the oxygen-removing mechanism could be the volatilization of YOF.

## Pump Bearing and Seal Tests

Measurements of the viscosity of samples of the bulk oil taken at intervals during the course of the pump bearing and seal gamma-irradiation test at the MTR showed that it increased gradually from an initial value of 90 SUS to a final value of 131 SUS at 100°F as a result of a bulk oil gamma-ray dosage of $2.2 \times 10^8$ r. It was also found that a drop of 1 to 2 points in the SUS value was caused by a 1.6% dilution with fresh oil. These relatively small changes in viscosity would be expected to have negligible effects on the operation of either seals or bearings. A more detailed examination of the pump components has revealed no significant changes in dimensions during the course of the test.

## Engineering Research

Test 14 has been completed in the study of surface thermal-stress cycling of Inconel in the pulse-pump apparatus. The test piece configuration was identical to that used in tests 12 and 13; operating conditions differed only in a 28% reduction in the fluid thermal amplitude and an increased exposure time. The cyclic frequency was 1.0 cps with a maximum fluid temperature amplitude of 210°F and an estimated inside surface temperature amplitude of 54°F. The inside wall fiber strains per 1/4 cycle corresponding to these conditions were calculated to be 0.042, 0.033, and 0.024% for wall thicknesses of 0.147, 0.091, and 0.060 in., respectively. The test was terminated after $2.2 \times 10^6$ cycles (612 hr). In contrast to previous tests in which definite cracking was noted, examination of the test section revealed a general intergranular attack and subsurface void formation. The depth of attack decreased progressively from 0.012 in. in the thick upper section (0.147 in.) to about 0.002 in.

in the upper part of the thinnest section (0.060 in.), and finally disappeared completely in the lower 1-in. portion of the 0.060-in.-wall section.

## Analytical Chemistry

Colorimetric methods of analyzing for a number of metals were modified for application to yttrium metal. These include: (1) iron as the o-phenanthroline complex after extraction with tri-n-octylphosphine oxide in cyclohexane (TOPO), (2) nickel as the dimethylglyoxime chelate, (3) titanium as the thiocyanate complex after extraction with TOPO, and (4) chromium with diphenylcarbazide. In addition, analytical procedures for the determination of nitrogen and fluorine in yttrium were evaluated. Flame-photometric methods for determining lithium and magnesium in the metal were established.

## Chemical Studies

Seven 50-lb batches totaling 160 kg of $LiF-MgF_2-YF_3$ (58.3-18.6-23.1 mole %) mixture were processed for use in the production of Y-Mg alloy. Each of these batches was treated for 8 hr with anhydrous HF; oxygen concentrations ranged from 150 to 900 ppm, with a mean of 400 ppm. Material produced in the 5-lb-scale test equipment continues to show 150 to 250 ppm of $O_2$ if hydrofluorination times of 6 hr or longer are used. Tests are under way with the small equipment to determine whether a finishing treatment with $F_2$ in the HF will lower this oxygen concentration. Meanwhile the effect of longer hydrofluorination times on the quality of material from the production equipment is being studied.

Examinations of several batches of product have indicated that unusually pure BeO is obtained by calcination of beryllium oxalate obtained by fusion of crude BeO with oxalic acid hydrate, although minor modifications have been made in the fusion technique. Reproducibility of the procedure appears to be a consequence of the fact that the phase relationships in the separations process are quite insensitive to a number of variables. Changes in amount of water present, for example, merely alter the relative amounts of beryllium oxalate hydrate and saturated solution. Removal of impurities from BeO in this process results from (1) a slow conversion of impurities to oxalate, (2) insolubility of oxalates formed from impurities, and (3) fractional crystallization of the product from a mother liquor containing soluble impurities. The relative importance of each of these mechanisms for various types of impurities is being studied.

## Radiation Damage Studies

Equipment has been completed for in-pile tests of the thermal-shock resistance of moderator materials for use at high temperatures. In the first assembly, now ready for installation in the ETR, yttrium hydride and beryllium oxide bodies will be exposed at temperatures up to 1800°F to gamma heating rates up to 25 w/g. Temperature control will be achieved by controlled flow of a helium-argon mixture over the specimen surface. The first test is expected (1) to demonstrate the range of temperatures at which operation is possible, (2) to yield data on changes in crystal structure of the specimens, and (3) possibly to yield data on failures due to thermal cycling. Additional assemblies are being readied for subsequent irradiations.

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