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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

PROGRAM 4700

NOVEMBER 1957

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C-85 Reactors - Aircraft
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SPECIAL PROGRESS REPORT
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November 1957

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SPECIAL PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

November 1957

PROGRAM 4700 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT (AEC Activity 4701)

Experimental Engineering

Testing of a semicircular 20-tube fluoride fuel-to-NaK heat exchanger was interrupted after 123 thermal cycles because of failure of the NaK-to-air radiator in the test system. The radiator was replaced and thermal cycling was resumed. By November 25, 155 thermal cycles had been completed at ART design conditions: fuel inlet temperature of 1600°F and an isothermal temperature of 1200°F.

The NaK dump valve which has a Stellite-coated seat and a spherical poppet plug with a Stellite overlay, and which was rebuilt according to a stress-free seat design, is being tested at 1000°F with a pressure of 50 psig across the seat. After 624 hr of testing, including 50 opening and closing cycles, the maximum opening force required was 84 psig. The average leakage rate is 0.5 cm^3/hr.

Chemistry

Investigations of the use of molten salts for extracting impurities from liquid metals, such as lithium, are under way. The major factors which influence the separation of the melts into two discrete phases appear to be surface tension and nucleation. Further study of the phenomena resulting from the surface tension behavior and the nucleation characteristics is to be undertaken.

Techniques were investigated further for the production of the oxide-free yttrium metal required for the fabrication of hydrided yttrium moderator materials. A mixture of YF_3-MgF_2-LiF (53.9-21.1-25 wt %) is now being routinely produced at a rate of 5 lb/week that melts at 680°C and contains no detectable oxide. High-purity yttrium metal is prepared by lithium metal reduction of the mixture of fluorides.

Metallurgy

Methods for the production of yttrium metal from the fluoride mixture described above were studied further. Improved facilities for charging the materials to the reaction chamber are being developed. Studies are under way in order to correlate the impurity content of the yttrium metal with its mechanical properties. Techniques for hydriding the metal are being investigated. Exploratory hydriding experiments on small yttrium specimens gave encouraging results.

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Niobium is being investigated as a possible container material for lithium. Four thermal-convection loops constructed of sintered niobium were tested at hot-leg temperatures of 1500 or 1600°F for time periods ranging from 23 to 500 hr. Heavy grain-boundary penetration of the niobium occurred in at least two of these tests. This type of attack is presently believed to be due to dissolution of grain-boundary impurities.

Niobium loops are presently being fabricated by heliarc welding with an 85% Zr-15% Nb filler material. Static corrosion tests show this filler alloy to have excellent corrosion resistance to lithium at 1700°F for 100 hr. The mechanical properties of such joints are being investigated.

The fabrication of BeO bodies containing 0.5 to 1.0% B is being studied. Such material is of interest to GE-ANP as a capture-gamma-ray suppressor. Zirconium boride is also being investigated as a possible boron carrier.

Radiation Damage

Experimental studies were initiated of the effects of irradiation on photo cells. The thin films of chemically deposited lead sulfide used in photo cells are very sensitive to infrared radiation and have a wide variety of commercial and military applications. Both neutron and gamma irradiation were found to decrease the photo response of the cells in an amount that is proportional to the total integrated flux. The cells appear to have a fixed tolerance for gamma irradiation. If the total flux is maintained below this tolerance, the physical changes in the matrix can be effectively annealed out, and the cell will revert to its original state. The cell recovers in a first-order process that has a time constant of 3.8 min for neutron damage and 2.5 min for gamma-ray damage.

Shield Design

A calculation of the energy and angular distribution of gamma rays emerging from the Bulk Shielding Facility (BSF) reactor was initiated. The results will give the input spectrum for a Monte Carlo calculation of the gamma-ray heating in the GE-ANP XMA-1 shield mockup to be tested at the BSF.

Monte Carlo calculations were carried out to determine the air-capture gamma-ray dose rate at a detector located 50 to 65 ft from either a point-isotropic or a line-beam source of monoenergetic neutrons. The program allows the neutrons to scatter and degrade in energy until they reach 0.025 ev. They are then allowed to diffuse without further energy degradation. At each collision a 1/v probability of capture is included, and a statistical estimate of the gamma-ray dose rate at the detector is made. The program was run for initial neutron energies of 0.025, 0.1, 1.0, 10.0, 100.0, 1000.0, and 10,000 ev for line beams emitted at various angles with respect to the source-detector axis and for isotropic sources. The output includes the angular distribution of the gamma-ray dose rate at the detector and the distribution of the dose rate with respect to the energy at which the neutrons were captured.

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Tower Shielding Reactor-II (TSR-II)

Specifications for the water demineralization system were written and the piping layouts for the complete water system are being drawn. Potential suppliers of hose to transport the water to and from the reactor indicated that a 6-in. rubber hose that meets the specifications is available. The heat generation in each fuel channel in the core was calculated, and thus the orifice design needed to obtain the proper flow in each channel can be completed as soon as the flow studies are made. The test stand for measuring the flow will be completed in about 2 months.

Further investigations of methods for lead-aluminum bonding indicated that the results being obtained are not completely satisfactory. Adequate heat removal from the lead region adjacent to the core depends on the quality of the bond between the lead and its aluminum container. Efforts to improve the bond are being extended to include vacuum pouring of the lead at elevated temperatures. Two methods of supporting a unit shield for the TSR-II are being considered. One method permits a beam to be rotated horizontally; the other permits vertical rotation of a beam.

Tower Shielding Facility (TSF)

The measurements designed to determine the relative importance of gamma-ray production from inelastic scattering and air capture of neutrons in nitrogen are continuing. Gamma-ray spectra were taken both with and without a thin sheet of B_4C on the mouth of the reactor collimator. The difference between these measurements gives the effect of capture gamma rays produced by neutrons leaving the reactor collimator at low ($\sim$thermal) energy. Faster neutrons penetrate the B_4C, are moderated to some extent in air, and are also captured in the nitrogen of the air. The capture gamma-ray spectra from both these sources are the same, and the 10.8-Mev peak is very prominent. By normalizing on this peak it is possible to estimate the contribution of capture gamma rays at all energies, and from the difference between this estimate and the total observed spectrum with the B_4C filter it is possible to obtain an estimate of gamma rays produced by other processes, such as inelastic scattering. Analysis of this work is incomplete, and further measurements will be made with improved detector collimation in an attempt to eliminate any possibility of interference from neutron captures in the collimator itself.

The excess reactivity of the TSF reactor was measured by adding boric acid to the reactor tank until, with the reactor just critical, the shim and regulating rods were fully withdrawn. The excess reactivity was found to be 1.04% by a hand calculation, but it is planned to check this result with a machine calculation.

Edited by A. W. Savolainen

Approved by Alvin M. Weinberg, Director

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