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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

PROGRAM 4700

DECEMBER 1957

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ORNL-2459

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SPECIAL PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

December 1957

PROGRAM 4700 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT (AEC Activity 4701)

Tower Shielding Facility (TSF)

Fast-neutron dose-rate and thermal-neutron flux measurements were made in air at various distances from the TSF reactor in order to obtain data with which the production of gamma rays from inelastic scattering and neutron capture in the nitrogen of the air can be calculated. The results of the calculations will be compared with data being obtained in experimental measurements of the gamma-ray production.

Preparation for the operation of the Convair Aircraft Shield Test Reactor (ASTR) at the TSF has begun. Most of the detector instrumentation was set up and checked. The reactor was received and is being installed.

Lid Tank Shielding Facility (LTSF)

The production of secondary gamma rays by neutron capture in stainless steel is being investigated. In support of the Pratt & Whitney ANP program, data were taken on the thermal-neutron flux and the fast-neutron and gamma-ray dose rates behind various thicknesses of stainless steel. Similar data were obtained behind a fixed thickness (4 in.) of stainless steel sandwiched between 1/2-in.-thick sheets of boral. In addition, data were taken with the boral placed at different positions within the 4-in. steel slab. The evaluation of the data is not yet complete.

Experiments were also performed in support of the GE-ANP program which were designed to give additional information on secondary gamma-ray production in uranium, Hevimet, and stainless steel in configurations similar to those measured previously. In these further experiments the configuration consisted of 4 in. of beryllium followed by the gamma-ray shield and 12 in. of lithium hydride; boral was then added around the gamma-ray shield.

A new electrometer for use with the gamma-ray detecting instruments at the LTSF was developed and is currently being tested. It is expected that this new instrument will expedite data taking. It will also provide a permanent record in the form of a strip-recorder graph.

Metallurgy - Niobium-Lithium Systems

Corrosion tests of niobium-lithium systems with the use of thermal-convection loops have given anomalous results. One niobium loop clad with type 310 stainless steel on the outside and operated with lithium for 500 hr at hot- and

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cold-leg temperatures of 1500 and 1250°F showed no attack or embrittlement. However, several similar but unclad loops constructed of both sintered and arc-cast niobium and operated in an evacuated chamber under the same conditions showed heavy intergranular attack to a maximum depth of 20 mils in the hot-leg regions. No mass transfer of niobium from the hot leg to the cold leg was found in any of the loops. The reasons for the differences in corrosion attack are being investigated.

In loops that show intergranular attack, the attack is deeper, by a factor of 2, in the longitudinal weld zone than in the other parts of the tubing. The longitudinal weld is made by the fabricator, and it has been observed that the welds are porous. All unscheduled terminations of loop operation have been the result of leaks at the welds.

Successive 5-mil cuts from the hot and cold legs of three loops which showed hot-leg attack were analyzed for lithium. Good correlation was found between the depth of attack observed metallographically and the lithium content of the attacked areas.

The 85% Zr-15% Nb brazing alloy used to make saddle welds in several loops was unattacked by lithium, and there were no failures or cracks. Static capsule tests showed that this brazing alloy forms low-melting alloys with nickel- and iron-base materials, and thus it cannot be used in the fabrication of steel-clad loops.

Coast Metals alloys 52 and 53 are being investigated as possible protective coatings for niobium. After approximately 700 hr at 1700°F in air a sample coated with Coast Metals alloy 53 showed a maximum weight gain of 1.05 mg/cm^2, or about the same as would be expected of Inconel. The sample coated with Coast Metals alloy 52 lost weight initially but then gained weight rapidly.

Metallurgy - Yttrium Production

In the reduction of $YF_3 \cdot MgF_2 \cdot LiF$ with lithium to form the Y-Mg alloy, it was found to be feasible to transfer both the lithium and the fluoride mixture in the molten state into the reduction retort. Thus it will be possible to connect the fluoride processing apparatus directly to the reduction retort and thus eliminate intermediate handling steps.

Studies were initiated in an effort to correlate the tensile properties of yttrium with composition. A tensile specimen which can be readily machined from finger castings was designed and tested. Reproducible results obtained on three zirconium specimens showed this specimen production technique to be satisfactory.

Metallurgy - Production of Boride Compounds

Methods for the production of boron compounds to be added to BeO as a capture gamma-ray suppressor are being investigated. The compounds of initial interest are the borides of the transition metals in the fourth,

fifth, and sixth periodic groups whose physical properties, such as thermal stability and oxidation resistance, are in the applicable range. Borides of the fourth-group elements, Ti, Zr, and Hf, appear to be particularly attractive since they are extremely refractory (melting points of $\sim 3000^{\circ}C$), they have relatively good oxidation resistance, and they have a tendency toward one thermally stable phase, that is, a simple, hexagonal, AlB_2-type of a crystal structure.

Diborides of Ti, Zr, Hf, Ta, and Cr were synthesized by reacting the metal oxides, or, in the case of zirconium, the metal silicate, with boron carbide in graphite crucibles heated by high-frequency induction to temperatures in excess of $2000^{\circ}C$. Because of reaction-product gases, it was difficult to determine the exact temperatures of the reactions by the available optical methods; therefore, visual observation of ignited outgases and time-power control of the induction unit aided in determining reaction progress. X-ray diffraction patterns were made of the compounds, and in each case they were found to be predominantly diboride.

Heat Transfer

The investigation of the effects of thermal cycling on Inconel tubing in the presence of the fuel mixture $NaF-ZrF_4-UF_4$ (56-39-5 mole %) was continued with the use of the pulse-pump apparatus. Two additional experiments were completed for which thick-walled test sections (approximately 3/8-in. wall thickness) machined from bar stock were used in order to eliminate welds. One specimen (test 6) was tested for 23 hr (32,000 cycles) at a cyclic frequency of 0.4 cps and a mean fluid temperature of $1404^{\circ}F$. The amplitude of the temperature fluctuation at the metal surface was $\pm 177^{\circ}F$. Metallographic examination showed cracks approximately 5 mils deep throughout the test section. The specimen used for test 7 was tested for approximately 155 hr (223,000 cycles) at a mean temperature of $1410^{\circ}F$ and a frequency of 0.4 cps. The amplitude of the temperature fluctuation was $\pm 102^{\circ}F$. A partial plug in the pulse-pump reduced the temperature fluctuation to $\pm 70^{\circ}F$ for 48 hr of the test. Metallurgical examination of the specimen is under way.

The study of the effect of screens in a diverging annular channel on the thermal structure of a fluid under volume-heat-source conditions was continued. In order to reduce the magnitude of the temperature fluctuation at the outer wall, four screens were installed in which the solidity was adjusted radially to force an increased flow along the outer wall. The magnitude of the temperature fluctuations at the wall in relation to the total temperature rise of the fluid was found to be 5% at the inner wall and 8% along the outer wall. These results show considerable improvement over the earlier data for constant solidity screens where the maximum fluctuations were 3% at the inner wall and 29% at the outer wall. A test made with the variable screens and unsymmetrical entrance flow resulted in only a slight increase in temperature-fluctuation magnitudes and showed essentially no circumferential flow asymmetry in the channel.

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Experimental Engineering

An ART fuel pump has operated in the cavitation region for a period of 2100 hr, and operation has been satisfactory in all respects. This test will be continued until at least 3000 hr of operation have been accumulated.

Testing of the 20-tube semicircular fuel-to-NaK heat exchanger was interrupted after 169 of a proposed 300 thermal cycles by a fuel-heat-source faulure. The heat source was repaired and the test was resumed.

Edited by A. W. Savolainen

Approved by A. M. Weinberg, Director

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