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MEMORANDUM TO FILE

FROM: R. R. Herries

March 15, 1955

This document consists of 4 pages

Trip Report No. 1 of 14 Copies, Series A
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W. J. O'Leary and R. R. Herries visited BMI in company with C. C. McBride, SRL, to discuss the results of subcontract research on the extended surface fuel element program and to discuss with BMI personnel the programs included in the recent contract extension.

SUMMARY

1. Double and triple melts from two 9-10 pound ingots of arc-melted Horizons' thorium showed decreasing porosity. Physical and chemical data, on these as well as on eight previous double melted ingots, are being obtained.
2. The problems involved in obtaining uniform castings of uranium-aluminum alloy for co-extrusion billets were discussed, with emphasis upon those phases to be investigated at BMI.
3. A program was outlined to evaluate the effects of outgassing, by vacuum annealing, on the corrosion resistance of nickel-plated uranium.
4. Data obtained from diffusion studies at BMI show that the mutual diffusion at high temperatures of thorium and aluminum is slow, with the diffusion of the thorium into the aluminum proceeding somewhat faster than that of the aluminum into the thorium.

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5. Possible methods of applying an inner cladding of aluminum to a tubular uranium fuel element were discussed.
6. "Half-dollar" size uranium corrosion samples, nickel-plated and press-clad with 30-mil aluminum at 10 and 15 thousand psi (950°F) are exhibiting better corrosion resistance than did similar samples pressed with 6 thousand psi.

DISCUSSION

Uranium

Uranium-Aluminum Alloy

Experience with the uranium-aluminum alloys at both Nuclear Metals and SRL has shown that the alloys do not behave upon casting as would be expected from a study of the constitution diagram of the uranium-aluminum system. Alloys cast at compositions other than in the eutectic range, 13% to 14% uranium, have a marked tendency toward radial segregation, specifically toward inverse segregation. In view of the requirement for homogeneous alloy billets for co-extrusion, the SRL work will be supplemented by an investigation at BMI of alloys containing 16% to 40% uranium. The purpose of these studies will be to determine:

- (1) what controls are required to produce homogeneous castings in the range 14% to 18% uranium,
- (2) the composition of the alloy at the peritectic point, and
- (3) the location of the liquidus line above and below the peritectic point.

In order to assist BMI with this study, C. C. McBride reviewed SRL work with the uranium-aluminum alloys, and reviewed their procedures for casting alloys in the range of 13% to 16% uranium.

Outgassing Nickel-plated Uranium

In bonding aluminum claddings to extended surface uranium fuel elements, a diffusion barrier of nickel is used. When the uranium is electroplated with nickel from an aqueous bath, there is a possibility of entrapping moisture, plating solution, hydrated oxides, and also of forming uranium hydrides; these may seriously affect the bond continuity and corrosion resistance of the fuel element. Vacuum annealing, or outgassing, presents a possible means of eliminating or minimizing the effects of such occluded substances, thereby improving the corrosion resistance of aluminum-clad fuel assemblies. Consequently, BMI has been asked to undertake a program to study the effects of outgassing methods on nickel-plated cores, as evaluated by corrosion testing.

A tentative outline of the program was discussed with BMI, including the outgassing of plated cores, at 500°C for 60 minutes, both separately and in aluminum sheaths as evacuated assemblies. As-plated cores will provide a basis for evaluating these samples. The standard SRL plating procedure and a procedure from which the anodic etch has been eliminated will be used to provide two sets of specimens for each condition of the as-plated and the outgassed preparation for bonding. Thus, the effects on corrosion resistance of a smoother uranium surface, possibly having less occluded oxide, will also be determined.

The thickness of nickel electroplate on the cores to be outgassed and evaluated has been established as 0.3 to 0.5 mils. SRL, however, would like to see the range of nickel thickness extended to 0.1 mil.

Internal Cladding of Tubes

Although several methods appear feasible for aluminum cladding the outside surface of tubular uranium fuel elements, the cladding of the inner surface appears more difficult. BMI has contracted to investigate the possibility of accomplishing this by means of an "inverse die sinking" process, similar to a "hot draw". Variations of this process, the problems involved, and the equipment necessary for this work were discussed in the first meeting concerning the program.

Corrosion

"Half-dollar" size uranium samples for the purpose of evaluating the effects of higher bonding pressures upon corrosion resistance, were press-clad with 30-mil aluminum at BMI. The specimens of uranium, 1" in diameter X 0.180" thick, electroplated with 0.3 to 0.5 mils nickel, were bonded using 10 and 15 thousand psi at 950°F (510°C) for five minutes. After pressing, the assemblies were "pinch-welded" around the edges of the aluminum sheath and were "pinholed" with a 15-mil drill. Samples were similarly prepared and bonded at 6000 psi to serve as a basis for comparing the corrosion behavior of the samples bonded under the higher pressures when tested under the same conditions.

Upon corrosion testing the samples in boiling distilled water, it was found that the higher bonding pressures produced more continuous bonds between the relatively rough interfaces, and better corrosion resistance, than did the lower pressure of 6000 psi. All the samples pressed at 6000 psi failed after 21 to 35 days on test, while only one sample from the 10,000 psi group has failed after 35 days exposure. In each case the sample failed when the pimple which appeared at the pinhole grew in diameter until it reached the edge of the uranium, from which edge the corrosion spread rapidly over the opposite face. This is an indication of poorer bonding on the edge than on the flat surfaces.