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DPW-55-24-9
SR/H--804

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July 1, 1955

This document consists of 4 pages
No. 5 of 11 copies, Series A

MEMORANDUM TO FILE

FROM: R. R. Herries

# Trip Report
## BATTELLE MEMORIAL INSTITUTE
## June 21-22 and 27, 1955

R. R. Herries visited BMI to discuss the progress of subcontract research on both the natural uranium and the enriched uranium fuel element programs.

SUMMARY

1. The poor corrosion resistance of recent samples press-clad with 6,000 psi at 950°F is believed to have been due to the presence of a large number of stringers intersecting the surfaces of the uranium cores. A better quality metal and an improved pinch-weld will be used in the future.

2. Machining of extrusion dies and mandrel tips by Moczik for the BMI extrusion cladding work is expected to be completed about mid-July.

3. The first attempt to clad the internal surface of a tube by "hot drawing" has been completed. A plug was drawn through an aluminum billet placed in the tube and heated to 955°F. A weakly bonded cladding with a poor surface was produced.

4. Several uranium-aluminum billets have been cast into a water-cooled steel mold as a means of varying the cooling rate of the alloy. Billets previously cast into a graphite mold are being examined by radiography in order to determine the effects of the rate of solidification on the segregation of the alloy.

## DISCUSSION

### Outgassing of Nickel-Plated Uranium

A series of corrosion specimens which were recently press-clad under similar conditions has exhibited markedly different behavior when corrosion tested in boiling water. An earlier series of nickel-plated uranium samples, press-clad with 6,000 psi at 950°F, had shown excellent containment of corrosion when pinholed and placed on test. Blisters were formed at the pinholes and grew slowly in diameter without undercutting until they reached the edge of the uranium core; the samples were then removed from test (31 to 49 days).

The most recent set of eight specimens press-clad with 6,000 psi at 950°F behaved quite differently from those described above. Four of the eight samples failed by undercutting within 21 days; the remaining four samples failed due to the growth of the pimples, as did the previous set, within only 28 days. Since the corrosion resistance of these eight samples was considered to be inferior to that of the series tested previously, the history of the samples was reviewed in an attempt to determine the reason.

It was found that several of the pinch welds which sealed the circumferences of the samples were defective. This has been corrected. However, of greater concern was the fact that metallographic examination of the uranium cores after corrosion testing showed that they contained a very large number of stringers which were greatly enlarged during exposure to boiling water. Since the samples were transverse sections cut from a 1" round of Hanford reject material, all of the stringers were perpendicular, and open, to both flat surfaces of the core. Such defects, if not sealed by the nickel plate, would provide paths for the corrosion to proceed through the core and over both surfaces of the uranium. Consequently, a quantity of sounder metal will be provided to BMI for future corrosion work.

Samples from several previous sets of specimens will be examined for similar defects which would tend to explain the irreproducibility experienced from series to series.

### Extrusion Cladding

Extrusion cladding experiments at BMI are awaiting the delivery of the streamlined porthole dies and mandrel tips from Moczik Tool and Die Co. They are expected to arrive about mid-July.

Drawings of the extrusion tools in use at both the Aluminum Co. of Canada and the Bureau of Mines have been received from the AECL. These have been discussed with BMI personnel and will be shown to Mr. DeBuigne of Moczik for consideration as possible designs for extrusion cladding equipment.

Internal Cladding of Tubes

The first attempt has been made to clad the internal surface of a tube with aluminum by the "inverse die sinking" process. The goal is to bond 30-mil aluminum to the inner surface of a uranium tube.

For the initial run a 1-foot long nickel-plated steel tube was inserted into the steel jig which was heated to 1000°F. A 7-inch long aluminum billet was inserted in the tube and the drawing plug was placed in position. The plug and the lower end of the billet reached 955°F, although the billet was not uniformly heated over its entire length.

The plug was drawn through the assembly at a speed of 1 inch/minute with a maximum force of 18,600 pounds required for a reduction from 0.150" to 0.120" in the thickness of the aluminum wall. The aluminum drew successfully to a length of 8 inches, although pick-up on the plug resulted in a rough surface of the cladding. The tube was sectioned and was found to be unbonded except for spots of weak bond.

Variables to be investigated include per cent reduction, speed of draw, temperature of tube and billet, lubrication, and use of multiple draws.

Uranium-Aluminum Alloy

Several billets of 16% uranium in aluminum alloy have been cast into a graphite mold and into a water-cooled steel mold. These were used to provide a wide range of cooling rates in order that the effect of the rate of solidification upon segregation of the alloy may be determined.

The first six billets which were cast into a graphite mold preheated at temperatures up to 700°F have been radiographed. These castings were cooled at rates varying from 40F°/min. to 120F°/min. Radiographs produced by the scanning technique show little segregation from top to bottom or around the circumference of the billet. These castings will be sectioned into transverse slices to show the radial segregation as well.

Castings have also been poured into a steel mold preheated to 1100°F or 1300°F. In this case, the metal remains molten until the cooling water rises around the outside of the mold, thereby providing a fast chill which starts at the bottom of the ingot. Cooling rates and radiographs have not yet been obtained from billets cast by this method.

The work at BMI to determine more accurately the constitution diagram for the uranium-aluminum alloys in the range 16% to 30% uranium is progressing. The peritectic temperature was established at 729°C-732°C by means of a differential thermocouple technique. However, another means must be employed to locate the liquidus line at the higher temperatures.

Physical Properties of Dingot Metal

B. W. Dunnington of SRL met with H. A. Saller and the writer to discuss a possible program to evaluate dingot metal. Such an evaluation would follow closely a similar evaluation of ingot metal which was carried out at SRL. BMI will submit to Wilmington a proposal on the work to be done.

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