RECORDED

E. I. du Pont de Nemours & Co.
Explosives Department
Atomic Energy Division
Wilmington, Delaware

- cc: #1 - R. M. Evans - B. H. Mackey
2 - L. Squires - H. Worthington
3 - D. F. Babcock
4 - R. T. Huntoon
5 - J. C. Woodhouse
6 - M. S. Cecil - R. E. Fisher
7 - K. G. Jones - B. W. Dunnington
8 - W. File
9&10 - L. M. Arnett, ANL
11 - P. H. Permar - M. H. Wahl, SRL
12 - C. C. McBride - C. D. Smith
13 - V. I. Montenyonl - M. McKeenan
14 - TIS File
15 - S. A. McNeight, Hanford
16 - H. C. Vernon - E. M. Mahla, ED

DFW-53-1048-Del.
(SR/H--839)
July 16, 1953

UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION

9/26/88
J. C. Woodhouse

Document consists of 4 pages
No. 8 of 16 copies, Series A

MEMORANDUM TO FILE
FROM: R. T. HUNTOON

REPORT OF MEETING AT BATTELLE MEMORIAL INSTITUTE
June 29, 1953

On June 29, L. Squires, H. Worthington, J. C. Woodhouse and R. T. Huntoon visited BMI to discuss the status of the bonding program and to learn the recommendations of the BMI people concerning a bonding technique for MTR test plates.

SUMMARY

During the meeting each of the bonding mechanisms under study at BMI was reviewed by the engineer directly responsible for the work. These methods were solder bonding, extrusion cladding, roll cladding, and pressure bonding. The pressure bonding method, using an electroplated copper bonding layer, appeared to be most suitable for immediate use in MTR test plates. Roll cladding appears feasible only if further work indicates that bonds can be obtained either at temperatures in the high alpha range or using low deformations. Extrusion cladding is in a preliminary stage and requires considerable development before being considered as a production technique. However, it was felt this last method is promising and offers the highest production speed of any under consideration.

A brief discussion of the corrosion of the 5% zirconium-uranium alloy resulted in the conclusion that, because of the tendency toward crevice attack, work in this field should be diminished and no new projects started.

SOLDER BONDING - (D. C. Martin)

Work in this field was directed toward obtaining a bond between aluminum and uranium using a bonding agent which was molten during some period in the process. The major difficulty encountered was in obtaining "wetting" of the components. The surface oxide films, particularly on aluminum, are relatively adherent so that the surfaces must be previously tinned to obtain bonding.

DECLASSIFIED

with Deletions

MASTER

J. C. Woodhouse
9/26/88
9/11/89

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Bonding agents used in this investigation were zinc, tin, zinc-tin alloy and aluminum-silicon. The uranium cores were variously prepared using electroplated coatings of nickel, iron, and chromium or hot-dipped coatings of AlSi. The best combination seemed to be zinc on an AlSi-coated uranium core. Even in this case the bond was discontinuous and tended to fracture during cooling. Using AlSi alone, fair bonds can be obtained at temperatures less than the AlSi melting point; however, the growth of the uranium silicon compound layer is extensive. At temperatures greater than the AlSi melting point the molten AlSi is almost completely forced out of the bond area under pressure, and a poor bond is obtained.

Based on the above results, the solder bonding system appears the least promising, and it was decided to discontinue this work unless the use of gaseous fluxes renders the system more attractive. Experiments to evaluate the use of gaseous fluxes are expected to be undertaken in the near future.

EXTRUSION CLADDING (C. J. Slunder)

It is the purpose of the work in extrusion cladding to form a complete aluminum envelope around the uranium core in a manner analagous to cable sheathing. Up to the present time only exploratory experiments, using cylindrical steel cores, have been carried out so that the problems to be encountered with this system might be evaluated. In all cases sheaths of approximately 1/8-inch thick have been used.

The two extrusion methods used in this work were "direct" and "indirect". Indirect extrusion is used to designate the system wherein the die is forced against a billet supported by a stationary ram. In direct extrusion the die is stationary and the billet is forced through the opening by a movable ram. In indirect extrusion at a temperature of [REDACTED] each attempt resulted in tensile failure of the core caused by the frictional forces between the core and the billet. This indicates that the force exerted by the extruded sheath outside of the die is strong enough to carry the core along so that control of the core motion becomes essentially automatic. In direct extrusion at [REDACTED] frictional forces do not allow the core to move as rapidly as the aluminum is extruded causing uneven aluminum deposits around the core just outside the die orifice. Both of these experiments show the necessity for a guide tube for the core to prevent upsetting the aluminum billet against the core and allow free flow through the die orifice. It is planned to incorporate such a tube in the direct extrusion system in the near future. In using a guide tube the die must be designed so that the core enters the aluminum stream at the point where the extrusion velocity reaches its maximum.

The obvious advantages of the extrusion cladding system, operational simplicity and speed, make this method attractive. For this reason considerable further effort will be devoted to the development of a satisfactory process. In addition to the details and mechanics of extrusion, consideration must be given to control of the sheath thickness and formation of a satisfactory bond.

ROLL CLADDING - (S. J. Paprocki)

The study of roll cladding techniques has resulted in the conclusion that bonds can be obtained between aluminum and either bare or AlSi-coated uranium, using the "picture frame" technique. However, in each case large reductions at temperatures between [REDACTED] were required. At present, all available information indicates that stable uranium can be fabricated in the alpha phase only at temperatures greater than [REDACTED]. Until it is determined that deformations at temperatures less than [REDACTED] do not produce instability, roll cladding can be considered only at temperatures greater than [REDACTED] or at low deformations.

In view of the requirements stated above, an effort has been made to develop techniques which do not require reduction of the uranium core. To date, the best results have been obtained using successive reductions of less than 10 mils per pass on AlSi coated cores. In this manner pack reductions of up to 25% can be achieved without reduction of the core. However, bonds obtained with this technique are not as good as those obtained using large initial total reductions; in fact, there is reason to believe that core reduction may be necessary to get a satisfactory bond.

Future work in roll cladding will continue the determination of the minimum core reduction required for good bonding. In addition to this work on the aluminum--aluminum-silicon--uranium system, it is planned to investigate the use of the aluminum--copper--uranium system to develop a system which can be fabricated at temperatures greater than [REDACTED]

PRESSURE BONDING -(R. F. Dickerson)

Pressure bonding test results have shown that this method is the most readily available for production of MTR test plates. Satisfactory bonds have been obtained using barrier layers of copper, nickel, and aluminum-silicon. Because of the reproducibility of the bonds obtained with copper, the aluminum--copper--uranium system tentatively was recommended over the other systems. This system produced bonds at temperatures and pressures higher than the conditions determined by the equation: [REDACTED]. Initial experiments were carried out on small "1-inch square" specimens. Subsequent tests using 3x5-inch specimens in a closed die produced a complete bond over the whole surface area of the core. However, in order to produce 100% bonding the flow of aluminum across each surface was required. Minimum flow conditions have not yet been determined.

Although the copper system has been tentatively selected, the nickel and AlSi systems are still under consideration because of the uncertainty of corrosion resistance in the copper-uranium interface. It is conceivable that a sheath failure in this system would result in rapid spread of attack around the penetrated area and ejection of the large quantity of corrosion products into the coolant stream. A comparative study of the corrosion resistance of the copper, nickel, and AlSi bonding systems is now under way, and final selection of the copper system cannot be made until the results of this study are available. In the event the copper-uranium interface is excessively attacked, either nickel or AlSi will be selected, with preference in the above order. This preference, again, is based on the results of the bonding experiments rather than corrosion resistance of the bond.

CORROSION - (A. H. Pray)

Recent results in the study of corrosion characteristics of the 5% zirconium-uranium alloy were reviewed by Dr. Pray. In the study of the effect of dissolved hydrogen and oxygen on corrosion in demineralized water at 97°C it was found that water saturated with ratios of from 2/1 to 10/1 hydrogen-to-oxygen produced high resistance to attack for exposure periods greater than 7 weeks. Specimens exposed in water saturated by a ratio of 35/1 hydrogen-to-oxygen showed a deterioration of corrosion resistance after 2 and 3 weeks exposure. A specimen exposed to a ratio of 230/1 hydrogen-to-oxygen has been tested for two weeks and remained satisfactory during this period. These data lead to some doubt that the alloy will have satisfactory resistance in water of a composition to be expected in reactor operation. (The best estimate of the gas content of reactor moderator is a ratio of 70 parts hydrogen to 1 part oxygen.)

A study of the effect of crevice conditions has been undertaken. In this experiment, small rods of the alloy were clad with aluminum by swaging and the sheathing was then perforated. The specimens were exposed to water at 97°C. Examination of the specimens showed very little attack at the aluminum alloy interface and no evidence of undercutting, although some loose oxide was visible. No dependence on the gas content of the water was noted.

On the basis of the results to date it was decided that no new work in the development of the uranium-zirconium alloy would be undertaken. However, authorization was made to continue any studies previously started to a logical termination. Unless significant new information is developed during the termination period, it was agreed that du Pont would cease to support work on the uranium-zirconium alloy system.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

RTH/jss