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THULIUM OXIDE IRRADIATION

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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THULIUM OXIDE IRRADIATION

INTRODUCTION

A study has been made based on the request by the Boeing Company to irradiate thulium and thereby provide a heat source of 1000 thermal watts. This report reviews how thulium oxide can be irradiated as part of a special production test to meet the requirements specified in the request.

SUMMARY

Thulium oxide can be irradiated to meet the desired specific heat generation of 1.5 watts per gram as part of a flux amplification test, which will be conducted the early part of FY-1965. To obtain the heat generation level, it is calculated that a 120-day irradiation will be required at a flux of 1.1×10^{14} neutrons/cm²-sec. This can be attained in the test assuming the proposed target element is modified by reducing the thulium oxide wafer thickness from 0.080 to 0.050 inch. Also, the length of the target element should be reduced to not more than 20 inches to minimize the possibility of sticking in the process tube. This would require four targets rather than a single element as proposed.

Prior to undertaking this irradiation, it would be desirable to place a prototype target element in the Hanford Test Reactor to determine the approximate rise factor (change in neutron flux level between the target element and adjacent tubes of fuel elements). This would provide more precise data for planning the loading pattern in the production test.

DISCUSSION

Irradiation of target materials (thorium, depleted uranium, neptunium, etc.) have been evaluated as alternate products in the present production reactors. In each case, it has been advantageous to irradiate the target element at higher flux levels than presently exist in the normal plutonium production loadings. Therefore, plans⁽¹⁾ have been made to initiate a program of limited production tests to obtain physics and reactor engineering data in support of operating at higher flux levels with different types of reactor loadings.

The request for irradiating a thulium oxide target element could be combined with these tests assuming the scheduling of tests and availability of target elements were compatible. Present plans are to design a specific production test by July, 1964, in which a process tube containing target material would be surrounded by eight process tubes containing uranium of 0.947 per cent U-235. This would provide a flux of 1.1×10^{14} neutrons/cm²-sec. and the desired activity level in the thulium oxide after 120 days of irradiation. The over-all length of the thulium oxide target elements would be 80 inches with the remainder of the active flux zone loaded with bismuth for polonium production. The space occupied by the thulium oxide elements

(1) T. W. Ambrose, Higher U-235 Content Fuel, HW-81396. March 19, 1964. (CONFIDENTIAL).

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would normally have produced 39 grams of plutonium. The maximum flux level attainable in thulium oxide with conventional target loading would be in the order of 5×10^{13} neutrons/cm²-sec. which would produce a specific power of 0.7 watt per gram of thulium oxide after 120 days of irradiation. Thulium irradiations, in general, require a high neutron flux because of the relatively large thermal cross section of Th-169 (130 barns) and the short half life of end product Th-170 (127 days). Another factor is that Th-170 has a thermal cross section of 150 barns which results in a loss of product as the irradiation time is extended.

One of the unknowns associated with the thulium oxide irradiation is the rise factor, since the proposed target assembly is made up of neutron source material (Be) as well as absorber. The ability to accurately calculate this factor (and hence the flux level on the target atoms) is limited; however, simple tests can be conducted in the Hanford Test Reactor to arrive at usable values. Therefore, prior to undertaking this irradiation, a prototypic thulium oxide target element should be placed in the Test Reactor and the approximate rise factor determined. This phase of testing would not damage the element in any way and the element would be returned to Boeing Company. This phase of testing would require about two days and would be carried on as part of the over-all Reactor Research and Development Program.

TARGET ELEMENT

The proposed target element design as shown in Figure 1 consists of beryllium spacers and thulium oxide wafers all clad in aluminum and will require several minor modifications in order to attain the desired activity levels of 575 curies per gram or 1.5 watts per gram of thulium oxide. Reducing the thickness of the thulium oxide wafers from 0.080 to 0.050 inch will minimize the localized flux depressions within the target element and thereby provide a greater over-all flux level which is needed to provide the specific heat generation rate. The length of an individual target element should be not more than 20 inches to minimize the possibility of sticking in the reactor process tube. Another desirable alternative would be to increase the diameter of the jacket material to 1.45 inches, maintaining an 0.050 inch aluminum wall. This would eliminate the need for spacer lugs as shown on the proposed design which could possibly damage the bottom portion of a ribbed process tube, as the target element is charged and discharged.

The assumption is made that the welded end caps and cladding will prevent water entry throughout the irradiation. Heat generation rates are estimated to be low and should not present any problem. Reaction rates of water and thulium oxide have not been evaluated and preliminary tests would be desirable to assure that there are no adverse effects.

SHIPPING AND HANDLING

It was assumed that the target elements would be shipped after irradiation without being disassembled in a cask provided by the Boeing Company. The method of transportation would depend upon what arrangements had been made by the Boeing Company.

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Research and Engineering Section

FIGURE 1

PROPOSED THULIUM OXIDE TARGET ELEMENT

<p>1 Spacer lugs (2219 Al)
6" linear, 120° radial</p> <p>2 Tubing (2219 Al) 1.250" O.D. x
1.050" I.D. x 1" long</p> <p>3 Beryllium spacers
1.030" dia. x 0.300" thick</p> | <p>4 Thulium oxide wafers
0.900" dia. x 0.080" thick</p> <p>5 Keeper rings (2024 Al)
1.050" O.D. x 0.950" I.D. x
0.085" thick</p> <p>6 End caps (2) (2219 Al)
1.050" dia. x 0.250" thick</p> |
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