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February 12, 1964

SOME DESIGN DETAILS FOR THE TARGET COMPONENT
OF THE CO-PRODUCER TEST ELEMENT

INTRODUCTION

A request for procurement of the target alloy for the 36 tube co-producer demonstration test (using 1.25% enriched driver elements) is about to be made of the AEC, with the objective of having the material cast at the Savannah River Plant. Several details of the target element design were established at a meeting attended by V. L. Gelezunas, G. A. Last, J. C. Tverberg and the writer on February 11, 1964. The purpose of this note is to record the conclusions reached and the result of a calculation of the alloy composition required.

SUMMARY

The nominal composition of the target alloy for the 36 tube co-producer demonstration test (using 1.25% enriched uranium driver elements) should be aluminum-0.94 wt. % lithium, assuming use of lithium enriched to 40 wt. % Li-6. The purchase requisition may be written, alternately to specify a Li-6 content of 0.368 wt. % and a total lithium content not to exceed 2.0 wt. %.

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DETAILS

The target alloy composition was specified by R. J. Shields⁽¹⁾ as 0.65 wt.% Li (enriched to 40 wt.% Li-6) in aluminum in a rod of 0.505" diameter. This was converted by T. W. Evans, et al⁽²⁾ to a Li-6 content of 0.272 grams per foot of target element. However, these values pertain to an infinite length of target rod, i.e. with no end caps. In addition, the actual target element will have an inner cladding of aluminum. The lithium content of the core will have to be increased above the original value to compensate for these changes.

The pertinent attributes of the idealized and of the actual target component are given below. The driver element length is 26.100 ± 0.060" and the outer and inner diameters of the Zr-2 cladding of the target element are 0.565" and 0.505" respectively, for both cases.⁽²⁾

A. Idealized Target Element

Core diameter	0.505"
Core length	26.1"
Composition	0.65 w/o Li (40w/o Li-6)
Density	2.63 gms/cm ³

B. Actual Target Element

Aluminum cladding diameter	0.503"
Aluminum cladding thickness	0.035"
Core diameter	0.433"
Element length	25.900"
Zr-2 cap thickness	0.250"
Al cap thickness	0.1875"
Total longitudinal gap*	0.210"
Core length	24.815"
Core density**	2.65 gm/cm ³

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(1) HW-79630, "Fuel Element Design for Co-Product Pilot Load", R.J. Shields, November 11, 1963 (SECRET)

(2) HW-80028, "Technical Criteria for Co-Producer Fuel Demonstration Loading", T.W. Evans, E.G. Pierick, R.J. Shields, and R.H. Shoemaker, December 16, 1963 (SECRET)

*This gap is left between the aluminum-clad core and the Zr-2 end caps to allow for the greater thermal expansion of the core compared to that of the cladding.

**This value is for Al-1% Li, data provided by V.L. Gelezunas.

C. Composition Calculation

The total amount of lithium-6 in the actual target element core must equal the amount of lithium-6 in 26.1 inches of the idealized target element core.

$$\left[\pi \frac{d^2}{4} \times l \times \rho \times c \times e \right]_{ideal} = \left[\pi \frac{d^2}{4} \times l \times \rho \times c \times e \right]_{actual}$$

where d, l, ρ , c and e are, respectively, the diameter, length, density lithium content and lithium enrichment of the target cores.

$$\frac{\pi}{4} \times (0.505)^2 \times 26.1 \times 16.387 \frac{\text{cm}^3}{\text{in}^3} \times 2.688 \times 0.0065 \times 0.40 =$$

$$\frac{\pi}{4} \times (0.433)^2 \times 24.815 \times 16.387 \frac{\text{cm}^3}{\text{in}^3} \times 2.65 \times C \times 0.40$$

Solving for C:

$$C = \frac{(0.505)^2}{(0.433)^2} \times \frac{26.100}{24.815} \times \frac{2.688}{2.65} \times 0.0065$$

$$C = 0.00943$$

Thus, with the nominal dimensions given above for the actual target element, the target alloy should be Al-0.9% w/o Li, assuming use of lithium enriched to 40 w/o Li-6. Since it is the lithium-6 content that is important for the test and because target alloy behavior under irradiation has been found to be very good for total lithium contents up to 2 w/o, the target alloy specification may be written more generally as a Li-6 content of 0.388 w/o and a total lithium content of 2.0 w/o or less.

T.W. Evans

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