NEUTRON ABSORPTION LITHIUM DETECTOR

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INTRODUCTION

It is planned to manufacture ceramic target elements for use in N-Reactor. The potential exists for overdilution of the lithium-aluminate with aluminum powder. The visual appearance of the overdiluted material is identical to standard material so a method of nondestructively determining the difference is needed. One method of nondestructively determining the target element type is by neutron absorption. This technique makes use of the different thermal neutron cross sections of aluminum and lithium. Natural lithium has a cross section of 71 barns while the cross section of aluminum is only 0.23 barns. The target element to be tested is placed between a neutron counter and a neutron source -- the neutron count with the unknown sample is then compared with that of a standard.

DESCRIPTION

An experiment was conducted to determine if a neutron absorption instrument could be used to identify a lithium or aluminum target element. A sketch of the test arrangement is shown in Figure 1. A conventional, Hanford-made, BF_3 neutron detector was placed behind the fuel element and shielded with 0.040 inches of cadmium as shown. This assembly was then immersed in a 12 x 12 x 18 in. water-filled vessel along with the fuel element. A five curie plutonium-beryllium neutron source was placed in the water-filled tank and counts taken for varying source distances from the fuel-neutron counter assembly. This was done for both a lithium and an all-aluminum element. Water was used to moderate the fast

neutrons from the source since the lithium has a large cross section for slow neutrons only. The same experiment was also run using two different diameter polyethylene cylinders. This arrangement is shown at the bottom of Figure 1.

RESULTS

The results of this experiment are shown in Table I and Figure 2. Table I shows the count rates obtained for each element at the different distances along with the ratio of the aluminum count to the lithium count. Since this figure corresponds to the instrument signal-to-noise ratio, it was also plotted against fuel-to-source spacing in an effort to determine the optimum neutron moderation distance. The two points obtained using a polyethylene moderator are also shown on Figure 2. The water moderator produced maximum count ratios of slightly over five, while the polyethylene resulted in about four. This indicates that it would probably not be worth the problems encountered to go to a water moderator just to achieve this increase in signal-to-noise ratio. The mechanical design of the instrument would be much simpler, and an adequate count ratio maintained, if the polyethylene moderator is used.

The high counting rates and the high signal-to-noise ratio indicate that the five curie source used here is probably larger than necessary. In any operational instrument of this type, a one curie source should be sufficient and much easier to handle. This should decrease all count data by a factor of five. With this consideration and using the 9-1/2 centimeter polyethylene data, a ten second count should result in 837 counts for the lithium fuel and 3290 counts for the aluminum. Considering the two sigma value (95 percent confidence level) the minimum separation of the counts would be 895 for the upper limit of the lithium and 3176 for the lower limit of the aluminum fuel. With these large count differences a count rate meter could probably be utilized

in any production instrument, eliminating the expense and operational difficulties of a scaler.

Some radiation hazard is involved in this instrument and for this reason readings were taken at the sides of the water tank and the surface of the 27 centimeter diameter polyethylene cylinder. Combined gamma-neutron readings at the surface were under 70 mr per hour in both cases. This value would probably be reduced by five if a one curie source were used.

NEUTRON ABSORPTION EXPERIMENT

COUNT DATA

TABLE I

Water Moderator

Distance	Ratio, $\frac{Al}{Li}$	Lithium Fuel	Counts/min Aluminum Fuel	No Fuel
3.5 cm	2.43	89,978	218,992	-
5.0	3.22	86,096	276,912	198,121
7.5	4.12	61,506	253,319	150,776
10.0	4.73	41,530	196,386	99,004
12.5	4.86	25,355	123,190	57,512
15.0	5.13	15,234	78,206	36,939
17.5	5.06	8,211	41,527	18,604
20.0	4.95	5,985	29,598	13,870
25.0	4.53	2,409	10,921	5,152
30.0	4.18	1,049	4,390	2,226

Polyethylene Moderator

Distance	Ratio	Lithium Fuel	Counts/min Aluminum Fuel	No Fuel
9.5 cm	3.93	25,087	98,697	119,336
15.0	3.87	10,270	39,736	49,471

NEUTRON ABSORPTION EXPERIMENT

FIG 1

COUNT RATIO PLOTTED AGAINST DISTANCE

NEUTRON ABSORPTION EXPERIMENT

FIG. 2