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Nuclear Technology - Materials

AEC Research and Development Report

ASSAY OF LITHIUM-ALUMINUM BILLETS BY NEUTRON ABSORPTION

by
T. R. Herold
Applied Physics Division

January 1962

[redacted]

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ABSTRACT

An instrument was developed for assaying the lithium content of solid lithium-aluminum billets that contain between 1 and 5% lithium by weight. A neutron absorption technique is used. Billets approximately 8 inches in diameter, 24 inches long, and weighing about 100 pounds can be assayed in 15 minutes to within an accuracy of ±0.08 wt %.

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[redacted]

ASSAY OF LITHIUM-ALUMINUM BILLETS BY NEUTRON ABSORPTION

INTRODUCTION

Control rods for nuclear reactors may be fabricated by extruding short billets of lithium-aluminum alloy into slender elements of the desired length. Before the extruded elements are used in a production reactor they are measured in a test reactor to determine if their lithium content is within acceptable limits.[1]

An accurate measure of the lithium content of the billets prior to extrusion would prevent the extrusion of unacceptable elements and would facilitate matching the extruded elements. The lithium content of a given run of billets is held to close tolerance but may fall between 1 and 5% of the total weight, depending on the strength of rod required.

Laboratory experiments showed that a neutron absorption technique that was previously used on thin control rods[2,3] could be used to assay the lithium content of the massive billets. Measurement by neutron absorption is especially attractive because the results reflect directly the Li^6 content, which is the pertinent quantity.

SUMMARY

An instrument was constructed for assaying the Li^6 content of solid Li-Al billets that are approximately 8 inches in diameter and 24 inches long. The assay is made by directing a thermal neutron beam through the billet and counting the transmitted neutrons with BF_3 counters. The reduction in the number of transmitted neutrons due to absorption in the billet is proportional to the amount of Li^6 present. By using a 10-curie Pu-Be source, seven closely spaced BF_3 counters electrically connected in parallel, and counting times of 15 minutes, the following results were obtained:

Range of Total Lithium Content of Billets, wt %	Accuracy of Measurement at Midpoint of Range, wt %
Up to 1.5	±0.02
1.5 to 3.0	±0.04
3.0 to 4.5	±0.08

[redacted]

DISCUSSION

THE PROBLEM

The Li-Al billets that are extruded into control rod stock weigh about 100 pounds. The lithium content ranges between 1 and 5% lithium by weight. In order to minimize the cost of manufacturing control rods, it is necessary to test the billets prior to extrusion to be certain that their lithium content is within the desired limits. In the past, two chemical analyses have been made on drillings from each billet to determine the lithium content. Such chemical analyses are time consuming, relatively expensive, and necessitate removing the billets from the production line.

An in-line instrument with which operating personnel could quickly and accurately test the billets would eliminate the time-consuming chemical analyses and improve production efficiency. The most favorable location for conducting the tests was near the end of the production line where the billets were moved by chain hoist from a lathe to a cutoff saw. A mechanical handling system was required that could accept the billets from the hoist about 30 inches above floor level and position them in the instrument for testing.

INSTRUMENT DESIGN AND OPERATION

The billet tester operates by determining the extent to which a beam of thermal neutrons is attenuated in passing through the billet. The amount of attenuation that takes place is proportional to the Li^6 concentration. The billet is lowered by a chain hoist onto a dolly, which is then pushed along a track until the billet is located at a predetermined position in the neutron beam. The neutrons that are transmitted through the billet are monitored by an array of BF_3 counters. A count is taken during a predetermined time interval and is correlated to lithium concentration by a calibration curve. Neutrons that are not stopped by the counter tubes are absorbed by a "beam shield".

Figure 1 shows how the component parts of the assembled tester are supported by an angle iron framework. A billet is shown in position on the dolly. Figure 2 shows an end view of the tester with the billet in position under the "howitzer" for testing. This view also shows how the connecting cables from the seven BF_3 counters are terminated in a junction box from which a common lead connects to an electronic counting system.

The total radiation level at the surface of the howitzer is approximately 50 mrem/hr. A 2-inch-thick shield filled with borated paraffin is positioned 8 inches from the sides and top of the howitzer to reduce the radiation level. (This shield was not in place when the photograph was made.) The radiation level at the outer surface of the shield is approximately 5 mrem/hr.

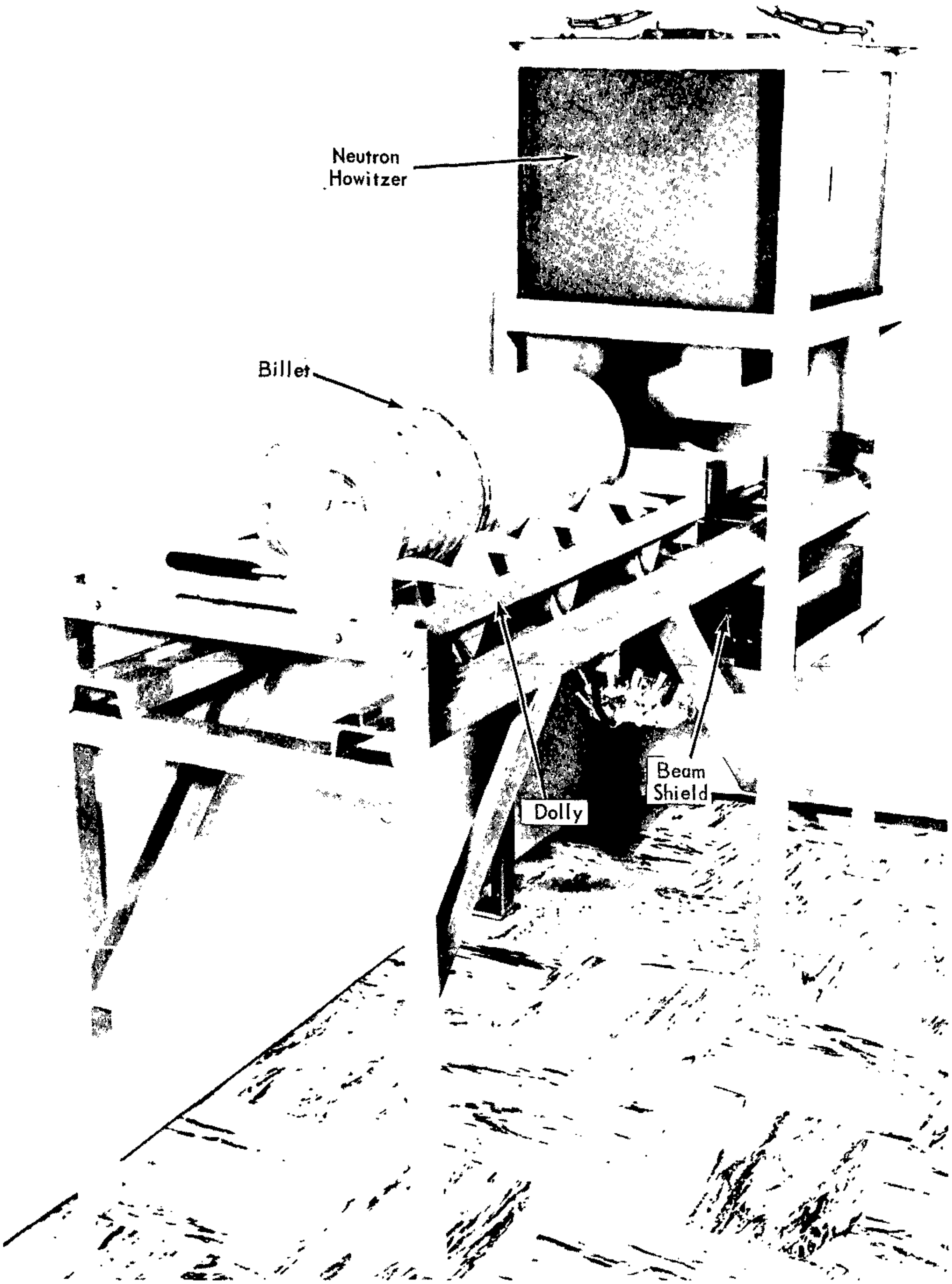

FIG. 1 SIDE VIEW OF ASSEMBLED BILLET TESTER

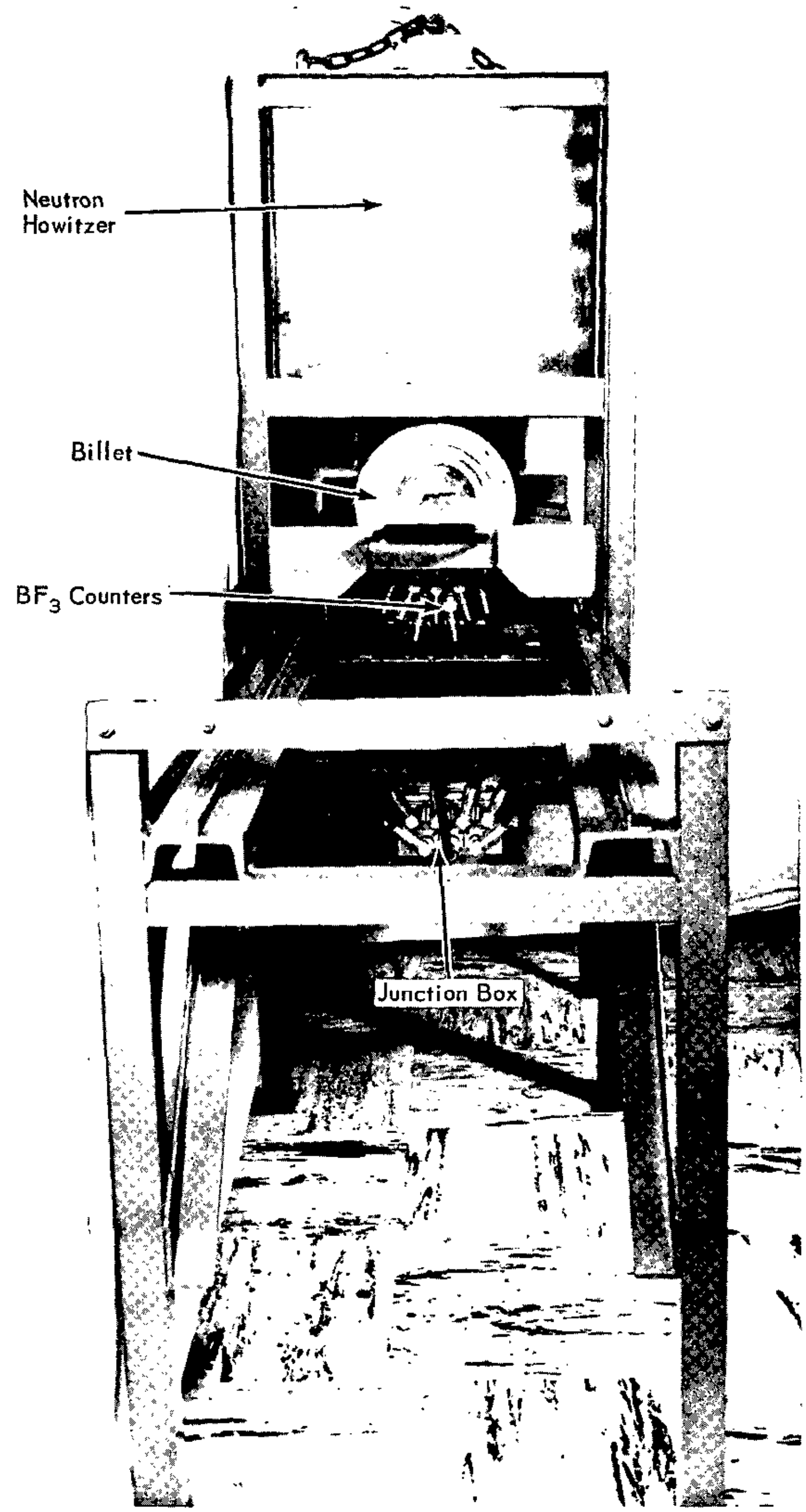

FIG. 2 END VIEW OF ASSEMBLED BILLET TESTER

DESCRIPTION OF INSTRUMENT COMPONENTS

The major components of the instrument are shown in cross section in Figure 3.

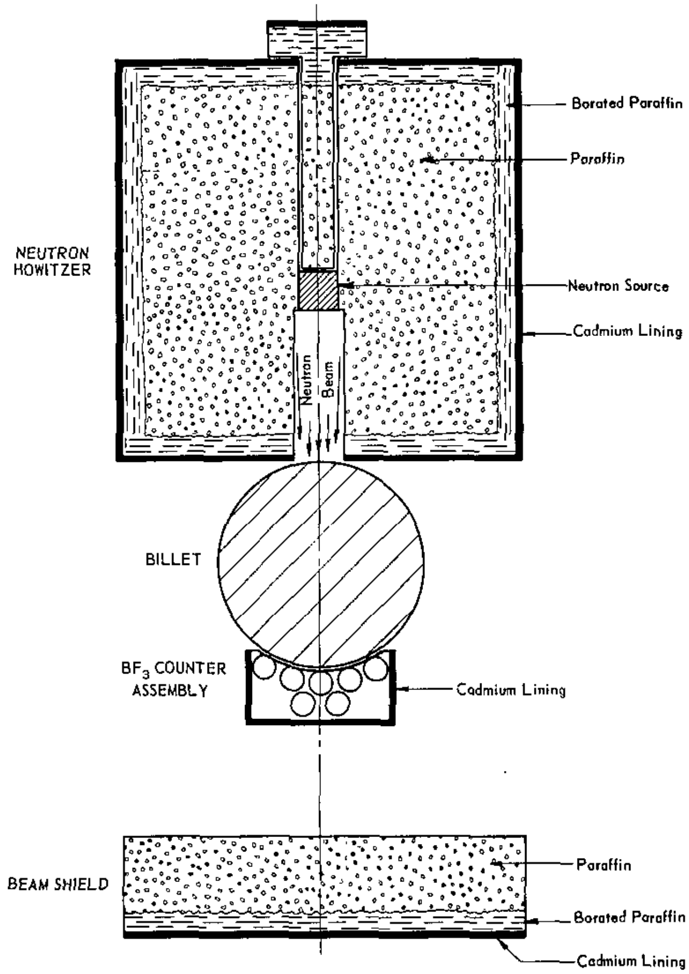

FIG. 3 CROSS-SECTIONAL VIEW OF THE BILLET TESTER

The neutron howitzer was designed to contain the neutron source and to provide a thermal neutron beam through the billet for the absorption measurements. The howitzer consists of a 14-inch cube of paraffin surrounded by a 1-inch-thick layer of borated paraffin within a 16-inch cubical box of cadmium-lined stainless steel. The borated paraffin consists of two parts B_2O_3 to one part paraffin by weight. A 10-curie Pu-Be source with a rated emission of 1.8×10^7 neutrons/sec is located near the center of the howitzer. A beam shield consisting of a 16x16x4-inch stainless steel box containing a 1-inch-thick layer of borated paraffin covered by 3 inches of paraffin is provided to absorb all neutrons that pass through the billet and BF_3 counter assembly. The bottom of the shield is lined with cadmium. A cadmium lining is also placed on the bottom and sides of the counter assembly to prevent neutrons from being scattered back into the counter tubes.

The neutron counters are Model G-10-5, manufactured by N. Wood Counter Laboratory, and are filled to 30-cm pressure with enriched BF_3. Seven of these counters are arranged in electrical parallel. Since the counters are temperature sensitive, the instrument is operated in an air-conditioned room.

An Atomic Model 1070-A electronic counter is used to record the pulses from the BF_3 counters. This counting system is commercially available and has a self-contained, high voltage power supply.

CHECKOUT AND CALIBRATION

The BF_3 counters were selected and the counting system was adjusted so that neutrons were counted in the plateau region of each counter.

To determine the best positions along the billet to make the concentration measurements, several billets were measured with the neutron beam at 2-inch intervals along the billet length and the profiles of count rate versus distance were plotted. Figure 4 shows a typical profile and indicates that the best locations for testing appear to be about 6 and 12 inches from the front end of the billet. The front end of the billet is the end first poured into the mold and is generally free of the voids and inclusions that often occur at the opposite end. Two stops were provided for the dolly so that billets could be readily positioned at 6 and 12 inches from the front end.

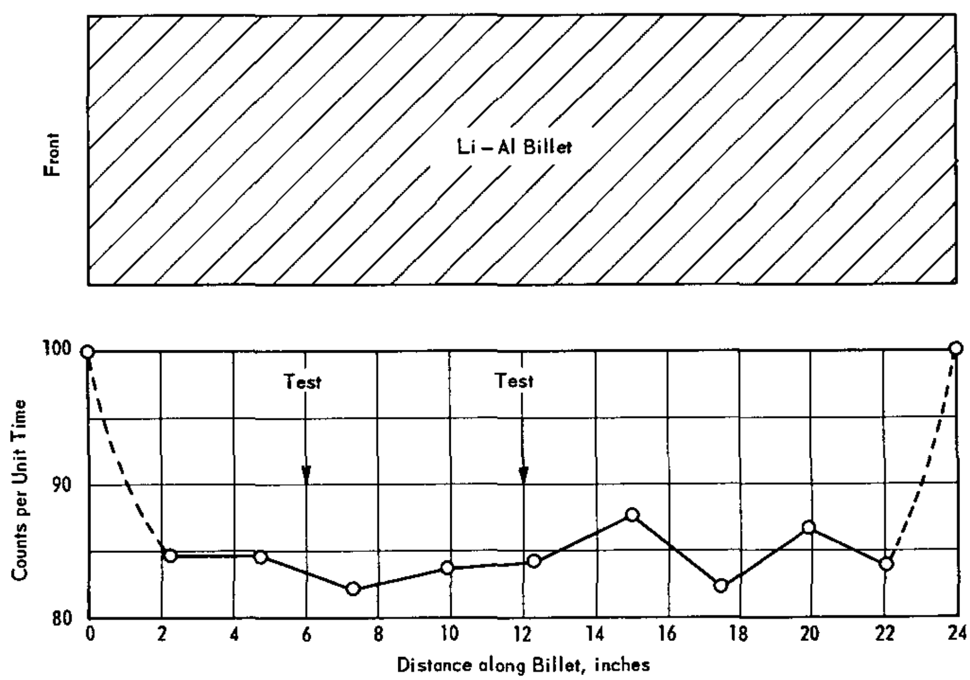

FIG. 4 TYPICAL PROFILE OF COUNT RATE VS. DISTANCE ALONG BILLET

The billets were uniform at a given distance from the front face. A rotation of 90° did not change the measurement significantly. Seven billets whose lithium content had been carefully determined by chemical analysis were tested repeatedly over a six-day period with 15-minute counting times. No adjustments to the electronic circuit controls were made during this period. The average count for each billet during the six-day period, together with the maximum spread in the count, was plotted against the corresponding lithium content to obtain the calibration curve shown in Figure 5.

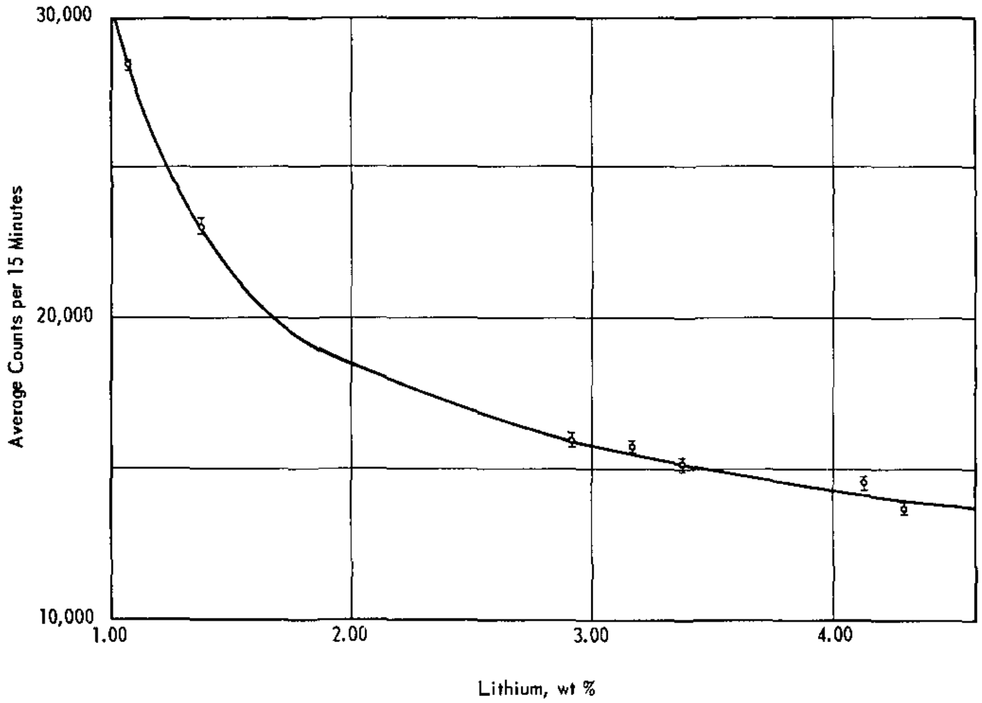

FIG. 5 CALIBRATION CURVE FOR THE BILLET TESTER

The accuracy of the measurement depends on the lithium content, the counting time, and the counting reproducibility.

While one 15-minute count is sufficient to analyze a billet, one count is usually made at each of the two test positions to ensure that the billet is uniform.

PERFORMANCE

The instrument has been in operation for eight months on a routine basis and has required no maintenance during this period. A "Stabiline" voltage regulator provides steady AC power to the electronic counting system. The end points of the calibration curve are confirmed daily before the instrument is used.

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