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DOCUMENT NO.

HW-75465 E

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February 4, 1964

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SUPPLEMENT A TO PRODUCTION TEST IP-546-A
IRRADIATION OF DIFFUSION-BONDED FUEL ELEMENTS

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SUPPLEMENT A TO PRODUCTION TEST IP-546-A
IRRADIATION OF DIFFUSION-BONDED FUEL ELEMENTS

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K. L. Hladek

February 4, 1964

By Authority of CC-PR-2
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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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SUPPLEMENT A TO PRODUCTION TEST IP-546-A IRRADIATION OF DIFFUSION-BONDED FUEL ELEMENTS

INTRODUCTION

The original test authorized the irradiation of about 20 fuel columns containing hot-die-sized, diffusion-bonded fuel elements. The test elements were charged in July 1963, and discharged in December 1963, after accumulating an exposure of about 900 Mwd/t. Although the results of that first test⁽¹⁾ were different than anticipated, areas needing process development work were indicated and, hopefully, future test work will permit evaluation of the modifications to the process. The fuel elements to be irradiated under authorization of this supplement test were fabricated by the same process that produced the elements for the original test.

OBJECTIVES

The objectives of this supplement test are to permit irradiation of an additional ten columns of hot-die-sized, diffusion-bonded fuel elements, and to obtain data on the relationship of the coolant temperature distribution and fuel element behavior.

TEST SUMMARY

Ten fuel columns containing hot-die-sized, diffusion-bonded elements will be irradiated in smooth-bore Zircaloy-2 process tubes in the C Reactor. The fuel elements used in this test will have the self-support heights reduced 0.005 inches from the presently specified dimensions. Five of these fuel columns will be equipped with downstream thermocouple probes to monitor the coolant temperature distribution. The fuel columns will be irradiated to an average exposure of 500 Mwd/t. Upon discharge, the elements will be given a post-irradiation examination in the 105-C Metal Examination Facility.

DISCUSSION

Irradiation of the initial columns of hot-die-sized, diffusion-bonded fuel elements produced unforeseen results. Discharging the irradiated fuel columns at 900 Mwd/t required forces up to 6000 pounds. Practically every column of the test containing hot-die-sized elements was difficult to discharge. Discharge of enriched uranium, hot-die-sized elements of another test yielded almost identical results in discharging.⁽²⁾ Measurements of fuel elements from the first test indicate that during the

(1) Hladek, K. L., and C. A. Burgess. Production Test IP-546-A, Irradiation of Hot-Die-Size Diffusion-Bonded Fuel Elements, HW-75465. June 27, 1963. (SECRET)

(2) Hladek, K. L. Production Test IP-616-A, Irradiation of Enriched Hot-Die-Sized Diffusion-Bonded Fuel Elements, HW-78960. August 17, 1963. (SECRET)

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irradiation, fuel diametrical changes were greater for the hot-die-sized material.⁽³⁾ Average diameter change at the center of the hot-die-sized fuel element was about 0.008 inches greater than for the AlSi elements.

At the present time, the cause of this irradiation behavior in the hot-die-sized elements is not known. Investigations of the bonding process are now being conducted in an effort to determine if some measurable characteristic of the elements; i.e., uranium grain structure, stresses, could be the cause of this undesirable irradiation behavior.

The elements authorized by this supplemental test were fabricated by the same process as the elements of the previous test. Although there is no reason to anticipate a different behavior of these elements, irradiation of the pieces will be beneficial. The development of an alternate fuel fabrication process has reached "operational" status and continual irradiations are advantageous from the standpoint of gaining additional irradiation experience. To date, only about 40 columns of fuel containing this new element have been irradiated and further fabrication and irradiation experience will aid in demonstrating the process.

The elements of this test are of the same "vintage" as the elements of the original test. To minimize any problems that might be encountered in discharging this fuel, the fuel element support heights will be 0.005 inches lower than presently specified for these fuel models. This reduction of support height will increase the fuel-tube clearance, thus reducing the probability of a fuel element binding in the tube as a result of irradiation-induced growth. To further reduce the chances of discharge difficulty, the goal exposure of the fuel columns of this test is set at 500 Mwd/t.

By reducing the support height of the fuel elements, the minimum fuel-tube clearance at the bottom of the tube will also be reduced. This decrease in clearance will produce a somewhat higher R value* for these fuel columns than for the fuel columns of the original test. The three thermocouple probes in the original test measured maximum R values of about 1.14. Maximum anticipated R values for the fuel columns of this test are 1.20. To monitor the temperature distribution in the fuel columns, and thus provide assurance of corrosion conditions compatible with scheduled exposures, five thermocouple probes will be installed in tubes of this test. The thermocouple probes will also provide data for evaluating the effect of fuel element growth on the annular coolant temperature distribution.

The combination of steps taken with these elements provides a conservative approach to the irradiation with all factors adding together to minimize operational problems.

* R is defined as $R_x = \frac{\Delta T_x}{\Delta T_b}$ where R = R value, unitless; ΔT = temperature rise,

any temperature units; subscript x = any particular point on the fuel circumference; and subscript b = bulk coolant conditions.

(3) Bloomstrand, R. R. Post-Irradiation Measurements of PT-516 Fuel Elements, HW-80281 RD. January 5, 1964. (SECRET)

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TEST DETAILS

The test details established in the original test will apply for this irradiation, except as noted below:

2. Fuel Elements

d. Self-Supports

Minimum support heights for both element types will be 0.077 inches; the maximum circumscribed support circle will be 1.656 inches.

e. Quantity

This test requires 240 hot-die-sized elements and 80 AlSi elements. Spare pieces of both types will be supplied with the test columns.

g. Column Make-up

Five fuel columns will be formed with 32 hot-die-sized, diffusion-bonded elements and five columns will be formed by alternating hot-die-sized and AlSi elements in the column positions, 16 of each element type per fuel column.

4. Irradiation

c. Goal Exposure

All fuel columns of this test will be discharged at average exposures of 500 Mwd/t. Changes in this goal exposure plan may be made by the test author, with the concurrence of the Manager, C Processing.

e. Operating Limits

The fuel columns of this test will operate with maximum R values of about 1.20. Process Standard A21.03 dictates use of a 1.15 R value in calculating operating limits for CIVNS fuel. For the fuel columns of this supplemental test, Process Standard A21.03 is temporarily waived and an R value of 1.20 shall be used in calculating the operating limits.

5. General

b. Duration

The elements of this test are expected to complete their irradiation in less than three months from the time of charging. This test authorization will expire on January 1, 1965.

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RESPONSIBILITIES

The responsibilities outlined in the original test document remain unchanged.

K. L. Hladek

Engineer, Reactor Engineering
Process and Reactor Development
Research and Engineering Section

KL Hladek:go

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