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PRODUCTION TEST IP-708,
OIL-QUENCHED HOT-DIE-SIZED ELEMENT EVALUATION

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OIL-QUENCHED HOT-DIE-SIZED ELEMENT EVALUATION

By

K. L. Hladek

August 24, 1964

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-708.
OIL-QUENCHED HOT-DIE-SIZED ELEMENT EVALUATION

OBJECTIVE

The objective of this test is to evaluate the effects of oil quenching, alpha annealing, and an Al-Si braze pre-canning treatment on the irradiation behavior of hot-die-sized fuel elements.

TEST SUMMARY

Eighteen fuel columns containing hot-die-sized elements will be irradiated in smooth-bore Zircaloy-2 process tubes of the C Reactor. Each of the fuel columns will contain 32 elements--24 test and 8 "filler" elements. The test elements were formed from cores which had varying treatments of water quench during heat treatment, oil quench during heat treatment, alpha annealing, and Al-Si process braze temperature conditions. The fuel columns will be irradiated to average exposures of 800 Mwd/t. Post-irradiation measurement and examination of the elements will be accomplished in the 105-C Irradiated Fuel Examination Facility.

BASIS AND JUSTIFICATION^[1]

This production test was designed to evaluate the effects of various core treatments on the dimensional behavior of hot-die-sized fuel during irradiation. The test fuels were fabricated with uranium cores which had varying treatments of (1) water quench during heat treatment, (2) oil quench during heat treatment, (3) alpha annealing, and (4) cores subjected to Al-Si process temperature conditions. The test material contains matched uranium cores, with the oil and water quench cores being obtained from alternate rod positions during core fabrication. No changes in the hot-die-sizing process were made during fabrication of the test fuels.

Previous work on core heat treatment with the Al-Si process indicated that oil quenching provided more stable uranium cores. In extracting heat at a slower rate, oil quenching allows for greater stress relief and less residual stress in the cores. These changes have tended to reduce the anisotropic growth of Al-Si cores during irradiation. Alpha annealing of Al-Si cores has also provided some additional stress relief and slight changes in grain orientation. These treatments, which have provided improvement in dimensional behavior of Al-Si cores, require evaluation in their application to the hot-die-sizing process.

Previous production tests were designed to evaluate hot-die-sizing process variables on the dimensional behavior of the fuels during irradiation. The subject test includes an evaluation of the effects of Al-Si processing conditions on the in-reactor growth of hot-die-sized fuels. In the event that the fuel growth which has been experienced is a core-related phenomenon, some degree of stress relief of the cores may be afforded by the duplex and canning baths in the Al-Si process.

[1] Letter, H. F. Tew to S. M. Graves, "HDS Production Test PT-IP-708-A," dated August 5, 1964.

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To evaluate this variable, a portion of the subject test cores has been subjected to Al-Si canning conditions, recovered, and then processed through the hot-die-sizing process.

The level of risk of operational problems in the subject test is similar to that assumed in previous tests directed toward resolution of the growth problem. Again, the risk appears warranted in view of the objectives of the hot-die-sizing program. The direction of development work on the process will be heavily influenced by the results of this and other irradiation tests related to the fuels growth problem.

TEST DETAILS

1. Reactor

Since the existing equipment for fabricating hot-die-sized fuel produces elements corresponding to the CVNS model, irradiation of the elements of this test will take place in the C Reactor.

2. Fuel Elements

a. Model

All fuel elements used in this test will be of the CDBIIN model.

b. Fabrication

The elements used in this test will be fabricated according to the detailed procedures outlined in the process specifications.^[3]

As the objective of this test is to evaluate the effects on dimensional stability of various uranium heat treating methods, the fuel cores used in this test differ from those of standard production elements. Two types of heat treating quench will be employed on the cores of this test; one half of the cores will be quenched by the standard production methods using a brine solution and one half of the cores have been quenched in Houghto-K oil.^[2] Approximately one third of the cores of each of the quench media groups will be subjected to alpha annealing. Another one third of the cores will be given an Al-Si canning treatment prior to canning. Identification of all fuel elements with regard to heat treating history and ingot position history of the cores will be maintained throughout the fabrication.

c. Self-Supports

All supports used on elements of this test will be fabricated in accordance with drawing H-3-7948 for CVNS fuel elements.

[2] Hladek, K. L. Production Test IP-607-A, Evaluation of Oil-Quenched Enriched Uranium Fuel Cores, HW-78666. October 28, 1963. (SECRET)

[3] Schweikhardt, G. M. Provisional Specifications for Hot-Die-Sizing Process, HW-77683. July 15, 1963. (SECRET)

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Minimum support heights for the elements will be 0.087 inch; the maximum circumscribed support circle will be 1.700 inches.

d. Quantity

A total of 576 fuel elements are required for this test. Seventy-two elements of each heat treatment type are required--a total of 432 test elements. One hundred forty-four filler elements will be needed. Spare elements of each type will be supplied.

e. Pre-Irradiation Testing and Measurements

In addition to all the normal quality tests and measurements, fuel elements of this test will have OD and ID at the three standard locations, warp-ellipticity, and length measurements taken and recorded. The weight of all of the test elements, three types, will be recorded. All fuel element support heights will be recorded. Uranium core history will be maintained on all elements of this test.

f. Fuel Columns

A total of 18 fuel columns are required for this test. Each fuel column shall contain four elements from each of the six fabrication groupings. These elements shall be arranged within the individual columns as described by Stewart.^[4] Three groups of six columns each are also to be formed.

All elements of this test will be identified as to position number within the fuel column and a series number will identify each fuel column. In addition, each column type, as described by Stewart, will be identified. These identifying letters and numbers will be stamped on the base end of the elements.

3. Process Tubes

The elements to be used in this test are self-supported and of the CVN model; hence, use of the regular-size smooth-bore Zircaloy-2 process tubes is mandatory. The six fuel columns of each group of this test must be irradiated under similar conditions. This necessitates irradiating the fuel columns in near adjacent process tubes. Discharge of fuel columns in these process tubes at sub-goal exposures are authorized to permit charging of test material.

4. Irradiation

a. Charging

All test columns will be hand-charged in numerical order, number one piece downstream. Each column series number and type will be recorded as to the

[4] Letter, K. B. Stewart to C. A. Strand, "A PT Design for a 2 x 3 Factional Test," dated June 18, 1964.

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tube into which the fuel was charged. The particular column locations will be specified by the test author prior to scheduling the charging. A representative of Research and Engineering will monitor the fuel charging.

b. Data

Daily flow and temperature data for the tubes of this test will be recorded on data sheets provided by the test author.

c. Goal Exposure

All fuel columns of this test will be irradiated to 800 Mwd/t. Changes in this goal exposure plan may be made by the test author with the concurrence of the Manager, C Processing; the Manager, Process and Reactor Development; and the Manager, Production.

d. Discharge

All fuel columns of this test will require special pickup and subsequent transfer to the 105-C Irradiated Fuel Examination Facility. No more than four fuel columns may be combined into one bucket.

No fuel element failures are anticipated in this test. Should a fuel failure occur, however, all fuel columns of this test may be discharged providing they can be specially picked up.

e. Operating Limits

The fuel columns of this test will operate with maximum R values up to 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 test, Process Standard A21.03 is temporarily waived and an R value of 1.20 shall be used in calculating the operating limits. All other operating conditions and limits that apply to the CIVNS fuel element model will be applicable to this test material. Existing Process Standards will be used as the basis for these operating conditions and limits.

HAZARDS

No new or unusual hazards are associated with this test.

PROCESS STANDARDS

Process Standard A21.03 is temporarily waived and an R value of 1.20 shall be used in calculating the operating limits. (See Section 4.e under Test Details.)

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GENERAL

1. Schedule

The elements for this test have been fabricated and are now ready for reactor use. Charging of the test material is therefore requested for the first C-Reactor outage following approval of this test document.

2. Post-Irradiation Examination

All fuel elements of this test will receive the normal post-irradiation visual and dimensional measurements in the 105-C Irradiated Fuel Examination Facility. Weight of all test elements will also be required. Selected elements may require additional measurements as requested by the test author. Upon completion of the post-irradiation measurements, all fuel elements are to be retained by the Irradiated Fuel Examination Facility until released by the test author.

COSTS

The outage time lost as a direct result of this test may be charged to cost code XXXX-5R23-XXX.71. An estimate of outage time required:

Charge-discharge	<u>Hours</u>
	5
Special pickup	<u>2</u>
Total	7 hours

ISSUE AND EXPIRATION DATES

The elements are expected to achieve the goal exposure in less than four months from the time of charging.

Issue Date 8/24/64

Expiration Date 1/1/66

K. L. Hladek

K. L. Hladek, Engineer
Process and Reactor Development
Research and Engineering Section

KLH:go

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RESPONSIBILITIES

Production Fuels Section shall be responsible for canning, finishing, testing, quality control, and pre-irradiation measurements of fuel elements used in this test.

W. N. Mohler

Research and Engineering Section

Process and Reactor Development Subsection shall be responsible for over-all coordination of the test, monitoring of charging of material of the test, reporting in-reactor performance of test material, analysis of the reactor operating data, and notifying Process Technology that the test has been charged.

AMS

Process Technology Subsection shall be responsible for providing assistance to both Processing Operation and Process and Reactor Development Subsection in the pre-shutdown scheduling, forwarding operating data to the author, and specification of operating limits.

R. M. Reid

Testing Subsection shall be responsible for post-irradiation fuel element examination and measurement.

C. B. R.

Manufacturing Section

Production Subsection shall be responsible for maintaining accurate records of material charged under this program and for scheduling discharge of the test columns.

Ray E. Dunn

C Processing Operation shall be responsible for operational safety and production continuity of the reactor, charging and special pickup of the test material, and recording operating data as requested.

C. R. Barker

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APPROVALS

T. W. Ambrose, Manager
Process and Reactor Development
Research and Engineering Section

J. T. Stringer, Manager
Fuels Engineering Subsection
Production Fuels Section

R. W. Reid, Manager
Process Technology Subsection
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9/1/64
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R. S. Bell, Manager
MANUFACTURING SECTION

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