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PRODUCTION TEST IP-684-A,
HOT-DIE-SIZED PARAMETERS EVALUATION

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PRODUCTION TEST IP-684-A,
HOT-DIE-SIZED PARAMETERS EVALUATION

By

K. L. Hladek

July 16, 1964

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PRODUCTION TEST IP-684-A
HOT-DIE-SIZED PARAMETERS EVALUATION

INTRODUCTION

The hot-die-sized concept has been under investigation as an alternate manufacturing process for several years. Irradiation testing of the elements began in mid 1963. Some dimensional behavior problems were encountered with the fuel and a test is now being irradiated which may provide sufficient data to remedy the situation. Pre-irradiation examination of fuel elements has shown a significant dimensional change of the cores during the fabrication process, and this dimensional change is thought to contribute to the irradiation behavior of the elements. This test will evaluate the irradiation effects of fabrication parameters that influence the dimensional stability of the core during manufacture.

OBJECTIVE

The objective of this test is to evaluate the effects of end bonding pressure and machined core size on the irradiation characteristics of hot-die-sized diffusion bonded fuel elements.

TEST SUMMARY

Four groups of hot-die-sized elements will be used in this test--the combinations of high and normal end bonding pressure, and regular and slightly smaller (0.025 inches less in diameter) cores. Twenty-four columns of 32 elements each, 768 elements total, with the four hot-die-sized element types and Al-Si control elements in each column, will be irradiated. The elements are of the CVN and the CDBIIN self-support models and will be irradiated in smooth-bore Zircaloy-2 process tubes in the C Reactor. Goal exposure for the columns is 800 Mwd/t. Examination and measurement of the elements of this test will take place in the 105-C Irradiated Fuel Examination Facility.

BASIS AND JUSTIFICATION

This production test was designed to evaluate the effects of hot-die-sizing process variables and core characteristics on the dimensional behavior of the fuel during irradiation. Ex-reactor tests and studies indicate that the temperatures and pressures to which hot-die-sized fuel are subjected during the end bonding operation may be inducing a change in the uranium grain structure. The changes may be sufficient to account for the differences in behavior between the hot-die-sized and Al-Si brazed fuel which have been experienced in earlier tests. A prior test, PT-IP-665-A, which is now undergoing irradiation in the C reactor, will permit an evaluation of the end bonding temperature effects on the irradiation behavior. The test will extend

[1] Hladek, K.L., Production Test-IP-665-A, Evaluation of Hot-Die-Sized End Bonding Processes, March 30, 1964, HW-81015. (██████).

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the evaluation of the end bonding operation to include the pressure effects. End bonding pressures for the test material were varied from 3.75 to 4.25 tons while end bonding temperatures remained constant.

The test material includes hot-die-sized fuel with the uranium cores having the same diameter as Al-Si brazed fuel elements. Fabrication of uranium cores at the feed site involves rough machining of core blanks which undergo heat treatment prior to the finished machining. The same size core blanks were used for both the hot-die-sizing process cores and the Al-Si process cores. During the final machining operation, the Al-Si cores have 0.013 inch more uranium removed from the surface of the core than do the hot-die-sized cores. The very steep temperature gradient close to the surface of the core blank could be influenced by the removal of relatively small amounts of surface metal. Metallography work has indicated that there are subtle differences in core grain structure, most pronounced at the surfaces of the core. The fabrication and testing of hot-die-sized and Al-Si brazed fuel having like cores will permit evaluation of this factor.

Hot-die-sized elements of previous tests have been reluctant to discharge from the process tubes, requiring more than normal amounts of outage time for their removal. The test now under irradiation¹ may indicate a partial solution to the problem; this test is an additional step in the overall evaluation of the process. The schedule established for hot-die-sizing development cannot tolerate a delay which would significantly effect the final evaluation. As the process is being committed for early use, a result of obtaining the necessary funding arrangements, some risk must be assumed by both development and operational groups. With this test, additional outage time may be required for the discharge of the fuel elements, as the test is one of investigating new parameters, not establishing the behavior of old ones. The risk of up to 10 hours additional reactor outage time appears warranted for this test.

TEST DETAILS

1. Reactor

This test will be conducted in the C Reactor.

2. Fuel Elements

a. Model

All Al-Si fuel elements used in this test will be of the CVNS model, all hot-die-sized diffusion bonded elements will be of the CDBIIN model.

b. Fabrication

The hot-die-sized elements used in this test will be fabricated according to the detailed procedures outlined in the process specifications.² No formal process specifications, however, for induction end bonding have been issued. The techniques developed for induction end bonding will

[1] op.cit.

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

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serve as guidelines for fabrication of elements of this test.

As the objective of this test is to evaluate the effects on dimensional stability of fabrication process parameters, several modifications of the manufacturing steps will be undertaken for this test. No modifications of the quality control procedures or techniques will be required by this test. All elements will pass the same inspection standards as normal production elements.

One portion of the hot-die-sized test elements will contain cores which have the same diameters as the Al-Si cores (hot-die-sized cores are normally about 25 mils larger in outside diameter than the Al-Si cores). These elements will therefore have about a 12-mil thicker aluminum can wall than normal hot-die-sized elements, since the outside diameter of the finished elements remains constant. This change in no way sacrifices fuel element performance potential.

The hot-die-sized elements were fabricated in four groups, as represented by the combinations of high and normal end bonding pressures and normal and smaller core diameters. Each of these groups is, within itself, a test group.

All Al-Si elements used in this test will be fabricated according to the "F" process³ and shall meet all fabrication and quality specifications in effect at the time of manufacture.

Aluminum components will be of 8001-F alloy; all fuel element cores will be of natural uranium formed by the ingot process.

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.

Minimum support heights for both Al-Si and hot-die-sized elements will be 0.077 inches; the maximum circumscribed support circle will be 1.656 inches.

d. Quantity

A total of 384 fuel elements of each type--Al-Si and hot-die-sized-- are required for this test. Ninety-six elements of each hot-die-sized group will be used. All of the hot-die-sized elements and 192 Al-Si are matched in pairs, a matched pair containing cores from adjacent positions in the ingot uranium rod. The remaining Al-Si elements are "fillers" to be used in non-test portions of each column.

e. Pre-Irradiation Testing and Measurement

In addition to all the normal quality tests and measurements, fuel elements

[3] Process Specifications, Fuel Element Manufacturing Processes, HW-47029
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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 will be recorded. Uranium core history will be maintained on all elements of this test.

f. Fuel Columns

A total of 24 fuel columns are required for this test. Each fuel column will contain 8 matched Al-Si elements, four of each hot-die-sized fabrication group, and 8 Al-Si filler elements, for a total of 32 elements per column. The specific fuel column arrangement of the elements as described by Stewart⁴ will be used.

All elements of this test will be identified as to position number within the fuel column, and a series number will identify each 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, used of the regular size smooth-bore Zircaloy-2 process tubes is mandatory. The 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. The actual tubes to be used for this test will be selected by the test author and the assigned Process Engineer, with the concurrence of the Manager, C Processing.

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 tube into which the fuel was charged. The particular column location 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

[4] Letter, K. B. Stewart to C. A. Strand, "PT Design," May 4, 1964.

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this goal exposure plan may be made by the test author with the concurrence of the Manager, C Processing.

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 in one bucket.

No fuel 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 the 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. Water shutoff times for the fuel columns of this test will be identical with those for the CIVN fuel elements. These water shutoff times may be obtained from Process Technology Subsection.

5. Hazards

No new or unusual hazards are associated with this test.

6. General

a. Schedule

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

b. Duration

The elements are expected to achieve the goal exposure in less than four months from the time of charging. This test authorization will expire on January 1, 1966.

c. Post-Irradiation Examinations

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 Examination Facility until released by the test author.

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d. 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 the outage time required:

Charge-discharge	12 hours
Special Pickup	4 hours
Total	<u>16 hours</u>

RESPONSIBILITIES

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

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, and analysis of the reactor operating data.

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

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

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.

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

K. L. Hladek

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

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