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GROUP 1

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PRODUCTION TEST-IP-616-A
IRRADIATION OF ENRICHED HOT-DIE-SIZE DIFFUSION-BONDED FUEL ELEMENTS

By

K. L. Hladek

Classification Cancelled and Changed To
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PRODUCTION TEST-IP-616-A
IRRADIATION OF ENRICHED HOT-DIE-SIZE
DIFFUSION-BONDED FUEL ELEMENTS

INTRODUCTION

Testing of hot-die-size diffusion-bonded fuel elements began under authority of Production Test-IP-546-A[1] in the C Reactor in July 1963. Eighteen columns of natural uranium fuel elements of that test are currently under irradiation. This test authorizes the initial irradiation of enriched, 0.947 w/o U-235, uranium hot-die-size diffusion-bonded fuel elements.

OBJECTIVES

The objectives of this production test are: (1) to authorize the irradiation of enriched uranium hot-die-size diffusion-bonded fuel elements; (2) to provide information for further evaluation of the hot-die-size process; (3) to evaluate the relative corrosion behavior of the enriched hot-die-sized fuel as compared to the corresponding Al-Si fuel model; and (4) to determine the gross dimensional stability of the fuel under irradiation.

TEST SUMMARY

This test authorizes irradiation of 19 monitor columns of enriched self-support fuel elements in the C Reactor. The columns will contain 28 fuel elements each; each of the columns will contain 14 fuel elements fabricated by the hot-die-size diffusion-bonded process and 14 elements of the standard Al-Si type. Ten of the columns will contain, in alternate positions in the downstream half of the charge, "paired" Al-Si and hot-die-size elements--elements containing cores from adjacent ingot rod positions. The remaining nine columns will contain hot-die-sized and Al-Si elements, paired by ingot only, in alternate positions in the downstream half of each column. The upstream portion of all charges will contain hot-die-sized and Al-Si elements in alternate column positions.

All of the columns of this test will be irradiated to an average column exposure of 1000 Mwd/t. The elements will be specially picked-up after discharge and subsequently examined in the 105-C Metal Examination Facility.

BASIS AND JUSTIFICATION

The incentives for the hot-die-sizing process now appear to be centered around the need for a "high performance" fuel element, probably of an enriched (w/o U-235) variety. The need for this element is derived from a proposed alternate product use of one or more of the Hanford reactors. If a product other than plutonium is to become a major portion of the plant production, a nonfissionable material

[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)

[redacted]

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may be irradiated in fairly large quantities. To support the irradiation of the non-fissionable material a relatively high powered "driver" element may be required. This new element would ideally be capable of withstanding substantially more severe operating conditions than those imposed on the present fuel elements.

Although the demand for such elements is still speculative, should they be required, a relatively short period of time would probably be available for design and testing this element type. Any testing of proposed fuel concepts in advance of the actual schedule will enhance the probability of successfully meeting the demands of the proposal. At the present time, there is no irradiation experience at Hanford to indicate that hot-die-sizing will provide a "high performance" fuel element. Certainly much additional irradiation testing will be required before any statements can be made about the relative fuel performance of hot-die-sized elements.

This test is not designed to provide information for evaluation of the ultimate limitations of the hot-die-sized diffusion-bonded fuel elements. It will provide data for evaluation of certain basic parameters of the fuel element behavior.

TEST DETAILS

1. Reactor

Irradiation of the fuel elements of this test will take place in C Reactor.

2. Fuel Elements

a. Geometry

The geometry of fuel elements used in this test will be similar to the CDB2 E fuel element. All elements of this test will contain enriched uranium, 0.947 w/o U-235, fuel cores. All elements will be self-supported.

b. Dimensions

Nominal dimensions in inches for elements used in this test are:

	Bare Core			Finished Element		
	O. D.	I. D.	Length	O. D.	I. D.	Length
Hot-Die-Sized	1.432	0.437	6.600	1.494	0.375	7.034
Al-Si	1.406	0.488	6.053	1.494	0.375	6.593

c. Fabrication

The process specifications document[2] presents the detailed fabrication procedures for the hot-die-sized fuel elements. All Al-Si elements will

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

[redacted]

be fabricated according to the "F" process[3] and shall meet all fabrication and quality specifications in effect at the time of fabrication. Aluminum components will be of 8001-F alloy; all fuel element cores will be of enriched uranium, 0.947 w/o U-235, fabricated by the ingot process.

d. Self-Supports

All supports used on elements of this test will be fabricated in accordance with Drawing H-3-7950 Revision 10 as specified for CIVES fuel elements. Placement of the supports on the fuel elements will be as specified on the same drawing. The supports are to be attached by ultrasonic welding techniques in accordance with the ultrasonic welding specifications.[4]

Minimum attached support heights for both element types will be 0.082 inches; the maximum circumscribed support circle will be 1.666 inches for all elements of this test.

e. Quantity

This test requires 266 hot-die-sized elements and 266 Al-Si elements. Approximately ten spare elements of each type will be supplied with the test columns.

f. Column Make-up

All fuel columns of this test will contain 14 hot-die-sized elements and 14 Al-Si elements. These element types are to be alternated in the fuel column positions. Ten fuel columns shall contain in the downstream half of the column, positions 1 through 14, seven "pairs" of elements, a pair consisting of an Al-Si element and a hot-die-sized element whose cores came from adjacent positions in the uranium ingot rod. The remainder of the column will contain hot-die-sized and Al-Si elements in alternate positions.

Nine fuel columns will contain Al-Si and hot-die-sized elements, in alternate positions, in the downstream half whose cores are from the same ingot rod, but not from adjacent rod positions. The upstream half of the columns will contain hot-die-sized and Al-Si elements in alternate positions.

All elements of this test will be identified as to position number within the fuel column, number one piece being downstream, and a series number will identify each fuel column. These identifying numbers will be stamped on the base end of the fuel element. All spare pieces will also be identified by numbers stamped on the base end.

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[3] Process Specifications, Fuel Element Manufacturing Processes, HW-47029. (CONFIDENTIAL)

[4] Stringer, J. T. Provisional Process Specifications for the Attachment of Projection Rails by Ultrasonic Spot Welding, HW-69886 REV2. December 3, 1962. (CONFIDENTIAL)

g. Pre-Irradiation Testing and Measurements

In addition to all the normal quality tests and measurements, all fuel elements of this test will have O.D. and I.D. at the three standard locations, warp-ellipticity, and length measurements recorded. The weight of all fuel elements in column positions 1 through 14 will be recorded; the weight of all fuel elements in column positions 27 and 28 will be recorded.

3. Process Tubes

Regular size, smooth-bore, Zircaloy-2 process tubes will be utilized in this test. Eighteen of the 69 tubes of this type in C Reactor are now in use with irradiation of natural uranium hot-die-sized elements and are unavailable for use with this test.

Since the elements of this test contain enriched uranium, they will be charged into tubes located on the far side of the reactor, to avoid problems associated with the overbore tube pattern on the near side of the reactor.

The test author, assigned Process Engineer, and assigned Pile Physicist, with the concurrence of the Manager, C Processing, will select the specific tubes for this test.

4. Irradiation

a. Charging

All test columns will be hand-charged in numerical sequence, number one piece being downstream. Each column series number will be recorded as to the tube into which it was charged. The location and number of any spare pieces used will be recorded. The charging will be monitored by a representative of Research and Engineering.

This test authorizes discharge of up to 19 subgoal fuel columns to permit charging of test fuel columns.

b. Downstream Dummy Pattern

The downstream dummy pattern for tubes of this test will be modified to position the center of the fuel charge about one element further upstream than the normal fuel columns. The downstream dummy pattern will contain, in addition to the normal thirteen 8-inch and one 5-inch perforated aluminum spacers, seven 8-inch spacers.

c. Operating Limits

The operating conditions and limits that apply to the CIVNS fuel element geometry will be applicable to this test material.* Existing process standards will be used as the basis for all operating conditions and limits.

*Personal communication with P. A. Carlson.

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d. Operating Conditions

Expected operating conditions for the fuel columns of this test, as calculated by MOFDA*, are listed below. The parameters, as calculated by the program for CIIN and CIIIE fuel elements, are also listed.

Fuel Type	Fuel Elements per Column	Tube Flow gpm	Tube Δt C	Tube Power kw	Average Specific Power kw/ft
CIIN	32	50.2	90.9	1205	68.6
CIIIE	32	56.5	85.1	1268	82.8
Hot-Die-Sized	28	52.1	95.2	1308	88.8

The hot-die-sized fuel columns will be operating at about 108 per cent of the calculated CIIN tube power and at about 103 per cent of the calculated CIIIE tube power.

e. Water Shut-Off Time

Chart I gives the water shut-off times, time to reach boiling, for the fuel columns of this test.

f. Data

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

g. Goal Exposure

All fuel columns of this test will be scheduled for discharge at average tube exposures of 1000 Mwd/t. Changes in this goal exposure plan may be made by the test author with the concurrence of the Manager, C Processing.

h. Discharge

All fuel columns of this test will require special pickup after discharge and subsequent shipment to the 105-C Metal Examination Facility. No more than four columns of metal may be combined in one bucket.

No fuel element failures are anticipated in this test, should a failure occur, the disposition of the remaining columns will require the concurrence of the Manager, C Processing.

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* MOFDA - An integrated physics and engineering fuel design program, by R. O. Gumprecht.

[redacted]

[redacted]

5. General

a. Schedule

Elements for this test have been fabricated and are now ready for reactor use. The charging of the elements of this test will take place at the first outage of C Reactor following approval of this test.

b. Duration

The elements are expected to complete their irradiation period in approximately four months from the time of charging. This test authorization will expire on December 31, 1964.

c. Post-Irradiation Examination

All fuel elements of this test will receive the normal post-irradiation visual and dimensional measurements in the 105-C Metal Examination Facility. Weights of those elements that had been weighed before irradiation are required. Selected elements may require additional measurements as requested by the test author. Upon completion of the post-irradiation measurements, all fuel elements of this test are to be retained by the Metal Examination Facility until released by the test author. Elements of special interest may be sent to the Radiometallurgy Laboratory for destructive examination.

d. Costs

The outage time lost as a direct result of this test may be charged to cost code XXXX-5R23-XXX.71. Anticipated times required for charging and special pickup are:

Charging - 15 min/tube	5 hours total
Special Pickup - 10 min/tube	3 hours total

e. Hazards

The fuel elements of this test contain cores enriched to 0.947 w/o U-235. The normal precautions exercised in handling fuel elements enriched to this level must be exercised with the elements of this test. Although the elements of this test are somewhat larger in diameter and in length than any currently used enriched fuel elements, they (the elements of this test) are less reactive than the KIVE on which the nuclear safety specifications are based. The basis, therefore, for transporting and storing unirradiated enriched fuel elements will apply for the elements of this test. The critical mass per unit area of 420 lb. per square foot, or 63 fuel elements per square foot, should under no circumstances be exceeded.

The storage of irradiated elements of this test is governed by the requirements of this test--no more than four fuel columns, 112 elements, per storage bucket. Requirements for shipment of irradiated elements of this test will be provided by Process and Reactor Development and approved by Process Technology.*

*Personal communication with H. Toffer.

[redacted]

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RESPONSIBILITIES

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

2. Research and Engineering

   a. Process and Reactor Development Subsection will be responsible for over-all coordination of the test, reporting in-reactor performance of test material, and analysis of the reactor operating data.

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

   c. Operational Physics Subsection will be responsible for making reactivity adjustments as required by this test.

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

3. Manufacturing Section

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

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

K. L. Hladek

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

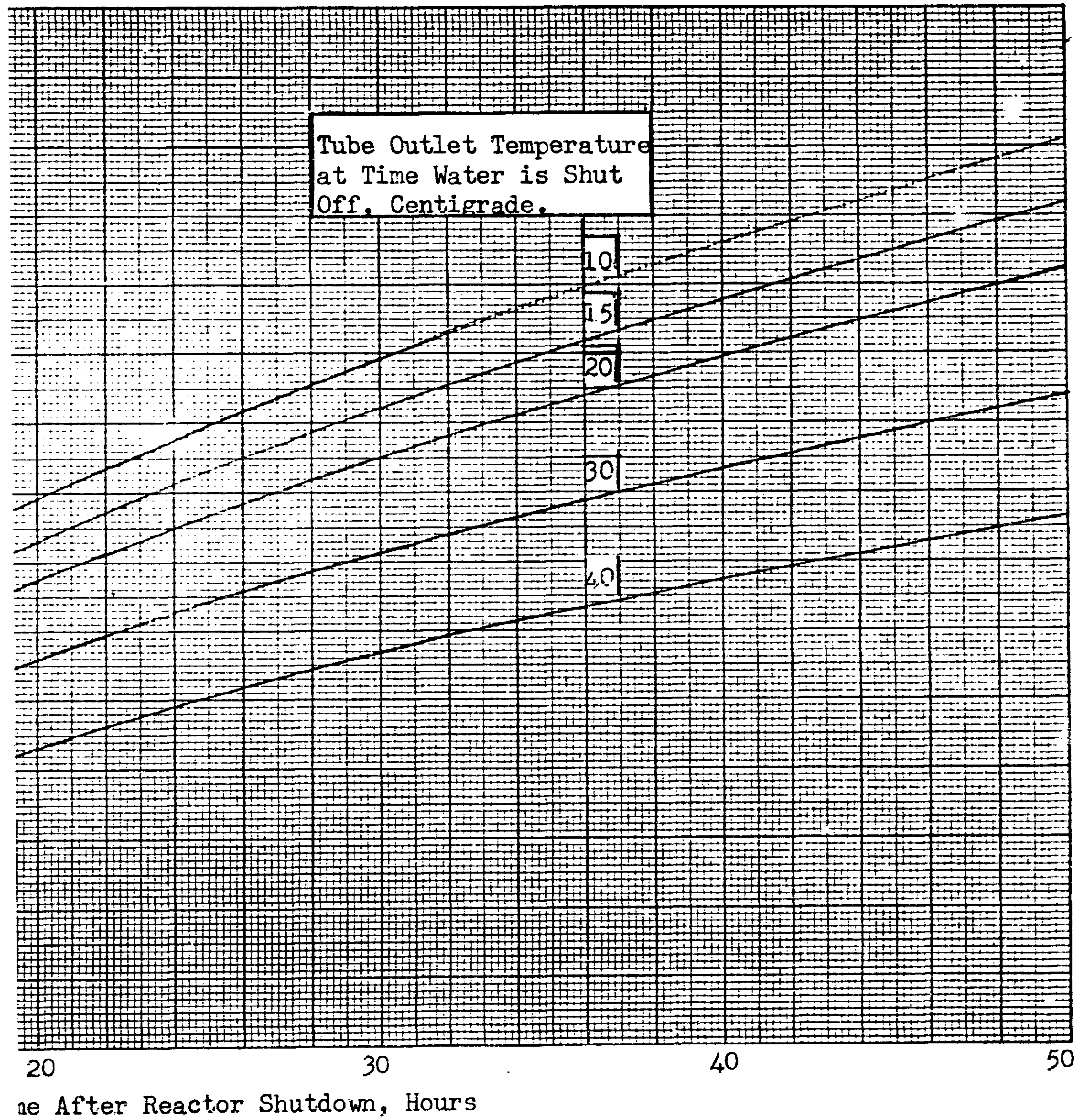
KLH:go

[redacted]

CHART 1

WATER SHUT OFF TIMES TO BOILING

TWENTY EIGHT CDB2E FUEL ELEMENTS



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