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PRODUCTION TEST IP-654-A
EVALUATION OF TEN-INCH ENRICHED URANIUM
FUEL ELEMENTS

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PRODUCTION TEST IP-654-A
EVALUATION OF TEN-INCH ENRICHED URANIUM
FUEL ELEMENTS

By

K. L. Hladek

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By Authority of *R.M. Otten*
4-5-94 CG-PR-2

February 3, 1964

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-654-A
EVALUATION OF TEN-INCH ENRICHED URANIUM
FUEL ELEMENTS

INTRODUCTION

At the present time, fuel elements of two basic lengths are used in the IPD reactors --a "six-inch" enriched uranium element (0.947 w/o U-235) and an "eight-inch" natural uranium element. Although fuel element diameters vary from model to model, the length of the uranium cores is reasonably constant. An evaluation of fuel element lengths has been made and the economic incentive for producing and irradiating longer fuel elements is fairly large. This test is a first step in evaluating the irradiation behavior of a new fuel model.

OBJECTIVE

The objective of this production test is to evaluate the irradiation behavior of "ten-inch" enriched (0.947 w/o U-235) uranium fuel elements.

TEST SUMMARY

A total of 20 fuel columns containing "ten-inch" enriched (0.947 w/o U-235) uranium fuel cores will be irradiated in D Reactor. Sixteen of the fuel columns will contain five matched pairs of elements, a pair of elements consisting of one ten-inch element and one six-inch element containing fuel cores from adjacent uranium ingot rod positions. The four remaining columns of this test will contain 18 ten-inch elements and four six-inch elements.

Five of the fuel columns containing the matched pairs will be discharged at 600 Mwd/t, six of the columns at 800 Mwd/t, and the remaining five columns at 1000 Mwd/t. The four columns containing 18 ten-inch elements will be discharged at 800 Mwd/t.

All of the fuel columns will be examined in the 105-C Metal Examination Facility.

BASIS AND JUSTIFICATION

Investigations of the incentives for using longer fuel elements in the IPD reactors have been conducted many times. Recent studies of this type have shown that fairly large annual savings could be obtained by using longer fuel cores.^(1,2,3) Although the incentives are rather large, production of longer fuel cores cannot be undertaken without extensive study of potential problem areas associated with use of the longer elements.

(1) Wheaton, R. H. Increased Length Fuel Elements, HW-76429. February 4, 1963. (SECRET RED LABEL)

(2) Mobley, W. N. Research and Development Activities on Long Fuel Elements, HW-77723. May 27, 1963. (SECRET)

(3) Snyder, D. A. Increased Length Fuel Elements, HW-80089. December 27, 1963. (SECRET)

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One of the major concerns of the use of longer fuel elements is the ability of the uranium feed-site to produce acceptable cores. The added length introduces problems not only in machining and handling but also in the behavior of the uranium during heat treating. During heat treating, the uranium cores often distort, generally by warping. This warping is more pronounced in longer elements. A relationship of heat treating warp and irradiation-induced warp in fuel elements has been observed but no definite performance can be predicted from the relationships. Since dimensional distortion during irradiation is definitely related to fuel element performance,⁽⁴⁾ any increase in this distortion is generally undesirable. A difference in length of about two inches now exists between standard production enriched and natural uranium elements. Increasing the length of the enriched uranium elements to that of the natural uranium elements might appear to be an easy way to overcome any large fabrication obstacles, while obtaining a portion of the economic advantage available with use of longer elements. Nuclear safety considerations, however, prevent having the same length uranium cores for different enrichment levels.

All of the estimated benefits through use of longer fuel elements are now based upon theoretical studies with the general assumption that once the fuel is in the process tube, it works. This test is necessary as a first step in the experimental evaluation of the irradiation behavior of longer fuel elements.

TEST DETAILS

A. Reactor

Irradiation of the test elements will take place in D Reactor.

B. Fuel Elements

1. Model

All fuel elements used in this test will contain enriched uranium, 0.947 w/o U-235, fuel cores. The standard production elements used as controls in this test will be of the OIIIE model. The long test elements will be designated as OIVE model. The OIVE elements will have the following nominal dimensions:

	<u>Finished Element</u>	<u>Bare Core</u>
Outside diameter	1.444 inches	1.356 inches
Inside diameter	0.310 inches	0.423 inches
Length	10.965 inches	10.378 inches

All elements of this test will be nonbumped.

2. Fabrication

All fuel cores used in this test will be canned by the F Process⁽⁵⁾ and will be clad in 8001-F aluminum alloy. The cores and finished fuel elements will

(4) Hagie, L. T., and J. L. Jaech. Analysis of Quality Certification Data--Effect of Warp on the Incidents of Hot Spots, HW-67120. October 14, 1961.

(5) Callen, A. C. Process Specifications, Fuel Element Manufacturing Processes, HW-47029. March 15, 1957. (CONFIDENTIAL)

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meet all fabrication and quality specifications in effect at the time of fabrication.

Identification of all fuel elements with regard to uranium ingot position history of the cores will be maintained throughout the fabrication of these elements.

3. Quantity

This test requires the use of 152 OIVE elements and 352 OIIIE elements. Water-mixer elements and spare elements of both fuel models will be supplied with the test elements.

4. Fuel Columns

A total of 20 fuel columns will be formed from the elements of this test. Sixteen of the fuel columns will be formed from 26 OIIIE elements and five OIVE elements, with the OIVE elements and corresponding paired OIIIE elements to be placed in column positions 11 through 20.

Four of the fuel columns of this test will be formed from 18 OIVE elements and four OIIIE elements. These OIIIE elements are to be placed in column positions 19 through 22 (upstream).

Water-mixer elements, while to be supplied with the test elements, are not to be placed into column positions or assigned a column position number.

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

5. Pre-Irradiation Testing and Measurement

In addition to all the normal quality tests and measurements, all fuel elements of this test will have OD and ID measurements at the standard locations, warp-ellipticity, and length measurements recorded. The weight of all OIVE elements and the corresponding paired OIIIE elements will be recorded.

Due to the different length of the OIVE elements, a sample of OIVE elements will be saved for additional measurements at various time intervals. A similar sample of OIVE elements will be selected for measurement at the 105-C Metal Examination Facility.

C. Irradiation

1. Charging

The fuel columns of this test will be hand-charged in numerical sequence, number one piece downstream. The fuel identification numbers, series numbers,

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will be recorded to correspond to the tubes into which the elements were charged. A representative of Research and Engineering will monitor the charging of elements of this test.

This test authorizes discharge of sufficient columns of sub-goal fuel elements to permit charging of all the test elements during one reactor outage.

The use of water-mixers in these fuel columns will be as specified by the Supervisor, Process Analysis Unit, Process Technology Subsection.⁽⁶⁾ The water mixer shall be placed either the same distance from the downstream end of the fuel column that the seventh element is in the standard 34-piece OIIIE fuel charge, or the closest feasible position upstream from there.

Length of the fuel columns of this test will vary slightly from the length of 34-piece OIIIE fuel columns. The 34-piece OIIIE element column has a nominal length of 222.4 inches. The columns of this test containing 18 OIVE and four OIIIE elements have a length of 221.7 inches and the columns containing five OIVE elements have a length of 224.4 inches. These deviations of column length will require no modification of the normal downstream aluminum spacer pattern.

2. Process Channels

Only process tubes located below process tube row 20 may be used for the elements of this test. Each process tube to be utilized by this test shall be probed before charging with a probe assembly to be supplied by Process and Reactor Development Subsection. The actual process tubes to be used for this test will be selected by the test author, assigned Reactor Physicist, and Process Engineer with the concurrence of the Manager, D Processing.

3. Operating Limits

The operating conditions and limits that apply to the OIIIE fuel elements will be applicable to this test material. Existing Process Standards will be used as the basis for all operating conditions and limits.

4. Data

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

5. Goal Exposure

Of the fuel columns of this test containing five OIVE elements, five will be discharged at average tube exposures of 600 Mwd/t, six discharged at average tube exposure of 800 Mwd/t, and the remaining five at 1000 Mwd/t. The four fuel columns containing 18 OIVE elements will be discharged at 800 Mwd/t. The individual tubes to be discharged at each exposure level will be specified by the test author within one month after fuel has been charged.

(6) Spencer, H. G. Mixer Position for PT-IP-654-A, March 20, 1964. (SECRET RD)

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6. Discharge

All fuel columns of this test require special pickup after discharge and subsequent shipment to the 105-C Metal Examination Facility. No more than three fuel columns may be placed in a storage bucket and identification of the columns in a particular bucket must be maintained.

Should a fuel column of this test be reluctant to discharge, the disposition of the columns scheduled for further irradiation will be reviewed by the test author and the Manager, D Processing. The maximum discharge force for each column of this test shall be recorded.

No fuel failures are anticipated in this test. Should a fuel failure occur, examination of the failed element will be required before determining the disposition of the remaining fuel columns. The final decision for continued irradiation of test columns will be made by the test author with the concurrence of the Manager, D Processing.

D. Hazards

The OIVE elements of this test are longer and consequently weigh more than the OIIIE elements. The nuclear safety requirements established for fuel elements containing 0.947 w/o U-235 are based on uranium weight. For convenience, however, the number of elements permitted in given situations is also stated. The numbers of elements so stated do not apply for the OIVE elements of this test. The weight specifications are valid; the number of elements permitted in given situations must therefore reflect the heavier weight of these elements, 9.21 pounds per element. Pre-irradiation storage requirements for the longer fuel elements, based on 420 pounds per square foot, dictate that a density no greater than 45 OIVE elements per square foot be observed. Pallets containing elements of this test should therefore be stacked no more than two high. Post-irradiation storage of the longer fuel pieces requires no more than 120 randomly stacked OIVE elements or no more than 200 closely stacked elements per storage bucket, with unrestricted storage bucket location. In the discharge chutes, each OIVE element should be counted as two OIIIE elements in determining the quantity of elements permitted in the chutes.

E. General

1. Schedule

Charging of the fuel columns of this test is requested for the first outage of D Reactor following approval of this test.

2. Duration

Irradiation of these test elements may require about five months. This test authorization will expire April 1, 1965.

3. Post-Irradiation Examination

All fuel elements of this test will be examined after discharge in the 105-C Metal Examination Facility. Examination and measurement of the OIVE elements will require some special handling and equipment modification. To handle the relatively small quantity of longer elements of this test, some temporary changes in equipment may be desirable. Since measurement of the longer fuel elements is not a routine operation, several sets of measurements may be advantageous in identifying random and nonrandom measurement errors. The test author will specify any repeated measurements that are required.

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A comprehensive visual examination of the external surface, measurement of inside and outside diameters, warp-ellipticity, and length of all pieces of this test are required. All pairs of elements will be weighed and the weight of additional elements may be requested. Elements of special interest may be sent to the Radiometallurgy Laboratory for destructive examination.

4. Cost

The primary outage time losses resulting from this test will be associated with charge-discharge and special pick-up of the test elements. The outage time lost as a direct result of this test may be charged to cost code XXXX-5R23-XXX.71. Anticipated times for charge-discharge and special pick-up are:

Charging - 15 minutes per tube	5 hours
Special pick-up - 10 minutes per tube	<u>3 1/2 hours</u>
Total	8 1/2 hours

RESPONSIBILITIES

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

Research and Engineering Section

Process and Reactor Development Subsection will be responsible for over-all coordination of the test, analysis of operating data, reporting of in-reactor performance, specifying post-irradiation measurements to be taken, and for provision of bases for operating limits.

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

Operational Physics Subsection will be responsible for providing assistance in selecting test channel locations, and for reactivity adjustments as required by this test.

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

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Manufacturing Section

Production Scheduling will be responsible for scheduling and maintaining accurate records for material charged under this test.

D-DR Reactor Operation

D Processing Operation will be responsible for scheduling, for operational safety and production continuity of the reactor, for charging and discharging test material, and for special pick-up of the fuel columns.

K.L. Hladek

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

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