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DESIGN OF PRODUCTION TEST - IP-409-A-FP PILOT TEST OF SELF-SUPPORTED FUEL ELEMENTS IN K SIZE SMOOTHBORE ZIRCONIUM PROCESS TUBES

By

M. A. CLINTON
and
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DESIGN OF PRODUCTION TEST - IP-409-A-FP PILOT TEST OF SELF-SUPPORTED FUEL ELEMENTS IN K SIZE SMOOTHBORE ZIRCONIUM PROCESS TUBES

INTRODUCTION

In the Plant Improvement Program[1], it is proposed to retube the K-Reactors with standard size Zircaloy-2 smooth-bore process tubes and to charge self-supported fuel elements starting March 15, 1964. The first step in support of this transition program is to confirm compatibility of the fuel-tube geometry and secondly to obtain fuel-tube performance information prior to full scale commitment of the K-Reactors to this design.

In view of the testing of self-supported fuel which has been accomplished to date and that which is planned, there is little incentive to install more tubes in a K-Reactor than are required to make the fuel-tube geometry check. To accomplish this, ten tubes are viewed as the maximum number that would be required.

This report presents the design of a test to fabricate and irradiate "K" self-supported fuel elements in limited quantities.

OBJECTIVE

The objective of this test is twofold: 1) to obtain preliminary operating experience with smooth-bore Zircaloy-2 process tubes and self-supported fuel elements in a K-Reactor, and 2) to confirm the design of the fuel-tube geometry.

SUMMARY

This test authorizes installation of up to ten non-overbore size zirconium smooth-bore process tubes into KW-Reactor and continued charging of these tubes with KVNS fuel elements until authorized by other means (Process Standards or PITA) or until this test is terminated.

(1) HW-67952, "Plant Improvement Program, Irradiation Processing Department, FY-1962-1971", A. B. Greninger, March 27, 1961 ([redacted]).

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While the test authorizes up to ten tubes, only two process tubes are immediately available and are all that will be planned for the initial installation and charging. Goal exposure will be set at 800 MWD/T.

BASIS

Self-supported fuel performance data have been and are being collected from several sources. Since this information is vital in the program to evaluate self-supported fuel in K plants, it is reviewed here:

a) Some 83 charges were irradiated in a smooth-bore aluminum tube facility at B-Reactor. Twenty-two of the OIINS charges were irradiated to a nominal 1200 MWD/T exposure with individual tubes as high as 1300 MWD/T. Visual examination of these elements has revealed a drastic reduction in the number of hot-spot flow patterns.

b) Over 150 CIVN self-supported charges similar to the K size have been discharged from the 69 smooth-bore Zircaloy-2 tube facility at C-Reactor at a nominal 800 MWD/T.

c) The overbore test facility at C-Reactor which currently consists of 20 tubes is to be expanded to a total of sixty-two tubes and will provide additional fuel data for self-supported fuel elements operating at high specific powers (up to 110 KW/ft).

The self-support concept appears sound since all experience with self-supported material to date has been favorable.

Similarly the operating experience with Zircaloy process tubes has been favorable. The installation of both standard size and overbore size tubes at C-Reactor has involved no serious difficulties. Removal of Zircaloy tubes has been accomplished at C-Reactor. Removal is complicated by the high exposure rates caused by the very high radioactivity of the Zircaloy tubes. However, no serious difficulty was encountered.

TEST DETAILS

1) Reactor

KW-Reactor has been chosen to run this test since it is equipped with downstream thermocouple probe readout equipment.

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2) Material

A) Fuel Elements

(1) Cores - All cores will be natural uranium.

(2) Components - Jacketing components will be X-8001 aluminum alloy.

(3) Projections - Collapsible self-support rails will be fabricated from X-8001 alloy and will be attached to the fuel element with an ultrasonic weld in accordance with drawing H-3-7950 Rev. 4.

(4) Nominal Dimensions - The finished fuel elements will be designated as a KVNS element and shall have the following nominal dimensions:

Dimension (Inches)	KVNS
Canned OD	1.520
Canned ID	0.420
Canned Length (Flat Base)	8.865
Self-Support Rail Height	0.095
Self-Support Rail Length (0.032" thick)	2.313
Distance Rail from End of Fuel Element	1.250
Maximum Support Diameter	1.710

All components will meet requirements set forth in fuel element process specifications(2) and all finished dimensions except length shall be with normal fuel tolerances(3).

(5) Assembly - All fuel elements will be fabricated by the "F" process with necessary adjustments to fabrication cycle times as required by the larger cores. A detailed description of the deviations is contained in PWR-147-92.

(6) Water Mixers - Watermixer elements are not required for this test.

(2) HW-47029, "Process Specifications, Fuel Element Manufacturing Processes", Fuels Preparation Department.
(3) H-3-7350 Rev. 9, "Canned Uranium Fuel Elements", 8-4-60.

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(7) Quality - All elements shall pass the normal quality control specifications in effect at the time this material is prepared.

(8) Quantity - While only two columns of fuel are required initially for this test, enough fuel components to support a ten tube facility for over a year were ordered[4] and there are presently five acceptable columns made up and ready for irradiation. A column will contain 38 fuel elements.

(9) Pre-Irradiation Measurements - All columns charged under this test authorization will be designated monitor charges and each piece will carry a fuel identification number (piece number and series) in addition to other required numbers. The following measurements will be made on the finished fuel elements:

a) Length, OD and ID (3 locations), and warp of all pieces will be recorded.

b) All pieces, one through fifteen, will be weighed.

3) Irradiation

A) Charging

All fuel columns will be serially numbered and will be charged in numerical order with piece number one downstream. Each column shall have the fuel identification number (series number) recorded opposite the tube number on the front face sequence sheets. Charging will be followed by a representative of Research and Engineering. Goal exposure for all columns charged under this test will be 800 MWD/T; however, should experience indicate that goal exposure changes are appropriate, they may be modified by mutual approval of the authors and the Manager of KW Processing.

B) Post-Irradiation Examination

All elements will be 1) visually examined and weaseled, 2) have warp, ellipticity, diameter, and length recorded, 3) have weight of downstream fifteen pieces recorded, and 4) be bond tested if possible.

(4) Letter to J.T. Stringer from TW Ambrose, "Request For Test Quantities of KVNS Fuel Elements", 4-5-60.

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Hot spot and hot area flow patterns shall be examined in detail and any elements showing unusual dimensional distortions shall be set aside for further examination, and, if deemed advisable, selected elements will be sent to Radiometallurgy for destructive examination.

C) Test Audit

The Fuels Preparation data for this production test are recorded in the summary to PWR-147-92. HW-69964 will serve as the PT notebook.

D) Hazards

Hazards peculiar to this test are primarily associated with the presence of the self-support projections on the fuel surface. It is conceivable that these self-supported elements could stick tighter than do non-supported elements since the supports restrict fuel displacement within the process tube; however, it appears that no extreme risk is involved in this testing program with regards to safety.

WH Hodgson
Engineering Section
Fuels Preparation Department

MA Clinton
Research and Engineering Section
Irradiation Processing Department

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APPENDIX

Data to be Recorded in Production Test Notebook

I. Fuel Element Core

A. Lot Numbers

1. Ingot Numbers and Chemical Analysis
2. Unusual Treatment
3. Fabrication Technique

B. Finished Dimensions (Pre-Assembly)

II. Aluminum Components

A. Lot Numbers

1. Alloy Type
2. Unusual Treatment

B. Finished Dimensions (Pre-Assembly)

III. Pre-Assembly Treatment of Cores

A. UT-2, Record Data
B. Surface Tester, Record Data

IV. Assembly Process

A. Process Used
B. Brief Explanation of Each Process
C. Attendant Conditions
D. Total Bond Count, Record Data

V. Post-Assembly Treatment

A. Support Attachment
B. Autoclaving
C. UT-4 Test, Record Data
D. Stud Pulling, Record Data
E. Inspection
F. Other Treatment

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VI. Irradiation

A. Coolant Temperature

1. Inlet
2. Outlet

B. Panellit and Crossheader Pressures
C. Number of Shutdowns (Controlled and Scram)
D. Other

VII. Post-Irradiation Examination

A. Visual
B. Warp
C. Total Bond Count, Record Data
D. Critical Examination of Bond Quality by Stud Pulling and Metallography

VIII. Log - Running account with dates recording the progress of the PT, unusual incidents (such as slight change in process during assembly), and other deviations whether or not they seem pertinent at the time of occurrence.

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