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

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

By

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June 19, 1961

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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OBJECTIVE

The objective of this test is two fold: 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.

While the test authorizes up to 10 tubes, only two process tubes are immediately available and are all that will be planned for in the initial installation and charging. Goal exposure will be set at 800 MWD/T.

DISCUSSION

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 on 3-15-64. The first step in support of this transition program is to confirm compatability 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. 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 CIIN 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 currently consists of 20 tubes and is to be expanded to a total of sixty tubes and will provide additional fuel data for self-supported fuel elements operating at high specific powers (up to 110 KW/ft.).

(1) HW-67952, "Plant Improvement Program Irradiation Processing Department FY-1962 - 1971", A. B. Greninger, 3-27-61.

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All experience with self-supported material to date has been favorable and little doubt is associated with the concept.

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.

2. Material

A. Fuel Elements

1. Cores - All cores will be natural uranium
2. Cladding - Cladding 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 element will be designated as a KVNS element and shall have the following nominal dimensions:

<u>Dimension (inches)</u>	<u>KVNS</u>
Canned OD	1.520
Canned ID	0.420
Canned Length (Flat Base)	8.865
Self-Support Rail Height	0.095
Self-Support Rail Length (.032" thick)	2.313
Distance Rail from end of F.E.	1.250
Maximum support diameter	1.710

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

(2) HW-47029, "Process Specifications, Fuel Element Manufacturing Processes", FPD.

(3) H-3-7350 Rev. 9, "Canned Uranium Fuel Elements", 8-4-60.

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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 - Are not required for this test.
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 10 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.

B. Process Tubes

The tubes required for this test will be smooth-bore zircaloy-2, uniform wall thickness tubes having an inside diameter of 1.724" $\pm$.005". The outside diameter (1.814" maximum) will be 0.004" larger than that of the ribbed aluminum tube currently in use at K Plant. The tubes will be installed into channels in the central flow zone and the location will be chosen by the assigned process engineer with the concurrence of the Manager, KW Processing Operation. Since the tubes will be equipped with downstream thermocouple probes, it is suggested that they be located in the near-center region of the reactor.

C. Dummies and Seating

C size self-supported aluminum spacers as described by drawing H-1-12347 Rev. 1 will be used in the downstream dummy charge. The seating method and downstream dummy length in use for 38 piece natural uranium charges at the time this test is charged shall be used.

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

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D. Thermocouple Probes

Downstream thermocouple trains to measure annular temperature distribution may be utilized as specified by the test author. Initially both tubes will be equipped with probes. While it is anticipated that up to twenty probes may be required to evaluate the KVNS - Zr-2 fuel-tube geometry, a maximum of six probes are authorized by this test.

E. Nozzles

Inlet and outlet nozzles which have been modified to allow charge-discharge of the self-supported fuel elements will be utilized only if covered by an approved design change, otherwise, it will be necessary to remove both inlet and outlet nozzles during charge-discharge operation.

F. Charge Machine

Current K charge machines are inadequate for charging projection fuel elements. Modified machines have been developed for charging C size self-supported fuel (1.500" OD, and 1.991" OD) and it is suggested that a similar machine or a C machine adapted for use in K be considered to eliminate the need for hand charging.

3. IRRADIATIONA. 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. Hand charging and nozzle removal and installation are authorized by this test if required.

B. Irradiation

Daily data will be recorded for all tubes equipped with thermocouple probes on data sheets which will be provided by the test author. 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.

C. Discharge

All columns from this test will require special pickup and shipment to the 105-C MEF for post-irradiation examination and measurement. During discharge operations particular care should be taken to report pertinent observations relative to removal forces and post-discharge handling. Should a failure occur in any of the test columns, it will be extremely

desirable to obtain the failed piece for examination along with the remainder of the column. If a charge should stick, regardless of the cause, stuck charge and rupture removal procedures will be reviewed by representatives of R&E before use. If a tube can not be recharged, procedures for operation with an empty tube will be reviewed by representatives of R&E before startup.

D. Operating Conditions and Limits

Prior to reactor charging, flow laboratory data shall be obtained for the 38 KVNS fuel element loading in a prototype smooth-bore zirconium tube. The operating conditions are not expected to differ from those presently experienced with the KIVN fuel.

4. GENERAL

A. Duration and Further Testing

This test authorization will remain in effect for two years unless otherwise terminated. It is expected that the size of the test facility will be increased beyond ten tubes before two years and this further testing will require a supplement to this PT or PITA.

B. Schedule

Five columns of fuel elements have been fabricated and received pre-irradiation measurements. Two zircaloy-2 tubes have been delivered, one is located at K Plant and the other at 189-D where it will be used to obtain flow data for the fuel-tube geometry prior to reactor installation. It is expected that all ex-reactor preparations will be completed in time to meet the 7-5-61 scheduled outage at KW Reactor.

C. 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.

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.

D. Costs

The following costs may be charged to XXXX-5R24-XXX.73.

1. Time required for thermocouple probe installations and removal.
2. Time required to charge-discharge the tubes and that required for special pickup.

3. If nozzle removal is necessary to charge or discharge the tubes, this is authorized to be charged against the above code.
4. Lost time due to ruptures or stuck charges.

All other costs such as nozzle modifications and charge machine modifications to support this test shall be borne by the processing operation.

E. Hazards

Hazards peculiar to this test are primarily associated with the presence of the self-supported 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.

5. RESPONSIBILITIES

Fuels Preparation Department

Manufacturing Section shall be responsible for fabrication of all elements used in this test, providing the elements to others for attachment of the projections, element quality, and pre-exposure measurements of all pieces.

Engineering Section - shall be responsible for attachment of the projections, liaison contact and coordination of the 300 Area portion of the test.

Irradiation Processing Department

Research and Engineering

Process Technology Sub-Section - will be responsible for providing assistance in pre-shutdown scheduling and charging, reporting of operating data to the author, for specifying of operating limits and for specifying column locations.

Process and Reactor Development Sub-Section - shall be responsible for coordination of the test, analysis of operating data, reporting of in-reactor performance, and for provision of bases for operating limits.

Operational Physics Sub-Section - shall be responsible for assistance in choice of test location and reactivity changes required.

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

KE-KW Reactor Operation

KW Processing Operation - shall be responsible for scheduling, the operational safety, and production continuity of the reactor, charging

of test material under the direction of a representative of Research and Engineering, and for collection of operating data.

KW Maintenance Operation - shall be responsible for all maintenance required by this test to include nozzle modifications, nozzle removal and installation, charge machine modifications, and thermocouple probe installation and removal.

M. A. Clinton

Reactor Fuels Unit
Process & Reactor Development Subsection
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

D. H. Curtiss

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