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TITLE

PRODUCTION TEST IP-541-A
REACTOR EFFLUENT STUDIES

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AUTHOR

R. G. Geier

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PRODUCTION TEST IP-541-A
REACTOR EFFLUENT STUDIES

By

R. L. Geler

October 29, 1962

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By Authority of WA Snyder

CG-PR-2, 3-15-94

By DK Hanson, 4-16-94

Verified By Jerry Maly, 4-18-94

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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OBJECTIVE

The objective of this test is to determine the concentrations of radioisotopes in the effluent from a Zircaloy tube and an aluminum tube when both are charged with Zircaloy clad fuel elements and cooled with deionized water.

JUSTIFICATION

Deionized water is currently being used as the coolant for a Zircaloy and an aluminum tube at KE Reactor. To date the fuel for these tubes has been aluminum clad. Progress is being made in assessing the relative importance of fuel element film and tube film on the radioisotope content of the effluent as well as the contribution of aluminum corrosion to effluent activity. However, there is no information available at present on a channel in which corrosion is reduced to a minimum. It is anticipated that the data supplied by this test will permit a complete evaluation of the variables delineated above.

TEST DETAILS

A. Process Tubes

The tubes to be used in this test will be 4963-KE, a standard ribbed aluminum tube and 5063-KE, a C-size smooth-bore Zircaloy tube.

B. Fuel Elements

1. Tube 4963-KE

The fuel elements to be charged in Tube 4963-KE will be fabricated as shown in Figure 1. Cladding will be Zircaloy-2, and uranium core material will be 0.947 per cent enriched uranium. These fuel elements have been irradiated previously without incident at KW Reactor⁽¹⁾.

2. Tube 5063-KE

The fuel elements to be charged in Tube 5063-KE will be identical to those charged to Tube 4963-KE except that they will be fitted with appropriate self-supports. These fuel elements have been approved for irradiation in a smooth-bore C-size Zircaloy tube⁽²⁾.

3. Charge Length

The initial charge will consist of 32 fuel pieces in each tube. Calculations indicate that such a charge length will produce a tube outlet temperature between 95 and 105 C. If the tube outlet temperature does not fall in this range, the charge length will be adjusted as appropriate during the first outage after the start of the test to result in a 95 to 105 C tube outlet temperature.

(1) HW-68598, "Production Test IP-397-A, Coextruded Zircaloy Clad Enriched I&E Fuel Elements," by L. E. Kusler and M. A. Clinton, 3-27-61 (Secret).

(2) HW-73102, "Production Test IP-500-A, Reactor Effluent Studies," by R. G. Geier and M. A. Clinton, 3-22-62 (Secret).

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C. Dummies and Spacers

An important condition of this test is that there be no aluminum (other than the tube in the case of Tube 4963) in or immediately adjacent to the flux zone. Therefore, dummies or spacers required in or adjacent to the flux zone will be fabricated from stainless steel (Figure 2). Downstream dummies may be aluminum. Special pieces required will be supplied by Process and Reactor Development Subsection.

D. Coolant

The coolant for both tubes will be the effluent from the deionizing equipment installed in 1706-KE Building. This water is currently being supplied to the tubes under Production Test IP-449-A⁽¹⁾.

The deionized water will be supplied to the tubes both during normal operation and during reactor shutdown periods.

In case of malfunction of the 1706-KE equipment, process water may be used.

E. Exposure

Exposure will be based on the variable goal limit normally used for KIVN fuel elements.

F. Discharge

The Zircaloy clad fuel elements will be picked up special and will be stored until Zircaloy clad fuel processing is inaugurated by the Chemical Processing Department. Storage and handling will be done in accordance with the specifications set forth in HW-66539⁽²⁾.

G. Sampling

Sampling the effluent from the two tubes will be required throughout the test. A detailed description of sampling requirements will be supplied by the test author.

H. Corrosion Studies

In order to provide corrosion information under conditions of low aluminum surface to water volume ratio coupon holders shown in prints No. SK-1-23211, H-1-33319, or H-1-33320 will be included in the downstream dummy pattern. The number and location

(1) HW-71338, "Production Test IP-449-A, Effluent Activity Studies in the 1706-KE In-Reactor Facility," by R. G. Geier, 10-14-61 (Secret).

(2) HW-66539, "General Limits for the Storage of Enriched Metal," by R. E. Tiller, 8-18-60 (Secret).

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of the coupon holders will be selected by Coolant Systems Development Operation, HLO with the concurrence of Coolant Testing Operation and KE Processing Operation, IPD.

I. Duration of Test

This production test authorizes the irradiation of one fuel charge as described in each tube.

J. Premature Discharge

If necessary for the timely initiation of the test, premature discharge of green metal from the tubes is authorized. In addition, if sufficient information is obtained prior to the completion of the test, premature discharge of Zircaloy clad fuel is authorized.

THERMAL HYDRAULICS

Thermal hydraulic considerations give rise to the operating criteria discussed below.

A. Process Water Backup

In case of failure of the 1706-KE pumps, the safety of the tubes depends on the process water backup system. The system is simple and can be considered highly reliable. Process water is available to the system through interconnecting lines, but it is excluded from the system by check valves. The check valves are held shut by maintaining the pressure in the 1706-KE supply system higher than the reactor process water pressures. When pump failure occurs, the pressure in the normal supply lines decays and the check valves open.

A second check valve is situated in the 1706-KE supply lines upstream from the point of process water intertie. This valve will prevent the flow of water from the backup system to the 1706-KE pumps. It also protects the system from the remote chance that a line rupture occurs between the 1706-KE pumps and the process water intertie.

In order to insure protection, it is necessary to lock and tag open all stop valves on the process water lines upstream from the check valves.

B. Instability Limits

In order to insure safe and stable operation of the tubes, the provisions of Process Standards A-050 will be met for both high and low venturi trip limits.

The use of crossheader pressure to detect upstream plugging is advantageous in that it is higher than the venturi throat pressure and thus is more sensitive to upstream flow stoppages. Therefore, the crossheader low trip setting must be set at least 50 psi above the venturi high trip setting.

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These trip settings are valid for front crossheader pressures greater than 325 psig and a differential between high and low venturi trip settings of less than 90 psi. All pressures are to be measured at a common elevation.

Tube outlet temperature limits shall be calculated according to Process Standard A-020. In no case shall the outlet temperature be allowed to exceed 130 C.

C. BPA Outage Limits

In case of a BPA outage, the 1706-KE pumps trip out and the tubes are supplied with coolant from the process water system. In such an event, two critical periods exist. The first comes within a few seconds after the BPA outage. The flow to the tubes decays in two steps after the power decays. The supply pressure to the tubes drops immediately to that supplied by the process water system. Next, the pressure supplied by the process water system decays as the flywheel energy on the 190-KE pumps is used up.

In order to pass through the first critical period safely, it is necessary to insure that the total flow decay before the beginning of tube power decay is not excessive. Such protection is obtained by the limits shown in Figure 3 which are based on a flow reduction of not more than 20 per cent before tube power decay commences.

The second critical period occurs about 100 - 150 seconds after the outage. At this time, the coolant flow has decayed about 85 per cent and the tube power has decayed about 88 per cent. Both the flow and power will remain relatively constant at these values for a considerable period of time. It is desirable that the tube exit temperature not exceed the rear cross-header saturation temperature. A maximum tube outlet temperature of 130 C has been specified under instability limits. Inasmuch as this is 9 C below rear crossheader saturation temperature, safe operation is assured.

HAZARDS

Since the tubes will be supplied with coolant by the 1706-KE pumps both during normal operation and during shutdown, the flow to the tubes will be valved down during shutdown (currently standard practice) to avoid the consequences of inadvertent cap removal.

COSTS

A. Outage Time

Two hours for each charge-discharge and special pickup.

B. Sampling

Operator time for sampling will be required in amounts depending on the sampling schedule chosen. Charge for sampling over and above that which can be carried out by the normal operating staff will be borne by Process and Reactor Development Subsection.

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C. Cost Code

XXXX-5R20-XXX.71

RESPONSIBILITIES

Irradiation Processing Department

KE-KW Reactor Operation

KE Processing Operation will be responsible for:

1. The operational safety of the reactor.
2. Production continuity.
3. Charge-discharge of the tubes.
4. Obtaining samples.

Research and Engineering Section

Coolant Testing Unit will be responsible for:

1. Operation of 1706-KE equipment.
2. Recording of operating data.

Process and Reactor Development Subsection will be responsible for:

1. Making process recommendations.
2. Termination of the test and issuing the final report

Operational Physics Subsection will be responsible for:

1. Reactivity adjustment if necessary.

Hanford Laboratories Operation

Chemical Research and Development Operation

Radiological Chemistry Operation will be responsible for:

1. Delivery of samples to the laboratory.
2. Analyzing effluent data and issuing technical reports.

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Reactor and Fuels Research and Development Operation

Coolant Systems Development Operation will be responsible for:

1. Analyzing corrosion data and issuing technical reports.

R. G. Geier
Process and Reactor Development Subsection
Research and Engineering

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NOTE: DIAMETERS MARKED
THUS: ϕ , TO BE
CONCENTRIC WITHIN
0.015"

TUBE GAGE SIZE: 1.483
MANDREL SIZE: 0.414

APPROVED!

DWG. NO.	DRAWING TITLE
REFERENCE DRAWINGS	
CLASSIFICATION	CLASS. BY DATE
NONE	Geo. E. Smith 3-24-61

U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC

COEXTRUDED T & F

NO.	REVISIONS	REV. BY DATE	APPD. BY	FOR	DATE
	SCALE: NONE				
	NEXT USED ON				
	APPROVALS FOR				
	DRAWN BY				
	CHECKED				
	ISSUED				
	DES. ENG.				
	UNIT				
	INDEX				
	NUMBER				

FIGURE 2

DUMMIES

MATERIAL: TYPE 304L STAINLESS
STEEL

DUMMY DESCRIPTION	DIMENSION (INCHES)				
	A	B	C	D	E
8" SELF SUPPORTED	8	1.50	1.26	1.66	0.4
8" NON SUPPORTED	8	1.32	1.05	—	—
16" SELF SUPPORTED	16	1.50	1.26	1.66	0.4
16" NON SUPPORTED	16	1.32	1.05	—	—

FIGURE 3
BPA FAILURE LIMIT

Maximum 1706-KE Tube Supply Pressure as Measured in the Pipe Tunnel - PSIG

Backup Process Water Pressure - PSIG

APPROVALS

J. H. Brown, Manager
Process & Reactor Development Subsection
Research and Engineering Section

G. C. Fullmer, Manager
Operational Physics Subsection
Research and Engineering Section

R. W. Reid, Manager
Process Technology Subsection
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Manufacturing Section

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Manufacturing Section

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8 / 9 / 94

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