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HW--67491

DE93 003949

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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE
November 21, 1961

TITLE

SUPPLEMENT F, PRODUCTION TEST IP-314-A,
MEASUREMENT OF FUEL ELEMENT TEMPERATURE
CHANGES AS THE RESULT OF FILM DEPOSITION

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November 21, 1960

SUPPLEMENT F, PRODUCTION TEST IP-314-A,
MEASUREMENT OF FUEL ELEMENT TEMPERATURE CHANGES
AS THE RESULT OF FILM DEPOSITION

OBJECTIVE

The objectives of this supplement to PT-IP-314-A⁽¹⁾ are to authorize (a) a third thermocouple element to measure the temperature effect of film deposition subsequent to decontamination of a carbon steel system (b) the use of heater elements not previously authorized, and (c) performing a third decontamination of KER-1.

(1) Kratzer, W. K. Production Test IP-314-A, Measurement of Fuel Element Temperature Changes as the Result of Film Deposition, HW-64800. April 13, 1960 (SECRET)

SUMMARY

Irradiation of a third thermocouple train with a thermocouple element of the same design as used on the previous two trains, but with different train design and heater elements, is authorized to an exposure no greater than 1000 MWD/T. A third (2) decontamination of KER-1 using the same procedures as for the first decontamination is also authorized.

BASIS AND JUSTIFICATION

The test program of evaluating the temperature effect of crud film build-up on fuel element heat generating surfaces in a carbon steel system has three phases:

- a. Measurement of the effect of film build-up during normal high pH equilibrium operation.
- b. Measurement of the temperature effect of film build-up subsequent to a loop decontamination.
- c. Measurement of the effect of film build-up in the event of loss of pH control.

Phase (a) was completed with the first thermocouple train. Testing was interrupted by a failure in the loop, apparently in one of the heater elements, since careful examination of the thermocouple element in the Radiometallurgy Laboratory failed to show any signs of failure. A second train was charged and the loop decontaminated. Before meaningful film build-up data could be obtained, however, the thermocouple element failed at the cap-jacket weld. As well as could be determined by radiometallurgical examination, the failure was in no way connected with the decontamination. A third thermocouple train authorized by Supplement E, PT-IP-314-A, (3) was prepared, but stuck in the process tube during charging. The reason for the inability to charge is not known; however, the inclusion of the heater elements in the train may have contributed to the difficulty. The train has been disassembled, shortened three feet, and reassembled without the heater elements. Heater elements of a design different from those used previously will be loaded downstream of the train. This supplement authorizes a modified third thermocouple train to complete the last two phases of the test program.

A thermocouple element of the same basic design as the first two will be used in this test. It has, however, been subjected to more rigorous nondestructive testing and examination than the others.

TEST DETAILS

1. Fuel Elements

a. Thermocouple Element

The thermocouple element is a natural uranium rod coextruded with 0.020 inch thick Zircaloy-2 cladding. The one inch O.D., twelve inch long finished rod

(2) Miller, N.R., et al, Production Test IP-323-A, Decontamination of the KER-1 Loop, HW-65586. June 9, 1960. (SECRET)

(3) Kratzer, W.K., Supplement E, Production Test IP-314-A, Measurement of Fuel Element Temperature Changes as the Result of Film Deposition, HW-67193, October 24, 1960 (SECRET)

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is mounted concentrically in a 1.820 inch O.D., 1.450 inch I.D., sixteen inch long stainless steel sleeve. Five stainless steel sheathed thermocouples are mounted in the rod-sleeve assembly; three in the rod to measure center and edge uranium temperatures and two in the coolant annulus. The stainless steel thermocouple sheaths are attached to the Zircaloy-2 fuel element end cap by a stainless steel to Zr-2 eutectic braze joint. The fuel rod was checked by ultrasonic and eddy current methods for cladding thickness and bond layer integrity. All welds, both stainless steel and Zr-2, as well as the eutectic braze joints, have been radiographed and found to be sound. Voids were seen in the eutectic braze joints but they were small and isolated. There was sufficient continuous braze layer to provide an adequate barrier to water penetration.

After radiographic testing the thermocoupled fuel element was autoclaved for 48 hours in 400°C, 1500 psi steam, followed by a second autoclave test for 7 days in 300°C, 1500 psi water. The steam autoclaving was done to check the welds for uranium contamination and to apply a black oxide film on the Zr-2 surfaces. The water autoclaving was done to determine whether water corrosion might have any noticeable effect on the eutectic braze joints. No effect was observed.

b. Heater Elements

The heater elements will be either natural uranium coextruded single tubes (KSN-3)⁽⁴⁾ sixteen inches long or 1.6% enriched single tubes (KSE-3) eighteen inches long. The tubes were extruded to a nominal 1.739 inch O.D. and 1.074 inch I.D. with 0.025 inch thick jackets. The 0.200 inch thick end caps are affixed by the brazing procedure described in HW-66807⁽⁵⁾. The end caps are brazed, faced, and fusion welded over the braze zone.

The fuel tubes are supported at each end by four 1/4 inch wide semiflexible iron supports mechanically held to the fuel element by 1/8 inch Zr-2 studs spot welded to the fuel element jacket.

Each element contains a 0.740 inch solid Zr-2 rod the same length as the fuel tube mounted concentrically in the fuel tube to provide balanced coolant flow over the two heat generating surfaces. The Zr-2 inner rod is held in position by three semiflexible Zr-2 supports spot welded to the rod at each end.

All heater elements have been nondestructively tested for jacket thickness and bonding and the closures have been ultrasonically checked for bonding. As in the case of the thermocouple element, the heater elements have received both a steam and water autoclave. Samples of the braze closure are being tested in the decontaminating solution, and the elements will not be charged until favorable results have been obtained from this corrosion test.

(4) Kusler, L.E. and W.K. Kratzer, Method for Designating Experimental Coextruded Zircaloy-2 Jacketed Fuel Elements, HW-67225, October 26, 1960 (CONFIDENTIAL-UNDOCUMENTED)

(5) Alexander, W.K. Preliminary Process Specification CX 707.0, HW-66807, November 1, 1960 (CONFIDENTIAL)

2. Loading

The loading will consist of the thermocouple train upstream and three to six heater elements downstream, depending on the type used. The thermocouple train is made up of the sixteen inch thermocouple element and sleeve assembly and thirty eight-inch spacers. The thermocouple wires pass from the thermocouple element through the thirty spacers and out of the process tube through pressure fittings on the front nozzle insert. A protecting tube used to prevent vibration of the thermocouple wires in the front nozzle is shown in Figure 1.

Three to six natural or enriched heater elements will be loaded in the downstream half of the process tube, depending on the type of elements available. The entire column length will be six inches shorter than the space available in the process tube to permit differential thermal expansion between the fuel column and the process tube. A detailed loading approved by Process and Reactor Development Operation and Process Technology Operation will be provided prior to charging.

3. Operating Conditions

Decontamination of KER-1 is authorized as described in HW-65586, reference 2, with the thermocouple train in the loop.

During operation the coolant shall be pressurized water with the pH adjusted to not higher than 10.5 nor lower than 7.0, depending upon the phase of testing. The desired operating flow is 50 gpm with the low flow trip set at 40 gpm. The desired operating outlet temperature, high outlet temperature trip, and boiling point suppression trip for the actual loading used will be provided prior to charging in a document approved by Process and Reactor Development Operation and Process Technology Operation.

4. Exposure

The maximum exposure authorized for any elements in the fuel loading is 1000 MWD/T.

5. Hazards

Based on previous thermocouple train performance, fuel failure in the thermocouple train is obviously possible. Every step short of completely redesigning the thermocouple element, however, has been taken to insure that the element has no detectable defects. The heater elements have good jacket thickness uniformity and the Be-Zr brazed closures have been inspected and corrosion tested. There is no reason to assume that the closures would fail as the result of exposure to either the coolant or the decontaminating solution.

An upstream thermocouple train has been tried only one time before in the KER loops. The thermocouple wires broke at the front nozzle insert because of vibration of the wires in the front nozzle. The protecting tube arrangement shown in Figure 1 should prevent this from happening on the current train.

Another potential hazard of the upstream thermocouple train exists in the

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five pressure fittings in the nozzle insert through which the 1/16 inch diameter thermocouple wires pass out of the process tube. A leak in one of the pressure fittings would require low pressure or single pass operation; however there would be no risk of loss of flow since the holes in the nozzle insert are only 1/16 inch diameter.

Continuing tests of the decontamating solution planned for use in KER-1 give assurance that a third decontamination of KER-1 will in no way damage the loop.

6. Other Aspects of the Production Test

All requirements of the original production test and approved supplements not specifically modified by this supplement will remain in effect.

RESPONSIBILITIES

Fuels Preparation Department

Engineering Section

Coextruded Products Engineering is responsible for fabricating the heater elements.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuel Element Design Operation is responsible for fabrication of the thermocouple element assembly, analysis of data, and issuance of technical reports.

Materials Development Operation

Coolant System Development Operation is responsible for assembly of the thermocouple train, providing and maintaining the thermocouple leads, junctions, and temperature recorders, analysis of data, and issuance of technical reports.

Irradiation Processing Department

Research and Engineering Operation

Component Testing Operation is responsible for post-irradiation examination and testing of components in the test charge.

Coolant Testing Operation is responsible for:

- a. Operation of the KER loops.
- b. Taking basic operating data.
- c. Scheduling the loop charge with the concurrence of KE Processing Operation.
- d. Reactor safety and production continuity as they are affected by loop operation.

RESPONSIBILITIES (cont'd)

Process and Reactor Development Operation is responsible for:

- a. Technical aspects of the fuel element irradiation.
- b. Termination of the production test and issuance of the final report.

KE-KW Reactor Operation

KE Processing Operation is responsible for:

- a. Operational safety.
- b. Production continuity, except where inconsistent with provisions of this test.

W. K. Kratzer
Process & Reactor Development
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

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FIGURE 1
NOZZLE INSERT AND THERMOCOUPLE WIRE
SUPPORTING TUBE FOR UPSTREAM THERMOCOUPLE TRAIN

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