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MANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

Production Test IP-229-A
Evaluation of the Uranium-Al-Si Bond
at High Temperature

AUTHOR

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PRODUCTION TEST IP-229-A
EVALUATION OF THE URANIUM-AL-SI BOND
AT HIGH TEMPERATURE

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OBJECTIVE

The objective of this production test is to determine the changes that occur in the uranium-Al-Si bond during irradiation at bond temperatures between 255 and 285°C.

SUMMARY

Twenty-five M-388 jacketed dip canned depleted uranium solid fuel elements will be irradiated to an exposure of 500 MWD/T in high temperature water. The location and size of unbonded areas on the fuel elements will be measured by ultrasonic mapping before and after irradiation to show the changes in bonding resulting from irradiation at high temperature.

BASIS AND JUSTIFICATION

Although high temperature corrosion tests have shown a relatively low corrosion rate for M-388 aluminum alloy in pH 4.5 water with H_3PO_4 added, the ability of the fuel-jacket bond to withstand high temperature irradiation without deterioration is not known. A test is being planned to compare the high temperature bond retention characteristics of Al-Si dip canned and nickel plated hot-press canned fuel elements. Since the dip canned Al-Si bond is expected to be the poorer of the two types, this short term screening test will be run to low exposure to reveal bond instability, if it exists, in Al-Si dip canned fuel elements. If no gross bond impairment is shown by this production test, Al-Si dip bonds and nickel plated hot-press bonds will be compared at higher exposures.

High temperature bake tests out of reactor⁽¹⁾ have indicated that aluminum-uranium diffusion will not be a problem at the temperatures encountered during this irradiation. Depleted uranium is used in the fuel elements to maintain the maximum uranium temperature below the alpha-beta transformation temperature.

TEST DETAILS

1. Fuel Elements

The twenty-five fuel elements irradiated under this production test will consist of 0.14% U-235 depleted uranium cores 1.336 inches in diameter and 8.000 inches long dip canned in 1.440 inch OD M-388 jackets. Removable support spiders will be attached to the ends of the fuel elements, as shown in H-3-7582, to center them in the process tube. The size and position of the unbonded areas on the fuel elements have been determined

(1) HW-56300, "Progress Report, High Temperature - High Pressure Bake Testing and Diffusion Studies of Aluminum Clad Fuel Elements", J. W. Goffard and R. G. Wheeler, July 25, 1958.

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by ultrasonic mapping. In addition, the fuel elements have received all standard inspections, including penetration and autoclave tests.

Removable end spiders were used for these fuel elements, rather than the normal welded collapsible supports, because the supports must be removed before the unbonded areas can be ultrasonically mapped after irradiation.

An x-ray specimen irradiation capsule will be irradiated with the fuel element charge. This capsule consists of a 1.500 inch diameter, 4-inch long Zircaloy-2 can with 0.060 inch walls supported on collapsible rails, as shown in SK-3-8051. The capsule contains a Zircaloy-2 irradiation sample mounted in an aluminum block. To avoid annealing the irradiation sample, the capsule has not been autoclaved. The welded closures have been radiographed and helium leak tested, however, and the capsule has been subjected to a 3400 psi hydrostatic pressure test.

Internal and external flow corrosion coupon holders, SK-1-22424 and SK-1-22425, will be loaded in the spacer columns of the charge.

A thick walled M-388 jacketed doe alloy thermocouple element may be loaded upstream of the active charge to measure changes in fuel element temperature resulting from the build-up of corrosion film. The thermocouple element is the same as the one successfully irradiated under PT IP-190-A⁽²⁾ and is completely described in that test. The thermocouple train will be positioned at the front of the charge, with the leads passing through a modified front nozzle cap, as described in HW-58829(3).

2. Loading

The desired loading is given in Table 1.

<u>Position from Downstream end</u>	<u>Effluent Length</u>	<u>Material</u>
1	6"	Nozzle insert
2-14	8"	Spacers or coupon holders
15-24	10.1"	Depleted fuel elements
25	4"	X-ray sample
26-40	10.1"	Depleted fuel elements
41	210"	Thermocouple train

(2) HW-56855, "Production Test IP-190-A, Irradiation of Aluminum Clad Doe Elements in the KER Recirculation Test Facility", N. R. Miller and W. K. Kratzer, July 22, 1958.

(3) HW-58829, "Proposed Design for Front Face Thermocouple Lead-out From KER Loops", D. R. Doman, January 15, 1959.

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If the upstream thermocouple train is not used, up to 18 eight-inch spacers or coupon holders may be loaded upstream of the active charge. A detailed charging procedure approved by Coolant Testing Operation and KE Processing Operation will be provided before the upstream thermocouple train is loaded.

If, for any reason, the loading must be modified, Process and Reactor Development Operation will provide a revised loading pattern and set of operating conditions prior to charging. If a revised set of operating conditions cannot be obtained, the loop will be operated at low temperature until a new set of operating conditions has been provided.

3. Irradiation Facility

The fuel elements may be irradiated in any one of KER Loops 2, 3, or 4, tubes 2864, 3565, or 4268 KE. The loops consist of 2.100 inch Zircaloy-2 process tubes through which coolant of controlled composition, pressure, and temperature is recirculated. The fuel elements may not be irradiated in KER Loop 1 because of the high pH water required in the carbon steel loop.

4. Operating Conditions

The coolant will be pressurized water with the pH adjusted to 4.0 to 5.0 by the addition of H_3PO_4 . The operating conditions are:

- a. Desired operating flow - 60 GPM
- b. Low flow trip - 48 GPM
- c. Low pressure trip - 785 psig
- d. High outlet temperature trip - as shown in Figure 1
- e. Desired operating outlet temperature - as shown in Figure 1
- f. Boiling point suppression trip - as shown in Figure 1.

If recirculation with system pressures less than 785 psig is required, the outlet temperature should be reduced and maintained at least 100°C below the system saturation temperature.

5. Power and Temperature Relationships

The high outlet temperature trip, desired operating outlet temperature, and boiling point suppression trip have been set as functions of the observed tube ΔT so that, regardless of the power produced by the fuel elements, the fuel element surface temperature will not exceed the system saturation temperature during normal operation; the fuel elements will not burn out at the limiting conditions, and bulk boiling will not occur in the tube. The maximum uranium temperature, as calculated, should not exceed 650 °C at limiting trip conditions.

6. Exposure

The maximum exposure authorized for the fuel elements in this production test is 500 MWD/T or 80 operating days at temperature.

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7. Special Procedures

The fuel elements from this production test will be discharged into a special tray to avoid the fall of the fuel elements to the basin which, by mechanically damaging the pieces, could obscure the jacket-uranium bond changes this test is intended to show.

A detailed discharge procedure approved by Coolant Testing Operation and KE Processing Operation will be provided before discharge. If an approved procedure has not been supplied, the fuel elements will be discharged normally.

8. Priority

Additional down-time is authorized if charging or discharging cannot be accomplished during a normal outage.

9. Costs

a. Cost Code - XXX.5320-XXX.14

b. Time

	<u>Elevator Time, Hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge	3	1	7
Discharge	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{8}{15}$

c. Reactivity change - The test loading will have a reactivity intermediate between that of a dummy charge and a standard charge of normal fuel elements.

10. Data Desired

Routine operating data, including coolant flow, inlet and outlet temperature and pressure, system pressure, and operating time at temperature, will be taken during irradiation. After irradiation the fuel elements will be weighed with the supports attached. The supports will then be removed and the elements weaseled, ultrasonically tested for bond changes, and measured for dimensional changes and distortion on the profilometer.

11. Hazards

The probability of failure of the aluminum jacketed fuel elements is most likely higher than that associated with Zircaloy-2 jacketed extruded surface elements, however, the low specific power, short irradiation time, and high operating temperature should make a failure unlikely. If a fuel element failure should occur, there is sufficient volume in the coolant annulus around the fuel element to accommodate the water-uranium reaction products without damage to the process tube.

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DEVIATION FROM PROCESS STANDARDS

This production test authorizes deviation from Process Standard K-040, Section 40.01, which limits the maximum uranium temperature to 600°C. Maximum uranium temperature may be as high as 650°C, although they should not exceed this value within the range of trip conditions provided.

RESPONSIBILITIES

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Reactor Engineering Development Operation

Coolant Systems Development Operation has engineering responsibility for assembly, installation, and functional checking of the thermocouple train, analysis of data, and issuance of technical reports.

Fuels Preparation Department

Engineering Operation

Research and Projects is responsible for fabrication, inspection, and pre-irradiation measurements of the fuel and thermocouple elements.

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.

Process and Reactor Development Operation is responsible for:

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

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KE-KW Reactor Operation

KE Processing Operation is responsible for:

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

Reactor Fuels Operation
Process & Reactor Development Operation
IRRADIATION PROCESSING DEPARTMENT

WK Kratzer:dgm

FIGURE 1
Operating Temperatures and Trip
Settings as a Function of the Observed
Tube ΔT.

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9/16/94

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