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June 21, 1960

GENERAL ELECTRIC

WATFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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PRODUCTION TEST IP-334-A, IRRADIATION OF
ENRICHED TUBE-AND-TUBE REACTORS
END CLOSURES

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June 21, 1960

PRODUCTION TEST IP-334-A, IRRADIATION OF ENRICHED
TUBE-AND-TUBE ELEMENTS WITH BRAZED END CLOSURES

OBJECTIVE

The objective of this production test is to evaluate Zr-5 w/o Be brazed end closures on enriched tube-and-tube elements irradiated in high temperature coolant in the KER Loops.

SUMMARY

Tube-and-tube elements containing 1.6% enriched 2 w/o Zr alloyed uranium with brazed and welded end closures will be irradiated in the KER Loops either alone or in conjunction with fuel elements authorized by other production tests or supplements.

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provided the required operating conditions are compatible. The exposure of the brazed elements will not exceed 3000 MWD/T. The tube loading pattern and operating conditions will be provided by Process and Reactor Development Operation and approved by Process Technology Operation prior to charging.

BASIS AND JUSTIFICATION

Most of the coextruded Zircaloy-2 jacketed fuel elements irradiated at HAPC in course of NPR fuel element development have had unbonded welded end closures. Although no difficulties have been encountered with the unbonded closure, procedures for producing bonded closures are being investigated to provide an element with a secondary barrier to coolant entry to the uranium through a defective weld and to provide an element capable of withstanding high longitudinal compressive loads during charging without buckling the jacket at the end cap. One method of bonding the end cap to the jacket wall and the uranium is brazing.

A 95 w/o Zr-5 w/o Be eutectic alloy has been found to be suitable for brazing Zr-2 to U. The corrosion resistance of the alloy in high temperature water is almost as good as that of Zr-2 and acceptable bonds can be produced between the Zr-2 fuel element end cap and the can wall and uranium. A disadvantage of this particular braze alloy is the high temperature (1050°C) required for melting and bonding. During brazing, the uranium at the end of the fuel element is heated into the gamma phase, resulting in some increase in grain size, and the jacket-uranium bond increases in thickness. A single post-brazing beta heat treatment will adequately refine the uranium grain size. Use of the U-2 w/o Zr alloy tends to minimize the increase in bond thickness. The status of the development and evaluation of the braze closure method is reported by Tverberg and Goffard in EW-65079.(1)

There has been no known fuel element irradiation experience with brazed end closures in high temperature coolant. A previous KER loop irradiation test⁽²⁾ authorized the irradiation of unalloyed natural uranium tubular elements with brazed end closures. It is doubtful that any information will be available from these elements before the enriched alloyed tube-and-tube elements are charged; probably the two types of material will be irradiated simultaneously. The combination of the two tests will permit an evaluation of the performance of the brazed closure during irradiation with three different fuel element tube sizes, a wide range of surface heat fluxes and coolant temperatures, (depending on the fuel element position in the process tube) two fuel enrichment levels, and a comparison of unalloyed and 2 w/o Zr alloyed fuel.

TEST DETAILS

1. Fuel Elements

The fuel elements consist of a 1.050 inch OD, 0.500 inch ID inner tube mounted concentrically in a 1.820 inch OD, 1.450 inch ID outer tube. The tubes are

- (1) Goffard, J. W. and J. C. Tverberg, Status of Brazed Closures for NPR Applications, EW-65079, May 6, 1960 (CONFIDENTIAL)
- (2) Kratzer, W. K., Supplement B, Production Test IP-309-A, Irradiation of Heavy Walled Tubular Elements In the KER Loops, EW-65581, June 8, 1960 (SECRET)

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seventeen inches long with 3/16 inch brazed and welded end caps. Some of the elements may be shorter than seventeen inches because of re-worked closures. In all cases, however, the inner tube will match the outer tube in length. Both inner and outer tubes have 0.020 inch coextruded Zircaloy-2 jackets and are supported at the ends by Zircaloy-2 semi-flexible supports.

The initial loadings under this production test will contain enriched U-2 w/o Zr alloyed elements. Availability of fuel elements in the future may require that some of the testing be done with unalloyed or natural uranium fuel. This test consequently authorizes the irradiation of the brazed tube-and-tube elements prepared from natural or unalloyed uranium.

The brazing procedure used in preparing the fuel elements consists of: a) chemically milling the ends of the pieces, b) cleaning, etching, and rinsing, c) loading powdered Zr-5 w/o Be braze alloy under and over the end caps, d) induction melting the braze alloy in vacuum, and e) cooling in vacuum or inert gas atmosphere. After brazing, the elements are welded, beta heat treated to refine the uranium grain size in the heat affected zone, and inspected and autoclaved according to standard procedures.

2. Operating Conditions and Tube Loading

The process tube loading and the operating conditions for this test, including temperature, pressure, and flow trip settings, will be specified by Process and Reactor Development Operation and approved by Process Technology Operation prior to charging. All operating conditions shall be in accordance with the appropriate process standards and normal loop operating practice. The coolant will be pressurized water with the pH adjusted to 10.0 ± 0.5 by the addition of LiOH.

The operating conditions shall be chosen so that surface boiling will not occur on the fuel elements during normal operation, burnout will not occur at the limiting trip conditions, and the maximum uranium temperature will not exceed 600°C.

The fuel elements authorized by this production test may be irradiated in conjunction with elements authorized by other tests provided the loading and operating conditions are in accordance with the restrictions imposed by this document. Coupon holders of a design approved by Coolant Testing Operation and Process and Reactor Development Operation may be included in positions not affecting test behavior.

3. Irradiation Facility

The fuel elements for this production test may be irradiated in any KER high temperature recirculating loop.

4. Exposure

The maximum exposure authorized by this production test is 3000 MWD/T for the brazed tube-and-tube elements.

5. Special Procedures

The fuel elements from this production test will be discharged into a special tray according to procedures developed by the KE Maintenance Operation.

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6. Priority

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

7. Costs

a. Cost Code - XXX-5320-XXX-54
b. Time

Elevator Time, Hours		Manhours	
Front	Rear		
1	1	7	7
2	4	10	14
3	5		

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.

8. Data Desired

Routine operating data, including coolant flow, inlet and outlet temperatures and pressure, system pressure, and operating time at temperature, will be taken during irradiation.

9. Hazards

As with any untried development in fuel fabrication, there may be some greater probability of failure with the brazed closed elements than with similar elements that have been tested extensively. The severity or consequences of a failure should be no greater than with other tube-and-tube elements.

RESPONSIBILITIES

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuel Fabrication Development Operation is responsible for the fabrication of the brazed tube-and-tube elements, 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:

- Operation of the KKR loops.
- Taking basic operating data.
- Scheduling the loop charge with the concurrence of the Processing Operation.
- Reactor safety and production continuity as they are affected by loop operation.

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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.
- c. Special discharges.

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

WK Kratzer:gb

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