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TITLE

PRODUCTION TEST IP-362-A, IRRADIATION OF HEAVY WALLED TUBULAR ELEMENTS WITH THICK OUTER JACKETS

AUTHOR

W. K. KRATZER

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PRODUCTION TEST IP-362-A, IRRADIATION OF HEAVY WALLED TUBULAR ELEMENTS WITH THICK OUTER JACKETS

OBJECTIVE

The objective of this production test is to evaluate the effect of a 36 mil Zircaloy-2 outer jacket on the behavior of heavy walled tubular elements during high temperature irradiation.

SUMMARY

Zircaloy-2 jacketed unalloyed natural uranium fuel elements nominally 1.43 inch OD, 0.52 inch ID, with 36 mil jackets on the outer surfaces will be irradiated in the KER Loops to an exposure not greater than 3500 MWD/T.

BASIS AND JUSTIFICATION

Several of the fuel element failures that have occurred during testing in the KER Loops have apparently resulted from localized jacket thinning on the external surfaces of high exposure elements. One of the methods proposed to prevent this failure mechanism was to increase the Zircaloy-2 jacket thickness on the fuel element outer surface. The fuel elements authorized by this production test have been prepared with nominally 36 mil external jackets. The behavior of these elements will be compared to the behavior of similar elements with 20 mil jackets currently being irradiated in KER-3.[1]

TEST DETAILS

1. Fuel Elements

   Each element consists of a single unalloyed natural uranium co-extruded Zircaloy-2 jacketed tube 16 inches long containing 15.5 inches of uranium. The elements are nominally 1.43 inch OD, 0.52 inch ID, with a 0.036 inch thick Zr-2 jacket on the outer surface and a 0.024 inch thick Zr-2 jacket on the inner surface. The ends are closed with 0.25 inch unbonded welded end caps. The fuel tube is supported at each end by three 1/4 inch wide semi-flexible iron supports mechanically held to the fuel element by 1/8 inch Zr-2 studs spot welded to the fuel element jacket. The studs pass through matching holes in the support and the protruding ends are friction heated and upset to hold the support in position.

   Each element is mounted in a Zr-2 flow distributing sleeve 1.90 inch OD, 1.75 inch ID, and 16 inches long. The sleeve is supported in the process tube by four semi-flexible iron supports at each end affixed in the same manner as the

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1. Kratzer, W. K. Production Test IP-309-A, Irradiation of Heavy Walled Tubular Elements in the KER Loops, HW-64183. March 7, 1960. (SECRET)

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supports on the fuel element. In addition, one or more of the sleeves will have a Zr-2 locking clip welded to the inner sleeve surface at one end. The locking clip, described in HW-66546,[2] will engage one of the fuel element supports and prevent relative longitudinal motion between the fuel element tube and the sleeve.

2. Loading

The tube loading planned for these elements is given in Table 1. The loading may be changed if a revised loading approved by Process Technology Operation and Process and Reactor Development Operation is provided prior to charging. Coupon holders of a design approved by Coolant Testing Operation and Process and Reactor Development Operation may be included in the charge in positions not affecting the fuel element test.

3. Irradiation Facility

The fuel elements may be irradiated in any KER high temperature recirculating loop. The loading and operating conditions given in this document are valid for Loops 2, 3, and 4. Irradiation in Loop 1 will require revised operating conditions applicable to this loop.

4. Operating Conditions

The coolant will be pressurized water with the pH adjusted to 10.0 $\pm$ 0.5 by the addition of LiOH. The low pressure trip will be set at 1500 psig. For a charge in Loops 2, 3, or 4, the desired operating flow is 60 gpm, the low flow trip will be set at 48 gpm, and the high outlet temperature trip, maximum operating outlet temperature, desired operating outlet temperature, and boiling point suppression trip given in Figure 1 will apply. Outlet temperatures at or below the maximum operating outlet temperature, Figure 1, may be specified at the discretion of the test author. For either a changed loading, or irradiation in KER-1, revised operating conditions approved by Process Technology Operation and Process and Reactor Development Operation will be provided prior to charging.

If recirculation with system pressures less than 1500 psig is required, the outlet temperature will be reduced and maintained at least 100°C below the system saturation temperature.

5. Power and Temperature Limits

The operating conditions have been 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.

6. Exposure

The maximum exposure authorized by this production test is 3500 MWD/T.

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2. Wheeler, R. G. Device for Locking Coaxial Nuclear Reactor Fuel Elements Together, HW-66546. July 28, 1960.

[redacted]

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7. 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.

8. Priority

Additional downtime is authorized if charging or discharging cannot be accomplished during a normal outage.

9. Costs

a. Cost Code: XXX-5R24-XXX.75

b. Time for each loading:

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

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.

11. Hazards

The probability of failure of the heavy walled tubular elements is about the same as for other charges of tubular elements irradiated in the KER Loops. The thicker Zr-2 jacket on the fuel element outer surface should reduce the probability of failure by the jacket thinning mechanism. The risk of process tube damage from hydriding in the event of a failure is practically eliminated by the presence of the Zr-2 sleeves around the elements.

RESPONSIBILITIES

Fuels Preparation Department

Engineering Section

Co-Extruded Products Engineering is responsible for co-extruding the fuel elements.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

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Fuels Development Operation

Fuel Element Design Operation is responsible for the heat-treatment, applying fuel supports, assembly, and testing of the 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:

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.

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.

W. K. Kratzer

W. K. Kratzer
Process and Reactor Development Subsection
Research and Engineering Section

WKK:kmn

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TABLE I

FUEL ELEMENT LOADING PATTERN

POSITION	NUMBER	MATERIAL
1	1	8" stainless steel triangular perf.
2-27	26	8" numbered cylindrical carbon steel spacers
28	1	8" stainless steel triangular perf.
29	1	16" fuel element
30	1	8" stainless steel triangular perf.
31	1	16" fuel element
32	1	8" stainless steel triangular perf.
33	1	16" fuel element
34	1	8" stainless steel triangular perf.
35	1	16" fuel element
36	1	8" stainless steel triangular perf.
37	1	16" fuel element
38	1	8" stainless steel triangular perf.
39-48	10	8" numbered cylindrical carbon steel spacers
49	1	8" stainless steel triangular perf.

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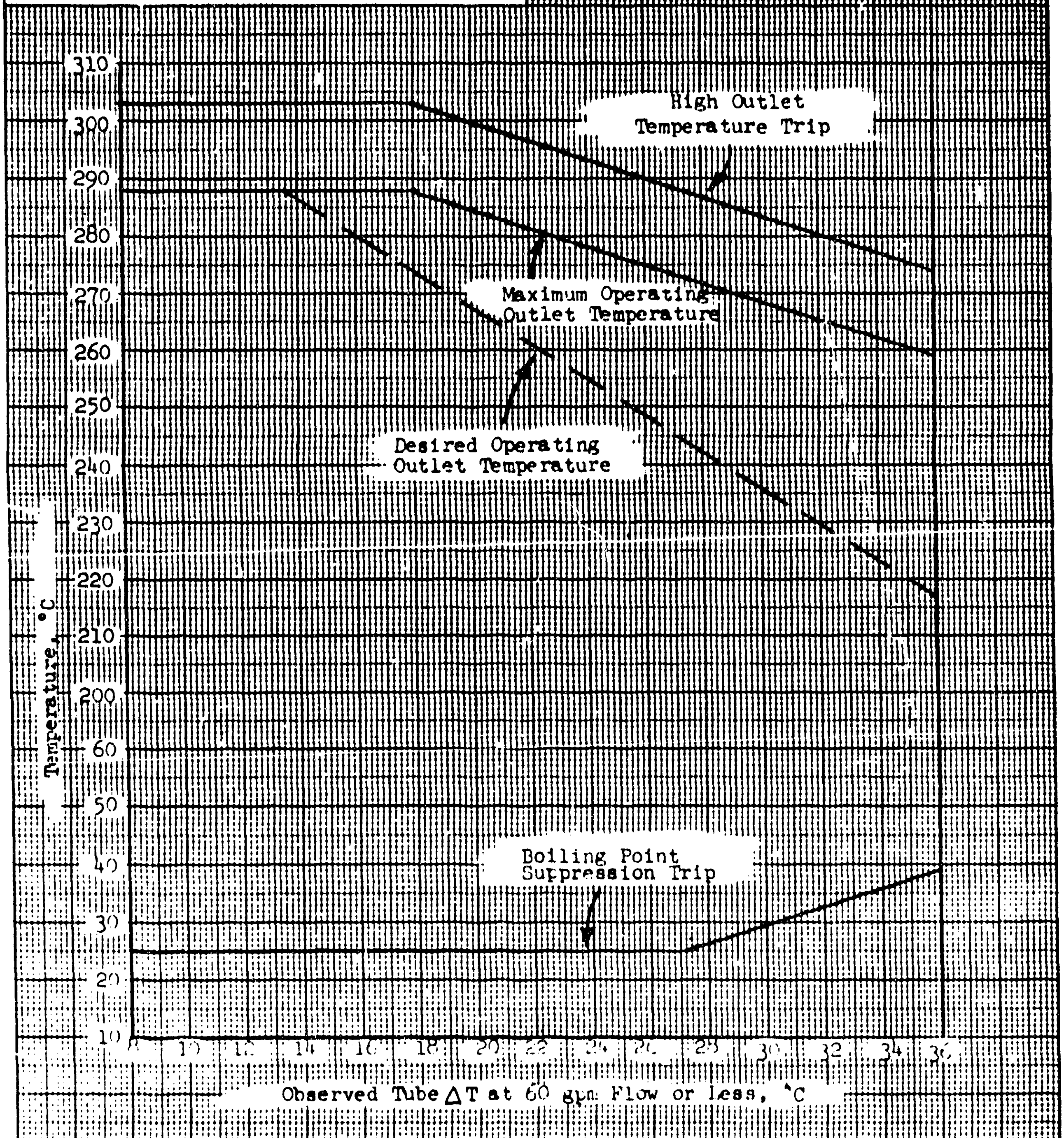
FIGURE I

Operating Temperatures and Trip Settings as a Function of the Observed Tube Δ T.



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APPROVALS

R. Nilson, Acting Manager
Process & Reactor Development Subsection
Research & Engineering Section
IRRADIATION PROCESSING DEPARTMENT

R. W. Reid, Manager
Process Technology Subsection
Research & Engineering Section
IRRADIATION PROCESSING DEPARTMENT

C. G. Lewis, Manager
Testing Operation
Research & Engineering Section
IRRADIATION PROCESSING DEPARTMENT

O. H. Greager, Manager
Research & Engineering Section
IRRADIATION PROCESSING DEPARTMENT

S. L. Nelson, Manager
KE Processing Operation
KE & KW Reactors Operation
IRRADIATION PROCESSING DEPARTMENT

R. S. Bell, Manager
KE & KW Reactors Operation
IRRADIATION PROCESSING DEPARTMENT

E. R. Astley, Manager
Applied Reactor Engineering
IRRADIATION PROCESSING DEPARTMENT

O. C. Schroeder, Manager
Manufacturing Section
IRRADIATION PROCESSING DEPARTMENT

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