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TITLE
PRODUCTION TEST IP-221-A, MEASUREMENT OF FLOW CHANNEL TEMPERATURES IN SEVEN-ROD CLUSTER ELEMENTS IN THE KER LOOPS

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PRODUCTION TEST 221
PRODUCTION TEST IP-122-A
MEASUREMENT OF FLOW CHANNEL TEMPERATURES IN SEVEN-ROD CLUSTER ELEMENTS IN THE KER LOOPS

MASTER

[redacted]

OBJECTIVE

The objective of this production test is to measure the coolant temperature in the internal and external flow channels of a column of seven-rod cluster elements to determine the amount of flow mixing that occurs between channels.

SUMMARY

Eight Zircaloy-2 jacketed natural uranium seven-rod cluster elements instrumented to measure flow channel temperatures will be irradiated to determine the amount of flow mixing between channels.

BASIS AND JUSTIFICATION

Off-site experimental work[1] has shown that little coolant mixing occurs between the flow channels in a close-packed cluster element. The inner flow channels of the seven-rod cluster elements irradiated in this production test should receive 41% of the power generated by the elements, and 16% of the total flow, provided no coolant mixing occurs between the channels. With such an unbalanced heat-flow split, the bulk outlet temperature is severely restricted by the high local water temperature in the inner channels. By measuring the coolant temperature in the inner and outer flow channels, the actual amount of inter-channel coolant mixing can be calculated. This information is needed for production test design and as a base for evaluating the effectiveness of a wire-wrap support system in promoting coolant mixing.

TEST DETAILS

1. Fuel Elements

The individual rods in the eight natural uranium Zircaloy-2 jacketed seven-rod cluster elements are 0.593 inches in diameter, 13 inches long, with 0.030 inch thick jackets. Each rod contains 11.4 inches uranium. The rods are assembled in a cluster with triangular end supports. The fuel elements have been visually examined, ultrasonically tested for jacket-uranium bonding, and autoclaved at 270°C and 2250 psig.

A stainless steel dummy seven-rod cluster element is used to maintain the channeled flow from the eight active elements and to position the thermocouples in the flow channels. By using the dummy element, which has the same external dimensions as the uranium clusters, temperature measurements can be made in relatively undisturbed flow channels without placing the thermocouples near a heat generating surface.

(1) D. A. Dingee and J. W. Chasten, "Heat Transfer from Parallel Rods in Axial Flow", U. S. A.E.C., November 1, 1956.

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2. Loading

The loading will consist of the thermocouple train downstream, eight seven-rod cluster elements, and various non-heat generating coupon holders or samples upstream, provided these samples have been authorized either by a supplement to this production test, or by a separate production test.

The thermocouple train will consist of twenty-seven eight-inch stainless steel spacers which support the thermocouple wires and the thirteen-inch stainless steel seven-rod cluster dummy to which the thermocouples are attached.

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 smaller process tube size.

4. Operating Conditions

The coolant will be pressurized water with a pH of 4.0 to 11.0. 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 then 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 tem-

[redacted]

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perature during normal operation; the fuel elements will not burn out at the limiting trip conditions(2), and bulk boiling will not occur in the tube. The maximum uranium temperature, as calculated, should not exceed 600°C at limiting trip conditions.

6. Exposure

The maximum exposure authorized for the fuel elements in this production test is 1000 MWD/T. It is not planned to leave this test in the reactor more than one or two operating periods, however, since the desired data can be obtained during two weeks of equilibrium operation.

7. Special Procedures

The fuel elements and thermocouple train will be charged from the rear face with the elements and thermocouple dummy aligned by the positioning pins on the elements. Detailed charge and discharge procedures, approved by KE Processing Operation and Coolant Testing Operation, which are similar to those used with previous thermocouple loadings in the KER Loops will be provided prior to charging.

8. Priority

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

9. Costs

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

b. Time

	Elevator Time, hours		Manhours
	Front	Rear	
Charge	1	3	10
Discharge	1	2	4
	2	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

(2) F. W. Van Wormer, "Burnout Limits in KER loops, Rod-and-Tube and Seven-Rod Cluster Fuel Elements, September 18, 1958.

[redacted]

taken during irradiation. Temperatures from the in-reactor thermocouples will be continously recorded.

11. Hazards

Failure of the cluster elements is improbable. The corrosion resistance of the Zircaloy-2 jackets, the high operating temperature, and the extended surface geometry should preclude either a jacket or a core failure. If a failure should occur, there is sufficient volume in the coolant channel to accommodate the uranium-water reaction products from a failure without process tube splitting.

RESPONSIBILITIES

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuels Design is responsible for the fabrication of the cluster elements, analysis of data, and issuance of technical reports.

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.

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 Operating.

Process and Reactor Development Operation is responsible for:

a. Technical aspects of the fuel element irradiation.
b. Analysis of fuel performance data and flow channel temperature 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.

W K Kratzer

Reactor Fuels Operation
Process & Reactor Development Operation
IRRADIATION PROCESSING DEPARTMENT

WK Kratzer:dgm

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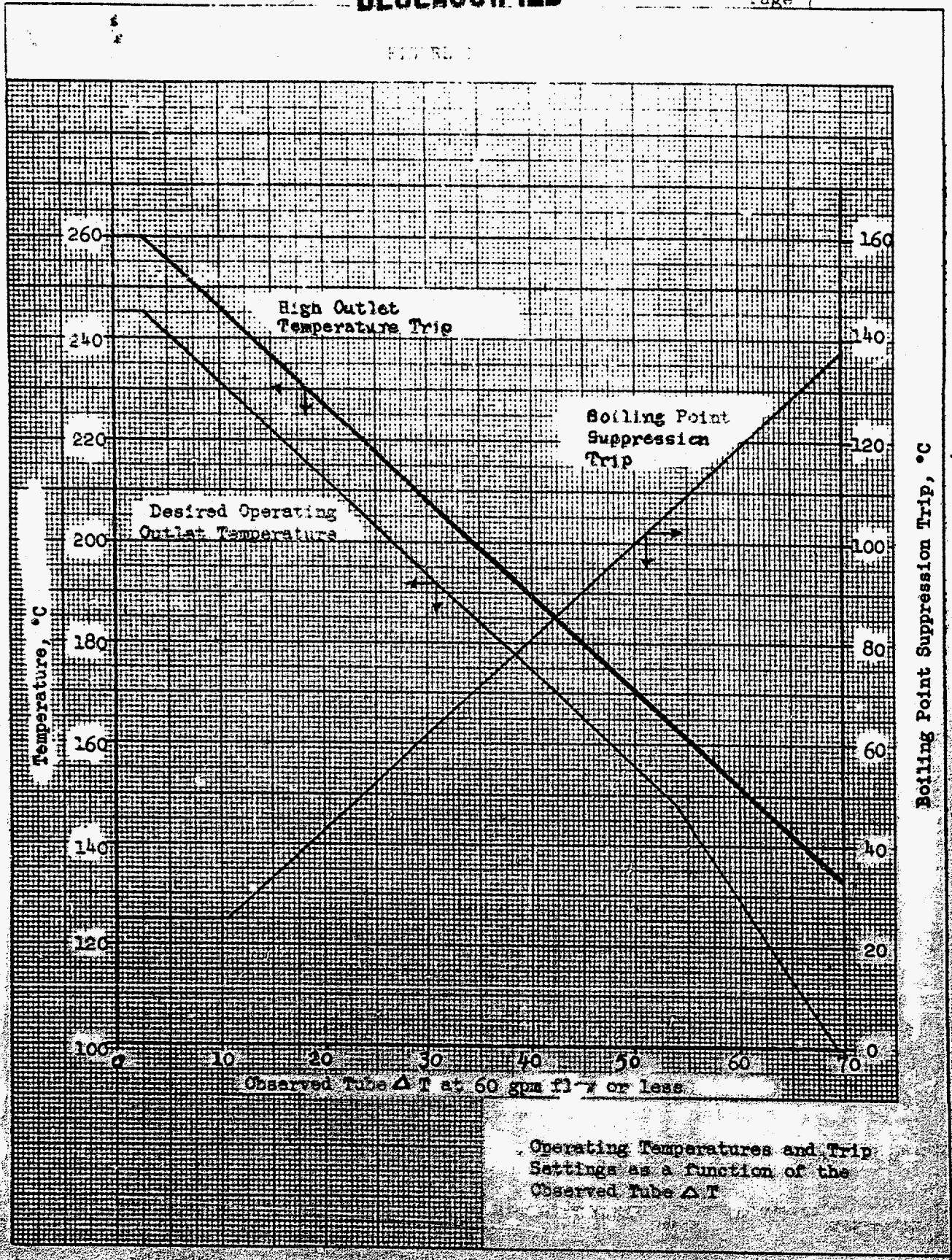

Operating Temperatures and Trip Settings as a function of the Observed Tube ΔT

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