Cover Sheet for a Hanford Historical Document Released for Public Availability

Released 1994

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

[redacted] (CLASSIFICATION)

DECLASSIFIED

DOCUMENT NO.

HW-58253

[redacted] SERIES AND COPY NO.

DATE [redacted]

November 24, 1958

GENERAL ELECTRIC

HANFORD A[redacted]MIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

[redacted]STRIC[redacted] DAT[redacted]
[redacted]S DO[redacted]NT CON[redacted] RESTRIC[redacted]ATA A[redacted]
[redacted]EFIN[redacted] THE [redacted]C ENER[redacted]T OF [redacted]
ITS [redacted]MITTA[redacted] THE DIS[redacted]RE OF [redacted]
CO[redacted]S IN A[redacted]NNER TO [redacted]AUTHO[redacted]
[redacted]N IS PR[redacted]TED.

OTHER OFFICIAL CLASSIFIED INFORMATION

THIS MATERIAL CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

TITLE

PRODUCTION TEST IP-214-A, IRRADIATION OF ENRICHED ZIRCALOY-2 JACKETED SEVEN-ROD CLUSTER ELEMENTS

AUTHOR

WK Kratzer

ISSUING FILE

CIRCULATING COPY
RECEIVED 100D AREA
NOV 26 1958
RETURN TO

TH[redacted]CUMEN[redacted]T NOT BE [redacted]NATTENDE[redacted]ERE AN [redacted]RIZE[redacted] TECHNICAL INFORMATION FILES [redacted]
[redacted] WHEN[redacted]IN USE, IT [redacted]E STORED [redacted] APPROVED[redacted]ED REP[redacted]ORY WITHI[redacted] APPR[redacted]
[redacted]RDED A[redacted] WHILE IT [redacted]UR POSSESS[redacted]AND UNTIL [redacted] HAVE O[redacted]NED A SIG[redacted]ECEIPT[redacted]M
[redacted]ASSIF[redacted]ILES, IT IS[redacted]R RESPONSI[redacted]TY TO KEE[redacted] AND ITS[redacted]TENTS WI[redacted]THE LIM[redacted] OF
THIS P[redacted]CT AND FROM[redacted] UNAUTHORIZ[redacted]ERSON. IT[redacted]NSMITTA[redacted], AND ST[redacted]E AT YOU[redacted]LACE
OF R[redacted]ENCE IS PRO[redacted]ED. IT IS [redacted] TO BE DU[redacted]ATED. IF[redacted]DITIONAL [redacted]IES ARE [redacted]IRED,
OBT[redacted]THEM FROM [redacted]RELATED ISS[redacted] FILE. AL[redacted]RSONS REA[redacted] THIS DO[redacted]ENT ARE RE[redacted]ESTED
TO[redacted]N IN THE SPA[redacted]ROVIDED BELO[redacted]

ROUTE TO:	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
~~[illegible]~~	~~469~~	762	12-1-58	WKer 12-1

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

C-3195-MS (7-55) AEC-GE RICHLAND, WASH.

[redacted] (CLASSIFICATION)

DECLASSIFIED

04/20/1994

[redacted]

DECLASSIFIED

DISTRIBUTION

1-2. AEC-HOO, Att: AT Gifford
3. FW Albaugh
4. WK Alexander
5. JA Ayres
6. JT Baker
7. RS Bell
8. JL Benson
9. WA Blanton
10. AG Blasewitz
11. RV Bowersock
12. RW Bown
13. RO Brugge
14. JJ Cadwell
15. AC Callen
16. TT Claudson
17. TL Deobald
18. RL Dickeman
19. DR Dickinson
20. RV Dulin
21. EA Evans
22. JM Fouts
23. FC Franklin
24. GC Fullmer
25. SM Gill
26. OH Greager
27. RE Hall
28. TM Hall
29. AK Hardin
30. WM Harty
31. ME Jackson
32. PC Jerman
33. WK Kratzer
34. RJ Lobsinger
35. WK MacCready
36. LH McEwen
37. NR Miller
38. MK Millhollen
39. JE Minor
40. JF Music
41. JG Myers
42. R Nilson
43. HM Parker
44. CA Priode/WG Albert
45. T Prudich/RE McGrath
46. RW Reid
47. RJ Shields
48. HG Spencer
49. JT Stringer
50. WL Swanson
51. JW Talbott
52. P Thompson
53. LD Turner
54. RE Trumble
55. FW VanWormer
56. PC Walkup
57. EC Wood
58. FW Woodfield
59. HF Zuhr
60. 300 Files
61. Record Center

November 24, 1958

This document consists of 9 pages. [redacted]

[redacted]

COPY 1 OF 1, [redacted]

This document classified by
E. C. Wood

PRODUCTION TEST IP-214-A, IRRADIATION OF ENRICHED ZIRCALOY-2 JACKETED SEVEN-ROD CLUSTER ELEMENTS

MASTER

OBJECTIVE

The objective of this production test is to obtain information about the behavior of Zircaloy-2 jacketed enriched uranium cluster elements during irradiation at high coolant temperatures. Specifically, this test should provide information about fuel element dimensional stability, suitability of the cluster support system, behavior of the uranium-Zircaloy-2 bond, and distortion of co-extruded rod with integral end closures.

[redacted]

[redacted]

SUMMARY

Four Zircaloy-2 jacketed enriched seven-rod cluster elements, one three-foot three-rod Zircaloy-2 jacketed enriched cluster element with integral end closures, and two eighteen-inch Zircaloy-2 jacketed wire wrapped cluster elements containing UO_2 will be irradiated at jacket surface temperatures up to 270° C in the KER loops to an exposure of 3500 MWD/T on the enriched seven-rod cluster elements.

BASIS AND JUSTIFICATION

Three types of extended surface fuel elements are being considered for high temperature use in an NPR---seven-rod cluster elements, rod-and-tube elements, and tube-and-tube elements. Development work is proceeding on all three types. One phase of the development program includes high temperature irradiation testing of sample fuel elements of each type to observe fuel element distortion, behavior of the support system, and changes in the jacket-uranium bond. This test provides the initial high temperature irradiation of Zircaloy-2 jacketed enriched seven-rod cluster elements. The distortion of enriched rod with integral end closures will also be investigated.

TEST DETAILS

1. Fuel Elements

The individual rods in the enriched 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 of 1.6% enriched uranium. The rods are assembled in a cluster with triangular end supports, as shown in figure 1. The fuel elements have been visually examined, ultrasonically tested for jacket-uranium bonding, and autoclaved at 270° C and 2250 psig.

The three-foot three-rod cluster element consists of 0.593 inch diameter rods, 38 inches long, containing 34 inches of 1.6% enriched uranium. The Zircaloy-2 jacket is 0.030 inches thick. The rods are supported at the ends and at the third points by flexible Zircaloy-2 supports. In addition to the inspections provided the seven-rod elements, the integral end closures have been X-rayed to verify the jacket thickness at the uranium-end cap junction and to insure that the end closure is free of uranium stringers. After final assembly and testing, the fuel elements will not be modified without the concurrence of Process and Reactor Development Operation.

The UO_2 fuel element consists of seven Zircaloy-2 jacketed rods assembled in a cluster with a 0.072-inch spacing between the rods. The rods are separated by Zircaloy-2 wire wrapped on a ten-inch pitch around the rods and the element is supported in the tube by 0.115-inch Zircaloy-2 wire wrapped around the cluster on a ten-inch pitch. Each rod is eighteen inches long with sixteen inches of fuel-swaged UO_2 of 85 to 87% theoretical density made from natural uranium. The clad rod is 0.560-inch O.D. with a 0.030-inch Zircaloy-2 jacket. The rods were X-rayed for weld integrity and autoclaved for seventy-two hours in 400° C, 1300 psi water.

2. Loading

The tube charge, listed from the downstream end of the process tube, is given in Table 1. All of the spacers and perfs will be made of stainless steel or Zircaloy-2. Coupon holders of equivalent strength and dimensions may be substituted in positions 3 to 18 and 31 to 38.

[redacted]

[redacted]

Table 1

Tube Loading

Position	Description
1	8" triangular spacer
2	8" triangular perf
3-18	8" triangular spacers
19	38" 3-rod cluster
20	18" 7-rod UO_2 element
21	8" triangular perf
22	18" 7-rod UO_2 element
23	8" triangular perf
24	13" 7-rod cluster
25	8" triangular perf
26	13" 7-rod cluster
27	8" triangular perf
28-29	13" 7-rod cluster
30	8" triangular perf
31-38	8" triangular spacers

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 I.D. 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 proces 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 2.
e. Desired operating outlet temperature - as shown in figure 2.
f. Boiling point suppression trip - as shown in figure 2.

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

[redacted]

[redacted]

DECLASSIFIED

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 trip conditions[1]; and bulk boiling will not occur in the tube. The maximum uranium temperature, as calculated, should not exceed the alpha-beta transformation temperature during operation.

6. Exposure

The goal exposure of the enriched seven-rod elements is 3500 MWD/T average exposure.

7. Special Discharge Procedure

The fuel elements from this production test will be discharged into a special tray and lowered to the basin to prevent fuel element damage which might obscure fuel element distortion occurring during irradiation. A detailed discharge procedure approved by Process and Reactor Development Operation, Coolant Testing Operation, and KE Processing Operation will be issued prior to the time of discharge. If the approved discharge procedure has not been issued, the fuel element 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 - XXXX.5320-XXX.14

b. Time

	Elevator Time, hours		Manhours
	Front	Rear	
Charge	3	2	4
Discharge	1	4	24
	4	6	28

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

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

1. F. W. Van Wormer, "Burnout Limits in KER Loops, Rod-and-Tube and Seven-Rod Cluster Fuel Elements", Sept. 18, 1958.

[redacted]

DECLASSIFIED

[redacted]

occur, there is sufficient volume in the coolant channel to accommodate the uranium-water reaction products from a failure without process tube splitting. The stability of UO_2 in high temperature water will prevent fuel element swelling or tube splitting if the UO_2 cluster element should fail.

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. This production test authorizes maximum uranium temperatures above 660° C - the alpha-beta transformation temperature. Although the production test design calculations indicate that the maximum uranium temperature should not exceed 660° C, the possibility always exists that the temperatures may actually go higher. For this reason, deviation from the Process Standard is authorized.

Maximum fuel temperatures of the UO_2 elements may exceed 2000° C at the center. Operation with oxide at these temperatures in both the MTR and the KER loops has given no difficulty.

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.

Ceramic Fuels Development Operation is responsible for fabrication of the UO_2 cluster element, 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.

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.

[redacted]

04/20/1994

[redacted]

DECLASSIFIED

KE-KW Reactor Operation

KE Processing Operation is responsible for:

a. Operational safety.
b. Special discharge procedure.
c. 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:lmb

[redacted]

04/20/1994

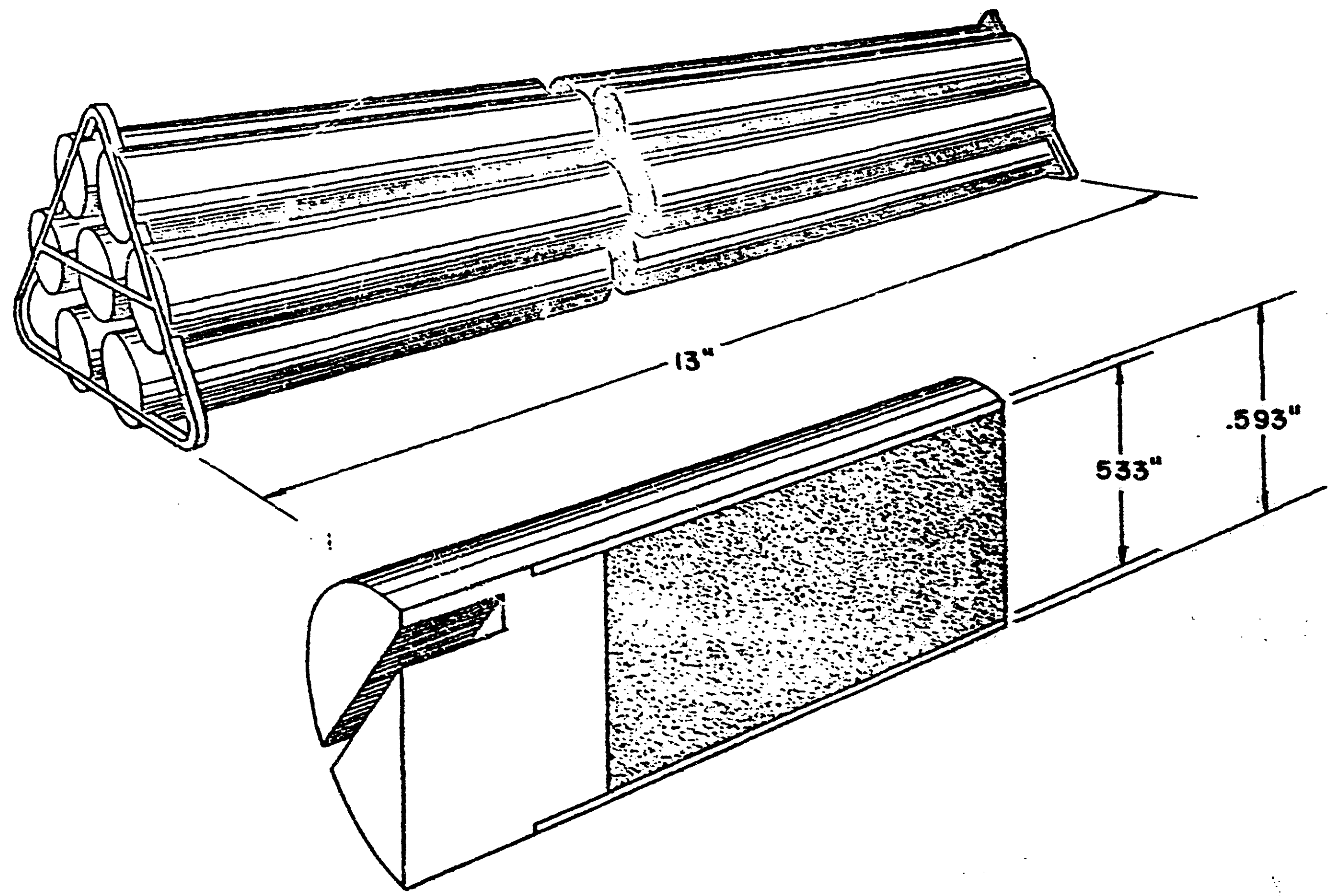

FIGURE I

ENRICHED 7 - ROD CLUSTER ELEMENT

[redacted]

DECLASSIFIED

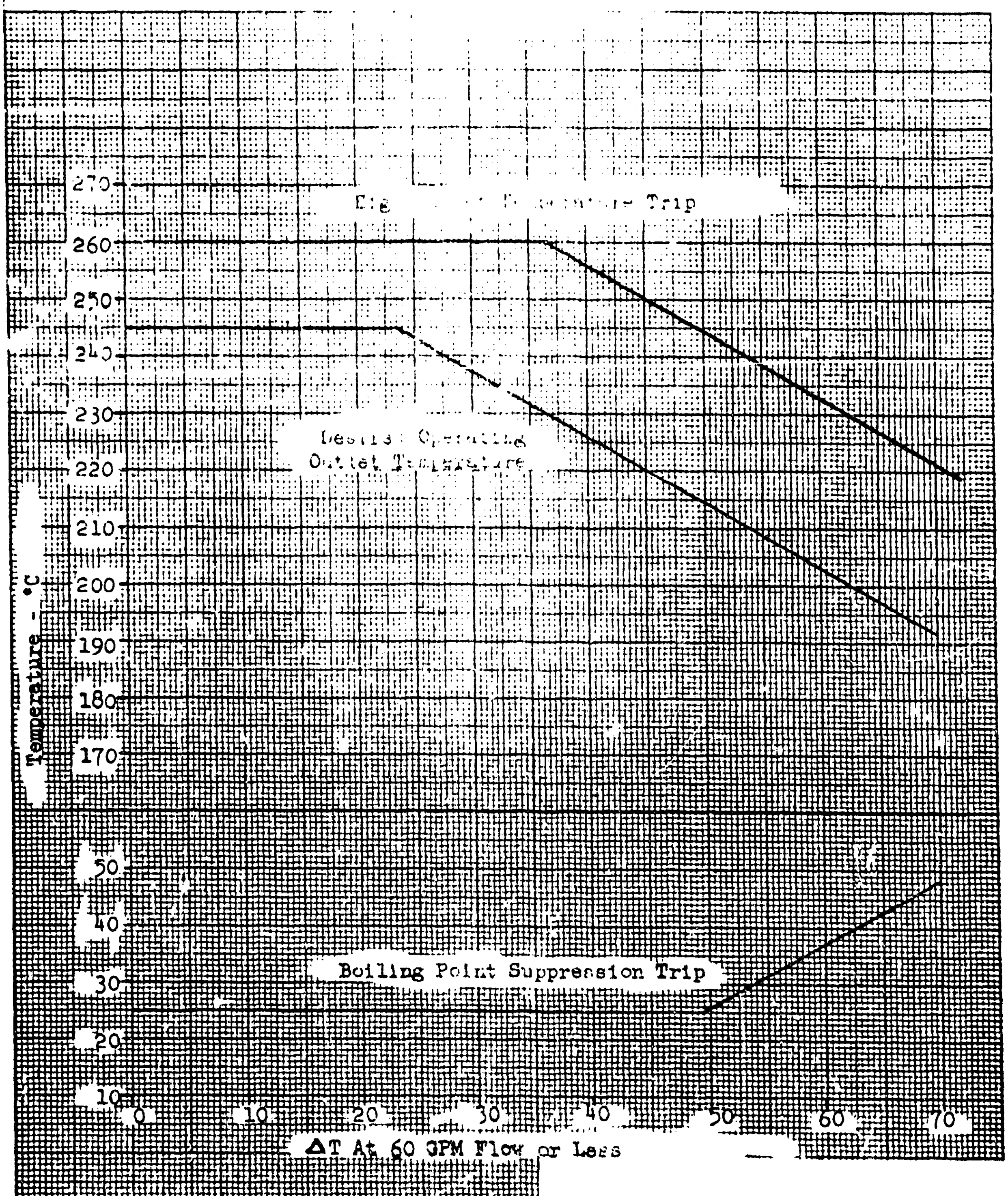

FIGURE 2

OPERATING CONDITIONS

[redacted]

BM-5300-040 (2-58)

04/20/1994

APPROVALS:

R. L. Dickeman, Manager
Process & Reactor Development Operation
IRRADIATION PROCESSING DEPARTMENT

J. F. Music, Manager
Process Technology Operation
IRRADIATION PROCESSING DEPARTMENT

M. E. Jackson, Supervisor
Coolant Testing Operation
IRRADIATION PROCESSING DEPARTMENT

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

R. S. Bell, Manager
KE-KW Reactor Operation
IRRADIATION PROCESSING DEPARTMENT

[redacted]

DATE
FILMED
7/5/94

END