AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

**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Historical Document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**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

~~DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED~~

DISCLAIMER

This is a **historical document** that is being released for public availability. This was made from the best available copy. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, 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.** The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

(CLASSIFICATION)

DECLASSIFIED

DOCUMENT NO.

HW-69378

SERIES AND COPY NO.

DATE

April 25, 1961

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

☒ **RESTRICTED**
THIS DOCUMENT 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

SUPPLEMENT G, PRODUCTION TEST IP-314-A,
MEASUREMENT OF FUEL ELEMENT TEMPERATURE
CHANGES AS THE RESULT OF FILM DEPOSITION

☐ **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.

AUTHOR

W. K. Kratzer

ISSUING FILE

CIRCULATING COPY
RECEIVED 100D AREA

MAY 2 1961

RETURN TO

THIS DOCUMENT IS NOT TO BE LEFT UNGUARDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN IN USE, IT MUST BE KEPT IN AN APPROVED REPOSITORY WITHIN THE PROJECT. WHEN GUARDED, WHILE IT IS IN POSSESSION AND UNTIL IT HAS BEEN OBTAINED A SIGNATURE RECEIPT IN CLASSIFIED FILES, IT IS THE RESPONSIBILITY OF THE PROJECT AND ITS CONTENTS ARE TO BE KEPT IN THE LIMITS OF THE PROJECT AND FROM UNAUTHORIZED PERSONS. TRANSMITTAL TO, AND STORAGE AT YOUR PLACE OF RESIDENCE IS PROHIBITED. IT IS NOT TO BE REPRODUCED. IF ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE RELATED ISSUING OFFICE. ALL PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:

PAYROLL NO.

LOCATION

FILES ROUTE
DATE

SIGNATURE AND DATE

ROUTE TO:

PAYROLL NO.

LOCATION

FILES ROUTE
DATE

SIGNATURE AND DATE

RECORD
COPY

DECLASSIFIED

Indefinite Retention

Disposal Date

Authority

Authority

MASTER

DECLASSIFIED

HW-69378

Page 1

DISTRIBUTION

1-2. AEC-HOO: RL Plumb	28. WK Kratzer
3. AEC-HOO: PM Midkiff	29. LE Kusler
4. FW Albaugh	30. GA Last
5. WK Alexander	31. CG Lewis
6. TW Ambrose	32. LH McEwen
7. ER Astley	33. NR Miller
8. JA Ayres	34. JE Minor
9. GF Bailey	35. SL Nelson
10. LV Barker	36. R Nilson
11. RS Bell	37. WA Oldham
12. WA Blanton	38. RE Olson
13. RW Bown	39. GF Owsley
14. JH Brown	40. CF Poor
15. JJ Cadwell	41. CA Priode
16. RL Call	42. T Prudich
17. WA Crossman	43. RW Reid
18. DR Dickinson	44. OC Schroeder
19. G Fiorelli	45. WR Smit
20. JM Fouts	46. HG Spencer
21. GC Fullmer	47. JT Stringer
22. SM Gill	48. GF Thomas
23. SM Graves	49. RE Trumble
24. OH Greager	50. FW Van Wormer
25. RE Hall	51. EE Weyerts
26. AK Hardin	52. FW Woodfield
27. PC Jerman	53. 300 Files
	54. Record Copy

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of RM-Hen

CG PR-2 2-28-94

By J E Savely 3-4-94

Verified By DK-Hanson 3-17-94

~~This document contains restricted information as defined by the Atomic Energy Act of 1954. Its transmission or the disclosure of its contents in any manner to an unauthorized person is prohibited.~~

This document classified by

FW Ambrose

This document consists of
12 pages, No. of
54 copies.

April 25, 1961

SUPPLEMENT G, PRODUCTION TEST IP-314-A,
MEASUREMENT OF FUEL ELEMENT TEMPERATURE CHANGES
AS THE RESULT OF FILM DEPOSITION

OBJECTIVE

The objectives of this supplement to PT-IP-314-A⁽¹⁾ are to authorize (a) a third thermocouple train to measure the temperature effect of film deposition subsequent to decontamination of a carbon steel system (b) the use of heater elements not previously authorized, and (c) performing a third decontamination of KER-1.

(1) Kratzer, W.K. Production Test IP-314-A, Measurement of Fuel Element Temperature Changes as the Result of Film Deposition, HW-64800. April 15, 1960 (SECRET)

DECLASSIFIED

DECLASSIFIED

HW-69378

Page 2

SUMMARY

Irradiation of a third thermocouple train with a thermocouple element of the same design as used on the previous two trains, but with different train design and heater elements, is authorized to an exposure no greater than 1000 MWD/T. A third decontamination of KER-1 is also authorized.

BASIS AND JUSTIFICATION

The test program of evaluating the temperature effect of crud film build-up on fuel element heat generating surfaces in a carbon steel system has three phases:

- a. Measurement of the effect of film build-up during normal high pH equilibrium operation.
- b. Measurement of the temperature effect of film build-up subsequent to a loop decontamination.
- c. Measurement of the effect of film build-up in the event of loss of pH control.

Phase (a) was completed with the first thermocouple train. Testing was interrupted by a failure in the loop, apparently in one of the heater elements, since careful examination of the thermocouple element in the Radiometallurgy Laboratory failed to show any signs of failure. A second train was charged and the loop decontaminated. Before meaningful film build-up data could be obtained, however, the thermocouple element failed at the cap-jacket weld. As well as could be determined by radiometallurgical examination, the failure was in no way connected with the decontamination.

After the failure of the second thermocouple element, two additional attempts were made to charge thermocouple trains. Both attempts were unsuccessful. Although the exact cause of the inability to insert the train into the process tube is not known, the design of the tubular spacers in the train and the inclusion of the heavy heater elements in the train appear to be responsible. The steps taken to insure successful charging of the current thermocouple train include: (a) a redesign of the train permitting separate charging of the heater elements, (b) modification of the spacer element design, and (c) more thorough pre-charging testing, including the charging and discharging of a complete tube loading through an out-of-pile mock-up tube and through KER-1. A second thermocouple train identical to the one to be used during reactor operation will be used for the trial discharges, since the thermocouple wires must be cut for this operation.

A thermocouple element of the same basic design as the first two irradiated will be used in this test. It has, however, been subjected to more rigorous nondestructive testing and examination than the others.

This Supplement to PT-IP-314-A authorizes the irradiation of a third thermocouple train to complete the last two phases of the test program.

TEST DETAILS

1. Fuel Elements

a. Thermocouple Element

The thermocouple element is a natural uranium rod coextruded with 0.020

DECLASSIFIED

HW-69378

Page 3

inch thick Zircaloy-2 cladding. The one inch O.D., twelve inch long finished rod is mounted concentrically in a 1.820 inch O.D., 1.450 inch I.D., sixteen inch long stainless steel sleeve. Five stainless steel sheathed thermocouples are mounted in the rod-sleeve assembly; three in the rod to measure center and edge uranium temperatures and two in the coolant annulus. The stainless steel thermocouple sheaths are attached to the Zircaloy-2 fuel element end cap by a stainless steel to Zr-2 eutectic braze joint. The fuel rod was checked by ultrasonic and eddy current methods for cladding thickness and bond layer integrity. All welds, both stainless steel and Zr-2, as well as the eutectic braze joints, have been radiographed and found to be sound. Voids were seen in the eutectic braze joints but they were small and isolated. There was sufficient continuous braze layer to provide an adequate barrier to water penetration.

After radiographic testing the thermocoupled fuel element was autoclaved for 48 hours in 400°C, 1500 psi steam.

b. Heater Elements

The heater elements will consist of natural uranium coextruded single tubes (KSN-3)⁽²⁾ sixteen inches and twelve inches long and 1.6% enriched single tubes (KSE-3) eighteen inches long. The tubes were extruded to a nominal 1.739 inch O.D. and 1.074 inch I.D. with 0.025 inch thick jackets. The 0.200 inch thick end caps are affixed by the brazing procedure described in HW-66807⁽³⁾. The end caps are brazed, faced, and fusion welded over the braze zone.

The fuel tubes are supported at each end by four 1/4 inch wide semiflexible iron supports mechanically held to the fuel element by 1/8 inch Zr-2 studs spot welded to the fuel element jacket.

Each element contains a 0.740 inch solid Zr-2 rod the same length as the fuel tube mounted concentrically in the fuel tube to provide balanced coolant flow over the two heat generating surfaces. The Zr-2 inner rod is held in position by three semiflexible Zr-2 supports spot welded to the rod at each end.

All heater elements have been nondestructively tested for jacket thickness and bonding, the closures have been ultrasonically tested for bonding, and the elements have been steam autoclaved.

2. Thermocouple Train

The thermocouple train consists of the thermocouple element in its 16 inch sleeve, one 16 inch tubular spacer, one 8 inch slotted triangular perf, twelve 16 inch tubular spacers, one 8 inch slotted triangular perf, one 8 inch tubular spacer, one 8 inch triangular perf, one 8 inch tubular spacer, and the 2 inch nozzle insert. The thermocouple wires pass from the thermocouple element through the spacer column and out through the pressure fittings

(2) Kusler, L.E. and W.K. Kratzer, Method for Designating Experimental Coextruded Zircaloy-2 Jacketed Fuel Elements, HW-67225, October 26, 1960 (CONFIDENTIAL-UNDOCUMENTED)

(3) Alexander, W.K., Preliminary Process Specification CX 707.0, HW-66807, November 1, 1960 (CONFIDENTIAL)

in the nozzle insert. Vibration of the wires at the nozzle insert is prevented by a protecting tube as shown in Figure 1.

The thermocouple train is held together by a 1/16 inch stainless steel cable joining the thermocouple element sleeve and the nozzle insert. This cable, which passes through the spacers with the bundle of thermocouple wires, is adjusted so that it, rather than the thermocouple wires, will be subjected to any tensile stress resulting from the force of the flowing coolant on the train or from pulling on the train. Use of the cable avoids the problem of requiring excessive slack in the thermocouple wires to accommodate the thermal expansion of the full tube charge.

3. Charge-discharge Procedure

a. Pre-charging Checks

In an attempt to insure capability of charging and discharging the thermocouple train, a series of tests will be applied to the actual thermocouple train or to an identical dummy train, depending on whether the test is destructive or not. A full length KER process tube has been set up out-of-pile and distorted until it presents the same resistance to passage of a 24 inch plug gauge as the in-pile process tube. The pre-charging checks consist of:

- 1) Charging the thermocouple train in the distorted mock-up tube, and removing the train.
- 2) Charging the dummy train in the distorted mock-up tube, charging the full column of heater elements and spacers in the other end of the tube, and then discharging the train and heater elements in the same manner as will be done in the reactor.

b. Charging Procedure

Charging the thermocouple train will require the thermocouple train and dummy train on the front elevator and the heater elements and spacers on the rear elevator. The procedure will consist of:

- 1) Charging the heater elements and spacers into the downstream end of the process tube.
- 2) Seating the heater elements against the rear cap.
- 3) Charging the dummy train into the upstream end of the process tube.
- 4) Discharging the entire column with a push pole from the front. The heater elements must be caught as they emerge from the process tube to avoid damage.
- 5) Charging the heater elements and spacers into the downstream end of the process tube; installing the rear nozzle insert and cap.
- 6) Seating the heater elements against the rear cap.
- 7) Charging the thermocouple train into the upstream end of the process tube.

DECLASSIFIED

HW-69378
Page 5

- 8) Installing the front cap.
- 9) Stringing the thermocouple lead wires across the front face of the reactor.
- 10) Pressure testing the process tube.

c. Discharging Procedure

Discharging the thermocouple train at the conclusion of the test period will require:

- 1) Hanging rupture shielding.
- 2) Installing the long hinged tip-off.
- 3) Pulling the front nozzle insert clear of the front nozzle and cutting the thermocouple wires and 1/16 inch cable.
- 4) Discharging the column with a push pole.

4. Loading

The fuel element loading is given in Table 1. Because of the potential for damage to the KSN3 and KSE3 heater elements during the trial charging, and because of the limited number of replacement elements available, this Supplement authorizes modification of the heater element loading pattern by rearranging or deleting some of the KSN3 or KSE3 elements provided the revised loading and operating conditions are approved by the managers of Process and Reactor Development Operation and Process Technology Operation prior to reactor start-up.

Any fuel elements authorized for irradiation in KER-1 may be used as heater elements provided the loading pattern and associated operating limits are approved by the managers of Process and Reactor Development Operation and Process Technology Operation prior to charging into the reactor.

5. Decontamination Procedure

The loop will be decontaminated using a two-step process in which the solution is recirculated around the entire loop. The solution used in both steps will be Turco 4512, a proprietary, inhibited phosphoric acid solution. In both steps, the solution will be maintained at $60^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The first step will continue for about twenty minutes; the second step for about ninety minutes.

After decontamination is completed, the loop will be drained and thoroughly rinsed with demineralized, deoxygenated water.

6. Operating Conditions

The operating conditions for the loading given in Table 1 are given in Figure 2.

In this figure, dashed lines indicate the desired operating temperature and trip settings needed to maintain the maximum uranium temperature below 660°C . In the absence of other information, the dashed lines will guide the selection

DECLASSIFIED

HW-69370
Page 6

of operating conditions. One of the thermocouples in the thermocouple element, however, indicates the maximum uranium temperature directly. Based on the thermocouple readings, the outlet temperature and trip settings may be set to exceed or fall short of the values designated by the dashed lines provided:

- a. The temperatures do not exceed the limitations set by the solid lines, which are based on the requirements that boiling will not occur on the fuel elements during normal operation and burnout will not occur at the limiting trip conditions.
- b. The maximum uranium temperature does not exceed 660°C .

During operation the coolant shall be pressurized water with the pH adjusted to not higher than 10.5 nor lower than 7.0, depending upon the phase of testing. The desired operating flow is 50 gpm with the low flow trip set at 40 gpm. The desired operating outlet temperature, high outlet temperature trip, and boiling point suppression trip for any loading other than the one in Figure 1 will be approved by Process and Reactor Development Operation and Process Technology Operation as noted above.

7. Exposure

The maximum exposure authorized for any elements in the fuel loading is 1000 MWD/T.

8. Costs

- a. Cost Code: XXX-5R24-XXX.73
- b. Time required:

	<u>Elevator time, hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge	4	4	20
Discharge	1	2	12
	5	6	32

- 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.

9. Hazards

Based on previous thermocouple train performance, fuel failure in the thermocouple train is obviously possible. Every step short of completely re-designing the thermocouple element, however, has been taken to insure that the element has no detectable defects. The heater elements have good jacket thickness uniformity and the Be-Zr brazed closures have been inspected and corrosion tested. There is no reason to assume that the closures would fail as the result of exposure to either the coolant or the decontaminating solution.

An upstream thermocouple train has been tried only one time before in the KER loops. The thermocouple wires broke at the front nozzle insert because of vibration of the wires in the front nozzle. The protecting tube arrangement shown in Figure 1 should prevent this from happening on the current train.

DECLASSIFIED

HW-69378

Page 7

Another potential hazard of the upstream thermocouple train exists in the five pressure fittings in the nozzle insert through which the 1/16 inch diameter thermocouple wires pass out of the process tube. A leak in one of the pressure fittings would require low pressure or single pass operation; however there would be no risk of loss of flow since the holes in the nozzle insert are only 1/16 inch diameter.

Continuing tests of the decontaminating solution planned for use in KER-1 give assurance that a third decontamination of KER-1 will in no way damage the loop.

10. Other Aspects of the Production Test

All requirements of the original production test and approved supplements not specifically modified by this supplement will remain in effect.

RESPONSIBILITIES

Fuels Preparation Department

Engineering Section

Coextruded Products Engineering is responsible for fabricating the heater elements.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuel Element Design Operation is responsible for fabrication of the thermocouple element assembly, analysis of data, and issuance of technical reports.

Materials Development Operation

Coolant System Development Operation is responsible for assembly of the thermocouple train, providing and maintaining the thermocouple leads, junctions, and temperature recorders, 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

DECLASSIFIED

HW-69378

Page 8

RESPONSIBILITIES (cont'd)

Process and Reactor Development Operation is responsible for:

- a. Technical aspects of the fuel element irradiation, including effect of the fuel elements on reactor safety.
- 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.

W. K. Kratzer
Process and Reactor Development
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

WKK:gb

FIGURE 1
NOZZLE INSERT AND THERMOCOUPLE WIRE
SUPPORTING TUBE FOR UPSTREAM THERMOCOUPLE TRAIN

DECLASSIFIED

DECLASSIFIED

HW-69378
Page 10

TABLE I

FUEL ELEMENT LOADING FROM THE DOWNSTREAM END
OF THE PROCESS TUBE

<u>Position</u>	<u>No. of Pieces</u>	<u>Description</u>
1	1	8 inch perf
2-16	15	8 inch spacers
17	1	8 inch modified triangular perf
18	1	18 inch KSE3 element
19	1	12 inch KSN3 element
20	1	8 inch modified triangular perf
21	1	12 inch KSN3 element
22-23	2	8 inch modified triangular perfs
24	1	16 inch KSN3 element
25	1	8 inch modified triangular perf
26-30	5	8 inch spacers
31	1	8 inch modified triangular perf
32	1	16 inch KSN3 element
33	1	8 inch modified triangular perf
34		Thermocouple train in upstream end of the process tube.

FIGURE 2

OPERATING CONDITIONS AND TRIP SETTINGS
FOR THE LOADING GIVEN IN TABLE 1.

DECLASSIFIED

DECLASSIFIED

APPROVALS

J. H. Brown, Manager
Process and Reactor Development Subsection
IRRADIATION PROCESSING DEPARTMENT

R. W. Reid, Manager
Process Technology Subsection
IRRADIATION PROCESSING DEPARTMENT

C. G. Lewis, Manager
Testing Operation
IRRADIATION PROCESSING DEPARTMENT

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

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

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

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

C. Schroeder, Manager
Manufacturing Section
IRRADIATION PROCESSING DEPARTMENT

**DATE
FILMED**

6/22/94

END