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

PRODUCTION TEST IP-601-D:
EVALUATION OF CRUD-FORMING CHARACTERISTICS OF
KER LOOP COOLANT CONTAINING NH₄OH FOR pH CONTROL

By

DECLASSIFIED

R. Neidner

August 6, 1963

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of D S Lewis

CG-PR-2, 3-25-94

By J E Savely 4-16-94

Verified By Gerrit Maly, 4-18-94.

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

NOTICE

This report was prepared for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1) - 1350, and any views or opinions expressed in the report are those of the author only. This report is subject to revision upon collection of additional data.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

DECLASSIFIED

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

HW-78552
Page 2

DISTRIBUTION

1-2. AEC-RL00: RL Plum	27. WK Kratzer
3. AEC-RL00: PM Midkiff	28. GA Last
4. AEC-RL00: CN Zangar	29. LC Lessor
5. FW Albaugh	30. MC Leverett
6. DG Albertson	31. CG Lewis
7. TW Ambrose	32. DW Leiby
8. ER Astley	33. JE Minor
9. JA Ayres	34. R Neidner
10. LV Barker	35. RH Nelson
11. RS Bell	36. R Nilson
12. CE Bowers	37. RD Widrig
13. RW Bown	38. CA Priode
14. GN Brown	39. T Prudich
15. RO Carlson	40. RW Reid
16. RG Clough	41. JW Riches
17. WA Crossman	42. DL Condotta
18. TW Evans	43. OC Schroeder
19. VF Fitzpatrick	44. HG Spencer
20. GC Fullmer	45. RE Trumble
21. SM Gill	46. FW Van Wormer
22. JW Goffard	47. OJ Wick
23. AB Greninger	48. MJ Wise
24. JL Guthrie	49. 300 Files
25. AK Hardin	50. Record Copy
26. PC Jerman	

This document classified by:

C. G. Lewis

This document consists of 12
pages, [REDACTED]

August 6, 1963

PRODUCTION TEST IP-601-D EVALUATION OF CRUD-FORMING CHARACTERISTICS OF KER LOOP COOLANT CONTAINING NH₄OH FOR pH CONTROL

I. Objective

The objective of this production test is to characterize the effects of NH₄OH as a pH control agent in a recirculating, high temperature and pressure water system having NPR characteristics. Of particular interest is the crud forming and decomposition characteristics of NH₄OH at potential NPR conditions.

DECLASSIFIED

HW-78552
Page 3

August 6, 1963

II. Basis and Justification

LiOH has been used extensively for coolant pH control in the primary systems of high pressure, high temperature, water-cooled power reactors and in-reactor loops. From 1957 to 1963, LiOH has been used for pH control of the KER loops during high pH operation, and current plans for N Reactor call for using LiOH for primary system pH control.

Despite its demonstrated suitability for many pH control applications, LiOH has a serious potential disadvantage. In a Zr-2 system, concentration of LiOH in crevices by boiling or leaks from the system can lead to rapid corrosive attack of the Zr-2⁽¹⁾. Such concentrations might occur in the N Reactor primary system at the crevice between the fuel element and fuel element support in the event of fuel element nucleate boiling and at the Zr-2 process tube nozzle-rolled joint if a leak should develop at this location.

Primary coolant with the pH adjusted with NH_4OH is inherently free from corrosive attack of Zr-2 caused by caustic concentration in crevices because NH_4OH vaporizes without concentrating at any point where the coolant vaporizes. On this basis, NH_4OH would be an ideal substitute for LiOH in the N Reactor primary system. The behavior of NH_4OH in high pressure, high temperature coolant has not been completely characterized, however. Principal areas of uncertainty include rate of radiolytic and thermal decomposition of NH_4OH , corrosion effects of decomposition products, and crud-forming characteristics during steady operation, periods of variable pH, and subsequent to system decontamination. The stability, corrosion characteristics, and crud-forming characteristics of NH_4OH during steady operation are being evaluated in the KER loops.^(2,3) The purpose of this production test is to evaluate the crud-forming behavior of NH_4OH during periods of variable pH and after a system decontamination.

III. Summary

This document authorizes:

- A. Use of NH_4OH for pH control in KER-1 with pH varying between 7.0 and 10.5.
- B. Decontamination of KER-1 to provide clean carbon steel piping surfaces to simulate "worst case" crud-forming characteristics.
- C. Use of UO_2 , stainless steel jacketed thermocouple elements in KER-1 during the test to measure the temperature effect of crud deposition on heat generating surfaces in the active zone.

DECLASSIFIED

HW-78552
Page 4

August 6, 1963

IV. Test Details

A. Fuel Elements

1. Heater Elements - Standard 17-inch N Reactor inner fuel elements in Zr-2 sleeves having either bonded or unbonded end closures as authorized by PT IP-536-A and Supplement A (4,5) will be used in the process tube loading to provide heat for each charge.
2. Thermocouple and Crud Deposition Fuel Elements - The specially designed fuel elements to monitor for the presence and rate of crud filming will contain a 4.5 per cent enriched core of 65 per cent theoretical density UO_2 , encased in a thick wall 310 stainless steel jacket. Three longitudinal thermocouple wells are drilled in the jacket, 120 degrees apart, with the thermocouples mechanically sealed in the wells by modified Swagelok fittings. A drawing of this element is given in Figure I, H-1-33591. So that crud deposition characteristics can be studied on Zr-2 surfaces, as well as on stainless steel, special elements to study both materials will be used. To obtain the Zr-2 surface, a shrink-fit Zr-2 sleeve will be fitted over the stainless steel jacket. Either arrangement is authorized by this production test.

Fabrication of the fuel pieces will be by pneumatic hammer packing of a selected blend of UO_2 powders to achieve the desired 65 per cent theoretical density. End cap closure will be made by the standard TIG process. The completed elements will be helium leak tested and visually inspected to assure thermocouple well alignment and weld integrity.

This production test authorizes the following alternative loadings for the above thermocouple elements: (1) the use of two elements, one located upstream and one downstream of the remaining fuel charge; (2) the use of one element, either in the upstream or downstream location; or (3) no thermocouple element upstream or downstream.

In addition to the thermocouple monitored fuel elements, with or without Zr-2 sleeves, this production test also authorizes the irradiation of similar non-instrumented fuel pieces. These non-instrumented fuel pieces will vary from the instrumented ones only by the absence of the three thermocouples and the re-enforcing flange around the end of the jacket. All other materials and fabrication techniques will be identical.

B. Spacers and Coupon Holders

Carbon steel spacers, H-1-33507, and stainless steel spacers, H-1-20543, authorized by PT IP-536-A will be used for tube loadings of this production test. Coupon holders of a design shown in H-1-33584 and SK-1-23419 authorized by PT IP-567-D are also authorized for use in tube loadings of this production test.

DECLASSIFIED

HW-78552
Page 5

August 6, 1963

C. Thermocouple Train

The thermocouple trains are composed of four stainless sheathed thermocouples threaded through a series of spacers, three of which terminate in the cladding of a special fuel element and the fourth in the coolant stream adjacent to the element end cap. The over-all length of a train assembly is approximately 234 inches. The various components of the train are as follows, starting from the nozzle end: a special nozzle plug, two perforated tubular spacers, two slotted triangular spacers, ten tubular spacers, one triangular spacer, one triangular coupon holder and the special thermocouple fuel element. Attached to the nozzle plug assembly is a 1/16-inch diameter stainless steel rope which parallels the thermocouple leads and is fastened to the fuel element. The wire rope eliminates tensile stress on the upstream thermocouple leads which otherwise would be imposed on the leads during irradiation. The diagonally slotted triangular spacers are designed to be fitted into the assembly during charging. This technique allows for train flexibility during pre-insertion handling. The train assembly is shown in Figure II, H-1-34044.

D. Loading

The tube loadings shall consist of fuel elements and components authorized by this production test. Detailed tube loadings will be given in a document approved by the Managers of the Testing, Process and Reactor Development, and the Process Technology Subsections prior to charging.

E. Irradiation Facilities

The test samples and components authorized by this production test may be irradiated in the KER-1 loop, tube 2160.

F. Operating Conditions

All operation will be in accordance with the Reactor Process Standards applicable to the KER-1 loop and with normal loop operating practice.

The coolant will be pressurized water with the pH controlled between 7.0 and 10.5 by the addition of either LiOH or NH₄OH. The low pressure trip will be set according to the applicable Process Standard. The desired operating flow is 36,000 #/hr with a low flow trip set according to the applicable Process Standard. The high outlet temperature trip, maximum operating outlet temperature, desired operating outlet temperature, and boiling point suppression trip will be given for each loading in a document approved by the Managers of the Testing, Process and Reactor Development, and Process Technology Subsections prior to charging.

DECLASSIFIED

HW-78552

Page 6

August 6, 1963

If recirculation with system pressures less than those specified by the Process Standards is required, the outlet temperature will be reduced and maintained at a temperature such that fuel surface temperatures will be less than the coolant saturation temperature and local channeled coolant temperatures are sufficiently below the coolant saturation temperature to preclude sub-cooled burnout. Outlet temperature values to satisfy this requirement will be provided by the test author in a document approved by the Managers of the Testing, Process and Reactor Development, and Process Technology Subsections prior to charging.

G. Power and Temperature Limits

The operating conditions will be chosen so that surface boiling will not occur on any of the fuel elements during normal operation, sub-cooled burnout will not occur at the limiting trip conditions, and the maximum heater element uranium temperature will not exceed 600 C.

H. Exposure

The maximum exposure authorized for the thermocouple elements is 4000 MWD/T (of enriched U), approximately 75 equivalent days of full power operation. The maximum exposure for the heater elements is 2500 MWD/T.

I. Charge-Discharge Procedure

1. Pre-charging Checks - The assembled thermocouple train will be charged in a distorted KER sized mock-up tube to assure capability of charging and then pressure tested at 4000 psi cold in a pressure tube to verify the tightness of the pressure fittings.
2. Charging Procedure - One thermocouple train will be taken to the rear work platform and the other to the front. The two UO₂ non-instrumented elements, the heater elements, spacers, and coupon holders will be charged from the front. The downstream thermocouple train will be charged first, into the rear of the process tube, and the nozzle cap installed. The balance of the tube charge will then be charged from the front. After the upstream thermocouple train has been charged, the nozzle will be replaced and the tube pressure tested.
3. Discharge Procedure - Sheet metal rupture shielding will be hung to prevent the thermocouple wires from becoming entangled with the rear tube hardware. The rear nozzle cap will be removed, the thermocouple train pulled out a few inches, and the nozzle insert cut off and saved. The long hinged tip-off will then be mounted on the rear nozzle. The front nozzle cap will then be removed and the upstream train pulled out a few inches, the insert cut off and saved. The tube charge will then be discharged directly into the basin.

DECLASSIFIED

HW-78552

Page 7

August 6, 1963

J. Decontamination

During the period required to perform this production test, decontamination of the loop will be accomplished as required. Prior to initiating a loop decontamination, the procedure and agents involved will be documented and approved by the Managers of the Testing, Process and Reactor Development, and Process Technology Subsections.

K. Priority

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

L. Costs

1. Cost Code - XXX-5R53-XXX.1A

2. Time for Each Loading

	Work Platform Time Hours	Man-hours
Normal charging	2	6
Thermocouple discharging	2	8

M. Data Desired

1. Coolant Testing - Routine operating data will be required in addition to element thermocouple readings.
2. KE Processing - Spline flux traverse will be requested in tubes adjacent to KER-1 when these measurements can be made.
3. Component Testing - Detailed fuel element post-irradiation examinations will be requested by the test sponsor for each charge.

N. Hazards

The principal hazard associated with this test is an unscheduled reactor outage resulting from either a heater or thermocouple element failure. Irradiation of the heater elements in Zr-2 sleeves should preclude damage to the process tube if fuel failure should occur. The thermocouple elements have a relatively large flow annulus, about 3/10-inch, which would allow for any unlikely swelling in the event of a cladding failure.

The thermocouple well in the thick cladding will be located so that there will be greater than .100 inch steel between the well and the fuel. Should a thermocouple seal fail, the fuel will be adequately protected from the flooded thermocouple well. In the event a crud probe element, instrumented or uninstrumented should sustain a fission break, no further irradiation of crud probe elements will be permitted by authorization of this PT.

DECLASSIFIED

HW-78552
Page 8

August 6, 1963

V. Responsibilities

Irradiation Processing Department

Research and Engineering Section

Testing Subsection has over-all responsibility for the production test, including safety and adequacy of the test elements, test design, and special equipment and procedures needed for the test.

Component Testing is responsible for post-irradiation examination of heater elements in the test charge while in the 105 Building.

Coolant Testing is responsible for:

1. Operation of the KER loop
2. Taking basic operating data
3. Scheduling the loop charge with the concurrence of KE Processing
4. Reactor safety and production continuity as they are affected by loop operation

Manufacturing Section

KE-KW Reactor Operation

KE Processing is responsible for special discharges.

Hanford Laboratories Operation

Engineering Development Operation

Coolant Systems Development Operation is responsible for:

1. Providing detailed procedures for water quality changes and control and the analyses of temperature and water quality data
2. Supplying the thermocouple trains and the instrumented and non-instrumented crud probe elements

N Reactor Department

N Reactor Fuels Section

DECLASSIFIED

HW-78552
Page 9

August 6, 1963

N Fuel Products Engineering Subsection

Product Development and Specifications Unit is responsible for supplying, measuring, and maintaining records of the heater elements.

R Neidner

Engineer, Testing

R Neidner:pb

References

1. WK Anderson and MJ McGott, Corrosion of Zircaloy in Crevices Under Nucleate Boiling Conditions, KAPL 2203, April 13, 1962
2. WK Kratzer and MJ Wise, Supplement B, Production Test IP-477-A, Irradiation of N Reactor Fuel Elements in KER Loops 3 and 4, HW-75772, November 29, 1962 (Secret)
3. WK Kratzer and MJ Wise, Supplement C, Production Test IP-536-A, Irradiation of N Reactor Inner Fuel Tubes in KER Loops 1 and 2, HW-75773, November 29, 1962 (Secret)
4. WK Kratzer, Production Test IP-536-A, Irradiation of N Reactor Inner Fuel Tubes in KER Loops 1 and 2, HW-75280, October 16, 1962 (Secret)
5. WK Kratzer, Supplement A, Production Test IP-536-A, Irradiation of N Reactor Inner Fuel Tubes in KER Loops 1 and 2, HW-75298, October 17, 1962 (Secret)

DECLASSIFIED

HW-78552
Page 10

August 6, 1963

Approvals

C. G. Lewis

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

T. W. Ambrose

T. W. Ambrose, Manager
Process & Reactor Development Subsection
IRRADIATION PROCESSING DEPARTMENT

R. W. Reid

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

O. H. Greager

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

R. G. Clough

R. G. Clough, Manager
KE Processing Operation
IRRADIATION PROCESSING DEPARTMENT

R. S. Bell

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

E. R. Astley

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

O. C. Schroeder

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

A

B

C

D

E

F

G

TACK WELD (TYP)

1 ASSEMBLY

6 304L SST 22 GA (.081)

2 310 SST

310 SST
310 SST
310 SST

QTY.	RE	DESCRIPTION	MATL.
X	1	ASSEMBLY	
1	2	BODY	
1	3	CLADDING	
1	4	END CAP 1/4" DIA X 1/4" THK	316 SST
3	5	WIRE CONNECTOR (MODIFY AS SHOWN)	
6	6	SUPPORT	
AS REQ	7	UO ₂ POWDER 6.5% ENRICHED 98% DENSITY

TYP 3 PLACES EQ
SP ON PERIPHERY

NOTES

1. TOLERANCES: FRACTIONAL $\pm \frac{1}{64}$ DECIMAL ± 0.005 ANGULAR $\pm 0^{\circ}30'$
2. ALL MACHINED SURFACES $\sqrt{16}$
3. ALL MATERIAL TO BE AS SPECIFIED OR APPROVED EQ

3 ZR₂

EXISTING THDS

EXISTING HOLES

5 SWAGELOK 100-1-2-316

H-1-33591

1/1

APPROVED FOR DESIGN DATE: 1/1/76 BY: J. J. PATRICK		APPROVED FOR MANUFACTURE DATE: 1/1/76 BY: J. J. PATRICK	
SCALE: NONE		THERMOCOUPLE ELEMENT SST MARK I	
DRAWN BY: J. J. PATRICK CHECKED BY: J. J. PATRICK DATE: 1/1/76		H-1-33591	
NONE		H-1-33591	

7 6 (REV) REV PART 2 0.05% DENSITY 0.05% DENSITY		0.05% DENSITY 0.05% DENSITY	
0.05% DENSITY 0.05% DENSITY		0.05% DENSITY 0.05% DENSITY

RANGEMENT

9'-7" (REF)

QTY.	NO.	DESCRIPTION
X	1	ARRANGEMENT, THERMOCOUPLE TRAIN
X	2	ASSEMBLY, NOZZLE PLUG
1	3	THERMOCOUPLE ELEMENT
2	4	FLOW SPACER (DEEP) BY CUSTOMER
2	5	TRIANGULAR SLOTTED SPACER
1	6	TRIANGULAR SPACER
1	7	8" TRIANGULAR COUPON HOLDER, BY CUSTOMER
10	8	16" TUBULAR SPACER, C STL
1	9	NOZZLE PLUG
2	10	ROD, 2" x 1/2" SST
1	11	TUBING, 1/2" OD x .095 WALL x 64 LB, SST
1	12	TUBING SUPPORT,
AD	13	CABLE, 1/4" DIA SST

GENERAL NOTES

UNLESS OTHERWISE SPECIFIED;

1. TOLERANCES: FRACTIONAL $\pm \frac{1}{64}$ DECIMAL ± 0.005

2. FINISH $\sqrt{16}$ (AIA B46.1-1962)

3. ALL MATERIAL TO BE AS SPECIFIED, OF APPROVED EQUAL QUALITY.

5 AS SHOWN
304 SST x 1/8 THK.

6 AS NOTED

3-1/16" MILLED SLOT
EQ. SA

SECTION A-A

22 GA (.031)
SST 900 SERIES

3

H-1-34044 1/10

APPROVED FOR CONT. APPROVED FOR PURCHASE APPROVED FOR REVISION DATE 7/1/63		U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION THERMOCOUPLE TRAIN ARRANGEMENT NDR SUPPORT 105 KE 1303 H-1-34044 1/1	
SCALE 1/4" = 1" DRAWN BY CHECKED BY DATE 7/1/63		NONE	

DATE

FILMED

8/11/94

END