OAK RIDGE NATIONAL LABORATORY

Operated by

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

Post Office Box X
Oak Ridge, Tennessee

MASTER OCT 20 1958

~~For Internal Use Only~~

ORNL
CENTRAL FILES NUMBER

58-10-44

COPY NO. 15

DATE: October 3, 1958

SUBJECT: Transfer of Initial Fuel from the HRT and
Recovery of the Associated Heavy Water

TO: S. E. Beall

FROM: R. H. Winget 6083 6076

SUMMARY

The initial HRT fuel charge, contaminated with over 500 g corrosion product nickel, was processed to recover the D₂O and was transferred to Bldg. 3503 on September 26, 1958, for uranium decontamination. A total of 379 lb of D₂O was recovered from an estimated inventory of 410 lb. A total of 5.92 kg of uranium was transferred compared to a book inventory of 6.32 kg. The difference is thought to be that held up in the reactor or transfer piping since no known losses occurred in the transfer operations.

NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report. The information is not to be abstracted, reprinted or otherwise given public dissemination without the approval of the ORNL patent branch, Legal and Information Control Department.

RELEASE APPROVED
BY PATENT BRANCH

7-6-59 m8.
DATE SIGNATURE

728-1

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.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

INTRODUCTION

The initial HRT fuel charge was removed from the reactor high-pressure system because of the excessive buildup of nickel in solution which resulted from high corrosion rates in the first power run (R-13) in February, 1958. The used fuel had been stored in the reactor fuel storage tank since that time. This report covers the details of the transfer of the fuel from the reactor system, the recovery of heavy water from the fuel in the waste evaporator, and the subsequent transfer of the fuel in light water to Bldg. 3503 for decontamination.

CRITICALITY CONTROL

The 33-gal shielded carrier used for the transfer operations is critically safe for only 1.63 kg enriched uranium.¹ $\text{Gd}_2(\text{SO}_4)_3$ was chosen as a poison because of its chemical stability in fuel solution, high nuclear cross section, and ease of removal by solvent extraction. Tests in the Chemical Development Section had demonstrated the stability of the poison in all concentrations to be handled during these operations. Calculations by O. O. Yarbrow showed that 60 g of Gd would effectively poison the 6.32 kg of uranium in any geometry assuming it to be the only nuclear poison present. A 50% excess was deemed adequate and it was decided to add the poison to the waste evaporator where adequate mixing could be accomplished and samples analyzed prior to transfer to the carrier. Consequently 94.5 g of gadolinium as $\text{Gd}_2(\text{SO}_4)_3$ dissolved in 15.5 liters of D_2O was added to the waste evaporator prior to transferring the fuel.

An additional 88 g of Gd was added to the carrier as an added safety factor. Thus a total of 182.5 g of Gd was present in the carrier after the fuel transfer.

DETAILED PROCEDURE

The initial HRT fuel charge containing 6,320 g of fully enriched uranium, 420 g of Cu, 525 g of Ni, 5,775 g of sulfate and 45 g of Mn had been held in the fuel storage tanks in approximately 100 liters of D_2O since March, 1958. After drying the evaporator

¹H. O. Weeren to W. D. Burch, Criticality Review of HRT-CP, ORNL CF-58-7-110 (July 28, 1958).

and adding the gadolinium poison, this solution and 16 liters of D_2O from the transfer tank was pressurized with oxygen to the waste evaporator. Ninety pounds of D_2O was used to rinse the fuel storage tanks and associated piping. The final volume of fuel, poison, and rinse was 170.3 liters, based on liquid level and density instrumentation of the evaporator. The condenser from the waste evaporator was connected to a clean, dry 55-gal stainless steel drum suspended from scales for collecting the recovered D_2O . To mix the fuel, poison, and rinse, 121 lb of D_2O was boiled off prior to the initial sampling. Results of fuel analyses are discussed in a separate section of this report.

After sampling, an additional 258 lb of D_2O was recovered making a total of 379 lb from a total of 410 lb initially present in the evaporator. The recovered D_2O was sampled as a flowing stream during recovery and again sampled as a composite at the conclusion of boilup. The D_2O flowing stream sample indicated 95.0% D_2O with 0.7 ppm chloride compared to 94.85% D_2O and 1.4 ppm chloride in the composite sample. Decontamination factors for the D_2O are shown in the analytical section of this report.

Upon completing the D_2O recovery, leaving an estimated 8 liters of D_2O in the evaporator with the fuel, 83.3 liters of H_2O was charged to the evaporator. The evaporator solution was again boiled down to 59 liters to mix thoroughly, and sampled.

To insure that a highly concentrated uranium solution was not left in the transfer line below the waste evaporator, 8 liters of condensate were backflushed into the evaporator. After backflushing this line, the evaporator volume was reduced to 54.1 liters and sampled. This solution was left in the waste evaporator for approximately one week before taking the final samples. Then on September 23, 1958, just prior to the fuel transfer, the additional poison was added to the carrier.

Following the transfer of the fuel, 150 liters of condensate was added as a rinse to the evaporator, boiled down to 11.9 liters after rinsing of sampler lines, and transferred to the carrier. A second 150-liter rinse volume was reduced to 36.3 liters and sampled. The effectiveness of rinsing was fully demonstrated as only 71.2 g of uranium or 0.012% of the uranium originally present was found. Then this 36.3 liters was reduced to 12.1 liters and also sent to the carrier.

The carrier was delivered to Bldg. 3503 on Friday, September 26, 1958, without incident. Results of uranium recovery from this fuel charge will be covered in a later report.

ANALYTICAL RESULTS

Table I summarizes analyses made on the samples taken from the waste evaporator during various stages of operations.

The highest value of total uranium present was found in the initial samples from the evaporator while in the D_2O cycle. This amount, 6.64 kg, is probably in error due to the inherent inaccuracy of the level instrument at high liquid level in the evaporator. The final two uranium analyses from samples taken one week apart indicate uniform samples. The volume determination was also more accurate in this liquid level region. For these reasons, the actual amount of uranium present is believed to be 5.9-6.0 kg. Discrepancies between this value and the 6.3 kg reactor book inventory can probably be accounted for in holdup in the reactor and transfer piping since no known losses occurred during the transfer.

The reason for the variation by a factor of 2-3 in Ni analyses between spectrographic and polarographic methods is unknown.

The variations in analyses of the poison, $Gd_2(SO_4)_3$, were probably analytical since chemical stability had been adequately demonstrated.

The second set of samples from the fuel (after D_2O recovery) and the composite sample of D_2O were analyzed for individual fission product constituents to determine decontamination factors obtained. Table II shows results of these analyses and decontamination factors.

The decontamination factors for the recovered D_2O were quite satisfactory. The drum of D_2O read 3-5 mr at the surface.

R. H. Winget
R. H. Winget

RHW:ms

TABLE I. ANALYTICAL RESULTS OF INITIAL HRT FUEL SOLUTION

Sample Number	System	Volume, liters	U g/l (1)	(2)	Total U kg (3)	(4)	Ni g/l (5)	(6)	Gd g/l (7)	Total Ni Analyzed (8)	(6)	Total Gd Present, g	Total Gd Analyzed, g
CPL-17-150,151	D ₂ O	121 ^A	-	54.9	-	6.64	2.9	-	0.87	351	-	94.5	105.3
CPL-17-157,158	91.5% H ₂ O	59 ^B	86.12	95.8	5.08	5.65	1.7	-	1.3	103	-	94.5	76.7
CPL-17-165,166	94.5% H ₂ O	54.1 ^C	99.5	108.4	5.38	5.87	3.5	7.7	1.65	189	416	94.5	89.2
CPL-17-174,175	94.5% H ₂ O	54.1 ^D	-	110.1	-	5.96	2.5	9.6	1.45	135	520	94.5	78.4

A. After boiling off 121 lb of D₂O.

B. After boiling off 379 lb of D₂O and adding 83.3 liters of condensate and reducing evaporator volume to 59 liters.

C. After backflushing lines and reducing evaporator volume to 54 liters.

D. No change, solution was left standing in evaporator for one week.

(1) and (3) Colormetric uranium
 (2) and (4) Coulometric uranium
 (5) Spectrographic
 (6) Polarograph
 (7) Spectrographic
 (8) Inventory value 525 g

728
5

TABLE II. DECONTAMINATION FACTORS FOR RECOVERED D₂O

	TRE	G γ	G β		Ru-103	Sr-89	Zr-95
Fuel, c/m/ml	7×10^8	1.22×10^8	8.25×10^8	d/m/ml	1.66×10^7	2.21×10^7	7.7×10^7
D ₂ O, c/m/ml	2.5×10^2	520	3×10^3	d/m/ml	380	1.28×10^4	980
D. F.	1.1×10^6	7.8×10^4	9.5×10^4		1.5×10^4	5.93×10^4	2.7×10^4

DISTRIBUTION

1. HRP Director's Office	26. J. W. Hill, Jr.
Rm. 259, Bldg. 9204-1	27. C. D. Hylton
2. H. F. Bauman	28. G. H. Jenks
3. S. E. Beall	29. P. R. Kasten
4. R. E. Blanco	30. M. T. Kelley
5. E. G. Bohlmann	31. J. O. Kolb
6. N. C. Bradley	32. R. B. Korsmeyer
7. J. C. Bresee	33. W. H. Lewis
8. R. E. Brooksbank	34. R. B. Lindauer
9. K. B. Brown	35. R. N. Lyon
10. F. R. Bruce	36. R. A. McNees
11. J. R. Buchanan	37. D. M. Richardson
12. W. D. Burch	38. D. Scott
13. A. D. Callihan	39. I. Spiewak
14. F. L. Culler	40. W. Terry
15. W. K. Eister	41. J. W. Ullmann
16. J. R. Engel	42. W. E. Unger
17. D. E. Ferguson	43. H. O. Weeren
18. J. D. Flynn	44. R. H. Winget
19. D. F. Frech	45. C. E. Winters
20. W. R. Gall	46. O. O. Yarbrow
21. H. E. Goeller	47-48. REED Library
22. R. H. Guymon	49-50. Document Reference Library
23. R. J. Harvey	51. ORNL-RC
24. P. A. Haas	52-53. Central Research Library
25. P. N. Haubenreich	54-55. Laboratory Records
	56. M. J. Skinner