X-822

OAK RIDGE NATIONAL LABORATORY
Operated by
UNION CARBIDE NUCLEAR COMPANY
Division of Union Carbide Corporation
Post Office Box X
Oak Ridge, Tennessee

ORNL
CENTRAL FILES NUMBER
58-7-53

6010

DATE: July 8, 1958

COPY NO. 32

SUBJECT: Thorex Pilot Plant: Criticality Review of the Thorex Pilot Plant Using the Int-23 Process

TO: F. L. Culler

FROM: W. T. McDuffee and O. O. Yarbro

ABSTRACT

The results of a criticality review of the ORNL Thorex pilot plant are presented for the condition where a low TBP (INT-23) flowsheet is used in recovering U-233 from irradiated thorium. Criticality control will be maintained by limiting the U-233 inventory in the solvent extraction system to less than 550g by means of stream-volume and U-233 material balances determined at 8 hr intervals. Equipment modification and improved operating procedures for safe plant operation are outlined.

DISCLAIMER

1.0 INTRODUCTION

The criticality aspects of the Thorex pilot plant during processing of irradiated thorium have been reviewed in detail by O. O. Yarbro (A Criticality Study of the Thorex Pilot Plant, ORNL-2332, Aug. 28, 1957). The study was based on the assumption that the ORNL Thorex Co-decontamination Flowsheet would be used. However, it is currently planned to process the remaining irradiated thorium through the first cycle according to the Int-23 flowsheet. (K. H. McCorkle and R. B. Keely, Short Term Production of U-233 in the Interim-23 Facility, ORNL-CF-55-4-80, April 13, 1955) which features a 1.5 per cent TBP extractant. This memo supplements Yarbro's earlier report with the results of a criticality review of the pilot plant when operated according to the Int-23 flowsheet and includes the action taken to insure nuclear safety during this program. Assisting in the series of conferences held during the review were the following:

Chemical Technology Division

F. L. Culler, R. E. Leuze, W. H. Lewis, R. B. Lindauer, W. T. McDuffee, J. R. Parrott, E. M. Shank, R. H. Vaughan, W. R. Winsbro, O. O. Yarbro

Criticality Review Committee

Joe Thomas, Reginald Gwin

2.0 GENERAL CONCLUSIONS

The U-233 inventories in the feed preparation system, the first cycle solvent extraction system, and the U-233 isolation system are essentially the same as with the high TBP flowsheet for a given feed; however, owing to the higher throughput with the Int-23 flowsheet (approximately 600 kg Th/day compared to approximately 200) a critical mass could accumulate in about one-third the time it took with the co-decontamination flowsheet. The low TBP concentration used in the Int-23 flowsheet limits the U-233 concentration of the solvent to 6 g/l, well below the safe 10 g/l maximum.

Of most concern were the consequences of reduced (or stopped) HCX flow. With the 1.5 per cent TBP system the uranium distribution coefficient strongly favors the aqueous phase---at 100 per cent uranium saturation in the solvent, the aqueous uranium concentration approaches 150 g/l (Fig. 1). As the bottom disengaging section of the stripping column (P-60) is 18" OD x 15" depth (not a geometrically safe design), a critical mass could be accumulated in this volume. A nuclear incident could occur (1) if the HCX flow had remained low (assuming the U-233 rich HAP continued to flow) for a long period (~24 hr) permitting the U-233 to reflux to high concentration in the aqueous phase and then was adjusted to its normal rate with a resulting discharge of U-233 rich solution to the end section, and ultimately, to tank R-2 (also not geometrically safe), and (2) if the HCX had been left off entirely for 8 to 10 hr while the HAP continued to flow allowing the static aqueous phase in the plate-filled section of the column to strip U-233 from the solvent until saturation was reached (~150 g/l). Upon restoring the HCX flow the same results would occur as already mentioned above. Therefore, early recognition of the development of the described condition is the first objective and the second, equally important, is the development of a safe procedure to follow in correcting the potentially hazardous condition once it is recognized.

If the normal U-233 in-process inventory of the solvent extraction system is known, this knowledge plus a running material balance determined at 8-hr intervals around the system will indicate any accumulation of U-233 in the system above normal. By limiting the total solvent extraction system inventory to less than 550 g U-233 (observed plant holdup is about 300 g) the operation will be critically safe. In the event that the U-233 system inventory exceeds the safe 550 g, the plant will be shut down immediately and supervision notified. The procedure to be followed in reducing the system inventory before resuming operations will be detailed, stepwise, and will be conducted under close supervision of qualified personnel.

3.0 MODIFICATIONS

The following modifications to procedure and equipment are made to improve and insure nuclear safety:

a. The recommendations and procedures outlined in Yarbro's report will be followed as they apply to feed preparation, first cycle solvent extraction and isolation laboratory operation. A series of batch runs was made to determine the normal solvent extraction system U-233 inventory. During continuous operation a U-233 material balance about the solvent extraction system will be determined at 8-hr intervals and the total U-233 unaccounted for inventory will be maintained at less than 550 g.

b. A detailed check list will be prepared for conducting all operations requiring strict criticality sensitive control. In particular, a procedure will be prepared for resuming operation in the event the U-233 inventory in the solvent extraction system exceeds 550 g.

c. A special tag to be known as a criticality tag will be designed for identifying valves, pumps, switches, toggles, etc., which if misoperated might lead to a nuclear incident. This tag will be coded for easy identification both by color and shape and fabricated from acid-, alkali-, and solvent-resistant material.

d. The lines leading from the central decontamination panel to tanks R-2, R-3 and R-9 will be tagged with criticality tags to prevent accidental addition of caustic soda to these vessels.

e. The Laboratory Operations Division personnel will not add caustic soda to waste collection tank W-1 without approval of Thorex pilot plant supervision. The cell floor drainage from Building 3019 is collected in W-1 and might contain U-233.

f. The overflow level of the isolation laboratory hood will be inspected to insure that the maximum liquid depth that may collect will be less than the safe 2 in. Also the vessel in which the hood overflow is

collected will be geometrically safe; the overflow line will be inspected for alternate routing of the stream and if present such will be eliminated.

g. The handle on the valve in the line leading from isolation laboratory recycle collection tank (L-24) to chemical waste will be locked and tagged with a "criticality tag." Only the Problem Leader will be in possession of the one key to the lock. This minimizes the possibility of accidental transfer of high concentration U-233 solution to the tank, W-5, which normally contains highly alkaline solution.

h. Drip pans, draining to the cell 3 equipment basin under the third uranium cycle equipment, will be placed under all pump, pulsers, etc. The equipment basin is designed to contain the entire contents of the system in a liquid depth of less than the safe 2 in.

i. A high liquid level alarm is to be installed in the cell 3 equipment basin (3A sump) that will give an audio-visual signal at the control panel.

j. A high liquid level alarm is to be installed in the catch basin surrounding the glass disengaging section of the 3A-column. This system will give an audio-visual signal at the control panel should the glass section rupture while the column is in operation.

W. T. McDuffee

O. O. Yarbro

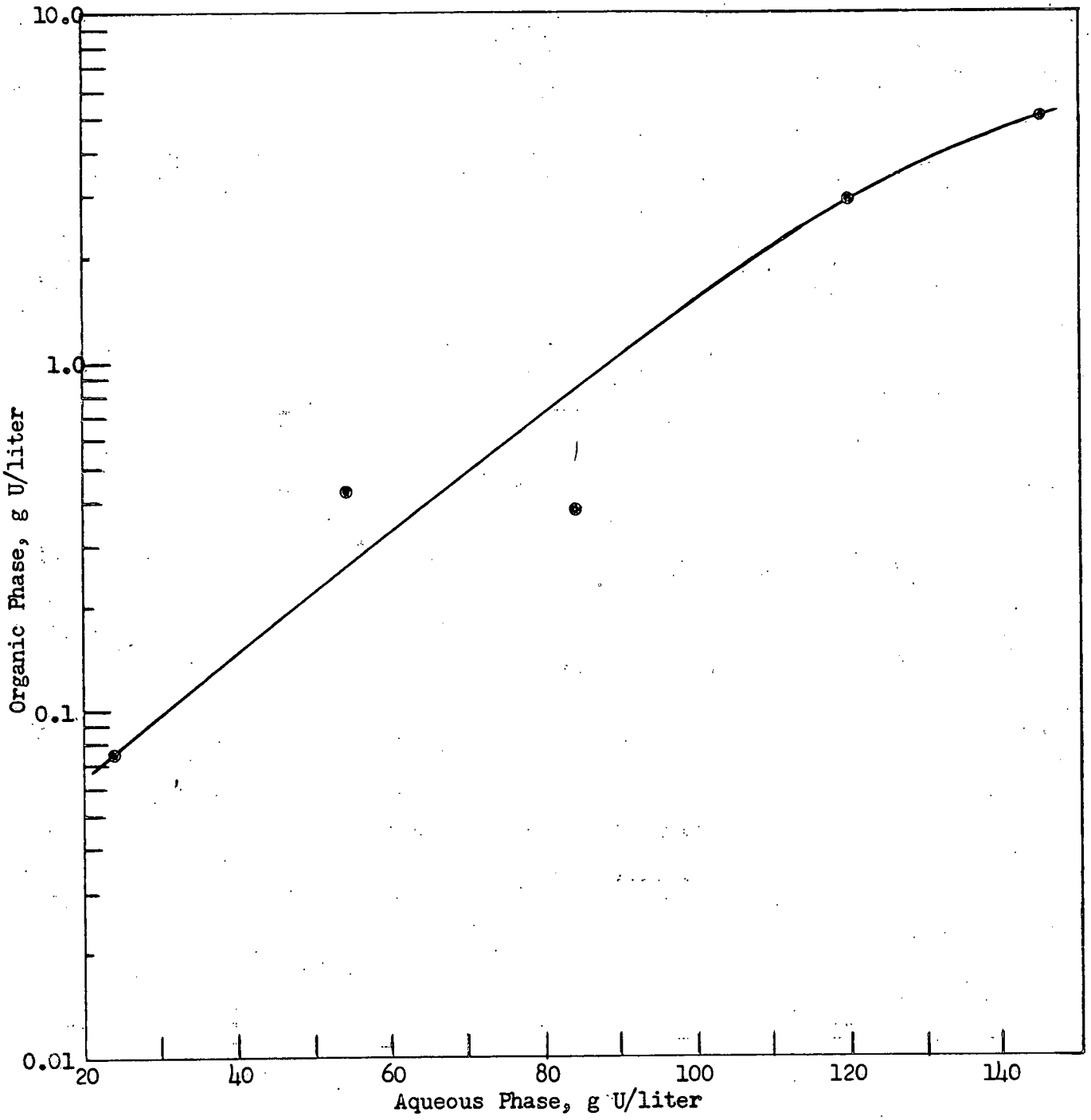

Fig. 1. Equilibrium concentrations uranium in 1.5% TBP-98.5% Amsco in contact with aqueous $UO_2(NO_3)_2$ solutions

DISTRIBUTION

1. F. L. Culler
2. E. D. Arnold
3. R. E. Blanco
4. R. E. Brooksbank
5. J. C. Bresee
6. K. B. Brown
7. F. R. Bruce
8. A. D. Callihan
9. C. V. Ellison
10. D. E. Ferguson
11. H. E. Goeller
12. A. T. Gresky
13. J. W. Landry
14. W. H. Lewis
15. R. E. Leuze
16. R. B. Lindauer
17. J. L. Matherne
18. W. T. McCarley
19. W. T. McDuffee
20. E. L. Nicholson
21. J. R. Parrott
22. Reginald Gwin
23. G. S. Sadowski
24. E. M. Shank
25. J. W. Ullman
26. W. E. Unger
27. R. H. Vaughan
28. W. R. Winsbro
29. O. O. Yarbro
30. Lab Records - RC
31. M. J. Skinner
32-33. Laboratory Records