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MASTER

KILOROD PROGRAM: CHANGES AND ADDITIONS TO THE NUCLEAR SAFETY REVIEW FOR BLDG. 3019 SOLVENT EXTRACTION PLANT

M. G. Baillie

ABSTRACT

Changes in the uranium purification reference flowsheet are summarized, and their effect on the original criticality review is presented. Some additional criticality control means are given, where cold operation has shown the initial proposals to be questionable.

A review of nuclear safety for the dissolving of massive U-233 metal pieces from the Jezebel assembly is also given.

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1.0 INTRODUCTION

ORNL has been given a program to prepare 1000 rods containing a mixture of U-233 and thorium as mixed oxides. Preparation of the rods includes the solvent extraction purification of about 30 kg of U-233. A review of nuclear safety for this step has been written by E. M. Shank to the Criticality Review Committee in CF-62-3-93. Since that time, some modifications have been made to the reference flowsheet, and some additional information obtained on the form of the U-233 metal to be used in the process.

This report is intended as a supplement to the original review, and deals only with the changes and additional data.

2.0 PROCESS CHANGES

The revised chemical flowsheet (on drawings D-45609, Rev 3, and C-45621) is presented at the end of this report. The changes may be summarized as follows:

(a) Flow rates, based on the feed flow rate, have been reduced to one half those originally proposed.

(b) The flow ratio (organic to aqueous) has been reduced from 2.5 to 2.0 in the extraction column and from 5.0 to 4.0 in the scrub column and strip column. This results in an organic phase loading of 2.5 g/l compared with 2.0 g/l previously.

(c) The thorium concentration in the feed has been reduced from 350 g/l to 200 g/l. No aluminum is present.

(d) The acid deficient conditions in the feed have been changed so that the feed solution is now 2 M in nitric acid. The scrub solution will be -0.4 N acid deficient to ensure that no acid is carried into the strip column.

(e) The extraction column will be operated with the interface controlled in the upper expanded section.

(f) It should be noted that the decision has been made to use di-secondary butyl phenylphosphate (DSBPP) as extractant and di ethyl benzene (DEB) as diluent. This alternative extractant was considered in the original review. Analytical work is in progress to ensure that the required concentration controls can be maintained during the program.

The effect of each of these changes on the nuclear safety controls imposed is given below.

(a) Changes in overall flow rates or throughput do not effect solution concentrations or hold up. The original criticality safeguards are therefore unaffected.

(b) The increased uranium concentration of 2.5 g/l in the organic stream is still well within the imposed limit of 10 g/l which is always safe.[1] This limit is fixed by controlling the extractant concentration (DSBPP) at a value less than 3% as outlined in CF-62-3-93, and is independent of the actual loading. The theoretical loading capacity of 3% DSBPP in DEB is 14 g/l. However, with the system being used, it is impossible that the loading could exceed 10 g/l.

(c) The U/Th ratio in the feed is 0.025, and the concentration of uranium 5 g/l. This is considered to be satisfactory from the standpoint of nuclear safety, as the thorium addition will be made before the uranium addition in the dissolver and volume control will be exercised to ensure that the concentration of 10 g/l U-233 is not exceeded.

(d) The new feed and aqueous scrub stream concentrations will result in a higher uranium concentration in the organic product from the extraction column and the scrub raffinate. The expanded section at the base of the scrub column is safe for solutions up to 40 g/l in uranium and should therefore be limited below 20 g/l. The composition of the scrub solution has been selected so that the concentration of uranium in the aqueous scrub raffinate can never exceed 20 g/l. However, should this solution be made up incorrectly such that the acid deficiency were greater than -0.6 N, the uranium concentration in the scrub raffinate could rise to a level greater than 40 g/l. To guard against such a possibility, no scrub solution will be sent to the scrub feed tank until analyses show that it is of the correct composition. The solution will be made up in a separate tank, and the valve in the transfer line will be locked. The procedure will be outlined in the run sheets. The effect of the higher uranium concentration on the top section of the extraction column is discussed in (e). For additional safety, the lower

(1) TID 7016 Nuclear Safety Guide.

expanded section of the "B" column will be filled with Pyrex Raschig rings.

(e) To ensure nuclear safety when operating with a top interface, the top expanded section of this column will be filled with one inch Pyrex glass Raschig rings. Under these conditions this section is safe for all concentrations of uranium.

3.0 ADDITIONAL NUCLEAR SAFEGUARDS

A possible nuclear hazard has been recognized in the sumps of cells 5, 6, and 7, which are not of safe geometry. These will be filled with Pyrex glass Raschig rings, and the overflows blocked off to prevent loss of any spill which may occur.

A further hazard has been recognized in the catch tanks N-7 and N-8. If a large quantity of organic were dumped from the extraction column into N-2 or N-4, jetting this liquid to N-8 may result in any uranium present being stripped and concentrated into the aqueous jetting liquid. Since N-7 and N-8 are both geometrically unsafe, it has been decided to fill these tanks with Raschig rings to guard against this possibility. 250 g/hr.

Cold operating experience has shown that the temperature override on the evaporator may not be reliable, as the temperature which is measured is affected by the steam temperature in the coil and jacket. It is therefore proposed that the liquid volume accumulation in product tank R-25, and the depletion in CU catch tank R-3 be checked routinely on a 2 hour basis. Under normal operating conditions (feed rate 25 l/hr of 10 g/l U-233) even if no product were obtained over the two hour period, the uranium concentration in the evaporator would rise only from 100 g/l to 133 g/l. This is well below the imposed limit of 200 g/l. It is of interest to note that the primary density control has been tested in cold runs, and with a few modifications has proved to be completely satisfactory.

4.0 DISSOLUTION OF MASSIVE U-233 METAL

4.1 Procedure

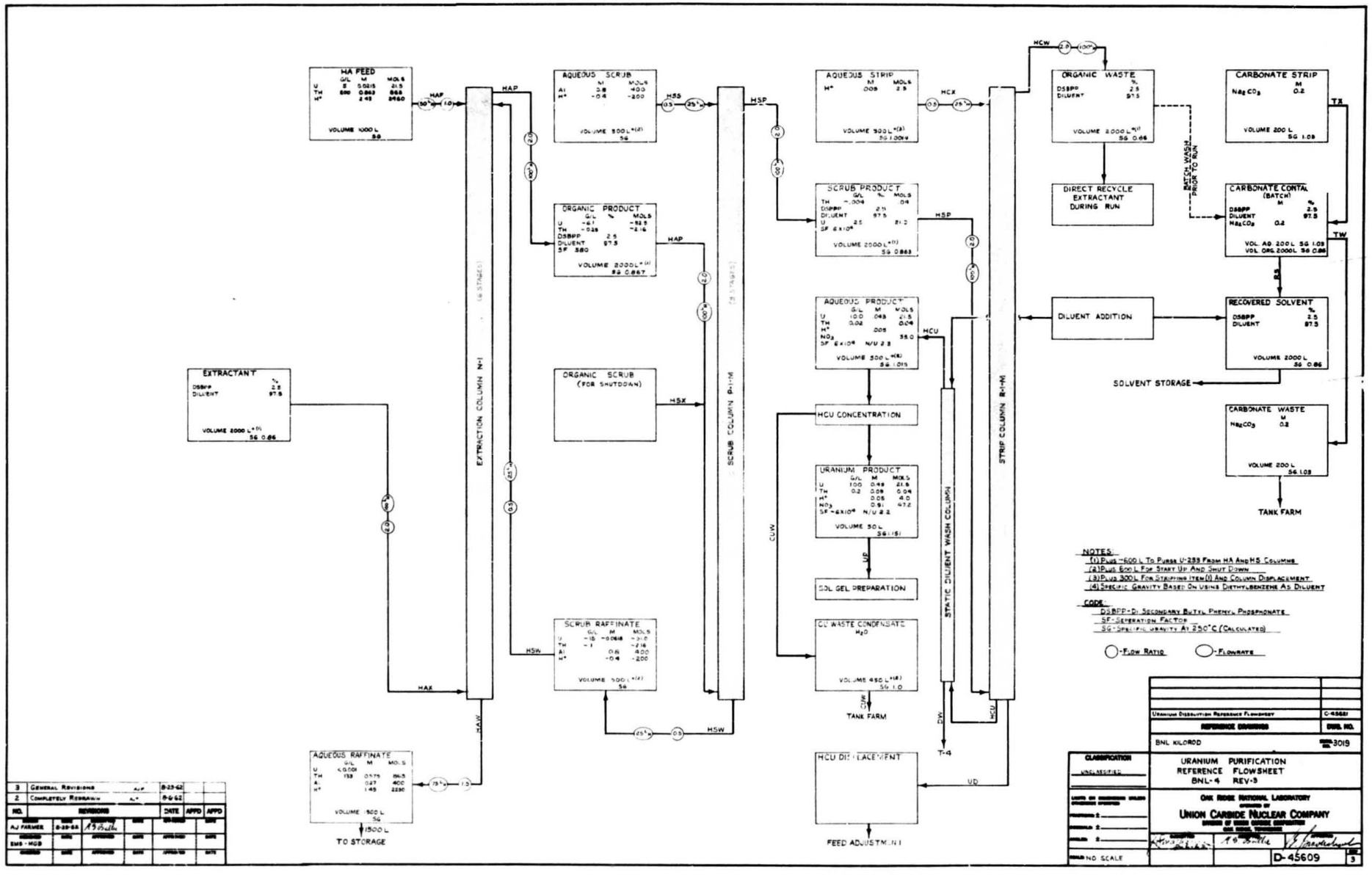
Appropriate quantities of thorium (BTC feed) and nitric acid will be charged to the dissolver (S-1) so that the ratio of Th: U-233 will be the same as that in the feed solution. Dissolution will occur in

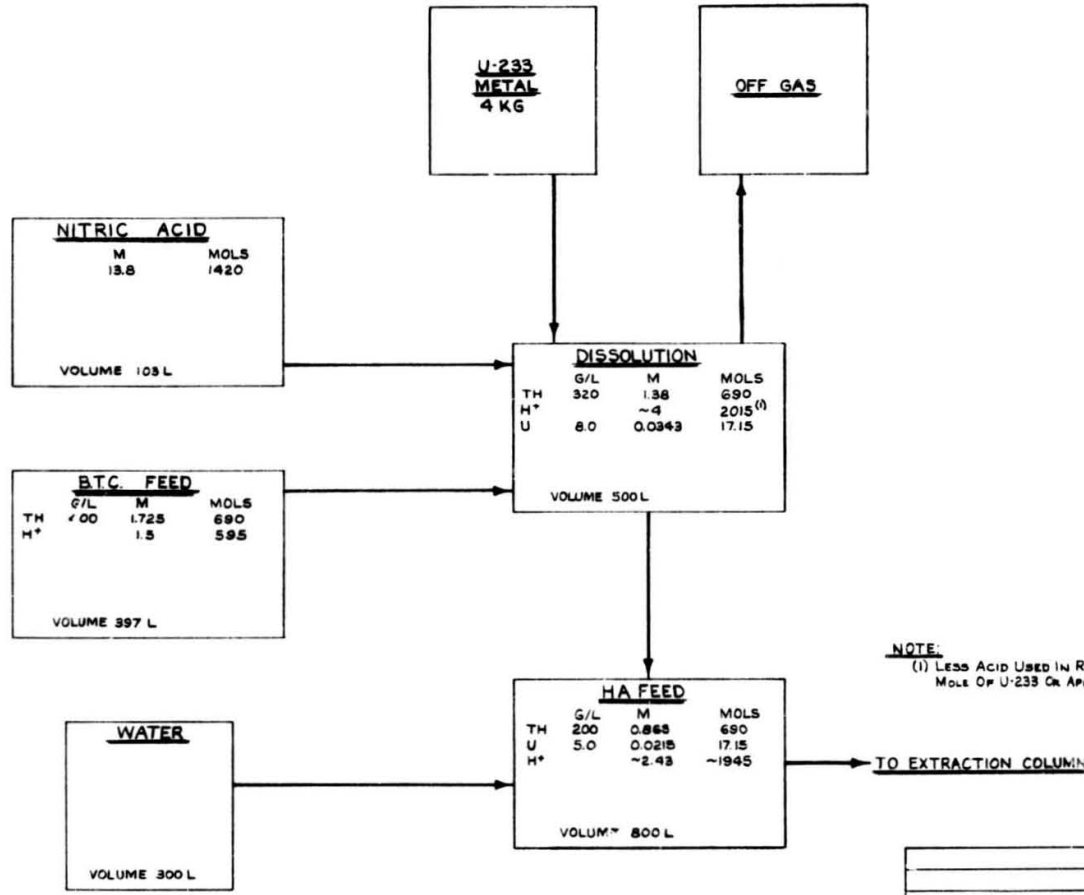
sufficient volume so that a U-233 concentration of 10 g/l U-233 is never exceeded. Total U-233 mass will not exceed 5000 g in one dissolution and the solution will be analyzed to ensure complete dissolution before it is sent to the feed adjustment tank.

After dissolution, the feed adjustment will be made simply by diluting the dissolver solution with water to give a final uranium concentration of 5 g/l.

4.2 Safety

During dissolution, nuclear safety will be assured by volume (level) control which will be set to alarm if the volume should drop to such a level that the concentration could exceed 10 g/l U-233 with all the uranium dissolved, and by the presence of the thorium which gives a U-233: Th ratio of 0.025.


HA FEED
AQUEOUS SCRUB
ORGANIC PRODUCT
ORGANIC SCRUB (FOR SHUTDOWN)
SCRUB RAFFINATE
AQUEOUS RAFFINATE
EXTRACTANT
EXTRACTION COLUMN N-1
SCRUB COLUMN P-1-M
AQUEOUS STRIP
SCRUB PRODUCT
AQUEOUS PRODUCT
HCU CONCENTRATION
URANIUM PRODUCT
SOL GEL PREPARATION
CU WASTE CONDENSATE
TANK FARM
HCU DISPLACEMENT
FEED ADJUSTMENT
STATIC DILUENT WASH COLUMN
STRIP COLUMN R-1-M
ORGANIC WASTE
DIRECT RECYCLE EXTRACTANT DURING RUN
DILUENT ADDITION
BATCH WASH PRIOR TO RUN
CARBONATE STRIP
CARBONATE CONTAC (BATCH)
RECOVERED SOLVENT
SOLVENT STORAGE
CARBONATE WASTE
TANK FARM
TO STORAGE
NOTES:
(1) Plus ~600 L To Purge U-233 From HA And HS Columns
(2) Plus 600 L For Start Up And Shut Down
(3) Plus 300 L For Stripping Item (1) And Column Displacement
(4) Specific Gravity Based On Using Diethylbenzene As Diluent
CODE:
DSBPP - Di Secondary Butyl Phenyl Phosphonate
SF - Seperation Factor
SG - Specific Gravity At 250°C (Calculated)
-Flow Ratio
-Flowrate
Uranium Dissolution Reference Flowsheet
C-45621
Reference Drawings
Dwg. No.
BNL KILOROD
3019
Classification
Unclassified
Uranium Purification Reference Flowsheet BNL-4 REV-3
Oak Ridge National Laboratory
Union Carbide Nuclear Company
No Scale
D-45609
3
General Revisions
Completely Redrawn
Revisions
Date
Appd
AJ Farmer
EMS - MGB



NOTE:
(1) Less Acid Used In Reaction - 4.5 Moles Per Mole Of U-233 Or Approximately 70 Moles

U-233 Metal Dissolution

Uranium Purification Reference Flowsheet	D-45609
REFERENCE DRAWINGS	DWG. NO.
BNL KILOROD	BLDG. NO. 3019

CLASSIFICATION
UNCLASSIFIED

LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED
FRACTIONS: ±
DECIMALS: ±
ANGLES: ±
SCALE: NO SCALE

URANIUM DISSOLUTION
REFERENCE FLOWSHEET
BNL-4

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A DIVISION OF UNION CARBIDE CORPORATION
OAK RIDGE, TENNESSEE

SUBMITTED: A J Barker
ACCEPTED: [signature] 5-24-62
APPROVED: [signature]

C-45621

REV

NO.	REVISIONS			DATE	APPD	APPD
DRAWN AJ FARMER	DATE 8-23-62	SUBMITTED A J Barker	DATE	APPROVED		DATE
DESIGNED MGB	DATE	APPROVED	DATE	APPROVED		DATE
CHECKED	DATE	APPROVED	DATE	APPROVED		DATE

END