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NITRIC ACID UTILIZATION IN HANFORD
SEPARATIONS PLANT

AUTHOR

J. O. LUDLOW

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NITRIC ACID UTILIZATION IN HARTFORD SEPARATIONS
PLANTS

by

J. O. Ludlow

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February 1, 1956

J. B. Fecht, Head
Separations Design & Development
762 Building, 700 Area

NITRIC ACID UTILIZATION IN HANFORD
SEPARATIONS PLANTS

INTRODUCTION

As a result of the operation of separations plants at Hanford, considerable quantities of nitric acid are recovered in the 224-U Building as a dilute solution. At the present time, and until approximately a year from now, this acid can be used at the tank farms for dissolving sludge for TBP Plant feed. However, the TBP Plant is scheduled to shut-down in approximately one year. As a result of the above, this dilute acid must be used for other purposes at HAPO.

PURPOSE

This document presents the results of a study made to ascertain the most desirable method, both from an economical and operational consideration, of utilizing the acid recovered in the 224-U Building.

SUMMARY AND CONCLUSIONS

The study of the acid utilization in the separations plants at Hanford results in the conclusion that all of the 224-U recovered nitric acid can be used in the Purex Plant at a strength of 40%. This method of operation allows maximum operation of the Redox Plant. No additional burden is placed on the Purex Plant Fractionator, ~~its feed material being only Purex Plant Fractionator~~, its feed material being only Purex stock, and is constant, independent of the rate of operation of the Redox Plant.

RECOMMENDATIONS

It is recommended that the method of acid utilization outlined in this document be implemented for use at HAPO. It is further recommended that detailed scope or scopes of the work required be prepared.

DISCUSSIONA. General

As a preliminary to the study, a nitric acid balance around the Purex Plant and around the Redox dissolver section was made. Figure 1 is the nitric acid balance around the Purex Plant based on HW #4 Flowsheet. This balance includes the recovery of nitric acid from the dissolvers. Equipment for this recovery is not presently installed but is being designed. Investigation of the Purex acid balance indicates that 1,853 pounds of nitric acid per ton of uranium at a minimum strength of 24.8% is required for uranium scrub streams. The nitric acid equivalent of the Purex production sent to 224-U Building is considerably less, namely 1,098 pounds per ton of uranium. Of this amount sent to the 224-U Building approximately 1,043 pounds per ton of uranium is recovered. Thus, a considerable amount of dilute nitric acid recovered from Redox shipments to 224-U Building can be used for the Purex uranium scrub streams. In addition, acid from 224-U Building can be blended with 60% nitric acid to give a mixture at a concentration of 50% for use in the Purex dissolvers. The amount of this acid that can be used is a function of the concentration of the 224-U acid. If one adopts as a premise that all of the 224-U acid is to be used for the uranium scrub streams in the Purex Plant or blended for dissolver acid in the Purex Plant, then the tons production at Redox per ton of production at Purex can be considered a function of the concentration of the 224-U acid.

Figure 2 - The Redox Dissolver Acid Balance - shows the quantity of nitric acid required for Redox dissolving per ton of uranium processed, and its strength. The amount of acid recovered from the proposed Redox absorber at 50% strength is also shown. From these figures the quantity of 60% nitric acid required for the dissolver can be calculated.

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Figure 3 presents a graph of the tons of uranium processed at Redox per ton of uranium processed at Purex versus the strength of the nitric acid recovered at 224-U Building. Investigation of this plot indicates that up to a production ratio of 0.8 tons of uranium processed in the Redox Plant per ton of uranium processed at the Purex Plant, all of the 224-U acid accumulated from both Purex and Redox operation can be consumed as uranium column scrubs in the Purex Plant at any concentration above 24.3% nitric acid. If one also blends 224-U acid with 60% nitric acid to give 50% nitric acid for the Purex dissolvers, operation at the minimum concentration of 24.8% nitric acid can be extended to processing slightly more than one ton in the Redox Plant per ton processed in the Purex Plant. If one considers the concentration increasing in the 224-U acid, larger amounts can be utilized for Purex dissolving. The ratio gradually increases until at 50% nitric acid concentration from the 224-U Building, all of the Purex dissolving acid is being supplied from 224-U Building. At this point 2.4 tons of uranium can be processed in the Redox Plant per ton of production in the Purex Plant. Further increase in concentration in the 224-U acid product is not of benefit to the Purex Plant, since we have now saturated all of the uses in the Purex Plant for which this acid is suitable.

B. 224-U Modifications

Since the 224-U acid requires lag storage at the 224-U Plant and must be transported to the Purex Plant before use, a study of the quantity of acid to be stored and shipped versus the tons of uranium processed at Redox per ton of Purex production, with acid strength produced as a parameter is shown as Figure 4. The line marked "limit" is derived from the curve in Figure 3 and is the maximum that can be utilized in the Purex Plant at the given acid concentration.

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Investigation of Figure 4 shows that the quantity/^{to}be stored and shipped increases quite rapidly at acid strengths below 40% nitric acid from the 224-U Building. In order to evaluate the magnitude of the storage required for 224-U acid it is necessary to investigate the case wherein the Purex Plant temporarily has suspended operations and the Redox Plant is operating at its proposed capacity of 300 tons of uranium per month. A plot of the storage required in gallons per month for acid recovered from the Redox operation at 300 tons per month versus the strength of the acid produced at 224-U Building is shown as Figure 5. This figure shows that a change in 224-U acid strength from 50% down to 40% results in an increase in the quantity of acid to be stored in a month from 55,000 gallons to 73,000 gallons. A further reduction to 24.8% nitric acid increases the quantity per month to be stored to 125,000 gallons. Investigation of past 224-U operation indicates that an average concentration of 40% nitric acid can be produced quite easily using the present pot facilities. If it is necessary to increase the concentration above 40%, this can be accomplished as a result of careful scheduling of pot operation. With an absorption unit receiving ¹⁰stoichiometric gas, ~~the~~ production of 53% nitric acid can be made. All of the uses of this 224-U acid in the Purex Plant require that it be blended with either water or 60% nitric acid as it is introduced into the process. For this reason, it is mandatory that the 224-U acid be shipped at a constant concentration to the Purex Plant. In view of the past operation of the 224-U Building, the acid recovery facilities can produce at all times acid stronger than 40%.

It is, therefore, recommended that the 224-U facilities be operated to produce acid stronger than 40% and that the strength of this acid be adjusted to a constant value of approximately 40% in the 221-WR vault facilities. Pipe facilities are available from TK-C-4 to WR-006, a 40,000 gallon surge tank in the WR vault. It is recommended that this piping be altered so that the C-4

product will be routed to tanks WR-007, 008 and 009. These are the present 40,000 gallon condensate surge tanks for 221-U Building. Material would be received in TK-C-4 acting as a floating tank, and pumped to TK-WR-007, 008 and 009 in rotation, acting as receiver tanks. These tanks would then, by a minor pipe alteration be pumped into TK-WR-006 where concentration adjustment would be made and WR-006 would also serve as a terminal shipping point. Existing facilities are available for loading tank trucks from this tank. ~~the~~ Jumper changes and considerable piping at Purex would be required if it were found desirable to pump this acid to the Purex Plant via the existing east-west pipe line.

Since the 221-U Building would not be operating at this time, Tanks WR-007, 008 and 009 would not be required as condensate surge. Overheads from the 100 per cent evaporators in 224-U would be received in TK-C-5 and pumped via existing facilities through the limestone bed to crib.

It is further recommended that a by-pass line be installed from the pump outlet in TK-C-5 to the existing line from TK-C-2 to TK-X-1 and TK-X-2. By means of this line, condensate that may be high in uranium from excessive entrainment can be recycled through the process for recovery.

C. Purex Plant Modifications

If Figure 1 is re-examined, it will be noted that the input acid requirement is larger than the sum of the acid recovered from the Purex fractionator and that portion of the 224-U acid that originated from Purex product. This means that some 224-U acid can be received in the Purex Plant without requiring part of the Purex fractionator acid to be shipped out.

Figure 6 is a graph giving the excess gallons of Purex fractionator acid available for shipment to Redox versus the tons of production at Redox per ton processed in the Purex Plant. This figure shows that approximately a half a ton of uranium can be processed at Redox per ton of uranium processed at Purex

without Purex fractionator acid having to be shipped to Redox. This merely means that the acid losses in the entire chain are being made up in Purex by 224-U acid which originated at Redox. As the tons of uranium processed at Redox per ton of uranium processed at Purex increases above 0.5 the Purex fractionator in recovering the nitric acid from the Purex process produces more nitric acid than can now be used in the Purex Plant since additional quantities of 224-U acid originating from the Redox Plant are being used. This acid should be shipped to the Redox Plant and used to blend with the 50% acid recovered from the absorber to a strength suitable for use in the Redox dissolver. It should be emphasized that this does not mean that the Purex fractionator is operating for the benefit of the Redox Plant. Regardless of the rate of operation of the Redox Plant, or whether it is operating at all, the Purex fractionator will produce 4,316 pounds of nitric acid per ton of uranium as a 60% solution. All that is being proposed is that varying quantities of a more dilute acid at constant concentration be used in the Purex process where feasible, instead of diluting this fractionator acid. A portion of the Purex fractionator acid then is utilized at the Redox dissolver. The quantity depends upon the tons of uranium processed at Redox per ton of uranium processed at Purex as shown on Figure 6.

Facilities are provided at the Purex Plant for receiving 224-U acid and by means of existing piping introducing this into the dissolvers, the 1AF and 2DF tanks, and blend facilities are available from this piping to provide HAIS and LAS. Piping will have to be provided to extend from header 7500, the recovered nitric acid header, to metering facilities now fed by line K054 to provide 2DIS. Tanks 13 and 14 provided for lag storage of 224-U acid are 8,200 gallons each, therefore, each tank, at expected operating rates, will provide about 24 hours capacity. It would be advantageous to disconnect the 1AF Tank and the 2DF Tank - TK-J1 and J-5 from header 7500.

It will be necessary to intertie between line U-034 coming from TK-U1 and U2, the Purex fractionator surge tanks, to Purex header 7002. By this means, Purex fractionator nitric acid can be transferred to Tank 10. The piping from this tank can be altered so as to provide truck loading for transporting Purex fractionator acid to the Redox Plant. The existing piping including header 7002, 8200 and lines 3-016 would allow Purex fractionator acid to be accumulated in either TK-11 or 12 if desired. If TK-11 or 12 are not used for fractionator acid, it will be necessary to intertie headers #7002 and 7001 in the pipe gallery to supply the continuous nitric acid requirements of the Purex Plant not suitable for 224-U acid. Fractionator acid at 60% is therefore available by existing piping to supplant 40% - 224-U acid for all uses when, as, and if needed.

Figure 7 presents graphically the movement of nitric acid in gallons per ton of Purex production to and from the various plants versus tons of uranium processed at Redox per ton of uranium processed at Purex. The gallons of UNH shipped from Purex is also shown. From this figure reading the curve at the left it can be seen that as the quantity of uranium processed at Redox per ton of uranium processed at Purex increases, the fresh 60% nitric acid from off-site required for the Purex Facility decreases from 56 gallons per ton of uranium processed at Purex to zero at about 0.48 tons of uranium processed at Redox per ton of uranium processed at Purex. At this production ratio no virgin 60% acid is used in the Purex Plant, its acid requirements being satisfied at this point by the acid from 224-U Building ~~and the acid recovered by the acid from the fractionator~~ and the acid recovered by the Purex fractionator. At higher production ratios the increased amount of 224-U acid being used for uranium column scrub solution and ultimately for dissolving, results in a surplus of Purex fractionator acid for shipment to the Redox Plant. This

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risers to a maximum of 285 gallons per ton of uranium processed at Purex at 2.4 tons of uranium production at Redox per ton of uranium produced at Purex. This quantity of nitric acid, when combined with the 50% nitric acid recovered from the dissolver section at the Redox Plant, is not sufficient to completely supply the Redox dissolvers. The gallons of fresh or virgin 60% nitric acid required in the Redox dissolvers is shown by another curve at the left side of Figure 7. This shows that the fresh nitric acid to the Redox Plant increases on a smooth curve from 18 gallons per ton of uranium processed at Purex to 85 gallons and then increases at a slower rate since Purex fractionator acid is used for some of the Redox dissolving.

Also at the left of Figure 7 is a curve showing the amount of 60% fractionator acid to be diluted for scrubs in the Purex Plant. Figure 3 shows that at 0.8 tons of uranium processed at Redox per ton of uranium processed at Purex, all the uranium scrubs were being supplied by 224-U acid. Figure 7 shows that as the Redox processing rate decreases below this figure, increasing quantities of 60% fractionator acid must be diluted to provide for the uranium scrub streams.

At the right of Figure 7 are two plots showing respectively the amount of UNH to be trucked from Purex to 224-U Building and the gallons of 40% nitric acid to be moved from 224-U Building to the Purex Plant. This graphically illustrates that if it is deemed desirable to truck the 40% acid from 224-U Building to Purex, it can be done by the return trip ^{or} the same truck that brought the Purex UNH to 224-U Building up to the point where Redox is producing 1.15 tons of uranium per ton of uranium processed at Purex.

D. Redox Plant Modifications

In order to properly handle the Purex fractionator acid at the Redox Plant, it is recommended that either the 221-U Building spare 15-6 or 16-6 tank be located in a suitable diked area adjacent to the Redox chemical tank farm.

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This tank should be provided with facilities for receiving acid from a tank truck and should be piped to TK-A-2-A, B-2-A and C-2-A located in the Redox operating gallery. These tanks are presently provided with ^{METERING}~~metering~~ facilities for adding acid to the dissolvers at a controlled rate.

Proposed operation of the Redox dissolvers would be as follows:

1. Addition of the equivalent quantity of 50% acid recovered in the absorber in perhaps two increments in order to properly control the reaction rate.
2. Addition of the balance of the dissolver acid required as 60% acid at a controlled rate from the appropriate acid feed tank.

← Since virgin 60% acid is required in the Redox dissolver regardless of the division of production between Redox and Purex, dissolving using Purex fractionator acid should be made only as required to hold the new surge tank within limits. The Purex Plant, meanwhile, will operate to use as much Purex fractionator acid as possible, exporting to Redox only that required to maintain its inventory within feasible limits.

J. C. Chinery Ludlow
Separations Design & Development
Design Section
ENGINEERING DEPARTMENT

JO Ludlow:vsc

Attachments

FIGURE 1

DECLASSIFIEDPUREX ACID BALANCE
BASED ON H₂SO₄ FLOW SHEET

	Input #100 % HNO ₃ / T Strength % Required	Output #100% HNO ₃ / T Strength %
HAIIs	556	24.8
IAC	751	17.4
2DIS	556	24.8
U-Scrubs	1 853	
Dissolvers	1 654	50
C Type Extraction	54	-
LEX	11	-
2AF	964	60
HCU Butt	661	60
LCU Butt	633	60
2AS	13	-
	<u>5 843</u>	
Fractionator		4 316 60
Stack		29 -
Neutralizer		397 -
2EU		1 098 -
LPC		3 -
		<u>5 843</u>
224-U Acid from Purex (95% Rec)		1 043

FIGURE 2
REDOX DISSOLVER ACID BALANCE

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	Input #100% HNO ₃ /T Strength %	Output #100% HNO ₃ /T Strength %
Dissolver	2 648	54
Absorber		1 430
Stack		159
As UMH		1 059
		<hr/> 2 648

	#HNO ₃	#H ₂ O	# Total
Dissolver MU from			
Absorber	1 430	1 430	2 860
60%	1 218	812	2 030
			<hr/> 4 890

$$\frac{2648}{4890} \times 100 = 54\%$$
 224-U Acid from Redox
 (95% Rec.)

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TENS PERCENT PUREX

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