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INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

RECORDS ADMINISTRATION
AIUG

December 16, 1980

TO: E. O. KIGER, SUPERINTENDENT
SEPARATIONS DEPARTMENT

FROM: G. W. WILDS, SUPERINTENDENT
SEPARATIONS TECHNOLOGY DEPARTMENT

EVALUATION OF TWO SOLID FORMS FOR SHIPPING ENRICHED URANIUM

INTRODUCTION

Enriched uranium is shipped as a solution in tank trailers from SRP to Oak Ridge, Tennessee and National Lead Co. of Fernald, Ohio. Because of the possibility of a spill in transit, a program has been initiated to develop safer methods of shipment[1,2]. Safer methods studied previously include shipping solution in tankers designed to withstand accidents, conversion to UO_3 for shipment in solid form and on-site recycle.

A new method, shipping uranium loaded on cation resin has been proposed[8]. This memorandum compares uranium on resin with conversion to unpurified UO_3, and provides information needed to judge the relative merits of the processes to produce these two solid forms.

SUMMARY

It is recommended that the oxide be chosen as the preferred form for further consideration for shipment in the SST. The oxide is preferred over the resin for the following reasons:

- o The oxide process has a lower total capital cost ($19.6 million for oxide vs $29.4 million for resin).
- o If a decision were made in the future to recycle uranium on-site, much of the oxide process equipment could be used.
- o The oxide process is in use at other sites. Shipping packages for UO_3 are already designed and licensed.
- o Accountability methods for oxides are available and give good results. Accountability methods for the resin that would give results equivalent to that of the oxide are not available.

Consideration should be given to making process changes in the oxide process which would eliminate the need to adjust the pH with ammonia and consequent denitration of ammonium nitrate. If solvent extraction were used for this purpose, the equipment could be used in a future program to recycle uranium on-site.

DISCUSSION

Enriched uranium is recovered from irradiated spent fuel in 200-H area and shipped off-site as a nitrate solution in 15,000 liter tank trailers. Highly enriched uranium ($\geq$ 20% ^{235}U) is shipped to Oak Ridge, and low-enriched uranium (< 20% ^{235}U) is shipped to National Lead Co. of Ohio. Shipping uranium as a liquid presents the possibility of a spill because the trailers were not designed to withstand other than minor accidents. The safety of these shipment should be improved to prevent a spill and avoid possible detrimental environmental effects and adverse public opinion.

Several studies[3,4,5,6,7] have been made to evaluate and determine the cost of methods to improve the safety of shipping enriched uranium. The methods evaluated were:

- o Shipping solution in a tanker designed to withstand accidents (super-tiger).
- o Conversion to unpurified UO_3 for shipment.
- o Conversion to purified UO_3 for shipment (includes solvent extraction)
- o Converting to uranium metal for on-site recycle.
- o Conversion to U_3O_8 for on-site recycle.

A new method, shipping uranium loaded on cation exchange resin, was proposed by EED[8]. The simplicity of the process suggested that the resin process would have a significant cost advantage over other methods for preparing and shipping a solid form of uranium. The current program was initiated by Separations Technology to compare the resin process with the process to convert uranium to unpurified UO_3, the process which had previously been determined to be the least expensive method of converting uranium to solid form. Either of these solid forms, resin or UO_3, could be shipped in an SST (safe, secure transporter) and would give the required protection for safe transport[9].

Separations Technology coordinated work by SRL, EED, Project, Oak Ridge and National Lead Co. to develop venture guidance estimates from conceptual process flowsheets. SRL prepared the flowsheets and scopes of work[10], EED estimated the cost of the shipping packages[9], Project estimated the cost of the process equipment at SRP[11], and Oak Ridge[12] and National Lead[13] estimated the costs of additional process equipment required at their locations. Table 1 summarizes the individual cost estimates. It shows that the SRP cost for the resin process would be about half the cost of the oxide process ($7.6 million vs $13.8 million), but the total cost, SRL plus off-site, would be about 1.5 times the cost of the oxide process ($29.4 million vs $19.6 million).

On-site, plus off-site operating costs of the two processes were not included in this analysis. However, the operating cost of the resin process would be expected to be about the same as for the oxide process.

Advantages and disadvantages of the oxide and resin processes plus brief process descriptions are given in the following sections.

DESCRIPTION OF OXIDE PROCESS

A schematic of the flowsheet for conversion of uranium nitrate to uranium oxide is shown in Figure 1. Dilute uranium nitrate solution would be concentrated to 140g U/ℓ in two stages using steam in tube-bundle-type evaporators. The concentrate would be adjusted to a pH of 2 with NH_3 gas and evaporated to 500g U/ℓ in a wiped-film evaporator. The final concentrate would be converted to UO_3 in a rotary-bed calciner. UO_3 powder would be packaged in stainless steel shipping tubes, sampled, weighed and placed in "bird cages" for shipment. At Oak Ridge, the uranium oxide would be dissolved and then processed normally. At National Lead, the oxide would be stored. Accounting for the uranium by sampling and weighing is a standard and accepted practice.

The process proposed for SRP is a combination of the oxide processes used at Oak Ridge and National Lead Co. as shown in Figure 2. Equipment enclosed in heavy lines is the same or similar. If a decision were made in the future to recycle uranium on-site, the three stages of evaporation and possibly the denitrator could be used in the new process.

ADVANTAGES OF OXIDE PROCESS

1. The process is in use at other sites.

2. Visual inspection, chemical analyses, and weighing is an acceptable accountability method that has a low limit of error.

3. The shipping packages for UO_3 are already designed and licensed.

4. Total on-site plus off-site cost is less than for resin process.

5. If a decision were made in the future to recycle uranium on-site, much of the oxide process equipment could be used in the new on-site recycle process.

DISADVANTAGES OF OXIDE PROCESS

1. Operation of the equipment requires close process control to produce acceptable feed for denitration.

2. Denitration of ammonium nitrate may present an explosion hazard.

Simplified process control could be obtained by providing run tanks between evaporator stages rather than cascading all three stages. The need to adjust the acid concentration with NH_3 could be eliminated if acid were removed by the solvent extraction steps done by Oak Ridge or by formic acid denitration. Solvent extraction equipment could be used in a future on-site recycle process. Acid adjustment might be unnecessary if process development found high-acid denitration would produce acceptable product and corrosion of equipment would not be excessive.

DESCRIPTION OF RESIN PROCESS

The flowsheets for loading uranium on ion exchange resin beds at SRP and unloading at Oak Ridge and National Lead are shown in Figures 2, 3, 4 and 5. At SRP; dilute uranium nitrate solution would be fed to a resin package where uranyl ions would be absorbed on cation exchange resin. The resin package would contain an array of resin bed columns which would be sized and spaced for nuclear safety. After loading, the resin would be washed free of feed, drained, and the package placed in a protective overpack for shipment. At Oak Ridge, the uranium would be eluted from the resin, evaporated, and then processed in the normal manner. At National Lead, the uranium would be eluted, evaporated, denitrated, and stored as the oxide.

Accountability would be a problem. Oak Ridge and National Lead could measure the amount of uranium removed from the resin, but would not be able to determine the amount left on the resin when the package is returned to SRP. At SRP, two methods of accountability are available, but both are indirect. One would measure the amount of uranium removed from the feed tank and subtract the amount received in the raffinate tank to determine the amount absorbed on the resin. The other method would be to weigh the drained resin package before and after loading, and then to calculate the amount of uranium absorbed from the increase in weight. Neither method would measure the heel of uranium left on the resin when the package is returned by Oak Ridge or National Lead. The A & BA position is that indirect methods of accountability are unacceptable and should be considered only as a last resort [14]. Oak Ridge and National Lead also believe that there would be increased shipper-receiver accountability problems.

ADVANTAGES OF RESIN PROCESS

1. It is a simple process easily operable over a wide range of conditions. Operating cost would probably be less than oxide process.

2. Cost to SRP would be about half the cost of the oxide process.

DISADVANTAGES OF RESIN PROCESS

1. The only methods of accountability available are indirect, which are unacceptable to A & BA.

2. Additional process development is required, uncertainties include:

a) Effect of fission products and transuranics on the resin beds.

b) Resin life and cost of replacement.

c) Development of acceptable accountability methods.

3. The resin package would require design, testing, and licensing.

4. The total cost (SRP plus off-site) would be more than the oxide process.

CEP:mhl
Attachment

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1. R. S. Swingle, letter to E. O. Kiger, "Shipping Methods to Replace the HM Trailer", March 14, 1980.
2. R. S. Swingle, letter to E. O. Kiger, "Program Schedule for Investigation of Alternate Shipping Methods", April 10, 1980.
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9. R. H. Towell, letter to G. W. Wilds, "Cost of Shipping Packages for Alternatives to HM Trailers", November 19, 1980.
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12. J. M. Case to R. S. Swingle, "Y-12 Cost Estimate for Alternate Savannah River Shipping Proposals", November 20, 1980.
13. L. M. Levy to C. E. Pickett, "Alternate Shipping Methods for Enriched Uranium From SRP", October 6, 1980.
14. W. T. Dickenson, letter to J. E. Owen, "Solid Shipping Form for Enriched Uranium", August 18, 1980.

TABLE 1
VENTURE GUIDANCE ESTIMATES
FOR UO_3 AND URANIUM ON RESIN SHIPPING METHODS

	Costs (FY-1981)	
	Oxide $\$ \times 10^6$	Resin $\$ \times 10^6$
SRP Process Equipment	13.5	7.0
Shipping Containers:		
High Enriched	0.1	0.3
Low Enriched	0.2	0.3
Oak Ridge	5.5	21.0
National Lead	0.3	0.8
TOTAL	$19.6	$29.4

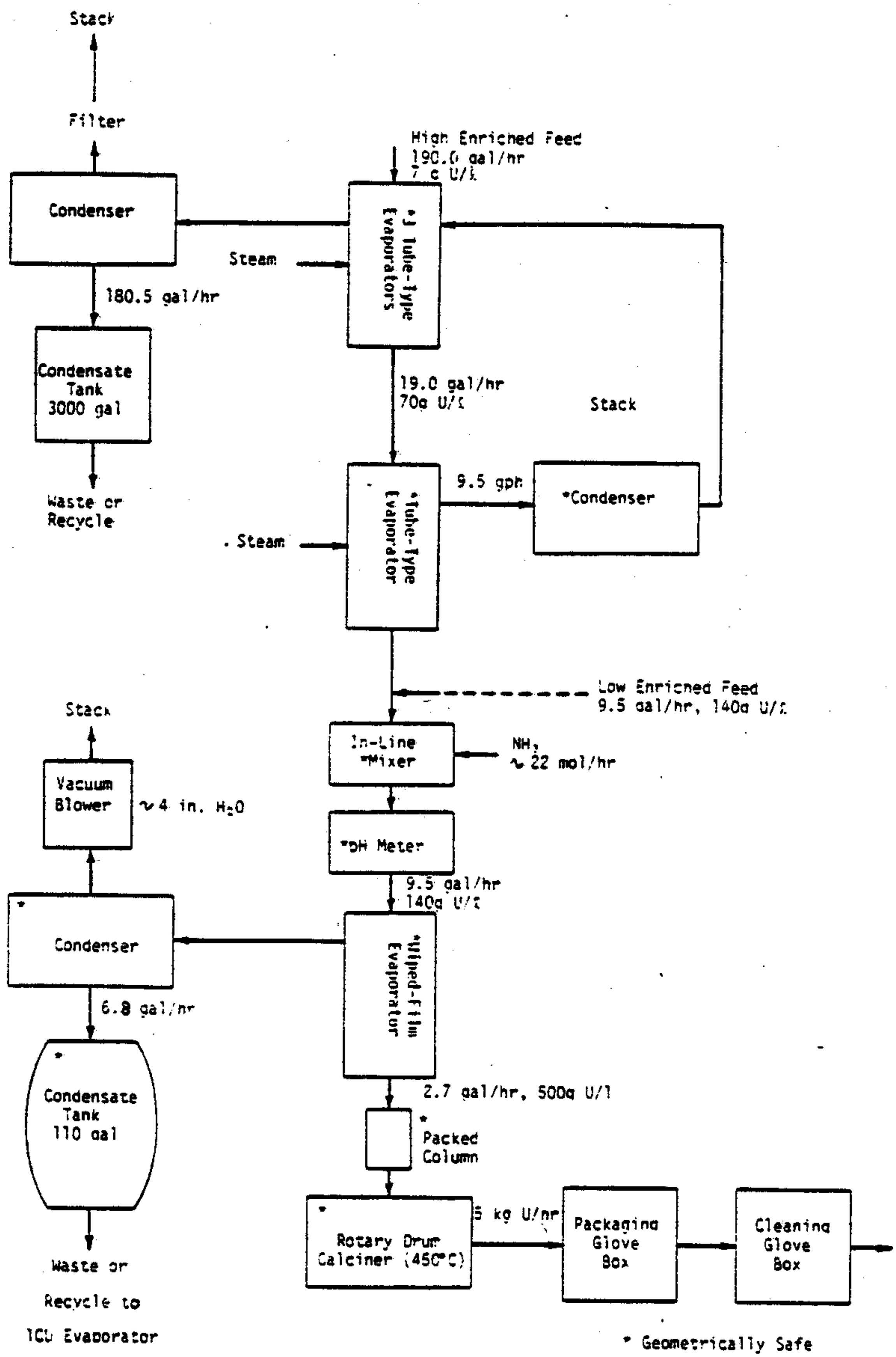

Figure 1. Oxide System

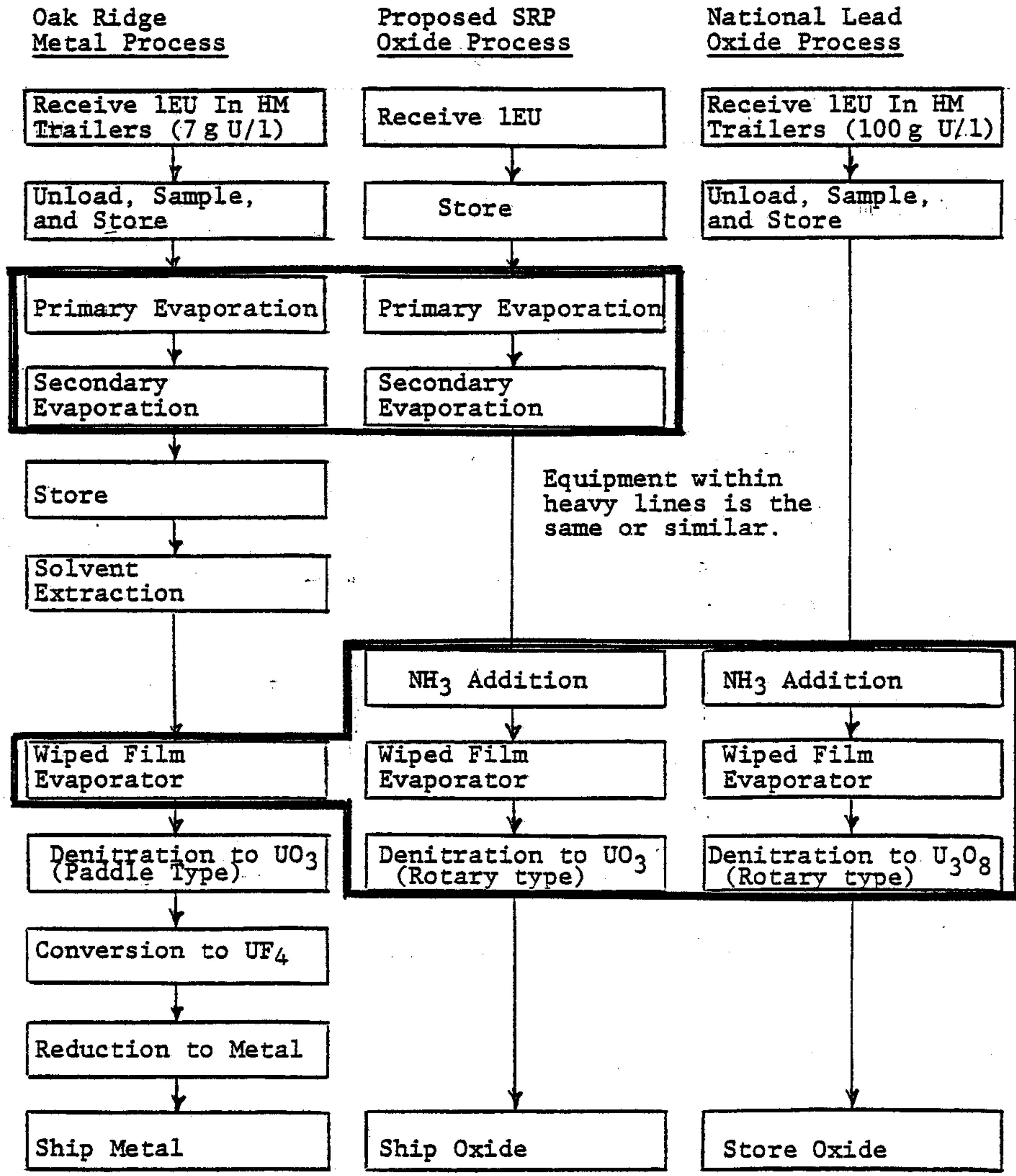

Figure 2. Comparison of Oak Ridge, National Lead, and Proposed SRP Oxide Processes.

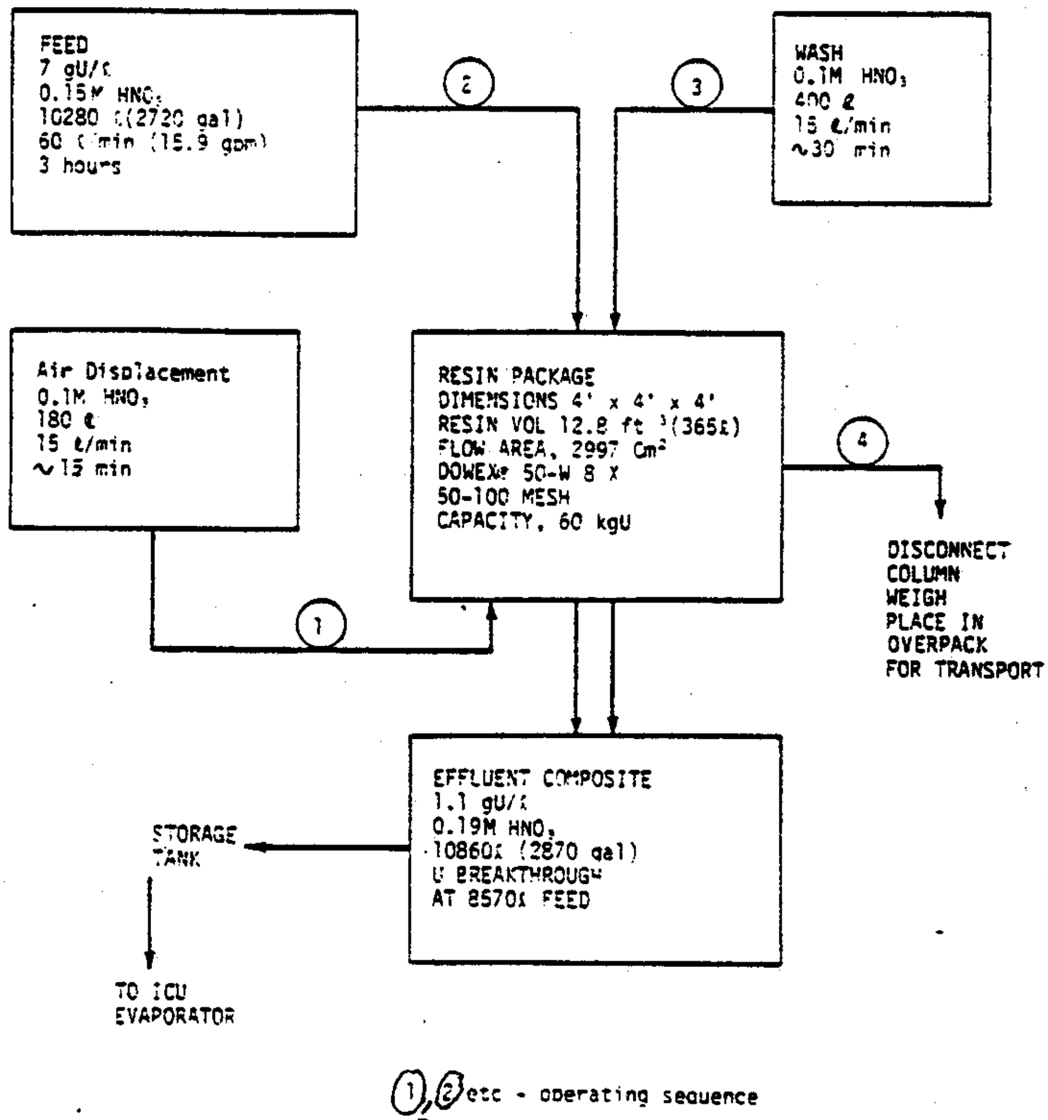

Figure 3. SRP Resin Loading Flowsheet-High Enrichment

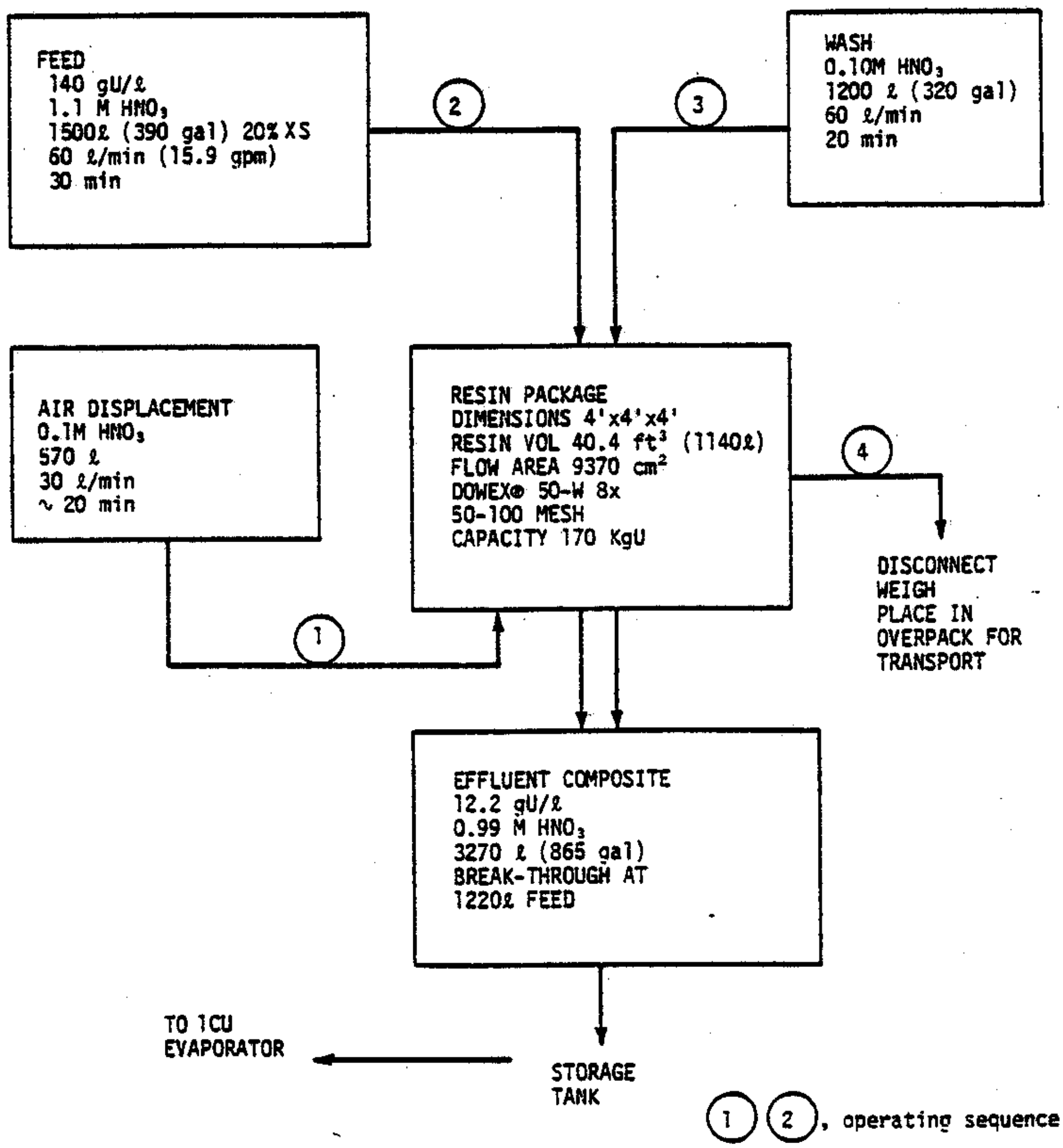

Figure 4. SRP Resin Loading Flowsheet-Low Enrichment

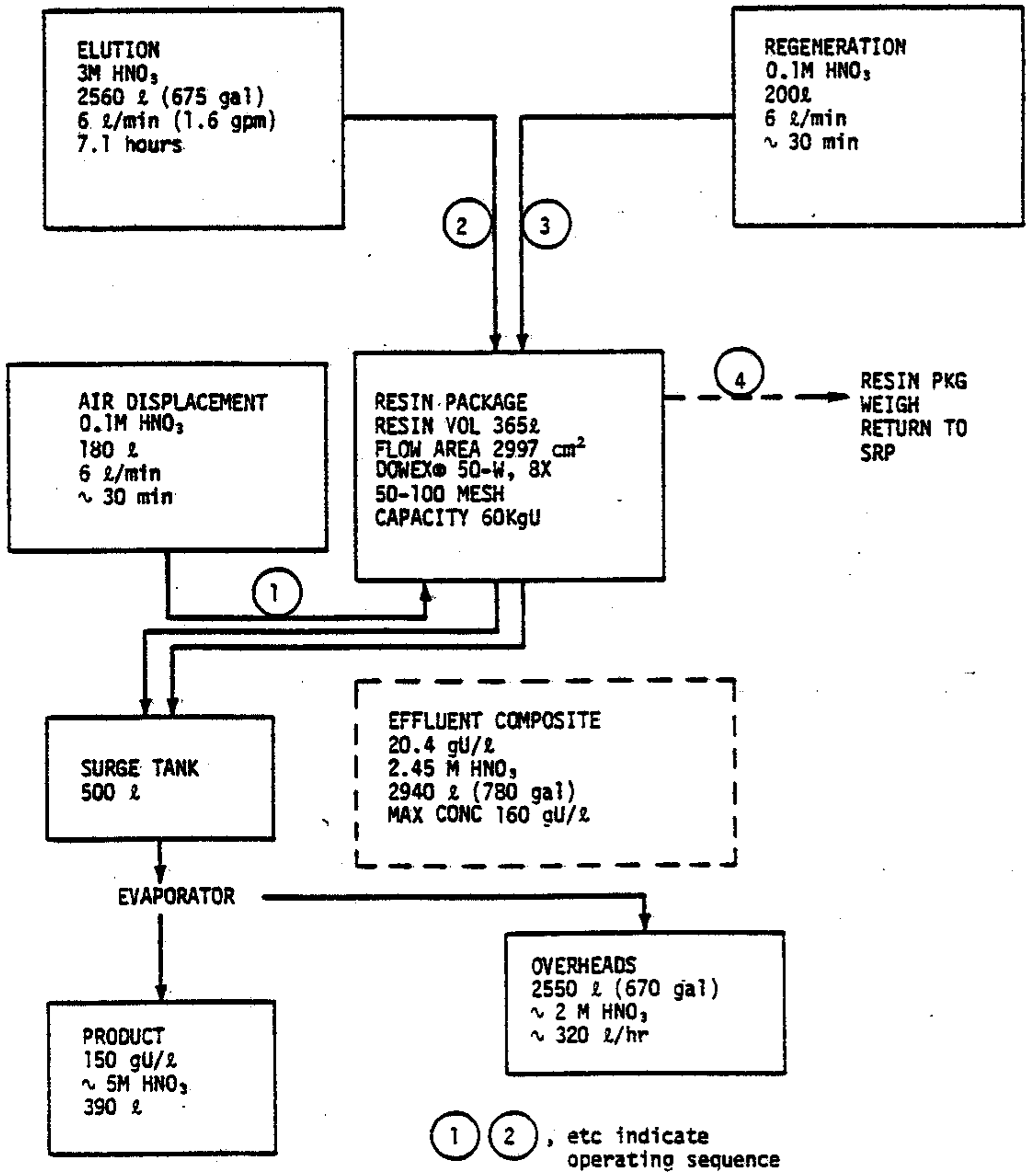

Figure 5. Resin Unloading Flowsheet-High Enrichment (Y-12)

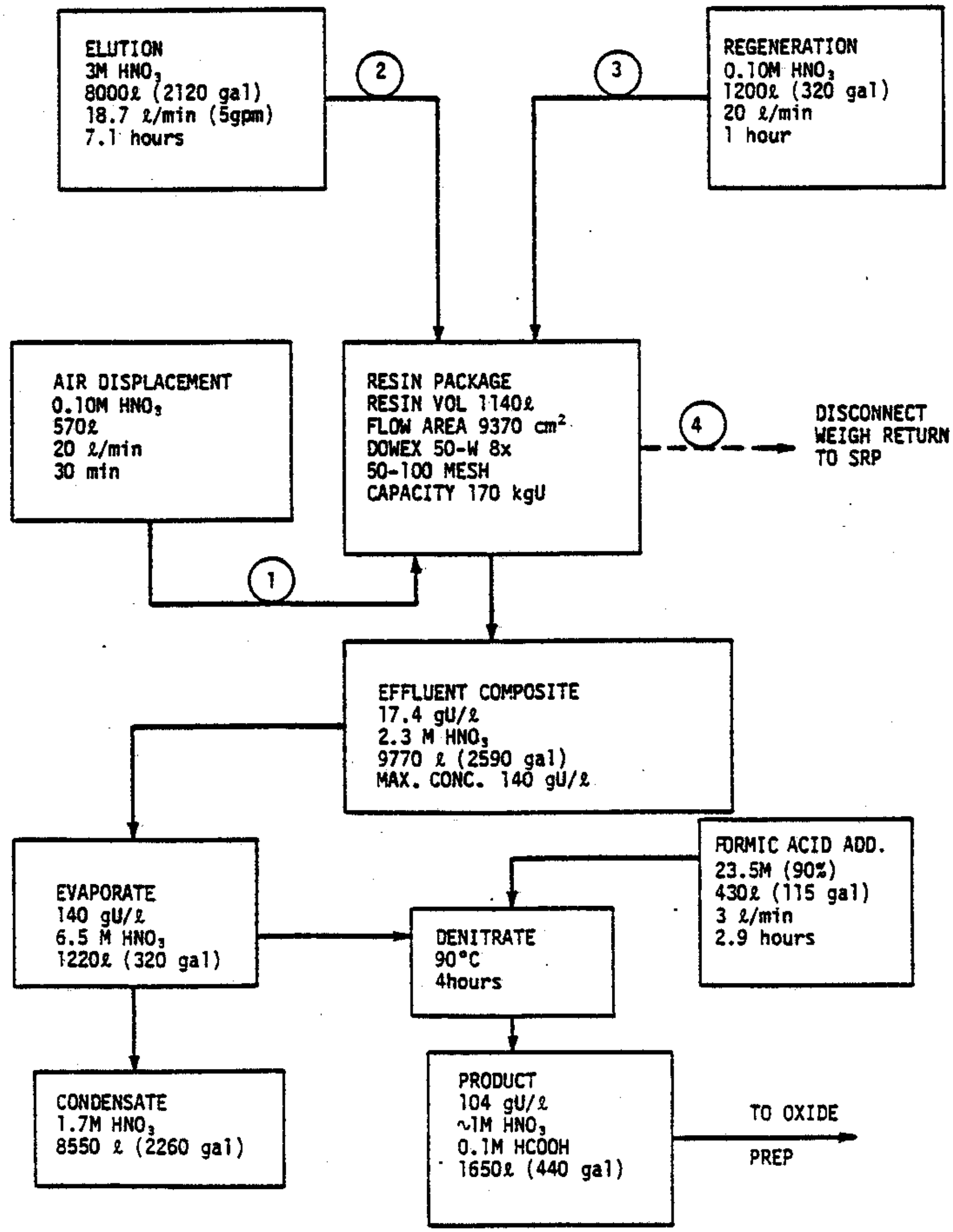

Figure 6. Resin Unloading Flowsheet-Low Enrichment (NLO)

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