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EVALUATION OF ULTIMATE DISPOSAL METHODS FOR LIQUID AND SOLID RADIOACTIVE WASTES: STATUS REPORT*

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ABSTRACT

Cost studies of interim liquid storage and pot calcination of radioactive wastes based on a hypothetical 15,000 Mw nuclear economy are summarized.

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A comprehensive study has been undertaken to evaluate the economics and hazards associated with alternative methods for ultimate disposal of highly radioactive liquid and solid wastes. All steps between fuel processing and ultimate storage will be considered, and the study should define an optimum combination of operations for each disposal method and indicate the most promising methods for experimental study.

A 6-tonne/day fuel processing plant is assumed, processing 1500 tonnes/year of uranium converter fuel at a burnup of 10,000 Mwd/tonne and 270 tonnes/year of thorium converter fuel at a burnup of 20,000 Mwd/tonne. This hypothetical plant would process all the fuel from a 15,000-Mw_e nuclear economy, which may be in existence by 1970. The preliminary operations to be evaluated are interim liquid storage, conversion to solids by pot calcination, interim storage of solids in pots, and shipment as either liquids or calcined solids. The ultimate disposal methods to be evaluated are calcined solids in salt deposits, in vaults, and in vertical shafts, and liquids in salt deposits, in deep wells, by hydrofracture, and in tanks.

A cost study of interim liquid storage was completed. Costs for storage of acidic Purex (50 gal/tonne of uranium processed), neutralized Purex (60 gal/tonne), acidic conventional Thorex (400 gal/tonne), and neutralized Thorex (640 gal/tonne) wastes were estimated for storage times of 0.5 to 30 years. Tanks of Savannah River design were assumed, with stainless steel construction for acidic wastes and mild steel construction for neutralized wastes. Stainless steel and zirconium decladding wastes were assumed to be stored separately from the high-level wastes. The costs of intermediate-level waste disposal will be assessed later.

For the high-level wastes, with interim storage time defined as filling time plus full time (equivalent to average liquid residence time if emptying time is equal to filling time), tank costs were minimum when the full time was roughly 40 to 75% of the interim storage time, using present worth considerations. For waste storage times of 0.5 to 30 years, costs ranged from 2.0×10^{-3} to 9.3×10^{-3} mill/kwh_e for storage of acid wastes and from 1.5×10^{-3} to 4.7×10^{-3} mill/kwh_e for alkaline wastes. Details of this study are given in ORNL-3128 (1).

The cost study was extended to include wastes from a new Thorex process, in which the use of nitric acid rather than aluminum nitrate as a salting agent forms a waste stream much lower in metal salts than the conventional Thorex waste (2). Use of the acid Thorex waste composition lowered interim liquid storage costs for 30 years to 6.8×10^{-3} mill/kwh_e for acidic wastes and 3.7×10^{-3} mill/kwh_e for neutralized storage (Fig. 1)

A cost study on conversion of high-activity solutions to solid by pot calcination was completed. Costs were calculated for processing Purex and Thorex wastes in acidic and reacidified (after alkaline storage) forms and for producing Thorex glass from acidic wastes. Calcination vessel designs were right circular cylinders similar to those used in engineering development studies. The vessels chosen for study were 6, 12, and 24 in. dia, made of schedule 40 type 347 stainless steel pipe, 10 ft high. Vessel costs used, based on estimates from private industry, were $500, $855, and $2515.

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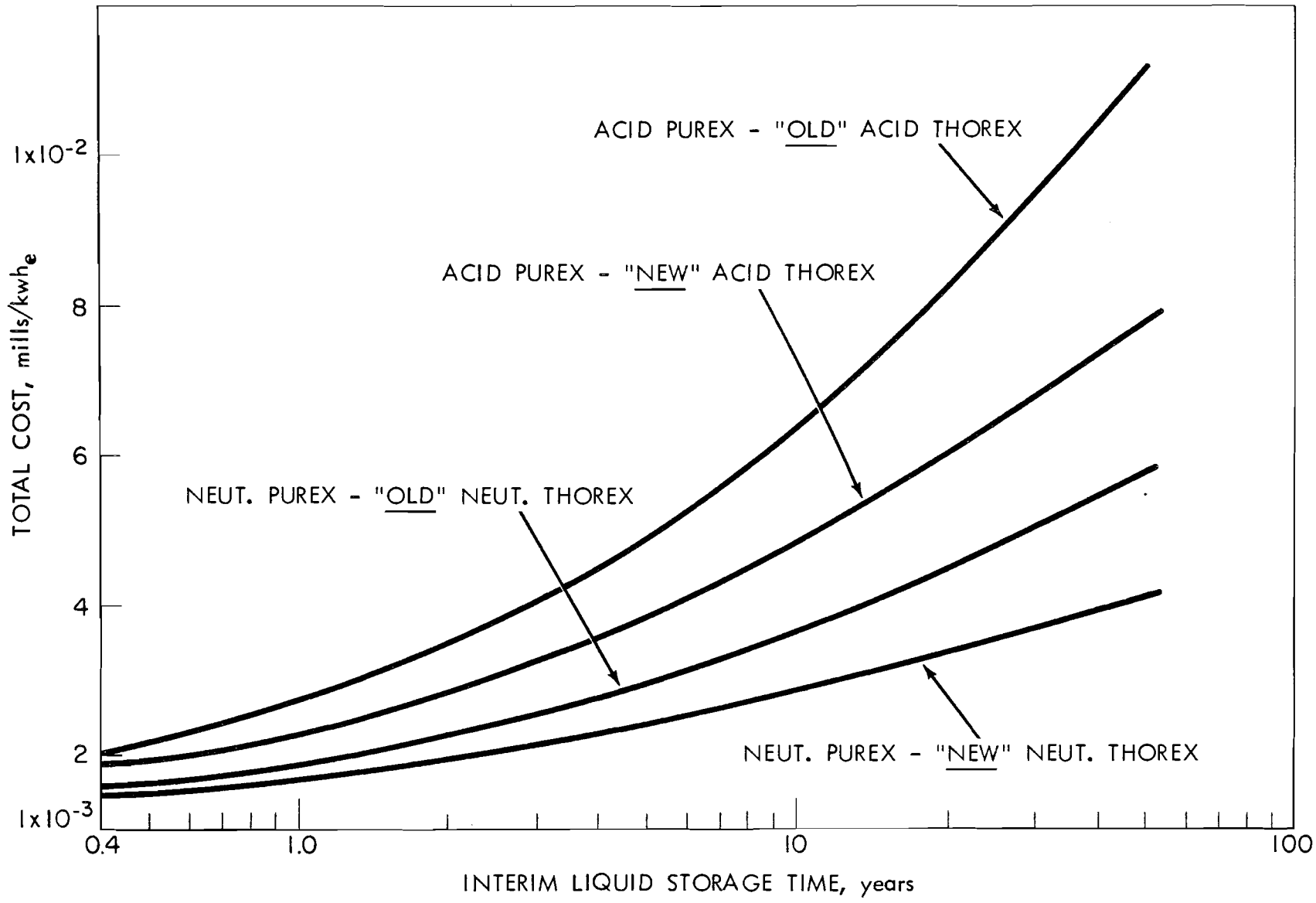

Fig. 1. Cost of interim liquid storage.

Costs were calculated for wastes decayed 120 days and 1, 3, 10, and 30 years after reactor discharge prior to calcination. Aging had negligible effect on costs for processing in a given vessel size, because vessel and operating costs were much higher than capital costs in all cases. Aging permits larger vessels to be used, however, and costs for processing in 6-in.-dia vessels were 2 to 3 times as high as for processing in 24-in.-dia vessels.

The lowest cost was 0.87×10^{-2} mill/kwh$_e$ for processing acid Purex and Thorex wastes in 24-in.-dia vessels, and the highest was 5.0×10^{-2} mill/kwh$_e$ for processing reacidified Purex and Thorex wastes in 6-in.-dia vessels (Table 1). About 7 years of interim liquid storage would be required before acidic Purex waste could be processed in 24-in.-dia vessels. Details of this study are given in ORNL-3192 (3).

Table 1. Pot Calcination Costs as Affected by Wastes Types and Vessel Sizes

Waste Type	Total Processing Cost, mills/kwh$_e$		
	6-in.-dia Vessels	12-in.-dia Vessels	24-in.-dia Vessels
Acidic Purex-acidic Thorex	1.6×10^{-2}	0.98×10^{-2}	0.87×10^{-2}
Acidic Purex-acidic Thorex glass	2.2	-	-
Acidic Purex-reacidified Thorex	3.8	1.9	1.5
Reacidified Purex-acidic Thorex	2.8	1.5	1.2
Reacidified Purex-acidic Thorex glass	3.4	-	-
Reacidified Purex-reacidified Thorex	5.0	2.4	1.9

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