EVALUATION OF THE MISCELLANEOUS WASTE EVAPORATOR AT RANCHO SECO

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ABSTRACT

In June 1984, Sacramento Municipal Utility District gave Impell Corporation the authority to proceed with an evaluation of the operation of the miscellaneous waste evaporator. The purpose of the evaluation was to optimize the operation of the evaporator with the intent to simplify and reduce the cost of waste handling within the plant. This paper analyzes on a cost basis, several suggested solutions to achieve the above.

The miscellaneous liquids waste treatment subsystem is designed to collect, store, process, and dispose of liquid wastes, other than reactor coolant wastes, generated during normal plant operation and during plant shutdowns. The system removes and concentrates the contaminants present in the water (radioactive and non-radioactive ions and solids), and temporarily stores the concentrates (bottoms from the miscellaneous waste evaporator) in the "A" waste coolant hold-up tank (AWCHUT). When the AWCHUT is full, the contents are pumped to a liner for solification by a contractor. The other waste form from the miscellaneous liquid waste treatment subsystem is cartridge filters.

Prior to disposal, the contents of the AWCHUT are routinely reprocessed to increase the concentration of activity and solids in the tank. The reconcentrating process presently requires that the AWCHUT contents be reprocessed through the miscellaneous waste filters before concentrating in the evaporator. These filters can become very radioactive and become very difficult to ship if they exceed waste class A or 10 nanocuries per gram of transuranics. The concentrate activity is increased during this reprocessing until a gross gamma activity of approximately 0.2 uCi/cc is achieved. Exceeding this level of activity requires that the solidified liner be shipped in a cask because the 2 meter dose rate limit of 10 mr/hr is exceeded.

Because of the desire to reconcentrate the contents of the AWCHUT prior to solidification to minimize the volume of evaporator bottoms, several solutions were suggested and analyzed on an operating cost basis.

The 0.2 uCi/cc activity limit is not the only variable in reprocessing that must be considered. The boric acid concentration is also a limiting factor in determining how much concentration can take place. These two variables result in four processing options on whether the utility should reconcentrate with or without the inline miscellaneous waste filters. A chart was developed to detail when filters should be utilized and when the evaporator feed need only pass through an inline strainer.

Finally, the costs of solidification, transporation and burial of evaporator bottoms is analyzed with and without a cask (bottoms activity can then be vastly increased) versus selective intermittent use of filters and the ultimate disposal of lower activity bottoms and several filters. Because of the extraordinary cost of either limiting the evaporator bottoms to 0.2 uCi/cc when they could be reconcentrated further or shipping evaporator bottoms in a cask, the latter was selected as most cost effective and volume reducing for the utility.

OPERATING EXPERIENCE AND BACKGROUND

Prior to disposal, the contents of the AWCHUT are routinely reprocessed to increase the concentration of activity and solids in the tank. The reconcentrating process presently requires that the AWCHUT contents to be reprocessed through the miscellaneous waste filters (F-692A&B, main and pre) (Fig. 1) before concentrating in the evaporator. These filters can become very radioactive and, as delineated in the Impell Report, "Optimization of Filter Loading",[1] become very difficult to ship if they exceed waste class A or 10 nanocuries per gram of transuranics. The concentrate activity is increased during this reprocessing until a gross gamma activity of approximately 0.2 uCi/cc or 12% boric acid is achieved. Exceeding 0.2 uCi/cc requires that the solidified liner be shipped in a cask because the 2 meter dose rate limit of 10 mr/hr is exceeded.

An overview of some of the problems encountered in previous reconcentrating process runs include:

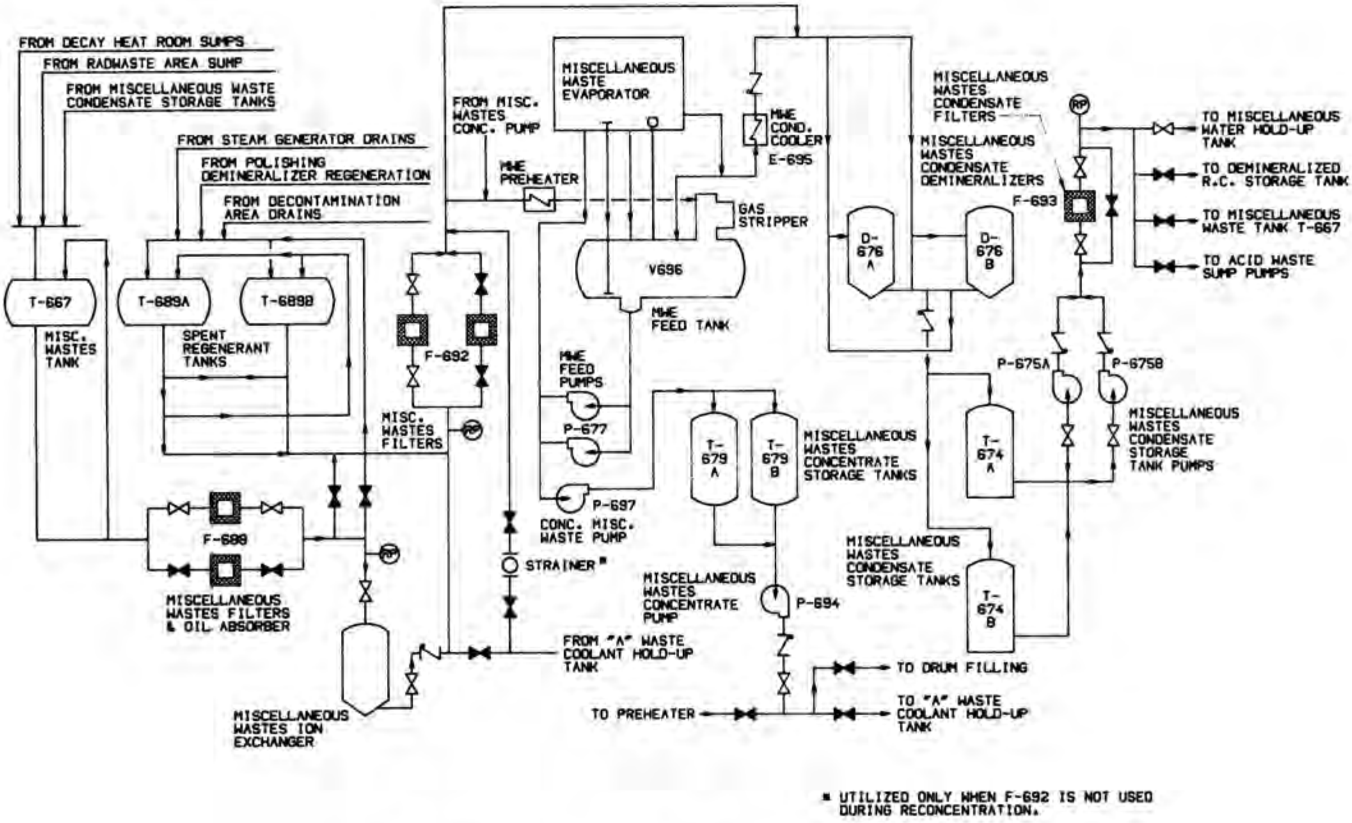

Fig. 1. Miscellaneous Liquid Radwaste System Flow Diagram.

1) High activity on waste filters (F-692)

2) Precipitation of boric acid in piping causing:

   a) the feed pumps (P-677) and the concentrate miscellaneous waste pump (P-697) to cease operation as a result of the pump recirculation line clogging with crystallized boric acid thereby preventing the fluid from lubricating the bearings.

   b) concentrate lines leaving the evaporator to become clogged with crystallized boric acid.

The problems with boric acid precipitation have been alleviated. For example, the Chempump feed pumps have been replaced with Tri-clover feed pumps. The reason for this problem is a result of the design of the Chempumps. The pump has only one moving part, a combined rotor-impeller assembly which is driven by the magnetic field of an induction motor. A small portion of the pumped fluid is recirculated through the motor cavity to cool the motor and lubricate the bearings. The recirculating fluid passes through a cylindrical filter, through the recirculation tube, to the rear of the pump. It then moves through the rear bearing, across the rotor, through the front bearing and back into the low pressure eye of the impeller[2]. As a result of the high boric acid concentration in the process fluid, the non-heat traced recirculating line would cool and become plugged preventing the fluid from cooling the motor and lubricating the bearings. The newer pumps are of a traditional centrifugal pump design with separate pump and motor. Their use has eliminated the boron crystalizing problems particular to the Chempump design and have added the convenience of rapid pump seal changeouts, when required, to reduce total man-rem exposure. In addition to heat-tracing, flanges have been added to the concentrate lines so that segments of the pipe can be removed and cleared of obstructions when problems arise.

The filters have been/are being replaced with a higher micron-size rating. The main filters have had a 3 micron rating, although the original specifications allowed up to 50 microns. The prefilters are now a 25 micron filter and the main filter is 30 microns. This may benefit operations as the filters should not require as frequent changeouts.

SUGGESTED SOLUTIONS

All feed to the evaporator from the miscellaneous waste tank and spent regenerant tanks is filtered. Thus, the contents of AWCHUT have already been filtered and additional suspended solids are expected to be minimal. Several possible alternatives have been suggested in operating this subsystem during reprocessing. These are:

- Continue with the present method. Fluid would be pumped back to the miscellaneous waste evaporator through the existing miscellaneous waste filters (now 30 micron).

- Remove the cartridges from one train (A or B) of prefilter and main miscellaneous waste filters during reprocessing. The reprocessing feed would then not be filtered. All filtration would be done during initial feed.

- Install a bypass line containing a sock type filter or a strainer around the miscellaneous waste filters. During recirculation the feed would be filtered using the sock filter or strained to remove large particles, such as resin beads.

- Continue evaporating and reprocessing to exceed the 0.2uCi/cc concentration to a point where it is cost effective to ship the increased activity liner in a cask.

Each of these alternatives will be analyzed for cost effectiveness in the following section.

ANALYSIS

The alternatives outlined in the previous section required an analysis on all the costs involved. These include filter costs, solidification costs, shipping costs, and burial costs. Table I lists the assumptions made on the costs involved. The first step was to determine the cost effectiveness of the last alternative, namely, exceeding the 0.2uCi/cc concentration. Table II lists the assumptions and values used. The approach was to determine the total charge for reconcentrating a given quantity of water and:

1) Maintaining the activity below or at 0.2uCi/cc and thus being able to ship the liners bare.

2) Exceeding 0.2uCi/cc and shipping the liner in a cask.

Appendix A shows the cost of solidifying, shipping and burial of 30,000 gallons evaporator bottoms in bare liners. By equating the cost of reprocessing 30,000 gallons with bare liners to the cost of shipping liners in a cask (and the increased activity allowed), the number of gallons after reprocessing is reduced to 22,349 gallons as shown in Appendix B.

The options are as follows:

1) Solidify and ship 30,000 gallons at 0.2uCi/cc at a cost of $838,827 dollars.

2) Reconcentrate to 22,349 gallons at 0.26uCi/cc, ship in a cask for burial at the same cost as 1) above.

3) Reconcentrate to 22,349 gallons and remove excess activity using filters so that the concentrate is at 0.2uCi/cc allowing shipment to be made using bare liners. Total cost of this option as shown in Appendix C is approximately $640,000.

Option 3 shows that a cost savings of $200,000 can be achieved by using filters to remove some of the activity. Obviously, there are an infinite number of operating points, that is, the amount of activity removed by filters versus the amount of concentration of bottoms.

However, activity is not the only variable in reprocessing that must be considered. The boric acid (H_3BO_3) concentration as well as total dissolved solids are usually the limiting factors in determining how much concentration can take place. A boric acid concentration of 12% is usually the maximum allowed in a solution before it starts to precipitate. These two variables, activity and percent boric acid (along with total dissolved solids), present four processing options as delineated below:

Option	$\%H_3BO_3$	Activity (uCi/cc)	Processing Required
1	$\geq$ 12%	< 0.2	Solidify as is
2	$\geq$ 12	> 0.2	Filter to achieve 0.2uCi/cc
3	< 12	< 0.2	Reconcentrate to 12% and filter, as necessary, to achieve 0.2uCi/cc
4	< 12	> 0.2	Reconcentrate to 12% and filter to achieve 0.2uCi/cc

Option two suggests filtering to achieve an activity equal to 0.2uCi/cc. As mentioned earlier, this is done because it is cheaper to use filters than to utilize a cask. Furthermore, there is no cost advantage for filtering to less than 0.2uCi/cc.

RECOMMENDATIONS

The contents of the AWCHUT prior to the first concentrating process will fall under option 3 in the previous section. Specifically, the boric acid concentration will be less than 12% and the activity less than 0.2uCi/cc.

Based on activity and boric acid concentration, Fig. 2 shows whether filtering is required or not. The area below the 0.2uCi/cc vs. 12% line requires no filter while the area above the line requires a varying amount of filtering as required to obtain 12% and 0.2uCi/cc.

When filters are not utilized during reprocessing, as outlined above, the concentrate should be routed through a strainer to prevent potential fouling of the evaporator. The size of the strainer should be approximately 500 microns, small enough to catch loose resin beads if necessary. The strainer can be inserted in the filter housings in place (without the filter) to keep capital expenditures to a minimum. However, to increase operational flexibility, a bypass line with a strainer housing is recommended (see Fig. 1). Ample space exists in the miscellaneous filter room in the space formerly used for the radiation monitor for this addition. Based on differential pressure, the strainer could be removed and cleaned as necessary.

The alternative of using a sock filter which would reduce filter material costs as well as easing packaging requirements, either in an existing housing or in a bypass line to prevent the addition of large debris to the evaporator and/or pumps, was rejected for two reasons. The first was ALARA considerations due to the difficulty during installation and changeouts. The second was that the filter could be as difficult to dispose of as the existing filters as a result of the potentially high activity loading. The strainer recommended is believed to more adequately address these two concerns.
An additional area of concern is the service life of the remaining Chempump, specifically the concentrated miscellaneous waste pump, P-697. Because of the high

TABLE I

COST ASSUMPTIONS

(Shipment to Hanford, Washington)	Price
Transportation Charge per Load	\$1600
Basic Burial Charge per Cubic Foot	\$18.91
Cask Rental Fee	\$6750
Cask Handling Fee	\$638
Labor Cost per Person-Hour	\$25
Bare Drum Cost, Each	\$28
Material Costs	\$50
Disposal Cost, per drum	\$142
Overweight Surcharge - over 10,000 lbs	\$172.90 + 0.09/lb
Solidification by Contractor, per cubic foot	\$152
Filter Cartrige Material Costs	
F-692 Main	\$1480
F-692A Prefilter	\$65
Filter Changeout Labor for an Unsolidified drum[2]	20.7 Person-hours

TABLE II

ASSUMPTIONS USED IN APPENDIX A

Liner weight, when solidified	18,000 lbs
Volume of Evap. Bottoms put in liner	850 gal
Volume of miscellaneous water to flush lines	50 gal
Burial volume of liner	200 cubic feet
Number of bare liners per shipment	2

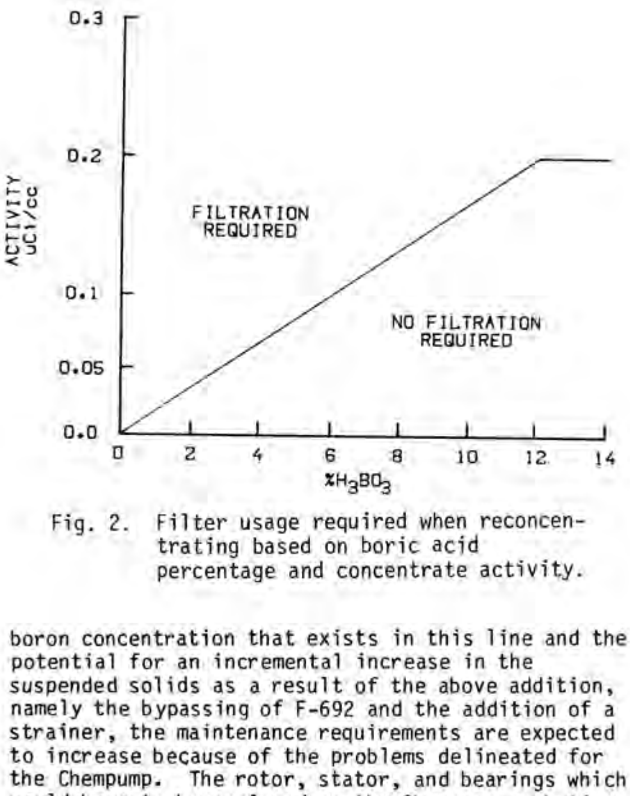

Fig. 2. Filter usage required when reconcentrating based on boric acid percentage and concentrate activity.

boron concentration that exists in this line and the potential for an incremental increase in the suspended solids as a result of the above addition, namely the bypassing of F-692 and the addition of a strainer, the maintenance requirements are expected to increase because of the problems delineated for the Chempump. The rotor, stator, and bearings which would have to be replaced on the Chempump each time it fails, cost approximately \$6,000. A new Tri-clover pump costs approximately \$4,000 and would require 20 man-hours to install[3]. The savings increase when maintenance is required on the new pump as the entire pump casing can be "quick-disconnected". This allows maintenance to work on the pump in the shop thereby reducing the man-rem exposure for the job. The concentrated miscellaneous waste pump is only operated infrequently and, as such, may not require replacement.

CONCLUSION

From this evaluation of the operation of the miscellaneous waste evaporator in conjunction with other portions of the radwaste system, the primary concern was to simplify waste handling in a cost effective manner within the plant. Because of the difficulty in shipping waste class B & C filters and the ease (but not necessarily inexpensive) in shipping solidified evaporator bottoms, the goal of minimizing the volume of filters through intermittent use has been achieved. The addition of a strainer adds an additional capital cost requirement because of the manhours required to install a line bypassing the waste filters (F-692) and possibly the replacement of a pump to reduce downtime and additional costs to the system.

The addition of the bypass line requires a procedural and operational change in the way the system is currently operated. However, this additional requirement is expected to be minimal.

REFERENCES

1. "Optimization of Filter Loading", Waste Management 85, John Turney, Impell Corp. and Dennis Gardiner, Sacramento Municipal Utilities District.

2. Product literature, Chempump Instruction Manual.

3. Gordon Clefton, SMUD, Personal Communication, July 18, 1984.

APPENDIX A

COST OF SOLIDIFICATION, TRANSPORATION, AND BURIAL OF EVAPORATOR BOTTOMS

Liner Shipment Only

$30{,}000 \text{ gal} \times \frac{\text{liner}}{850 \text{ gal}} = 35.3 \text{ liners}$

Solidification

$900 \text{ gal} \times \frac{\text{cu ft}}{7.48 \text{ gal}} \times \frac{\$152}{\text{cu ft}} \times 35.3 \text{ liners} = \$645{,}594$

Transportation

$\frac{35.3 \text{ Liners}}{2 \text{ liners/shipment}} \times \frac{\$1600}{\text{Shipment}} = 28{,}240$

Overweight Surcharge

$\$172.70 + 0.09\ (18{,}000 - 10{,}000) = \$892/\text{Liner}$

$\frac{\$892}{\text{Liner}} \times 35.3 \text{ Liners} = 31{,}488$

Burial Charge

$35.3 \text{ Liners} \times 200 \frac{\text{cu ft}}{\text{liner}} \times \frac{\$18.91}{\text{cu ft}} = \underline{133{,}505}$

TOTAL CHARGE FOR 30,000 GALLONS SOLIDIFIED $838,827

APPENDIX B

EQUIVALENT COST COMPARISON FOR LINERS SHIPPED IN A CASK

Liner in Cask

Solidification

$900 \text{ gal} \times \frac{\text{cu ft}}{7.48 \text{ gal}} \times \frac{\$152}{\text{cuft}} = \$18{,}290/\text{liner}$

Transportation

$1600 (transport) + $6700 (cask rental) = $8,300/liner

Overweight Surcharge

$\$172.70 + 0.09\ (18{,}000 - 10{,}000) = \$893/\text{liner}$

Cask Handling Fee = $638/liner

Burial Charge

$\frac{\$18.91}{\text{cu ft}} \times 200 \frac{\text{cu ft}}{\text{liner}} = \underline{\$3{,}782/\text{liner}}$

TOTAL PER LINER IN CASK $31,903/liner

$\frac{\text{TOTAL COST FOR 30,000 gal (Appendix A)}}{\text{TOTAL COST FOR LINER IN CASK}} = \frac{\$838{,}827}{\$31{,}903/\text{liner}} = 26.3 \text{ Liners}$ (For same cost as bare liner only)

$26.3 \text{ Liners} \times 850 \frac{\text{gal}}{\text{liner}} = \underline{22{,}349 \text{ gallons}}$

APPENDIX C

COST COMPARISON OF REMOVING ACTIVITY USING FILTERS

Cost of reprocessing 30,000 gallons, from Appendix A, $838,827

Required volume 22,349 gallons, 0.2uCi/cc

Cost of reprocessing above:

$$\frac{22{,}349 \text{ gal}}{30{,}000 \text{ gal}} \times \$838{,}827 = \underline{\$624{,}901}$$

Required Activity Removal Due to Reconcentrating:

$$30{,}000 - 22{,}349 = 7{,}651 \text{ gal} \times \frac{\text{cu ft}}{7.48 \text{ gal}} \times \frac{2.83\text{E } 4\text{cc}}{\text{cu ft}} \times 0.2\frac{\text{uCi}}{\text{cc}} \times \frac{10^{-6}\text{Ci}}{\text{uCi}} = \underline{5.8\text{Ci}}$$

Using Ref 2, "Optimization of Filter Loading", the following number of filters are required to remove 5.5Ci and still keep the filters at a Class A loading:

$$\text{F-692 MAIN:} \quad \frac{5.8\text{Ci}}{.7976\text{Ci/filter}} = 7.26 \text{ filters}$$

$$\text{F-692 Pre:} \quad \frac{5.8\text{Ci}}{.4092\text{Ci/filter}} = 14.15 \text{ filters}$$

The operating costs for shipping these filters are:

	F-692 MAIN	F-692 Pre
Number of Filters	7	14
Filter Cost	$10,360	$910
Labor Cost	$3,623	$7,245
Drum Cost	$196	$392
Media Cost	$350	$700
Shipping Cost	$156	$311
Disposal Cost	$994	$1,998
TOTAL	$ 15,679	$ 11,546

TOTAL COST FOR SHIPPING, BURIAL, ETC.:

Solidified bottoms	$624,901	$624,901
Filters (main, pre)	15,679	11,546
	$640,580	636,447