EVALUATION OF WASTE PROCESSES AT SAVANNAH RIVER SITE FOR TREATMENT OF MIXED WASTE

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ABSTRACT

The optimum treatment strategy for an aqueous mixed waste stream generated by an incinerator at the Savannah River Site (SRS) has been determined utilizing a systematic graded approach. This methodology included cost, technical feasibility, permitting, and schedule considerations in evaluating treatment of mixed waste by existing SRS high-level and low-level radioactive processes in addition to various mixed waste vendor processes. The evaluation showed that approximately $30 MM could be saved through implementing an existing facility over obtaining a "new" treatment process or utilizing a vendor. The evaluation also revealed two additional cost savings that could be realized with operational changes: 1) $44 MM could be saved in disposal costs by campaigning the incinerator waste feed so as to allow most of the stabilized waste to be disposed of in low-level vaults which are approximately 8X less expensive than mixed waste vaults and 2) $18.3 MM could be saved in disposal costs by substitution of PVC in the waste feed reducing the incinerator's generation of the aqueous waste stream.

INTRODUCTION

The Consolidated Incineration Facility (CIF), a mixed waste incinerator at SRS, will generate aqueous mixed waste, referred to as blowdown, that requires treatment prior to disposal. The original treatment process was a bulk-grouting and disposal facility. However, the original project was stopped in the early design phases since a study indicated that significant cost savings could be realized in disposal of the waste with prior volume reduction. After the project was stopped, subsequent plans were to build a "new" mixed waste treatment process at SRS that included volume reduction. A vendor would be used to treat the incinerator waste stream during design or construction of the "new" facility.

An evaluation of various on-site treatment processes was initiated recently since it was realized that additional cost savings could be made by utilizing an existing facility rather than constructing/purchasing a "new" process. Existing SRS low-level and high-level radioactive facilities that were not considered previously could now be considered for treatment of mixed waste because of two reasons: 1) site waste minimization efforts that included replacing the PVC in the CIF waste feed would reduce the future CIF blowdown production by up to 85% (the lower volumes allow dilution of the blowdown with existing waste streams so that the acceptance criteria of the existing facility can be more easily met), and 2) campaigning the incinerator waste feed (listed hazardous separated from characteristic hazardous) would allow most of the blowdown to be treated in existing on-site processes with minor modifications. The approach taken in the evaluation was to determine what upgrades would be required to ensure an existing low or high-level process could successfully treat the incinerator's mixed waste stream. The upgrades included both engineering (i.e., equipment) and administrative (i.e., permitting) modifications.

ALTERNATIVES

All feasible processes/technologies were evaluated in this study. Eight of the alternatives were existing SRS facilities and one alternative included treatment of the blowdown through procurement of vendor services and/or construction of a "new" process. The "new" process could be one of several technologies (i.e., cement, thermoplastics, thermosetting polymers, or glass stabilization). Selection of the optimum technology for the "new" process was based on previous studies (1). Table I lists the alternative treatment strategies that were considered in the evaluation.

WASTE COMPOSITION

The evaluation of each of the nine alternatives was based on treating two cases of CIF blowdown composition as shown in Table II. The blowdown composition will vary based on both the volume generated and the assumptions used to predict the CIF waste feed characteristics. The radioisotopic content in the blowdown will be limited to 3000 ci/yr based on maximum permit limits. The hazardous contaminant concentration in the blowdown is based on test results from offsite incineration testing. The CIF blowdown volume is dependent on the quantity of polyvinylchloride (PVC) in the waste feed. The two cases in Table II are based on two different PVC concentrations in the CIF waste feed: Case 1 is based on 2 wt% PVC in the waste feed and Case 2 is based on 10 wt% PVC in the feed.

The following assumptions were used in both blowdown composition cases :

- Chloride Content in Liquid Waste Feed: 0.5 wt%
- Annual CIF Waste Feed Quantity: 4,149,300 lbs
- Ash Content in Liquid Waste: 0.5 wt% in liquid waste and 5.0 wt% in solid waste
- 50% ash carryover
- Hazardous metals are assumed to be in the "worst-case" form, i.e., soluble form (metal salts) which is more readily leachable than the insoluble form (metal oxides).

EVALUATION CRITERIA

All nine alternatives that could potentially treat the mixed aqueous waste were evaluated systematically using a grading system. "Weighted" evaluation criteria included the technical feasibility of the alternative, cost to implement, permit considerations, and schedule impact. The rationale used in assigning points for each of the criterion is discussed below.

Technical Feasibility

Technical feasibility is one of the two most important criterion in evaluating an alternative. Therefore, this criterion

TABLE I
Alternative Treatment Strategies for the CIF Blowdown

Alternative	De-Watering	Stabilization	Current Waste Stream
1. Ashcrete	Evaporation	Cement In-Drum Tumbling Process	Mixed Waste (CIF) Incinerator Ash
2. Defense Waste Processing Facility (DWPF)	Various Physical and Chemical Separation Processes	Glass for High-Level Waste & Cement for Low-Level Waste	High-Level Tank Farm Waste
3. Effluent Treatment Facility	Wastewater Treatment (WWT) (filtration, reverse osmosis)	Cement Bulk Grouting Facility	Rainwater/Evaporator Overheads
4. Saltstone	None	Cement Bulk Grouting Facility	Low-Level Tank Farm Waste
5. M-Area Facility	WWT process (co-precipitation, filtration)	Cement In-Drum Tumbling Process or Vendor Process	Low-Level Mixed Waste Stream
6. Navel Fuels Facility	Evaporation	Cement Stationary Stirred Batch Mixer	No Designated Waste stream
7. 211-F Evap.	Evaporation	See DWPF	Rainwater
8. CIF Offgas Re-design	Evaporation	Cement In-Drum Tumbling Process	Future Process for CIF Blowdown
9. Vendor	Evaporation or WWT	Cement, Glass, or Plastic	Future Process for CIF Blowdown

was assigned a maximum point allotment of 35 points (35% of the total score). The technical feasibility of each alternative was graded based on the success of prior test work on similar waste simulants and on the degree of test work (i.e., lab-scale or pilot-scale) that had been previously conducted as shown below:

Score	Technical Feasibility
35 pts -	Alternative has been proven through treatability studies.
25 pts -	Alternative is considered technically feasible based on previous test work on similar waste streams, but treatability studies and potential demonstration work is required to confirm the judgment.
0 pts-	Alternative is not considered technically feasible.

As stated earlier, the approach taken in this evaluation was to determine the operational or engineering (i.e., equipment or process) modifications that would be required to ensure that low or high-level radioactive processes could successfully treat mixed waste. Process and equipment modifications required to upgrade existing facilities included 1) addition of new equipment, 2) replacement of existing equipment, and 3) tie-ins and/or adjustments to existing equipment. New equipment usually included de-watering processes (evaporators), receipt tanks at the existing process, or truck unloading stations. Replacement of existing equipment was necessary in some cases because of the corrosive nature of the CIF blowdown. Tie-ins to existing equipment was needed to provide required waste transfer lines, flush water lines, and utilities.

Operational modifications were considered to offset the cost required to upgrade the existing facilities to meet RCRA requirements. Campaigning of the incinerator waste feed would allow 90% of the incinerator's mixed waste stream to be treated in existing low and high-level radioactive processes without major modifications to existing permits. The remaining 10% of the waste stream could be treated by an existing on-site facility permitted to treat listed waste, i.e. M-Area.

Cost

Cost is the most important criterion in addition to technical feasibility for evaluating the alternative, and therefore, is assigned a maximum of 35 points. The cost for each alternative is based on a"life-cycle" cost estimate, which includes 1) total project cost (TPC), 2) operating cost, and 3) disposal cost. The TPC cost is a "one-time" cost while the operating and disposal costs are annual costs that are incurred over the life of the process. The scores assigned to the cost to implement a treatment alternative are shown below:

Score	Life-Cycle Cost
35	$ 25 MM
33	$ 27 MM
31	$ 29 MM
29	$ 31 MM
27	$ 33 MM
25	$ 35 MM

TABLE II
CIF Blowdown Composition (Hazardous)

	Case 1 2% PVC in Feed	Case 2 10% PVC in Feed
Blowdown volume (gal.)	50,000	185,000
Wt% NaCl salt	9.5%	10%
Wt% Solids (i.e., ash, metals)	10%	2.7%
Hazardous Metals (ppm)		
Arsenic	0	0
Barium	149	40
Cadmium	4	1
Chromium	977	262
Lead	6,861	1,841
Mercury	596	160
Silver	2,877	772
Nickel	3,424	918
Thallium	4	1
Antimony	0	0

23	$ 37 MM
21	$ 39 MM
19	$ 41 MM
17	$ 43 MM
15	$ 45 MM
13	$ 47 MM
11	$ 49 MM
9	$ 51 MM
7	$ 53 MM
5	$ 55 MM
3	$ 57 MM
1	$ 59 MM
0	>$ 59 MM

Total Project Cost

The total project cost (TPC) consist of the total estimated cost (TEC) and the other project cost (OPC). The TEC cost is based on capital equipment cost, but also, includes site factors, process engineering, and etc. as shown in Table III.

Other project costs (OPC) include permitting, process development and support, personnel training, procedure development, start-up testing, etc. The OPC cost for the existing facilities was negligible since the training, start-up, and procedure development tasks had been completed during the start-up phase of the process. The OPC cost for most of the alternatives included costs associated with process development or R&D work and permitting.

Operating and Disposal Cost

Operating costs included maintenance (estimated at 10% of installed capital), utilities, and material costs. Disposal costs were based on 50,000 gallons of blowdown (Case 1 in Table II) with only 2 wt% PVC in the CIF waste feed. This volume of blowdown will generate 685 drums (5,035 ft^3) of stabilized waste (based on a 16 wt% waste loading from previous studies by Brookhaven National Laboratory using mixed incinerator flyash from the WERF Incinerator at Idaho National Engineering Laboratory). The TPC cost to dispose of this waste in the planned SRS mixed waste disposal vaults @ $374/$ft^3$ is $1,883,000/yr.

If the waste was campaigned such that the listed and characteristic hazardous waste were burned separately, 90% of the waste (617 drums) could be de-listed and disposed of in the low-level vaults assuming 10% of the waste contains listed hazardous contaminants. The cost to dispose of the campaigned waste would be approximately $409,000/yr as shown in Table IV.

Permitting Considerations

Permitting was considered an important criterion because it can affect the viability of an alternative based on the time and difficulty in obtaining the required permit. This criterion was assigned a maximum point allotment of 20 points as shown below:

Score	Permitting Requirements	Estimated Time to Obtain Permit
20	- Modify existing permit	6 months
15	- Modify existing permit but SCDHEC negotiations required	1 Year
	- "Minor Modifications" to RCRA permit	
10	- Modification of >2 permits with SCDHEC negotiations	1 - 1.5 Years
5	- "Major Modifications"	2 Years
0	- New RCRA permit	3 - 4 Years

Schedule

The schedule criterion was used to bench-scale the impact of implementation of an alternative on the CIF start-up date. The alternatives were scored based on the following schedule impacts:

Score	Schedule Impact
10	Will not significantly impact the CIF start-up (2/96)

TABLE III
Total Estimated Costs

Cost	Cost Factor	Description
• Capital Cost (C)	None	Equipment, Piping, etc.
• Site Factor Cost (S)	30 - 44% of C	Site Preparation
• Process Eng. Cost	22% of C&S	Prep. of Design Documents
• Labor	10% of C&S	Non-Manual Labor
• Project Management	7 - 20% of C&S	Management of effort
• Safety Modification	None	Cost to modify Safety Doc.
• Contingency	25% of all above costs	Additional Misc. Cost

TABLE IV
Disposal Cost Based on Campaigning CIF Waste Feed

Waste Type	Secondary Waste Volume	Disposal Cost/ft^3	Annual Disposal Cost
Characteristic Mixed to Low-Level Vaults	90% (617 drums or 4,534 ft^3)	\$49/ft^3	\$222,000
Listed Mixed to Mixed-Waste Vaults	10% (68 drums or 500 ft^3)	\$374/ft^3	\$187,000
			\$409,000

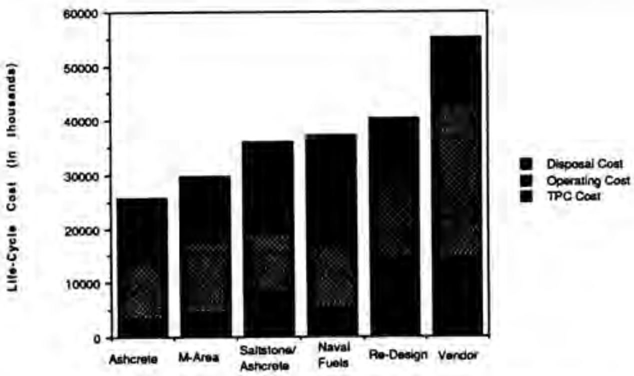

Fig. 1. Life-cycle cost comparison (in thousands).

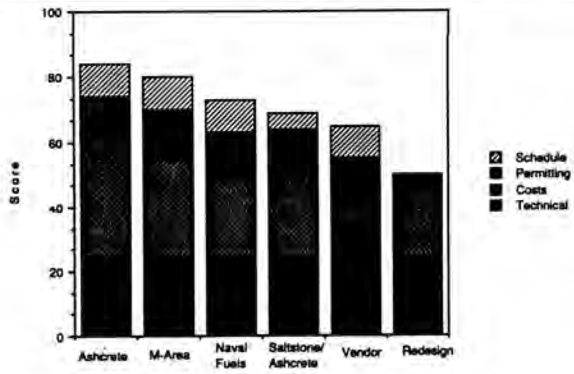

Fig. 2. Score of graded-point evaluation.

5 Could potentially impact CIF start-up (>6 months <1 year)

0 Will significantly impact CIF start-up (>1 year)

RESULTS OF EVALUATION

Cost is one of the most important considerations in implementing a treatment alternative for the CIF blowdown. Figure 1 summarizes the 30-year "life-cycle" costs for the six most economically-feasible treatment alternatives considered.

The figure differentiates between the total project cost (TPC), operating, and disposal costs. Figure 1 indicates that Ashcrete is approximately \$30 MM less expensive than vendor treatment of the waste. The cost to upgrade the existing Ashcrete process is less expensive than to pay rental fees for utilizing a vendor treatment process or to construct a "new" process. In addition, Fig. 1 indicates that the operating cost for existing processes is less expensive than that for a "new" or vendor process since additional personnel are not required for an existing facility. The disposal costs for all alternatives were relatively the same except for Saltstone and Naval Fuels which are slightly more expensive since 10% of the total waste stream which is stabilized in an existing mixed waste facility (i.e., Ashcrete) is not de-watered. De-watering the blowdown significantly decreases the disposal costs. Previous studies indicated that blowdown de-watering with subsequent stabilization would save \$270 MM over bulk grouting in a mixed waste vault.

Eventhough cost is the most important consideration in selecting a feasible alternative, it is not the only consideration. In selecting the best alternative treatment, permitting and schedule must also be considered. Figure 2 graphs the results of the "graded-scored" approach for the 6 best alternatives. The scores in Fig. 2 indicate, that when all factors (i.e., cost, permitting, technical feasibility, and schedule) are considered, the alternatives rank differently than when only the cost factor is considered.

The evaluation also revealed additional cost savings that could be realized through operational changes, i.e., changes in waste feeds and campaigning of waste feeds. Reduction of PVC in the CIF waste feed reduces the blowdown volume by up to 75% (i.e., from 185,000 gallons/yr to 50,000 gallons/yr), and therefore, results in a "life-cycle" disposal cost savings of \$18.3MM. Table V, from which Fig. 1 was developed, shows the costs for implementing an alternative based on both

TABLE V
Estimated Cost in Thousands

ALTERNATIVE TREATMENT	TREATMENT COST		DISPOSAL COST	TOTAL COST		
	A (ONE-TIME) TPC COST ($)	B ANNUAL OPER COST	C ANNUAL DISPOSAL COST	A (ONE TIME) TPC COST	B+C ANNUAL COST	(A)+(B+C) X 30 "LIFE-CYCLE" COST
1. Ashcrete						
- no campaign	3,653	328	1,883	3,653	2,211	69,983
- campaign	3,653	328	409	3,653	737	25,763 (1)
2. a. Tank Farm	19400+	1,963	7,622	19,400	9,585	306,950
b. Tank Farm/Ashcrete	18,600	1,963	7,622	18,600	9,585	306,150
3. ETF	N/A	N/A	N/A	N/A	N/A	N/A
4. a. Saltstone	90,000+	350	567	90,000	917	117,510
b. Saltstone/Ashcrete	8,430	350	567	8,430	917	35,940 (3)
5. M-Area LETF						
- no campaign	4,528	433	1,883	4,528	2,316	74,008
- campaign	4,528	433	409	4,528	842	29,788 (2)
6. Naval Fuels WWTF						
- campaign	5,660	353	701	5,660	1,054	37,280 (4)
7. 211-F Evaporator	Refer to 2a.b.					
8. Re-Design of CIF Offgas						
- no campaign	14,800	443	1,883	14,800	2,316	84,280
- campaign	14,800	443	409	14,800	852	40,360
9. Interim Vendor*(IV) &						
a. permanent process	14,773	941	409	14,773	1,350	55,273
b. purchase IV equip.	14,773	941	409	14,773	1,350	55,273
c. new Interim Vendor	33,240	941	409	33,240	1,350	73,740

* Based on Campaigning waste

* Table based on 50,000 gal/yr blowdown

campaigning and not campaigning the waste feed. Campaigning the CIF waste feed will result in a life-cycle disposal cost savings for both the Ashcrete and the M-Area alternative of over $44.2 *MM (b*ased on 50,000 gallons/yr blowdown generation and a 30 year life) as shown below:

CIF Operation	Life-cycle Disposal Costs
- "No-campaigning" of waste	$56.5 MM
- "Campaigning" waste feeds	$12.3 MM
Disposal Savings	$44.2MM

This operational change will require the listed hazardous waste to be incinerated separately from the characteristic hazardous waste such that only a portion of the blowdown will be considered listed (based on the "derived-from" rule). The blowdown generated during the characteristic waste feed campaign can be stabilized and de-listed allowing disposal in the less expensive low-level radioactive vaults (@ $\$49/ft^3$). The blowdown containing listed contaminants will require disposal in the mixed waste vaults at a disposal cost of almost 8X higher (@ $\$374/ft^3$). Campaigning the CIF waste feeds allows up to 90% of the stabilized waste volume to be disposed of in the low-level radioactive vaults

REFERENCES

1. BURNS, H. HOLMES, "Waste Treatment Evaluation for Aqueous Secondary Waste from Mixed Waste Incineration," Proceedings from the 11th Annual Incineration Conference, Albuquerque, N. M., WSRC-MS-92-143, 1992.