OPTIMIZATION OF FILTER LOADING

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ABSTRACT

The introduction of 10 CFR Part 61 has created potential difficulties in the disposal of spent cartridge filters. When this report was prepared, Rancho Seco had no method of packaging and disposing of class B or C filters. This work examined methods to minimize the total operating cost of cartridge filters while maintaining them below the class A limit. It was found that by encapsulating filters in cement the filter operating costs could be minimized.

INTRODUCTION

The introduction of 10CFR61 and the associated Branch Technical Positions[1,2] (BTP's) have placed additional requirements on the analysis and packaging of low-level waste. Part 61 requires classification of waste into Class A, B, or C based on the concentration of certain nuclides. In addition, it requires that the waste packaging meet requirements based on waste class. Spent filter packaging at Rancho Seco has been satisfactory for Class A waste. Present methods for filter packaging at Rancho Seco would not meet Class B or C requirements.

In addition to 10CFR61, the operating license of U.S. Ecology's Hanford burial site contains a limit of ten nanocuries per gram for all transuranics (TRU), including Pu-241 and Cm-242[3]. Until the implementatation of 10CFR61, analyses for TRU in routine power plant wastes were not conducted and the general assumption was made in the industry that they did not exist in significant quantities. In order to meet the requirements for classification and reporting in 10CFR61, power reactor facilities, including Rancho Seco, have had to send waste samples to outside laboratories for analysis. The results of those analyses and the scaling factors that have been derived from them have indicated that TRU, especially Pu-241 and Cm-242, may be present in significant quantities. These isotopes may be present in quantities sufficient to render Class A waste unsuitable for burial at Hanford without special permission.

When waste, such as filter cartridges, is packaged in absorbent, the NRC's BTP on waste classification states that waste classification should be based only on the volume and weight of the waste without the absorbent. When filters are encapsulated into 210- liter (55 gal) drums using a solidification agent, classification may be based on the waste plus the solidification agent. This is not allowed for larger containers because of the large difference in size between the waste and container. Since the volume and weight of a solidification agent such as cement is considerable, the activity that can be placed in a drum is increased accordingly. It was felt that the cost savings available by increasing filter loading and, hence, reducing the number of filter changeouts may offset the increased cost to dispose of each filter.

APPROACH

An evaluation of the operating costs associated with three packaging aternatives was made. The evaluation balanced the filter changeout costs against individual filter disposal costs for the three alternatives. These were arranged from lowest to highest individual disposal cost:

- Filter loaded to Class A limit or ten nanocuries of TRU per gram, whichever is lower, and packaged in absorbent.
- Filter loaded to LSA limit when encapsulated in cement
- Filter loaded to Class A limit when encapsulated in cement.

The DOT regulations for determining if waste is LSA use only the filter cartridge weight in either the absorbent or cement case. The weight of the absorbent or solidification agent may not be included since the activity is "essentially uniformly distributed" only throughout the filter cartridge. If the filter cartridge cannot qualify as LSA waste, then the cartridge must be shipped in Type A packaging. Dot 17H, 210-liter drums are qualified as Type A packaging unless the total package weight exceeds 380 Kg (840 lb). It was estimated that drums containing filters encapsulated in cement might exceed this weight. The drums would then require transportation in a Type A cask if the filter were not LSA. The cost of transportation and disposal would then increase.

Two other cases were not considered in detail. These were:

- Encapsulation of a filter or filters in a large, 3 to 6 M^3 (100 - 200 ft^3) liner. This was not considered further because the NRC BTP does not allow credit in classification for the solidification agent for containers larger than 210 liters.

- Encapsulation of a filter or filters in a high integrity container (HIC). This was not considered further because the density of the package would not be increased over the filter in absorbent case. Since the limits on TRU are in nanocuries per gram, no advantage would be gained.

Because this evaluation is theoretical, an activity distribution had to be chosen for the filters. For the gamma emitting isotopes, the results from the composite filter sample sent to EAL Corporation were used. The composite filter sample was sent for laboratory analysis to develop scaling factors for the nongamma emitting isotopes. Non-gamma emitting isotope concentrations were derived from those scaling factors. Impell's WASTETRAK computer program[4] was used to find, for each filter size:

- The activity at which the Class A limit was reached for filters packaged in absorbent and cement.

- The activity at which the 10 nanocurie per gram limit was reached for filters packaged in absorbent and cement.

- The activity at which the LSA limit was reached.

- The contact dose rate external to the filter housing when the LSA, Class A and 10 nanocurie per gram limits were reached.

After the computer runs were made to determine the curie levels for each of the foregoing limits, then cost estimates were developed. The individual costs and assumptions used in the cost estimates are shown in Tables I, II, and III. An additional assumption made was that filter run length would be proportional to curie loading. This assumption is considered reasonable in general. However, some filters would likely become plugged before reaching the maximum allowable curie loading.

TABLE I

Filter Cartridge Material Costs

FILTER		COST/CHANGEOUT
F-230	Makeup	$ 468
F-232	Seal Injection	345
F-275	Spent Fuel Cooling	1480
F-468	CRD Cooling Water	1420
F-626	Reactor Coolant Storage Tank	1420
F-628	Boric Acid Concentrator Feed	1480
F-688	Misc. Waste & Oil Absorber Main	1497
F-688A	Misc. Waste Prefilter	65
F-692	Miscellaneous Waste Main	1480
F-692A	Misc. Waste Prefilter	65
F-693	Misc. Waste Condensate	1480
F-711	Boric Acid	1420

TABLE II

Filter Changeout Labor

STEP	HOURS	PERSONS
Makeup Absorbent Drum	2.0	2
Transport Empty Drum	0.5	2
Filter Changeout	1.0	3
Surveys	1.5	1
Filter Packaging in Absorbent or Temporary Drum	0.1	2
Transport Loaded Drum	1.0	8
Filter Repackage into Cement	2.0	3
Package Records Preparation	1.5	1
Work Request	0.5	1
Ship Loaded Drum	0.5	2
Total for Filter in Absorbent Drum	20.7 Person-Hours	
Total for Encapsulated Filter Drum	22.7 Person-Hours	

TABLE III

Assumptions for Disposal Costs

Shipment to Hanford, Washington:

Transportation Charge Per Load	$1,594.50
Basic Burial Charge Per Cubic Foot	$18.91
Radiation Surcharges-Per US Ecology Jan. 4, 1984 Table	
Quantity of Drums per Truck Unshielded	72
Cask Used when Required	CNS-14-195H
Cask Rental Fee	$6,750
Labor Cost Per Person-Hour	$25
Bare Drum Cost, Each	$28
Cement Cost, lb.	$0.10
Material Cost, Absorbent Drum	$50
Weight of Cement, Per Drum	320 kg (600 lb)

Only two filters were used in the cost evaluations, F-230, the Makeup Filter, and the F-688A Miscellaneous Waste Prefilter. The cost evaluation for F-230 (which was done first) indicated that filter changeout costs formed the majority of the cost difference between cases. Since F-230 is a medium-priced cartridge, a low-priced cartridge (F-688A) was used for the remaining evaluation. Those filters which used high-priced cartridges would show an even greater fraction of the cost difference attributed to cartridge changeout cost.

RESULTS

The results of the computer runs are shown in Table IV. For each filter the housing dose rate and total curies that corresponds to the Class A limit in absorbent, the 10 nanocurie limit in absorbent, and the Class A limit in cement are shown. The 10 nanocurie per gram limit in cement, at 6.9 curies, is approximately 71% higher than the Class A limit. Table IV also shows that, for some filters, the 10 nanocurie per gram limit is lower than the Class A limit. It was found that when filters were loaded to the Class A limit in cement, they were no longer LSA. The LSA curie quantities for the filters which were used in the cost evaluations were calculated. Those quantities are shown in Tables V and VI.

Tables V and VI show the relative changeout frequency and associated costs for the three cases studied for filters F-230 and F-688A (PRE). For filter F-230, a medium-priced filter, Table V shows

TABLE IV

FILTER	CLASS A IN ABSORB. HOUSING D.R.	Ci	10nCi/gr IN ABSORB. HOUSING D.R.	Ci	CLASS A SOLIDIFIED HOUSING D.R.	Ci
F-230	1148 mR/Hr	0.2206	1250 mR/Hr	0.2402	20.9 R/Hr	4.016
F-232	95.5	6.03E-3	325	2.05E-2	63.5	4.016
F-275	1692	-	1541	0.7976	7.76	4.016
F-468	1721	0.8758	1494	0.7604	7.89	4.016
F-626	1721	0.8758	1494	0.7604	7.89	4.016
F-628	1692	-	1541	0.7976	7.76	4.016
F-688 Mains	1797	-	1372	0.6689	8.24	4.016
F-688A Pre	248	0.3930	258	0.4089	2.53	4.016
F-692 Mains	1692	-	1541	0.7976	7.76	4.016
F-692 Pre	1692	0.3935	1760	0.4092	17.3	4.016
F-693	1692	-	1541	0.7976	7.76	4.016
F-711	1721	0.8758	1494	0.7604	7.89	4.016

TABLE V

Operating Costs
Filter F-230, Makeup Filter

Loaded to:	Class A in Absorbent	Class A, Solidified	Class A, Solidified
DOT Subtype	LSA	LSA	Non-LSA
Total Curies	0.221	1.57	4.02
Surface Dose Rate	200-300 mR/hr	120 mR/hr	310 mR/hr
Cartridge Changeouts	18.2	2.6	1 (Base)
Cartridge Cost	$8,518	$1,217	$468
Labor Cost	$9,421	$1,477	$568
Drum Cost	$510	$73	$28
Media Cost	$910	$156	$60
Drums/Load	72	72	14
Shipping Cost/Load	$1,595	$1,595	$8,345
Shipping Cost	$403	$58	$596
Disposal Cost	$2,584	$369	$142
Radiation Surcharge	$197	-	$11
Cask Handling Fee	-	-	$46
TOTAL	$22,543	$3,350	$1,919

TABLE VI

Operating Costs
F-688A Prefilter, Miscellaneous Waste Prefilter

Loaded to:	Class A in Absorbent	Class A, Solidified	Class A, Solidified
DOT Subtype	LSA	LSA	Non-LSA
Total Curies	0.394	2.99	4.02
Surface Dose Rate	100-150 mR/hr	358 mR/hr	480 mR/hr
Cartridge Changeouts	10.2	1.34	1 (Base)
Cartridge Cost	$663	$87	$65
Labor Cost	$5,282	$763	$568
Drum Cost	$286	$38	$28
Media Cost	$510	$81	$60
Drums/Load	72	45	14
Shipping Cost/Load	$1,595	$1,595	$8,345
Shipping Cost	$226	$48	$596
Disposal Cost	$1,449	$191	$142
Radiation Surcharge	-	$15	$11
Cask Handling Fee	-	$46	$46
TOTAL	$8,416	$1,269	$1,516

that the operating cost is driven by cartridge cost and labor cost. This more than offsets the higher costs of disposal. Because cartridge and labor costs account for approximately 80% of the cost to dispose of makeup filters in absorbent, it was decided that the costs for the lowest-cost filter cartridge should be examined.

Table VI shows the operating costs for the Miscellaneous Waste Prefilter. In this case, the difference in activity level between LSA and Class A in cement is small. Thus, the increase in disposal cost for loading the filter to the Class A limit is not offset by savings in cartridge and labor costs. For the large (12 in. diameter) filters (F-676, 275, 711, 688 main, 692 main, 628, 693) when the filter is loaded to the Class A limit in cement it will still be LSA.

CONCLUSION

From this study of operating expenses it can be concluded that filters should be loaded to their Class A limit when encapsulated in cement. The only exception would be the F-688A prefilter, which should be loaded to the LSA limit.

At present, no facilities exist at Rancho Seco for encapsulating filters in cement. The capital cost for such a system was not considered. A complete cost study which considers both capital and operating costs would require that the filter changeout frequency (per year) and the reasons for changeout be known. This information is not readily available but data is being collected. Loading of filters beyond the Class A limit to the 10 nanocurie per gram limit in cement would require that the waste form be qualified for Class B stable waste. This is expected to be far more costly, especially in capital costs, than a form not qualified. Additionally, the increased filter loading would be relatively minor.

REFERENCES

1. "Low-Level Waste Licensing Branch Technical Position on Radioactive Waste Classification", May 1983, NRC Bulletin.

2. "Technical Position on Waste Form", May 1983, NRC Bulletin.

3. State of Washington, Radioactive Materials License WN-I019-2 (U.S. Ecology), Amendment No. 16, December 23, 1983.

4. Impell Corporation, WASTETRAK, A Low Level Radioactive Waste Tracking and Shipping Optimization Program, Version 3C.