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NUCLEAR HAZARDOUS WASTE COST CONTROL MANAGEMENT (U)

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A paper proposed for presentation at the
American Association of Cost Engineers 35th Annual Meeting
Seattle, Washington
June 23-26, 1991

and for publication in the proceedings

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INTRODUCTION

The effects of the waste content of glass waste forms on Savannah River high-level waste disposal costs are currently under study to adjust the glass frit content to optimize the glass waste loadings and therefore significantly reduce the overall waste disposal cost. Changes in waste content affect onsite Defense Waste Processing Facility (DWPF) costs as well as offsite shipping and repository emplacement charges. A nominal 1% increase over the 28 wt% waste loading of DWPF glass would reduce disposal costs by about $50 million for Savannah River wastes generated to the year 2000.

In the Savannah River plan for high-level waste disposal, aqueous radioactive wastes are incorporated in glass for final disposal. Sludge components (Strontium 90) and (plutonium) are processed and converted to glass by melting in the Defense Waste Processing Facility (DWPF), and the decontaminated salt solutions are fixed in concrete for onsite burial. After a period of interim storage, the waste glass contained in the stainless steel canisters will be shipped to a federal geologic repository for final disposal.

Optimization of the glass waste forms to be produced in the DWPF is being supported by economic evaluations of the impact of the forms on waste disposal costs. Glass compositions are specified for acceptable melt processing and durability characteristics, with economic effects tracked by the number of waste canisters produced. This paper presents an evaluation of the effects of variations in waste content of the glass waste forms on the overall cost of the disposal, including offsite shipment and repository emplacement, of the Savannah River high-level wastes. The status of recent investigations undertaken to optimize compositions of the sludge-salt glasses are outlined.

BACKGROUND

High-level radioactive wastes at the Savannah River Site, now contained as aqueous sludges and salts in large underground tanks, will be processed to solid form for final disposal. The principal activities involved in the disposal operations are represented in Figure 1. Sludge components, which contain most of the Sr-90 and long-lived actinides, will be washed and treated with sodium hydroxide in tank-farm operations to reduce aluminum hydroxide content, mixed with glass frit and fed as slurry to the DWPF melter. The product of the DWPF melting operation is a borosilicate glass containing nominally 28 wt% waste oxides in stainless steel canisters about 2ft (60-cm) diameter by 10ft (300-cm) length.
For a representative glass composition, the DWPF output at 75% attainment is 410 canisters per year. Initial DWPF processing will be limited to wastes providing canister heat ratings less than 460 watts; after 5 years of operation, wastes providing up to 690 watts per canister may be processed.

Soluble salt components of the wastes will be decontaminated in the waste tanks prior to solidification in concrete for onsite burial. In the salt decontamination operation, radio cesium (principally Cs-137) will be separated along with potassium in the wastes by precipitation as tetrapetylborate (TPB) salts, and residual Sr-90 and actinides will be removed by adsorption on sodium titanate. The precipitated solids, concentrated

FIGURE 1. Reference High-Level Waste Disposal Activities
by filtration and accumulated in the tank, will be treated using a formic acid hydrolis process (termed "precipitate hydrolysis") to decompose the organic salt, and the product fed along with sludge components to the glass melter. After filling with glass, the DWPF canisters will be decontaminated, sealed, and stored onsite in a fan-cooled vault, pending availability of a federal repository for permanent waste disposal.

The decontaminated salt solution will be converted to solid form (termed "saltstone") by mixing with a blended cement for onsite burial as low-level waste. Salt solution will be processed at a rate of about 6-million gallons per year, including recycle washes. Saltstone facilities limit the age of salt solution processed to a minimum of 15 years following reactor discharge.

Following interim storage, the canisters in special casks are assumed to be shipped by truck or rail to the repository site at a rate equal to or somewhat in excess of the rate of DWPF production. At the repository, the canisters will be packaged in appropriate overpack containers and emplaced for permanent disposal in underground facilities. In a representative case, the DWPF canisters would be buried in salt, tuff, or basalt geologic formations in conjunction with commercial nuclear wastes, using a repository design specially augmented to accommodate the defense wastes.

SAVANNAH RIVER SITE WASTE DISPOSAL COSTS

Cost Model

The cost model developed for the Savannah River Site high-level waste disposal defines basic input parameters for the specific processing activities in the waste disposal system. The input parameters include fixed and variable cost components dependent on the quantity of waste (for example, the number of waste canisters) processed annually. Since economic effects of the waste content of the glass waste forms arise primarily from changes in the number of waste canisters processed, only the variable costs associated with DWPF processing (including interim storage), off-site transport, and repository emplacement of the canisters are evaluated in this study. Variable costs associated with sludge washing,
salt precipitation, and salstone processing activities are not affected by changes in the number of canisters processed, and fixed costs representing capital expenditures for all the waste processing activities are considered constant.

Reference DWPF Operation

Derivation of incremental costs from input parameters of the cost model requires projection of reference operating scenarios for on-site and offsite waste processing facilities. For the onsite (DWPF) facilities, it is assumed that SRS reactors will operate at approximately the current level of waste generation to the year 2000. This is an arbitrary assumption of the cost model, since actual SRP operation will depend on demand for nuclear materials. For the year 2000 operation as represented in Figure 2, current and future inventories of waste will utilize full DWPF operating capacity until completion of sludge processing about the year 2005, following which the DWPF is assumed to be maintained in standby condition to allow batching of a residual inventory of 15-year aged salt for workoff in a final campaign. Typically 7500 canisters would be produced over the approximately 25 years of DWPF operation (including standby) required for processing waste sludge and salt generated to the year 2000.

Incremental canisters resulting from adjustments of glass compositions impact the reference DWPF operating scenario by increasing (or decreasing) the time of full-capacity DWPF processing before shutdown (standby) on completion of sludge processing operations. For a nominal 3.5% decrease in the number of canisters produced (equivalent to 1% increase in canister waste content), the time of DWPF operation at full capacity is decreased by somewhat less than one year, as shown in Figure 2. Incremental costs assigned correspond to the difference in costs of full-capacity and standby DWPF operation over this period. The incremental annual costs of DWPF operation, summarized in Table 1, are about $46.4 million corresponding to $113,000 per canister.
1985 dollars at about $11,000 per canister.

Repository Packaging and Emplacement

Repository costs of SRP high-level waste disposal are projected on the assumption that the wastes will be emplaced in a commercial repository augmented to accommodate the defense waste canisters. As previously detailed, emplacement of 7500-DWPF canisters in a salt, tuff, or basalt repository of standard design would require an underground area typically about 5% of that committed to the commercial high-level wastes. The incremental costs incurred under these circumstances are principally variable costs proportional to the number of DWPF canisters handled.

Prior to emplacement, the waste canisters would be packaged in appropriate overpack containers as required to meet regulatory requirements for the specific repository geology involved. The overpack containers consist generally of carbon steel or stainless steel assemblies of sufficient thickness to withstand hydrostatic or lithostatic pressures of the repository, sometimes encased in a titanium alloy sheath for corrosion resistance.

The waste packages are assumed to be emplaced in boreholes excavated either vertically or horizontally in underground rooms or tunnels of the repository, with spacing dependent on heat output of the packages and thermomechanical properties of the geologic medium. Placement room areas for defense wastes in vertical boreholes are typically 30 m² per package (15 to 23 W/m² for 460 to 690 watt DWPF canisters) compared to commercial (spent fuel) wastes ranging from 85 to 250 m² per package (15 W/m²) depending on heat output. The lower placement room areas compared to commercial wastes are a consequence of the lower heat loading (lower radioactivity content) of the defense waste packages. The defense waste packages are generally not emplaced at heat load limits for the repository because of mechanical constraints on borehole spacing, so that nominally increased waste loadings can be tolerated with the same placement room areas, especially for lower heat wastes processed in early DWPF operations.

A repository fee for defense waste disposal analogous to that charged utilities for commercial waste disposal is under current consideration in the Department of Energy. The fee
established for commercial waste disposal, equal to 1.0 mill per kWh electricity generated using nuclear facilities, depends primarily on the quantity of radioactivity in the commercial wastes, and not on the volume of waste or the number of waste packages emplaced. An analogous assignment of repository fee for defense wastes would thus provide no dependence of repository costs on the number of waste canisters emplaced. Over the long term, however, the repository fee for defense waste must cover the real costs of disposal, so that reduced numbers of canisters emplaced would be reflected in lower repository fee assessments.

The real costs of repository emplacement of defense waste canisters are projected in the Savannah River model in two general categories as follows:

1) Direct costs representing incremental capital and operating expenditures.
2) Indirect costs representing prorated charges assessed for use of facilities in common with commercial wastes.

Since incremental expenditures are of primary interest for evaluation of waste content effects, only the direct costs are considered in this study. Variable components of the direct costs that are dependent on the number of canisters emplaced include incremental expenditures for waste packaging components and operations, for mining of placement rooms and boreholes, for emplacement and monitoring operations, and for backfill operations. Such costs depend on repository geology, waste packaging requirements, and underground emplacement patterns. Representative values for SRP waste disposal are derived as average costs for canisters in steel overpacks emplaced in characteristic patterns (vertical or horizontal boreholes) in salt, tuff, and basalt repositories. The variable costs are projected in 1985 dollars at about $55,000/canister, including packaging costs of about $31,000/canister and mining and emplacement costs of $24,000/canister.

Incremental Costs of Increased Glass Waste Content

The cost impacts of increasing the waste content of DWPF glass, summarized in Table 2, are established by the foregoing projections. As shown in Table 1, costs dependent on the number of canisters processed, including costs of DWPF processing, offsite transport, and repository emplacement, total $179,000/canister.
No. of Canisters/Yr. Incremental Wastes (3.5%) 1% increased waste content

500 Future Wastes
400
300 Current Wastes
200
100 Salt Ppt

Residual Wastes

1984 1990 2000 2010 2020 Year

FIGURE 2. Schedule for Processing Year 2000 High-Level Waste Inventory DWPF Canisters

TABLE 1. Incremental Costs of SRS High-Level Waste Disposal Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Incremental Costs $10^3$(1985)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual</td>
</tr>
<tr>
<td>DWPF Operation</td>
<td>46,400</td>
</tr>
<tr>
<td>Offsite Shipment</td>
<td>--</td>
</tr>
<tr>
<td>Repository Emplacement</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

* Unit costs assume 410 DWPF canisters/year.

Offsite Transport

Transport of the SRS waste canisters to a federal repository following interim onsite storage is projected in accord with previous studies. Shipment of the SRS canisters contained in a single canister truck cask of appropriate design to a repository located in the Northwest is assumed at a rate of 500 canisters per year beginning about the year 2000. The incremental canisters would be shipped and emplaced in the repository near the end of the SRS waste processing campaign in the year 2015. Incremental costs estimated using updated tariff rates are projected in
For a total of 7500 waste canisters produced by processing SRP waste generated to the year 2000, a nominal 1% increase in waste loading represents a decrement of 268 canisters, equivalent to $48 million in 1985 dollars in reduced waste disposal costs. Assuming DWPF processing of the incremental canisters about the year 2005 in accord with Figure 2 and transport and repository emplacement of the incremental canisters about the year 2015, present values of the incremental waste loading costs are $24 million and $5.5 million (1985 dollars) discounted at 3% and 10%, respectively.

Table 2. Cost Impact of Increased Waste Content in DWPF Glass

<table>
<thead>
<tr>
<th>Waste Content Increase</th>
<th>Incremental Canisters</th>
<th>Cost Reduction (10^6) $(1985)^*$</th>
<th>Present Value Nominal</th>
<th>Present Value 3%</th>
<th>Present Value 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit (1, wt%)</td>
<td>268</td>
<td>48</td>
<td>24</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Frit Adjustment (8 wt%)</td>
<td>2200</td>
<td>394</td>
<td>198</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Increased Sludge (7 wt%)</td>
<td>1500</td>
<td>269</td>
<td>135</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

* SRS wastes generated to the year 2000.

Two modifications of waste loading are under current study at the Savannah River Site. In a first modification now being optimized as the reference glass composition, precipitate hydrolysis product is substituted for frit rather than added as a waste component of the glass. This reduces the frit content from 72 to 64% and affectively increases the waste content by about 8%. The accompanying decrease of 2200 waste canisters required for SRS waste generated to the year 2000 results in a cost reduction of $394 million in 1985 dollars before discounting, with present values of $198 million and $45 million after discounting at 3% and 10%, respectively. Changes in frit composition at this waste loading needed to optimize properties of the glass do not additionally affect the cost reduction produced by the frit adjustment.

In a second modification, sludge-salt glasses with increased sludge content are being investigated. There are no present plans
for increasing sludge loadings in the DWPF glass, but the cost effects indicate this may be a fruitful area for development after DWPF startup. An increase of the sludge content from 28 to 35% further decreases the frit content from 64% to about 57%, providing an additional 7% increase in waste content. The accompanying 1500 decrease in the number of waste canisters produced for SRS reactor operation to the year 2000 results in a cost reduction of $269 million in 1985 dollars, with present values of $135 million and $31 million at discount rates of 3% and 10%, respectively.

CONCLUSION

Waste form modifications under current study include adjustments of glass frit content to compensate for added salt decontamination residues and increased sludge loadings in the DWPF glass. Projected cost reductions demonstrate significant incentives for continued optimization of the glass waste loadings.

REFERENCES


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ACKNOWLEDGMENT

The information contained in this article was developed during the course of work done under Contract No. DE-AC09-89-SR18035 with the U. S. Department of Energy.
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DATE FILMED

4/23/92