ALTERNATIVE DISPOSAL OPTIONS FOR ALPHA-MIXED LOW-LEVEL WASTE

G. G. Loomis and M. J. Sherick
Idaho National Engineering Laboratory
P.O. Box 1625
Idaho Falls, Idaho 83415-3710
(208) 526-9208, (208) 526-6802 Fax

ABSTRACT

This paper presents several disposal options for the Department of Energy alpha-mixed low-level waste. The mixed nature of the waste favors thermally treating the waste to either an iron-enriched basalt or glass waste form, at which point a multitude of reasonable disposal options, including in-state disposal, are a possibility. Most notably, these waste forms will meet the land-ban restrictions. However, the thermal treatment of this waste involves considerable waste handling and complicated/expensive offgas systems with secondary waste management problems. In the United States, public perception of offgas systems in the radioactive incinerator area is unfavorable. The alternatives presented here are nonthermal in nature and involve homogenizing the waste with cryogenic techniques followed by complete encapsulation with a variety of chemical/grouting agents into retrievable waste forms. Once encapsulated, the waste forms are suitable for transport out of the state or for actual in-state disposal. This paper investigates variances that would have to be obtained and contrasts the alternative encapsulation idea with the thermal treatment option.

INTRODUCTION

This paper presents several disposal options for the Department of Energy alpha-mixed low-level waste (AMLLW). The AMLLW contains 10–100 nCi/g of transuranic contamination and was primarily generated by the Rocky Flats Plant. There is presently no disposal option for this waste; however, the mixed nature of the waste favors the thermal treatment option resulting in iron-enriched basalt or glass encapsulation of the main contaminants. The popularity of the final waste form is well-founded in that much of the hazardous material is destroyed during the process, and the other particulate contaminants are "locked up" in a glass matrix that has natural analogs considered geologically stable.

MASTER

Melter design and offgas systems are being examined to process much of the transuranic waste, including the AMLLW. Even though this plan of attack is under way, there exists a potential problem for the thermal treatment option that may render it unworkable, and that is one of public acceptance of radioactive offgas systems. Because of this uncertainty, it behooves the DOE complex to have alternatives available for consideration.

As an example, at the Idaho National Engineering Laboratory (INEL) alone in above ground storage there is about 36,000 m^3 of transuranic waste commingled with 24,000 m^3 of alpha low-level waste containerized in 55-gal drums and 4 x 4 x 7-ft boxes. The primary contaminants are micron-sized particles of plutonium/americium oxide intermingled with cutting oils and volatile organic solvents. Retrieval and segregation of this waste is currently under way as a waste management operation, with the material assayed as transuranic slated for ultimate disposal at the Waste Isolation Pilot Plant.

However, the AMLLW has no identified disposal option. Without an identified disposal option, costly temporary interim storage is required. Even though the interim storage capability is currently under construction, long-term management of this material in interim storage is also costly.

The thermal treatment option is strongly recommended for treatment of this class of waste by special crosscutting task forces involving all phases of DOE's Environmental Management. Unfortunately, the costs associated with the thermal treatment options are expensive (up to $16,000/ton).[1] Because of the cost and the potential problems with public acceptance of offgas systems, it behooves the DOE complex to aggressively pursue cheaper disposal options that can be instituted in a timeframe at least commensurate with the transuranic waste disposal option. This paper presents several alternatives for the AMLLW.

This work builds on work done for alternative options for retrieved buried transuranic waste as well as stored transuranic waste at the INEL and represents a collaborative effort between the DOE Office of Technology Development and Waste

Management. This paper focuses on nonthermal disposal options applicable for both out-of-state or in-state disposal.

NONTHERMAL DISPOSAL OPTION

The concept of disposing of stored AMLLW is technically feasible, and by imposing improved confinement techniques to the waste along with simple shallow-land burial, the concept can gain public acceptance.

Previous work on potential disposal of AMLLW at the INEL[2] claims that siting the AMLLW in shallow-land burial can meet the performance assessment for final waste forms, including glass, iron-enriched basalt, and some forms of cementation encapsulation. In that study, two locations for internment of the encapsulated waste were considered, including one site near the present Radioactive Waste Management Complex and Well Site 14 at the central part of the INEL. Simultaneously, the INEL Environmental Restoration Program is performing risk assessments that show E-6 additional cancer deaths for leaving the buried transuranic waste in the current shallow-land burial with some improved confinement.[a] At E-6 additional cancer deaths, the "no action" alternative or, in this case, leaving the waste buried in shallow-land burial is considered a viable option in the Record of Decision.

Buried waste at the INEL is approximately equal in volume and consistency to the stored waste; therefore, addition of the AMLLW to the currently buried waste increases the source term by less than a factor of 2. It is therefore technically defensible to consider disposal of the stored AMLLW in Idaho at the INEL; however, by improving the confinement and providing an in-depth safety factor, public acceptance can be enhanced.

It is not clear at this time whether improved in-state disposal will have more public acceptance than thermal treatment at the INEL and out-of-state disposal. That

---

a. Personal communication with Doug Kuhns, manager of the Environmental Restoration Program transuranic pits and trenches.

question should be explored by decisionmakers, including members of the public, at early stages of decisionmaking. What follows are details of the in-state disposal option.

The in-state disposal option involves using encapsulating techniques developed by the Office of Technology Development for buried transuranic waste disposal. These techniques were developed for subsurface application in buried wastes for in situ disposal of transuranic waste but apply equally to stored AMLLW. This option involves creating retrievable monoliths by encapsulating and agglomerating the waste with materials that have natural analogs and are chemically compatible with the surrounding environment.

The monoliths are placed in shallow-land burial and covered with a simple clay cap meeting dose-limit requirements.[2] On top of the cap will be placed an intruder cap consisting of large-diameter (greater than 1.22 m mean diameter) basaltic cobble. The basaltic cobble layer renders the waste disposal site unsuitable for residential and farming use, and the monolithic structure of the waste seam itself is immune from subsidence. A society capable of removing 1.22-m-diameter cobble for future building material will be capable of deciphering universal warning symbols on top of the waste material. This waste disposal option has no secondary waste stream as will occur with the thermal treatment option.

For this option, the stored waste is first homogenized using the demonstrated CRYOFRACTURE shredding technique.[3] In this process, the waste is frozen to liquid nitrogen temperatures, brittle fractured, and sheared. A test matrix, in which typical Rocky Flats waste material in 55-gal drums and in 2 x 2 x 8-ft boxes were shredded with the CRYOFRACTURE technique, resulted in a mean size of debris described as follows: 76-94 wt% of the debris fell through a 3-in. screen and 97-100 wt% of the debris fell through a 6-in. screen.[3]

The advantages of using the CRYOFRACTURE technique over the conventional shredders[4] is the inherent contamination control aspects of the cryogenic process, in that it agglomerates the particles together into larger particles that are not easily aerosolized. In addition, the ultracold temperatures associated with the cryogenic techniques (-320°F) eliminate the potential for fire and explosion during the shredding process that is assumed to be required for the thermal process. Also, the volatile organic material in the AMLLW will be rendered to the solid phase during the cryofracture operation and therefore is not prone to volatilization.

Next, the homogenized waste is blended with a chemical or grouting agent and poured into movable retrievable shapes. The material is formed into convenient-sized blocks for creating a monolith. In this manner, the waste is stabilized against subsidence and packed into a retrievable matrix mimicking a naturally occurring mineral or material that is stable in a wide range of expected climatic conditions. Finally, the top soil and intruder cap are installed with local materials.

Nonthermal plastic grouting agents that are of interest to the Technology Development Office buried waste work are classified as either cementation grouts, organic polymers, inorganic polymers, or blends of these materials. Some of these materials are thermal-setting or high heat of hydration reactions but are generally less than 240°F. Preliminary criteria for the grouting materials have been developed by the Landfill Focus Area, and a list of potential encapsulating agents are being evaluated against the list.

The list of grouting agents currently includes the following materials: CEMENTATIONS GROUTS: Portland Type 1 (neat-1:1 by wt. water/Portland), plasticized latex cement developed by Brookhaven National Laboratory, INEL-developed iron-oxide solutions to form Hematite, Pacific Northwest Laboratory-developed phosphoric solutions to form apatite, TERRAN-developed solutions to form calcite, INORGANIC POLYMERS: Polysiloxane (PSX-10-Dow Corning) to form a flint-like material, Ludox-Dupont to also form a flint-like material, ORGANIC POLYMERS: Acrylic developed by 3M with a natural analog of amber, proprietary materials developed by HELO and Ernie Carter (KEI, Inc. in Houston), and Montan Wax (Romanta Amsdorf in Germany).

Preliminary criteria for this material include (1) the grout must have low enough viscosity to be jet groutable, (2) the resulting soil/waste/grout matrix must have a resulting hydraulic conductivity of E-7 cm/s, (3) the soil/waste/grout matrix must be retrievable,

(4) the soil/waste/grout matrix must be chemically stable and the hazardous materials must be compatible with the grouting agent, (5) the grout must have a natural analog or be demonstrated to surpass a similar natural analog based on durability studies, (6) the material must result in compressive strengths at least 50 psi and may be as high as 800 psi. Materials already examined by the Landfill Focus Area for the transuranic pits and trenches include Portland cement,[5] Hematite,[6] and acrylic polymer.[7]

As an aside, the same process can be applied to the waste for out-of-state disposal, most likely at the Nevada Test Site in shallow-land burial.

The identical process for forming the monoliths will be applied to the waste; however, the material will be placed in inexpensive polyethylene boxes. These boxes could be shipped via common carrier or train to a DOE-approved disposal site. The most likely disposal site for this material is the Nevada Test Site, in that ground water is not a concern at that site.[2] The waste would be shipped in about five escorted convoys involving the state police, national guard, and U.S. military as escorts.

To save operating costs and provide a reasonably manageable program that does not span multiple presidential elections, the waste would be shipped to the disposal site within 5 years. One report claims that glass and cementation waste forms meet the performance criteria at the Nevada Test Site.[2] The usual problems associated with politics will render this idea on hold until there is a national push at the presidential/congressional level to solve the disposal site issues.

An alternative to the Nevada Test Site is the Waste Isolation Pilot Plant near Carlsbad, New Mexico. The politics of opening that system for the stored transuranic waste have been intense and compromises may be required to limit the waste to the original amount—the stored transuranic waste only. The actual out-of-state disposal option is beyond the scope of this paper; however, presumably, the option at Nevada would involve shallow-land burial of the retrievable waste forms created in Idaho, and the option at the Waste Isolation Pilot Plant would create more drifts in the salt matrix and simply place the waste in the drifts.

WAIVERS ARE REQUIRED

The proposed nonthermal disposal option for the AMLLW does not meet all the treatment requirements specified by the Resource Conservation and Recovery Act (RCRA) for hazardous waste. Specifically, this approach would not satisfy the treatment criteria established in the Land Disposal Restrictions, which require that the hazardous components of the waste be reduced below certain concentration limits or that the treatment be accomplished using the best demonstrated available technology. Therefore, in order to implement this option, a variance or waiver would have to be obtained from the regulatory authorities (U.S. Environmental Protection Agency and State of Idaho Department of Environmental Quality).

There are two alternatives for variances provided by RCRA: (1) a "No-Migration" Petition, and (2) a "Delisting" Petition (delisting the hazardous waste to lift the requirements imposed by the Land Disposal Restrictions).

The No-Migration Petition is a waiver that allows disposal of RCRA hazardous waste that has not been treated to Land Disposal Restrictions. In order for the No-Migration Petition to be granted, the applicant must show that in the particular environmental setting, the contaminants in question will not migrate outside the boundaries of the disposal facility.

A Delisting Petition allows for a "listed" hazardous waste, as defined by RCRA, to be exempt from regulation under RCRA. In order for a Delisting Petition to be granted, the applicant must show that the reason the contaminant in question was listed as being hazardous under RCRA is no longer valid/applicable to that particular waste stream.

Waivers will have to be obtained for the volatile organic compounds, transuranics, and heavy metals. However, there are circumstances that affect migration of these materials: (1) volatile organic compounds have a short half-life in nature due to microbial attack and evaporative loss, (2) there is no known migration mechanism for the insoluble plutonium/americium particulates through the surrounding soils or in the inner-bed soil sandwiched between basaltic flows below the disposal site, (3) many of the proposed encapsulating agents tend to capture and hold heavy metals and transuranics. In addition, the region has proved hostile to agricultural use and is currently uninhabited.

Basically, when making the final decision on which option to approach for disposal of AMLLW, the public acceptance of offgas systems will have to be weighed against the difficulties of obtaining RCRA waivers. In the environmental arena, there is a tendency toward more cost-effective risk-based decisions. The cost of making offgas systems acceptable to the public may outweigh the difficulties of obtaining RCRA waivers.

CONCLUSIONS

Implementing ideas offered in this paper would require changes in thinking about acceptable waste forms, performance assessments, and disposal sites. Additionally, special waivers would be required to place encapsulated mixed waste in the ground. This paper was not meant to criticize the thermal treatment option; rather, it was designed to stimulate thinking by offering alternative ideas in the eventuality that the thermal treatment option cannot be realized for either financial or political reasons.

It is concluded that there are a multitude of encapsulating materials that have natural analogs and are chemically compatible with the waste material as well as the surrounding geology. In addition, there are no substantive technical problems for disposal at either the INEL or out-of-state sites because of the long-term encapsulating nature of the material.

As with any new technology, technical issues would have to be addressed. Some of these issues may include hydrogen generation in the matrix caused by radiolysis, and integrity of the waste material caused by plutonium recoil. However, by applying an in-depth encapsulation approach with capping and armored barriers, these issues may be rendered moot.

ACKNOWLEDGMENTS

Work supported by the U.S. Department of Energy, Office of Technology Development (Landfill Focus Area), under DOE Idaho Operations Office Contract DE-AC07-94ID13223.

REFERENCES

1. Fred Feizollahi, William J. Quapp, *Second Draft Integrated Thermal Treatment System Study Phase 2 Results*, LITCO-MS-11211, October 1994.

2. T. H. Smith and G. L. Anderson, *A Preliminary Parametric Performance Assessment for the Disposal of Alpha-Contaminated Mixed Low-Level Waste Stored at the Idaho National Engineering Laboratory*, WM-95 Tucson, Feb. 25-29, 1995.

3. Guy G. Loomis, Denise Osborne, and Mike Ancho, *Executive Summary of the Cryofracture Demonstration Program*, EGG-WTD-9916, September 1991.

4. G. Ross Darnell and Wesley C. Aldrich, *Low-Speed Shredder and Waste Shredability Tests*, EGG-2226, April 1983.

5. Guy G. Loomis and D. N. Thompson, *Innovative Grout/Retrieval Demonstration Final Report*, INEL-94/0001, January 1995.

6. Jerry R. Weidner and Peter G. Shaw, *In Situ Encapsulation Bench-Scale Demonstration Report FY-94*, INEL-95/0039, January 1995.

7. John H. Heiser and Laurence W. Milian, *Laboratory Evaluation of Performance and Durability of Polymer Grouts for Subsurface Hydraulic/Diffusion Barriers*, BNL-61292, May 1994.