IN-SITU IMMOBILIZATION OF RADIOACTIVE WASTE

R. M. Neal, Rockwell International, Joint Integration Office, Albuquerque, New Mexico
V. F. FitzPatrick, Battelle Northwest Laboratories, Richland, Washington
J. L. Low, Idaho National Engineering Laboratory, Idaho Falls, Idaho
E. W. McDaniel, Oak Ridge National Laboratory, Oak Ridge, Tennessee

ABSTRACT

Immobilization technologies are being developed by the Defense Transuranic Waste Program. These technologies can provide remediation alternatives for buried TRU waste management. Up-to-date developments of the immobilization technologies at Idaho National Engineering Laboratory (INEL), Oak Ridge National Laboratory (ORNL), and Battelle Pacific Northwest Laboratory (PNL) are discussed. There are two types of immobilization technology being developed. The immobilization methods being developed at INEL and ORNL will employ grouts. The method undergoing development at PNL is in-situ vitrification. Work in progress on technology development for in-situ immobilization technologies will determine suitability of application. These technologies have the potential to reduce leaching of contamination from burial sites. Data on costs, safety, and radiological risks will be established for evaluation.

BACKGROUND

Transuranic contaminated wastes in boxes and drums were disposed of by shallow-land burial prior to 1970 at the DOE defense sites. No distinction was made between TRU waste and other low-level waste for this disposal. These wastes have been considered to be adequately disposed of.

The DOE policy as stated in the Defense Waste Management Plan (DWMP) provides for continuous radiological monitoring of these disposed wastes with major evaluations being performed as necessary or about every ten years. The evaluations will determine if remedial action for buried TRU waste management is required.

Immobilization technology development has been promoted by DOE in order to provide options for remedial action, if such action is deemed necessary. Successful field demonstrations of these technologies need to be accomplished in order to have them available for implementation.

At INEL, test trenches have been excavated with cold mock up compositions of transuranic wastes in barrels and drums to be emplaced and receive grout injection for immobilization. Chemical tracers that will simulate hydrologic behavior will be injected into the trenches. Completion of this task will demonstrate in-situ grouting at an arid site.

At ORNL, a grout polymer will be injected into an actual burial trench in order to demonstrate in-situ grouting at a humid site. Post waste form verification will be conducted at both INEL and ORNL to determine the effectiveness and longevity of grout as an immobilization method.

At PNL, ISV technology is being developed as an alternative treatment to provide further immobilization or isolation to satisfy either regulatory requirements or to respond to concerns for public perception of adequate long term safety. Pending completion of the on-going NEPA process, the reference plan for TRU liquid waste site management specifies in-place stabilization of the previously disposed wastes. In-place stabilization by emplacement of engineered barriers and markers may not be sufficient to comply with long-term disposal system performance requirements for some sites containing high TRU concentrations. Further, the Comprehensive Environmental Response Conservation Act and Washington State regulations for chemical and mixed hazardous waste may impose requirements that cannot be met safely by barrier emplacement. Consequently, immobilization of some portion of the TRU elements and/or destruction or encapsulation of hazardous waste (prior to engineered barrier emplacement) by in-situ vitrification may be necessary to assure that the wastes are disposed in a way that further reduces the hazard to man. The focus of the program at Hanford is contaminated soil sites.

THE NEED FOR IMMOBILIZATION TECHNOLOGIES

If evaluation of the pre-1970 buried transuranic wastes identifies requirements for remediation, then a systems approach based upon criteria and standards developed to protect the public and environment from the potential radiological hazards will be implemented. The need to implement immobilization technologies will be determined on a site-specific basis. Statistically valid, quality-assured monitoring programs will also be implemented to ensure that immobilization technologies will provide safe isolation from the biosphere.

INEL GROUT INJECTION OF A MOCK-UP BURIED TRANSURANIC WASTE TRENCH FOR DEMONSTRATION AT AN ARID SITE

An improved confinement technology, in-situ grouting, is being evaluated during FY-1985 and FY-1986 by EG&G Idaho, Inc., a prime operating contractor at the INEL. The in-situ grouting technology will be demonstrated in a nonradioactive field scale engineering feasibility test, at the end of FY-1986.

In-situ grouting involves forcing a fluid (grout) into the waste/soil matrix of the buried waste pit. Three Buried waste pits have been constructed at the INEL for injection grouting. A detail of a general waste pit is shown in Fig. 1.[1]

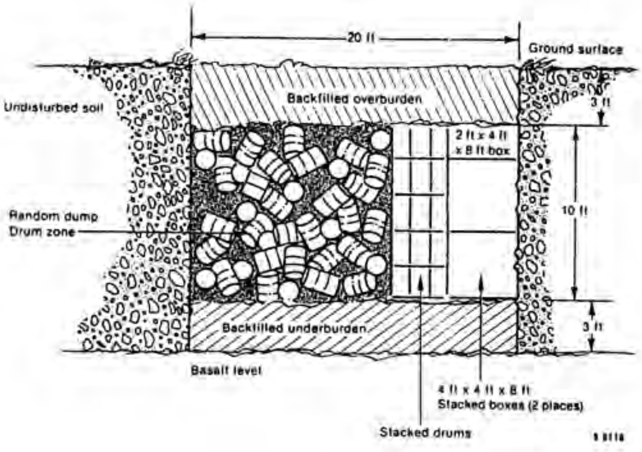

Fig. 1. Detail of General Waste Pit Design.

As the grout flows into the matrix, it will fill the voids in the soil and displace and compact the host soil. The grout solidifies around waste containers, inside breached containers, and around loose waste. The waste is immobilized in place as it becomes encased in a massive impermeable block of grout. After the grout sets, the waste becomes a cohesive mass that is lower in permeability than the host soil. With lower permeability of the waste pit, any leaching of TRU contamination from the buried waste is minimized. This method also alleviates any pit subsidence problems and minimizes site maintenance.

The two-year in-situ grouting test initiated at the INEL in FY-1985 will demonstrate the applicability of grouting technology to the INEL's arid unsaturated soil zone conditions. In support of the INEL test, Oak Ridge National Laboratory performed engineering studies during FY-1985 and produced two particulate grout formulations to be used for the injections.[2] One of the formulations is designed to fill large void structures, while the other will fill and encapsulate small void spaces.

Three simulated waste trenches have been constructed at a site near the Radioactive Waste Management Complex (RWMC). The RWMC is a facility within the INEL encompassing 144 acres, provides shallow land burial for disposal of solid low-level radioactive waste generated by the INEL and other DOE activities. Prior to 1970, approximately 2.2 million cubic feet of solid transuranic (TRU) waste generated by national defense programs were buried at the RWMC.

Two of these simulated trenches will be grouted, the ungrouted trench will serve as a control pit and provides the reference case for leaving the waste in place with no improved confinement. The 2000 cu. ft. volume trenches will contain simulated defense TRU waste prototypical of what was buried at the RWMC and will be equipped with data acquisition instrumentation (suction lysimeters, neutron moisture probes, and thermocouples) to monitor moisture movement within and outside the trench.

In FY-1986, the waste forms and instrumentation will be emplaced in the excavated trenches, the trenches will then be backfilled with the excavated soil and compacted. A matrix of hydrological tracers used to track water movement within the grouted pit will be developed and loaded with the waste containers. The grout will be injected in-situ and be allowed to set. Approximately one month after the final injections, one of the grouted trenches will be destructively examined to investigate grout penetration characteristics. To accelerate tracer migration within the grouted matrix so that sampling instrumentation can detect the tracers within the data sampling period, a dike will be constructed around the trenches to facilitate periodic flooding of the trench surface. These trenches will then be monitored over an eight-year period for moisture movement.

ORNL GROUT INJECTION OF A TRANSURANIC WASTE TRENCH FOR A DEMONSTRATION AT A HUMID SITE

This task will be a demonstration of the in-situ hydrologic stabilization of buried transuranic waste at a humid site via grout injection. The leaching of buried waste by infiltration of precipitation or intrusion of groundwater is a serious potential long-term problem in the management of these wastes. Pre-1970 burial trenches at ORNL will be identified and their hydrologic condition documented. Their hydrologic characterization will include the spatial distribution of hydraulic conductivity within the trench's waste backfill mixture and within the surrounding soil formation. Water pump-in tests will be employed to measure the trench's total void space as an estimate of the volume of grout required. Any groundwater within the trench will be characterized for its content of radionuclides as well as standard chemical components. A polyacrylamide or polyacrylate grout formulation will be used for the initial trench demonstration because of the absence of particulates within these grouts and their low viscosites.[3] The grout will be poured into the trench via several trench-penetrating wells and allowed to set.

Grouting performance will be evaluated in four ways. First, the fraction of the trench's void space filled by the grout will be determined from the measured injection volumes. Second, the degree of reduction in the hydraulic conductivity of the initially permeable waste backfill will be determined by comparing in-situ permeation tests before and after grouting; these will also be monitored for several years after grouting to demonstrate the stability of the grout through time. Third, laboratory specimens of the grout, which have been prepared with carbon-14 labels, will be monitored for microbial degradation rates to establish long-term estimates of grout stability. By this technique, even extremely slow rates of degradation, e.g., 0.1% per year, can be determined. Fourth, standard leaching tests will be performed on the solidified grouts to verify that transuranic elements and compounds are fixed within these grouts. Based on all these tests, the long-term performance of the grouted trenches can be assessed and documentation of this waste-isolating technology established.

PNL IN-SITU *VITRIFICATION* FOR CONTAMINATED SOIL AND TRANSURANIC WASTE BURIAL SITES

In FY-1985, the large-scale ISV system under went a thorough and rigorous Operational Acceptance Test. Corrective actions identified during the testing have been completed and preparations for a Large-Scale Radioactive Test (LSRT) are underway. A detailed description of the melting sequence of the large-scale ISV system has been provided in Ref. 4, 5, and 6. Off gases released for the melt are contained in the hood, which is kept at a slightly negative pressure with respect to atmospheric pressure. The gases are cooled and decontaminated by the off gas treatment system, prior to release to the environs. Analysis of data from the 36 pilot and engineering scale tests and the large-scale tests have shown that the off gas released after treatment meets all DOE and EPA requirements, as measured at the process stack. Further, public and occupational safety analyses show that even under the worst case accident conditions, releases are within prescribed limits.[6]

Activities in FY-1986 are directed toward completion of the Verification test. The purpose of the Verification test is two fold: 1) to verify that the corrective actions implemented as a result of the Operational Acceptance Test achieve the required results, and 2) to provide a dress rehersal for the LSRT which is currently scheduled for July 1987. The site recommended for the LSRT is the 216-Z-12 crib. A portion of the 300W ISV test site has been prepared to provide a nearly exact mock-up of the configuration of that portion of the 216-Z-12 site that is proposed for the LSRT. A cross-section of the view of the 216-Z-12 site is shown in Fig. 2.

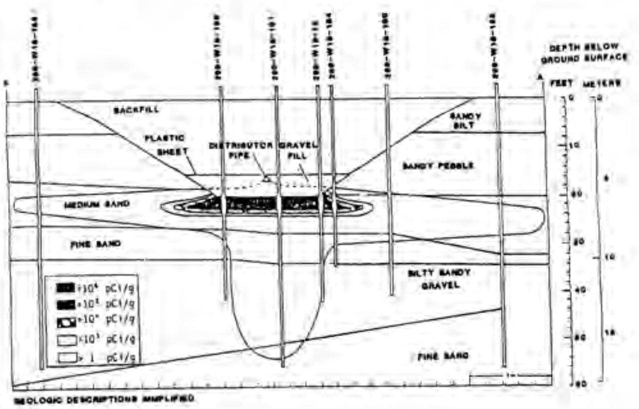

Fig. 2. Cross Section of 216-Z-12 Site.

Chemicals that were deposited in the 216-Z-12 site during its active life will be added to the mock-up site, however, no radionuclides will be present during the Verification test. Chemical compounds and quantities scheduled for incorporation in the mock-up site include:

CHEMICAL	QUANTITY (kg)
CaF	556.0
Mg(NO3)2	1.8
Al(OH)3	247.0
MnO2(pyrolucite)	18.4
NaF	31.2
SrO	214.0
CsNO3	14.5

The quantities of Sr and Cs were selected to provide chemcial detection equivalent to the radiochemical levels expected in the LSRT. The data from the successful Pilot-Scale Radioactive test were used to predict the retention in the melt[7], and to estimate the quantity of Sr and Cs to be treated by the off gas system.

In FY-1987, the large-scale system will be moved from the 300W test site to the 216-Z-12 site, and final preparations for the LSRT will begin. A key element in the preparatory activities will be a joint Battelle/Rockwell readiness review. An independent committee will verify that preparations are complete and that all reasonable precautions have been taken. When the readiness review committee certifies that the preparations are complete, Battelle will request permission to conduct the test from the DOE-RL. The test is expected to require about 150 hours of operation at 3.7 MW. Based on experience obtained during the OAT, this is a very realistic goal.

Post test activities will consist of decontamination of the hood and off gas treatment system and placing the large-scale system in a safe standby mode. The site will be restored to its original condition, and backfilled to grade with clean soil. Cooling of the block is expected to require about 10 to 12 months. The block will be selectively core drilled to obtain samples for waste form verification testing, and the soil adjacent to the block will be sampled to verify that no migration occurred during testing. (Based on the results from the PSRT, and other non-radioactive testing, no migration is expected.) Waste form verification test will be the standard Material Characterization Center tests. Completion of these activities will be sufficient demonstration of the technology for contaminated soil sites to assure availability if it is required. Additional site specific demonstrations may be required in the mid-1990's, and these can be conducted on an as needed basis. Activities required to provide an alternative for the on-going NEPA process will be complete.

After completion of the near term mission, the scope of the program will be adjusted to support the national needs as defined by the lead-site offices for solid waste burial grounds. The existing large-scale system was designed to accommodate the requirement.

SUMMARY

The grouting and in-situ vitrification technologies show great potential as candidate methods for in-situ immobilization of pre-1970 buried transuranic wastes. It must be emphasized that development of immobilization technologies for possible remediation of buried transuranic wastes does not preclude mandatory application of those technologies at any of the DOE defense waste program field sites. The basis for development of these technologies supports the DWMP by providing possible options for remedial action.

REFERENCES

1. J. O. LOW, "Annual Technology Assessment and Progress Report for the Buried Transuranic Waste Program at the Idaho National Engineering Laboratory," DOE/DE-AC07-76ID01570, December 1985.

2. E. W. McDANIEL and T. TAMURA et al., "Grout Testing and Characterization for Shallow Land Burial Trenches at the Idaho National Engineering Laboratory," ORNL/TM-9881 (Draft), November 1985.

3. B. P. SPALDING, L. K. HYDER, AND I. L. MUNRO, "Grouting as a Remedial Technique for Problem Shallow Land Burial of Low-Level Radioactive Solid Waste," ORNL/NFW-83/14, July 1983.

4. V. F. FITZPATRICK et al., "In-Situ Vitrification-A Potential Remedial Action Technique for Hazardous Waste," PNL-SA-12316, Pacific Northwest Laboratory, Richland, Washington (1984).

5. J. L. BUELT et al., "Electrical Technique for In-Place Stabilization of Contaminated Soils," CEP, March 1985, Pgs. 43-48.

6. K. H. OMA et al., "In-Situ Vitrification of Transuranic Wastes: Systems Evaluation and Applications Assessment," PNL-4800, Pacific Northwest Laboratory, Richland, Washington (1983).

7. C. L. Timmerman et al., "An In-Situ Virtification Pilot-Scale Radioactive Test," PNL-5240, Pacific Northwest Laboratory, Richland, Washington (1984).