BURIED TRANSURANIC WASTE RETRIEVAL USING CRYOGENIC TECHNIQUES*

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ABSTRACT

This paper presents the results of a full scale demonstration for a buried transuranic waste retrieval technique that involves ground freezing and remote excavation. The demonstration was performed at the Idaho National Engineering Laboratory's cold test pit, which is a simulated transuranic waste pit without hazardous or radioactive material. Details of the ground freezing process, remote excavation process, and an assessment of the contamination control aspects of the technology are presented. Freezing of a soil and waste mixture was accomplished with freeze pipes and injection of liquid nitrogen. Water was also injected into the pit to facilitate the freezing process. The soil and waste matrix was brought to temperatures below -100°F and then remotely excavated. The remote excavation was accomplished with a specially designed breakout tool, jackhammer, shear, and grapple. Contamination control was assessed by examining filter samples for the spread of rare earth tracers that were placed in the waste containers in the cold test pit; the freezing process was monitored using thermocouples within the pit; and water injection was tracked using moisture probes.

INTRODUCTION

This paper presents field demonstration results of an innovative technique to retrieve buried transuranic waste. The technique involves ground freezing and remote removal of a soil and waste mixture. Retrieval and processing for final disposal is one of the options being considered at the Idaho National Engineering Laboratory (INEL) for over 2 million cubic feet of transuranic waste buried in shallow land burial. Previous retrieval demonstrations at the INEL (1,2,3) involved excavation using conventional earth moving equipment. These activities relied on extensive contamination control strategies (3), and there was the potential for considerable dust generation. Defense-related transuranic waste, primarily from the Rocky Flats Plant, was buried at the INEL between 1952 and 1970. Since transuranic waste retrieval is expected to create considerable dust spread, and therefore contamination spread, the concept of freezing the soil and waste into cohesive chunks is desirable for controlling the spread of transuranics.

This paper first discusses the operational aspects of the retrieval technology including details on how the soil and waste matrix was frozen and the remote excavation technique. Next, the contamination control aspects of the technique are discussed by comparing air and smear samples for tracer concentrations to background concentrations. Finally, recommendations and conclusions are given on application of this technology to environmental restoration needs. Reference 4 contains details of the demonstration summarized in this paper.

TECHNOLOGY DEMONSTRATION

The field demonstration was conducted in a full scale, simulated waste cold test pit that contained typical waste containers such as boxes and drums. The boxes and drums contained simulated waste debris similar to that contained in the original Rocky Flats waste. This waste material consisted of paper, cloth, metal, asphalt, concrete, glass, sludge, and wood. The cold test pit was constructed using the same land fill techniques that were used during burial of the Rocky Flats material. The pit consists of four zones representing different internment techniques, including random dump 55-gal drums, random dump 55-gal drums, and 4 x 4 x 8-ft boxes, stacked drums, and stacked boxes. The ground freezing and remote retrieval technique was developed by Sonsub Inc. of Houston, Texas, based on a set of requirements from the Buried Waste Integrated Program sponsored by the U. S. Department of Energy's Office of Technology Development. The demonstration involved excavation of a 9 x 9 x 10-ft block of waste in various zones of the pit.

Sonsub's concept of cryogenic retrieval involved freezing the ground with liquid nitrogen (LN_2) (-320°F) using a series of freeze pipes that were driven into the soil and waste mixture (Fig. 1). Water was added to the pits to expedite the freezing process. The temperature of the soil and waste mixture between the pipes approached -100°F. The freeze pipes also served as vertical supports to pry the waste off the dig face in cohesive pieces. This was accomplished with a specially designed, remotely operated, hydraulically driven breakout tool. A large remotely operated hydraulic shear was used to sever freeze pipes that did not break outright from dig face, and a remotely operated jackhammer (Fig. 2) was used to remove frozen soil and waste mixtures that were not readily removed with the breakout tool. A specially designed grapple was used to retrieve and place the waste into a transport box for removal from the covered gantry crane assembly. The movable covered gantry crane assembly was positioned over the waste pit

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and provided a weather shield and containment to limit the spread of contamination. All the apparatus were remotely controlled, and a color television system was provided to view operations.

The signature response for cooling a soil and waste matrix is shown in Fig. 3. Figure 3 displays the centerline thermocouple response between freeze pipes. There is a general, slow multiday oscillatory cooldown caused by injecting LN_2 during the day but not the night. This is caused by the progression of an oscillatory frostline, behind which there is a high thermal conductivity and in front of which there is relatively low thermal conductivity. The fact that the temperature shows a pronounced decrease following water injection (Fig. 3) does not necessarily mean that the water injection caused the decrease (the frostline may have been near the thermocouple at the time of water injection). Other thermocouple responses on the wet side of pits (other than the one shown in Fig. 3) show an increased change in temperature with time once the water injection occurred but before the arrival of the frostline at the thermocouple position. This is due to a change in the general diffusivity of the soil and waste matrix from the water addition. Therefore, it is concluded that the addition of water enhances the cooldown process and reduces the need for LN_2 injection before excavation. Excavation was to start at a general pit temperature of -4°F because below this temperature additional cohesiveness of the soil and waste is not gained. Although the goal of -4°F was chosen, many of the thermocouples in the pit indicated considerably colder temperatures before excavation. LN_2 consumption averaged about 78,000 gal per 9 x 9 x 10-ft pit; however, this quantity does not represent a required amount for use in actual radioactive pits. Prior to performing the demonstration, the amount of water required and the effect on the need for LN_2 was unknown, so during this demonstration, considerable experimentation with the application of water and LN_2 injection occurred. About 1500 gal of water was added to each of the pits, and some leakage out of the pits occurred (verified visually and with moisture probe monitors). The remote equipment was capable of removing and handling the various frozen soil and waste mixtures at a rate that was scalable to production rates. The television cameras were unaffected by condensation.

CONTAMINATION CONTROL ASPECTS OF THE DEMONSTRATION

During transuranic waste retrieval activities, contamination control is mandatory because of the low uptake limits for plutonium and americium isotopes (3). It was determined in this demonstration that freezing the soil into cohesive chunks before excavation did reduce the spread of contaminants. This was assessed by examining the spread of a rare earth tracer that had been placed in each simulated waste container in the cold test pit and comparing this value to a statistical valid background measurement. The spread was measured by analyzing filters from high volume air samplers and smears and comparing these to background values. Table I compares the average measured rare earth concentration (each section of the pit had its own tracer) during the excavation to the statistical background values. Dust was collected in high volume samplers, and the filters were analyzed using Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS). The statistics for the background measurement are based on 24 measurements and a 99% confidence that the reading is from background only.

Table I includes data from both the wet side and dry side of the pit. For each pit, there was a side in which water was added and one in which water was not added (shown as the wet side and dry side in Table I). For all cases except for the random drum zone (wet side), the measured sample concentration of tracer is less than the background at the 99% confidence level (99% means that for any readings higher than this background value, there is only a 1% chance that the reading would be a background). For all readings in the random dump zone, dumping of the retrieved waste into a transporter box occurred without a funnel to focus the waste and resulted in spilling a considerable amount of debris around the box. For the other cases, the funnel was used to focus the waste and the spills were minimized. Therefore, the single case where the tracer concentration while digging was higher than background is attributed to an operational problem rather than a problem inherent with retrieval associated with the ground freezing technology.

TABLE I

Comparison of tracer Concentration During Retrieval to Backgrounds

Zone	Average Tracer Concentration (ppm) During Excavation/ Background at 99%	
	Wet Side	Dry Side
Random drums (Dysprosium oxide)	103/29.5	33.6/29.5
Random drums and boxes (Ytterbium oxide)	9.5/29.4	4.7/29.4
Stacked boxes (Neodymium oxide)	34.2/74.8	34.2/74.8

Driving freeze pipes into the soil waste matrix did not spread contaminants to the surface. The freeze pipe driving technology used a mud slurry mix at the pipe top, soil surface interface to prevent any entrainment of fine contaminated soil particles to the air. To assess this, smear samples were taken on several of the freeze pipes as they were driven into the soil and waste mixture. For all cases, ICP-MS was used to analyze the samples, and the tracer concentrations on the smear samples were below the background samples. Therefore, it is concluded that by using a mud slurry mix at the pipe top soil interface, contaminate spread can be precluded.

RECOMMENDATIONS AND CONCLUSIONS

This demonstration showed a positive feasibility of using ground freezing and remote retrieval for removing buried transuranic waste. The technology exhibits some superior contamination control aspects by causing cohesiveness of the soil and may allow retrieval with minimal containment buildings, which offers a cost advantage over conventional retrieval. The remote equipment was quickly mobilized (within a few months), and operations were not impaired by the cold temperatures. To fully assess the capability, it is recommended that several issues be examined including a) reduce the freeze time and thus the amount of LN_2 required by optimizing the injection of water; b) determine a way to introduce LN_2 without adding a multitude of freeze pipes or alternatively

Fig. 1. Orientation of freeze pipes for several pits.

Fig. 2. Jackhammer removing cohesive pieces of soil and waste from the dig face.

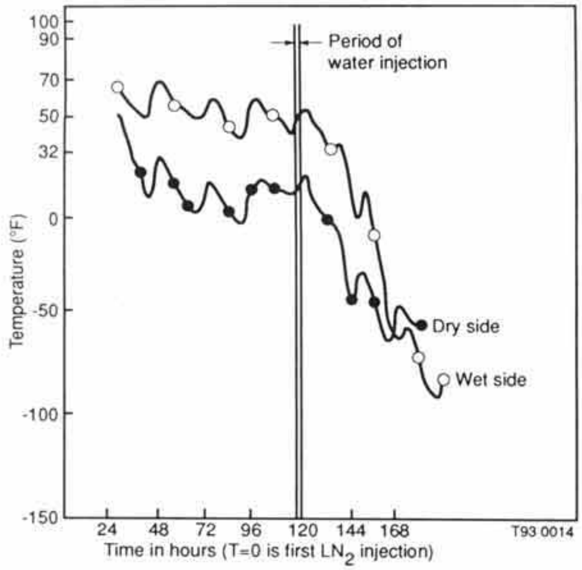

Fig. 3. Temperature History for Random Boxes and Drums at 8-ft Elevation.

determine a technique to remove and reuse the pipes; c) apply the technology to a large area of the cold test pit to allow a multiple block efficiency study; and d) apply the technology to the large object area of the pit to assess the application to large objects. Following successful demonstrations in the cold pit area, the technology should be tested in an actual transuranic contaminated waste pit or trench.

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