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THE ACCELERATED SITE TECHNOLOGY DEPLOYMENT PROGRAM/ SEGMENTED GATE SYSTEM PROJECT

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ABSTRACT

The Department of Energy (DOE) is working to accelerate the acceptance and application of innovative technologies that improve the way the nation manages its environmental remediation problems. The DOE Office of Science and Technology established the Accelerated Site Technology Deployment Program (ASTD) to help accelerate the acceptance and implementation of new and innovative soil and ground water remediation technologies. Coordinated by the Department of Energy's Idaho Office, the ASTD Program reduces many of the classic barriers to the deployment of new technologies by involving government, industry, and regulatory agencies in the assessment, implementation, and validation of innovative technologies.

Funding is provided through the ASTD Program to assist participating site managers in implementing innovative technologies. The program provides technical assistance to the participating DOE sites by coordinating DOE, industry, and regulatory participation in each project; providing funds for optimizing full-scale operating parameters; coordinating technology performance monitoring; and by developing cost and performance reports on the technology applications.

BACKGROUND

In 1995, the Department of Energy's Innovative Treatment Remediation Demonstration (ITRD) Program initiated the "Ohio Heavy Metals in Soils Project", to investigate the use of innovative technologies for the remediation of contaminated soils. Preliminary technology assessments indicated that processing radionuclide contaminated soils through physical separation using advanced sensors was cost-effective and could significantly reduce the volume of soil requiring either further treatment or off-site disposal. The ITRD program sponsored a study using the Segmented Gate System (SGS) for separating uranium and plutonium contaminated soil from clean soil. Based on these results, Sandia National Laboratories' Environmental Restoration Project and the ITRD Program sponsored a soil remediation effort at Sandia's Technical Area II in August and September 1997 using the SGS. The system was used to cost effectively separate clean and contaminated soil for four different radionuclides: plutonium, uranium, thorium, and cesium. Based on those results, the DOE's Ohio Field Office submitted an ASTD proposal to use the SGS at seven other DOE sites across the country.

SEGMENTED GATE SYSTEM DESCRIPTION (1)

Introduction

The ThermoRetec (formally Thermo NUtech) Segmented Gate System (SGS), Figure 1, is a combination of conveyor systems, radiation detectors, and computer controls that remove contaminated soil from a moving feed supply on a conveyor belt. Contaminated or suspect soil is loaded into a screening plant with a front-end loader. The soil is extracted by a series of conveyor belts and is spread evenly across the sorter belt and conveyed under an array of sodium-iodide (NaI) detectors that measure the gamma-ray emitting radionuclides in the soil. The control computer processes signals from the detectors and controls the gates at the end of the sorter belt. The contaminated soil is diverted to the contaminated soil conveyor belt by the segmented gates where the contaminated soil is discharged to a container or stockpile for further processing or final disposition.

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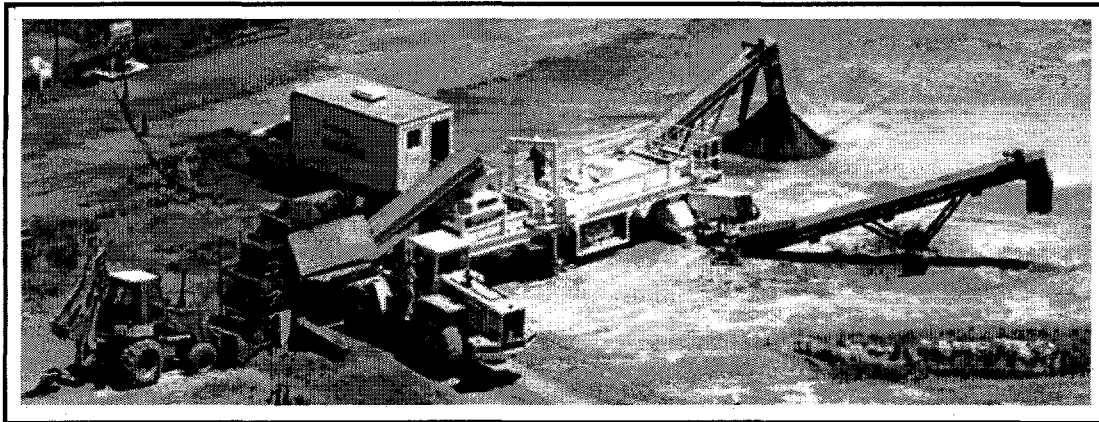


Figure 1. ThermoRetec's Segmented Gate System in Operation

Mechanical System Description

Thermo NUtech's SGS is a mobile, radiological soil assay system with motorized conveyor belts, a variable belt speed motor controller, air actuated segmented gates, a radionuclide assay computer system, and two sets of radiation detector arrays deployed across the 81.3-cm (32-in.) wide assay conveyor. The SGS unit includes a material feed conveyor, a sorting conveyor coupled to a sophisticated motor control unit to assure constant belt speed, a contaminated material conveyor, and a below criteria material conveyor.

Process Description

Contaminated soil is excavated with heavy equipment and relocated to the feed point of the SGS processing plant. Feed soil is loaded into and screened by the SGS mobile screen/hammermill plant where all oversized material (typically 1½ inches) is removed. The remaining soil is deposited in the feed surge bin using the conveyor built into the screen/hammermill plant. The surge bin deposits soil on the SGS conveyor belt using a screed to control the thickness and width of the soil layer. Process material is conveyed, at a constant speed, underneath the detector arrays. These arrays are linked to a control computer, which toggles pneumatic diversion gates located at the end of the sorting conveyor. Contaminated material that exceeds the criteria for radioactive materials is diverted to the contaminated material conveyor, where it is transferred to a stacking conveyor. The below criteria material falls directly onto the below criteria conveyor which transports it to the other stacking conveyor, Figure 2.

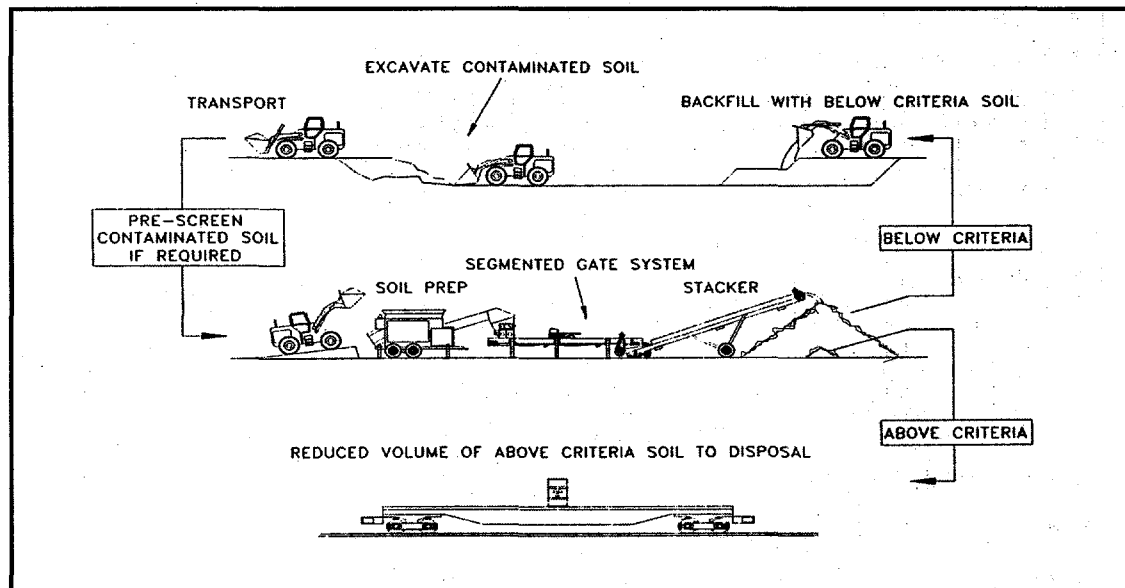


Figure 2. Process Flow - Segmented Gate System Operations

Radiation Detectors

Two sets of radiation detector arrays are housed in shielded enclosures that can be adjusted vertically above the flat assay conveyor belt allowing for various soil thicknesses. The detector arrays have a shadow shield below the conveyor belt that is constructed of steel plate lined with 5 cm (2 in.) thick lead brick to reduce the intensity of the background radiation immediately below the detectors. The detector arrays, arranged in two rows of eight detectors, span the entire width of the belt can be operated simultaneously. The SGS was designed for the detection of gamma-ray emitting radionuclides using NaI detectors; however, minor software and hardware changes can be implemented for deployment of detectors to allow for the detection of some beta-emitting radionuclides.

System Electronics

The electronics housing contains the detector interfacing and signal processing electronics for operation of the detectors and segmented gates. The housing also contains a control computer, for required data processing, and modular detector board (MDB) cards for communication interfacing to the detectors.

The segmented gates, Figure 3, have magnetically activated limit switches that provide electrical signals when the gates are fully extended or retracted. The control computer monitors the position of each segmented gate during soil processing operations. A safeguard alarm will activate if a gate is not in the required position for any reason. This alarm will automatically stop the processing conveyor belts and the system must be reset manually after the cause for alarm has been corrected.

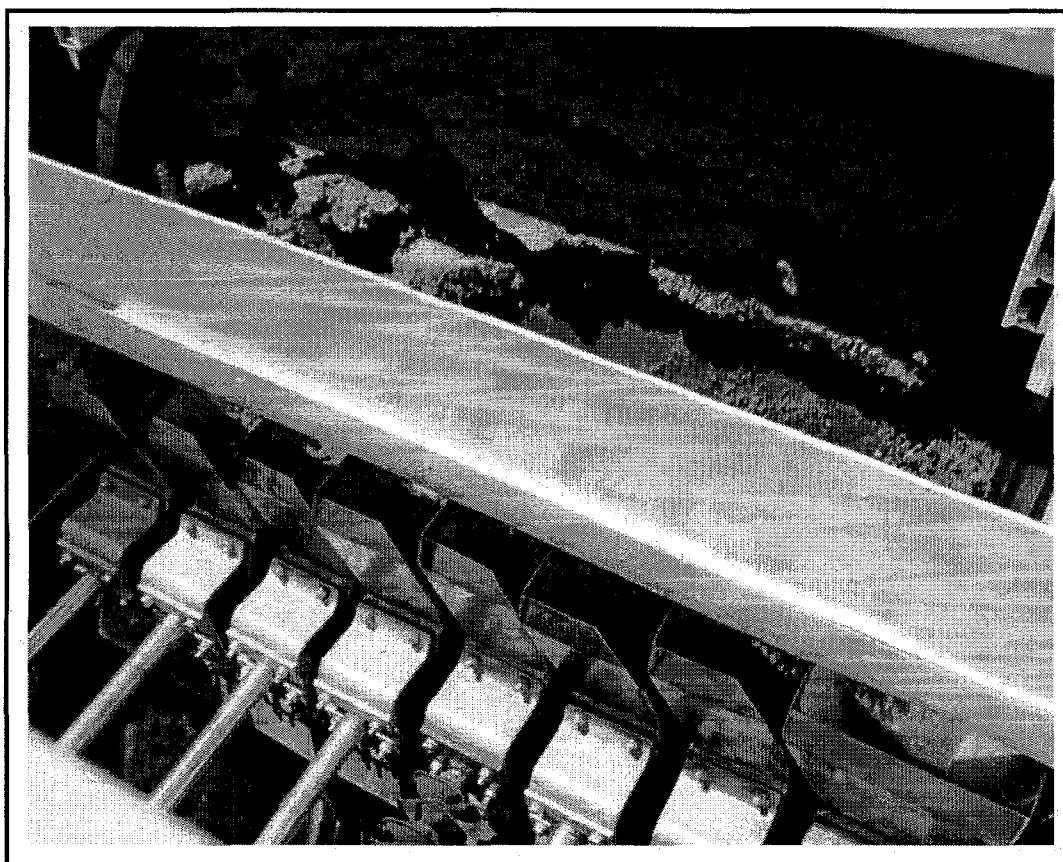


Figure 3. Pneumatically Operated Segmented Gates

The control computer interfaces with a remote computer located in an adjacent control van. The remote computer has a local display and keyboard and stores proprietary software on its internal hard drive. The remote computer monitors soil processing based on operating parameters supplied by the operator. The operating display on the

remote computer shows real-time status of the conveyor monitor system and will shut down all conveyor belts when abnormal conditions are detected or on operator command.

System Algorithm

The primary function of the control computer is to count the soil increments under the detector and make count rate and data processing, hot particle and distributed activity determinations using several proprietary mathematical algorithms via its on-board counters. As the control computer analyzes the detector data, the results are used to control the divert commands to the segmented gates, tracks contaminated material on the assay conveyor belt and determines when each increment of soil will reach the segmented gates. The computer signals the appropriate gate(s) to activate, catch, and route contaminated material to the proper path.

Data Storage

The control computer records the date, time, activity amount, gates used, and mass of each contaminated soil diversion. The SGS software calculates the mass of the below criteria material processed and volume of contaminated material diverted. The calculation is based on a value for material density entered by the operator and material thickness on the assay belt at a specified speed. This information is stored on the control computer for data archiving and report generation. The data is backed up daily on removable storage media. Upon command, the control room computer can generate production reports.

Segmented Gate System - Technology Advantages

The system physically surveys the entire volume of soil processed and typically reduces the volume of soil requiring treatment or disposal by 50% to 90%. Though limited primarily to gamma emitting radionuclides, the system can be modified to detect beta emitting radionuclides. Through processing, no chemicals or other additives are used. Dry decontamination has repeatedly been proven effective for free release of the system from the sites so the generation of secondary waste is generally limited to personnel protective equipment.

Segmented Gate System - Technology Limitations

Employing two detector arrays limits the ability of the system to analyze a maximum of two radionuclides at a time with different gamma energies. The soil cannot be properly sorted for unknown radionuclides so prior knowledge of the primary radioactive contaminate is required. Material greater than a nominal 1.5 inches in diameter inches, for a typical 2-inch soil thickness on the belt, cannot be processed without pre-crushing. The radioactive contaminate must be heterogeneously distributed within the suspect soil.

ACCELERATED SITE TECHNOLOGY DEPLOYMENT PROGRAM - SUCCESSFUL SITE DEPLOYMENTS

Sandia National Laboratories; Environmental Restoration Site 16; Albuquerque, New Mexico (2)

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were to reduce the volume of soil at Sandia National Laboratories' Environmental Restoration Site 16 requiring off-site disposal. The volume reduction would therefore, reduce the overall ER Site 16 remediation costs. The results of the deployment would also provide a basis from which to estimate SGS cost/performance for similar sites projected for future operations.

The SGS was used to sort 661.8 cubic yards of soil suspected of depleted uranium contamination excavated from ER Site 16 in February and March 1998. The reduction in the volume of contaminated soil was determined based upon the total soil processed versus the amount of soil that was determined to be below the release criteria for the site.

Performance Summary

Mobilization and calibration of the system were accomplished in eight days. This period included site-specific

training for Thermo NUtech personnel. Excavation included pre-screening of the soil using a vertical bar field grizzly to remove material and debris with a minimum dimension of 6 inches. Upon completion of the pre-screening process, this oversize material was deposited in a single layer for future hand survey by Sandia personnel. The remaining soil was stockpiled for processing.

Soil was processed for five days with a volume reduction of 98.5 percent after processing the entire volume of soil on the first pass. The above criteria soil was reprocessed with a final overall volume reduction of 99.9 percent resulting in 358 kg of contaminated soil requiring off-site disposal.

Radiological Data

Depleted uranium was the only radionuclide of concern on this project. The risk based clean-up criterion of 540 pCi/gm was established and the sorting criteria for the distributed contamination was set at an ALARA level of 54 pCi/gm. The below criteria soil average activity was 4.2 pCi/g, after the first sorting pass. The above criteria soil average was 406.5 pCi/g after the first pass.

Pantex Plant, Firing Site 5; Amarillo, Texas (3)

Summary

Thermo NUtech conducted a radioactive material volume reduction project for the Pantex Plant at Firing Site 5 (FS-5). The goal of the project was to reduce the volume of contaminated soil that would require off-site storage and disposal. The soil was contaminated with depleted uranium from test operations conducted at the Pantex Plant. The firing site had been excavated and material had been screened for activity by surveying each loader bucket of soil using a hand held survey meters. Soil was segregated, dependent upon the activity measured with the survey meters, into separate piles.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to Pantex FS-5 on March 27, 1998 to an area covered immediately adjacent to the FS-5 site. Pantex has active operations at adjacent firing sites preventing access during firing site operations. These active operations dictated a work schedule of Friday through Monday, so work was planned on a 10-hour day schedule, Friday through Monday.

High winds postponed the mobilization of the SGS until March 29th. Soil processing began on April 17, 1998 and continued through April 19th when the decision was made to discontinue processing due to a lack of volume reduction. A processing time of 10.7 hours of was logged. Based on a 7 hour processing day, 1.7 days of downtime were accumulated for weather conditions and mechanical challenges not under the contractor's control. Average daily operational time, impacted by adverse weather conditions, was 2.67 hours with a total of 294 cubic yards processed through the SGS and an estimated 15 percent additional volume in oversize material that was not processed through the SGS.

Overall volume reduction reported by the SGS after processing soils from various areas of the firing site was 38.5 percent based on the SGS separation criteria of 50 pCi/g. The client selected this criterion as an appropriate level below the soil cleanup action level to insure that soil designated as below criteria by the SGS could be used to backfill the excavation. Soil excavated from the firing site was segregated into three categories for processing by the SGS. Soil from a staging area that was characterized as above site cleanup action levels resulted in no significant volume reduction. A stockpile from the edge of the gravel pit excavation characterized as slightly above the site cleanup action level produced a 60 percent volume reduction.

Soil that was excavated from the berm surrounding the firing site and was characterized as below the site cleanup action level resulted in an 89 percent volume reduction based on the SGS criteria. Very little volume reduction was lost to unscheduled pauses, which causes an information loss for the soil on the conveyor belt. Most halts in production were associated with changing the source of the soil to be processed, and had no impact on volume reduction.

Radiological Data

Depleted uranium was the only radionuclide of concern during the processing on this project.

The average activity for soils from the berm that were originally characterized as below criteria using the hand survey method and determined to be above criteria by the SGS was 125 pCi/g, while the average activity for the below criteria soils from the berm was 20 pCi/g. The overall average activity for the soil processed from the berm was 31.3 pCi/g, which was below the site criteria. The average activity for soils classified as above criteria by the hand survey method was 206.8 pCi/g. There was no volume reduction obtained for the 53.2 cubic yards of soil processed from this source.

Performance Observations and Lessons Learned

The primary factor for the less than desirable volume reduction was the pre-sorting of the soil using the hand survey method prior to SGS processing. While this method is primarily an indicator of activity near the surface of the soil in the loader bucket, it does succeed in segregating high activity soil from soils that may contain lower levels of activity that still exceed the established criteria. The SGS does provide a 100 percent assay of the soil, insuring that small areas of elevated activity can be removed while allowing the averaging over larger volumes, as was done with the hand survey method. Loader buckets of soil that were classified as above the Pantex soil cleanup action levels with the hand survey method appeared to be relatively homogeneous. In contrast, soils that were classified as slightly above or below the Pantex soil cleanup action levels were indeed mostly below the SGS criteria but still contained localized elevated activity.

Conclusions

The application of the SGS to the remediation of the Pantex Plant FS-5 resulted in very little volume reduction in the soils classified as above the Pantex soil cleanup action levels. The results were significantly better in soils that were classified as slightly above or below the Pantex soil cleanup action levels, where isolated volumes of soil with elevated activity were found and removed. The SGS may be a viable, cost-effective alternative to the hand survey classification if it were used to process all soils excavated from a firing site rather than just the soils with elevated activity.

Tonapah Test Range; Clean Slate 2; Tonapah, Nevada (4)

Summary

On May 4, 1998, the ASTD Program, in cooperation with Bechtel Nevada, deployed Thermo NUtech's Segmented Gate System for a radioactive material volume reduction project. The deployment took place at the U.S. Department of Energy, Nevada Operations Office (DOE/NV), Clean Slate-2 soil remediation site. The DOE/NV Environmental Restoration Program includes sites with large quantities of soil contaminated with finely dispersed plutonium resulting from safety shot experiments conducted in 1963. Processing continued through mid-June.

A total of 333 cubic yards of soil was processed through the SGS. The soil volume reduction ranged from 4 percent to 99 percent and was dependent on the activity in the processed soil compared to the set-point value used to activate the sorting gates. Since a corrective action level had not been established, different set points were tested relative to the soil activity level in order to maximize data points for comparison.

Operating Parameters

The operating parameters for the SGS at Clean Slate-2 were varied to provide a large number of data points to help determine the acceptable level of contaminant reduction. Seventy-nine separate periods of operation or "runs" occurred, each characterized by different soil activity levels and equipment operating parameters that included set points and soil thickness on the belt.

Project Objectives and Approach

The operations were designed to assess various operating parameters and determine their influence on the volume of plutonium that could be removed, thus potentially reducing the volume of soil requiring off-site disposal. Comprehensive results of the multiple runs can be found in the Cost and Performance Report, July 1999, for the Clean Slate-2 Deployment (4).

Performance Observations and Lessons Learned

An accurate estimate of system throughput cannot be extrapolated from test runs when the set point criteria are changed so frequently. The 333 cubic yards of soil were processed during 79 different set points were tested, relative to the soil activity level, in an effort to maximize data points for comparison of separation efficiencies.

Soil excavation using a motor grader to scrape soil into windrows significantly mixes the soil, homogenizing potentially high concentration areas and rendering the SGS less effective. Some type of marking system to identify hot areas within the windrow would tell the loader operator which sections of the windrow to transport to the SGS feed point for processing and which sections should not be processed for volume reduction.

Los Alamos National Laboratory; Technical Area 33; Los Alamos, New Mexico (5)

Summary

Thermo NUtech conducted a radioactive material volume reduction project for Los Alamos National Laboratory at Technical Area (TA)-33 during April and May 1999. Actual processing occurred on 15 days and a total of 91.10 hours of processing time were logged.

Within TA-33, three sites were included in this remediation effort, C33-003, Water Tower Site; C33-010 (c), Gully Site; and 33-007(b), Bunker Site. The goal of the project was to reduce the volume of contaminated soil that would require off-site storage and disposal. The soils at the sites were predominately contaminated with natural uranium (NU). A set point of 50 pCi/g for NU was established as the ALARA target for the project. The actual Primary Remediation Goal (PRG) for this site was 600 pCi/g.

A volume of 2,526 cubic yards was processed through the SGS. A set point of 65 pCi/g was used to reprocess the diverted soil from the Gully Site since the contamination was more uniformly distributed but still significantly below the PRG. The separation efficiencies listed in Table III include the reprocessed soil from the Gully Site.

Table I. LANL TA-33 Processing Results by Site

TA-33 SITE	SEPARATION SET POINT	SEPARATION EFFICIENCY
C33-003, Water Tower Site	50 pCi/gm	99.65%
C33-010 (c), Gully Site	65 pCi/gm	99.79
C33-007 (b), Bunker Site	50 pCi/gm	75.47

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were to reduce the volume of soil at TA-33 requiring off-site disposal reducing the overall TA-33 remediation costs and provide a basis from which to estimate SGS cost and performance for similar LANL sites projected for future operations.

Performance Summary

Soil was processed, using the SGS, for 15 days. The average daily processing time was 6.48 hours, just below the target of 7 hours of processing time per each 10-hour workday. There were 8 processing days where the volume of soil processed exceeded 200 yd³.

Performance Observations and Lessons Learned

A total of 253 cubic yards of material from the hot piles were processed a second time to attempt addition volume reduction. A 6yd³ hot pile from C33-003 was processed yielding an additional 94% volume reduction. After all site soils were processed, 24 yd³ of soil was excavated from around the equipment, as a part of the decontamination, and processed yielding a volume reduction of 94.6%.

Idaho National Engineering and Environmental Laboratory; Auxiliary Reactor Area 23;

Idaho Falls, Idaho (6)

Summary

Idaho National Engineering and Environmental Laboratory (INEEL) at Auxiliary Reactor Area-23 (ARA-23). ARA-23 is a 41.8-acre CERCLA site containing cesium-137 contamination. The contamination resulted from the accidental destruction a reactor in 1961 and subsequent clean-up activities. The remediation goal site was 23 pCi/g.

The SGS was on site during June 1999 with soil processing from June 10th - 30th. The goal of the project was to reduce the volume of contaminated soil that would require disposal. Soils were excavated and stockpiled from two areas within ARA-23, representing sediment (spill) and windblown type contaminant depositions. Since expected volume reduction was not being achieved, only 442 yd³ of the 1,040 yd³ of stockpiled soil was processed when the client discontinued production sorting.

Operating Parameters

The operating parameters for the SGS at ARA-23 were selected to provide the optimum sensitivity for the contaminant of concern, cesium-137. The thin detector array was replaced with gas proportional beta detectors in monitoring mode. Once processing changed to an evaluation mode, parameters were changed for each test.

Performance Summary

Area A - Sediment Contaminant Deposition - 113 yd³ were processed with 97.3% of the soil exceeding 23 pCi/g. The low separation efficiency achieved for these soils was expected. The homogeneous contaminant distribution associated with a spill or sediment type deposition was expected.

Area C - Windblown Contaminant Deposition - Poor separation efficiency was observed with these soils and led to termination of routine soil processing. The windblown radionuclide contamination in this area was thought to be heterogeneous in nature and there was not an obvious explanation for the poor separation efficiency. At this point the parties involved agreed to investigate the reason(s) for the poor separation results. The investigation consisted of a series of performance tests to verify proper operation of the SGS and determine the reason(s) for the poor results.

A number of tests were performed at varying operating parameters, employing varied excavation techniques and reprocessing soil at decreasing detection set points. The proper operation of the SGS was verified indicating that the radionuclide contamination was homogeneous in nature and well above the established clean-up criteria. A separation efficiency of 90% to 95% could be achieved at approximately 90 pCi/gm. The results of these evaluation tests are outlined in the November 1999 ASTD Cost and Performance Report for the INEEL Deployment (6).

Conclusions

Although the desired volume reduction of 90% at the separation criteria of 23 pCi/gm was not met, several lessons were learned and are outlined and discussed in the Cost and Performance Report (6).

REFERENCES (References 2 – 6 are available on the SGS Home Page)

1. "Final Report, Segmented Gate System Demonstration at West Valley Demonstration Project", Thermo NUtech (August 1997)
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4. "Cost and Performance Report, Thermo NUtech's Segmented Gate System, Tonapah Rest Range, Clean Slate 2" ASTD (July 1999)
5. "Cost and Performance Report, Thermo NUtech's Segmented Gate System, Los Alamos National Laboratory, Technical Area 33", ASTD (November 1999)
6. "Cost and Performance Report, Thermo NUtech's Segmented Gate System, Idaho National Engineering and Environmental Laboratory, Auxiliary Reactor Area 33", ASTD (November 1999)