MANAGEMENT OF TRANSURANIC WASTE RETRIEVAL PROJECT RISKS – SUCCESSES IN THE STARTUP OF THE HANFORD 200 AREA WASTE RETRIEVAL PROJECT

R.D. Greenwell
Duratek Federal Services of Hanford

ABSTRACT

A risk identification and mitigation method applied to the Transuranic (TRU) Waste Retrieval Project performed at the Hanford 200 Area burial grounds is described. Retrieval operations are analyzed using process flow diagramming, and the anticipated project contingencies are included in the Authorization Basis and operational plans. Examples of uncertainties assessed include degraded container integrity, bulged drums, unknown containers, and releases to the environment. Identification and mitigation of project risks contributed to the safe retrieval of over 1700 cubic meters of waste without significant work stoppage and below the targeted cost per cubic meter retrieved. This paper will be of interest to managers, project engineers, regulators, and others who are responsible for successful performance of waste retrieval and other projects with high safety and performance risks.

INTRODUCTION

Successes in the retrieval of TRU wastes from the Hanford 200 Area burial grounds resulted from thorough project risk identification and the full integration of mitigation strategies into daily operations. From November 2003 to January 2005, 7,524 containers (1,700 cubic meters) of waste were retrieved. Of this population, 625 heavily corroded, breached, damaged, and bulged containers required the application of predetermined risk response actions that were completed with no significant safety incidents or work interruptions.

PROJECT BACKGROUND

Over 15,000 cubic meters of suspect-TRU waste was retrievably stored in earth-covered trenches at the Hanford 200 Area burial grounds from 1970 to 1988 (1). Suspect-TRU waste was defined as a separate waste category by the U.S. Atomic Energy Commission (AEC) in 1970 and was separated from low-level waste (LLW) and retrievably stored. In 1973, the AEC changed the definition of TRU waste to waste containing greater than 10nCi/gm (nanocuries/gram) of TRU radionuclides. The definition of TRU was changed again in 1984 to specify only waste containing greater than 100 nCi/gm of TRU radionuclides; therefore, some of the suspect TRU waste initially placed in storage would now be defined as LLW. After 1988, TRU waste was stored in the Central Waste Complex (CWC), a Resource Conservation and Recovery Act (RCRA) permitted storage unit.

The majority of the Retrievably Stored Waste (RSW), consisting of approximately 26,200 drums, is placed on asphalt-floored trenches in 3 to 4 high vertical stacks layered with plywood. Additionally, boxes of various size and construction and other miscellaneous containers are intermingled with the drums. Storage configurations varied including horizontal and diagonal arrays, and random dumping. A plastic tarp material was placed over the stacks during the later years of retrievable storage and 1 to 3 meters of soil cover was typically placed over each trench. Vertical plastic pipe “vent risers” were placed, extending from the asphalt pad through the earthen cover in some trenches. The vent risers were intended to reduce moisture content in RSW stacks; however, they were later determined to be ineffective. The RSW trenches are located in four separate burial grounds of the 200 Area.

A pilot retrieval project was performed in 1994 to investigate container integrity and provide planning information for future full-scale retrieval operations. In-situ inspections were performed on tarp-covered 208 liter (55 gallon) RSW drums to evaluate drum corrosion degradation. The pilot project concluded that drum corrosion was less than expected, affecting only a small percentage of drums. Corroded drums were predominately those on the outer edges of the stack and in contact with the tarp material or soil. Breached containers causing contamination were encountered. The maximum drum wall corrosion rate was estimated to be 2 mils/year.

Retrieval of uncovered RSW drums began in 1996. An earthen-cover was never completed over several stacks of drums at the end of retrievable storage operations in 1988. About 1,100 drums were retrieved from 1996-2001, removing the uncovered RSW containers. Further retrieval required completion of a revised Authorization Basis for the earthen-covered portions of the trenches. Vadose zone and near-surface soil vapor sampling for volatile organic compounds (VOCs) were conducted in the 218-W-4C burial ground and adjacent areas during August and September 2002. This investigation was conducted under a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) remedial investigation of VOC releases in the general area. Carbon tetrachloride was detected at all but one of 27 vent risers sampled. A distinct “hot spot” with a maximum concentration of 1,760 ppmv was detected at the east end of Trench 4 (2). The discovery of VOCs in the trenches raised stakeholder concerns about releases from RSW and ultimately became an impetus to revise the enforceable milestones for TRU waste retrieval established in the Hanford Tri-Party Agreement. The new regulatory agreement, finalized in the fall of 2003, directed the order in which trenches will be retrieved, included near-term project start-up milestones, and created new retrieval production milestones that accelerate yearly, i.e., 1200 cubic meters in 2004, 1500 cubic meters in 2005, etc. (3).

The 33-year history of waste storage preceding full-scale retrieval created significant uncertainties in the waste configuration and site conditions. These uncertainties, combined with safety and regulatory requirement challenges, created high risks that needed to be managed to assure project success.

RISK IDENTIFICATION AND STRATEGY DEVELOPMENT

Retrieval project planning began with a review of similar TRU waste retrieval projects performed across the DOE complex. Occurrence reports were reviewed including those of past operational experiences within the Hanford burial grounds (4,5,6). Project personnel from Savannah River Site, Idaho National Environmental Engineering Laboratory, Los Alamos National Laboratory, Rocky Flats, and Oak Ridge National Laboratory were contacted. Good practices and retrieval techniques were identified. Hazards discussed include chemical/radiological contamination, industrial safety, and site-specific conditions such as burial ground subsidence. A significant concern across the DOE complex is the presence of hydrogen and VOCs in un-vented TRU waste drums due to radiolysis and chemical corrosion of drum and waste contents. Concentrations of hydrogen above the lower flammability limit have been observed in retrieved waste drums at several DOE sites, posing the threat of fire or deflagration. Venting of suspect-TRU drums was not commonly performed prior to 1978 at the Hanford Site, and therefore, an estimated 8,190 drums are stored in the RSW trenches without venting devices. An evaluation was conducted of the DOE complex-wide experience with hydrogen generation, accumulation, diffusion, and leakage from retrieved TRU waste containers (7). The study identified over 42,000 drums retrieved across the complex. Hydrogen data were available from venting operations of 23,677 drums. Greater than 15 % by volume (vol.%) hydrogen was found in 4 percent of un-vented drums. A deflagration event with hydrogen greater than 15 vol.% is expected to cause energetic drum lid loose and partial ejection of drum contents. One objective of the study was to identify parameters such as radionuclide content or waste form that could be used to predict hydrogen generation without reliance on conservative modeling codes such as RADCALC (8). The hope of the project team was that judgments about the potential for hydrogen gas buildup in drums could be made, based on a review of storage records. However, no reliable correlations could be made through review of existing data. Differences in the distribution of radionuclides within a container, waste packaging methods, and other variables complicate attempts to predict hydrogen levels and support the need to vent all TRU waste containers using appropriate handling and venting methods to protect workers.

Input from related DOE projects formed the basis for the Hanford TRU waste retrieval strategy; however, no project performed to date could be identified with analogous uncertainties, safety, regulatory, and performance requirements. Controlling project risks became the overarching consideration during retrieval planning. Key features of the retrieval strategy selected include: continuous year-round operations, mobile equipment and support facilities, outdoor retrieval (no enclosure structure), multiple retrieval sites operated simultaneously, dig-face radiological/chemical monitoring, and field sorting of waste streams prior to transportation to treatment, storage, and disposal (TSD) facilities to prepare for final disposition.

PROCESS FLOW DIAGRAMMING AND RISK ANALYSIS

The retrieval Project Execution Plan documented a rigorous approach to monitor and control risks (9). Storage records exist for much of the RSW providing information on waste generators, radionuclide inventories, and to a lesser degree, chemical inventories. However, the completeness and reliability of records greatly diminishes with age, creating uncertainty in work definition and hazards analysis for older trenches. Many containers were expected to be degraded due to the number of years stored underground. A number of variable steps are involved with the retrieval process to account for the issues involved with degraded containers. It was recognized early in project planning that a detailed process flow examination was needed to assure integration of Authorization Basis documents, selection and sizing of unit operations, and identification of contingencies. A basic process description was developed from planning inputs (10). The normal process steps for retrieval operations consist of: 1) trench module records analysis and retrieval safety evaluation, 2) vapor vacuum extraction operations in trenches with elevated VOCs, 3) exploratory and final trench excavations, 4) removal of containers from the uncovered stack, 5) initial container inspection and staging, 6) waste designation including nondestructive assay to sort TRU from non-TRU waste, 7) venting of TRU drums without venting devices, and 8) transportation to treatment, storage, and disposal (TSD) facilities for further processing and disposition. TRU waste containers are characterized at Hanford TSD facilities, repackaged if necessary, and certified for shipment to the Waste Isolation Pilot Plant. MLLW and LLW are processed for compliant disposal at Hanford. Development of the process description and flow diagram provided the detailed information needed to complete the Preliminary Hazards Assessment, National Environmental Policy Act evaluation, air permit, operational procedures, and final selection of equipment and materials. Contingency process flow paths were also fully developed for all anticipated abnormal retrieval conditions including heavily corroded, breached, damaged, bulged, and unknown containers, as well as environmental releases, classified wastes, and unexpected emergent conditions (Figure 1).

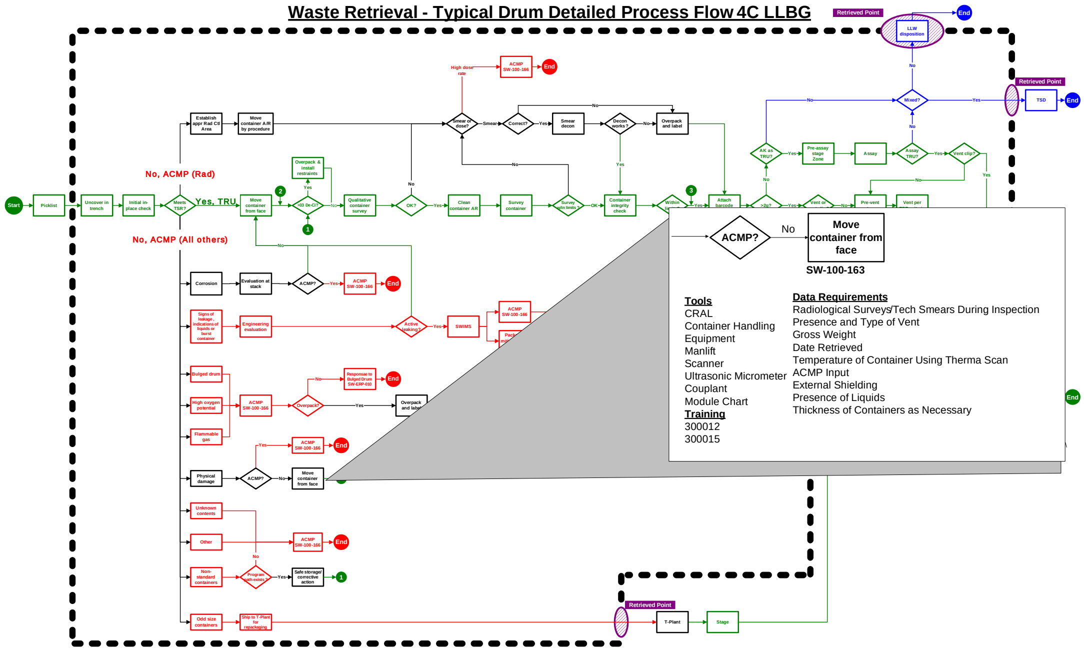

Fig. 1. The TRU Waste Retrieval Process Flow Diagram Was Developed to Analyze Contingencies and Develop Risk Response Plans

During project planning, the work steps are defined, hazards analyzed, and controls established for each contingent process flow path. Engineered features are designed and equipment is procured using a graded approach based on the estimated frequency that each flow path would be used. Work procedures and training incorporate all process flow paths. The project Authorization Basis and safety management systems recognize all flow paths and address their safety analysis and controls set (11). For example, several different drum-venting approaches are needed to address all possible conditions that could be encountered. Project Technical Safety Requirements (TSRs), air permits, and operating plans allow the use of different venting systems within the analyzed operations including: 1) a cold drilling system for the majority of drum venting needs, 2) a pneumatic dart system for abnormal sized containers and when venting in-trench, 3) sparkless drilling in a glove bag system for drums with contamination release concerns, and 4) emergency response procedures for bulged drums that cannot otherwise be safely vented. Similar flexibilities are designed into several process steps as needed to address the identified contingencies.

PROJECT EXPERIENCE

The project risk approach utilized for retrieval was highly successful, completing five enforceable regulatory milestones ahead of schedule while meeting aggressive cost targets during the first year of operation. Figure 2 illustrates typical retrieval operations. The key benefit of this risk strategy is that from a field operations point of view, planned contingencies become normal operations.

Fig. 2. Trench Excavation and Drum Exhumation Operations at 218-W-4C, Trench 4.

Workers are involved in the selection of equipment and development of procedures for all process flow paths improving performance, reliability of operations, and feedback from work teams. A mockup RSW trench constructed outside of the nuclear facility proved invaluable for testing equipment, demonstration of processes, and training work teams on retrieval procedures. Vapor vacuum extraction systems installed on vent risers of burial ground 218-W-4C, Trench 4 effectively reduced ambient VOC levels to below action levels before retrieval operations commenced. The readiness assessment and startup plan for the project were completed with minimal corrective actions due to the effectiveness of integration and work team training. Monitoring of initial field operations confirmed that the retrieval strategy was valid and that trench configurations and RSW container integrity were successfully predicted through the planning process, resulting in no significant work stoppages.

The most frequently encountered abnormal condition is excessively corroded drums. The distribution of abnormal containers so far is 80% corrosion, 17% damaged, and 3% other (includes contamination, high dose, liquids, unknowns, and bulging). Extensive corrosion in some trench locations have resulted in breached drums and contamination levels within the stack to 7,000 dpm/100cm^2 alpha, and 80,000 dpm/100 cm^2 beta-gamma. No releases to the environment have been identified. Hydrogen monitoring results within newly vented TRU waste drums are summarized in Table I. Gas chromatograph results confirmed the presence of significant hydrogen levels in a small percentage of the TRU waste drum population consistent with DOE complex experience. Following venting, drums with elevated hydrogen levels are retained in a protected zone until vent filter diffusion time is completed. Waste designations following initial processing approximate 55 percent TRU waste, 40 percent mixed low-level waste (MLLW), and 5 percent low level waste (LLW).

Table I. Hydrogen Concentrations at Venting of 2,052 Drums Retrieved From the 218-W-4C Burial Ground

	Percent by Volume Hydrogen in Drum Headspace[a]				
	<1%	1-4%	5-15%	16-30%	31-50%[b]
Un-Vented TRU Drums	1427	415	171	34	5
Percent of Population	69.6	20.2	8.3	1.7	0.2

[a] Hydrogen is flammable in concentrations of 4.1 to 74.2 vol.% in air
[b] 50% is the maximum concentration observed

The project manager uses process flow diagrams to optimize unit operation throughput. Drum counts at stages along the process flow are monitored and adjustments in work assignments and drum queuing are made to maximize productivity. Responses to changing weather and site hazards are also made as necessary. This analysis is also helpful to identify and prioritize investments to achieve innovations and continuous improvements.

LESSONS LEARNED

The following is a summary of lessons learned from the planning and implementation of TRU waste retrieval at Hanford.

1. Communications across the DOE complex by teams performing similar high-risk projects provide valuable input throughout the life of the job (12).

2. A pilot retrieval or similar site investigation provides vital information to the project plan about site conditions and hazards identification.

3. The risk response strategy is critical to the success of the project. The strategy should be utilized to guide development of the project execution plan.

4. A detailed process description should be developed early in the planning phase. Process flow diagramming or other appropriate tools can be used to identify contingencies that must be fully developed into the operational plan.

5. Design the operational plan for continuous throughput whenever possible to maximize efficiency. Avoid the stops and starts of batch-type operations.

6. Mockup facilities are invaluable for demonstrating equipment, processes, and training work teams.

7. Worker involvement should begin during the planning phase to obtain important feedback and ownership of the approach.

8. Maintain multiple retrieval faces whenever possible to provide flexibility in drum feed sources and the ability to shift operations as necessary to respond to abnormal conditions.

9. Monitor risk responses continuously to identify changing assumptions and to identify opportunities to improve the effectiveness of responses.

10. A potential disadvantage of this approach is that time and resources must be applied to the planning process to implement all analyzed flow paths. Unknown conditions will still be encountered and the project plan must provide for response to unknowns.

CONCLUSION

Process flow analysis has proven to be an effective method to identify and mitigate risks at the Hanford TRU waste retrieval project. Successful application of this approach requires full integration of risk responses into the operational plan. Equally important is the need to involve workers in the risk response process and provide them with the authority to select responses and apply process improvements. Project leaders and stakeholders must factor in realistic expectations about the planning investment necessary to achieve successful high-risk projects. Risk analysis must also be applied beyond the planning phase throughout the life of the project.

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