CONF-930205--37

PNL-SA-21393

HIGH-LEVEL WASTE MANAGEMENT AND TREATMENT PROGRAM FOR THE ANALYTICAL LABORATORY

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February 1993

Presented at the
Waste Management '93 Symposia
February 28 - March 4, 1993
Tucson, Arizona

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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HIGH-LEVEL WASTE MANAGEMENT AND TREATMENT PROGRAM FOR THE ANALYTICAL LABORATORY

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ABSTRACT

A new program has been successfully implemented for the treatment, storage, and disposal of high-level radioactive mixed wastes generated during chemical and radiological analysis at the Pacific Northwest Laboratory in Richland, Washington. This shielded laboratory facility has effectively treated RCRA waste generated predominantly from analyses of radioactive samples obtained during the Tank Waste Characterization Program on the Hanford Site.

Several batches of the radioactive mixed waste, generated during the full analytical characterization of four Hanford Single Shell Tank cores and the partial characterization of three other cores, were combined and successfully treated during January through August of 1992. The waste treatment process was specifically designed to treat a low-pH, high-chloride, high-gamma activity waste stream. The creation of the treatment, storage and disposal facility required an extensive six-month permit modification process resulting in state and federal regulatory approval.

INTRODUCTION

Waste management and environmental compliance programs for managing waste disposal and effluent release are a crucial part of laboratory systems. Analytical chemistry laboratories that characterize high-level radioactive mixed waste need to have the capability for onsite treatment of the waste generated during chemical analysis in order to ensure continued operations. The Analytical Chemistry Laboratory (ACL) at the Pacific Northwest Laboratory (PNL)[1] in Richland, Washington, has successfully implemented a program for treatment, storage, and disposal of high-level radioactive mixed liquid wastes generated during chemical and radiological analysis. This paper describes the state and federal regulatory approval required, the waste treatment processes selected, and operational experience with Hanford waste.

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[1] Operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

As the Hanford Site Research and Development Contractor, PNL is committed to supporting the Site Operations Contractor, Westinghouse Hanford Company, in addressing environmental restoration and complex tank safety programs. This includes helping to characterize all aspects of the Hanford Site from low-level radioactive soil or groundwater samples to the high-level radioactive materials from the Hanford Tank Farm Characterization Program. Much of this characterization effort is in support of Resource Conservation and Recovery Act (RCRA) or CERCLA projects resulting from the Hanford Federal Facility Agreement and Consent Order or Tri-Party Agreement signed between the Department of Energy (USDOE), the Environmental Protection Agency (USEPA) and the Washington State Department of Ecology (WDOE) in May of 1989. The Agreement specifies that remediation and restoration of Hanford will be completed by the year 2019.

FACILITIES

The Shielded Analytical Laboratory (SAL) facility within the ACL was selected as the area to treat radioactive mixed waste, i.e., waste exhibiting both radioactive and hazardous characteristics, since much of the waste requiring treatment is generated from analyses of high-level wastes in this facility. The SAL consists of six shielded cells that are interconnected in series, each with dimensions of 1.8 m high, 1.8 m wide, and 1.7 m deep. The cells are designed for handling samples with dose rates up to 2000 R/h and containing up to 1000 curies of 1 MeV gamma radiation. A photograph of the SAL facility is shown in Figure I. The SAL, with light duty remote handling capabilities, is specifically designed as a high-level radiation analytical chemistry facility integrated with the operations of other analytical chemistry laboratories in the building. The expected treatment volumes per year for radioactive mixed waste will not exceed 900 gallons, liquid or solid.

Figure I: Photograph of the PNL Shielded Analytical Laboratory

The Single and Double Shell Waste Tank Characterization programs will account for the majority of both liquid and solid waste forms generated in the SAL facility for many years to come. The liquid and solid waste is separated prior to treatment, as well as during and after treatment. This paper refers only to treatment of liquid waste, as this is the predominant waste form. The nonhazardous radioactive solid waste is sent to the Low Level Waste Burial Ground on the Hanford site. Solid radioactive mixed waste (RMW) is sent to the Hanford Central Waste Complex and stored for future batch-processing. The treated radioactive liquid wastes are disposed of through the site's Radioactive Liquid Waste System (RLWS) directly from the SAL facility. These waste storage and disposal facilities are operated by the Site Operations Contractor.

REGULATORY PERMIT PROCESS

The USDOE, the WDOE, and the USEPA require a laboratory or other facility to obtain a RCRA permit to operate a waste treatment, storage and disposal (TSD) facility. The permit acquisition process is a two-step procedure. The original Part A of the permit, which was required by law to be submitted by May 1988, informs regulators of the facility's intent to operate and sets operation guidelines and schedules. If filed prior to the 1988 deadline, a Part A permit enables the facility to operate under "interim status" conditions until the Part B is filed and accepted. The Part B outlines in detail how the facility will be operated and closed at the completion of service.

The operation of a TSD facility, specific to the ACL and described here, required a modification of the original Part A permit. The modification of the permit was required to allow treatment of wastes designated as hazardous by the USEPA since 1988. The existing 1988 Part A permit allows interim operation of a TSD prior to full regulatory approval of the final Part B. In contrast, any new TSD permit would require an extremely lengthy process for complete approval of TSD operations, with no interim operations allowed.

A coordinated effort between PNL and USDOE was necessary to obtain operational approval under the existing Part A Permit. The approach to the modification of the existing Part A permit was pre-reviewed with DOE and action plans were developed for obtaining regulatory approval. The Part A permit modification process undertaken at PNL for the TSD facility required about six months. This included four months to complete the required actions and another two months of reviews and approvals. The labor involved for the entire permit modification process, including all participating personnel and all required steps in the process, was approximately 600 man-hours. Interim status operations began in January 1992. The TSD continues to operate under this Part A interim status while the Part B permit process is in progress. The Part B is scheduled to be filed with WDOE and USEPA in December of 1994.

Completion and approvals of several key elements were required before treatment activities could be initiated: development of a detailed project plan describing capabilities and responsibilities; review and approval to proceed with Part A modifications; preparation of documentation, including the RCRA Compliance Plan, NEPA review documentation, and waste management procedures; performance, review, and approval of the Operational Readiness Review, RCRA Compliance Plan, and NEPA documentation; and finally, initiation of the Part B Permit preparation.

The RCRA Compliance Plan was developed to provide documentation of the SAL facility compliance with applicable federal and state environmental regulations. This plan, covering only those regulations for managing hazardous constituents, refers to the Washington State Dangerous Waste Regulations found in the Washington Administrative Codes 173-303. Where applicable, the plan also references the RCRA regulations found in 40 CFR, the USEPA section of the Code of Federal Regulations. The major sections of this multi-part plan discuss general facility standards, contingency plans and emergency procedures, the shipping manifest system, container management, record keeping for the facility, and the facility closure plans.

The Operational Readiness Review (ORR) consisted of developing a detailed ORR checklist, which included the areas of administration, safety, emergency preparedness, nuclear materials management, facility preparation, and security. An internal ORR board was appointed to review all documentation, training, and all items in the ORR checklist for approval. After identifying and addressing issues and providing feedback until all items were satisfactorily completed, the ORR was approved by the ORR board and PNL management, with final approval given by the USDOE.

FACILITY MODIFICATIONS AND TRAINING

Several requirements or procedural modifications were necessary as a result of the Part A permit process and state code regulations. Facility modifications included the addition of shielded cell door locks and entry seals and the installation of spill kits, eyewash stations, and storage tank liquid level indicator probes. Other requirements involved identification of the process for generating operational procedures, supporting documentation, and change control procedures; laboratory staff training; and exploration of new approaches for cost and waste minimization.

Washington Administrative Code (WAC) regulations require that all treatment, storage, and disposal facilities employ tight physical security measures and access control to the facility. This will be accomplished in the SAL facility by use of cipher door locks. Ancillary doors will remain locked with seals attached to reveal unauthorized facility access or egress.

Safety improvements were made in the areas of industrial and radiological safety. Spill kits and eyewash stations were added at strategic locations throughout the facility. Liquid level indication devices in the form of conductance and capacitance probes were installed in facility's single 200 gallon waste storage tank located directly beneath the facility. The conductivity probes control tank jettison activities in both the automatic and manual modes. The capacitance probe provides liquid level indication. Both probes are equipped with audible high level alarms. Annunciator panels are located in the SAL operating gallery and on the Building Power Operator's control board. Radiological hardware upgrades included both cell differential air pressure alarms and the installation of a cell liquid leak detection system. Adequate radiological administrative controls were in place prior to TSD startup.

In-cell liquid waste containers require secondary containment. The shielded cells are not considered adequate secondary containment because uncharacterized spillage could conceivably drain into the facility's waste storage tank. Drained waste is not retrievable from the tank, but must be jettisoned, after meeting acceptance criteria, to the RLWS facility for storage and disposal. Therefore, in-cell secondary containment is required. The SAL is presently using one-gallon glass containers for in-cell storing of the waste and two-gallon plastic containers for secondary containment. These storage materials are compactable at the end of a container's useful life.

Several areas of extended or new training requirements were established, in addition to the existing training requirements, as outlined in Table I.

Table I: Laboratory Training

WASTE TREATMENT PROCESS AND OPERATING EXPERIENCE

RCRA-governed waste handled in the ACL and its associated SAL facility include RMW that is regulated as EPA-listed waste, characteristic waste, Washington State-only regulated waste, and miscellaneous mixed waste from nonspecific sources. The low-pH, high-chloride content and unknown organic content of much of the liquid waste prevents it from being accepted into the existing waste system because of stringent waste acceptance criteria at the final TSD facility operated by the Site Operations Contractor. These wastes are generated predominantly from analyses of radioactive samples obtained from the Tank Waste Characterization Program on the Hanford Site, with other minor waste sources contributing. The RMW from the PNL ACL can be categorized as originating from several possible basic sources, as shown in Table II.

Table II: Description of Typical Wastes and Sources

The SAL TSD will primarily treat wastes generated within specific PNL laboratories (ACL and SAL). Constituent data provided by the client, along with process knowledge and characterization information from the analyses, provides the information necessary to adequately treat, store, or dispose of waste in accordance with all applicable laws, rules, and/or regulations.

Waste material from the ACL or SAL will be classifiable to a reasonable degree of assurance because rigid quality control is maintained during the analytical procedures performed in the ACL. Before a waste material is accepted at the SAL, its chemical and physical characteristics must be identified by analytical and/or process information obtained from the generator in sufficient detail to allow proper regulatory designation of the material. This certified information will be reviewed by SAL technical staff for acceptability.

The current waste treatment process involves preliminary sampling, analysis, and treatment, followed by final sampling and analysis, and, if required, a final treatment. A summary of the waste analysis and treatment methods is shown in Table III. The preliminary sampling and analysis for total organic carbon and anions governs the preliminary treatment step. The preliminary treatment involves chloride reduction, by the addition of $AgNO_3$ precipitant, and pH adjustment, both based upon the preliminary analysis results.

Table III: Summary of Waste Analysis and Treatment Methods

The analytical methods used for the anion and cation analyses of the liquid portion of the waste are ion chromatography and ICP-AES. The radiochemical analyses for total alpha, beta, and gamma activity are performed on the liquid portion of the waste batch. Sample characterization data, sample process knowledge, and radionuclide loading calculations based on container dose rates are also used.

The selection of hazardous $AgNO_3$ precipitant was due to the relatively small quantities of liquid waste per year expected for treatment. The expected annual quantity of five 5-gallon batches of liquid waste for treatment would require about 3 kg $AgNO_3$ per batch or 15 kg of total precipitant, costing about $2K per year. This quantity of solid RMW is a routine disposal matter for this laboratory. Other laboratories that do not have routine procedures in place for disposal of such wastes may need to consider alternative approaches for chloride treatment. Much larger waste quantities of waste would force consideration of an alternative chloride reduction method, such as electrodeposition.

Waste treatment processes currently used include pH adjustment; precipitation from solutions, slurries, and sludges; filtration from liquid matrices; ion exchange for selective removal of contaminants from waste solutions; and grouting. Processes that may eventually be utilized in the SAL could include waste concentration by evaporation; waste dissolution by pH adjustment; molten salt fusion with, perhaps, sodium metaborate as a more rigorous dissolution technique for materials not readily dissolved by pH adjustment; solvent extraction; solids washing for separation of contaminants from sludges; chemical oxidation in solution, such as wet oxidation; and electrolytic treatment processes for materials not readily dissolvable by other methods.

Several lots of RMW were combined and successfully treated during January through August of 1992. These wastes were generated during the full analytical characterization of four Hanford Single Shell Tank cores and the partial characterization of three other cores. The total waste generated was seven gallons of liquid high-level radioactive mixed waste and an equivalent volume of solid mixed waste. Five of the seven gallons of liquid waste have been successfully batch-processed and disposed of through the site's RLWS to the final disposal facility. The labor involved for the total treatment, including analytical support, was approximately 80 man-hours.

The maximum combined liquid waste volume that can be treated effectively using master-slave manipulators and limited cell space was set by prior knowledge at five gallons. All of the solid high-level waste generated to date still remains in the SAL. The solid waste is packaged in 5-quart cans with compression lids and labels identifying the contained hazardous components.

The SAL management is presently designing the method, cask, and hardware for removal of the solid waste containers from the cells.

CONCLUSIONS AND RECOMMENDATIONS

A treatment, storage, and disposal facility for high-level nuclear waste has been successfully created at the Analytical Chemistry Laboratory at PNL in Richland, Washington. This facility has effectively treated RCRA waste generated during chemical and radiological laboratory analysis. The waste treatment process was specifically designed to treat a low-pH, high-chloride, high-gamma activity waste stream. The creation of the TSD required a six-month permit modification process resulting in state and federal regulatory approval.

A summary of lessons learned during the permit acquisition process would be of benefit to other laboratories requiring on-site treatment of a wide variety of RCRA or CERCLA radioactive mixed wastes. Recommendations for the key areas in the permit acquisition process are shown in Table IV.

Table IV: Recommendations for Key Areas in the Permit Acquisition Process

The creation of a new waste treatment, storage and disposal facility within an existing laboratory originally designed for different purposes requires careful merging of both operations to ensure that all regulatory requirements are met. A benefit of this approach is that many of the needed structural components, operational capabilities and procedural requirements are already in place.

The specific waste treatment plan and required analytical support is driven by the makeup of the waste and the acceptance criteria of the final disposal facility. A preliminary sampling and analysis of the batched waste allows an initial treatment and, if required, a final analysis and treatment.

The USDOE waste treatment, storage and disposal permit acquisition process requires close cooperation between the laboratory's operations and waste management personnel and the USDOE Field Office. A well-defined and detailed project management plan, operational readiness plan and compliance notebook will help assure a smooth transition from the initiation of the permit process, through to the TSD operation.

Table I: Laboratory Training

Previously Established Training	Extended or New Training
Analytical Chemistry Procedures	State and Federal Regulations
Standard Operating Procedures	Waste Designation
Criticality Safety	Hazardous Site Worker
Emergency Preparedness	Administrative Procedures for Waste Collection, Storage and Disposal
Special Nuclear Material	Analytical Procedures for Waste Treatment
Waste Management	Operational Procedures for Newly Acquired Systems or Systems Modifications
Worker Right-To-Know	
Hazardous Material Shipping	

Table II: Description of Typical Wastes and Sources

Typical Mixed Hazardous Wastes	Main Sources
Hazardous mixed waste resulting from analyses of radioactive samples	PNL Laboratories, Hanford Tank Farms
Hazardous mixed waste from discarded commercial chemical products	PNL Laboratories, Offsite Generators
Hazardous mixed waste from chemicals synthesized or created in research laboratories	PNL Laboratories, Tank Characterization Simulants
Hazardous mixed waste from research using radioactive isotopes	PNL Laboratories, Multi-Isotope Production Programs
Hazardous mixed waste from nonspecific sources	PNL Laboratories, Lab Solvents

Table III: Summary of Waste Analysis and Treatment Methods

Treatment Process Step	Analysis or Treatment Method
Preliminary Analysis of Waste	• Total Organic Carbon Analysis • Anion Analysis by Ion Chromatography
Preliminary Treatment of Waste	• Cl^- Reduction by Ag Precipitation Treatment • pH Adjustment Treatment • Filtration Treatment for Separation of Liquids-Solids
Final Analysis of Waste	• Anion Analysis by Ion Chromatography • Cation Analysis by ICP-AES • Radiochemical Analyses for total α, β^-, gamma
Final Treatment of Waste (if required)	• Ion Exchange Treatment • Precipitation Methods Treatment

Table IV: Recommendations for Key Areas in the Permit Acquisition Process

Activity	Recommendations
Development of a Project Management Plan	Plan should be initially well-defined and well-detailed, setting responsibilities, limiting scope, and identifying funding sources.
Development of an Operational Readiness Plan	Plan should be initially comprehensive enough to minimize later changes. A detailed, comprehensive checklist for tracking progress worked well. Involvement of the DOE Site Representative early in the process is a necessity.
Creation of the Compliance Notebook	Other notebooks are available for guidance in content and form. The limited scope approach set boundaries and made the process manageable. The notebook ensured adequate communication for change control.
Modification of Existing Part "A" Permit	The regulatory process was well-structured and well-defined. Thorough understanding of requirements at start of project is a help.
Implementation of the Operational Readiness Plan	The team approach, initiated with the correct number of involved staff from the various company departments, is highly recommended.
Performance of the Operational Readiness Reviews	The participants were involved early in the process. The detailed Operational Readiness Plan enhanced the ORR board's effectiveness and ensured a comprehensive review.

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DATE FILMED

7/27/93