Example of a Risk-Based Disposal Approval: Solidification of Hanford Site Transuranic Waste - 8180

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ABSTRACT

The Hanford Site requested, and the U.S. Environmental Protection Agency (EPA) Region 10 approved, a *Toxic Substances Control Act of 1976* (TSCA) risk-based disposal approval (RBDA) for solidifying approximately four cubic meters of waste from a specific area of one of the K East Basin: the North Loadout Pit (NLOP). The NLOP waste is a highly radioactive sludge that contained polychlorinated biphenyls (PCBs) regulated under TSCA. The prescribed disposal method for liquid PCB waste under TSCA regulations is either thermal treatment or decontamination. Due to the radioactive nature of the waste, however, neither thermal treatment nor decontamination was a viable option. As a result, the proposed treatment consisted of solidifying the material to comply with waste acceptance criteria at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, or possibly the Environmental Restoration Disposal Facility at the Hanford Site, depending on the resulting transuranic (TRU) content of the stabilized waste. The RBDA evaluated environmental risks associated with potential airborne PCBs. In addition, the RBDA made use of waste management controls already in place at the treatment unit. The treatment unit, the T Plant Complex, is a *Resource Conservation and Recovery Act of 1976* (RCRA)-permitted facility used for storing and treating radioactive waste. The EPA found that the proposed activities did not pose an unreasonable risk to human health or the environment. Treatment took place from October 26, 2005 to June 9, 2006, and 332 208-liter (55-gallon) containers of solidified waste were produced. All treated drums assayed to date are TRU and will be disposed at WIPP.

INTRODUCTION

Coordinating early with regulators from the U.S. Environmental Protection Agency (EPA) led to timely document development [1] and approval of a risk-based disposal approval (RBDA) [2] for treating radioactive sludge from Hanford's K East Reactor Basin. EPA reviewed the draft document during preparation and provided insightful comments and suggestions, which allowed submittal of a final document that had a good chance of being approved quickly.

The U.S. Department of Energy (DOE), Richland Operations Office (RL) needed to solidify transuranic (TRU) sludge and associated free-standing water from the K Basins to meet the Waste Isolation Pilot Plant's (WIPP) disposal requirements, as well as any intervening storage requirements. Solidification is the preferred treatment for this radioactive waste to render it into a waste form that poses less risk. However, the waste also contained concentrations of polychlorinated biphenyls (PCBs) regulated under the *Toxic Substances Control Act of 1976* (TSCA). TSCA regulations state that "No person may process liquid PCBs into non-liquid forms to circumvent the high temperature incineration requirements of 761.60(a)." [40 Code of Federal Regulations (CFR) 761.50(a)(2)]. The prescribed disposal method for liquid and/or multiphasic (liquid and nonliquid) PCB waste is either thermal treatment (e.g., incineration) or decontamination. However, due to the radioactive components of the waste, thermal treatment and decontamination are not suitable options from a human-health and environmental- risk perspective. Without solidification, the waste would need to be placed into long-term storage at the Hanford Site since there currently is no viable disposal path.

EPA guidance [3] states: "Section 761.50(a)(2) prohibits the processing of liquid PCBs into nonliquid forms to circumvent the high-temperature incineration requirements of §761.60(a). If you would like to stabilize the sludge or solidify the sludge at a chemical waste landfill, you must obtain a 40 CFR 761.61(c) approval from the EPA Region." Therefore, an RBDA was requested from EPA Region 10.

K Basins' History

During the cold-war era, spent fuel basins – large pools of water (often more than a million gallons each) – were associated with each of the operating reactors on the Hanford Site. The basins allowed spent fuel to undergo a period of radioactive decay, after which, the fuel was chemically dissolved and reprocessed to separate out the plutonium. Specifically of note, the North and South Loadout Pit areas were used for loading buckets containing the irradiated elements into railroad cask cars for shipment to reprocessing facilities. Loading and shipping the irradiated fuel from the Loadout Pits was a routine operation.

During the 1960s and early 1970, most of the reactors at Hanford were shut down. As each reactor closed between 1964 and 1970, its spent fuel basin also closed. In 1972, the last radiochemical-processing plant at the Hanford Site, the PUREX (plutonium-uranium extraction) Plant entered a long shutdown period. The N Reactor, because of its dual-purpose design, was kept operational to support Pacific Northwest electrical power needs, and as result, it continued to produce spent fuel. The fuel-storage basin for the N Reactor was not sized to support the resultant fuel inventories. In 1975, the decision was made to use the K Reactors spent fuel basins to accommodate the need for additional storage of N Reactor spent fuel. As time passed, some of the fuel corroded, resulting in releases of radionuclides to the basins' water, sludge, and structure. Therefore, a cleanup of the K Basins wastes was initiated.

The sludge found in the K East Basin and the associated North Loadout Pit (NLOP) was predominantly non-radioactive material (e.g., sand, silt, debris), fission products, and TRU isotopes that had accumulated over the course of decades of storage under water. The N Reactor fuel stored in the K East Basin caused the existing sludge to become contaminated with fission products and with TRU elements (atomic numbers higher than 92). Fission products – especially cesium, strontium, and their daughter products – are significant contributors to the sludge's radioactivity. The TRU elements, particularly Am-241, also are a major contributor to the radiological makeup of the sludge. Uranium and activation products are present in smaller quantities. About 30% of the radioactivity in curies in the sludge is derived from Pu-241, the parent for Am-241, a TRU isotope. As a result, the K Basin sludge meets the definition of TRU waste.

In evaluating the waste contained in the K Basins, DOE has applied the definition of TRU waste from the WIPP *Land Withdrawal Act of 1992* (LWA), as amended, and the definition of high-level waste (HLW) and spent nuclear fuel (SNF) from the *Nuclear Waste Policy Act of 1982* (NWPA), as amended. If properly processed, the NLOP sludge will meet the disposal requirements for TRU waste and thus be eligible for disposal at WIPP.

Basin Location and Description

The K Basins are located on the Hanford Site in southeastern Washington State, in the northern part of the DOE 100 Area, within 120 meters (400 feet) of the Columbia River.

The rectangular concrete basins are open pools approximately 38 meters (125 feet) long and 20 meters (67 feet) wide and adjacent to the reactor buildings (Figure 1). During spent fuel storage operation the basins, which are about 6.4 meter (21 feet) deep, were filled with approximately 4.9 million liters (1.3 million gallons) of water to a depth of approximately 4.9 meters (16 feet). This water provided radioactive shielding and also cooled the spent fuel rods.

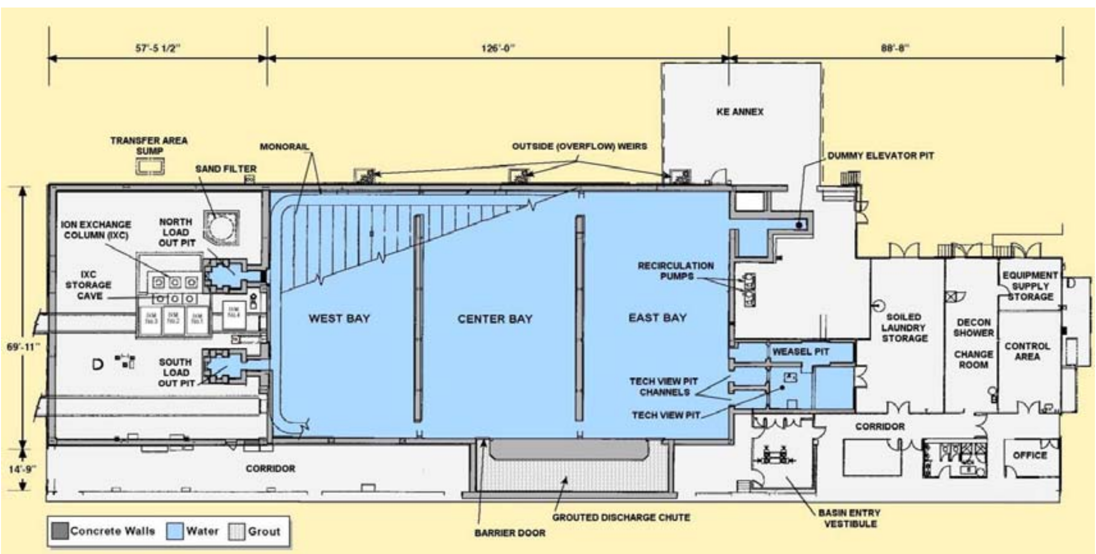

Fig. 1. This schematic shows the layout of the K East Basin.

Waste Retrieval Background

Approximately four cubic meters of sludge (equivalent to about 20 208-liter drums) were retrieved from the NLOP. Because the pit was most recently used to hold backwashed sand from the basin's water-filtration system, the sludge from this area was less radioactive than the sludge in the rest of the basin and, therefore, was identified for earlier treatment. The sludge was pumped into large containers. Fluor Hanford crews transported the containers to Hanford's T Plant Complex, where specialized equipment was used to process the material into a stabilized form.

Proposed Treatment Process

This material will be transferred as a slurry from the K Basin to the T Plant Complex using a large-diameter container (LDC) and treated using a Sludge Grouting System. The T Plant Complex is a RCRA-permitted treatment and storage facility. The Sludge Grouting System's function is to process the NLOP sludge waste for ultimate packaging in 208-liter drums with a cement grout. The process involves transferring the sludge from the LDC as a diluted slurry to a 1,140-liter buffer tank, agitate the mixture to a consistent suspended solids fraction and transfer the material to 208-liter drums, add grout formers, and mix to the prepared grout. The grout addition and mixing operation are designed to eliminate free-water in the cured grout matrix.

Polychlorinated Biphenyls

PCBs have been detected in the K East Basin's sludge in several sampling events. The nominal volume of the as-settled NLOP sludge is 6.30 cubic meters. The average water content is 87% by volume. The nominal PCB concentration is 9.41×10^{-5} g/cm^3 on a settled solids basis. Therefore, the calculated nominal dry weight analysis is 240 parts per million (ppm) PCB, which exceeds the regulatory threshold of 50 ppm. Therefore, the NLOP sludge is TSCA-regulated waste.

The most likely source of the PCBs in the basins came from maintenance activities conducted before the N Reactor fuel was stored in the basins. No PCB-containing equipment or material has been knowingly added to the basins during the N Reactor fuel storage. In addition, no PCB contamination was detected in the K West Basin. It is assumed that the PCBs came to be present in the sludge as a result of a spill or release of material containing PCBs at an unknown concentration. Based on this information, the sludge is assumed to meet the definition of a PCB-remediation waste.[1]

The NLOP waste is a multiphasic waste as described in the TSCA regulations at 40 CFR 761.1(b)(4); it has both a solid and a liquid phase. EPA guidance explains that when disposing of multiphasic waste, both phases shall be managed for disposal in a manner that assumes both phases contain PCBs. For example, even though PCBs had not been found in the liquid phase of the sludge using test methods with a detection limit of 0.5 parts per billion (ppb),

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[1] 40 CFR 761.3 of the TSCA regulations defines PCB remediation waste as "waste containing PCBs as a result of a spill, release, or other unauthorized disposal, at the following concentrations: Materials disposed of prior to April 18, 1978, that are currently at concentrations of ≥50 ppm PCBs, regardless of the concentration of the original spill; materials which are currently at any volume or concentration where the original source was ≥500 ppm PCB beginning on April 18, 1978, or ≥50 ppm beginning on July 2, 1979; and materials which are currently at any concentration if the PCBs are from a source not authorized for use under this part. PCB remediation waste means soil, rags, and any other debris generated as a result of any PCB spill cleanup, including but not limited to: (1) Environmental media containing PCBs, such as soil and gravel; dredged materials, such as sediments, settled sediment fines, and aqueous decantate from sediment; (2) Sewage sludge containing ≥50 ppm PCBs and not in use according to 761.20(a)(4); PCB sewage sludge; commercial or industrial sludge contaminated as a result of a spill of PCBs including sludges located in or removed from any pollution control device; aqueous decantate from an industrial sludge; (3) Buildings and other man-made structures, such as concrete or wood floors or walls contaminated from a leaking PCB or PCB-Contaminated transformer, porous surfaces and non porous surfaces."

the liquid phase is still treated as if it contains PCBs, unless it is physically separated from the non-liquid phase. The prescribed disposal method for liquid PCB remediation waste is thermal treatment or decontamination.

Issue

The solidification of K Basin sludge is addressed as part of a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) activity. However, because CERCLA documentation does not extend to treatment at an off-site facility such as the T Plant Complex, an independent record and decision under TSCA authority was required.

The CERCLA record of decision (ROD), among other actions, directed that the sludge be removed from the two K Basins and placed in interim storage. The ROD also required the sludge to be treated and packaged to meet the waste-acceptance criteria for disposal at a national repository or other suitable location before interim storage. The ROD eliminated long-term storage of untreated sludge, required sludge be treated for disposal via stabilization to remove free liquids, and required that the treated sludge be delivered to a national repository.

Description of Treatment Process

When the LDC was first placed on the floor of the T Plant canyon for treatment (Figure 2), the LDC was placed in an overpack and shielding was used to keep worker exposure as low as reasonably achievable (ALARA). The sludge was fluidized with water within the LDC and then transferred to the grouting system buffer tank (Figure 3) utilizing a suction wand to vacuum/transfer the slurry. A camera was used to verify the removal of sludge from an LDC. The design incorporated gamma dose measurements of the sludge at the buffer tank using an in-line gamma monitor mounted on the system. The amount of sludge added to each drum (which had been preloaded with the dry grout mixture) was determined based on a correlation between the gamma monitor reading and the volume of sludge so that, when grouted, the treated sludge would meet a contact dose rate of $\leq$200 mrem/hr.

Fig. 2. A system for treating the NLOP sludge was set up in T Plant.

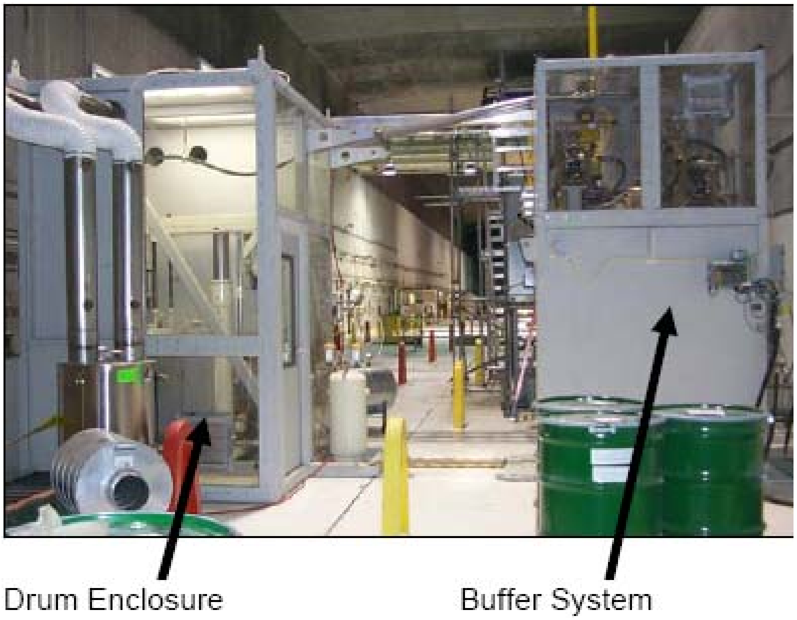

Fig. 3. The treatment system had several components (alternate view).

Enclosures to shield workers from radiation were used during sludge grout processing. Further, all exterior surfaces of the drums were covered with plastic to prevent the drums and shielding from becoming contaminated. The plastic did not interfere with the visual examination of the drums during filling and mixing operations. The drums were then lifted onto the drum conveyor system for transport to the enclosure (Figure 3).

Once in the enclosure, the drum was transferred along the conveyor to a grout-blending station. A grout mixer was lowered onto the drum and a cover plate used to seal the drum to prevent sludge from splashing out. Water was added to the sludge and the mixture blended with a disposable agitator. The drum was conveyed to an area where a vented lid was attached. The drum was then transferred out of the glovebag enclosure and a filter installed into the port on top of the drum. The container was then radiologically surveyed and set on a pallet for curing/storage prior to transfer.

Risk-Based Disposal Approval Elements

The RBDA evaluated environmental risks associated with potential airborne PCBs. The purpose of the RBDA was to demonstrate and document that the activities associated with solidifying the waste would not result in unreasonable risk or exposure to human health and the environment. Satisfying these requirements was a two-step process: first, a risk-assessment was performed to show that any airborne PCBs were well within acceptable limits, and second, that the engineered and administrative controls in place at the T Plant Complex as the sludge was being processed minimized the probability of releases of waste to the environment.

The risk-assessment calculation showed that volatilization of PCBs would be insignificant. For simplicity, a comparison was made with a previously approved risk assessment [4].

Aroclor 1254[2] was assumed for the calculations. The risk assessment for the 200 Area Liquid Waste Processing Facilities took into account the location and the variety of potential receptions sufficiently similar to this process to allow a direct comparison.

The risk assessment developed using the calculated maximum total PCB in each grouted container which, based on total PCBs in the sludge and estimated number of final grouted drums, is 1.3 grams. Only PCBs in the aqueous phase are able to volatilize into the atmosphere. PCBs preferentially partition into solid and organic phases over aqueous; therefore, the amount of PCBs available in the aqueous phase is far lower than the total PCB in the container. Assuming all PCBs are due to Aroclor 1254, the concentration of PCBs in the aqueous phase was calculated as 1.84×10^{-4} mg/L. Because concrete generates heat during hydration (the chemical process by which cement reacts with water to form a hard stable material), the partial pressure of PCBs at this higher temperature was calculated. A 20°C temperature increase is assumed for the curing process, giving a maximum temperature of approximately 45°C. The PCB evaporation rate was estimated from the partial pressure. For the first hour of curing, the drum is assumed to be open (surface is 57 centimeters diameter), which gives an evaporation rate of 1.4×10^{-8} g/s. After the first hour, the drum is capped with a NucFil[3] filter that allows an opening with a diameter of about 0.6 centimeter. With the smaller opening, the evaporation rate calculates to 1.7×10^{-12}g/s.

The PCB evaporation rate previously approved for the 242-A Evaporator [5], is 2.1×10^{-3} g/s. The higher evaporation rate of 1.4×10^{-8} g/s, for the open-top, curing process is 0.00067 % of that for the approved 242-A Evaporator. Therefore, it was concluded that the risk due to evaporation of PCBs during the treatment process was insignificant.

In addition, the RBDA used controls already in place at the treatment unit, the T Plant Complex, Engineered and administrative controls such as secondary containment, leak detection, training, and job-hazard analyses were in place at the T Plant to minimize the probability of releases of waste to the environment as the sludge from the during NLOP was being processed. Releases of liquid and solid materials would be confined within the secondary containment and would be detected and managed as discussed for leaks.

Based on the system's configuration, the air pathway was not considered viable due to controls in place. The T Plant's confinement system includes ventilation, filtration, exhaust fans, continuous monitoring, and a stack. To minimize the possibility of airborne contamination spreading, the canyon's ventilation exhaust fans maintain a negative differential pressure relative to that of the outside atmosphere. The air in the ventilation tunnel is drawn through the canyon ventilation exhaust system. The system consists of four high-efficiency particulate air (HEPA) filter banks. Each bank contains a prefilter, a primary HEPA filter, and a secondary HEPA filter. After HEPA filtration, there is a continuous monitoring system for radioactive constituents and final ventilation discharges to the 291-T stack.

The NLOP Sludge Grouting System has additional ventilation controls. The LDC, the transfer pump containment, the buffer-tank containment, and the grout-mixer enclosure are connected to

[2] Aroclor is a trade name of Monsanto.
[3] Nucfil® is a registered trademark of Nuclear Filter Technology, Inc., Lakewood, Colorado.

portable HEPA exhausters that maintain a negative differential pressure. This system is designed to maintain a minimum of 38 meters per minute air velocity at any opening from the containment structures during normal operating conditions. Back flow dampers are equipped on the grout mixing enclosure, the transfer pump containment, and the buffer tank containment to allow air flow to enter the enclosures, but to close if other air flow paths become available.

Additional EPA Concerns

EPA expressed some specific concerns with regard to the activities described in the RBDA and the ability of EPA to completely evaluate the process. Important issues that needed to be resolved with EPA included the following:

- TSCA does not provide criteria for either designing or closing a treatment process
- Possible generation of waste that does not have a path forward
- Robustness of Secondary Containment/Leak detection
- Scope of the RBDA
- Technical engineering information to demonstrate that compliance with conditions is possible.

As the authors worked closely with EPA in drafting the RBDA, several of these issues were resolved and incorporated directly into the application. For those that were not, EPA established conditions for the RBDA activities. On occasion, EPA borrowed from other regulations to provide criteria by which to evaluate the activities and information provided in the RBDA.
For design of the treatment process, EPA borrowed tank standards from RCRA, specifying in the approval conditions that the treatment system used for activities covered by the approval shall be designed and operated according to the technical standards of 40 CFR 265.192 through 265.196. Air emissions were referenced to the state's Radioactvie Air Emissions Notice of Construction Approval.

EPA also expressed concern about generating radioactive wastes without a designated path forward for disposal. This included both the grouted K Basin waste and the treatment system itself. Therefore, EPA required that the treatment system be decontaminated within a specified time period after use. This condition gave DOE the flexibility to propose a method of decontamination and to propose additional uses of the equipment. However, EPA ensured that it would be able to verify that periods of inactivity were not inappropriately applied in lieu of decontamination. In order to ensure that no grouted wastes were generated without a specific disposal option, EPA required that the RBDA verify that the possible candidate disposal units had the capability to accept the waste.

Important Considerations Not Initially Addressed in the RBDA

Determining and documenting the scope of the RBDA was important. This included the waste to be treated, as well as the spatial and temporal boundaries of the RBDA. Whenever possible, storage of waste was kept outside the scope of the RBDA to allow storage according to standard TSCA regulations or by other agreements. It was important to specify activities that would definitely be outside the scope of the RBDA. The wastes to be treated were described in sufficient detail to allow the EPA to evaluate the risks to human health and the environment. All waste that was expected to be treated in this manner needed to be included in the RBDA, or an amendment would be required to allow EPA to complete an evaluation. In addition to the K Basin sludge, treatment of the sand from the sand filter sand and the LDCs were included in the scope of the RBDA.

Secondary containment and leak detection were described in the application. A remote electronic leak-detection system was employed. However, it was noted after approval of the RBDA, that during extended periods of non-activity between approved campaigns maintaining the remote sensing equipment was unduly burdensome. An amendment to the RBDA was required to allow visual leak detection to be used during these periods.

In addition, technical specifications and diagrams were provided to EPA for evaluation prior to approval of the RBDA.

Recommendations

The most important factor in gaining a quick approval from EPA was to involve regulators early in the application-development process. EPA was allowed to view and comment on the draft application and their comments were addressed as fully as possible as early as possible. Design information was provided to EPA to help visualize the equipment prior to set up. In addition, and fortunately, a mock-up of the treatment process system was available for touring before it was installed within a radiation zone. This availability gave the workers and the regulators the opportunity to use and view the equipment and understand the associated safety measures.

Conclusion

The RBDA was approved in two months from the time it was submitted. Waste treatment began on October 26, 2005 and all the NLOP sludge had been processed by June 9, 2006. Currently 332 208-liter containers are awaiting shipment to WIPP. At present the treatment equipment is in stand-by mode waiting to treat the sand from the sand filter.

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