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# FIRST STABILIZATION AND DISPOSAL OF RADIOACTIVE ZINC BROMIDE MATERIAL AT THE SAVANNAH RIVER SITE

James K. Denny, BWXT Savannah River Company
Christine A. Langton, Westinghouse Savannah River Company
Gary M. Iversen, Westinghouse Savannah River Company

## ABSTRACT

Facilities Disposition Projects (FDP) personnel at Savannah River Site (SRS) implement the Inactive Facility Risk Management Program to drive down risk and costs in SRS inactive facilities. The program includes cost-effective techniques to identify and dispose of hazardous chemicals and radioactive waste from inactive facilities, thereby ensuring adequate protection of the public, workers and the environment.

In June 1998, FDP conducted an assessment of the inactive C-Reactor Facility to assure that chemical and radiological hazards had been identified and were being safely managed. The walkdown identified the need to mitigate a significant hazard associated with storing approximately 13,400 gallons of liquid radioactive Zinc Bromide in three aging railcar tankers outside of the facility (see Figure 1). No preventive maintenance was being performed on the rusting tankers and a leak could send radioactive Zinc Bromide into an outfall and offsite to the Savannah River. In 2001, DOE-Savannah River (DOE-SR) funded the FDP to eliminate the identified hazard by disposing of the radioactive Zinc Bromide solution and the three contaminated railcar tankers. This paper describes the innovative, cost-effective approaches and technology used to perform the first stabilization and disposal of radioactive Zinc Bromide at SRS.

Figure 1. Aging Railcar Tankers outside of C-Reactor Facility (June 1998)

## INTRODUCTION

The 13,400 gallons of neutralized radioactive Zinc Bromide stored in the three railcar tankers had been used in the shielded cell windows of the different reactors at SRS for neutron and gamma attenuation during reactor operations. The Zinc Bromide solution was removed from the shielded observation windows in the early 1990s as part of deactivation activities of the different reactors and eventually pumped into the railcars for long-term storage outside of the C-Reactor Facility. The solution was characterized as non-hazardous, low-level radioactive waste (LLW), containing 23.7 Curies of activity (primarily from Tritium).

The fifty-five year old railcar tankers and undercarriages were inspected and determined to be excessed (i.e., unsafe for further transportation use due to severe rust damage). The manufacturer of the Zinc Bromide was contacted and was not interested in re-using the contaminated solution. Estimates for materials and labor were determined to be cost prohibitive to support transferring the 13,400 gallons of solution from the tankers into waste drums, then transporting the drums from C-Area to a suitable waste processing facility. This traditional waste disposal approach would still leave the high costs of disposing of the three, empty contaminated railcar tankers. Therefore, in keeping with SRS waste minimization and cost-effectiveness efforts, FDP teamed with Savannah River Technology Center (SRTC) personnel to pursue the innovative strategy of performing the first stabilization and disposal of radioactive Zinc Bromide at SRS. The goal of the project was to successfully stabilize the 13,400 gallons of aqueous radioactive Zinc Bromide solution in-situ at the C-Reactor Facility using the three railcar tankers as the containers for direct disposal into the onsite burial trenches.

## INNOVATIVE DISPOSAL APPROACHES AND TREATMENT TECHNOLOGY

Extensive Nondestructive Evaluations (NDE) of the interior and exterior surfaces of the three railcar tankers determined that they could meet the requirements for use as “strong tight” disposal containers. However, wall thinning from rusting had reduced the safe allowable filling and lifting weight capacity of each tanker to a maximum of 80,000 lbs. Direct disposal of the railcar tankers into the trenches also required that any void space inside the tankers be minimized to less than 10 percent. FDP Engineering performed a mass balance verifying that the entire volume of 13,400 gallons of aqueous radioactive Zinc Bromide and the required 15,000 pounds of organic absorbent could successfully be mixed and stabilized together inside the three tankers, and still meet the weight and void space restrictions.

Transportation personnel determined that the extensive rusting and pitting of the railcar frames and wheels made them unsafe to support the weight needed to transport the tankers filled with stabilized waste from C-Area to the onsite disposal area. Therefore, each railcar tanker had to be emptied of aqueous Zinc Bromide into a holding tank previously used for storage of the Zinc Bromide, cut loose from the frame and wheels, carefully lifted unto a flatbed truck, and secured on specially designed wooden cribbing supports (see Figure 2). The railcar tankers, secured on top of the flatbed trucks, were then filled with absorbent and mixed one at a time with aqueous Zinc Bromide solution from the adjacent holding tank. The railcar tankers (filled 90 percent with solidified stabilized radioactive Zinc Bromide and associated job control waste) were immediately transported to the onsite burial grounds for disposal into the LLW trenches. The frames and wheels from each of the railcars were later transported on flatbed trucks in separate shipments for a similar disposal as LLW into the trenches.

Figure 2. Railcar Tankers lifted from frames onto flatbed trucks

SRTC personnel contacted commercial vendors and other DOE sites to determine treatment options for the radioactive Zinc Bromide solution. Portland cement technology was considered and tested to verify it met the treatment requirements. However, the reduced weight restrictions on the tankers led SRTC to conduct feasibility testing of treating the radioactive Zinc Bromide solution by light-weight organic absorbents to minimize weight and stresses on the aging tankers. Organic absorbents are reasonably priced, provide adequate solidification rates, and would not require extensive mixing. The study determined that solidification of the low level radioactive Zinc Bromide solution with organic polymers appeared to be an acceptable treatment for converting the non-hazardous aqueous waste into a solid form suitable to meet regulatory and SRS requirements for direct disposal onsite in the SRS Low-Level trenches.

Various commercially available aqueous absorbents were tested with water. The initial mixtures were prepared in different ways:

1. water added to the absorbent
2. absorbent added to the water
3. water added to the absorbent plus mixing
4. sodium chloride solution (2 weight percent) added to the water

In general, each of the absorbents performed according to the vendor claims for solidifying aqueous media (converting water to a solid form). However, at the higher waste loadings some of the absorbents produced waste forms that were wet gels with free water rather than completely a solid. More importantly, only a few of the absorbents were able to achieve the desired waste loading in the dilute salt solutions (i.e., absorbents showed a significant reduction in the absorption capacity when mixed with sodium chloride rather than water).

The most promising absorbents were then tested using actual radioactive Zinc Bromide solution samples taken from the railcars to determine the relationships between polymer performance, pH, and ionic strengths. The products were evaluated for the presence of free liquid, rate of absorption, the appearance of granular versus gel and opaque versus clear (see Figure 3). The two absorbents with best waste form processing and final properties, AquaSorbe 2212 and Water Works SP400, were selected for scale-up testing to determine the specific absorbent and waste loading ratios needed to perform the first stabilization of radioactive Zinc Bromide at SRS.


Figure 3. SRTC Absorbent Testing

The scale-up testing was performed using numerous dispersion and waste loading scenarios to select the absorbent most attractive for use in the solidification and disposal of the radioactive Zinc Bromide. AquaSorbe 2212 brand material at a one to ten ratio waste loading was recommended for use in this stabilization project because its coarser grain reacts somewhat slower with the Zinc Bromide solution and facilitated a more uniform waste form absorbent (i.e., meeting waste disposal requirements of no free liquids). The testing also determined that the liquid Zinc Bromide solution must be added within the absorbent bed rather than onto the bed to allow the liquid a greater opportunity to disperse and contact more of the absorbent.  Failure to distribute the liquid evenly within the absorbent bed would result in pockets of unreacted dry absorbent.  The testing identified approximately a

10 percent expansion of the absorbed bed, which was included in the mass balance calculation.

## STABILIZATION AND DISPOSAL ACTIONS

FDP operators pumped the radioactive Zinc Bromide solution from the three railcar tankers into an adjacent 20,000-gallon holding tank. The empty tankers were then cut loose from the railcar undercarriages and carefully lifted by large cranes unto flatbed trucks equipped with specially designed wooden cribbing. Because characterization of paint chips from the exterior of the railcars determined that the paint coatings contained polychlorinated biphenyls (PCBs) and lead above the Toxic Substance Control Act (TSCA) limits, special precautions and protective equipment were required to protect workers while cutting the tankers loose from the undercarriages. The radioactive PCB waste generated during the cutting task was segregated from the normal job control waste and disposed per specific regulatory requirements. Continuous radiological and industrial hygiene monitoring was required during the cutting phase of the project.

Heavy equipment was used to lift and pour 5,000 pounds of AquaSorbe 2212 absorbent through the 24-inch manway openings in the top of each railcar. Specially designed plastic PVC funnels directed pouring of the absorbent into the far ends of the 30-foot long railcars. Flexible polyvinyl chloride (PVC) rakes were designed and used to finish spreading the absorbent into place along the length of the railcars. A video camera was lowered inside each railcar to verify that the absorbent was evenly distributed prior to adding the aqueous radioactive Zinc Bromide solution. Radiological surveys were performed on any material removed from inside the tankers, and the tanker manways were continuously monitored for tritium.

Twenty separate one-half inch PVC lines of varying lengths were lowered into the railcar and pushed into place within the absorbent bed along the length of the railcar. The fill lines were connected to a specially designed liquid pumping system providing the needed 30 gallons per minute (gpm) flow (at approximately 20 pounds per square inch, gauge (psig) from the hold tank into each railcar. Operators monitored the flow rate and total flow, and shut off the pump when the total flow reached approximately 4,600 gallons per tanker. Engineering visually evaluated the conditions in the railcars during mixing to ensure that no free liquids were present and SRS disposal requirements were satisfied (e.g., homogenous mix and minimum void space). All job control waste associated with this stabilization process, including the PVC fill lines and protective equipment, was inserted into the tankers to top off the remaining void space prior to disposal (see Figure 4). The manways were bolted shut and the tankers safely transported by trucks from C-Area to the SRS onsite burial grounds. Due to the high tritium levels, the tankers were required to be entombed with one foot of grout as part of the final disposal process (see Figure 5).

Figure 4. Stabilized Radioactive Zinc Bromide (August 2002)

Figure 5. Disposal of Railcar Tankers into the burial trenches (August 2002)

## DISCUSSION OF RESULTS

Solidification and stabilization of the low level radioactive Zinc Bromide solution with light weight organic polymers was an acceptable treatment method for converting this aqueous waste into a solid form suitable for disposal at the SRS burial trenches. The scale-up testing by SRTC provided the correct ratios and method for mixing the absorbent and aqueous Zinc Bromide in the railcars to meet all regulatory and SRS disposal requirements (e.g., no free liquids, homogeneous mixture, minimum void space).

FDP successfully disposed of the entire volume of 13,400 gallons of aqueous radioactive Zinc Bromide into the onsite burial trenches using the three excess railcar tankers as the disposal containers. Operators skillfully performed the project work without any injuries, spills to the environment, or radiological incidents. The stabilization and disposal project was completed by FDP on time (i.e., September 2002) and within budget (i.e., Total Project Cost at $452,000.).

## SUMMARY

The innovative waste disposal approaches and technology utilized by FDP and SRTC personnel to support the first successful stabilization and disposal of radioactive Zinc Bromide solution at SRS were successful and should be applied to ongoing risk reduction efforts at SRS inactive facilities. Use of the railcars as the disposal containers and in-situ processing supported waste minimization and cost-effectiveness efforts at SRS. Lessons learned from this project on cost-effective disposal of contaminated large equipment and in-situ stabilization of radioactive material can lead to reducing costs and risks for conducting deactivation at SRS inactive facilities.