APPLICATION OF A TWO-COMPONENT FOAM SYSTEM TO IMMOBILIZE RADIOACTIVE CONTAMINATION IN WASTE CONTAINERS

S.M. Westcott, J.M. Rizzo
West Valley Nuclear Services Company (WVNSCO)

A. Al-Daouk
U.S. Department of Energy (DOE)

ABSTRACT

During preparations for off-site disposal of aluminum canisters and racks from the spent fuel pool at the West Valley Demonstration Project (WVDP), it was discovered that the contact dose rates at the bottom of some of the canister boxes were increasing with time. Since some of the dose rates were already close to U.S. Department of Transportation (DOT) regulatory limits or limits established by the Nevada Test Site (NTS) waste acceptance criteria (WAC), it was determined that the dose rates had to be stabilized before the waste containers could be shipped from the WVDP.

An investigation determined that scale and residue that originally adhered to the canisters was drying and flaking off the internal walls of the canisters. The canisters have several flow holes that allowed the dried residue to escape from the canisters and sift to the bottom of the waste boxes. This created elevated contact dose rates at the bottom of the waste containers. Removing the canisters and repackaging the waste or adding internal shielding was ruled out for As Low As Reasonably Achievable (ALARA) reasons, as some of the canisters had dose rates of several hundred mR/hr. A solution was needed that would immobilize the contaminated residue without removing the contents of the containers.

The solution was the application of a two-component foam system. The foam was applied to the waste containers and filled to the middle of the top row of canisters. It was determined that this level would ensure that no loose contamination would escape from the canisters and accumulate on the bottom of the container. After the containers were foamed, the contact dose rates were checked, rechecked, and determined to be stabilized.

The WVDP is not the first DOE site to apply foam to stabilize waste in containers. The Rocky Flats Environmental Technology Site (RFETS) employs several foam systems for various applications. However, the primary application for foam at RFETS is to provide blocking, bracing, and stabilization of large debris in newly packaged waste. The application at the WVDP was initiated to stabilize contamination in previously packaged containers without removing the contents. The application proved successful. The foam stabilized the contamination in the containers with the lowest possible worker exposure. The stabilized canister boxes were safely shipped to NTS for disposal.

INTRODUCTION

The WVDP is located on the site that was the only commercial nuclear spent fuel reprocessing facility in the United States. Nuclear Fuel Services (NFS) operated the reprocessing facility from 1966 to 1972. The facility operated under a long-term lease with the Western New York Nuclear Service Center (WNYNSC), which is located approximately 30 miles south of Buffalo, NY. NFS suspended operations in 1972 to modify the facility and expand its reprocessing capacity. In 1976, NFS notified the New York State Energy Research and Development Authority (NYSERDA) that due to changes in regulations and economic conditions it would not complete the modifications and that the facility would discontinue operations. The facility remained in standby state until 1982. Approximately 600,000 gallons of high-level waste (HLW) liquid remained in carbon steel underground tanks. In 1980, Congress passed the West Valley Demonstration Act and directed the DOE to carry out a technology demonstration project for the safe solidification and cleanup of the HLW, and the facilities used during the cleanup. The Act also required the DOE to develop containers suitable for the permanent disposal of the solidified HLW and to transport them to an appropriate federal repository. In 1982, the DOE awarded a contract to West Valley Nuclear Services Company (WVNSCO) to perform the required operations. The vitrification of the HLW was successfully completed in September 2002.

In addition to the 600,000 gallons (2.3 million liters) of HLW in the underground tanks, there were 750 spent fuel assemblies stored in the fuel storage pool (FSP). A total of 625 of the spent fuel assemblies were returned to the original commercial generators. The DOE took ownership of the remaining 125 fuel assemblies and they remained in the pool until 2001. In the spring of 2001, the fuel assemblies were removed from the pool and placed into two dry storage and shipping casks. The casks were shipped to the Idaho National Engineering and Environmental Laboratory (INEEL) in the summer of 2003.

Fuel Storage Canisters and Racks

After the 125 fuel rods were removed from the pool, WVDP set out to prepare for the complete decontamination of the fuel storage pool. The first major task was to remove the remaining 149 fuel storage canisters and 11 rows of storage racks. Of the 149 canisters, 100 were approximately 12 feet (3.7 meters) in length and 49 were 16 feet (4.9 meters) long. All had a diameter of approximately 15 inches and were constructed of an aluminum alloy. The canisters were carefully placed into custom-made shipping boxes, four across by four rows high, and blocked in place with wooden cribbing. The number and dimensions of the canister shipping containers are listed in Table I.

Table I

Number of Containers	Container Dimensions
6	7' (W) x 7'(H) x 12'6" (L) (2 x 2 x 3.8 meters)
4	7' (W) x 7'(H) x 16'6" (L) (2 x 2 x 5 meters)
1	5'6" (W) x 2' (H) x 16'6" (L) (1.7 x 0.61 x 5 meters)

Fuel Storage Canister Removal and Decontamination

Planning for the canister removal project began in the summer of 2001 and continued for several months due to the potential radiation exposure to the personnel conducting the removal operation. It was anticipated that some of the canisters dose rates would be equal to or greater than 450 mR/hr. To minimize dose rates, the canisters were subjected to high-pressure wash while still in the pool. They were then lifted vertically out of the pool and allowed to stand for a brief time to drain as much water as possible. The canisters were tipped horizontally and moved to the shipping containers, where they were sprayed with a fixative and placed into wood cribbing in the shipping containers. This canister removal and decontamination project was operational for approximately one month and the last canister was placed in a shipping container on December 20, 2001. Contact dose rates of the containers were obtained and reported to Waste Characterization Services, along with the container data sheets. The containers were then placed into storage awaiting off-site shipment for disposal.

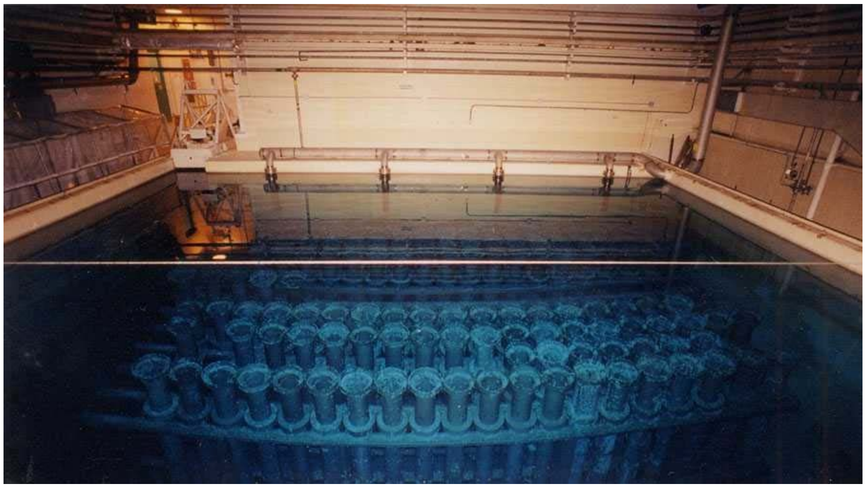

Fig. 1. Spent Fuel Canisters and Racks.

Increasing Dose Rates

In August of 2002, the WVDP began preparations to ship the FRS canisters and racks to NTS for disposal. The shipping containers were moved from their original storage areas for final package inspections and 1 meter dose rates. Radiation Protection (RP) technicians typically obtain new contact dose rates when requested to provide 1 meter dose rates. In the process of providing this information, it was discovered that several of the containers had contact dose rates greater than originally measured. Preliminary investigations ruled out the likelihood that the differences in dose rates were a result of personnel or equipment error. The only other explanation was that something was changing inside of the containers.

In September of 2002, one of the canister boxes, #SP-147, was taken into a containment area and opened for inspection. The contact dose rate on this container was 170 mR/hr. A video camera was carefully lowered into the container to observe the internal conditions. A WVNSCO operator gently tapped on some of the canisters, while a Radiation Protection supervisor measured the dose rates on the bottom of the box. The camera was able to record that dried residue and scale from inside of the canisters was sifting out of the flow holes and accumulating on the bottom of the box. The RP supervisor acknowledged a significant increase in the contact dose rate. It was also observed that dose rates declined as the accumulation of residue and scale were spread around the bottom of the box. The accumulation of the dried residue was an unexpected event because during previous decontamination efforts with the canisters, residues that could not be removed from the canisters using high-pressure water spray remained intact on the canisters.

The addition of external shielding was ruled out because even a small amount of residue and scale accumulation could cause a significant increase in the contact and 1-meter dose measurements. Without the ability to predict the potential dose increase while in transport between Western New York and NTS, it was not possible to predict the amount of shielding required to ensure that dose limits were not reached or exceeded. With this information, it was determined that the only solution to control the dose rates on the containers was to stabilize the source of radiation from within.

Fig. 2. Canisters prior to foaming (note the flow holes)

Two-Component Foam System

Once it was determined that the radiological contamination had to be stabilized from the inside, the question was which method to use. Two choices were to: 1) remove the canisters, individually wrap them, then place them back into the container, or 2) stabilize them in place. Application of a two-component foam system was the preferred choice as the personal exposure of removing the canisters was determined to be unacceptable.

NTS had informed the WVDP that the RFETS had experience with use of foam systems for various radioactive waste applications. In October 2002, WVNSCO conducted a benchmarking visit at the RFETS to learn more about Rocky Flats' experience in this area. The visit was extremely productive as personnel from RFETS and InstaCote Inc., their foam vendor, demonstrated the use of foam to block and brace large debris in cargo containers. After detailed discussion with RFETS and InstaCote personnel, it was determined that the two-component foam system would immobilize the residue and scale with the least personal exposure.

In November 2002, the WVDP purchased the necessary equipment to apply the foam to the canister boxes. The chemical portion of the system consisted of two pressurized tanks of isocyanate and a resin. When both of the materials are mixed together, they form a solid, expandable foam that is fully reacted in minutes. The foaming system is capable of dispensing 60 pounds (27 kilograms) of foam per minute.

Application of Foam

WVNSCO employees received three days of classroom and hands-on training from representatives of InstaCote and BASF, the foam manufacturer representatives. This training consisted of preparing a mock-up of the foam application using polyvinyl chloride (PVC) pipe in a plywood container to allow operators practice in determining the likelihood of airborne contamination. To measure airborne contamination, colored chalk was sprinkled onto the PVC pipe laid out in the plywood box. Air samples were taken from around the plywood box during the foaming and revealed that chalk was released to the air. The foam application technique was reviewed and suggestions were made to improve the dispensing operation and reduce the potential for airborne contamination.

In late November 2002, foaming of the actual canister boxes began. As discussed previously, the canister boxes were quite large. Some were as long as long as 16'6'' (5.06 meters) and as tall as 7 feet (2.13 meters). A scaffold was erected to allow sufficient access to all areas within the box. The foam was applied in layers. The dispenser gun was fitted with a 10 foot (3.05 meter) PVC ½"-diameter (0.013 meter) pipe. The foam was applied to the bottom of the box first. The gun was moved along the length of the box to facilitate an even layer. After the first layer was applied, the PVC pipe was cut shorter and the second layer was applied. This process continued until the box was filled to the middle of the top layer of canisters. The foam system is equipped with an automatic timer. The timer can be set to dispense for a selected amount of time and then automatically shut off or it can be operated in manual mode. Manual mode was selected for this foaming operation. Foaming each of the boxes took approximately two hours. Each box received 500 to 1100 pounds of foam depending upon the size of the box and contents.

Fig. 3 SP-149 after the application of foam.

Before the boxes were loaded for shipment, they were re-weighed and subjected to a thorough package inspection. The dose rates were measured again to ensure that there was no change from the dose rates recorded after the addition of foam. In all but one case, the dose rates after foaming were the same as before or lower. In one case the dose rate of one box increased as a result of adding the foam. It is believed that the foam may have pushed loose contamination on the bottom of the box and accumulated it in one area. Subsequent measurements demonstrated that the dose rate after foaming the box remained constant. External shielding was added to the box and it was shipped for disposal.

Personal Protective Equipment

The canister boxes contained loose contamination and therefore had the potential for airborne contamination. The polyurethane foam system contains a component with methyl diisocyanate (MDI). The Industrial Health and Safety (IH&S) department required that the foam application be done in supplied air until sufficient air samples could be collected and analyzed to determine the concentration of MDI in the area and in the breathing zone. **To ensure the safety and protection of workers,** air samples and personal breathing area samples were collected from the mock-up and actual foaming operations. The results of the testing are summarized in Table II.

Table II

Sample Area	Date	Substance	Allowable Limit	Sample Results
Personal	11/13/02	MDI	20 ppb	<0.18 ppb
Personal	11/15/02	MDI	20 ppb	<0.21 ppb
Containment Air	11/26/02	MDI	20 ppb	0.009 ppb
Personal	11/26/02	MDI	20 ppb	<0.29 ppb

After the sample results were reviewed, **the supplied air was replaced with air purifying respirators having organic vapor cartridges.** A high-efficiency purified air (HEPA) filter was also required for the radiological contamination. Personal protective equipment (PPE) consisted of paper suits and rubber or vinyl jackets for the individuals dispensing the foam. All personnel were required to don the normal “yellow” suit-ups required for radiologically contamination areas.

Lessons Learned

There were no major problems encountered during the actual foaming operation. However, there were some minor issues that required adjustments to the foaming procedures.

Description of Issue	Lesson Learned
Foam application operators became fatigued from holding the foam gun and hose.	The foam gun and hose assembly is quite heavy. A better system was employed to support the hose and maneuver it around the box.
After foaming one of the boxes, the containment area measured elevated contamination and required decontamination for release.	The pressure and volume of foam exiting the dispensing gun can cause airborne contamination. Changes to the technique of applying the foam prevented further airborne contaminations.
After foaming one of the boxes, it was noted that the sides of the canister box were bowed inward	The reaction of the two components is exothermic. The temperature of the foam can reach 140 degrees F. The canister boxes were quite large and variations in the temperature of the steel could cause the box to change shape slightly. Internal and external braces were installed and corrected this condition.
After foaming one of the canister boxes, it was discovered that the top row of canisters had been lifted above the top level of the box.	If the foam is applied to an area that **does not** allow expansion horizontally, it may expand vertically and lift the object that was blocking its expansion. Bracing was installed under the lip of the box to prevent future canisters from lifting.

Summary

The application of the two-component foam system was both effective and economical. The foam equipment and components are expensive to purchase, but when compared to the cost of labor to repackage the waste, the overall cost of foaming is significantly lower. This is especially true for ALARA. The dose rates of the individual canisters were as high as 450 mR/hr. The personnel exposure to remove the canisters, stabilize them, and repackage them was prohibitive. Foaming provided the security of immobilizing the loose contamination inside of the containers with the least personal exposure. The 11 canister boxes were safely shipped to NTS for disposal by the end of January 2003.

Fig. 3 Transport vehicle carrying waste off site

FOOTNOTES