HIGH LEVEL WASTE TANK CLOSURE PROJECT AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

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ABSTRACT

The Department of Energy, Idaho Operations Office (DOE-ID) is making preparations to close two underground high-level waste (HLW) storage tanks at the Idaho National Engineering and Environmental Laboratory (INEEL) to meet Resource Conservation and Recovery Act (RCRA) regulations and Department of Energy orders. Closure of these two tanks is scheduled for 2004 as the first phase in closure of the eleven 300,000 gallon tanks currently in service at the Idaho Nuclear Technology and Engineering Center (INTEC).

The INTEC Tank Farm Facility (TFF) Closure sequence consists of multiple steps to be accomplished through the existing tank riser access points. Currently, the tank risers contain steam and process waste lines associated with the steam jets, corrosion coupons, and liquid level indicators. As necessary, this equipment will be removed from the risers to allow adequate space for closure equipment and activities. The basic tank closure sequence is as follows:

- Empty the tank to the residual heel using the existing jets. Liquid and solids removed will be transferred to portions of the TFF tank system still in operations.
- Video and sample the heel.
- Replace steam jets with new jet at a lower position in the tank, and remove additional material.
- Flush tank, piping and secondary containment with demineralized water. Remove flush water with new jet.
- Video and sample the heel. Evaluate decontamination effectiveness.
- Displace the residual heel with multiple placements of grout.
- Grout piping, vaults and remaining tank volume.

Design, development, and deployment of a remotely operated tank cleaning system were completed in August 2001. The system incorporates many commercially available components, which have been adapted for application in cleaning high-level waste tanks. The system is cost-effective since it also utilizes existing waste transfer technology (steam jets), to remove tank heel solids from the tank bottoms during the cleaning operations. Remotely operated directional spray nozzles, automatic rotating wash balls, video monitoring equipment, decontamination spray-rings, and tank-specific access interface devices have been integrated to provide a system that efficiently cleans tank walls and heel solids in an acidic, radioactive environment. Through the deployment of the tank cleaning system, the INEEL High Level Waste Program has demonstrated the capability to clean tanks to meet RCRA clean closure standards and DOE closure performance measures.

The tank cleaning system deployed at the INTEC offers unique advantages over other approaches evaluated at the INEEL. The system's ability to agitate and homogenize the tank heel sludge will simplify verification-sampling techniques and reduce the total quantity of samples required to demonstrate compliance with the performance standards. This will reduce tank closure budget requirements and improve closure-planning schedules.

Design, development, and testing of a tank grouting approach were completed in October 1999. The system incorporates lessons learned from closures at other DOE facilities. The grout will be used to displace the tank residuals remaining after the cleaning is complete. To maximize heel displacement to the discharge pump, grout was placed in a sequence of five positions utilizing two riser locations. After the heel has been removed and the residuals stabilized, the tank, piping, and secondary containment will be grouted.

INTRODUCTION

Closure of the HLW storage tanks in the INTEC Tank Farm Facility will allow DOE to meet its long-term objective to close HLW facilities and meet applicable RCRA regulations and DOE orders. The tank cleaning approach is simple and utilizes commercially available equipment, modified to meet the specific needs of the INTEC tanks. The system directs high-pressure water throughout the tank interior to remove contaminates from the tank wall and floor. The contaminates are then removed from the tank by means of steam-jet transfer technology (which has been used for years in the tanks at INTEC). Grout will be used to displace heel material before final grouting occurs.

The tank closure approach and design features were selected after reviewing available systems throughout the DOE complex, as well as the commercial industry. Because of the unique configuration of the INTEC tanks and nature of the tank heel waste, many of the available technologies were not suitable. To ensure success, the selected components were simulated in full-scale mockup test facilities using simulated waste, which provided proof of principle demonstrations.

The lessons learned from mock-up tests were applied to the final design of the closure systems and the components were fabricated and installed at the Tank Farm Facility. Tank WM-182 was selected for the first deployment and the initial washball test was completed on August 29, 2001. An additional test of the washball was completed on October 16, 2001 and the system was shutdown for the winter.

Results of the cleaning system deployment compared favorably to the mock-up test results. Improvements were made to the system configuration between the August and October deployments, which resulted in improved performance.

TANK CLOSURE DRIVERS AND REQUIREMENTS

In 1992, the Department of Energy, Idaho Operations Office, was party to a Consent Order in response to a Notice of Noncompliance (IDHW 1992) issued by the Idaho Department of Health and Welfare, Division of Environmental Quality. In the Consent Order, DOE-ID agreed to interim status for the Tank Farm Facility (TFF) at the INTEC until the unit could be made to meet RCRA standards or emptied of waste. In 1998 a modification to the Consent Order (IDHW 1998) was issued and DOE-ID further agreed to submit, by December 31, 2000, a RCRA closure plan for at least one tank and no longer use the tank farm after the year 2012. The plan was submitted, as required, and the document continues to be reviewed and revised as the State of Idaho considers approval.

The TFF, along with hazardous materials, also contains significant quantities of radioactive waste. The tanks were formerly used to store wastes generated during spent nuclear fuel reprocessing campaigns. By definition, this waste was considered high-level waste (HLW) and, as a deactivated HLW unit, must comply with closure requirements defined in DOE Order 435.1 (DOE 1999) and associated guidance.

DOE-ID, therefore, is proceeding with tank closure planning and implementation at Tank Farm Facility. Prior to closure, the tanks must be cleaned to meet performance objectives of the Resources Conservation and Recovery Act (RCRA) for hazardous constituents and DOE Order requirements for the radioactive constituents. While both sets of requirements require removal of waste prior to closure, compliance is measured in terms of risk to the public and environment. Since complete removal of "all" waste is technically impossible, the goal is to provide the regulators with objective evidence that the waste has been successfully removed to meet performance objectives. Any doses from potential exposure pathways to tank residuals must be within the limits of acceptable risk.

TANK CLOSURE APPROACH

Compliance with the closure requires necessary to meet RCRA and DOE closure performance objectives is the driving force behind the tank closure approach. The closure approach for the HLW tanks at INTEC consists of three basic steps; 1) tank cleaning to remove contaminates 2) sampling and analysis of tank residuals and 3) addition of cement grout to displace remaining heel, and solidify and stabilize any remaining residuals.

The tank cleaning system consists of a wash ball washball, two directional spray nozzles, and a steam operated transfer jet (see Figure 1). The washball and directional nozzles are remotely operated and powered by high-pressure water. Both the and the directional nozzles are equipment with individual cameras and lighting. Using existing tank access points, the washball and directional nozzles will be lowered into a tank and will be deployed in unison to remove contaminates from the walls and floor with high pressure water.

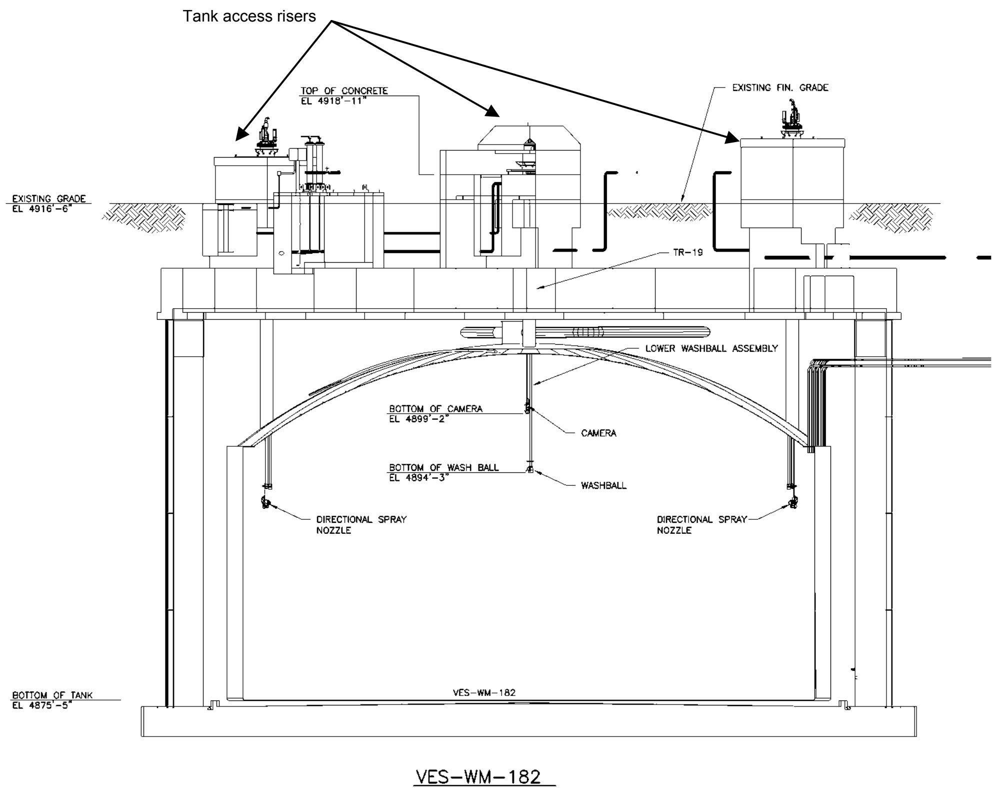

Fig. 1: Cross-section of Tank WM-182 and tank cleaning system

WASHBALL DESCRIPTION

The washball is a stainless steel rotating cleaning system typically used in cleaning petroleum tanks. The washball has two rotating nozzles, which are gear driven as pressurized water is applied to the unit. The nozzles rotate in a vertical plane as the washball gradually rotates in a horizontal plane - creating a systematic pattern to clean the entire interior surface of the tank. The spray pattern moves approximately 1.5 to 2.0 feet for every revolution. The washball completes a cycle (complete coverage of the interior surface of the tank) in approximately 14 minutes.

The washball is attached to a 1-1/2 inch diameter ridged pipe, approximately 25 feet long. The upper end of the pipe is attached to a flange, which bolts to the tank access riser near the ground surface after the washball is lowered into the tank. Water is supplied to the unit via a pump, which is designed to produce a flow rate of 75 gallons per minute at a pressure of 100 psi. The water supply is staged in four 5,000-gallon plastic storage tanks located just outside the tank farm fence next to the supply pump. The washball is connected to the pump via approximately 225 feet of 2.5-inch diameter flexible hose.

A remote camera is also attached to the washball assembly and is protected from the spray nozzle by a splashguard. The camera lens is also protected with a continuous air lance to prevent accumulation of water droplets that could obstruct the view. The camera is fitted with high-intensity lighting and has a full range of pan and tilt functions to allow complete inspection of the tank interior during cleaning operations. A camera monitor, video recording unit, and the camera remote controls are located in the control trailer just outside the tank farm fence next to the water supply tanks and pump.

During the summer for 2000 a mock-up tank was constructed to test a proto-type washball system. This testing helped establish the operating parameters and equipment designs necessary to ensure optimum use of added water to achieve performance objectives.

There are several crucial aspects for achieving maximum waste removal with the minimum amount of added water. Optimum pressure at the spray nozzles ensures adequate force at the end of the spray pattern without breaking up the water stream. Excessive pressure tends to atomize the spray pattern and reduce the water forces at the tank wall. Maintaining the water level in the bottom of the tank within a certain range, by transferring the heel during washball operation, affects the rate of solids removal. A minimum depth of liquid is needed to suspend the solids and facilitate transport toward the jet, however, if the depth is too high, the washball loses its effectiveness in agitating the solids. As washing proceeds and the quantity of solids is significantly reduced, the heavier solids tend to accumulate around the perimeter of the tank. The mock-up testing demonstrated the need for remotely controlled directional nozzles that can be focused at these accumulated solids and force them into suspension and toward the steam-jet for removal.

The washball is designed to operate at the following specifications:

- Supply water flow rate . . . . .70 to 80 gpm
- Water temperature . . . . Ambient (55^o to 75^o F)
- Water Source . . . . .De-mineralized
- Nozzle Orifice . . . . .10 mm
- Nozzle Pressure . . . . .80 to 100 psi
- Cycles per hour . . . . 4 to 5
- Gallons to clean tank (average) . . .. 77,000 gallons

DIRECTIONAL NOZZLE ASSEMBLY DESCRIPTION

The directional nozzle is similar to the washball and utilizes high-pressure water through a 10 mm orifice. The nozzle assembly, however, is not automated, but is controlled remotely by an operator. The operator's station and associated video monitor are located in the control trailer. The nozzle has a full range of motion (both pan and tilt) and is fitted with a camera and high-intensity light that follows the direction of spray. The operator directs the unit using a "joystick" type controller.

Like the washball, the directional nozzle is connected to a 1-1/2 inch diameter ridge pipe (supply water), which is connected at the upper end to a flange and bolted to the tank access riser.

Mock-up testing during the summer of 2000 revealed the need for capabilities to focus cleaning water at stubborn contaminates. The use of the directional nozzle also allows for displacement of sludge on the tank bottom toward the steam-jet for removal. Figure 2 shows the top and bottom of the 28 ft long assembly.

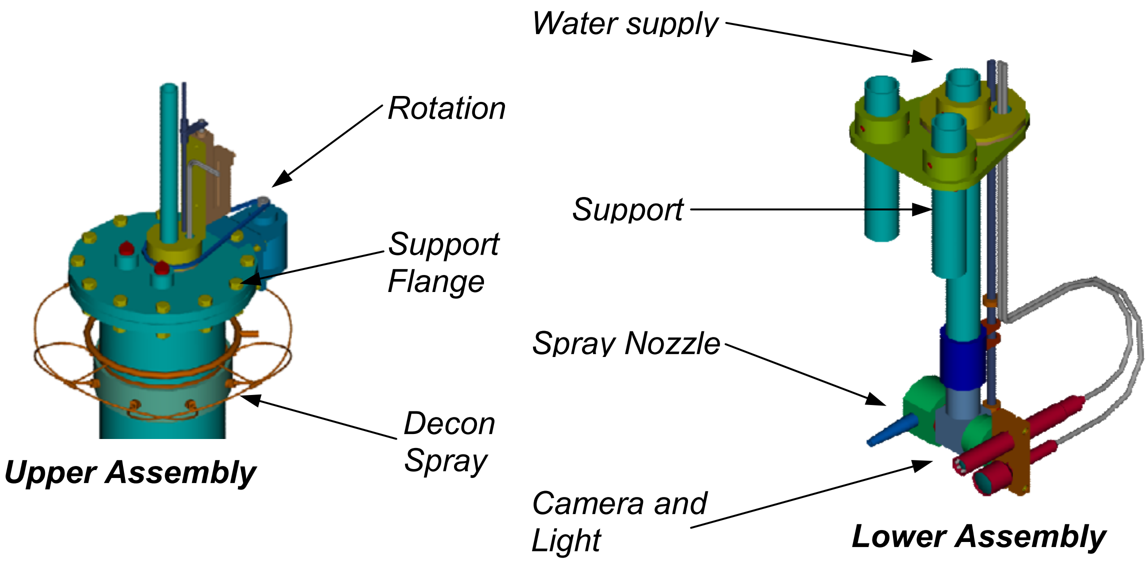

Fig. 2: Directional Nozzle Assembly

STEAM-JET DESCRIPTION

Steam-jets were previously installed in the tanks to allow vertical pumping of tank contents. Steam jet technology was selected over conventional pump technology since there are no moving parts. This means virtually no maintenance over the life of the tank. The steam-jets were not installed at the time of tank construction, but were added later during spent fuel reprocessing campaigns when it was decided to remove the tank contents for treatment. Adding the jets as a retrofit project resulted in the jet intake nozzles being located approximately 4 to 8 inches from the tank bottoms. Mock-up testing indicated that the optimum height of the jet inlet, to achieve maximum removal of solids, is approximately ½ inch above the tank bottom. Therefore, the existing jets will be removed and new jets will be installed to this optimum height. This will improve solids removal and minimizes the volume of water required for decontamination during the tank cleaning operations.

GROUT PLACEMENT DESCRIPTION

To simulate closure activities, a heel displacement test was conducted in a 3-ft high, full-diameter tank. The tank included simulated steam coils. The purpose of the test was to use grout placements to move the residual heel to the retrieval pump. Figure 3 shows one of the grout pours into the basin to cover the coils and displace heel material.

The grout pour evaluation was quite successful. By adding the grout in series of five pours, each focusing on separate areas of the tank, a method was developed to channel the remaining slurry to the entrance to the steam jet to permit additional slurry retrieval. The pattern described used a series of five pours that formed a star pattern. Consider the five points of a star with the steam jet located at the intersection between points 3 and 4. Pours one and two occurred on either side of the tank at points 2 and 5. After these pours, a channel exists between point 1 and the steam jet inlet. Pour three occurred at point 1, forcing fluid through the channel to the steam jet inlet. Pours four and five occurred at points 3 and 4, completing transfer of fluid from the tank floor to the steam jet. The final pour submerges the inlet of the steam jet.

Fig. 3: Pouring grout over the tank bottom to direct fluid to the steam jet entrance

WASHBALL INSTALLATION IN TANK WM-182

After completion of mock-up testing and detailed design, the project commenced with fabrication and installation of the tank cleaning system in tank WM-182 at the INTEC Tank Farm Facility. The washball assembly was the first unit to be fabricated, installed, and tested. Fabrication and installation of the directional nozzles and modified stream jet will be conducted in 2002.

The washball assembly was placed in tank WM-182 through tank riser TR-19. Before the assembly could be installed, the existing steam-jet located in that riser was removed. A stacked series of concrete shielding hatch covers, which protect the opening to the tank, were removed to allow access for demolition of the steam-jet

After the hatch covers were removed, demolition and removal of the existing steam-jet began. The interior surfaces of the steam-jet were rinsed with water to remove any residual contamination in the piping. The entire steam-jet assembly, which is approximately 40 feet long, was removed as a single unit using a crane. The exterior surfaces of the assembly were rinsed with water as it was lifted from the riser. After removal, the assembly was cut into 3-foot sections and boxed for removal from the tank farm. The radiation levels on the removed steam-jet assembly averaged around 50 mR/hr. with one hot spot at 150 mR/hr.

Before the washball assembly was installed in the tank, and exposed to the contaminated environment of the tank interior, it was tested to ensure proper operation. The assembly was connected to a temporary water supply and suspended from a crane in the laydown yard. No operational deficiencies were noted. The camera system had been previously tested in the fabrication shop. After final system checkout was completed the assembly was lowered into the open tank riser and the supply water and camera leads were connected. Prior to operation, the entire installation was reviewed in accordance with operating procedures and the system was certified as ready for operations.

DEPLOYMENT OF THE WASHBALL IN TANK WM-182

The washball was initially deployed and tested in tank WM-182 on August 28, 2001 and was tested again on October 18, 2001 after some minor modifications. The washball functioned as designed, providing adequate coverage to the interior surfaces of the tank while completing the desired revolutions of the assembly. The force of the spray was adequate to agitate the tank heel and suspended solids within the liquid to the extent that the cooling coils were no longer visible. The washball was also effective in removing contaminates from the tank wall and cooling coils on the walls. Some areas of the wall showed an "X" pattern where the spray nozzles had removed contaminates as the washball moved through its cycle. The results compared favorably to those of the mock-up test. Figure 4 illustrates the tank wall after the October test.

The pump was more than capable of providing the necessary flow rate to power the washball and produced adequate pressure at the nozzles. The control value just downstream from the pump discharge was opened approximately 25% and the flow rate at the washball (> 220 feet away) was over 80 gallons per minute. Head loss in the length of flexible hose from the pump to the tank access riser did not affect performance of the washball.

Fig. 4: Tank WM-182 after the October wash ball test.

The camera and lighting system attached to the washball also functioned as intended. The spray guard did not, however, completely protect the lens from over spray and water droplets. The air lance system was able to remove any accumulation of drops on the lens and visual capabilities were adequate to inspect the tank interior during and after deployment. The camera was in the tank for more than two months and there was no evidence of any degradation due to the radiation background. The radiation field, measured at the tank riser near ground level, was approximately 90 mR/hr. The field at the camera was estimated to be approximately 300 mR/hr.

The remote control system on the camera was also effective and provided for complete inspection of the tank interior. During the second deployment (October 18), the camera operator was able to focus on specific areas and record the removal of contaminants from the tank wall during washing operation. More than two hours of video footage was recorded during both deployments.

CONCLUSION

Based on the deployment of the washball in Tank WM-182, the proposed cleaning system will provide the necessary capabilities to remove contaminates from the tanks to achieve closure performance measures for both DOE and RCRA requirements. The system is primarily developed from commercially available components and the operational approach is simple. The components can be reused in every tank, which will reduce the overall cost and schedule for tank closure operations. The system requires very little preventive maintenance and any repairs or replacements are readily available. Operating procedures are simple and allow for many decisions concerning operating parameters to be made in the field by project personnel responsible for meeting closure objectives. The project is continuing with full development and deployment of the tank cleaning system.

REFERENCES

DOE (Department of Energy), 1999, *U.S. Department of Energy Order 435.1, Radioactive Waste Management,* U.S. Department of Energy, Office of Environmental Management, July 9.

EPA (Environmental Protection Agency), 2001, *EPA Region IX Preliminary Remediation Goal (PRG) Table,* http://www.epa.gov/Region9/waste/sfund/prg/index.htm

EPA 1989, *Risk Assessment Guidance for Superfund Volume1, Human Health Evaluation Manual (Part A),* EPA/540/1/1-89/002, December.

IDHW (Idaho Department of Health and Welfare), 1998, *Second Modification to Consent Order to the Notice of Noncompliance,* U.S. Department of Energy Idaho Operations Office; Idaho Department of Health and Welfare, Division of Environmental Quality; U.S. Environmental Protection Agency, Region 10, August 18.

IDHW, 1992, *Consent Order to the Notice of Noncompliance,* U.S. Department of Energy Idaho Operations Office; Idaho Department of Health and Welfare, Division of Environmental Quality; U.S. Environmental Protection Agency, Region 10, April 18.

Sullivan, T.M., 1996, *DUST-MS: Model Equations for Waste Form Leaching and Transport with Ingrowth Due to Radioactive Progeny,* Brookhaven National Laboratory, Environmental and Waste Technology Center.