D&D TECHNOLOGIES FOR POLLUTION PREVENTION

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Work supported by the U.S. Department of Energy, Office of Environmental Management, under DOE Idaho Operations Office Contract DE-AC07-99ID13727.

ABSTRACT

A new Accelerated Site Technology Deployment (ASTD) project was awarded in FY 2002 to the Idaho National Engineering and Environmental Laboratory (INEEL) to deploy technologies that decrease pollution and waste in the areas of facility characterization, sludge treatment, dust and contamination control, and concrete demolition. This project was called "D&D Technologies for Pollution Prevention" and planned to deploy four different technologies.

To reduce protective equipment requirements, waste generation, and risk of radiation exposure during facility characterization, the Russian Gamma Locater Device (GLD) and Isotopic Identification Device (IID) for remote characterization was investigated. The GLD detects gamma ray readings and video images remotely and uses radio communication to transmit the readings to personnel located a safe distance from the contaminated area. The IID, an integral part of the GLD, provides real-time spectrometric analysis of radiation sources for remotely identifying the specific radioactive isotopes present in the facility.

At the INEEL, sludge has accumulated in the bottom of a fuel storage pool and the presence of heavy metals in the sludge makes it a mixed waste. This project planned to use LEADX® to treat sludge in place to effectively make all heavy metals in the sludge insoluble. LEADX® is a dry granular chemical additive (apatite) used for in-situ treatment of heavy-metal-contaminated material. LEADX® chemically bonds to any free heavy metals that it contacts and forms a stable, non-leachable molecule. After treating the sludge with LEADX®, it was to be left in the basin and the pool filled with grout. The successful treatment of the sludge with LEADX® will reduce the amount of waste to be disposed at the burial ground by eliminating the need to remove the sludge from the basin.

Many off-gas and duct systems being dismantled contain dust and lint that has been contaminated. Encapsulation Technologies, LLC has developed a patented process for eliminating airborne radioactivity and fixing contamination in place remotely without the need for people or equipment to enter the area being treated. The process uses a device called the Passive Aerosol Generator (PAG) to create an aerosol of a capture coating. The aerosol condenses on surfaces, capturing the contaminants in place. Use of this fogging technology will reduce or eliminate the requirement for glovebags and extensive contamination control during cutting and removal of ductwork.

Demolition of building slabs and foundations is necessary at most DOE facilities undergoing D&D. The baseline method for their demolition at the INEEL is to use a hydraulic hammer on the end of a backhoe or trackhoe. However, the vibration of the hammer typically causes excessive wear and tear on the equipment (resulting in additional maintenance), and dust control

can be a problem. The SureStrike rock breaker, or Hammerhead, is used commercially in the mining and demolition industries. The modular impact hammer attaches to a conventional front-end loader or excavator and can be used to break up oversized materials such as equipment pedestals and heavy reinforced concrete foundations. The Hammerhead uses a coiled spring that generates 100,000 psi of single-blow impact energy through a breaker rod. It takes about 3 seconds for the equipment operator to load the spring and deliver the blow. The Hammerhead reduces noise pollution because it uses no motors, hydraulics, or air, and it reduces dust pollution because the single-blow impact energy forces the energy down into the concrete, rubblizing the concrete below the surface while leaving the surface with only breaks/cracks instead of a lot of loose pieces. In addition, equipment maintenance is reduced, and safety is improved because the amount of "fly rock" is minimal.

INTRODUCTION

This Accelerated Site Technology Deployment Project (ASTD) was awarded in January 2002 to accelerate schedules, reduce costs, and minimize pollution through technology deployments in the areas of facility characterization, sludge treatment, dust and contamination control, and concrete demolition. Specifically, this project was to deploy the following commercially available technologies in decontamination and decommissioning (D&D) projects:

- ⇨ Russian Gamma Locator Device (GLD) and Isotopic Identification Device (IID) for remote characterization
- ⇨ LEADX® sludge stabilization technology (or a similar compound) for immobilization of heavy metals
- ⇨ Passive aerosol fogging for control of dust-borne contamination
- ⇨ SureStrike Rock Breaker (Hammerhead) for concrete demolition.

Initial and secondary deployments of each of the technologies were planned at INEEL facilities. Deployment of these technologies was expected to result in less waste generation and lower D&D costs while at the same time accomplishing work faster and more safely. Due to changes in the Department of Energy (DOE) Environmental Management (EM-50) organization, this ASTD project along with most others was discontinued at the end of FY-02.

SLUDGE TREATMENT

A fuel storage facility at the INEEL's Idaho Nuclear Technology and Engineering Center (INTEC) is in the process of being decommissioned. The facility, CPP-603, consists of three 19-ft-deep storage basins connected by a transfer canal and one concrete hot cell that was used to conduct nuclear fuel cutting operations. The basins were used to store spent nuclear fuel beginning in 1951. In response to safety and environmental compliance requirements, all fuel was removed from the facility in 2000 and the facility is now being decommissioned. Seven to ten centimeters (3-4 inches) of sludge has accumulated in the bottom of the pools. The presence of heavy metals in the sludge makes it a mixed waste. The current baseline planning requires removing the sludge, mixing it with grout, and disposing of the grout/sludge mixture in shielded containers. This process is expensive and time consuming, and it will generate approximately 283 cubic meters (10,000 cubic feet) of waste for disposal at the burial ground. The overall plan for the facility decommissioning includes closure of the basins in place by filling them with grout.

Figure 1. CPP-603 fuel storage pools contain significant amounts of sludge in the bottom.

The intent of this project was to investigate using LEADX® or a similar product to treat the CPP-603 sludge in place to effectively make all heavy metals in the sludge insoluble. LEADX® is a dry granular chemical additive (apatite) used for in-situ treatment of heavy-metal-contaminated material. LEADX® chemically bonds to any free heavy metals that it contacts and forms a stable, non-leachable molecule. Chemical reaction occurs immediately upon contact. The long-term effectiveness of LEADX® has been proven by EPA Method 1320, "Multiple Extraction Procedures," which simulates 100-year stability of leachable lead (http://www.perdi.com/index3.html). The successful treatment of the sludge with LEADX® will reduce the amount of waste to be disposed at the burial ground by about 283 cubic meters (10,000 cubic feet), simply by eliminating the need to remove the sludge from the basin. Leaving the sludge in place when the pools are closed would save over $1.2M in D&D costs.

Since product performance is affected by many factors, laboratory studies were necessary to determine specific process parameters and the solubility of the final product in the intended application. Basin sludge samples were taken and treated with LEADX®. Toxicity Leaching Characteristic Procedure (TCLP) analyses were completed on multiple samples to determine the effectiveness of the binding of the metals. The laboratory testing was inclusive, probably due to the low levels of heavy metals found in the basin sludge. Further testing of samples with higher levels of metals could not be done due to a lack of funding.

FOGGING

During D&D, the INEEL Operations will frequently dismantle off-gas and duct systems that contain dust and lint that has been contaminated or need to enter areas with extensive radioactive contamination. To minimize air pollution and waste generation, additional measures in dust and contamination control are needed. One of the INEEL facilities being dismantled is the old laundry facility at the Central Facilities Area (CFA-617). The ventilation ducts contain low-level contamination. Typically, contamination control during D&D is maintained on these problem areas by putting glovebags around each cut location to contain any contamination spread. This is a very labor-intensive process that generates secondary waste from the glovebags and protective equipment. A second facility slated for cleanup is the old fuel cutting area at the CPP-603 pool.

Encapsulation Technologies, LLC has developed a patented process for eliminating airborne radioactivity and fixing contamination in place remotely without the need for people or equipment to enter the area being treated. The process uses a device called the Passive Aerosol Generator (PAG) to create an aerosol by submerging parabolic-shaped ultrasonic transducers in a solution of capture coating. The transducers create an aerosol that is gently introduced into the treatment area, were it condenses on surfaces, capturing the contaminants in place. The capture coating is formulated to remain tacky for prolonged periods, allowing any re-suspended contaminant particles to become captured when they contact the surface. Use of this fogging technology will reduce or eliminate the requirement for glovebags and extensive contamination control during cutting and removal of ductwork by fixing the contaminants to the surface so the danger of creating airborne contaminants is reduced.

Encapsulation Technologies (ET) has extensive experience in using fogging for contamination control at a number of facilities. At Rocky Flats it was used in Building 371 to reduced airborne plutonium by more than 99.99%. At Hanford, ET reduced airborne plutonium in the 233S Plutonium Concentration Facility by more than 99%. It has also been used with similar results at Humboldt Bay Power Plant, Oak Ridge National Laboratory, B&W Fuel Fabrication Facility, and other locations. This technology has proven reliable and effective in a variety of conditions and is considered mature. The cost of a weeklong fogging job (per vendor quote) is approximately $15K to $20K

Encapsulation Technologies, LLC was subcontracted to use their patented fogging process for eliminating airborne radioactivity and fixing contamination in place for the CFA-617 duct. The CFA-617 ducting was fogged on May 14, 2002. When the ducting was opened, a large amount of lint was found (Figure 2) instead of the small coating of dust/lint expected and planned for. When the operators touched the lint, they found it was very flocculent and easily rubbed off. The operators were expecting the lint to be better adhered to the surface, however, fogging is not the correct technology to "fix" this large amount of dust and lint (strippable or fixative coatings would be better). Fogging is intended to adhere the contamination floating in the air to surfaces (i.e. small particles).

Figure 2. Excessive Lint in the CFA-617 ducting prevented the fogging from working effectively.

A second fogging deployment was completed in October 2002 in the fuel cutting cave at CPP-603 using a fogging unit that the INEEL purchased from Encapsulation Technologies.

HAMMERHEAD

There is a need to minimize dust generation and equipment maintenance during the demolition of thick concrete pads, especially those that contain some radioactive contamination. The baseline method for demolition is to use a hydraulic hammer on the end of a backhoe or trackhoe. However, the vibration of the hammer typically causes excessive wear and tear on the equipment (resulting in additional maintenance), and dust control can be a problem. The SureStrike rock breaker, or Hammerhead, is used commercially in the mining and demolition industries. It serves as an alternative to explosives, drop balls, and hydraulic hammers. The modular impact hammer attaches to a conventional front-end loader or excavator (a medium-sized rubber-tire backhoe or small excavator is adequate) and can be used to break up oversized materials such as equipment pedestals and heavy reinforced concrete foundations. The Hammerhead mechanical concrete breaker is a mature technology used commercially by contractors for many applications, including: removal of sidewalk outside of schools during school hours, ATM bank island removals in less than 1 hour, factory floors during factory operating hours, and railroad crossing grades. Hammerhead users have reported production rates in excess of 56 square meters (600 square feet) per hour when breaking rebar-reinforced, 18 centimeter (7-inch) thick concrete in an old factory floor. This rate is typical for up to 25 centimeter (10-inch) thicknesses of concrete, with 8-hour day rates of 371 to 465 square meters (4000 to 5000 square feet). The Hammerhead lists for $10,700 including the bushings to fit most rubber-tired backhoes. Maintenance requirements include replacing low-cost buffers ($35 each) and trigger springs ($15 each) after about a thousand hours of use. Applicable web sites include www.hammerhead-breaker.com and www.rocktoroad.com/hammers.html.

The Hammerhead does not use air or hydraulics, but instead uses a coiled spring that generates 100,000 psi of single-blow impact energy through a 10 centimeter (4-inch) diameter breaker rod. It takes about 3 seconds for the equipment operator to load the spring and deliver the blow. The effect during operation is a heavy thud every few seconds, instead of the "machine gun" effect typical of conventional jackhammers and similar devices. The Hammerhead reduces noise pollution because it uses no motors, hydraulics, or air, and it reduces dust pollution because the single-blow impact forces the energy down into the concrete, rubblizing the concrete below the surface while leaving the surface with only breaks/cracks instead of a lot of loose pieces. In addition, equipment maintenance is reduced, and safety is improved because the amount of "fly rock" is minimal. A variety of Surestrike Hammerhead Breaker models are available; the largest capable of breaking concrete up to 1.2 meters (48-inches) thick.

INEEL D&D Operations deployed a model MB500 Hammerhead at Test Area North (TAN) on June 25, 2002. The Hammerhead MB500, with the mounting bracket installed, weighs about 567 kg (1250 lbs.), is 2.4 meters (8 feet) in length. The test was performed on the TAN-615 concrete pad area. The Hammerhead Breaker was attached to the Case 680L Backhoe in 15 minutes. The Equipment Operator (E.O.) moved the Hammerhead around for about 3 minutes to get familiar with its operation. Next, The E.O. begin using the Hammerhead on the 5" thick concrete pad. Although no major damage was noted from the Hammerhead impact area on the surface of the concrete, the concrete was rubblized underneath, as was expected. Hammerhead was effective on breaking up the concrete while creating little or no dust. The Radiological Control Technician was pleased with the lack of dust generated by the concrete breaker and stated that it would be very useful in radiological contaminated areas (Figure 3).

The model MB500 Hammerhead Breaker was deployed three additional times at the TAN-615 facility area in July 2002. The Hammerhead was used to break concrete around the sump and the cap on the sump. The Hammerhead worked very well on the 13 centimeter (5-inch) concrete (with rebar) around the sump. No dust or rockfly was noticed during operation. It did not rubblize the 20 centimeter (8-inch) concrete cap on the sump. The EO's stated that the baseline hydraulic concrete breaker could break concrete 20 centimeter (8-inch) thick with ease, but created dust and rockfly. The Radiological Control Technicians didn't want any dust or rockfly created due to low-level radioactive contamination in the sump. The D&D Operations Supervisor stated that the instrument of choice when dealing with radiologically contaminated concrete pads is now the Hammerhead. It should be noted that larger Hammerhead equipment is available for purchase that could break the thicker concrete sections. These larger units would also increase the rate of breakage that the operators indicate is slower with the current Hammerhead model than their baseline hydraulic hammer.

Figure 3. The Hammerhead reduced rock-fly and dust generation during pad demolition.

GAMMA LOCATOR DEVICE/ISOTOPIC IDENTIFICATION DEVICE (GLD/IID)

Before a facility is decommissioned, it must be characterized to identify hazardous and radioactive materials and to establish plans for D&D. Part of this initial characterization involves entry of radiation areas by radiological control technicians wearing protective clothing, i.e., personal protection equipment (PPE). Measurements taken by the technicians determine the types, amounts and locations of radiation, as well as the physical nature of the contamination (loose or fixed) in the facility. Sample technicians (also in PPE) make a second entry to collect physical samples of contaminated materials, which are shipped to a laboratory for isotopic analysis. These entries increase the risk of exposure to workers and the generation of secondary waste (i.e., PPE). Remotely deployed technologies will reduce or avoid these undesirable consequences. Potentially high radiation fields in initially unknown locations further increase the risk of worker exposure.

To reduce PPE requirements, waste generation, and risk of radiation exposure during facility characterization, the Gamma Locator Device (GLD), designed by NIKIMT in Russia could be used. The GLD can be mounted on a radio-controlled, battery operated robot. The GLD detects gamma ray readings remotely and uses radio communication to transmit the readings to personnel located a safe distance from the contaminated area. In addition to collecting radiation field data, the GLD captures video images of the area being surveyed and transmits the images to the operator via radio frequency communication. The Isotopic Identification Device (IID), an integral part of the GLD, provides real-time spectrometric analysis of radiation sources for remotely identifying the specific radioactive isotopes present in the facility.

A GLD demonstration was conducted in July 2001 at the INEEL as part of a Large Scale Demonstration and Deployment Project (LSDDP) as shown in Figure 4. The Russian GLD was used to quantify radioactive contamination levels and collect video images of the TAN-616 facility and the Power Burst Facility (PBF-602) cubicle 13. The Russian GLD was able to identify numerous contaminated areas. The hot spots found by the GLD correlated with those found in the baseline surveys conducted earlier by radiological control and sample technicians. Because the GLD has the ability to do 100% coverage in a short period of time, it was able to detect hot spots that the baseline manual surveys missed. The GLD data were collected in 5 to 10 minutes and were made available to D&D planners as needed. Cost/benefit information from the LSDDP Innovative Technology Summary Reports (ITSRs) on the GLD and IID indicate a baseline cost of $2,122 per sample. In comparison, the GLD costs averaged about $984 per scan.

As part of this ASTD project a marketing assessment was completed with Redzone robotics. This assessment included a comparison of competing technologies, a market study, a study on technology development and enhancement needs, and a commercialization plan. This marketing assessment was completed by Redzone in October 2002. Due to funding cuts in this project the follow-on purchase and deployment of the GLD/IID at the INEEL was cancelled.

Figure 4. The GLD/IID on an INEEL robot was used to survey a hot area to limit personnel exposure.

SUMMARY

Although this three-year project was cancelled after only 6 months due to DOE EM-50 restructuring, it accomplished over half of the scope of the project. Two technologies were deployed (Fogging and Hammerhead) multiple times at the INEEL. It is anticipated that D&D Operations at the INEEL will continue to use these technologies as appropriate.

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