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TECHNOLOGY DEMONSTRATIONS IN THE DECONTAMINATION AND DECOMMISSIONING FOCUS AREA

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ABSTRACT

This paper describes three large-scale demonstration projects sponsored jointly by the Decontamination and Decommissioning Focus Area (DDFA), and the three U.S. Department of Energy (DOE) Operations Offices that successfully offered to deactivate or decommission (D&D) one of its facilities using a combination of innovative and commercial D&D technologies. The paper also includes discussions on recent technology demonstrations for an Advanced Worker Protection System, an Electrohydraulic Scabbling System, and a Pipe Explorer™. The references at the conclusion of this paper should be consulted for more detailed information about the large-scale demonstration projects and recent technology demonstrations sponsored by the DDFA.

INTRODUCTION

In January 1994, the Office of Environmental Management (EM) of the DOE established five Focus Areas to concentrate technology development on the major environmental remediation and waste management problems within the DOE weapons complex. The five Focus Areas are Contaminant Plume Containment and Remediation; Mixed Waste Characterization, Treatment and Disposal; High-Level Waste Tank Remediation; Landfill Stabilization; and Decontamination and Decommissioning (D&D). These Focus Areas were selected based on prevalence of problems, need for technology development, and risk to workers, public, and the environment.

In February 1995, the DOE's Office of Science and Technology (formerly Office of Technology Development) within EM selected the DOE's Morgantown Energy Technology Center (METC) to lead the implementation of the Decontamination and Decommissioning Focus Area.

The D&D Focus Area is responsible for developing, demonstrating, and implementing cost-effective and safe technologies to deactivate approximately 7,000 contaminated buildings and decommission about 700 contaminated buildings that are currently on DOE's list of surplus facilities.

Overall, commercial technologies exist to deactivate and decommission the surplus DOE buildings, structures, and their contents. However, these technologies are labor intensive, time consuming, expensive, and can potentially increase exposure of workers to radioactive and hazardous waste. In addition, many commercial technologies generate secondary waste beyond those of the building materials and their contents.

The D&D Focus Area is addressing these problems by developing, demonstrating, and implementing technologies that generate lower quantities of waste materials, are lower in cost, require less labor, limit exposure of personnel to radioactive and hazardous materials, and improve worker safety.

A key phase of technology development and maturation in the D&D Focus Area is "demonstration" of the technology to potential end users. These demonstrations will be conducted by testing and evaluating the technology in the end users' facilities at a scale and test duration that is convincing. Test data from demonstration testing should give the end users all pertinent information needed in making decisions regarding subsequent use of the technology. The primary end users for the D&D Focus Area are DOE's EM-40 and EM-60 organizations.

LARGE-SCALE DEMONSTRATIONS

Concept

A cornerstone of the D&D Focus Area is a series of "Large-Scale Demonstrations." In the large-scale demonstration projects, a combination of commercial and innovative D&D technologies will be used to deactivate or decommission surplus DOE facilities. The intent of the large-scale demonstration projects is to show that there are substantial cost and other benefits by using a combination of innovative and commercial D&D technology compared with using only commercial D&D technologies. This approach provides a unique opportunity to test innovative D&D technologies side-by-side with commercial technologies in an active D&D project.

An Integrating Contractor or Integrating Contractor Team (hereafter referred to as Integrating Contractor) will conduct and manage each of the large-scale demonstration projects. The Integrating Contractor will coordinate and oversee the work of subcontractors who own the innovative and commercial D&D technologies. The Integrating Contractor and its subcontractors can apply the lessons learned during the large-scale demonstration projects in performing future D&D work at other DOE sites and commercial nuclear facilities. The D&D Focus Area and cognizant DOE manager at the site will co-manage the Integrating Contractor.

Selection of Large-Scale Demonstration Projects

In July 1995, the D&D Focus Area issued a Request for Letter Proposal to all DOE Operations Offices requesting that they offer facilities to be host to the large-scale demonstration projects. In August 1995, eight letter proposals were received by the D&D Focus Area. The letter proposals were evaluated and in October 1995, the D&D Focus Area selected three DOE facilities to host large-scale demonstration projects. These facilities are the Chicago Pile (CP-5) test reactor at Argonne-East near Chicago, Illinois; the Plant 1 uranium processing complex at Fernald near Cincinnati, Ohio; and the C production reactor at Hanford near Richland, Washington. Each of these projects will complete their technology demonstrations in 18 months after the start of the projects.

CHICAGO PILE 5 TEST REACTOR AT ARGONNE-EAST

Facility Description

This large-scale demonstration project will focus on the decontamination and dismantlement of the CP-5 test reactor facility (1). The CP-5 test reactor is a heavy-water moderated and cooled, highly-enriched, uranium-fueled thermal reactor designed to supply neutrons for research. The reactor had a thermal power rating of 5 megawatts and could generate a maximum flux of 100 trillion neutrons per square centimeter per second. The reactor was operated almost continuously for 25 years until its final shutdown in 1979. After the shutdown, the fuel rods were removed from the reactor and the heavy water was drained from the system.

The reactor containment building is 70-feet diameter and 42-feet high with reinforced concrete walls approximately 1-foot thick. The fuel rod storage area has tubes built into the floor to store highly-radioactive materials. The highly-radioactive materials have been removed from the tubes and some, but not all, of the tubes have been decontaminated.

The fuel pool contains about 50 shield plugs from the fuel modules. These plugs are highly radioactive and are classified as mixed waste. The hot cell was last used to disassemble an irradiated converter containing highly-enriched uranium.

Contamination

Tritium persists in most of the containment concrete and primary piping systems. Personnel protective equipment will be required to reduce the workers' internal exposure. Some work will require the use of supplied-air respirators.

Radioactivity inside the biological shield is estimated to exceed 100,000 Curies. Much of this activity is associated with ^{60}cobalt, ^{55}iron, and ^{63}nickel from activation of a steel tank adjacent to the biological shield.

The general exposure rates inside the containment shell are substantially less than one millirem per hour (mrem/h). However, some areas have much higher radioactivity readings and are controlled access locations. After the reactor vessel area is opened by removal of the shield plugs, the levels of radiation are expected to exceed 250 rad per hour in the reactor with corresponding changes to radioactivity readings in the general area.

Scope of Large-Scale Demonstration Project

Significant work in the large-scale demonstration project includes removal of the reactor internals, removal of the biological shield, decontamination of fuel rod storage area, decontamination of radioactive material storage and handling facilities including the fuel pool, and decontamination and dismantlement of the building.

Status

Duke Engineering and Services, and MACTEC are the lead Integrating Contractors for decommissioning of the

CP-5 facility. Technology rating criteria were developed and innovative D&D technologies are being reviewed for possible incorporation into a revised decommissioning plan. It is expected that innovative D&D technologies will begin to be demonstrated early in 1996.

PLANT 1 COMPLEX AT FERNALD

Facility Description

This project focuses on the decontamination and dismantlement of the Plant 1 complex at Fernald (2). The Plant 1 complex consists of Building 1A and six other buildings.

Building 1A is a four-story, irregularly-shaped process building measuring approximately 82 feet by 202 feet by 60 feet high. This building was originally used to receive all enriched-uranium materials processed at Fernald. Additionally, non-enriched ore concentrates and recycled materials were weighed, sampled, and milled in this plant before distribution to other process facilities. Uranyl nitrate hexahydrate solution was also prepared in Building 1A for use in the ore refinery plant. Building 1A has seven process areas including a drum sampling area; a crushing/milling area to size reduce enriched-uranium, magnesium fluoride, and uranium oxide; an enriched materials reclamation area to digest uranium and produce uranyl nitrate by adding nitric acid to uranium compounds; a drum washing area; a solvent reclamation area; a wastewater treatment area; and a repackaging materials area.

Other smaller buildings in the Plant 1 complex include two storage sheds, two drum storage buildings, a drum reconditioning building, and a thorium warehouse.

Contamination

Contamination at the Plant 1 complex consists primarily of low levels of uranium and thorium.

Scope of Large-Scale Demonstration Project

Decommissioning the Plant 1 complex will consist of decontaminating and removing the entire buildings and their contents. Dismantlement of Building 1A will consist of removing about 60,000 lineal feet of piping and conduct; 63,000 square feet of ductwork; 41,000 cubic feet of equipment; 400 tons of structural steel; 9,600 square feet of roof material; 43,000 square feet of interior transite panels; 49,000 square feet of batting insulation; and 30,000 square feet of exterior transite.

Status

Fernald is planning the schedule of tasks necessary to decommission the Plant 1 complex. They will identify "windows of opportunity" for demonstrating innovative D&D technologies, and evaluate and recommend innovative technologies to be demonstrated as part of the decommissioning project.

C-REACTOR AT HANFORD

Facility Description

This large-scale demonstration project is the safe storage or "cocooning" of the C-Reactor at Hanford (3). The C-Reactor is a full-scale production reactor that is presently in a surveillance and maintenance condition. The cocooning of the C-reactor will lower the risks and costs for surveillance and maintenance while awaiting final decommissioning of the reactor. In addition to the C-Reactor, the reactor facility includes a spent fuel storage basin, the control rod storage cave, a storage building, and concrete ventilation shaft, and two water towers.

The C-reactor was a single-pass, graphite-moderated production reactor. Startup of the C-reactor commenced in 1952 and operation was terminated in April 1969. Deactivation of the C-reactor was started soon after that. Fuel rods were removed from the reactor and water in the fuel storage basins was drained. Sediments in the basins were transferred into cask transfer pits. Contaminated surfaces in the basins were stabilized.

Building 105-C, which houses the C-reactor, is 346-feet long, 150-feet wide, and 120-feet high. Reinforced concrete walls that are three to five feet thick surround the reactor pile to provide additional radiation shielding.

The fuel storage basins served as an underwater collection, storage, and transfer facility for irradiated fuel rods discharged from the C-reactor. Next to the fuel storage basin is the Metal Examination Facility that contains manipulators, viewing stations, and tools for remotely handling irradiated fuel rods under 20 feet of water.

Contamination

The most recent survey of the C-reactor facility was conducted in September 1994. Four rooms had dose rates greater than 100 millrem per hour. Eighteen rooms and areas had smearable beta-gamma emission rates greater than 1,000 disintegrations per minute (dpm) above background. More than 20 rooms and areas had fixed contamination with greater than 1,000 dpm above background. In addition, the facility includes hazardous contaminants of lead, chromium, and cadmium.

Scope of Large-Scale Demonstration Project

Cocooning of the C-reactor will involve removal of all equipment and structures in the 105-C building, except the thick concrete shielding walls surrounding the reactor. All shielding walls will be extended with additional concrete to the height of the tallest shielding wall. A precast, double-tee roof will be installed on top of the shielding walls. All penetrations in walls will be filled with concrete. All ancillary buildings, water towers, and other structures will be removed, leaving a smaller footprint of the reactor block enclosure. The cocooning project will reduce the size of the C-reactor facility nearly 50 percent.

Status

In 1996, activities will include selection of innovative and commercial D&D technologies to incorporate into a deactivation (i.e., cocooning) plan. Currently, a conceptual design is being developed for the overall project.

OTHER D&D TECHNOLOGY DEMONSTRATIONS

Beyond D&D technology demonstrations in the large-scale demonstration projects, the D&D Focus Area funds technology demonstrations at other DOE facilities. More recent technology demonstrations include the Advanced Worker Protection System, Electrohydraulic Scabbling, and Pipe Explorer.

Advanced Worker Protection System

Current protective suits encapsulate the worker's body, which prevents heat generated by the worker's activity from leaving the suit. Most workers require a rest every 15 to 30 minutes to relieve heat stress. Worker productivity is low because time is lost to donning and doffing of suits and rest periods.

Oceaneering Space Systems (OSS) has developed a prototype of an Advanced Worker Protection System (AWPS), which will reduce the heat stress of workers performing D&D and enable them to be more productive for a longer time (4). The AWPS uses a liquid-air backpack to provide air to workers for breathing and cooling. Breathing air is provided to a pressure-demand respirator worn by the worker. Air is also used to cool water circulated in a liquid-cooling garment worn against the worker's skin. A heat exchanger within the backpack (i.e., dewar) uses warm circulating water being returned from the cooling garment to vaporize the liquid air. The worker wears a two-piece splash protection suit or a totally encapsulating suit.

The Institute for Environmental Research at Kansas State University completed human performance tests on an AWPS protective suit. Firefighters from Manhattan, Kansas, were the test subjects who walked on a treadmill at 3 miles per hour for up to 90 minutes wearing three different types of apparel. The three different types of apparel were shorts and shirt, the AWPS protective suit, and standard clothing and self-contained breathing apparatus worn by firefighters. The test subjects were monitored for heart rate, blood pressure, and body temperature. Firefighters could walk on the treadmill for 90 minutes when wearing the OSS suit compared with only 20 to 30 minutes when wearing the standard fire fighting suit. Tests were terminated at the discretion of the firefighter, or when the heart rate, blood pressure, or body temperature reached prescribed limits.

Electrohydraulic Scabbling

Textron Defense Systems has developed an electrohydraulic (EH) device that scabbles contaminated concrete surfaces (5,6). In this device, shock waves and cavitating bubbles are generated in water by strong electric discharge pulses between two mechanically positioned electrodes. The direct and reflected shock waves impinge on the concrete surfaces, crushing and cracking the concrete. The water efficiently transfers discharged energy and retains debris. How much water used is minuscule compared to scabbling with a high-pressure water jet.

The power supply, water pump, filters, tank, separator, and robot for controlling the position of the electrodes and water jet are mounted on a remote controlled mobile carriage. Concrete rubble is separated from the waste and retained in a tank; the filtered water is recirculated for additional scabbling.

In September 1995, a prototype electrohydraulic scabbling unit was demonstrated on a contaminated concrete floor in Plant 6 at Fernald. Data on core samples obtained from seven different test patches indicated that 72 to 95 percent of the uranium contamination was removed from the concrete. These results suggest that the back contamination by water or particulates on the floor was minimal, but that the depth of uranium penetration in the floor was deeper than the average scabbling depth, which was about 3/8th inch.

Pipe Explorer

Science and Engineering Associates has developed a Pipe Explorer™ System, which remotely surveys radiological contamination inside pipes (7). The Pipe Explorer™ uses an inverting membrane deployment system to tow standard radiation detectors through pipes. The initial radiation sensors were sodium iodide and cesium iodide scintillation detectors coupled to photomultiplier tubes. Electrical signals proportional to the radioactivity are transmitted via cable to a data acquisition system. The electrical signals can be analyzed for gross radiological contamination or for radiation levels associated with specific isotopes. Laboratory tests showed that the Pipe Explorer™ can tow a sodium iodide detector through at least 200 feet of two-inch (or greater) diameter pipe containing multiple elbows. Video cameras and pipe locators have also been successfully deployed with the Pipe Explorer™.

In April-May 1995, the Pipe Explorer™ was demonstrated for the DOE Formerly Utilized Sites Remedial Action Program (FUSRAP) at a facility in Adrian, Michigan. This facility had more than 1,000 feet of buried pipe containing varying amounts of uranium-contaminated oil. To quantify the degree of contamination, FUSRAP was the host to a demonstration of the Pipe Explorer™ at the facility. In all, thirteen survey events were conducted in eight drain pipes. Surveys were conducted before and after remedial efforts on the drain pipes. Both manually-operated and motor-operated deployment methods were evaluated during the surveys. In one survey of 120 feet of pipe, the Pipe Explorer™ equipped with a high-sensitivity beta detector could detect surface activities between 600,000 and 1.1 million disintegrations per minute per 100 square centimeters, except for a small ten-foot portion of the pipe that had no contamination. The Pipe Explorer™ saved about $1.5 million for characterization of the drain lines, which includes the avoided cost of excavating the lines to assess activity levels in them.

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