CLEANING UP THE COLD WAR MESS
REACTOR DECOMMISSIONING - A GROWING BUSINESS OPPORTUNITY

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ABSTRACT

With the fear that Hitler’s Germany might invent the world’s first atomic bomb, the U.S. began the top secret “Manhattan Project” in 1942. In less than three years the U.S. was successful in building both a uranium bomb and a plutonium bomb. During that time, the U.S. Army Corps of Engineers managed the construction of monumental plants to enrich uranium, production reactors to make plutonium and reprocessing plants to extract plutonium from the reactor fuel. However, following World War II, relations between the U.S. and Russia were strained and with as impending threat from the Soviets, the now infamous “Cold War” began. Over the next five decades the U.S. spent an estimated $300 billion manufacturing nuclear weapons until 1991 when the sudden collapse of the Soviet Union brought an abrupt end to the nuclear arms race and the Cold War. Because the end of the Cold War was so sudden, many of the facilities were not closed properly and still pose environmental and health risks. Now, the Corps is assisting the Department of Energy, the Army and NASA in decommissioning nuclear reactors that were used for research on and production of nuclear weapons during the Cold War.

INTRODUCTION

Like most industrial and manufacturing operations, the production of nuclear weapons has generated wastes. But unlike other wastes, these have unique radiation hazards. In the late 1980's all major facilities in the nation's nuclear weapons complex were shut down temporarily. Then, because the end of the Cold War came so suddenly, many of the facilities were not closed properly and much of the wastes remain in temporary storage posing environmental and health risks. The U.S. Department of Energy (DOE) currently owns and maintains more than 2,000 contaminated facilities that will require decontamination and decommissioning. It estimates that there are about 2,700 metric tons of spent fuel, 100 million gallons of high level waste, which is enough to fill up 10,000 tanker trucks, 100 metric tons of plutonium, and thousands of tons of contaminated scrap metal, steel and concrete. In addition, dozens of Cold War-era nuclear reactors have been shut down and are awaiting dismantlement.

Estimates to Clean Up the Nuclear Weapons Complex

In its 1996 Baseline Environmental Management Report, the DOE estimated that it would take 75 years and $227 billion to clean up the nuclear weapons complex. Because of this enormous price tag, in 1997, the DOE introduced its "10 Year Plan" which urges the use of innovative technologies, processes and thinking to complete clean up activities at most of its sites within 10 years and to significantly reduce the "Cold War Mortgage." Good results are being accomplished through this strategy; however, there is much more work to do.

The Corps’ Reactor Decommissioning Experience

The U.S. Army Corps of Engineers has decommissioned an Army nuclear reactor and was also an integral part of the team that decommissioned two DOE reactors. It is currently decommissioning two research reactors for NASA and is planning decommissioning efforts for three additional Army nuclear reactors in immediate need of decommissioning.

Army’s Research Reactor - Watertown, MA

The Corps successfully completed the decontamination and decommissioning of the Army’s first research reactor and the depleted uranium research facilities at the Army Research Laboratory in Watertown, Massachusetts. The actions were performed for the Army Materiel Command as part of the Base Closure program. The research reactor operated at 1-megawatt to 5-megawatts power levels from 1960 to 1970, and was then held in stand-by status until 1992, when the Army began the decommissioning process. The reactor was a “swimming pool” type, about 30 feet deep and 10 feet in diameter constructed of high density concrete up to 4 feet thick. The Corps prepared a decommissioning plan for U.S. Nuclear Regulatory Commission (NRC) review in October 1991 and performed the decontamination activities from June to December 1992, leading to license termination in October 1993. The cost of the decommissioning and subsequent building demolition was $18 million, which included about $5 million for disposal of low-level radioactive wastes (LLRW) at Barnwell, South Carolina. The Corps also successfully completed the decontamination and decommissioning of eight adjacent buildings used for depleted uranium research at Watertown. Decontamination methods included washing, scrapping and brushing, chipping and scabbling, excavation and removal of concrete and soil, and removal of equipment. Alternative methods such as CO_2 blasting, metal melt and materials recycling were used to reduce disposal volumes. The presence of mixed waste, in the form of cadmium and lead-contaminated soils, and acid and cyanide liquids, compounded the difficulty of treatment and disposal of radioactive waste. The facility decommissioning cost about $47 million and generated about 175,000 cubic feet of LLRW for disposal. The Corps and its contractors were able to complete both decommissioning projects without any NRC violations, which was of utmost importance to our customer, the Army Materiel Command. There were several lessons learned during the process including a need for close coordination with customer and understanding the importance of license responsibilities, the importance of adequate characterization and the ability to adjust when necessary, maintaining open communications with the NRC, and maintaining flexibility in the decommissioning plans.

DOE’s Chicago Pile 5 Research Reactor - Argonne, IL

Under an Interagency Agreement with the DOE’s National Energy Technology Laboratory (NETL), the Corps assisted the Department of Energy in the successful decommissioning of the Chicago Pile 5 (CP-5) Research Reactor in Argonne, Illinois. This facility was taken to an unrestricted release end state in 1998 at a cost of $30 million. This project was co-managed by NETL and the DOE-Chicago Operations Office utilizing an integrating contractor team composed of the Corps of Engineers, Duke Engineering and Services, Commonwealth Edison, ICF Kaiser, 3M, Florida International University, and Argonne National Laboratory. The Corps provided technical expertise for the evaluation and selection of innovative technologies to be used at the site and conducted cost analyses to determine if the technologies were cost effective. The CP-5 test reactor was 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 was capable of generating 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. During the course of this three-year decommissioning project, 22 improved decontamination and decommissioning technologies were demonstrated and validated, and 7 of these were further used to decontaminate and dismantle the reactor including 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 of the building.

DOE's 105-C Production Reactor - Hanford, WA

The Corps also assisted with the decommissioning of the DOE's 105-C Production Reactor in Hanford, Washington. This facility was taken to an interim safe storage end state in 1998 at a cost of $22 million. This three-year project was co-managed by NETL and the DOE-Richland Operations Office utilizing an integrating contractor team composed of the Corps of Engineers, Bechtel Hanford, CH2MHill, IT Corporation, ThermoElectron, Bechtel National, AEA Technologies, Montgomery Watson, Morrison Knudson, and the DOE Savannah River Operations Office. The Corps provided technical expertise for the evaluation and selection of innovative technologies to be used at the site and conducted cost analyses to determine if the technologies were cost effective. The 105-C production reactor was one of nine water-cooled graphite-moderated plutonium production reactors constructed and operated on the DOE Hanford Reservation between 1943 and 1971. In 1993, DOE issued a Record of Decision to complete the decommissioning of these reactors. An alternatives study identified five options, ranging from total dismantlement and a greenfield end state (unrestricted release) to interim safe storage for 50-75 years. The cost of unrestricted release was estimated to be $160 million. The interim safe storage alternative was selected, and completed at a cost of $24 million. The footprint of the facility was reduced by 70%, and surveillance, monitoring and maintenance costs were reduced by 90%. During the course of this three-year decommissioning project, 20 improved decontamination and decommissioning technologies were demonstrated and validated, and 13 of these were deployed in the project. These improved technologies have been incorporated into the technical baseline for the safe storage of the next two production reactors, F and DR, thereby lowering the projected cost from $24 million each to a total of $16 million. Ultimately, eight of the reactors will be placed into safe storage for less than the cost of proceeding to an unrestricted release end state for just one reactor and one of the reactors will be reserved as a museum. At present funding levels, the risk to the workers, public and environment will be substantially reduced decades earlier than could have been achieved for the unrestricted release end state.

NASA's Plum Brook Reactor Facility – Sandusky, Ohio

The Corps is presently decommissioning and dismantling NASA's only nuclear reactor facility at Plum Brook Station in Sandusky, Ohio. Sandusky is 56 miles west of Cleveland and Plum Brook Station consists of 6400 acres. The history of Plum Brook Station dates back to 1941, when the War Department acquired the land to construct a munitions plant. The plant produced TNT until the end of World War II. After the war, the land remained idle until 1956, when NASA obtained it for the construction of a nuclear research reactor facility to study the effects of radiation on materials used in space flight. In 1962, NASA began operation of the Reactor Facility which included a 60-megawatt nuclear test reactor and a 100 kilowatt mock-up reactor. In 1973, after successfully completing the moon landing, NASA was faced with severe budget reductions. As a result, NASA decided to cease operations at several research facilities across the country, including the reactor facility at Plum Brook Station.

By the early 1980's, NASA recognized the reactor facility would never be reopened and in 1997 the NRC requested that NASA decommission the reactor facility. In 1998, NASA requested the Corps to lead to team to develop a Decommissioning Plan and dismantle the reactor facility. The NRC approved the Decommissioning Plan in 2002 and construction at the facility began shortly thereafter. The Corps and its contractors have removed the reactor internals and shipped them offsite to Barnwell for disposal. They are in the final stages of tearing down all of the adjacent facilities and turning the site into a "greenfield" for unrestricted use.

Innovative Technology Demonstrations

The U.S. Department of Energy funded the demonstration of several innovative technologies during the dismantlement of the DOE's nuclear reactors. The purpose of the demonstrations was to facilitate acceptance of the new technologies that were successful and cost effective so that they would be deployed for repetitive and reliable uses across the nuclear weapons complex.

The Mobile Automated Characterization System (MACS) was one of the first innovative technologies to be tested. It is a battery-powered, autonomous robot with a laser positioning system. It can detect alpha and beta contamination on floor space in preparation for decontamination and can perform long-term surveillance and maintenance tasks. Because it is operated from a remote location, MACS reduces worker exposure and provides accurate characterization data.

A remote mobile work system called "Rosie" was another innovative technology that performed successfully during its demonstration. It provides a telerobotic, mobile platform from which other robotic tools can be deployed for a wide variety of demolition and decontamination tasks. In a demonstration at the Chicago Pile 5 Reactor Project it broke up high-density concrete in an hour compared to the traditional method of workers using jackhammers taking several days.

The Dual-Arm Work Platform was a new technology that has two hydraulic manipulator arms mounted on a hydraulic positioning base. Equipped with a circular saw, it cut up large sections of the Chicago Pile 5 Reactor, removed contaminated lead panels, and dismantled graphite bricks. It can accept a variety of tooling configurations and its remote operation removes workers from high radiation environments.

A position-sensitive floor radiation monitoring system was demonstrated at the Hanford C-reactor and mapped Beta/gamma contamination faster and more accurately than traditional methods. Using a wheel encoder, the detector scanned over the floor in a series of 4-foot-wide strips. Commercially available software then created a map that displayed radioactivity levels and corresponding locations without the need for human transcription.

One of the largest needs to be addressed was radiological clearance surveys on buildings targeted for demolition. Clearance is required before these buildings could be opened to the atmosphere in preparation for dismantling. A successful demonstration verified that a Laser Induced Fluorescence technology can reduce the amount of time it takes to perform these surveys. The technology also enhanced safety by eliminating the need for workers to climb scaffolding to obtain radiological swipe samples from overhead surfaces.

Future Decommissioning of Army Reactors

Under the Army Reactor Development Program, the Corps has operated and performed initial decommissioning of 3 more reactors within the Department of the Army. The Corps is currently involved in initial stages of decommissioning the Fort Belvoir and Sturgis Barge Reactors and is in the final decommissioning stage for the Fort Greely Reactor in Alaska. On February 2, 1953, the USACE issued a report entitled Army Nuclear Power. The report concluded that a military requirement existed for electric power plants at remote locations. The Corps’ research indicated that nuclear power plants were technically feasible and would be both militarily and economically justifiable for some of the Army’s future power generating facilities. Lt. Gen. Samuel D. Sturgis, Chief of Engineers, sent the report up the chain-of-command to the Military Liaison Committee who concurred and sent it to the Atomic Energy Commission. On April 13, 1953, Secretary of the Army, Robert Stevens, advised the Chief of Staff that he “wholeheartedly” subscribed to the Corps objectives and he directed the Army to “...explore vigorously all possibilities of atomic application in meeting military requirements.” In 1954, the United States Army began development of small nuclear power plants designed to generate electrical power. The program evaluated the development of different reactor designs including pressurized water, boiling water, gas, and liquid metal cooled reactors. The objective was to design nuclear power plants that could be transported by air, erected quickly, and operated under extreme environmental conditions. Nine concepts were designed, built, and operated by the Corps and seven additional reactors were designed but never built. The Corps is currently working to decommission three reactors at Fort Greely, Fort Belvoir and on the Sturgis Barge. All three are currently in safe-store condition. Essentially this means that after final shutdown, the nuclear fuel and control rods were removed from each reactor and returned to the DOE for disposition. Other structural materials that were radiological contaminated, and minor primary reactor system components, were cut up, placed in the reactor vessel, which was filled with gravel or concrete and sealed. Initially, it was decided that safe storage would be the safest and most cost-efficient mechanism to maintain the reactors until radiation in the reactors decayed to low levels and decommissioning could occur at much less risk. This could take over 50 years. However, a 1998 study by the U.S. Army Nuclear and Chemical Agency found that maintaining the three deactivated reactors in a safe storage may not be the most cost-effective strategy due to escalating decommissioning costs, maintenance costs, and the continuing decline of waste disposal options.

The first of three of the Army’s nuclear reactors to be selected for decommissioning was the SM-

1A at Fort Greely, Alaska. The SM-1A began operation in 1962 and produced power until 1973. It was a field application of the SM-1 Reactor at Fort Belvoir, Virginia, and was built to evaluate the use of nuclear power reactors under adverse weather and geographic conditions. The SM-1A was a 20-megawatt reactor capable of producing more than 1,600 kilowatts of power, plus steam for base heating and laundry services. The next Army reactor selected was the SM-1 Reactor at Fort Belvoir. This reactor is notable for being the first atomic power plant to feed electricity into a commercial power grid. The third Corps deactivated nuclear reactor to be selected for decommissioning is the mobile reactor, MH-1A, mounted inside the Sturgis, a World War II Liberty Ship converted to house a nuclear power plant. The reactor was built in 1966 and went critical in early 1967. The Sturgis, a 45-megawatt power plant, was first harbored at Fort Belvoir for operational testing and training. It was then towed to the Panama Canal Zone where it generated electrical power from 1968 through 1976. The MH-1 was shut down in 1976 and towed to the James River Fleet in Norfolk Harbor where it remains today.

Since deactivation, ensuring the safety of facility staff, the public, and the environment is the Corps' primary responsibility until the reactors are decommissioned. A Radiation Protection Program at each facility details safe procedures for working in or near the reactor facilities. The Program outlines activities to ensure the radiation dose from each facility to workers and the public is as low as reasonably achievable. A close working relationship between Corps' staff, the Army Reactor Office, and the installation Department of Public Works' staff ensures that appropriate protection of the public health and safety is maintained. The Alaska District is in the final phases of a clean-up operation at Fort Greely for the SM-1A. Low-level contamination of soils around a waste discharge pipeline was detected during a recent base closure and realignment action. The contaminated soil has been removed and is awaiting transport to a disposal facility. The Baltimore District has responsibility for the Fort Belvoir and Sturgis reactors. Low-level contamination around the SM-1 at Fort Belvoir has been removed and disposed of at a licensed facility. Baltimore is now performing an "All-Hazards Survey" of the Sturgis to identify the hazards (radiation, lead-based paint, asbestos, etc.) and quantity of hazardous materials present. This data will be used to develop accurate cost estimates for final decommissioning of the reactor and barge. The decommissioning could be performed much earlier than initially proposed under the safe-store model. Until then, the Sturgis is routinely structurally evaluated and maintained to ensure the environment is fully protected from any contamination.

CONCLUSION

With dozens of Cold War era reactors in need of decommissioning, this is now a tremendous business opportunity for the nuclear industry. The DOE estimates that it cost over $300 billion to build and maintain the nuclear weapons complex since the Manhattan Project. In its 1996 Baseline Environmental Management Report, the DOE estimated that it would take 75 years and $227 billion to clean up the Cold War mess. How the U.S. unleashed the fundamental power of the universe is one of the greatest accomplishments of our time. Although it was an enormous challenge to build the nuclear weapons complex, it is perhaps an even greater challenge to safely and effectively downsize much of these facilities. This endeavor will require perhaps a greater level of commitment and cooperation from government, federal and state regulators, industry, academia and the public. To be successful, we must draw on the ingenuity and experience of each of these groups to accomplish this enormous undertaking and clean up the aftermath of the Cold War.

REFERENCES

1. Closing the Circle on the Splitting of the Atom, U.S. Department of Energy, Office of Environmental Management, Second Printing, January 1996.