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Decommissioning Of A Facility In A Historical Reactor At SRS: Achieving Both Historical Significance Preservation And Effective In-Situ Decommissioning - 15275

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ABSTRACT

The Savannah River Site (SRS) is an 802 square-kilometer United States Department of Energy (USDOE) nuclear facility located along the Savannah River near Aiken, South Carolina, where Management and Operations are performed by Savannah River Nuclear Solutions, LLC (SRNS). In 2004, USDOE recognized SRS as a structure within the Cold War Historic District of national, state and local significance because it is composed of the first generation of facilities constructed and operated from 1950 through 1989 to produce plutonium and tritium for our nation's defense. USDOE agreed to manage the SRS 105-C Reactor Facility as a potentially historic property due to its significance in supporting the U.S. Cold War Mission and for potential for future interpretation.

The Disassembly Basin (DB) in C Reactor was evaluated for action under CERCLA. Data indicated there were over 830 curies of radioactivity associated with the basin sediments and approximately 9.1 million (M) liters (L) of contaminated water, not including a large quantity of activated reactor equipment, scrap metal, and debris on the basin floor. The release of DB water could potentially migrate to the aquifer and contaminate groundwater. The need for an action was identified to reduce risks to personnel in the facility and to eliminate the possible release of contaminants into the environment. In-situ decommissioning was selected as the remedy. The remedial action proceeded in stages:

- Above-grade modifications to the interior of DB building
- Relocation of irradiated scrap and reactor components to the deepest segments of the DB
- Construction of a metal building to house evaporators
- Forced evaporation of the DB's radiologically contaminated water
- Grouting with special hybrid grouts
- Removal of the evaporators and temporary building.

Since the building itself was not demolished and will remain unchanged in appearance with the exception of filling the DB with grout, this ISD removal action/methodology did not adversely impact the historical significance of the 105-C Reactor Building, in accordance with the National Historic Preservation Act, nor did it adversely affect the ability to determine the full extent and details of preservation at some later date.

Both special hybrid grout materials met all requirements. Overall average 7-day compressive strength for the dry area mix was 1.54 MPa (223 psi) and for the underwater mix 2.94 MPa (427 psi).Overall 28-day compressive strength for the dry area mix was 2.88 MPa (417 psi) and for the underwater mix 4.99 MPa (724 psi). A limited amount of testing was also performed at 91 days, where the overall compressive strength for the dry area mix was found to be 9.40 MPa (1363 psi) and for the underwater mix 13.98 MPa (2028 psi). All compressive strength values far exceeded the 0.34 MPa (50 psi) minimum requirements.

The special, flowable-fill grouts designed and used for P- and R-Reactor ISD and used again for this 105-C ISD removal action resulted in considerable labor, cost, and schedule savings versus conventional materials. As an added bonus/benefit, the $C0_2$ footprint of the SRS C-Reactor DB ISD was minimized by using a small amount of cement and byproduct material to produce the structural fill materials.

INTRODUCTION

The Savannah River Site (SRS) is an 802 square-kilometer United States Department of Energy (USDOE) nuclear facility located along the Savannah River near Aiken, South Carolina, where Management and Operations are performed by Savannah River Nuclear Solutions, LLC (SRNS). In 2004, USDOE recognized SRS as structure within the Cold War Historic District of national, state and local significance composed of the first generation of facilities constructed and operated from 1950 through 1989 to produce plutonium and tritium for our nation's defense. USDOE agreed to manage the SRS 105-C Reactor Facility as a potentially historic property due to its significance in supporting the U.S. Cold War Mission and for potential for future interpretation. This reactor has five (5) primary areas within it, including a Disassembly Basin (DB) that received irradiated materials from the reactor, cooled them and prepared the components for loading and transport to a Separation Canyon for processing. The 6,317 square meter (m^2) area was divided into numerous work/storage areas. The walls between the individual basin compartments have narrow vertical openings called "slots" that permit the transfer of material from one section to another. Data indicated there was over 830 curies of radioactivity associated with the basin sediments and approximately 9.1 million (M) liters (L) of contaminated water, not including a large quantity of activated reactor equipment, scrap metal, and debris on the basin floor. The need for an action was identified in 2010 to reduce risks to personnel in the facility and to eliminate the possible release of contaminants into the environment. The release of DB water could potentially migrate to the aquifer and contaminate groundwater.

USDOE, its regulators [U. S. Environmental Protection Agency (USEPA)-Region 4 and the South Carolina Department of Health and Environmental Control (SCDHEC)] and the SC Historical Preservation Office (SHPO) agreed/concurred to perform a non-time critical removal action for the In Situ Decommissioning (ISD) of the 105-C Disassembly Basin. ISD consisted of stabilization/isolation of remaining contaminated water, sediment, activated reactor equipment, and scrap metal by filling the DB with underwater non-structural grout to the appropriate (-4.877 meter [m]) grade-level, thence with dry area non-structural grout to the final -10 centimeter (cm) level. The roof over the DB was preserved due to its potential historical significance and to prevent the infiltration of precipitation. Forced evaporation was the form of treatment implemented to remove the approximately 9.1M L of contaminated basin water. Using specially formulated grouts, irradiated materials and sediment were treated by solidification/isolation thus reducing their mobility, reducing radiation exposure and creating an engineered barrier thereby preventing access to the contaminants. Grouting provided a low permeability barrier to minimize any potential transport of contaminants to the aquifer. Efforts were made to preserve the historical significance of the Reactor in accordance with the National Historic Preservation Act.

ISD provides a cost effective means to isolate and contain residual radioactivity from past nuclear operations allowing natural radioactive decay to reduce hazards to manageable levels. This method limits release of radiological contamination to the environment, minimizes radiation exposure to workers, prevents human/animal access to the hazardous substances, and allows for ongoing monitoring of the decommissioned facility.

Field construction was initiated in August 2011; evaporator operations commenced January 2012 and ended July 2012 with over 9M L of water treated/removed. Over 8,525 cubic meters (m^3) of grout were placed, completing in August 2012. The project completed with an excellent safety record, on schedule and under budget.

The USDOE concept for ISD is to physically stabilize and isolate intact, structurally robust facilities that are no longer needed for their original purpose of producing (reactor facilities), or processing (isotope separation facilities), or storing radioactive materials. Funding for accelerated ISD was provided under the American Recovery and Reinvestment Act. The objectives for this ISD action included:

- Prevent the migration of radionuclides from the disassembly basin structure, water, and/or sludges to the groundwater at concentrations that exceed regulatory standards (i.e., Maximum Contaminant Levels) to the extent practicable.
- Prevent industrial worker exposure to disassembly basin water, sludge, and activated reactor components and metal scrap exceeding 1E-06 industrial worker risk and 1E-03 Principle Threat Source Material risk thresholds.
- Prevent adverse impact to the historical significance of the 105-C Reactor Building by preserving its original configuration to the extent practicable while protecting human health and the environment.
- Eliminate or control all routes of human exposure to radiological and chemical contamination: and
- Prevent animal intruder exposure to radioactive and hazardous contamination.

The removal action objectives listed above were consistent with the *Early Action Record of Decision for Remedial Alternative Selection for the C-, K-, L-, and R-Reactor Complexes.* General technical requirements determined to be applicable to all grout materials being used to fill the 105-C DB were:

- Compressive strength >0.34 MPa (50 psi);
- Hydraulic conductivity $<10^{-5}$ cm/sec;
- Flowable and self-leveling; and have
- Zero bleed water.

The 105-C Reactor Building qualifies as a historically significant structure within the SRS Cold War Historic District per Section 3.3.1.1 of the SRS's Cold War Built Environmental Cultural Resource Management Plan. In accordance with the Programmatic Agreement among the USDOE, SHPO, and the Advisory Council on Historic Preservation, the USDOE has the responsibility for the Cultural Management of all historic properties at SRS. As has been the case with previous SRS decommissioning projects, to the extent practicable and not to impact human health and the environment, efforts were made to preserve the historical significance of the reactor complex in C-Reactor Area in accordance with the National Historic Preservation Act, even though some uncertainty still exists until some later date regarding the full extent and details of preservation for the facility. The ISD removal action of the 105-C DB will protect human health and the environment from potential exposure to radioisotopes remaining in the DB and prevent intruder or industrial worker access to hazardous substances. Furthermore, the ISD removal action does not adversely impact the historical significance of the 105-C Reactor Building, since the building itself was not demolished and will remain unchanged in appearance with the exception of filling the DB with grout, which mitigates the associated hazards to human health and the environment. Above-grade modifications to the interior of the DB needed to support construction activities related to dewatering and grouting of the basin were minimized to the extent practicable and mitigated where necessary. For example: holes that were core drilled through the interior concrete floors to allow for pumping of grout into certain segments of the DB were repaired; wooden boards removed for lowering scrap from hangers to the DB floor and/or grouting were carefully removed, stored and reinstalled once grouting was completed. Hanger rods were unloaded, but were abandoned and grouted in place.

DESCRIPTION

Forced evaporation of the DB's radiologically contaminated water and grouting of the DB with special hybrid grouts was determined to be the preferred method for achieving this removal action. The two (2) hybrid grouts used for the 105-C ISD utilize zero bleed, flowable structural fill technology developed at Savannah River National Laboratory. Both are based on a portland cement-Class F fly ash binder and were specified for bulk filling (dry placements and underwater placements, respectively). The underwater mix was utilized for initial grouting of the DB, displacing shield water upward until adequate grout was in place for shielding, after which remaining water was mechanically evaporated and grouting completed using the dry area grout formulation.

Effectiveness of this approach was determined to be "Good" because removing contaminated basin water and stabilization of the remaining radioactive materials in the basin reduces contaminant volume and mobility. The grouting of the DB and its deep wells stabilized and isolated all the remaining radioactive materials and created an engineered barrier, thereby preventing radiation exposure to human receptors by breaking the exposure pathway. The stabilization also provided radiation shielding to remedial and industrial workers and retarded pore-water velocity beneath the basin, thereby delaying any potential contaminant transport to the aquifer and increasing the decay time in the vadose zone. Stabilization also constituted treatment of the basin contents, satisfying the USEPA "bias for treatment" requirement.

Implementability of this approach was also determined to be "Good" because it is an engineered approach which creates a durable and long-term protective barrier. The evaporator equipment and the grouting equipment were readily available and there was no need for highly skilled technical personnel or operators, since the implementation employed standard construction implementation and operation methods. Additionally, SRS had significant construction experience with these special hybrid grout materials and grouting methodologies gained during recent ISD of the 105-P and 105-R Reactor Buildings, including the 105-P and 105-R DB.

Prior to beginning evaporation, irradiated scrap and reactor components were relocated to the deep segments of the DB (-9.144 m level) to enable the most evaporation possible before reaching the minimum level of shield water remaining (-4.877 m level) at the commencement of grouting.

A 427.4 m^2 temporary, pre-engineered metal building, 710-C **(Figure 1)**, was constructed to house the ten (10) commercially available fuel-oil-fired evaporators used to evaporate the 9.1M L of radiologically contaminated water.

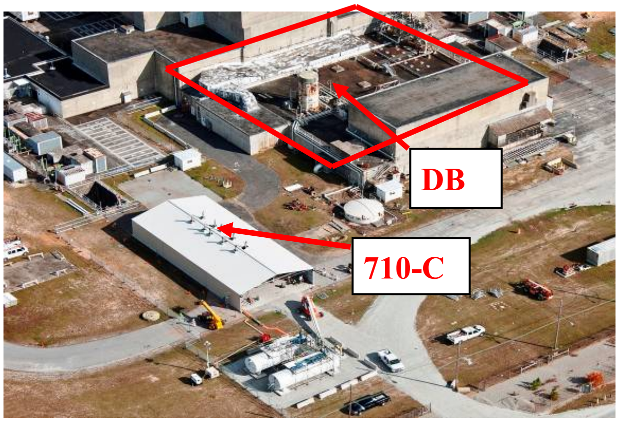

Fig. 1 – Building 710-C Before

Following evaporation of water down to the -4.877 m level, the DB was grouted up to the -4.877 m level, displacing the remaining shield water upward in the DB **(Figure 2)**. Grout was pumped into the basin segments using 10.16-cm diameter slick lines, diverter valves and tremies. Remaining shield water was then evaporated from the basin and the basin grouted up to approximately the -10 cm level (i.e., to/just below the bottom of the concrete floors/catwalks and wooden floors, respectively). Wooden boards, which had been removed to facilitate lowering/relocation of scrap and/or to perform grouting, were reinstalled in their original locations.

Fig. 2 – Building 710-C After

Following completion of evaporation, evaporators and related equipment/materials were removed and disposed and the 710-C temporary building was demolished **(Figure 3)**. Accordingly, this ISD methodology resulted in no significant physical change of the 105-C Reactor Building (except dewatering and filling the DB with grout to grade), thus preserving its architectural significance and original exterior appearance, since the structure over the disassembly basin was not disturbed or demolished.

Fig. 3 – Basin Segment After Grouting

CONCLUSIONS

Since the building itself was not demolished and will remain unchanged in appearance with the exception of filling the DB with grout, this ISD removal action/methodology did not adversely impact the historical significance of the 105-C Reactor Building, in accordance with the National Historic Preservation Act, nor did it adversely affect the ability to determine the full extent and details of preservation at some later date.

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