SAFE SHUTDOWN AND DEACTIVATION OF THE 105-K DISASSEMBLY BASIN AT THE
SAVANNAH RIVER SITE

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ABSTRACT

Nuclear production reactors at the Savannah River Site (SRS) were operated for several years in support of the United States nuclear weapons program. When this overall mission ended, the 105-K and 105-L reactors continued to perform vital missions, including the safe storage of spent nuclear fuel. A spent fuel consolidation effort is underway at SRS, and part of this effort was the safe shutdown and deactivation of the 105-K Disassembly Basin. 105-K ceased reactor operations in the early 1990s and was converted to a nuclear materials management facility. Although not originally designed for long-term storage, the 105-K Basin performed well as an interim, underwater location for reactor fuel and other radiation sources. Following the de-inventory of spent fuel in September 2002, the need to operate the 105-K Basin was eliminated.

During production, the Disassembly Basins were used to temporarily store irradiated components removed from the reactor vessel. They are large concrete pools containing approximately 3.4 million gallons of water to provide cooling and shielding for the stored components. In support of this mission, the Basins were furnished with equipment for maintaining water parameters, monitoring radiation, and handling and reconfiguring the fuel components. Some of this equipment is located within the Basin structures themselves, and other pieces are located elsewhere in the local reactor areas. 105-K Basin deactivation activities included the lay-up, removal, or abandoning of this equipment. Eventual decommissioning activities will likely follow the Site-established plan to evaporate much of the Basin water and use the remaining water to grout-in-place residual contamination and scrap materials.

Traditional deactivation projects include a substantial reduction in overall facility surveillance and maintenance activities and a relocation of all non-essential personnel to alternate work locations. In this case, however, the Disassembly Basin is not an individual facility, but rather is an integral part of the 105-K reactor facility. This facility has enduring DOE missions that are vital to national security and the cost-effective management of DOE nuclear materials. Therefore, the usual method of restricting facility access could not be utilized to provide the deactivated end state of the Basin. The ongoing missions in 105-K necessitate its status as an occupied and operational facility, whereas other SRS reactor buildings that have been deactivated are kept locked. Although comprising its own wing of the 105-K building, the Basin has an interface with the rest of the facility that required certain isolation measures.

This paper will describe the final fuel storage mission of the Basin prior to deactivation, the deactivation activities that were performed, the interface between the deactivated and operational portions of the 105-K facility, and will briefly touch on the eventual plans to decommission the Basin per the SRS methodology.

INTRODUCTION

Nuclear production reactors at the Savannah River Site (SRS) were operated for several years in support of the United States nuclear weapons program. When this overall mission ended the 105-K and 105-L reactors continued to perform vital missions, including the safe storage of spent nuclear. A spent fuel consolidation effort is underway at SRS, and part of this effort was the de-inventory of fuel, safe shutdown, and deactivation of the 105-K Disassembly Basin. 105-K ceased its final reactor operations in 1992 and was subsequently converted to a nuclear materials management facility. Although not
originally designed for long-term storage, the 105-K Basin performed well as an interim, underwater location for spent reactor fuel and other radiation sources. Following the de-inventory of spent fuel at the end of the 2002 fiscal year, the need to maintain the 105-K Disassembly Basin was eliminated, and steps were taken to achieve the deactivated state.

FACILITY DESCRIPTION

The Disassembly Basin (hereafter “Basin”) is a 3.4 million-gallon pool covering approximately 30,000 square feet with a varying water depth between 17 and 30 feet. It is a nearly self-contained wing of the 105-K reactor facility and is enclosed in a reinforced concrete structure with a limited number of entrance doors for personnel and equipment. During reactor operations, the hot, spent fuel assemblies, target assemblies, and other reactor components were discharged from the reactor vessel and placed into the Basin for temporary storage while they cooled and the short-lived reaction products decayed away. There were two main storage configurations: hanging vertically from monorails (SRS fuel assemblies are approximately 15’ long cylinders) and resting horizontally in racks. After their cooling period of up to nine months, the fuel assemblies were trimmed of excess non-fuel material and loaded into transportation casks for shipment via railroad to the onsite chemical separation facilities. 105-K ceased reactor operations in 1988, although a restart effort was subsequently initiated. When the decision was made not to restart the reactor in 1992, a considerable amount of fuel remained in the Basin. Competing resources limited the rate at which the fuel could be removed and dissolved by the separation facilities. SRS nuclear fuel is an aluminum-based uranium alloy and is susceptible to corrosion if stored underwater in adverse conditions. Water samples and aluminum test pieces were analyzed, and the results showed that fuel assemblies stored under the then-current chemical conditions might not survive long enough to be viable. Additionally, accelerated corrosion led to the dissolution of fuel and reaction products that might have eventually lead to environmental release. Although the Basin was already equipped with sandfilters external to the Basin designed to maintain water clarity for underwater fuel handling operations, the filters did not provide the non-corrosive environment needed for successful long-term fuel storage.

The solution for longer-term storage was to reduce the corrosion potential of the Basin water. Two parallel trains of monobed ion exchange vessels were installed in a new external building, each train with a cation and anion vessel in series. Since waste minimization is an important consideration, the system was designed to utilize regenerable ion exchange resin and the regeneration was performed at SRS. Projected radioactivity rates on the resin (due to dissolved radionuclides that adsorbed to the resin) indicated that workers performing the regeneration cycles could receive significant dosages. An additional feature was added to the deionizer system to compensate for this concern. Before reaching the resin, the Basin water was routed through two vessels containing zeolite to strip Cs-137 and other radionuclides from it. This would allow the workers to regenerate the contaminated resin containing non-radioactive electrolytes while minimizing radiation dosage. Once this system was installed in 1996, a side stream of filtered water was thereafter pumped through the zeolite, cation, and anion vessels. A dramatic reduction was observed in Basin water conductivity, the key observable component in corrosion reduction (see Figure 1). This helped ensure that fuel integrity would be maintained for the life of the storage mission. With the removal of all fuel and accountable nuclear material in September 2002, the mission for the Basin was completed, and the most cost-effective path forward was its safe shutdown and deactivation while minimizing surveillance and maintenance activities.
DEACTIVATION STRATEGY

Westinghouse Savannah River Company, the principal contractor at SRS, maintains a company-level manual entitled 1C Facility Disposition Manual. Its purpose is to define the SRS Facility Disposition Program in accordance with DOE Order 430.1A, Life Cycle Asset Management. This manual contains general procedures used by contractors at SRS to transition a facility from full operational status to decommissioning. Facilities are generally taken from full operations to safe shutdown in one step and deactivated in another step, after which it is maintained in safe storage until both funding and schedule allow its decommissioning. The Basin was taken directly from operational status to deactivation in one step due to its relatively simple nature and its location as an integral part of the 105-K facility. A plan based on the safe shutdown procedure was generated, but it contained elements of a formal deactivation plan so that it could serve both purposes.

DEACTIVATION ACTIVITIES

Every operating system in the Basin was removed from service in the process of deactivation, but equipment removal was minimized. Detailed descriptions of the systems and their dispositions follow.

Basin Water Filtration and Deionization Systems

As mentioned above, the filtration and deionization equipment was installed to provide water clarity and a minimally corrosive storage environment. Since all fuel handling was performed underwater for radiation shielding, the ability to see to a depth of several feet was crucial to Basin operations. The sandfilters are three parallel pressure vessels and were supplied by one of two parallel centrifugal pumps rated at about 1,000 gpm. Each vessel was periodically backwashed, and the particulate matter was flushed to an open-top, sub-grade settler tank where it accumulated as sludge. Of the 1,000-gpm flowrate through the sandfilters, approximately 200 gpm were pulled by booster pumps as a side stream that fed the zeolite vessels and deionizers.
The sandfilters and their supply pumps were retired in place, and the sandfilter vessels and associated pipes were drained to the extent possible without major dismantling. The contaminated filter media was left in the vessels because of the significant effort involved in removing it. Not only would the removal process require additional personnel exposure to radiation and contamination, its as-left configuration presents no additional hazard and the removal process would not have been a cost-effective use of facility resources (removing sand was not a routine activity with an approved procedure). Instead of generating waste containers to dispose the filter media, the contaminated sand will be buried along with the vessels during the decommissioning of the 105-K facility. The settler tank was not removed nor emptied since it is currently in a safe state. It was covered with sturdy plastic to prevent animal intrusion and entrainment of the sludge in a heavy wind. The booster pumps feeding the zeolite vessels and deionizers were also retired in place. The zeolite vessels and deionizers were emptied of their contents and drained. Each vessel could have been removed from its location and disposed in a waste burial ground, but the principles of cost-effectiveness and waste minimization dictated that they remain. Consideration was given to leaving the resin and zeolite in their respective vessels (akin to the sand in the sandfilters), but since the radiation rates on the resins were high enough, the vessels’ location was not remote enough, there were existing procedures for resin removal, and there was a clearly defined waste disposal path, the vessels were emptied.

**Deionized Makeup Water System**

To compensate for evaporation, a deionized water system was used to provide makeup water. The system consisted of two parallel trains, each with a cation, anion, and mixed bed demineralization column. With water chemistry a vital part of the spent fuel program, using deionized makeup water eased the load on the large deionizers discussed above. During preparations for deactivation, this system was retired in place and physically isolated from the Basin.

**Radiation Monitoring and Sampling Systems**

Fissile material storage in the Basin required continuous monitoring by Nuclear Incident Monitors (NIMs). These monitors are designed to warn facility workers of potentially lethal doses of ionizing radiation from a criticality accident, including doses caused by fission product gasses. With no fissile fuel remaining, criticality is impossible and the NIMs are no longer needed. Other radiological monitoring instruments and air samplers were used for further protection and data gathering and have also been removed or retired in place. Although miscellaneous activated scrap, contaminated sludge, and contaminated water remain in the Basin, continuous monitoring is not necessary. All entries into the area require the assistance of Radiological Control Inspectors to ensure personnel safety.

**Disassembly (Fuel) Handling and Storage System**

Due to its high radioactivity, all fuel was handled remotely underwater with long-handled tools. When fuel was to be raised above the level of the Basin water, it had to be adequately shielded. This required the use of heavy shipping casks and necessitated maintaining overhead cranes, hoists, monorails, and chainfalls. With the removal of fuel, this equipment was no longer needed and was retired in place.

In addition to the fuel-moving tools, the underwater equipment used to trim the fuel assemblies and place them into bundles for storage was also retired in place. Eventual disposition of this equipment is discussed below.

**Basin Area Ventilation System**

All forced ventilation equipment (two exhaust fans and one supply fan) was shut down during preparation for deactivation. With a relatively small amount of natural ventilation through the Basin area, the routine environmental air sample was eliminated.
Basin Chemistry Control Program

Maintaining high-quality water was perhaps the most vital of all routine surveillance and maintenance activities. Poor quality leads to fuel assembly corrosion that could eventually result in the release of radioisotopes to the environment. Strict controls were placed on conductivity, pH, chlorides, metal ions, temperature, and radionuclides. Each of these parameters was closely monitored to provide trending data that was used to ensure fuel integrity and a minimal radiation dose to facility workers performing resin regeneration and Basin operations.

With the discontinued fuel storage mission in the Basin, the water quality has been allowed to take its natural course. There is no equipment or material left in the Basin for which a pristine chemical environment is warranted.

Discontinued Utilities

The only utility that is actively utilized in the Basin is electricity. Due to the design of the 105-K facility, some circuits and lighting panels that serve other parts of the facility are located in the Basin area. These circuits and panels were left energized. All other main breakers were opened. The power feed to the panels controlling Basin area lighting remains in service to allow turning on the lights during an entry into the Basin area.

Compressed air and various water supplies have been isolated from the Basin. The 105-K facility steam lines traverse the Basin, and have valves inside the area that must be manipulated twice per year. No changes were made to these lines.

Environmental Considerations

When dealing with contaminated facilities, steps must be taken to reduce the environmental impact. Waste generation was kept to a minimum during the deactivation activities. For example, a large amount of contaminated scrap and equipment is underwater in the Basin and could have been removed at great expense of time and money. However, due to the proposed decommissioning path forward (see discussion below), the most cost-effective and environmentally safe disposition was to leave this material in the Basin. Figure 2 below shows the state of much of the remaining scrap. As mentioned above, the contaminated filter media was left in place instead of relocating it to the waste burial grounds. The ventilation systems were shut down to reduce Basin water evaporation and thereby minimize the potential (although already very small) for any airborne release. Structural investigations will be periodically performed to ensure that the Basin walls are not suffering degradation that could lead to water release before decommissioning. All known hazardous materials that were not integral to the facility (e.g. installed lead for shielding) were removed from the Basin prior to deactivation. The overall goal was to safely deactivate the Basin using the minimum level of resources, while maintaining an environmentally and operationally safe and stable posture in accordance with the operational status of the rest of the facility.
Administrative Requirements

There are no routine radiological control activities in the Basin area during normal operations. The doors are locked to prevent casual entries, and anyone needing to enter the Basin is required to be escorted by a Radiological Control Inspector who will perform surveys and ensure that it is radiologically safe. Each person entering the Basin must have adequate radiological worker training and be an active participant in the SRS radiation monitoring program. All doors into the Basin area are padlocked, and the shift manager maintains control of the keys to prevent any unauthorized entry into the area.

There are several portions of the 105-K facility that are designated as “locked up areas.” By definition, these are areas where Life Safety Code requirements are not met, and per procedure all entries into such locations require a Controlled Entry Permit. Fire Protection Engineering must approve each entry permit, and Industrial Hygiene and Safety Engineering will be contacted as well. The Basin area has never had active fire suppression systems. All emergency light batteries and uncontaminated fire extinguishers have been removed from the area because the requirements for routine inspections would drive many more entries than are otherwise required. Upon deactivation, the Basin area became a “locked up area” and this level of control is in place for all entries to ensure personnel safety.

Minimum Surveillance and Maintenance

As mentioned above, activated and/or contaminated scrap remains in the Basin. This scrap consists of non-fuel reactor components (see Figure 2), aluminum fuel assembly end fittings, broken equipment,
tools, and other miscellaneous metallic pieces. Some of this scrap has been introduced into a reactor flux and is therefore activated. As such, some is highly radioactive and must be kept underwater for shielding. Since the Basin is still a part of an operating facility, the water level must be maintained to protect the facility workers. As a part of deactivation, the shift rounds were revised to change the way the level surveillance was conducted. Since entering the deactivated Basin area was not desirable and is administratively cumbersome, a few simple modifications were installed to allow both level detection and water addition to take place from outside the facility. There are two external weir boxes along one of the Basin’s exterior walls that contain an overflow pipe. An opening in the wall at about the desired water level yielded a simple way to monitor the level. A visual check is performed once per day, and if the level is lower than the control limit, water is added via a hose inserted through the opening in the wall.

FACILITY INTERFACE

A second reason for maintaining the water level was the way in which the Basin interfaces with another vital part of the facility. The 105-K facility is primarily a nuclear materials storage location, and the Basin is connected via submerged canal to the reactor process room where material is stored. If the water level should drop low enough, the canal would no longer be submerged, and an air pathway would be opened between the Basin and process room. Since the facility ventilation system maintains a negative pressure in the process room, the potential would exist for Basin contamination to be drawn through the opening into the clean, uncontaminated process room. The main concern was that a brisk flow of air over moist walls would dry them, possibly allowing contamination clinging to them to become airborne. Deactivating portions of facilities while the balance of plant remains operational can lead to problems if all the interfaces are not taken into consideration and mitigating controls put in place.

Aside from the pathway described above, the Basin was rather easily isolated from the rest of the facility. Personnel doors were padlocked, and the internal Basin ventilation systems were retired so that only a small natural draft occurs.

PROPOSED PLAN FOR DECOMMISSIONING

Although the Basin has been deactivated, the facility’s decommissioning is in the distant future. The DOE mission for the 105-K facility could easily span another two decades. Undergoing extensive demolition of the Basin is extremely unlikely to happen while the facility is engaged in vital missions, so any number of policy changes and technology developments could occur between now and Basin’s ultimate end. SRS has studied and developed the safest, most cost-effective ultimate disposition for the various reactor basins (1). The path forward outlined below is currently the most likely decommissioning strategy for the 105-K Basin.

There are basically two alternatives for handling a contaminated facility for permanent decommissioning. Either the contamination is completely removed, resulting in an unmonitored green field, or the contamination is secured in place such that it cannot migrate into the surrounding environment. Of course, the “do nothing” approach could be taken, but the eventual leakage of contaminated water into the water tables could prove disastrous and far more expensive than any decommissioning activity.

Removing the entire structure of the Basin, not to mention the rest of 105-K, would be a ridiculously expensive alternative. Massive amounts of contaminated waste would be generated as well. The only viable solution for a facility the size of an SRS reactor involves fixing the contamination in place. The Facility Disposition Projects group at SRS studied four alternatives for disposing the contaminated Basin water and immobilizing the balance. The first involved transporting about 90% of the water to a treatment facility and grouting (with concrete) the rest of the water, all contaminated equipment, and building rubble. Being the most expensive alternative, and creating a new potential danger of roadway accidents leading to contamination events, this alternative was eliminated from consideration. The second involved treating 90% of the water with an ion exchange process, then releasing it to existing ponds onsite. However, it was determined that radionuclides would still be added to these ponds,
possibly resulting in an offsite release of contamination. The third and fourth alternatives varied only in magnitude. Evaporating about 50% and 65%, respectively, these alternatives would use the remaining water to form the grout and secure all contaminated equipment and scrap in place. Evaporating only 50% of the water, however, would not leave enough space in the Basin after grouting to place contaminated building rubble. Reducing the water level by 65% would provide sufficient water to make the grout and still leave room to collapse much of the contaminated structure on top of the concrete (see Figure 3 below). A cap could then be placed on the site and the contamination would be effectively immobilized inside. Since the total excavation of the site is not feasible, total removal of contamination from the Basin site will not be pursued. Securely binding the contamination and preventing its infiltration into the environment will provide the safest and most cost-effective end state possible.

Figure 3. Illustration of decommissioning strategy: 1.) Evaporate from operational level to 35% full, 2.) Use remaining 35% to form concrete grout, and 3.) Demolish contaminated structure and fill remaining volume with building scrap.

CONCLUSION

Although the typical facility deactivation results in a dramatically reduced personnel concentration and a cessation of major operational activities, the deactivation of the 105-K Disassembly Basin did little to slow the operations of the 105-K reactor facility. The deactivation work was completed safely and within the normal operating budget for the 2001 fiscal year. No additional funds were obtained for the work, which ensured the most cost-effective disposition possible. Perhaps the most valuable lesson learned was in the area of waste disposition. Although the final decommissioning of the facility is several years in the future, it is likely that the grout-in-place method will allow a large amount of contaminated waste to be isolated and secured without the cost of filling up waste burial sites. The large volume of the Basin will be isolated anyway, and it makes good sense to utilize that space to the extent possible instead of using up additional burial volume. Traditional thinking might have led to extracting all scrap and contaminated waste prior to facility decommissioning, but leaving and securing it in place will exhibit better stewardship.

At the present time, the Basin is being minimally maintained (water level only) and will continue in this way until either the deactivation of the entire facility or the issuance of analyses that demonstrate that the water level maintenance is not needed. Deactivating part of the facility has resulted in significant annual cost savings that has been reallocated to additional missions at SRS. No doubt there are numerous other facilities across the DOE complex that could be partially deactivated to save valuable resources.
REFERENCE