Interim Safe Storage of Plutonium Production Reactors at the US DOE Hanford Site – 13438

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ABSTRACT

Nine plutonium production reactors located on DOE's Hanford Site are being placed into an Interim Safe Storage (ISS) period that extends to 2068. The Environmental Impact Statement (EIS) for ISS [1] was completed in 1993 and proposed a 75-year storage period that began when the EIS was finalized. Remote electronic monitoring of the temperature and water level alarms inside the safe storage enclosure (SSE) with visual inspection inside the SSE every 5 years are the only planned operational activities during this ISS period. At the end of the ISS period, the reactor cores will be removed intact and buried in a landfill on the Hanford Site. The ISS period allows for radioactive decay of isotopes, primarily Co-60 and Cs-137, to reduce the dose exposure during disposal of the reactor cores. Six of the nine reactors have been placed into ISS by having an SSE constructed around the reactor core.

INTRODUCTION

The decision to proceed with the ISS of eight of the plutonium reactors was published in the Record of Decision (ROD) for Decommissioning of Eight Surplus Production Reactors at the Hanford Site [2] after public review and comment on the ISS EIS [1]. The SSE of the first reactor was completed in 1998. The latest reactor put into ISS was the N Reactor, completed in July 2012, and is the most extensive SSE project completed to date. N Reactor was Hanford's longest operating reactor and served as a dual purpose reactor, producing plutonium and steam for electrical power production.

The cores of the Hanford plutonium projection reactors are massive objects weighing between 8,100 and 11,000 metric tons. The final disposal concept at the end of the storage period involves demolishing the remainder of the reactor building and removing the cores intact for transport from the bank of the Columbia River to a landfill on the Hanford Site. Washington Closure Hanford (WCH) was selected by DOE to manage the River Corridor Closure Contract Project at the Hanford Site in 2005. As part of that contract, WCH has the lead role in deactivation, decontamination, decommissioning, and demolition of ancillary facilities that supported the N Reactor.

Lessons learned from the demolition, design, and construction of prior SSE projects were applied to subsequent reactor SSE projects. Lessons from the previous eight reactor SSE projects will help pave the way for the last three SSE projects on the Hanford Site.

HANFORD PLUTONIUM PRODUCTION REACTOR OPERATION HISTORY

Between 1943 and 1987, the government constructed and operated nine graphite-moderated, light water-cooled, plutonium production reactors at the Hanford Site. Three of these reactors were built during World War II (1944 – 1945) and six were built during the Cold War (1949 – 1963). These reactors operated approximately 20 years as shown in Table I.

Table I. Hanford Site Reactors and Years Operated.

Reactor	Years Operated
105-B	1944 – 1968
105-D	1944 – 1967
105-F	1945 – 1965
105-H	1949 –1965
105-DR	1950 – 1964
105-C	1952 – 1969
105-KW	1954 – 1970
105-KE	1955 – 1971
105-N	1963 – 1987

As these reactors were shut down work began on deactivation, decontamination, decommissioning, and demolition of the support buildings and facilities around the reactor buildings. The reactor cores created special issues due to high levels of radioactive materials, predominately Co-60, which would cause significant radiological dose to workers demolishing the reactor buildings and cores.

REGULATORY PROCESS

A series of regulatory documents were generated as work planning identified and evaluated concepts for dealing with the reactor cores, as shown in the timeline below.

1980 Environmental Assessment (EA) on 105-F Reactor describing dismantlement of core.
1985 Notice of intent to file an EIS describing a unified approach for eight Hanford reactors. (B, C, D, DR, F, H, KE, and KW)
1985 Draft EIS issued for comments.
1993 Final EIS and Record of Decision issued for eight Hanford reactors. (ISS followed by deferred one-piece removal of the core)
1998 N Reactor deactivation completed.
2005 EE/CA and Action Memorandum issued for N Reactor. (ISS followed by deferred one-piece removal of the core).

These regulatory documents evaluated five alternatives for dealing with the reactor cores:

1. Safe Storage with deferred one piece removal
2. No Action – surveillance and maintenance (S&M) activities continue

3. Immediate one-piece removal
4. Safe Storage with deferred dismantlement
5. In situ decommissioning.

A sixth option of immediate dismantlement was not fully analyzed due to the high costs and high dose exposure from this method.

Options 2 and 5 were not chosen since these did not remove the core from the banks of the Columbia River, which was preferred by most of the commenters. Option 3 was preferred by the majority of commenters but was not chosen since storage of the cores has no significant environmental risk. Option 4 was not chosen due to the higher radiation doses and costs compared to one-piece removal. Option 1 was chosen as environmentally preferred, even though the total cost was slightly higher than option 3 due to the longer S&M period. This decision also took into consideration the relative priority of removing the cores to other work that needed to be completed on the Hanford Site.

The interim storage period of 75 years was calculated on the decay of Co-60. This storage period began in 1993 when the ROD was issued and applies to all reactor cores regardless of when the SSE is completed. The removal of the cores will begin in 2068 and has an anticipated duration of 12.5 years, putting the completion date for the removal of the cores sometime around 2080.

HANFORD REACTOR ISS PROGRESS AND LESSONS LEARNED

Work began on putting the reactor cores into a safe storage condition following completion of the EIS [1] and ROD [2] for reactor ISS. The Tri-Party Agreement signed by the EPA, DOE, and Washington State Department of Ecology established legally binding completion dates for the reactor SSE, all of which have been met so far. The following sections list the order that the SSE was completed for each reactor and lessons learned from the demolition, design, and construction of the SSE.

105-C Reactor (1998)

The 105-C Reactor was the first reactor put into ISS and was a technology demonstration project for demolition and construction of the SSE around the reactor core. A separate subcontract was awarded to an engineering firm to design the SSE. Subcontracts were issued to companies who applied new equipment and techniques to concrete cutting, coring, and radiological surveying activities. Another subcontract was awarded to a construction company to demolish portions of the building and construct the SSE structure. These contracts were concurrent.

Demolition work on the reactor building was also being done concurrently by construction subcontract workers and direct-hire workers on adjacent and overlapping portions of the building, which caused delays and cost inefficiencies. The design of the SSE required all of the existing structural steel on the reactor building to be removed and new structural steel to be installed.

Lessons from this project included completing demolition of unnecessary portions of the reactor building by direct hire work forces prior to starting the construction of the SSE by a subcontractor, having the subcontractor do the SSE design to minimize design change costs, and use as much of the existing structural steel in the SSE design as possible. It was recommended to combine more than one reactor SSE into a contract to gain value from the experience gained on the first SSE. (Fig. 1)

Fig. 1. C Reactor SSE shows low roof slope from removal of all existing roof structures above concrete.

105-DR Reactor (2002) and 105-F Reactor (2003)

The work planning for these two reactors implemented the lessons from the 105-C SSE project and were awarded in one subcontract. Numerous design problems were encountered during the construction of 105-DR and solutions were developed that were anticipated and implemented at the 105-F SSE. The subcontractor designed the SSE using the conceptual design provided in the contract; however, the construction contractor encountered constructability inefficiencies from the many roof peaks and ridgelines of the design. A simpler SSE design was desirable from a constructability perspective. (Fig. 2 and 3)

Fig. 2. The 105-DR (above) and 105-F Reactor SSEs were built to the same peaked-roof design.

Fig. 3. 105-DR and 105-F (above) Reactor SSEs were built to the same peaked-roof design.

105-D Reactor (2004)

A new company won the contract to design and build the 105-D SSE and encountered many issues with the design and construction of the SSE, which validated the lessons from 105-C Reactor SSE implemented at the 105-DR Reactor and 105-F SSE. Since demolition by plant forces was completed prior to awarding the SSE design/build contract, there were no work delays associated with adjacent work. The design of the SSE eliminated a number of the foof peaks and simplified the constructability of the SSE. (Fig. 4)

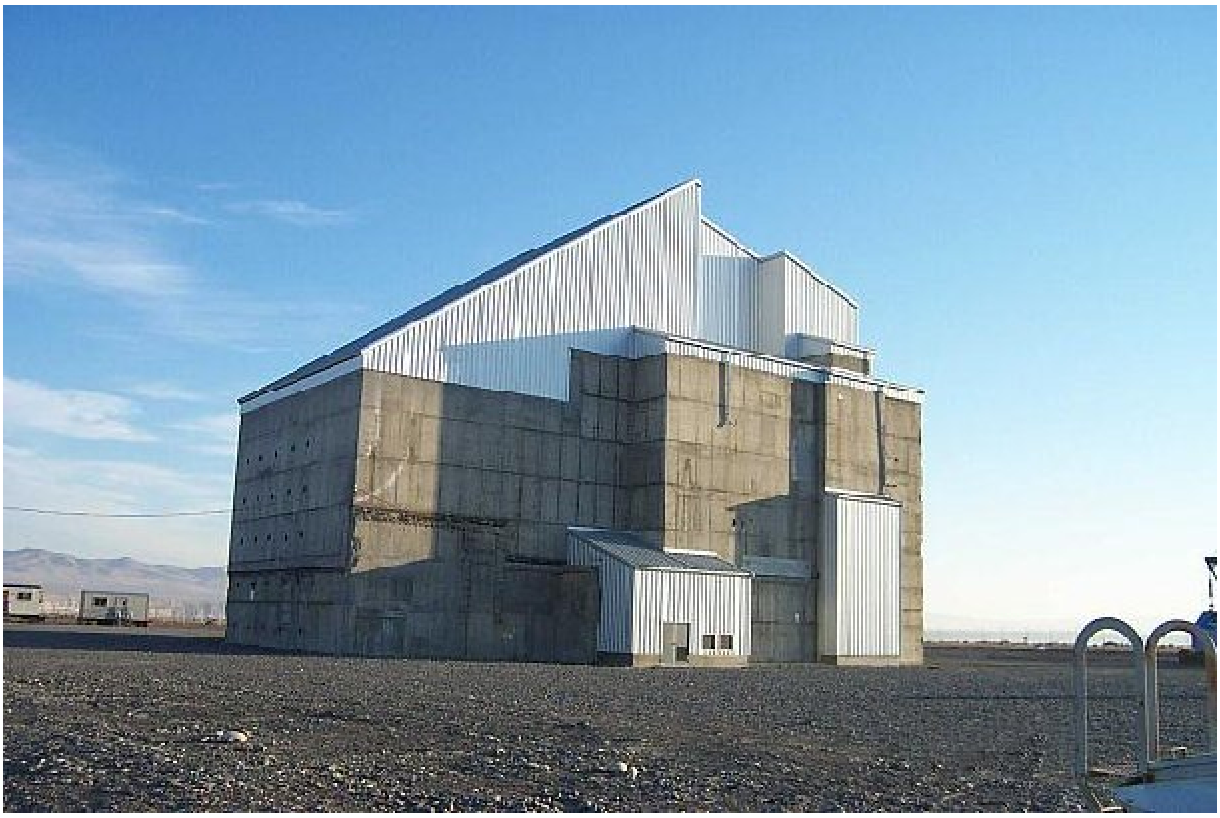

Fig. 4. D Reactor SSE beginning to show change to sloped shed roof design

105-H Reactor (2005)

The contract for 105-H Reactor was won by the same company that had built the 105-DR and 105-F SSEs and lessons were applied from their design and construction experience. The design of the SSE increased the amount of new steel, roofing, and siding materials to create a simple straight-line structure with minimal peaks and trim details. This increased the cost of materials, but the simplified construction reduced the cost of labor and more than offset the increase material cost. (Fig. 5)

Fig. 5. H Reactor SSE showing streamlined roofline design with structural steel erected.

N REACTOR 105-N AND 109-N BUILDINGS (2012)

The prior Reactor SSEs had been constructed by another Hanford Prime Contractor, but WCH was responsible for the hazardous materials removal, building demolition and construction of the SSE for the N Reactor and Steam Generator buildings. The work planning for the N Reactor SSE took a significant change when all of the work to remove hazardous materials and demolish unnecessary portions of the reactor and steam generator building was determined to be applicable to the Davis Bacon Act and was awarded to subcontract companies. The SSE structure consisted of two separate roof sections, one on the 105-N Reactor Building and one on the 109-N Steam Generator Building.

The demolition of the 105-N Building generated 100,204 tons of debris and reduced the footprint of the building from 7,947 to 2,016 m^2 (85,450 to 21,680 ft^2). The demolition of the 109-N Building generated 33,241 tons of debris and reduced the building footprint from 8,415 to 5,052 m^2 (90,480 to 54,318 ft^2). (Fig. 6)

Fig. 6. N Reactor complex prior to demolition (1997).

N Reactor History

The 105-N Reactor Facility was a 4,000-megawatt (thermal) nuclear reactor designed to operate as a dual-purpose reactor. The reactor core is a graphite-moderated, light water-cooled, horizontal pressure-tube facility designed to produce plutonium. By-product steam was routed to the nearby, now demolished, 185-N Hanford Generating Plant (HGP). The HGP was an electrical generation facility owned and operated by the Washington Public Power Supply System that produced 860 megawatts of electricity for use by the public. Construction of the 105-N Reactor Facility began in December 1959 and the reactor operated from 1963 through 1987.

On the south side of the 105-N Facility is the 109-N Heat Exchanger Building, which shares a common wall with the 105-N Facility. Reactor primary coolant water from the 105-N Facility was circulated through to steam generators located in the 109-N Building. Steam from the steam generators was routed to the HGP to generate electricity or sent to the dump condensers inside the 109-N Facility.

Deactivation of the 105-N and 109-N Buildings was completed in 1998, which included shutdown and isolation of all operational systems, cleanup of most radiological and hazardous wastes, inventory of remaining hazardous materials, sealing access areas, and securing both buildings.

N Reactor ISS Facility Modifications

Structural modifications included removal of the fuel storage basin, ancillary support buildings, and most portions of the 105-N Building structure outside of the shield walls that surrounded the reactor components. In addition, the 109-N Heat Exchanger Building was removed up to the steam generator cells. This portion was left because of high radiation levels in the cells and structural integrity concerns with the reactor building because of the shared wall. The reactor pressurizer and its surrounding walls were left in place as part of the SSE and a new roof was installed where it extends above the main roof of the 109-N Building.

A new steel roof was installed over the remaining structures using the existing concrete shield walls as the "new" outside walls of the buildings to enclose both the reactor and heat exchanger buildings within a weather-protected structure. All existing siding was removed and new siding installed over structural steel framing/supports. The roof panels of both buildings are constructed of a preformed aluminum-zinc, alloy-coated steel standing seam roof system (22 gauge). The siding panels are a 22-gauge preformed aluminum-zinc, alloy-coated steel siding system. The 109-N roof panels are laid over steel joists supported by a grid of steel beams and steel columns. The 105-N Building roof panels are laid over a grid of standard steel beams and purlins supported by steel columns. The original 105-N roof has been left in place and the remaining portion of the 109-N Building was demolished down to the 12 m (40 ft) level.

Penetrations in the concrete shield walls were sealed to prevent animal and insect intrusion and water in-leakage into the final SSE. Accessible loose contamination within the shield walls was either removed or fixed to the greatest extent possible. A remote monitoring system (for temperature and water intrusion), permanent power, and lighting were installed, as well as a provision for ventilation air exchange, if required.

An entryway into the 105-N Reactor at ground level is located on the east side of the 105-N Building to allow interior access for periodic inspections. In addition, the steel cover plate at the entrance to Corridor No. 7, located adjacent to the reactor entrance at Room 172, could be unbolted and the security welds removed to have access to the discharge side of the reactor, if considered necessary. Security welds have been installed on all building shield doors to the Zone 1 areas for both 105-N and 109-N and the access door to Stair #6 in Room 172, inside 105-N, and the exterior access doors for both 105-N and 109-N facilities have been locked. (Fig. 7)

Fig. 7. 105-N and 109-N Building SSEs with simplified shed roof designs (2012).

CONCLUSIONS

There are three more reactors at the Hanford Site identified for ISS. Of these, the 105-B Reactor ISS has been deferred while work is being conducted to preserve the reactor as a museum. The SSEs for the 105-KE and 105-KW Reactors will take the ISS project to the next level of maturity. These reactors will have demolition work similar to the previous six, but the SSE design is for a separate steel structure built to encapsulate the reactor building instead of a structure built on top of the existing concrete of the reactor building.

The lessons of using subcontractor companies for both building demolition and SSE construction are being applied and new lessons will be learned as the ISS project moves to completion at Hanford Site.

REFERENCES

1. DOE, 1992, *Final Environmental Impact Statement Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*, DOE/EIS-0119F, U.S. Department of Energy, Washington, D.C.

2 58 FR 48509, 1993, *Record of Decision; Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, WA,* Volume 58, pp. 48509 to 58513 (September 16).