Deactivation of Building 9206—A Manhattan Project Era Facility

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ABSTRACT

Building 9206 at the Y-12 National Security Complex (Y-12) was constructed in 1944 for the Manhattan Project as a predecessor to the much larger Building 9212. The purpose of Building 9206 was to perform chemical recycle, metal production, and recovery of highly enriched uranium, as well as to process product from the electromagnetic separation process. From 1944 until 1993, Building 9206 operated to support various production missions for the U.S. Department of Energy and its predecessor agencies. All operations in Building 9206 ceased in 1994 with the stand-down of operations at the Y-12 plant imposed that same year. A significant inventory of residual uranium-bearing materials and contaminated equipment was left behind in the Hazard Category 2 Nuclear Facility. De-inventory and decontamination of Building 9206 began in 1994 and was conducted intermittently until 2015 with various initiatives and funding sources, but in the absence of a clear deactivation and downgrade strategy. In 2016, with the development of the Building 9212 Exit Strategy, renewed interest for completing the deactivation of Building 9206 led to the development of a nuclear criticality safety downgrade strategy for the 9206 facility. The deactivation accomplishments and lessons learned from Building 9206 are helping to enable the proactive deactivation of Building 9212 prior to its planned shutdown.

MANHATTAN PROJECT

The origins of the United States (U.S.) Department of Energy (DOE) and the National Nuclear Security Administration (NNSA) Y-12 National Security Complex (Y-12) can be traced back to the Manhattan Project. The Manhattan Project was established with the objective of developing the world's first atomic bomb. The top-secret project was an undertaking of the Manhattan Engineer District, organized by the Army Corps of Engineers, which spanned the U.S. and relied on governmental cooperation and authorization to fast-track the creation of an atomic bomb by taking new scientific discoveries from the research and development stage to a full production environment as quickly as possible.

In 1939, Albert Einstein wrote to President Franklin D. Roosevelt warning that German scientists were involved with researching nuclear chain reactions with the intent to create a nuclear weapon. This letter introduced the possibility of nuclear weapons to the U.S., and as a result, President Roosevelt authorized the U.S. military to begin the same nuclear chain reaction research in what became the Manhattan Project. The Manhattan Project found two paths to create an atomic weapon: plutonium and uranium. In 1943, construction of the Y-12 Electromagnetic Plant began in Oak Ridge, Tennessee. This was to be the site of uranium-235 separation using calutrons to electromagnetically separate and collect the uranium isotopes.

Electromagnetic separation, the process of separating isotopes through deflection in electric and magnetic fields, was performed at the Y-12 plant in calutrons which were developed in 1942 by Ernest O. Lawrence at the University of California. There were 1,152 calutrons at the Y-12 plant during the Manhattan Project. Part of the Y-12 mission was to separate uranium-235 for use in the eventual development of the "Little Boy" atomic bomb. Separating the uranium isotopes was done in two stages: the Alpha stage and the Beta stage. The calutrons were arranged in "racetrack" configurations, and all Alpha and Beta stages of the electromagnetic process were performed in separate buildings, consisting of five Alpha buildings and four Beta buildings. The success of the mission depended on these buildings and the calutrons they housed as well as various support and chemical processing buildings, such as Building 9206.

BUILDING 9206

Building 9206, pictured in Figure 1, was constructed in 1944. The design and layout for the building was specific to its purpose of providing chemical processing for the Beta stage of the electromagnetic separation process. Building 9206 housed processes and operations for chemical recycle, charge preparation, highly enriched uranium (HEU) recovery, and enriched uranium (EU) product processing. Most of the uranium that ended up being used in the "Little Boy" atomic bomb was processed in Building 9206. Feed preparation and product processing continued in Building 9206 through 1947, and uranium recovery and reclamation continued through 1951. By 1945 however, most of the building's originally intended processes were being performed in a larger, sister facility—Building 9212. The purpose of Building 9206 began to shift once Building 9212 became operational after the end of World War II (WWII).

Figure 1. Building 9206

In 1947, responsibility and ownership of the Y-12 plant transferred from the Manhattan Engineer District to the newly established Atomic Energy Commission. The electromagnetic plant processes were shut down in 1949, and the Y-12 mission shifted to support other atomic and nuclear missions. During this period, the Y-12 Plant refocused its mission to reclaiming residual amounts of uranium found on equipment and scrap metal. Building 9206 was the main uranium reclamation facility and housed sanding, grinding, chemistry, and incinerator operations to accomplish the new mission. Operations to recover, recycle, or reclaim uranium included mechanical brushing and scraping, nitric acid washing, distillation, and reclaiming solid uranium compounds that had adhered to surfaces. Combustible materials were burned in muffle furnaces and incinerators to recover uranium.

Throughout its operational lifetime, Building 9206 was involved with processing EU, non-EU, and non-uranium materials, while supporting various governmental programs, missions, organizations, and activities. For example, the suitcases used in the NASA moon landing to hold collected rocks and transport them back to Earth were tested in the Building 9206 high-temperature/high-vacuum furnaces for their operational capability in space. A timeline provided in Figure 2 depicts the various operations throughout the lifetime of Building 9206. Accommodating new and diverse missions in Building 9206 required continual modifications to the equipment and processes as well as building additions.

Production of uranium compounds for other sites took place between 1949 and 1972. Uranium metal conversion took place between 1954 and 1964, and casting and machining of uranium metal took place between 1955 and 1965. Between 1972 and 1989, Building 9206 recovered HEU for the Savannah River Site, and converted excess HEU metal to feed for the Portsmouth Gaseous Diffusion Plant from 1980 to 1985. Non-uranium materials operations were introduced in 1950, and non-EU materials operations were introduced in 1951. Non-EU processes and activities carried out in Building 9206 have included reclaiming depleted uranium chips and canning normal assay uranium slugs for nuclear reactor use.

EU materials operations were continuous in Building 9206 until it ceased all production operations in 1993. The processing areas within the building are high contamination areas due to the varied materials and nature of the operations that were conducted throughout the building's lifetime.

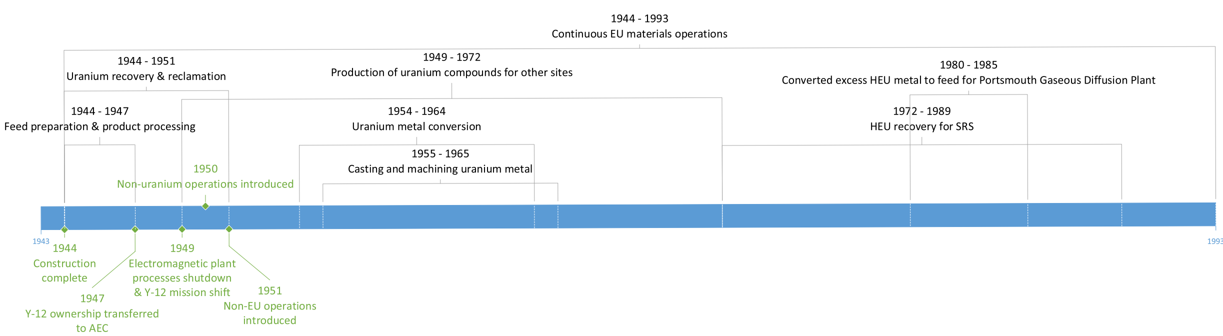

Figure 2. Building 9206 and Y-12 Processes Timeline

BUILDINGS 9206 AND 9212

Construction of Building 9212, the sister facility to Building 9206, was completed in 1945 and is pictured below in Figure 3. Once Building 9212 was operational, it became the primary location for EU processing for the electromagnetic separation process. Like Building 9206, Building 9212 was designed as a chemical process building used for feed preparation and product processing. After WWII, Building 9212 was expanded to accommodate the increased production of uranium from the gaseous diffusion plant and to provide the capability to recover and reclaim uranium from waste materials. Over the years, Building 9212 has been expanded with additional wings and support buildings, resulting in the current 9212 Complex. More than 100 different unit operations or processes have been performed in the 9212 Complex over the course of its life. Today, the 9212 Complex performs four primary functions: (1) uranium metal processing, (2) accountability of HEU from Y-12 plant activities, (3) recovery and reclamation of HEU in a form suitable for storage, and (4) serving as the U.S. source of all HEU used in test, research, or propulsion reactors and for isotope production. The 9212 Complex also supports the International Atomic Energy Agency in sampling surplus EU, packaging HEU for offsite shipment, and producing specialized uranium compounds and metal for research reactor fuel.

Figure 3. Building 9212, after construction (left) and the current Complex (right)

Buildings 9206 and 9212 have similar histories, processes, and operations. Both were constructed for the Manhattan Project as chemical processing facilities to process, recover, recycle, and reclaim uranium in support of the electromagnetic separation process. Similar systems and equipment were included in the building layouts and designs, including the stainless-steel floors. One significant difference between the two buildings is their footprints; Building 9212 is over six times larger than Building 9206.

The amount of nuclear material residing in both facilities drives them to be regulated as Hazard Category 2 Nuclear Facilities. This categorization means that both buildings contain enough special nuclear material for a nuclear criticality to occur, and there is potential for significant on-site consequences in an event of an accident scenario. Both facilities must eventually be turned over to the DOE Office of Environmental Management (EM) for demolition. Before facility turnover to DOE-EM can take place, accountable nuclear materials (both containerized material and removable holdup) must be removed to the extent that the facilities can be downgraded to Hazard Category 3 or radiologically contaminated status. Downgrading Buildings 9206 and 9212 will allow the cancellation of the nuclear criticality safety controls in those facilities, which in turn simplifies the facility turnover to DOE-EM for facility demolition.

BUILDING 9206 DOWNGRADE STRATEGY

In 1994, the Y-12 National Security Complex stood down all production operations. When the production processes were restarted over the following decade, priority was given to restarting key chemical processes and production capabilities in Building 9212. As a result of the stand down and prioritization to resume key capabilities, Building 9206 was left with an inventory of material and holdup within process equipment. In the years that immediately followed, activities to de-inventory and deactivate Building 9206 were conducted in a piecemeal manner as funds and manpower became available. These activities were conducted in the absence of a nuclear criticality downgrade strategy and a fully-funded plan for execution.

In 2016, Consolidated Nuclear Security (CNS), the managing contractor for the Y-12 National Security Complex, along with support from the NNSA Uranium Program Manager, renewed focus on dispositioning legacy materials and developing a plan to downgrade Building 9206. CNS developed the "Nuclear Criticality Safety Strategy for the Downgrade of 9206 Facility" to outline the steps necessary to cancel nuclear criticality safety controls, downgrade the facility from Hazard Category 2, and meet a key criterion for transferring Building 9206 to DOE-EM for demolition. The key steps to the Building 9206 Nuclear Criticality Deactivation and Downgrade Strategy are:

1. Identify and rank systems of nuclear criticality safety (NCS) concern, based on amount of uranium holdup.
2. Define system and endpoint criteria (i.e., < 700 grams uranium-235 per system or component).
3. Obtain non-destructive assay (NDA) data in order to fill data gaps and plan deactivation work packages.
4. Remediate systems as necessary to achieve desired endpoint and ensure nuclear material cannot migrate between systems by complete isolation and/or application of fixative.
5. Perform post-remediation inspection and analysis to confirm criteria are met.
6. Document basis for the incredibility of an inadvertent nuclear criticality in the 9206 facility once all systems have been deactivated and data collected.

The building must be transitioned from its current state to a deactivated state. This mitigates risks that are associated with Building 9206 by driving the potential for a nuclear criticality accident to be incredible, thus negating the need to maintain NCS controls and a credited nuclear criticality accident alarm system (CAAS) in the facility. The quantity of residual holdup present in many of the Building 9206 processing systems requires that the systems be deactivated using specific radiological and nuclear criticality controls. The key NCS criterion for deactivation that must be achieved is that each piece of equipment or connected equipment must be below 700 grams of residual uranium-235 and must include immobilization and/or robust isolation of the remaining equipment.

The general steps of the deactivation process for each of the approximately 80 systems in Building 9206 include:

1. Drain any residual fissile solutions.
2. Mechanically or physically remove solid holdup and highly contaminated components.
3. Isolate systems or components to prevent ingress of water and/or isolate and prevent movement of residual holdup with fixative.
4. Visually inspect equipment after material removal and isolation have been completed using a borescope (as needed) to confirm no visible remnants of material.
5. Final NDA examination to confirm the NCS criterion has been achieved.

All of this work is performed by a multidiscipline team consisting of electricians, machinists, pipefitters, and chemical operators, all of whom are specially trained as radiological workers. Chemical operators have additional training as fissile material handlers. Work activities are monitored by radiological control (RadCon) and Industrial Hygiene technicians to ensure personnel safety is maintained during the deactivation activities. The system deactivation work is labor-intensive and requires the use of personal protection equipment (PPE), respiratory protection, confined space entry, and air monitoring to control the spread of airborne radiological contamination. Due to the conditions of the Building 9206 facility and the PPE required, heat stress is a common safety issue that must be monitored and controlled during deactivation activities. Uranium-bearing solids harvested from the deactivated systems are containerized and sent to Building 9212 for processing and disposition. Any collected liquids are poured into NCS-approved bottles until they can be sampled and processed for disposal in Building 9206. Contaminated scrap metal generated during the deactivation work, such as piping components and ductwork, are staged in an NCS-approved location within Building 9206 until it can be size-reduced using hand tools, characterized, and packaged into U.S. Department of Transportation (DOT)-compliant containers for shipping and disposal. To date, all systems deactivated have been NDA measured, and the final weight of uranium-235 in each system is less than the Nuclear Materials Control and Accountability (NMC&A) waste discard limit of 1.5 weight percent uranium-235.

LESSONS LEARNED FROM BUILDING 9206 IN RELATION TO BUILDING 9212

Due to the historical missions and similarities between Building 9206 and Building 9212, CNS is using the process of downgrading and deactivating Building 9206 to proactively implement lessons learned into the downgrade and deactivation of Building 9212 prior to ceasing production operations in that facility. Following is a summary of lessons learned that are being applied.

Strategy—Having clear and achievable nuclear deactivation criteria is required. An NCS deactivation and downgrade strategy should be established early on in the planning stages so that all stakeholders understand and concur with the deactivation work process and objectives. Planning and execution of the system deactivations should first focus on systems with the highest removable hold-up (i.e., systems containing greater than 700 grams uranium-235). Solutions below or at waste requirements are processed in Building 9206, and solutions above waste requirements go to Building 9212 for processing. After the high-holdup systems have been completed, deactivation planning and execution should adapt to working co-located systems in order to minimize the amount of planning, NDA scanning, and mobilization/demobilization required. The NCS deactivation and downgrade strategy should be preceded by a robust nuclear material de-inventory effort to reduce material at risk from a facility safety standpoint and should also eliminate the need for maintaining a material access area from a security protection standpoint.

Process Knowledge—Being proactive with facility deactivation is essential. Process knowledge and reliable engineering documentation are invaluable commodities needed for work planning, lockout-tagout of energized equipment, and characterizing waste for disposition. A vast amount of Building 9206 process knowledge was lost due to production ceasing and the plant stand-down in the early 1990s. Plant resources and funding were prioritized to restart other production operations following the stand-down. In contrast today, deactivation work in Building 9212 has already begun prior to the end of its production mission in order to capitalize on process knowledge and engineering expertise while they are still available. This allows for the appropriate shutdown of process systems, minimizes the amount of investigation and engineering required, and reduces the volume of waste subject to regulatory oversight remaining in the facility after production ceases.

Resources—Dedicated resources are always ideal on any project; however, these are not always possible to acquire or sustain. The deactivation process starts with engineering, who define system isolation points and establish the basic steps necessary to deactivate each system, in compliance with the controls established by Nuclear Criticality Safety. Radiological Control and NDA technicians are needed for characterization of residual system holdup. A variety of skilled craft and technicians—including electricians, machinists, pipefitters, insulators, riggers, and chemical operators—perform the majority of the deactivation work. The skilled craft and technicians must be trained to handle hazardous and radiological materials, qualified to wear respiratory protection, and enter confined spaces to conduct deactivation work. Waste management and certification resources are needed to oversee the compliant packaging and disposal of waste materials that are generated as each system is deactivated. All of these activities must be managed and coordinated by a dedicated project manager or engineer who is familiar with the facility and nature of the work.

Facility Maintenance—Because of the facility age and the manner in which Building 9206 was abandoned, the general facility conditions affect the ability to perform deactivation work and pose potential safety risk. Deferring the deactivation of the Hazard Category 2 Nuclear Facility for years has resulted in escalating costs for surveillance and maintenance of the facility that must be sustained until Building 9206 can be transferred to DOE-EM. Water intrusion, CAAS maintenance, freeze protection for wet sprinkler systems, aging ventilation and electrical systems, etc. all contribute to unforeseen and unplanned costs that compete for funding and can impact routine deactivation activities. Moreover, inadequate facility ventilation, on-going roof and steam condensate leaks, and maintaining a 1950s-vintage CAAS system pose safety risks to the workers. For this reason, applying lessons learned from Building 9206 proactively to Building 9212 deactivation reduces the long-term surveillance and maintenance requirements for Building 9212.

Special Considerations—Because of the facility layout and system configurations in Building 9206 and 9212, it is important to realize that contamination and holdup under stainless steel floors and in ductwork can be problematic to characterize and remediate. Significant effort, planning, and creative engineering solutions are necessary for addressing these types of challenges. In addition, regulatory requirements for transportation and disposal of waste materials, specifically DOT and Resource Conservation and Recovery Act (RCRA) regulations, should be considered and planned for along with radiological waste disposal requirements. It is also necessary to have adequate workspace and capabilities for the decontamination, sorting, segregation, and packaging of contaminated scrap metal and harvested radiological materials.

Consistent Funding—Deactivating a Hazard Category 2 Nuclear Facility from the Manhattan Project era is not easy nor is it cheap. The later that the deactivation process starts, the more complex and costly it becomes. As described previously, efforts to clean-out and deactivate Building 9206 occurred in a piecemeal manner over the years, and these efforts were conducted with limited and diverse funding sources and without a clear deactivation strategy. Because of this and the continual competition for scarce production and craft personnel, steady and measureable progress toward completing the facility deactivation could not be maintained. In 2016, the “Nuclear Criticality Safety Strategy for the Downgrade of 9206 Facility” and the “9212 Exit Strategy” were developed. In 2017, NNSA began providing dedicated funding to focus on completing the deactivation and downgrade of Building 9206 by the end of 2025. Funding to begin deactivation of Building 9212 started in 2018. With the formation of the Uranium Modernization and 9212 Exit Strategy Programs at the Federal level, dedicated funding has been consistently provided to support the deactivation of Building 9206 and Building 9212 for the past few years. This funding has helped secure the necessary personnel, resources, and priority for successfully executing the work in a consistent manner each year. The cost to complete the deactivation and downgrade of Building 9206 by the end of 2025 is estimated to be $50–60 million. Additional cost will be incurred to remove excess items and decouple utilities from Building 9206 prior to facility turnover to DOE-EM. Building 9212 is scheduled to cease its production mission by 2026. Because of its size and complex configuration, the cost to complete the deactivation, downgrade, and facility transfer of Building 9212 to DOE-EM by the end of 2035 is estimated to be on the order of $300 million.

CONCLUSION

Buildings 9206 and 9212 are forever connected, not only in terms of their historical significance and contributions to the security mission of the United States, but also in terms of how the two nuclear facilities are being deactivated and downgraded. It is imperative that Building 9206 deactivation and downgrade be completed in conjunction with the cessation of production operations in Building 9212, and it is vital that Building 9212 be shutdown in a manner that proactively de-inventories and dispositions residual materials as production systems shutdown to capitalize on experienced staff who possess invaluable process knowledge. Completing the deactivation and downgrade of Building 9206 is on-track, and efforts to proactively de-inventory and deactivate systems in Building 9212 have begun. The timely disposition of these Manhattan Project facilities will reduce risks to the environment, the public, and the workers, and will significantly reduce the DOE legacy facility footprint when the two facilities are demolished. It is hoped that the lessons learned from these efforts will serve to promote and expedite future facility deactivation and downgrade efforts at Y-12 and across the DOE complex.