Deactivation of the K-27 Building at the East Tennessee Technology Park – 15554

Steven T. Dahlgren, D&D Projects Manager,
URS | CH2M Oak Ridge LLC, steve.dahlgren@ettp.doe.gov
East Tennessee Technology Park
P.O. Box 4699, Oak Ridge, TN 37831

ABSTRACT

In 1942, nearly 24,280 hectares (60,000 acres) of east Tennessee landscape became part of the most significant defense strategy in the history of the United States – the Manhattan Project. Three methods of uranium separation were pursued at the site in the effort to end World War II.

What became the K-25 site, now known as the East Tennessee Technology Park, focused on the gaseous diffusion method of uranium enrichment.

This paper focuses on the deactivation of the second of five gaseous diffusion plants built on the site. The four-level, rectangular-shaped K-27 came online in 1945 and was tied to the site's original gaseous diffusion plant, K-25. K-27 extended K-25's enriching stages to increase production. The plant supported weapons production and other security strategies until 1964.

K-27 spans 35,582 square meters (383,000 square feet) and contains approximately 92,903 square meters (one million square feet) of floor space. During deactivation, workers will use an assembly line process to tackle the 540 process stages housed in 90 cells.

While often the less publicized, less visible aspect of building decontamination and decommissioning, deactivation takes more than three times longer than demolition. Crews work in high-risk, high-hazard environments – exposed to extreme temperatures, radiological and chemical contaminants, and deteriorating infrastructure. Therefore, worker safety becomes the most rigorous task performed.

K-27 is the fifth and final gaseous diffusion building in the Department of Energy's Oak Ridge Environmental Management program to be demolished.

INTRODUCTION

In 1942, nearly 24,280 hectares (60,000 acres) of east Tennessee landscape became part of the most significant defense strategy in the history of the United States – the Manhattan Project. First known as Clinton Engineering Works, the site would ultimately become the Oak Ridge Reservation (ORR). Three methods of uranium separation were to be pursued: electromagnetic, thermal diffusion, and gaseous diffusion. More than $1 billion would be spent over the next three years to produce enough enriched uranium to create a new and different type of weapon, the atomic bomb.

What became the K-25 site, now known as the East Tennessee Technology Park, focused on the gaseous diffusion method of uranium enrichment. In September 1943, construction began on the site's first, and signature, process facility, K-25. The U-shaped structure would be four-stories high, over 1.6 kilometers (1 mile) long (from one end of the "U" to the other) and nearly .4 kilometers (one-quarter mile) in width. The building would enclose 185,806 square meters (two million square feet), making it the largest building in the world at the time. K-25's product would help fuel the world's first atomic bomb and aid in ending World War II.

Before construction was complete on the site's first gaseous diffusion building, K-25, design and construction of a second process building had begun. The need for more production capacity and the urgency to end the war drove the construction of K-27 in March 1945 (see Fig. 1). The facility was completed in December 1945, shortly after the war's end.

K-27 was originally constructed to operate as a "stand-alone" uranium enrichment building with its own support facilities. The slightly enriched uranium product from K-27 was then packaged and transferred to K-25 where the product was introduced as a supplemental feed material. In 1948, K-27 and K-25 were "tied" together by piping (or tie lines) to form a two building cascade operating in series in which K-27 continued to provide enriched feed material to the K-25 building. In late 1945, enriched product from the K-25 building was reported to be about 22 percent. After the K-27 building became fully operational, the K-25 building product assays quickly increased to weapons grade levels.

The four-level, rectangular building, constructed of steel and concrete, spanned more than 3.25 hectares (eight acres) and contained 92,903 square meters (one million square feet) of floor space (see Fig. 2). The Kellex Corporation, architect/engineer for K-27, based its design on the K-303 section of the K-25 Building because process gas flow rates in K-27 were expected to be similar to the flow rates in the K-303 section. K-27 included 540 enrichment stages in nine units and cost about $59 million to construct.

K-27, operating in conjunction with K-25, produced enriched uranium for nuclear weapons, first as part of the Manhattan Project and later supporting security strategies during the Cold War. K-27 was placed in standby in 1964 as a result of President Lyndon Johnson's order to reduce national enriched uranium production.

In the late 1970s, two units of K-27 were modified and began operating as the purge cascade for the K-25 site multi-building gaseous diffusion cascade. The purge cascade removed nitrogen, oxygen and other light gases from the cascade. These two units were shut down in 1985 along the remainder of the K-25 site production facilities.

Fig. 1. K-27 Construction.

Fig. 2. K-27 in 1946.

APPROACH

The K-27 D&D Project includes demolition of Building K-27 as well as ancillary and support trailers and structures. K-27 has 34,137 linear meters (112,000 linear feet) of piping that must be stabilized before demolition.

Demolition is implemented under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process as a non-time-critical removal action in accordance with the Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Building. Demolition of certain K-27 ancillary structures will be implemented under the CERCLA process in accordance with the Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park. Current plans for the demolition of K-27 will leave the basement slabs in place. Remediation of the slabs and underground soil and utilities will be addressed in a separate project.

Deactivation of K-27 was started in 2008 by a previous cleanup contractor, who performed asbestos abatement and vault level cleanout. Current site cleanup contractor, URS | CH2M Oak Ridge LLC (UCOR), began deactivation activities in K-27 in 2012. Activities include:

Cold and Dark

Crews begin the deactivation process by removing all hazardous energy sources. Utilities are isolated, mains are cut, and a thorough investigation is conducted to ensure that every conduit or pipe that goes into or out of the facility is suspended.

Characterization

Map and measure marks the start of the characterization phase of deactivation. At this point, crews identify all process piping and equipment and mark and measure for use during non-destructive assay

(NDA).

Non-destructive assay uses specialized equipment (see Fig.3) like high-resolution gamma spectroscopy to determine what and how much uranium residue is left behind in piping, components, and equipment without destroying the integrity of the structure. NDA helps prevent criticality accidents and enhances overall safety, safeguards, process controls and accountability.

Fig. 3. A worker performs non-destructive assay work inside K-27.

The process known as Vent, Purge, Drain and Inspect (see Fig.4) is another crucial aspect of the characterization phase. This work eliminates personnel safety hazards associated with the uranium hexafluoride materials retained in the system reacting with moisture in the atmosphere, which produces hydrogen fluoride gas. Workers drill holes in the piping using a hot tap to safely control the release of any internal pressure. Once residual pressure is relieved, moist air is pulled through the pipes to cause any remaining uranium hexafluoride to react and any residual hydrogen fluoride to flush from the system. The air is then pulled through a specialized HEPA vacuum to contain any contamination.

Fig. 4. A technician samples gases vented from a process gas system to verify the absences of hydrogen fluoride.

Piping and Equipment Removal
Piping and process equipment is removed based on both characterization results and regulatory direction for disposal.

Foaming
After removal of sections of piping containing highly contaminated material, an expanding foam is injected into the process pipes. The foam eliminates void space when the pipe is buried and it also acts as a fixative for any contaminants remaining in the pipe.

Equipment Tabbing
Following foaming, workers perform partial pipe cutting, or tabbing, of compressors and converters to support waste segregation and disposition during demolition.

CHALLENGES

Crews work in high-risk, high-hazard conditions – exposed to radiological and chemical contaminants, extreme temperatures, and deteriorating infrastructure.

Principal radiological inventories are uranium residues and technetium-99. Tc-99 is a low-energy beta emitter that is highly soluble in water. In the late 1970s, a unit in K-27 was restarted as a "purge cascade" to remove nitrogen, oxygen and light gases from process equipment. The K-27 purge cascade was contaminated with Tc-99. Uranium contamination was also encountered throughout the building. The highest areas of contamination were found within the process gas equipment, with the building structure being contaminated, to a much lesser extent.

Chemical hazards include polychlorinated biphenyls (PCBs) mercury containing components, lead, hydrogen fluoride, and asbestos. Physical hazards include poor lighting, electrical hazards, biological hazards, and poor structural conditions in portions of the building.

PROGRESS

Despite significant radiological, chemical and industrial hazards, K-27 crews have worked 1,484,448 hours (through 12/31/14) with only three total recordable injuries and three lost work days.

UCOR collaborated with the Department of Energy on a plan to accelerate the deactivation schedule for K-27 because of the building's deteriorated condition. Accelerating the schedule allows for safer demolition before the building becomes more deteriorated. It will also save surveillance and maintenance costs.

In 2012, workers began inventory management; collected of Non-Destructive Assay measurements of process pipe; began vent, purge, drain, and inspection of process equipment; and installed safety controls.

UCOR continued inventory management and characterized process equipment activities in 2013. Workers also vented, purged, and drained process equipment. Also in 2013, six sodium fluoride (NaF) traps were removed from K-27 (see Fig. 5). When K-25 and K-27 were operational, the NaF traps were part of the process gas system. Sodium fluoride pellets were used to trap the uranium, and these traps still contain uranium materials left behind after the facility was shut down decades ago.

Fig. 5. Safe removal of a NaF trap used in the K-27 Building.

In November 2014, inventory management, data management, and NDA personnel completed characterization of the process gas system in the K-27 facility. The system consists of piping, valves, expansion joints, tubing, and various types of operational instrumentation formerly used in the uranium enrichment process. More than 86,000 items related to the process gas system were labeled and measured. Once the NDA group completed its measurements and reported the results to the data management group, the process of determining which items are required to be removed from the building prior to demolition start.

As part of this process, the data management group compared the data against stringent Department of Energy standards for an accident planning scenario known as "Criticality Incredible (CI)." This requires a finding that the chance of a criticality accident during demolition and waste handling resulting from fissile material remaining in the building is not credible. Components that exceed CI limits are being scheduled for removal, one of the major steps in preparing the K-27 building for demolition.

CONCLUSION

Based on characterization results, approximately 20 percent of K-27's components must be removed and shipped offsite prior to demolition. The remaining equipment meets waste disposal criteria for onsite disposal and is demolished with the building structure.

UCOR crews will complete building deactivation in September 2016 (53 months). Demolition will commence in April 2017 with completion planned for August 2018 (16 months).

REFERENCES

1. S. T. Dahlgren, "Finishing an Era: Accelerated Decontamination and Decommissioning (D&D) at the K 25 Building, East Tennessee Technology Park, Oak Ridge, Tennessee – 14141," Waste Management Symposia (2014).

2. U.S. Department of Energy-Oak Ridge Operations, “K-27 Building D&D Project,” March 24, 2010.
3. U.S. Department of Energy-Oak Ridge Operations, “Cleanup Progress: Annual Report to the Oak Ridge Community,” pg. 10 (2013).
4. URS | CH2M Oak Ridge, Newsline, “Workers complete NDA of K-27 Building components,” Vol. 3, No. 42, November 10, 2014.