Demolition of the K-27 Building at the East Tennessee Technology Park (ETTP) — 17423

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ABSTRACT

On February 8, 2016, URS | CH2M Oak Ridge LLC (UCOR) initiated the demolition of the East Tennessee Technology Park's (ETTP's) final gaseous diffusion building in DOE's Oak Ridge Environmental Management program. Building K-27 was a 35,582 m^2 (383,000 ft^2) gaseous diffusion building that contained approximately 92,903 m^2 (1 million ft^2) of floor space. It was one of five gaseous diffusion buildings at the site, formerly known as the Oak Ridge Gaseous Diffusion Plant. The actual demolition of this facility took approximately seven months to complete; however, planning and preparation took more than three years.

The deactivation process was a critical element in preparing the building for demolition. UCOR's K-27 deactivation activities began in April 2012 with the installation of safe walking paths and fall protection systems to allow safe work access. Next, all mechanical and electrical systems associated with the facility were shut down and isolated, a process known as "cold and dark." More than 19.3 km (12 mi) of process piping and components were marked and measured. Additionally, workers performed nondestructive assay (NDA) and vent-purge-and-drain activities and applied foam to piping and components as needed [1]. Based on characterization results, approximately 4.8 km (3 mi) of process piping, and 372 converters and compressors were removed and shipped offsite prior to demolition. Lower-hazard materials and equipment were demolished with the building structure and transported to onsite disposal facilities.

Upfront waste characterization and ongoing monitoring were key to the successful disposal of demolition debris at onsite facilities. Due to process improvements in waste loading recommended by work crews, the project achieved a 50 percent improvement in the daily hauling rate during the 9,000-truckload shipping campaign.

Crews worked in high-risk, high-hazard conditions and were exposed to radiological and chemical contaminants, extreme temperatures, and deteriorating infrastructure. However, the hazard controls that were put in place, based on the Integrated Safety Management System (ISMS) walkdowns and hazard determination, made the effort manageable. The overall safety performance during demolition of the facility was excellent, with no significant injuries, and exceeded industry standards and DOE target levels. Outstanding safety performance was a testament to the dedication of the workforce, given the significant hazards presented by the demolition of the Hazard Category 2 nuclear facility.

Another key element to the success of the K-27 demolition was the support and approval of all stakeholders involved in this effort, including DOE, the surrounding communities, the State of Tennessee, the UCOR management team, and, most importantly, the workforce that performed this highly hazardous work. This $52 million demolition project was completed ahead of schedule with no significant injuries and in compliance with all DOE orders, site procedures, and environmental controls.

INTRODUCTION

In 1942, the Oak Ridge Reservation (ORR), first known as Clinton Engineering Works, was developed as part of the Manhattan Project, the U.S.'s World War II defense strategy. The effort focused on uranium enrichment.

The primary and most successful method of uranium separation at the time was gaseous diffusion. What became known as the K-25 Site, now called ETTP, focused on this enrichment method. In September 1943, construction began on the site's first process facility, K-25. The building would enclose 185,806 m^2 (2 million ft^2), making it the largest building in the world at the time. Before construction of the K-25 Building was complete, design and construction had begun on a second process building. The need for more production capacity and the urgency to end the war drove the construction of K-27 in March 1945. The facility was completed in December 1945, shortly after the war's end.

K-27 was a four-level, rectangular building constructed of steel and concrete, spanning more than 3.2 ha (8 acres) and containing 92,903 m^2 (1 million ft^2) of floor space. 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.

This second facility was originally constructed to operate as a standalone 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 it was introduced as a supplemental feed material. In 1948, K-27 and K-25 were tied together by piping (called tielines) 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 K-27 became fully operational, the K-25 Building product assays quickly increased to weapons-grade levels.

Operating in conjunction with K-25, K-27 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 on 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.

K-27 was the fifth and final gaseous diffusion building in DOE's Oak Ridge Office of Environmental Management (OREM) program to be demolished (see Fig. 1). Demolition was completed in August 2016, and coincided with completion of DOE's *Vision 2016*, which called for tear-down of all five gaseous diffusion buildings at ETTP by the end of calendar year 2016.

Fig. 1. First day of K-27 demolition, February 8, 2016.

APPROACH

The project team completed demolition of Building K-27 as well as the removal, packaging and shipment of almost 1,000 pieces of large process equipment, and the packaging and shipment of over 4,572 m (15,000 linear ft) of process piping that required special handling and shipment [2]. This effort required the constant diligence of the work crew to implement daily hazard mitigations that were identified and built into their work control documentation. They accomplished demolition with no Conduct-of-Operations violations, minimal safety occurrences, no security concerns, and no environmental issues.

Demolition was implemented under CERCLA 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 Buildings [3]*. The original scope of the demolition of K-27 left 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 that performed asbestos abatement and vault level cleanout. UCOR, the current site cleanup contractor, began deactivation activities in K-27 in 2012.

Cold and Dark

Crews begin the deactivation process by removing all hazardous energy sources, which is referred to as making the facilities "cold and dark." All utilities were investigated by professionals using engineering drawings and field walkdowns to ensure that every conduit or pipe going into or out of the facility on all six sides of the cube were identified. Once the identification was verified, the utilities were isolated and air-gapped prior to the start of deactivation and demolition activities [4].

Waste Handling

The UCOR quality program was implemented in all aspects of UCOR's waste generation documentation, work control documentation, and packaging and shipping documents. Any waste package (including debris in the back of a truck) has a Waste Specialist monitoring the loading and signing off on the package. All ETTP employees who have any function associated with handling, loading, generating or transporting waste receive special onsite training to ensure their understanding of the compliance requirements for each and every waste load and shipment. The training, experience and dedication of the workforce provided nearly flawless waste handling, packaging and shipping that allowed ETTP to transport over 9,900 truckloads of contaminated debris to an onsite disposal facility and the offsite shipment of 924 packages of process equipment and piping. Waste disposition was accomplished with no injuries, no Department of Transportation issues, and no identified discrepancies with the waste acceptance criteria for the various receiving facilities [5].

CHALLENGES

A demolition zone in any industry is a hazardous work site that has numerous industrial safety challenges that need to be identified and controlled. However, when the demolition is being performed on a Hazard Category 2 nuclear facility, the hazards are increased significantly by adding chemical and radiological concerns that not only put the co-located worker at risk, but if not performed correctly, can impact the environment and surrounding community.

The same skilled and experienced workforce that safely completed the demolition of Buildings K-25 and K-31 continued with the equal rigor of safety to successfully

complete the demolition of K-27. The knowledge and experience that the craft demonstrated played a valuable role in successfully completing the demolition of the facility in a safe and compliant manner. The demolition of Building K-27 offered many challenges for the team, including high-risk, high-hazard conditions with the potential for exposure to radiological and chemical contaminants.

Extreme weather temperatures and deteriorating building infrastructure presented the greatest risk to the workforce. However, the hazards were identified and mitigated by controls put in place through ISMS implementation. The overall safety performance of the project was excellent. The K-27 demolition project craft set the standard by taking ownership of their safety program, and continue to set the standard for the way that work is accomplished at ETTP. The project experienced three first-aid injuries and no lost-time or reportable injuries for the duration of the project. The safety issues rate for the overall project was significantly lower than industry standards and DOE target levels. Safety performance was a testament to the dedication of the workforce in the face of significant hazards.

Principal radiological inventories within the K-27 facility were uranium residues and technetium-99 (Tc-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 located within the process gas equipment, with the building structure being contaminated to a much lesser extent.

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

Airborne contamination was a potential with the open-air method of demolition that was required for a building of this size. The work team’s significant experience with these types of facilities provided a good defense-in-depth protection strategy for preventing any offsite releases to the environment or surrounding community. To minimize dust generation, the actual demolition was accomplished in a very controlled fashion by using fixative and water spray to control any dust caused by the activities (see Fig. 2).

Fig. 2. Demolition equipment operating in the demolition field with continuous water misting being used for dust control.

Process equipment and process piping containing the greatest quantities of nuclear material were separated from the building debris pile, placed in lined and protected work areas prior to processing, and containerized/packaged prior to being removed from the general work area (see Fig. 3). Over 14 air monitors encircled the demolition area to confirm that no contamination became airborne and traveled beyond the perimeter of the demolition area. At no time during demolition did the air monitors detect any reportable air release events.

Fig. 3. Special handling of process piping and equipment.

Waterways surrounded the K-27 demolition area on two sides, with a river less than 0.2 km (0.125 mi) to the west of the work area. Release to these waterways was a concern due to the risk of rainfall potentially carrying some contamination into the storm drains or surface water, then itself being carried to the river. Again, the experience of the team played an important part in developing a storm water pollution prevention plan robust enough to prevent any ground or building contaminants from being released from the demolition field, even during a large rainfall/storm event.

These controls included an overall water management plan, grouting penetrations and abandoned drainage systems within the demolition field, installation of diversion channels, and the installation of an impermeable berm made with poured concrete that extended from 0.9 to 3 m (3 to 10 ft) into the ground on the low terrain side of the demolition field. These controls were in addition to typical construction-type protection of storm drains, such as heavy-duty drain guards and filters. Periodic water monitoring was performed, as well as additional monitoring at any discharge locations for any significant rain event. At no time during demolition did sampling detect any reportable water release events.

UCOR developed numerous controls to mitigate industrial hazards, including:

1. Condemnation of the building, which prevented personnel from entering the structure.
2. Establishment of a work Exclusion Zone around the entire perimeter of the facility that extended to various distances from the structure depending on the type of demolition being performed (e.g., shearing metal with large equipment processors would require a 30-m [100-ft] exclusion zone). No personnel were

allowed to enter the work Exclusion Zone without additional controls being enforced.
3. Assignment of dedicated equipment spotters around the perimeter of the work Exclusion Zone to monitor each piece of demolition equipment and its movements. Up to 20 pieces of heavy equipment were used at the same time.
4. Additional protection was added to the operator's cab due to the potential for flying debris.
5. Oversight by a lead spotter of "the big picture," with real-time communication to all equipment operators and other spotters (see Fig. 4).

Fig. 4. Spotters overseeing the demo field and monitoring each piece of heavy equipment.

CONCLUSION

UCOR collaborated with DOE on a plan to accelerate the deactivation and demolition schedule for K-27 because of the building's deteriorated condition. Accelerating the schedule allowed for safer demolition before the building deteriorated further. It also saved surveillance and maintenance costs. The K-27 demolition project was completed nine months ahead of the baseline schedule (Fig. 5), with over $2.8

million in cost savings. K-27 was the last gaseous diffusion building at ETTP to be demolished. The accelerated completion schedule will allow DOE to the meet its *Vision 2020* goal of completing all remaining ETTP site cleanup by 2020 [6].

Fig. 5. The last portion of Bldg. K-27 comes down on August 30, 2016.

REFERENCES

1. URS│CH2M Oak Ridge LLC, *Newsline*, "Workers complete NDA of K-27 Building components," Vol. 3, No. 42, November 10, 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 Office of Environmental Management, "Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee," DOE/OR/01-1988&D2, February 13, 2002.

4. S. T. Dahlgren, "Deactivation of the K-27 Building at the East Tennessee Technology Park—15554," WM2015 Conference, March 15-19, 2015.

5. U.S. Department of Energy-Oak Ridge Operations, "Cleanup Progress: Annual Report to the Oak Ridge Community," pg. 10 (2013).

6. 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).