Managing Changed Conditions/Activities—D&D of the Paducah U.S. Department of Energy C-340 Metals Reduction Complex–14304

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ABSTRACT

In comments to the House Subcommittee on Energy and Water Development,[1] David Huizenga, Senior Advisor for Environmental Management for the U.S. Department of Energy, included the successful demolition of the Paducah C-340 Metals Reduction Complex as one of the EM Program's notable accomplishments for 2013. The Paducah site skyline changed significantly with the demolition of the C-340 Complex, as it was the tallest building at over 36 meters (120 feet) tall and contained approximately 5,700 square meters (61,000 ft^2) under roof. *The C-340 Complex, used for production of uranium metal from uranium hexafluoride, was one of the most contaminated buildings on-site.* The C-340 Complex was located on the eastern side of the operating Paducah Gaseous Diffusion Plant. The plant operator, the United States Enrichment Corporation (USEC), operated large, high voltage electrical switchyards immediately to the north and south of the C-340 Complex and a uranium hexafluoride processing and withdrawal building to the west. The demolition posed multiple challenges for the project team, including physical size, being surrounded by operating facilities, radiological and chemical contamination levels, and changing conditions. The successful demolition was accomplished through a combination of significant demolition preparation including contaminant removal, system stabilization, waste characterization and planning, and radiological surveying and fixative application; planning and preparation for the actual structural demolition; selection of an experienced demolition subcontractor; coordination with site tenants; implementation of the subcontractors demolition approach; and then responding to changing conditions or opportunities to improve throughout the project.

INTRODUCTION

The C-340 Metals Reduction Plant Complex was operated to convert depleted uranium hexafluoride (DUF_6) to uranium tetrafluoride (UF_4), using a hydrogenation process, and then to convert UF4 to uranium metal by reaction with magnesium. The C-340 Metals Reduction Plant Complex operated from 1956 into the 1980s, although the building remained in use for other purposes until 1991. In addition to uranium compounds, asbestos insulation was present throughout the facility, and several hydraulic systems present in the C-340 Complex had historically used polychlorinated biphenyl (PCB) oils. Certain large ventilation system duct gaskets also were impregnated with PCB as a fire retardant.

The Paducah C-340 Metals Reduction Plant Complex (Figure 1) had a combined footprint of approximately 5,700 m^2 (61,000 ft^2). It was made up of the C-340-A Powder Building (2,350 m^2 and 36 m 120 ft tall); C-340-B Metals Building (2,950 m^2 or 31,000 ft^2); and the C-340-C Slag Building (400 m^2 or 4,400 ft^2). These buildings were physically adjoining structures located near the eastern perimeter of the Paducah Gaseous Diffusion Plant, which, during the demolition, was an operating uranium enrichment plant operated by USEC.

Figure 1. C-340 Complex, View from Northeast

The C-340 Complex is surrounded on three sides by operating facilities, including large high voltage switchyards to the north and south and an operating process building immediately west of the facility. Coordination with USEC was required to ensure that demolition of the C-340 complex did not endanger plant operations personnel or impact plant operations activities or facilities.

Deactivation of the C-340 Complex initiated under the American Reinvestment and Recovery Act. A key part of the activities undertaken during the deactivation included removal of chemicals and radioactive material left in process lines and equipment when the building was shut down. The following are examples of activities undertaken during the deactivation:

- Complex was isolated from existing plant utilities and power grid;
- Asbestos insulation was abated;
- Stored waste was removed for disposition;
- Radioactive materials were removed from piping and equipment;
- Chemicals were removed from piping and equipment;
- Building was vacuumed and fixative application was begun; and
- Building characterization to support the demolition was undertaken

The C-340 Complex transite removal and demolition occurred between August 22, 2012, and February 12, 2013, under cost and without incident—four years ahead of the original baseline, which had included demolishing the C-340 Complex in FY 2017. Over 32 million kgs (3,600 tons) of waste was generated; approximately half of this waste was taken to the on-site landfill and the other half was shipped in 28 gondolas to Clive, Utah.

DISCUSSION

During the latter stages of the deactivation process and during the demolition of the C-340 Complex, the project team encountered and addressed several challenges and changed conditions. In addition, the project team implemented lessons learned from other sites or projects to minimize risk and improve performance where applicable. The following are some of the challenges, changed conditions, and identified lessons learned:

- Planning and implementing the safe removal of transite siding from the building at heights of up 36 m (120 ft);
- Implementing an approach to manage significant quantity of building debris cost effectively as PCB remediation waste based on unexpected characterization results;
- Discovery of hidden layers of asbestos in equipment during demolition;
- Use of colored fixative to ensure coverage;
- Coordination of the demolition and waste loading and movement in a congested area surrounded by operating facilities;

- Demolition in cold weather presented additional challenges and can impact productivity;
- Addressing elevated levels of uranium present in surface water in off-site ditches observed by sampling during the demolition process;
- Use of Posi-Shell for covering of debris piles during precipitation events.

Planning and Implementing Transite Removal

The exterior siding of the C-340 Complex consisted of transite, a corrugated siding made of a mixture of cement and asbestos. The transite panels are approximately 3 ½ feet (1.07 meters) wide and 10 ½ feet (3.2 meters) long, and weigh from 130 pounds (58.97 kilograms) to 170 pounds (77.11 kilograms) per panel. The panels are bolted with lead-containing fasteners to the building. An approach of manual removal of the approximately 2,000 transite panels was chosen. The higher levels were accessed via manlifts with “glazier attachments” mounted on the front edge of the lift basket. The glazier attachment provides a channel for the bottom edge of the transite panel to rest in. Workers lifted themselves up to the panel to be removed, cut the bolts, placed the bottom edge of the sheet in the glazier attachment, and then strapped the panel to the lift. The worker then lowered the basket to the ground where support crew removed the panel and stacks for containerizing and disposal. The lead-containing bolts were containerized separately for management as lead waste. Figure 2 illustrates workers accessing transite during removal activities.

Other options were considered for removing transite, including traditional scaffolds, window washer-type scaffolds that attach to the building, and pursuing waivers for performance of a mechanical removal of transite using heavy equipment. The mechanical was not selected because this approach was not consistent with applicable, relevant, and appropriate requirements for asbestos removal. Removal using manlifts was selected because of the flexibility and greater degree of maneuverability for addressing the irregular shape and configuration of the C-340 Complex, which would have been problematic for traditional scaffolding or scaffolding attached to the building structure.

Key to performing the transite removal safely was implementation of fall protection harnesses for workers in the manlift baskets; keeping those not involved with the removal outside of the work area; ensuring that the ground support crew remained clear while the manlift was elevated; applying fixative to transite prior to removal and water misting during removal to control fibers; monitoring of both breathing zone and work area for fibers; and using personal protective equipment consisting of protective suits and respiratory protection.

It was critical to select manlifts that had adequate lift capacity and to operate them in the correct mode to handle the combined weight of a sheet of transite and the two-man removal crew without exceeding the manufacturer’s safety limits. Additionally, the manufacturer's recommendation established 3.0 m^2 (32 ft^2) as maximum area for loads to be handled on the glazier racks due to wind loading on the manlift baskets. The C-340 Complex transite panels were larger, at about 3.7 m^2 (40 ft^2). To ensure safety of the workforce, an engineering evaluation was performed based on the larger area of the C-340 transite panels. This evaluation resulted in establishing a lower wind speed (than allowed by the manufacturer's recommendation) for safe operation of the manlifts when handling the transite panels. This lower wind speed then was incorporated into work controls for the transite removal activity.

Figure 2. Transite Removal at the C-340 Metals Complex

Implementing an Approach to Manage PCB Remediation Waste

CERCLA removal action documents estimated that most waste from the C-340 Complex demolition would be sanitary waste, low-level radioactive waste, with some PCB bulk product waste. Project baseline assumed that 30% of the debris from C-340 would require off-site disposal, and 70% would be disposed of on-site.

Sampling and analysis determined that there was a significantly larger amount of PCB waste in the building than projected. The equipment and structural debris from the bottom two floors of the seven-story C-340-A Powder Building, the C-340-C Slag Building, and the entire C-340-B Metals Plant Building were determined to be PCB remediation waste at concentrations greater than 50 parts per million PCB. This waste required off-site disposal.

Based on the waste characterization, the C-340 Complex demolition was sequenced to allow segregation of the waste streams. The sequence was to demolish the C-340-B Metals Plant Structure first, then packaging resulting debris in railcars for off-site shipment. This sequence also allowed access to the higher portions of the Slag Unit and Powder Building. The top floors of these two structures were demolished and transported to the on-site landfill, leaving the lower two floors of each structure to be demolished and packaged in rail cars for off-site disposal

During the demolition of the Powder Building, which had a substantially larger footprint than the other facilities, projections were made about the number of railcars expected to require loading. The projection, approximately 24 railcars, was based on the square footage of Metals Plant demolished to date, versus the number of railcars loaded at the time, then extrapolating the number of cars required to containerize the remaining square footage to be demolished.

As demolition progressed to the lower floors of the Powder and Slag structures, the rate of waste generation increased per square foot of building demolished. Effectively, more waste was produced per square foot demolished in the bottom two floors of the Powder and Slag Buildings, than was demolished per square foot of the building footprint of the Slag Building. The final tally required 28 railcars, exceeding the mid-project projection by 4 railcars.

Based on actual weights, approximately 1,850 tons of debris was loaded into railcars for off-site shipment, or a variance of approximately 14% greater mass than expected. Via downsizing of debris and careful loading of the railcars, an average density of nearly 50 pounds per cubic foot was achieved. Prior demolition activities and a scrap yard clean up on-site using railcar shipment achieved significantly lower densities (average of 20 pounds per ft^3), indicating the downsizing and railcar loading techniques were effective in reducing costs for the PCB remediation waste disposition. The downsizing was performed using shears mounted on excavators. Downsizing occurred at the C-340 Complex prior to movement across the plant site in roll-off bins to the rail head. Further downsizing to support packing in to the gondolas was performed at the railhead, as illustrated in Figure (Placeholder for C-340 video).

The higher rate of waste generation for the lower floors of the C-340 A Building can be attributed to two considerations. First, a majority of the Metals Plant Building was open and did not have a second floor. As a result, structural steel supports and steel floor plate waste was generated from the Powder and Slag Buildings that was had not been generated throughout the entire Metals Plant Building. Second, the columns, steel structure, and cross bracing of floors 1 and 2 of the Powder Building and Slag Building were designed to support the higher floors of the building and the building roof, while the columns in the Metals Plant Building were required to support only the building roof. As a result, the Powder Building and Slag Building columns and structural steel from floors 1 and 2 were substantially larger than the columns in the Metals Plant building, generating more demolition waste per square foot of building footprint. The structural framing of the Powder Building and Slag Buildings was robust in construction and generated more waste than a comparable area of the roof trusses and roofing material that created the top of the Metals Plant Building.

Figure 3. Downsizing (background) and Loading C-340 Debris into Gondolas

Discovery of Hidden Layers of Asbestos in Equipment

During demolition in December, the C-340 "B" Building crew identified suspected asbestos in an insulation layer in a heater box that was being demolished. The box had been characterized previously, and no asbestos was identified. Work was suspended immediately. The material was contained and sampled, confirming presence of asbestos. The material was cleaned up and debris containerized for disposal. Further investigation determined a hidden layer of asbestos insulation was present in the heater box.

Following identification of the hidden layer in the heater box, the project team evaluated other similar equipment to determine if potential for similar hidden asbestos layers existed. The 6th and 7th floors of the C-340 "A" Building contained "clamshell" type heaters that previously had samples collected from the accessible brick and insulation material, with results negative for asbestos. Subsequently, it was determined that there could be a thin layer of asbestos-containing material between the brick layers that had not been sampled previously. Upon sampling of the “A” Building heaters, it was determined that the clamshell type heaters in the “A” Building did contain the hidden layer of asbestos. To avoid a potential for a significant release of asbestos during demolition and to comply with regulatory requirements, demolition was paused and the asbestos was removed in accordance with asbestos regulations. Demolition was suspended for nearly three weeks while work crews removed the asbestos containing material from the 6th and 7th floors.

Removal of the abatement from the clamshell heaters was further complicated because the transite exterior walls had been removed from the building. The transite walls served as the outer walls of the building and the stair wells. Access to the upper floors required fall protection planning as the structure was open during the removal and subsequent movement of the asbestos waste to the ground for disposal.

Use of Colored Fixative to Ensure Coverage

Prior to the C-340 Complex Demolition, a clear fixative had been used to lock down any residual radiological contamination. The clear fixative was effective in asbestos abatement applications and had been determined to be effective in radiological areas. During the deactivation activities at the C-340 Complex, the loss of contamination control event occurred at the Separations Process Research Unit (SPRU). Based on lessons learned from SPRU and the concern for ensuring adequate coverage and application of fixative, especially inside of equipment or containers, the project identified a colored fixative that could be used. The selected fixative was a product by the same manufacturer as the clear fixative, with the same properties, application rates, and costs. Using the same product allowed the workforce to continue using a familiar product, and this did not require changes in procedures, techniques, or equipment.

The colored fixative allowed personnel applying the fixative to determine easily where the material had been applied. The green color also allowed for straightforward identification of spots that were missed during application. The fixative application, including better coverage due to the colored fixative, aided in locking down radiological contamination and allowing elimination of respiratory protection requirements in several areas of the building.

It is important to note that fixative application has limitations. During building demolition of the 6th and 7th floors of the C-340-A Building during January and February 2013, personnel observed that small chips or flakes of paint or fixative were being caught by the wind and carried outside the demolition boundary. Some of these flakes were radiologically contaminated from the surfaces to which the fixative had been applied. It was determined that the cold temperatures had an effect on the applied fixative, rendering it “brittle.” The combination of bending and cutting of the steel structure during demolition had resulted in the material not adhering as well. This was noted especially when the transite panels were removed and the interior of the building (also with fixative applied) had been exposed to the elements. For demolition of tall buildings where fixatives have been applied, controls are required for these light flakes that can “float” a considerable distance in the wind. Controls could include establishing wide areas around the structure for dislodged chips and flakes to fall, use of misting or water sprays from a high elevation to knock down the flakes, establishing wind speed limits for high reach demolition or a combinations of these and other controls.

Another limitation of some fixatives is the potential for the fixative to degrade into a carcinogen if heated or burned, as could occur if torches, grinding, or other hot work is performed. This can become a significant issue for buildings, like the C-340-A Powder Building, which had multiple elevated metal floors with substantial sized steel support structures. Cutting these floors with high-reach demolition equipment was difficult due to the size of shear available to use at height. The option to precut some floors or larger structural beams with torches in preparation for demolition with the high reach equipment in this situation would have been hampered, in part, due to the concerns with torch cutting the fixative and generating carcinogenic fumes.

Demolition in Congested Areas

The C-340 Complex is located within an operating uranium enrichment facility. Located immediately to the north and south are two high voltage electric switchyards, and located to the west of the facility is an operating uranium hexafluoride processing and cylinder handling facility. Plant roads surround the footprint of the facility, one of which was inside the demolition area during part of the structural demolition and downsizing. This road, located on the eastern side of the C-340 Complex serves as the only route to reach certain equipment USEC had to inspect and service multiple times per day.

Project team members reviewed the subcontractor’s demolition plan, routes, and assembly points for delivery and assembly of large equipment, specifically high-reach demolition machines and large excavators, and routes for waste hauling with USEC personnel and Security personnel to ensure ongoing enrichment operations or facilities would not be impacted by the demolition activities, and established road closures. Arrangements were put into place to halt demolition or downsizing activities when USEC personnel were required to pass through the demolition area to access their equipment. USEC personnel also scheduled their access to the area outside of the demolition subcontractor’s normal work schedule or during their lunch period. Finally, to provide assurance that no asbestos fibers were released during transite removal and building demolition, a network of asbestos monitors was established around the perimeter of the demolition site and monitored throughout the project.

Impacts of Demolition in Cold Weather

The C-340 Complex demolition occurred primarily during fall and winter. Cold weather produced concerns that can impact safety and productivity. These include freezing of water sources for dust control; runoff from dust control freezing and creating slippery surfaces; and paint and fixative becoming brittle due to cold and being more likely to fail and break off surfaces during demolition, carrying contaminants with them. During the C-340 complex demolition, fire hydrants equipped with back flow preventers were heat traced and insulated to prevent freeze ups, and fire hoses used to supply water to dust bosses were drained, rolled up, and stored in heated facilities to minimize time lost in the morning to thaw out hoses and nozzles. Safety personnel controlled work areas to minimize personnel entering areas where drift from dust bosses froze on the ground or run off from dust control water would froze and created slipping hazards.

Addressing Elevated Levels of Uranium Present in Surface Water Ditches Observed by Sampling during the Demolition Process

After precipitation events, it was determined that uranium levels had increased at the outfall that drained the C-340 Complex. As a result, it was determined that the underground roof drains that were plugged prior to demolition could have been impacted by heavy equipment. Additionally, one roof drain was found that was not shown on building drawings. This drain was under installed equipment and was not identified until equipment removed during demolition, thereby allowing some water to flow from the site during precipitation events. As a lessons learned, all sumps, pits, and floor drains must be identified and plugged prior to demolition activities, and consideration should be given to possibility of damaging plugged drains during the demolition process.

The storm water runoff controls installed for the C-340 project were robust and effective for suspended contaminants and particles, especially for radiological contaminants. The controls did not focus on dissolved contaminants, which were not expected. The identified contaminants in the outfall drains were, in some cases, dissolved. Additional controls that focus on control of dissolved phase contaminants are required for runoff if the potential exists for dissolved contaminants from the demolition area.

Use of Posi-Shell on Debris Piles

During demolition of contaminated facilities, preventing rainfall from coming in direction contract with waste can be an important storm water control. It is not always possible to complete loading and transport of debris on the same pace that demolition occurs, resulting in stockpiled debris piles. Covering the piles with tarps can generate safety issues for workers placing the tarps, as well as issues securing during wind. Additionally, the tarps can become damaged due jagged edges of demolition debris. The C-340 project used an alternative cover known as “Posi-Shell,” to cover waste during precipitation events. The Posi-Shell is sprayed onto the debris using a hydro-seeder, and forms a coating over the top of waste to minimize precipitation contact with the debris.

Spraying the material eliminates need to have workers on or immediately near the piles to place tarps, eliminates need to secure the tarps, and eliminates risk of tarps blowing away during wind. This was more effective than other conventional methods and reduced the risk of mobilizing contamination during precipitation events. Figure 4 shows an example of application of Posi-Shell during worker training.

Figure 4. Workers Being Trained to Apply Posi-Shell Alternative Waste Cover Using a Hydroseeder

CONCLUSIONS

Open air demolition of contaminated structures, even with significant infrastructure and equipment remaining in the facility, can be performed safely and without harm to the environment. However, extensive preparation and adherence to work controls is necessary. Professional judgment and evaluation of risk of contaminant release and nature of the contamination (significant quantity of soluble contaminants or transuranic contaminants, for example) need to be considered to determine if an open air demolition is preferred, versus a two-phase demolition. In such a two-phase demolition, equipment and material would be removed using heavy equipment, with the building shell remaining in place, followed by an open air demolition of the building structure.

It should be noted that demolition of these types of buildings is not a “one size fits all” circumstance, and in some cases, there may be unintended consequences associated with controls or implementation of these lessons learned. Methods and approaches must be selected carefully and take into consideration the specific contaminants, building condition, circumstances, and surroundings of the project.

REFERENCES

1 Written Statement of David Huizenga, Senior Advisor for Environmental Management, U. S. Department of Energy, before the Subcommittee on Energy and Water Development, Committee on Appropriations, United States House of Representatives, March 19, 2013.