618-10 Burial Ground: Vertical Pipe Units Remediation – 14532

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ABSTRACT

The Hanford Site, now in the process of being decommissioned, was the country's primary source of plutonium for nuclear weapons. Plutonium and other special nuclear materials were produced in nine production reactors built between 1944 and 1964. Irradiated fuel rods were removed from the reactors and transferred to processing facilities to recover the production material. Laboratories within these facilities used a wide range of metallurgical and chemical analyses to examine routine and failed fuel assemblies as part of a continual improvement program for safety and production. Waste material from these laboratories was disposed of in the 618-10 Burial Ground from 1954 through 1963.

The approach selected for destroying the containers within the vertical pipe units (VPUs) is to install a 122-cm (48-in.) steel casing around each VPU, extending several feet below the bottom of the VPU and several feet above surface. After the casings have been installed, a rock auger mounted on a deep-foundation drill will be used to destroy the contents of the VPUs. The method for removing material from suspect-transuranic (TRU) VPUs is still to be decided. The two leading candidate approaches are 1) mechanical retrieval and 2) vacuum extraction. Material extraction from suspect-TRU VPUs will be done in sealed confinement with negative pressure and high-efficiency particulate air (HEPA) filtration to ensure that no radioactive material escapes to the surrounding environment.

INTRODUCTION

The 618-10 Burial Ground consisted of a series of trenches and vertical pipe units (VPUs). Lower-activity waste material was disposed in the trenches, and higher-activity waste material was disposed in the VPUs. The VPUs are approximately 38-cm (15-ft) long pipes placed vertically about 3 m (10 ft) apart and backfilled to create a series of disposal silos. Three different styles of VPUs were installed at the 618-10 Burial Ground: 208-L (55-gal) drums, corrugated metal pipe (CMP), and possibly steel pipe. Early VPUs were constructed with CMP or steel pipe. Later, five 208-L (55-gal) open-end drums were welded together to form a larger-diameter VPU. The number and location of each type of VPU is not known with certainty; however, of the approximately 94 VPUs about 50% are thought to be drum style, 30% CMP, and 20% steel pipe.

Material disposed to the VPUs was typically high-dose metal fines from grinding and sawing, filters and residue, and fragments of fuel rods too small to return to the 200 Area for processing. Waste material disposed in the VPUs was typically placed in paint cans or other small, thin-walled containers, often centered within the container with gelatin to keep the contents from shifting during transport. These small containers were loaded into shielded casks on a special trailer for transport to the burial ground. The trailer was positioned over the VPU and a remote-operated trap door was opened at the bottom of the cask allowing the containers to fall through an opening in the floor of the trailer and into the VPU. Radiation emitted from the top of the VPUs was monitored, and dirt or concrete were dumped down a VPU to maintain acceptable levels of radiation at the surface.

VPU WASTE MATERIAL

According to available records, over 97% of the waste disposed to the 618-10 VPUs was generated at the 327 facility during operations to examine failed reactor fuel and reactor hardware. The majority of the waste in the 618-10 VPUs was composed of fuel and activation products; approximately 50% irradiated uranium fuel and 50% activated metals (by weight) [1].

Irradiated fuel examined at the 327 facility was typically prepared for examination by slicing thin wafers of failed fuel elements, polishing the wafers, and then subjecting the wafers to various metallurgical and other analyses. Because plutonium was so valuable, the portions of the irradiated fuel elements remaining after wafers were cut, as well as some of the actual wafer samples, were returned to the 200 Area for processing to remove desirable isotopes. Fine particles created by grinding and polishing the failed fuel elements, along with some of the examined wafers, were disposed of to the 618-10 VPUs.

VPU MATERIAL CHARACTERIZATION

In 2008 WCH installed four cone-penetrometers (CPTs) in a 90-degree pattern around each VPU. A gamma detector was then lowered through each CPT with total gamma measurements recorded every 0.3 m (1 ft) along the length of each VPU. These gamma readings were then processed to estimate the Cs-137 and potential TRU inventory for each VPU. The data from this non-intrusive characterization (NIC) program was in turn used to develop a preliminary ranking of VPUs in order of estimated TRU inventory. Under this ranking, approximately one-third of the 94 VPUs are estimated to be suspect-TRU, the other two-thirds can potentially be disposed of directly to Environmental Restoration Disposal Facility (ERDF).

The CPT data clearly indicate a significant stratification of waste material in most VPUs. A typical VPU has several “hot spots” of high-dose composition separated by often larger areas of relatively “cool” material. Based on models developed from historical and CPT data, the highest dose area appears to have approximately 60 Ci of Cs-137 in a relatively thin layer (approximately 0.3 m (1 ft) thick). The next highest dose area is estimated to have about 30 Ci Cs-137, and the third-highest dose area approximately 15 Ci.

A sampling and analysis plan is being prepared to perform further characterization of the processed VPUs. In-situ characterization and intrusive sampling are both being evaluated to determine the most appropriate means of obtaining data necessary to support characterization of the material in the VPUs. The end-point of this characterization program is expected to demonstrate that the TRU ranking based on NIC data, in conjunction with additional characterization efforts, is a sufficient basis for establishing compliance with ERDF waste acceptance criteria (WAC).

REMEDIATION ALTERNATIVES FOR 618-10 VPUs

Remediation of the 618-10 VPUs has been the subject of numerous papers and workshops over the last two decades. In 2007 Washington Closure Hanford (WCH) held a series of workshops to evaluate the potential remediation alternatives and to move towards a selection of the optimum approach. The approach selected for destroying the containers within the VPUs was to install a 122-cm (48-in.) steel casing around each VPU, extending several feet below the bottom of the VPU and several feet above surface. After the casings have been installed, a rock auger mounted on a deep foundation drill will be used to destroy the contents of the VPUs, and the material in the processed VPUs will be removed. Retrieved material that is determined to be TRU will be stored for future disposal at Waste Isolation Pilot Plant (WIPP), and the remaining material will be treated for potential lead contamination and disposed of at ERDF.

Processing and Material Retrieval

The effectiveness of destroying the contents of VPUs was established in a proof-of-concept demonstration. Surrogate VPUs were built, placed in a buried 122-cm (48-in.) steel casing, and material similar to Hanford Site soil was filled in around the annulus. A conventional rock auger was then advanced to the bottom of the casing at a rate of approximately 2.5 cm (1 in.) per minute. After the auger was withdrawn the processed material was removed with a rock bucket in approximately 15-cm (6-in.) lifts, sieved to remove objects larger than approximately 7.6 cm (3 in.), and cataloged by layer for future reference.

Results of this proof-of-concept demonstration clearly showed that the augering process was effective. The only indication of VPU contents were occasional small pieces of metal, a conclusive indication that all containers had been breached. Buckets 3.8-L (1 gal) in size of powdered pigment were placed in various locations of the surrogate VPU to demonstrate the effectiveness of mixing. No pigment was discernible in the removed material, indicating that the material within the 122-cm (48-in.) steel casing had been thoroughly mixed.

Suspect-TRU Waste

Material from VPUs determined to be suspect-TRU will be removed and placed in drums for further evaluation. Drums that are determined to be TRU will eventually be shipped to WIPP. Remaining drums that meet ERDF WAC will be disposed of at ERDF.

The current selected method for removing material from suspect-TRU VPUs is mechanical extraction. Mechanical retrieval will employ a clamshell or similar down-hole grab bucket developed for deep foundation construction. After retracting the grab tool from the VPU the material is dropped into a moveable hopper. The filled hopper then moves out of the way of the grab tool and deposits the VPU material onto a conveyor for transfer to the waste drum. A conveyor will move the material from the hopper and deposit it into a drum for disposal. Dose measurements will be taken along the transfer pathway to ensure that the total dose for a single drum does not exceed specified limits.

A retrieval enclosure has been designed for material extraction from suspect-TRU VPUs to provide a sealed confinement with negative pressure and HEPA filtration, thereby ensuring that no radioactive material escapes to the surrounding environment. Modifications to this design are being considered as part of an ongoing evaluation to determine the optimum configuration for retrieval of suspect-TRU material from the 618-10 VPUs. Potential alternatives being explored include 1) a fixed-hopper configuration and using a screw auger instead of a conveyor to transfer material from the hopper to the drum, and 2) vacuum extraction and pneumatic material transfer.

Non-TRU VPUs

Material in VPUs that are determined to be non-TRU can be removed in several ways including drum disposal, monoliths, and field excavation. All three methods are currently under consideration and each has significant potential advantages and challenges that must be addressed before concluding on any given method.

Drum disposal extends the process described above to VPUs that are not suspect-TRU. The primary advantage of drum disposal is familiarity. The experience gained in processing approximately one-third of the VPUs as suspect-TRU should result in a relatively efficient process that can simply be continued through the remaining VPUs. Additionally, no further mockups, readiness reviews, or training activities will be necessary to continue with drum disposal. There are some potential challenges with extending drum disposal that must be addressed including 1) all material disposed of at ERDF must be treated, thereby requiring double-handling of drummed material that goes to ERDF, and 2) a more thorough evaluation of the relative efficiency of drum disposal versus other retrieval alternatives may conclude that another method has sufficient advantages to overcome the additional time required to implement another approach.

Monolith Extraction

Under this scenario the processed material within the 122-cm (48-in.) steel casing would be grouted to treat for lead contamination in the material and to create a structurally-sound configuration for extraction and transfer to ERDF. Each monolith would be extracted from the surface using a casing jack and crane. The void space created by the withdrawing monolith will be filled with medium-density fill or similar material to prevent subsidence.

Removing a processed VPU as a single unit or monolith has potential advantages over drum disposal including the following

- Grouting the material is a relatively simple extension of the VPU processing sequence, thereby eliminating double-handling of drums.

- A VPU could be removed, prepared for shipment, and transferred to ERDF as a single unit, potentially saving significant time in comparison to the other retrieval alternatives.

Field Excavation

Field excavation is the remaining alternative for retrieval of processed VPU material that was determined to meet ERDF WAC. Under this alternative the casing from a VPU would be removed after processing and a larger (152-cm [60-in.]+) grout injection auger would be used to stabilize the processed VPU material by injecting a grout slurry and mixing with the processed VPU material and surrounding soil. Following the stabilization of all remaining VPUs, the VPU field would be removed with traditional field excavation techniques and disposed of at ERDF.

CHALLENGES AND ISSUES

Planning for and designing complex remediation systems invariably includes dealing with significant challenges and issues. The 618-10 VPU remediation has an even wider range of potential challenges stemming from the uncertainties about existing conditions and from the constraints of a closure contract.

Conditions Uncertainties

Although we have a good understanding of the basic processes that created wastes disposed to the VPUs, there are minimal records or information about individual waste packages disposed to specific VPUs. Consequently, the only information available about probable conditions for any given VPU come from the CPT gamma data obtained from 0.3-m (1-ft) intervals along quadrants of each VPU. These data provide a reasonable basis for anticipating probable conditions that will be encountered, but there is a considerable level of uncertainty and, therefore, a potential for conditions being considerably different than expected.

The planning and design of remediation for 618-10 VPUs has been in progress for several years, and during that time new information has been identified and refinements in the evaluation process have been pursued. These efforts have led to several significant changes in the expected conditions and remedial actions. For example, the number of VPUs expected to be potential TRU has increased from just a few to about one-third of all VPUs. Additionally, several photographs were discovered that appear to show that many of the VPUs are CMP or steel pipe, not welded 208-L (55-gal) drums.

System and Technology Uncertainties

Many aspects of the systems that will be used in remediation of the VPUs are both unique and complex. Although the underlying method of processing VPUs uses equipment and methods from deep foundation drilling, there are a number of significant differences that introduce complexity and uncertainty into the overall project plan. Beyond the relatively straightforward augering phase, all remaining aspects of removing and disposing of waste material from the VPUs are essentially custom processes that must be developed for the unique and uncertain circumstances of VPU remediation.

The fact that these systems are being devised largely from scratch inevitably also poses significant challenges, particularly since so many of the elements are tightly connected and making changes in one element often leads to changes in other areas. Changing a single element—either for optimization or because new information was uncovered—can, therefore, lead to a spiral of other changes.

Finally, a tailored implementation of the *DOE Standard for Integration of Safety Into the Design Process* was applied for the VPUs. [2] Periodic reviews by the Defense Nuclear Safety Board (DNFSB) at key stages of the planning and design process have provided a wider range of input for the team to incorporate. These reviews, a fundamental element of planning, and design for nuclear facilities are conducted with the full technical team, DOE managers, and DNFSB staff. The discussions and follow-on technical exchanges from these reviews ensure that the design is fully compliant with all applicable DOE safety standards.

The VPU remediation system and operating processes must be able to accommodate these and other uncertainties. The design team is planning for worst-plausible case outcomes and developing robust contingencies to ensure that the remediation can be executed without significant delays.

CONCLUSIONS

The WCH project team confronts a number of significant technical, operational, and process challenges in planning the design and execution of remediation systems for 618-10 VPUs. The known and unknown conditions of the VPUs impose a number of complex and unique issues that must be addressed to the satisfaction of the key stakeholders. The VPU project is one of the most technically challenging projects undertaken to date by WCH. The process of planning and design has been ongoing for several years.

Developing an effective, safe, and fully-compliant system for remediating the VPUs requires thorough planning, careful evaluation, and strong communication between the various technical team members, DOE managers, DNFSB reviewers, and other stakeholders. Although a number of significant complexities and uncertainties are inherent in a project such as this, the combined WCH, DOE, and DNFSB team has been able to make continual forward progress towards a complete and comprehensive remediation system for the 618-10 VPUs. By working together, the team can balance the requirements, constraints, and realities of cleanup work to accomplish this important mission.

REFERENCES

1. WCH, 2013, *Evaluation of In-Situ Characterization of the 618-10 Vertical Pipe Units*, WCH-574, Rev. 0, Washington Closure Hanford, Richland, Washington.

2. DOE, 2008, *DOE Standard for Integration of Safety into the Design Process*, DOE-STD-1189-2008, U.S. Department of Energy, Washington, D.C.