Design, Development, Pre-Testing and Preparation for Full Scale Cold Testing of a System for Field Remediation of Vertical Pipe Units at the Hanford Site 618-10 Burial Grounds -12495

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ABSTRACT

At the Hanford site, in the 1950's and 60's, radioactive waste materials, including Transuranic (TRU) wastes from a number of laboratories were stored in vertical pipe units (VPUs) in what are now the 618-10 and 618-11 burial grounds. Although the current physical condition of the VPUs is unknown, initial R&D studies had shown that in-ground size reduction and stabilization of VPU contents was feasible.

This paper describes the R&D work and testing activities to validate the concept of in-ground size reduction and stabilization of VPU contents, and the design and pre-testing of major plant items and augering systems on full size simulated VPUs. The paper also describes the full size prototype equipment which will be used in full size cold testing of simulated VPUs off the Hanford site, to prove the equipment, develop operating procedures, and train operators prior to deployment on site.

DESCRIPTION OF VERTICAL PIPE UNITS

Most of the vertical pipe units were constructed by cutting the tops and bottoms out of 200 liter (55-gallon) drums and welding five drums together to form a cylinder, approximately 4572mm (15 feet) long and 559mm (22 inches) in diameter. To install the 200 liter (55 gallon)-style VPUs, an excavation was prepared to a depth of about 4572mm (15 feet) and the VPUs were set vertically on the soil or a concrete footing (possibly cinder blocks or concrete payers) and the excavation was backfilled. The VPUs were positioned on approximate 3048mm (10 ft) centers.

The current physical condition of the VPUs is unknown. There have been no records found to indicate they were constructed of anything other than standard, carbon steel drums. Additionally, there is no indication they were painted or given any other corrosion protection prior to burial; therefore, it is concluded that corrosion has been in effect since initial placement. Corrosion rates for painted steel drums in Hanford Site burial grounds have been estimated to range from 0.05mm to 1.5mm per year. These VPUs were installed in the 1 950s and thus they have been in place for more than 40 years; therefore, they could have experienced corrosion in excess of 6.0mm. A typical 200 liter (55-gallon) steel drum is constructed of material approximately 1.6mm thick; the external shell of these VPUs may be completely corroded away. However, experience at other Hanford burial grounds shows that corrosion varies widely.

TRU wastes and other high dose rate waste with contact doses up to 500 R/h, and was packaged in “milk pail” disposal cans and placed in the VPUs. In addition to radioactive wastes, it is possible that quantities of energetic reactants have been placed in the VPUs. The VPU bounding condition for reactants is considered to be a single can containing 270 grams of un-reacted sodium potassium (NaK) that has oxidized to 120 grams of potassium superoxide (KO_2); that represents approximately 2.6E+05 joules of energy to be released in an explosion of the superoxide. This represents the bounding condition for any combination of energetic reactants (e.g., NaK and picric acid). Figure 1 shows a diagram of the VPU construction and contents.

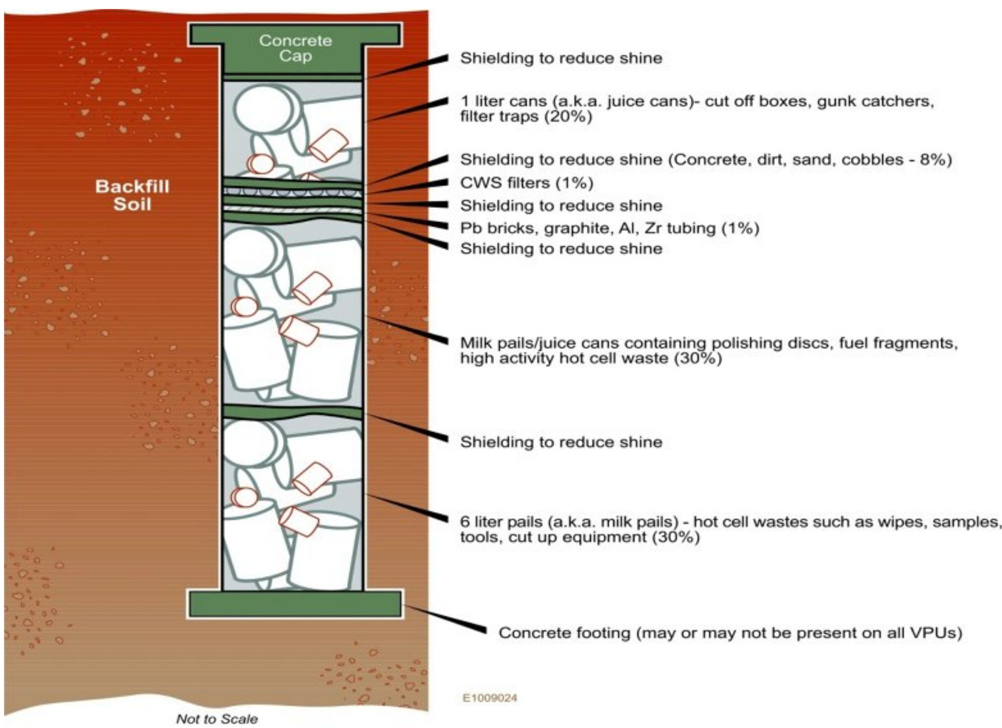

Figure 1. Diagram of Vertical Pipe Unit

REMEDIATION PROCESS

Initial R&D work, had indicated that the following concept for field remediation would achieve the required performance objectives.

Step 1: Insertion by vibratory hammer of a 7620mm (25 feet) long, 1219mm (48 inches) diameter, steel tube into the ground, to form an over-casing around the

VPU, and extending approximately 1524mm (5 feet) beyond the bottom of the VPU. See figure 2.

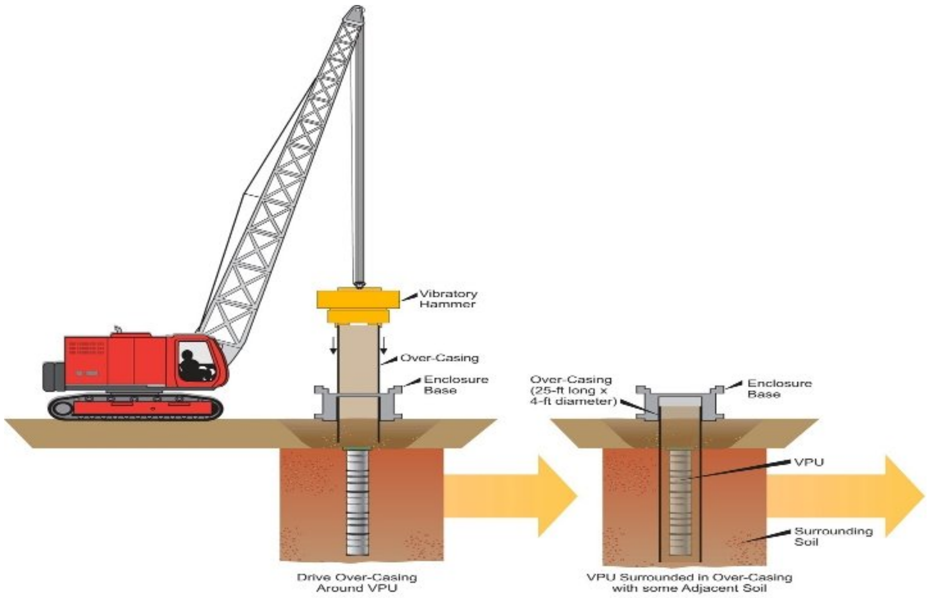

Figure 2. Over-casing Insertion

Step 2: Size reduce and stabilize the contents of the VPU, within the steel over-casing by means of a 1168mm (46 inch) diameter auger. See figure 3.

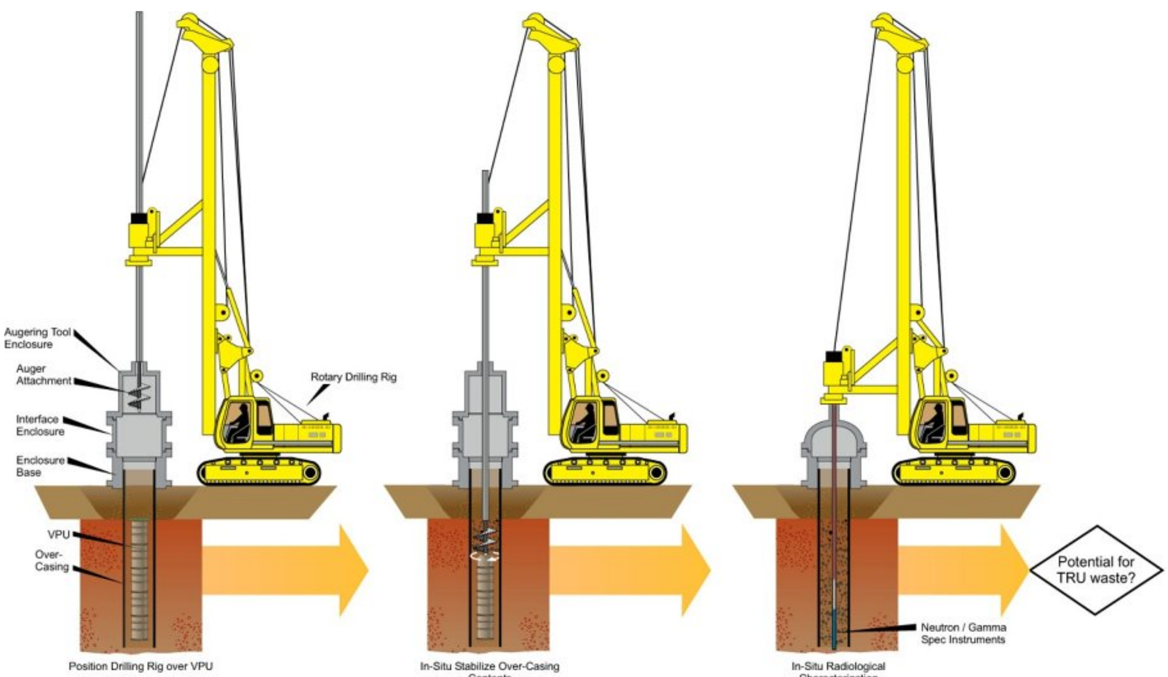

Figure 3. Size Reduction, Stabilization and Mixing.

Step 3: Determine if the waste is acceptable by Hanford ERDF, or if the waste is suspect TRU. This function was not part of the scope of work addressed in this paper.

Step 4: If the waste is acceptable for disposal at ERDF, introduce a highly penetrating cement based grout mix with the size reduced VPU contents. When cured the steel over-casing will contain the grouted VPU contents in “monolith” form. See figure 4.

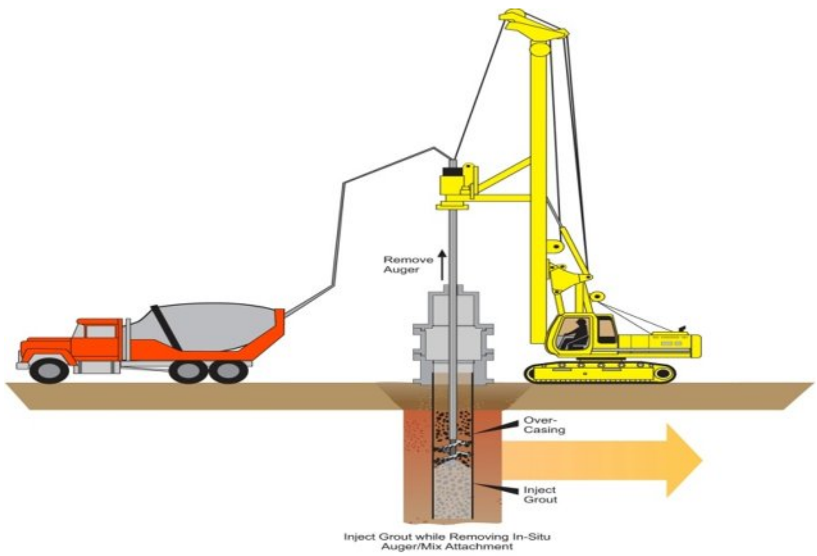

Figure 4. Grouting of Over-casing and VPU

Step 5: If the waste is suspect TRU, remove the waste and place into 55 gallon drums for characterization at CWC Hanford. See figure 4.

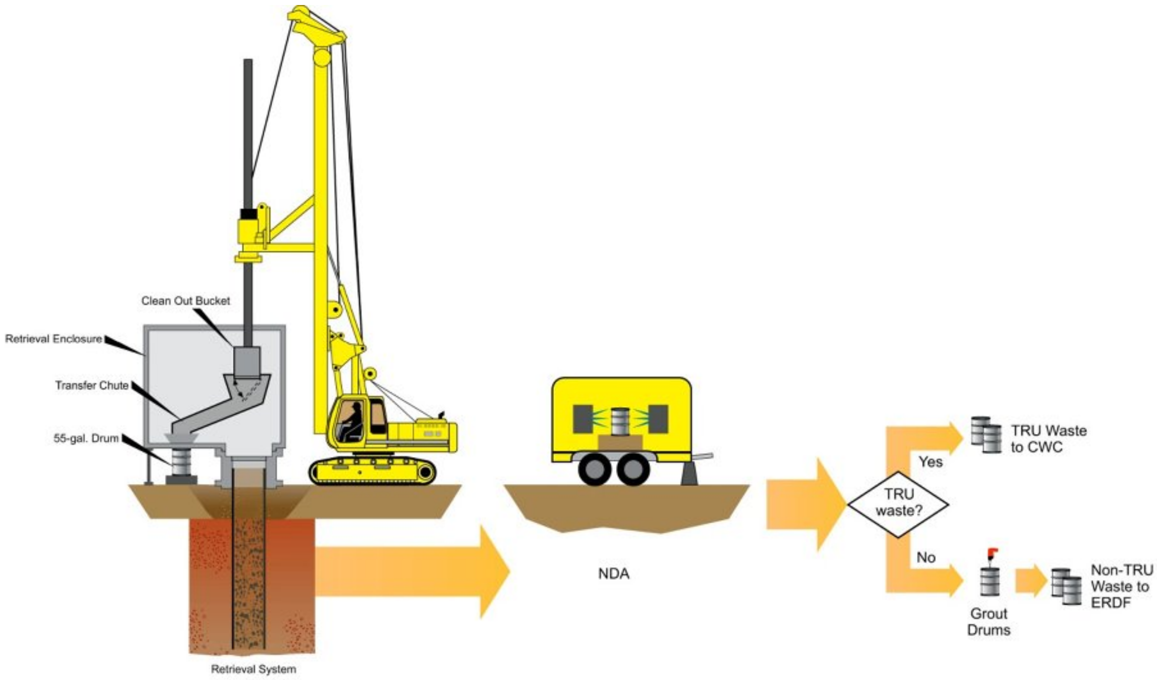

Figure 4. Waste Removal

Step 6: The cured monoliths will be removed by removing the soils alongside the VPUs to form a large trench that will enable the VPU monolith to be tilted, lowered to the horizontal, and moved to ERDF.

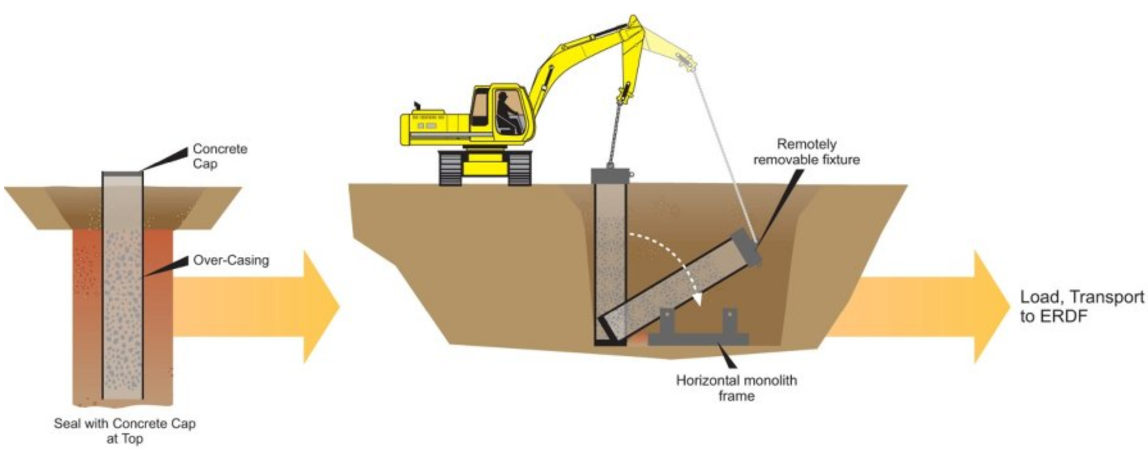

Figure 5. Removal of Grouted Monoliths

The Development and Pre-Testing stage which is described in the following section, was to further evaluate and to test under controlled conditions the equipment and subsystems required to implement the remediation process.

DEVELOPMENT AND PRE-TESTING OF EQUIPMENT

The first phase of work was to conduct a survey and assessment of commercially available augering, mixing and material transfer technologies and to identify those considered most applicable. The equipment and subsystems addressed were:

- Drilling Rigs
- Over-Casings (Steel tubes)
- Vibratory hammers for insertion of over-casings
- Grinding and Mixing Tools (Augers)
- Grouting
- Waste Removal Equipment

The methodology used in the survey and assessment included the following:

- Review of the historical application of each technology.
- Interview of equipment manufacturers, drilling contractors, vendors and experts.
- Review of equipment application, performance and specification through industry published technical data.
- Review of published papers for previous cold demonstration tests involving mock ups of VPUs and surrogate waste, and installation of steel casing.
- Review of the initial R&D work.

From this work the equipment and subsystems were selected for Pre-testing to evaluate the following:

- Installation of the steel over-casing around a VPU.
- Penetration, size reduce, and mixing of surrogate VPU contents and the soil within the over-casing.
- Grouting of a size reduced, and mixed surrogate VPU within the over-casing.
- Ability to remove the size-reduced and mixed materials from the over-casing.

Over-casing Selection
Two types of steel over-casings were considered;

1. Plate welded tubing, which is less readily available and more expensive, but potentially stronger.
2. Spiral welded tubing, which is cheaper, readily availability.

It was considered that an appropriately sized spiral welded tube would achieve the required insertion performance, and this type was selected for test.

Vibratory Hammer Selection
Vibratory hammers contain a system of counter-rotating eccentric weights, powered by hydraulic motors, and designed in such a way that horizontal vibrations cancel out, while vertical vibrations are transmitted into the over-casing, to which the vibratory hammer is fastened by a clamp mechanism.

Figure 6 shows a 1219mm (48 inches) over-casing and vibratory hammer at the test facility during pre-testing.

Figure 6: Over-casing with vibratory hammer

Auger Selection
Augers are available for wide variety of applications. The various types and their applications are summarized as follows:

Earth auger- These augers are primarily made for digging holes in dirt. They are efficient at penetrating soil, scooping material, and bringing material to the surface. The teeth of the auger are flat and angled horizontal relative to the surface of the ground. This orientation increases its ability to scoop material but greatly restricts it to grinding harder material. Its grinding and penetrating power is weak relative to other augers.

Figure 7: Earth Auger

Rock auger- Rock augers are designed for penetration of hard materials and surfaces. Appropriately specified, it optimizes the ability to grind and mix material while penetrating deeper depths. These augers can utilize carbide teeth, which help the augers ability to grind and shred material.

Figure 8: Rock Auger

Core Barrels- Core barrels are primarily used for grinding and shredding material on the edges of a shaft. It is a hollow bucket that may have teeth or bits on the circumference to enhance grinding. Roller Rock or Tri-cone bits are typical used.

Vertical shaft Tri-cone augers - This auger configuration uses a tri-cone bit to grind material at the bit surface. Although it is very effective at shredding rock and concrete it requires either air or water to move material to the surface and away from the bit head.

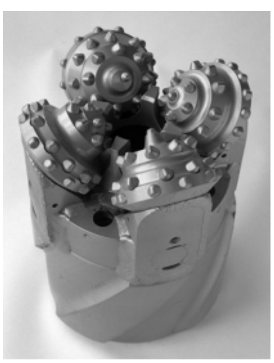

Figure 9: Tri-cone Auger

All but the rock augers were considered unsuitable for the VPU size reduction and mixing task, leaving the following characteristic to be considered for rock auger selection.

<u>Number of flights</u>- the number of flights can vary from a single flight to a continuous flight auger. The number of flights dictates the mixing power of the auger. The more flights, the better the mixing results due to material being lifted from flight to flight. As a practical matter however, increasing the number of

flights lengthens the auger, increases the torque required to rotate the auger during grinding and mixing, and increases the probability of damage to the auger. Taper angle- this is the angle of the flights and provides a difference in penetration and ability to grind/mix material at a particular depth. A higher taper angle allows for more/easier penetration. A lower taper provides for better mixing.

Type of teeth- Teeth can vary from small to large and the amount of carbide at the tip. Larger teeth may grind and mix better but it is more probable of material getting stuck in the teeth.

Position/orientation of flights- flights can be S-shaped, line-shaped, or circular. The distance between flights changes its ability to mix material and put more flights on the auger. The smaller the distances, the more mixing will occur however smaller distances facilitates the ability for material to get stuck in the flights.

Thickness of flights- The thicker the flights, the stronger the auger. With thicker flights, more torque and power is necessary to control and lower the auger.

Size of Auger- the diameter of the auger influences its ability to mix material and penetrate at different depths. The larger the diameter, the more torque required to penetrate but it greatly increases its ability to mix and grind material with a greater area at different depths. Smaller diameter augers will require less torque to reach deeper depths but will not be sufficient by itself at grinding and mixing a wider area.

Cutter head- also known as a “stinger”, it is an extension that appears on the tip of the auger below the flights. Stingers have different shapes and sizes, depending on the material being augured. Some contain teeth that point in different directions while others are just single cones that protrude at the tip of the auger. Stingers increase the penetration power of augers and help keep the auger centered.

Grout Selection
The grout mix that was selected for testing comprised:
Type I - Ia Portland Cement - ASTM C150
Potable Water
Retarder - ASTMC494 Type B
Grout Fluidifier - ASTM 978

Waste Removal Equipment Selection
The retrieval bucket was selected for pre-testing as the most appropriate method of waste removal. These buckets are shown in figures 10 and 11.

Figure 10. Drawing of Retrieval Bucket

Figure 11. Retrieval Bucket in use

Preparation for Pre-Testing

The preparation for Pre-testing comprised the manufacture of surrogate VPUs, and the installation of the surrogate VPUs into the ground on the test site and back-filled with soil which was representative of the soils surrounding the actual VPUs at Hanford.

The surrogate VPUs were constructed from 200 liter drums, 5 of which were filled with materials to represent the contents of the Hanford VPUs. Figure 12 shows a selection of contents of the surrogate VPUs, and figure 13 shows the various stages of assembly of the surrogate VPUs.

Figure 12. Surrogate VPU Contents

Figure 13. Assembly of Surrogate VPUs

Pre-Testing of Installation of the Steel Over-casing around a VPU

The pre-testing proved that the steel over-casing could be driven into the simulated Hanford soil to the required depth.

Pre-Testing of Penetration, Size Reduction, Stabilization by Mixing

A number of sizes of augers and auger types were tested, and it was proved that the surrogate VPUs could be size reduced as required, and that all containers within the VPUs were breached and that the VPU contents and surrounding soils were effectively mixed. Effective mixing will stabilize, in-ground any reactive materials such as un-reacted NaK or super oxides. The size reduced VPU contents were removed from the over-casing for examination. See figure 14.

Figure 14. Size Reduced VPU Contents

Pre-Testing of Grouting

It was demonstrated that the selected grout and size reduced VPU contents and soils could be mixed with a rock auger to produce a grouted monolith within the over-casing.

Pre-Testing of Removal of Materials

Retrieval of size reduced materials was effectively done using a bucket auger and a rock auger. See figure 15.

Figure 15. Removal by Rock Auger (Left photo) and by Bucket Auger (Right photo)

DESIGN

The success of the pre-testing of the selected equipment and subsystems, has provided the base data for the design of the actual equipment to be cold tested then deployed on the Hanford site. This equipment includes the augering and grouting containment systems and retrieval equipment containment systems needed for safe operation with the required radiological controls. This design is currently ongoing.

CONCLUSION/IMPORTANCE OF THIS WORK

Safe and effective field remediation, removal and disposal of the VPUs in the 600 area are critical to the success of the River Corridor Closure Contract at the U.S. Department of Energy's Hanford Site.

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