TRANSPORTABLE VITRIFICATION SYSTEM RCRA CLOSURE PRACTICAL WASTE DISPOSITION SAVES TIME AND MONEY

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ABSTRACT

The Transportable Vitrification System (TVS) was a large-scale vitrification system for the treatment of mixed wastes. The wastes contained both hazardous and radioactive materials in the form of sludge, soil, and ash. The TVS was developed to be moved to various United States Department of Energy (DOE) facilities to vitrify mixed waste as needed. The TVS consists of four primary modules: (1) Waste and Additive Materials Processing Module; (2) Melter Module; (3) Emissions Control Module; and (4) Control and Services Module. The TVS was demonstrated at the East Tennessee Technology Park (ETTP) during September and October of 1997. During this period, approximately 16,000 pounds of actual mixed waste was processed, producing over 17,000 pounds of glass. After the demonstration was complete it was determined that it was more expensive to use the TVS unit to treat and dispose of mixed waste than to direct bury this waste in Utah permitted facility. Thus, DOE had to perform a Resource Conservation and Recovery Act (RCRA) closure of the facility and find a reuse for as much of the equipment as possible.

As part of closure activities, historical documentation, including facility records, occurrence reports and other records were reviewed to determine contaminants of concern and develop a characterization plan to support waste disposition. The contaminants of concerns that were identified to be managed during cleanup activities included various "F" and "U" RCRA listed hazardous waste codes and radioactive nuclides (Tc-99, Co-60, U-234, U-235, U-238, Pu-238, Pu-239, and Np-237). Characterization activities included representative sampling and assessments of:

- Residuals left in tanks, pipes, process lines or equipment
- Rinseate/liquid effluent generated during the decontamination of equipment
- Asphalt and concrete pads
- Field or wipe samples taken of equipment for characterization purposes

Based on the results of these characterization activities the material was designated for reused/recycled within the DOE complex or disposal at appropriate facility.

Safety and Ecology Corporation (SEC) was awarded a subcontract by Bechtel Jacobs Company, LLC (BJC) in September 2001 to dismantle and disposition the TVS equipment to comply with the RCRA Closure Plan (1). After completing all pre-mobilization planning documentation, SEC mobilized to the TVS site on December 3, 2001 to begin dismantling and waste disposition activities and completed these activities on March 22, 2002. Conventional methods utilizing air handling tools were used to disconnect and isolate the individual units and support equipment. Large cranes were also used to place the equipment on the ground once disconnected. Items were segregated based on process knowledge as

either "clean" or suspect contaminated and staged for confirmation sampling. Some minimal decontamination was performed on some units that were marginally contaminated to allow them to be reused rather than disposed as waste. SEC working with BJC went to great lengths to minimize the amount of waste that was land disposed in support of pollution prevention goals.

The closure of the TVS site consisted of dismantling the modules; decontamination of the modules, parts and equipment, as needed; removal of the TVS structures, equipment, and parts for either reuse or disposal, decontamination of the pad and verification sampling. Three intermodals totaling 2057 ft^3 of material were shipped to Envirocare of Utah for disposal as mixed waste while only 540 ft^3 of material was sent to the Y-12 Landfill as construction debris. About 10,206 ft^3 of clean material and equipment was sent to a local licensed recycle/reuse vendor called ToxCo. The 20,000-gallon tank was sent to a local waste processor for smelting into shield blocks to be used in the future by the Spallation Neutron Source Project.

This paper will focus on the following items associated with this successful RCRA closure project.

- TVS site closure design and implementation
- Characterization activities focused on waste disposition
- Pollution prevention through reuse
- Waste minimization efforts to reduce mixed waste to be disposed
- Lessons learned that would be integrated in future projects of this magnitude.

SITE HISTORY

ETTP, formerly known as the K-25 Site and Oak Ridge Gaseous Diffusion Plant (ORGDP), was built by the US Army on a 706 acre tract near the confluence of Poplar Creek and the Clinch River, as part of the Manhattan Project during World War II. The TVS Site is located in an area between the south side of Building K-31 and Poplar Creek. The TVS was moved to the site and erected in 1996. A site photo showing the TVS setup is provided in Figure 1.

The TVS was a large-scale vitrification system for the treatment of mixed wastes. The wastes contained both hazardous and radioactive materials in the form of sludge, soil, and ash. The TVS was developed to be moved to various Department of Energy (DOE) facilities to vitrify mixed waste as needed.

The TVS consists of four primary modules as described below.

1. The Waste and Additive Materials Processing Module was used to store, weigh and add waste and glass forming materials into the melter.

2. The Melter Module contained the molybdenum rod electrode, joule-heated glass melter and auxiliary equipment.

3. The Emissions Control Module contained the quencher, venturi scrubber, HEPA filters, and other emissions control equipment designed to remove in excess of 99.99% of the 1μm particulates.

4. The Control and Services Module contained the control room and electrical power conditioning equipment. Virtually all the TVS equipment was controlled from this module.

Figure 1. TVS Site Setup.

Waste and glass forming materials were weighed, mixed, and stored for introduction into the melter. Dry wastes were fed into an external waste hopper that transferred the material to the blend tank through a screw auger. Wet or slurry wastes were pumped directly into the blend tank. The blend tank had a 240-gallon working volume and was set on three load cells that allowed the operator to measure the quantity of waste or additives introduced into the tank. The feed tank had a vaneless centrifugal pump that recirculated the mixture through a loop that passed into the melter module, where a side stream was drawn off to feed the melter. Both the blend and feed tank recirculation loops had provisions for flushing with water. From September 26 through October 18, 1997, twenty feed batches containing 7,328 kg (16, 158 lb) of actual mixed waste were successfully vitrified in the TVS resulting in 17,000 lbs of vitrified (glass) mixed waste product.

Mixed waste treated at the TVS consisted of dried B & C Pond Sludge and newly generated waste sludge from the Central Neutralization Facility (CNF). The mixed waste was transported to the site as needed and was not stored at the TVS location. At the end of waste feed operations, all tanks and lines from the inside of the batch module were flushed and the resulting flush water was fed to the melter. The melter was drained of glass to the lowest point without exposing the electrodes. Approximately 3 tons of glass, containing vitrified waste, remained in the melter. All treated and untreated wastes were removed from the area and placed in permitted storage facilities located elsewhere on the ETTP reservation. Aqueous waste remaining in the 20,000-gallon blow-down tank was removed and transported to CNF for disposal. Dried particulate residue from the melter was found in the packed bed cooler. During shutdown, non-contaminated calcium carbonate was vacuumed into the dry waste feed hopper and screw-fed into the mix tank in an effort to move any remaining waste from the dry waste feed hopper into the mix tank. A final closeout inspection was conducted on the TVS unit on December 5, 1997.

REGULATORY LEVELS

In order to determine if decontamination goals are met and when interpreting laboratory results to classify the waste streams as hazardous or non-hazardous, SEC used the levels specified in Table 1 of 1200-1-11-.02(2)(e) of the Tennessee Department of Environmental Conservation (TDEC) Rule. Contaminants, which contribute to the toxicity characteristic of a hazardous waste and their regulatory levels, are listed in this table in the TDEC Rule.

There are no numerical criteria for "no added radioactivity"; rather, the general approach is to demonstrate by Best Available Technology (BAT) that the rinseate sample contains no increase in radioactivity, above that in the liquid, before its use.

The analytical procedures recommended to satisfy BAT are those that would typically be used for bioassay, i.e., for measurement of radionuclide concentrations in urine samples. These procedures are chemical separation followed by alpha spectrometry for transuranics (Am-241, Cm-244, and isotopic Pu) and by gross beta counting for Sr-90. The minimum detectable activities (MDA) established for these analyses are typically approximately 0.02pCi/l for the transuranics and 2pCi/l for Sr-90, based on analysis of a minimum sample volume of 1-liter. For other general fission and activation products, the BAT analytical method of concentration and gross beta counting, using a minimum sample volume of approximately 100 ml, will provide an MDA of approximately 10pCi/l. The actual MDA achieved may vary, depending on the amount of dissolved and suspended material in the liquid.

To put these MDA in perspective, they can be compared with the following criteria (Table 1) for radionuclide concentrations in drinking water; the drinking water criteria have an associated potential dose equivalent of 4 mrem/y, (EPA community drinking water standard).

Table 1. Radionuclide concentration in EPA community drinking water standard

Radionuclide	Concentration for 4 mrem/yr*
Am-241	1.2 pCi/l
Cm-244	2.4 pCi/l
Pu-238	1.6 pCi/l
Pu-239	1.2 pCi/l
Pu-240	1.2 pCi/l
Sr-90	40 pCi/l
Other Beta emitters	120 pCi/l**

*4% x DCG for member of the public (DOE Order 5400.5)

** based on Cs-137 as anticipated predominant fission/activation nuclide

While the rinseate samples of concern for this application are not analogous to drinking water, and the limited quantities of liquid anticipated (~250 gallons) and the planned disposition into a hazardous waste facility, assure negligible future exposures to workers or the public, comparing the proposed acceptable concentrations in the wastes to those in drinking water provides a worst-case scenario. Concentrations of the magnitude of the MDA in drinking water would represent far less than 1 mrem/yr. Thus, if the level of radionuclides in the liquid waste was less than the MDA above the levels in the unused liquid, it is reasonable to conclude that the liquid waste contains no added radioactivity.

CHARACTERIZATION METHODOLOGY

Characterization by one of the following methods or a combination thereof, as applicable and appropriate were utilized to support site closure objectives:

- Process Knowledge – Process knowledge included historical analytical data, living memory, historic records, or other methods that quantify the chemical and radiological constituents of a waste stream.

- Sample and Analysis – Representative grab samples, field or wipe samples, and composite samples from homogenous materials depending on the nature of the material being sampled were collected and analyzed for suspect contaminants, including analysis for RCRA characteristics, the presence of selected metals and organics, and for radiological constituents as discussed above. A BJC-approved Sample Management Office audited laboratory was used to conduct the laboratory analyses.

- Direct Measurement and/or Nondestructive Analysis – Direct measurements of materials were made using a variety of field instruments. These field readings were correlated to the physical samples collected to determine the quantity of radionuclides present. This was done by determining the isotopic ratio in the sample and applying that to the total activity.

- Smears - Smears were taken and counted using a variety of field instruments to determine the removable contamination present. These field readings were compared to the applicable criteria.

Historical review and process knowledge indicate that the RCRA characteristics of concern include numerous "F" and "U" Hazardous Waste Codes as identified in the RCRA Closure Plan as per 40CFR 261.31 and 40 CFR 261.33, respectively. Characterization activities included representative sampling and assessments of:

- Residuals left in tanks, pipes, process lines or equipment
- Rinseate/liquid effluent generated during the decontamination of equipment
- Asphalt and concrete pads
- Field or wipe samples taken of equipment for characterization purposes

DISMANTLEMENT AND DECONTAMINATION

Dismantlement activities were accomplished utilizing conventional air-handling tools and manual labor to disconnect the TVS into its smallest parts. If a connection could not be disconnected with conventional air or hand tools then a plasma arc torch was used to cut the connection. The overhead connections were accessed using man lifts and scissor lifts to aid the workers whom were safely secured to reach these connections. Once these upper units and associated components were disconnected, a large crane was mobilized to the site to move the units to the ground. Various cranes were utilized ranging in capacities of 50- to 200-tons depending on the weight of the unit to be moved (see Figure 2). Prior to lifts, a Lift Plan was prepared, reviewed, and approved by qualified personnel. This plan was reviewed by all involved personnel prior to lifting units and qualified supervision was provided to ensure it was adhered to.

Figure 2. TVS Dismantlement Activities.

As modules/equipment were dismantled, they were surveyed and segregated based on process knowledge into contaminated and non-contaminated waste streams and staged on site. Surface radiological scans of the material were performed to initially determine whether the material is radiologically contaminated. Representative samples from the staged material were collected and sent off for laboratory analysis during the initial weeks of field operations, ensuring sufficient time for waste characterization and profiling. Composite rinseate samples were collected and analyzed for the selected radiological and RCRA contaminants of concern to verify the segregated materials meet the waste acceptance criteria (WAC) of the receiving facility.

In some cases the dismantled equipment had to be size reduced further to fit into transport container or to meet WAC requirements. The "gutted" Batch Feed Module was used as a size reduction area to contain any material from the hot cutting technique using the plasma arc on over-sized material. This module was also used as a decontamination area for slightly contaminated equipment. The decontamination method was simply a 3,000 psi steam cleaner with cleaning additive in rinse water.

Selected pieces of equipment (i.e. steel tanks) and components (modules) with minimum radiological contamination present were decontaminated to allow them to be reused within the DOE complex. In order to prove modules/equipment as non-contaminated and that decontamination was effective, the rinseate, or decontamination effluent, was sampled for the presence of the identified contaminants. If levels of these contaminants fell below regulatory levels, the equipment or components were released as clean for reuse. (See Figure 3)

To prove that the asphalt pad under the TVS fell below RCRA regulatory levels as specified in the TVS Site Closure Plan, four composite core samples were collected and analyzed after removal of equipment and decontamination of the asphalt pad.

WASTE DISPOSITION

The decision process and associated release surveys, scoping, and characterization activities to support waste disposition is presented in Figure 2. Characterization and sampling objectives for the TVS Site Closure to support waste disposition decisions were focused on the following.

- Characterize the TVS modules/equipment as mixed waste (radiologically and Resource Conservation and Remediation Act (RCRA) contaminated) and/or non-contaminated to facilitate segregation of waste and to meet the waste acceptance criteria (WAC) of the treatment, storage, and disposal facility (TSDF), and prepare the shipping documentation and papers.

- Provide documentation that decontamination levels have been achieved to certify the RCRA closure of the site.

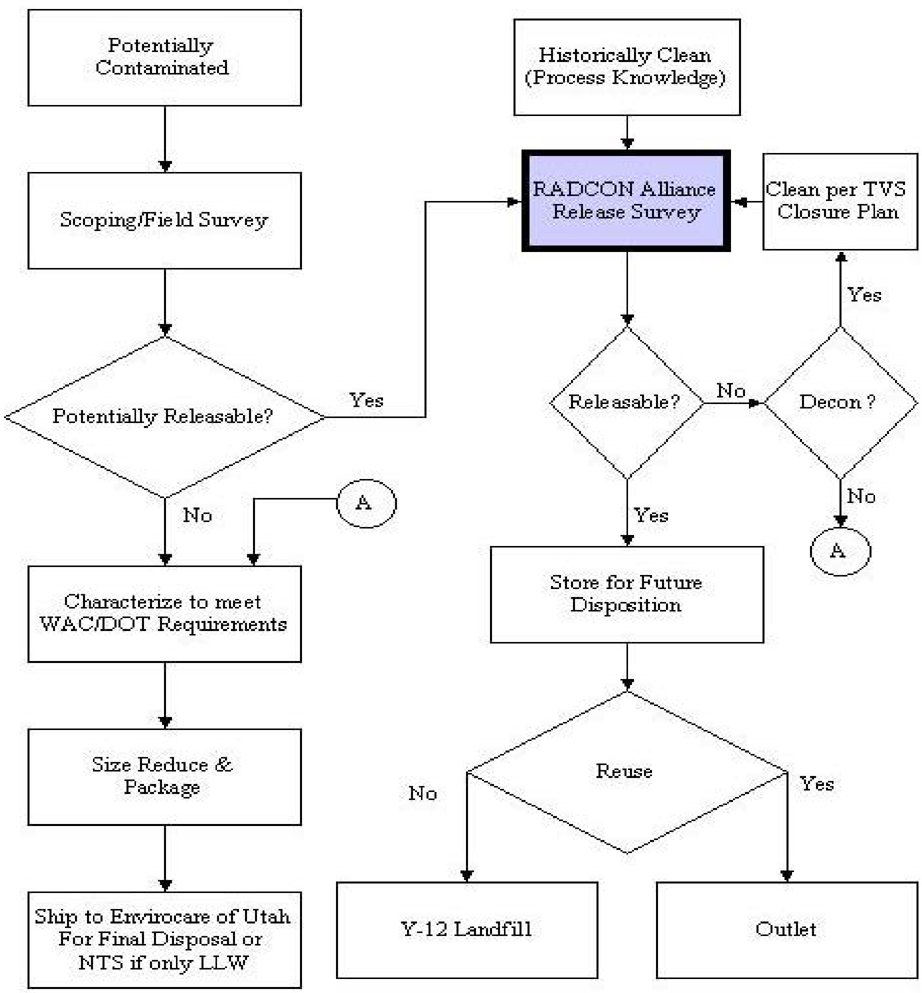

Figure 3. Waste Disposition Decision Process.

While many of the internal surfaces of the process lines and components in the contaminated modules were RCRA/radiologically contaminated, the exterior surfaces, supports, braces and much of the supporting equipment in these modules were clean. The contaminated modules were dismantled from the outside to the inside, taking care to segregate clean material from contaminated. Efficient segregation and careful dismantlement allowed considerable reduction in the volume of mixed waste requiring disposal.

Clean Material

Once the segregated waste was analyzed and verified clean it was size reduced (if necessary), packaged, profiled, and manifested for either transport to Y-12 Landfill (construction debris) or ToxCo for recycle/reuse. Waste disposed at the Y-12 Landfill conformed to either S-010, S-020, and/or S-040 master profiles that are maintained by this permitted disposal facility.

The material sent to ToxCo as clean metal material for reuse must have never been within a radiological control boundary and/or met the "no added radioactivity" criteria discussed previously. By keeping the metal material out of the Y-12 Landfill, SEC assisted BJC in meeting the Pollution Prevention (P2) goals at a considerable cost savings to the government.

SEC also salvaged the Control and Power Module after the release survey requirements for this unit was met. This module was placed on a flatbed trailer, secured, and shipped to Clemson Environmental Technology Laboratory in Anderson, South Carolina where it will be used for future research.

Mixed Waste

As contaminated modules are dismantled, surveyed, and segregated, the contaminated waste stream were segregated and staged on site. Surface scans of the material were used to initially determine whether the material was radiologically contaminated. Because of the association of radiological material with RCRA material in the parent waste stream, evidence of radiological contamination was considered indicative of RCRA contamination. Representative samples from the staged material were collected and sent off for laboratory analysis. Composite rinseate samples were collected and analyzed for the radiological and RCRA contaminants to verify that the segregated materials are contaminated and to prepare a waste profile compliant with the WAC for mixed waste debris at the Envirocare of Utah disposal facility.

Final Waste Disposition

The resulting waste disposition path and volumes generated during the RCRA closure of the TVS site are summarized below.

- Three intermodal containers totaling 2057 ft^3 of material were shipped via rail to Envirocare of Utah for disposal as mixed waste.
- 540 ft^3 of material were transported by dump truck to the Y-12 Landfill as construction debris.
- 10,206 ft^3 of clean material and equipment were sent to a local licensed recycle/reuse vendor ToxCo for reuse in the DOE complex.
- 20,000-gallon tank was sent to a local waste processor for smelting into shield blocks to be used in the future by the Spallation Neutron Source Project.
- Control and Power Module was shipped to Clemson Environmental Technology Laboratory where it can be used for future research.

CONCLUSIONS

Because all the waste treated at the TVS Site was mixed waste (radiological and RCRA), the radiological results were used as an indicator of RCRA contamination. The radiological survey data shows that all surface activity measurements were well within the radiological guideline levels for unrestricted release. Since no elevated radiological levels were detected, no remaining RCRA contamination is indicated. Furthermore, all sample results were below the acceptable cleanup criteria for all contaminants of concern and for all affected media as indicated in Table 2.

Table 2 – Sampling Results Versus Clean Up Criterion

CONTAMINANT OF CONCERN	CLEAN UP CRITERION (ppm)	HIGHEST POST REMEDIAL ACTION SAMPLE RESULTS (ppm)
Arsenic	5.0	0.044
Barium	100.0	0.599
Cadmium	1.0	Not Detected
Chromium	5.0	Not Detected
Lead	5.0	Not Detected
Mercury	0.2	Not Detected
Selenium	1.0	Not Detected
Silver	5.0	0.0095

All RCRA closure requirements were achieves and even exceeded allowing this area to ge made available for re-industrialization.

The efforts to minimize the volume of material that required land disposal resulted in over a $100,000 cost savings to the government while exceeding the P2 goals for this project and this DOE site. In addition, the material that was decontaminated or found to be free of contamination was able to be reused within the DOE complex resulting in cost avoidance in excess of $500,000. Working together SEC, BJC, and DOE was able to cost effectively close a site and find a reuse for a technology that was found to be too costly.

In summary, the lessons learned were as follows:

- Focusing the characterization towards waste disposition minimized the amount of off-site analytical requirements while capitalizing on on-site radiological survey techniques.
- Utilizing a radiological constituent as an indicator parameter minimized the need for costly TCLP analysis for RCRA characteristics while still achieving closure objectives.
- Integrating process knowledge with on-site radiological surveys minimized the number of samples required for full analysis at off-site laboratory.
- Minimum decontamination of units allowed the team to maximize the amount of equipment that could be reused within DOE complex.

Overall this was a very successful project that will be a model for future projects of this type.

REFERENCES

1. TVS Site RCRA Closure Plan….