



Summary Report DOE/EM-0479

Demonstration of ATG Process for Stabilizing Mercury (<260 ppm) Contaminated Mixed Waste

Mixed Waste Focus Area



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Mixed Waste Focus Area



Demonstrated at
East Tennessee Technology Park
Oak Ridge, Tennessee



Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at <http://OST.em.doe.gov> under "Publications."

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SECTION 1

SUMMARY

Technology Summary

Mercury contaminated wastes in many forms are present at various U. S. Department of Energy (DOE) sites. Based on efforts led by the Mixed Waste Focus Area (MWFA) and its Mercury Working Group (HgWG), the inventory of wastes contaminated with <260 ppm mercury and with radionuclides stored at various DOE sites is estimated to be approximately 6,000 m³ (Conley, Morris, Osborne-Lee, and Hulet 1998). At least 26 different DOE sites have this type of mixed low-level waste in their storage facilities. Extraction methods are required to remove mercury from waste containing >260 ppm levels, but below 260 ppm Hg contamination levels the U. S. Environmental Protection Agency (EPA) does not require removal of mercury from the waste. Steps must still be taken, however, to ensure that the final waste form does not leach mercury in excess of the limit for mercury prescribed in the Resource Conservation and Recovery Act (RCRA) when subjected to the Toxicity Characteristic Leaching Procedure (TCLP). At this time, the limit is 0.20 mg/L. However, in the year 2000, the more stringent Universal Treatment Standard (UTS) of 0.025 mg/L will be used as the target endpoint.

Mercury contamination in the wastes at DOE sites presents a challenge because it exists in various forms, such as soil, sludges, and debris, as well as in different chemical species of mercury. Stabilization is of interest for radioactively contaminated mercury waste (<260 ppm Hg) because of its success with particular wastes, such as soils, and its promise of applicability to a broad range of wastes. However, stabilization methods must be proven to be adequate to meet treatment standards. It must also be proven feasible in terms of economics, operability, and safety. To date, no standard method of stabilization has been developed and proven for such varying waste types as those within the DOE complex.

The MWFA is investigating possible stabilization methods for mercury-contaminated mixed waste streams and has funded demonstrations, several of which have been completed. The Technology Development Requirements Document (TDRD), developed by the MWFA, requires that the effectiveness of newly developed technologies be proven. New technology for mercury stabilization must adequately stabilize waste to the new UTS, and must provide measuring and monitoring methods to verify the process. In addition the new process should:

- minimize worker exposure,
- minimize volume increase as waste is treated,
- minimize secondary waste generation,
- maximize operational flexibility and radionuclide containment.

This report summarizes the findings from a stabilization technology demonstration conducted by Allied Technology Group, Inc. (ATG), under MWFA sponsorship.

Demonstration Summary

Three vendors, Allied Technology Group (ATG), International Technologies, Inc. (IT), and Nuclear Fuel Services, Inc. (NFS), conducted demonstrations of their technologies in response to the MER02 Request for Proposal (RFP). The ATG demonstration of mercury waste stabilization is the primary focus of this report. The IT and NFS demonstrations are reported elsewhere (MWFA 1999A, MWFA 1999B).

Building on the results of a companion bench-scale study (ATG 1998), ATG conducted a demonstration with full-scale stabilization equipment. Tests were performed at Mountain States Analytical Laboratory, located in Salt Lake City, Utah. The waste treated was an ion exchange process stream from the DOE



Portsmouth, Ohio, facility. The goal of the demonstration was to stabilize mercury and other RCRA metals in the mixed waste specimen to UTS limits.

The demonstration showed that a dithiocarbamate (DTC) formulation can be used to produce a stabilized waste that satisfies the UTS limits for mercury. ATG performed seven bench-scale tests and then processed three full-scale batches. In these runs, DTC formulations reproducibly stabilized over 99 percent of the mercury initially present at 40 times the UTS limit. The volume increase resulting from stabilization was small, 16 percent of the untreated waste volume. The DTC formulation also stabilized barium, cadmium, and chromium.

The full-scale batches showed that a transportable stabilization and solidification system is suitable for onsite management of homogeneous streams of liquid, sludge, and solid wastes containing mercury. ATG reports that RCRA Part B permits should not be required to treat mixed waste with their system at the point of generation or long-term storage.

For wastes containing more than a few percent of water, improved water management presents the greatest potential for minimizing life-cycle costs. Dewatering reduced the volume of stabilized ion exchange waste by 80 percent with proportional reductions projected for the cost of treating, transporting, and disposing of the waste.

Key Results

The key results of the demonstration are as follows:

- ATG succeeded in demonstrating a process for stabilizing the mercury contaminated mixed waste specimen to meet all UTS TCLP limits.
- The waste form produced was a damp paste, with no free standing water.
- Small but significant increases in volume were obtained, in most cases from 10–25 percent.
- Secondary waste is expected to amount to 10–20 lb of dunnage per day of full-scale operation.
- Life-cycle costs are estimated at less than \$2 kg, not including transportation and disposal of final waste. No significant decommissioning and site restoration costs are expected.

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This ITSR was prepared by the MWFA Mercury Working Group and Prairie A&M University.

All published ITSRs are available at <http://em-50.em.doe.gov>.



SECTION 2

TECHNOLOGY DESCRIPTION

Overview

The HgWG has identified over 30,000 m³ of mercury contaminated mixed low-level and transuranic wastes in the DOE complex. In addition to elemental mercury, these waste streams include sludges, soils, and debris waste with mercury concentrations ranging from less than 2 ppm to greater than 50,000 ppm. Approximately 6,000 m³ of these wastes are contaminated with <260 ppm mercury. RCRA regulations require that mercury wastes with contamination levels at or above 260 ppm Hg be recovered by a thermal process, such as retorting, and stabilized using an amalgamation process. No specific treatment method is specified for wastes containing <260 ppm; however, RCRA regulations require that such wastes that exceed a mercury concentration¹ of 0.20 mg/L be treated by a suitable method to meet this standard.

The HgWG conducted a source selection for vendors to participate in demonstrations of different types of technologies capable of stabilizing wastes containing <260 ppm of mercury to meet the TCLP limit. Until recently, no studies beyond bench scale had been conducted on the amalgamation and stabilization of mixed mercury wastes. The primary technical issue associated with the treatment of such waste was related to scale-up of the process to a cost-effective operations level. However, the HgWG now reports the completion of three technology demonstrations on the stabilization of mixed wastes contaminated with mercury at levels <260 ppm.

ATG, located in Fremont, California, has recently applied its stabilization process, employing bench- and demonstration-scale equipment to treat ion exchange resin from a DOE site. Duratek, located in Oak Ridge, Tennessee, has demonstrated the treatment of waste received from Los Alamos National Laboratory (LANL) with the Duratek stabilization process on several drums of sludge and laboratory residues. NFS, located in Erwin, Tennessee has demonstrated its proprietary stabilization process on ion exchange resin from the Picketon Gaseous Diffusion Facility. The Duratek and NFS technology demonstrations are each reported elsewhere in separate ITSRs (MWFA 1999A, MWFA 1999B). The ATG technology demonstration is the focus of this report. Other recent ITSRs address related issues, including: (1) the treatment technology for the amalgamation of waste contaminated to levels at or above 260 ppm Hg (MWFA 1998A, MWFA 1998B) and (2) the effects of speciation on the stabilization of mercury wastes (Osborne-Lee 1999). In the speciation studies, IT, NFS, and ATG performed stabilization tests at bench scale on surrogate soil wastes spiked with several different species of mercury at less than 260 ppm.

NFS Process Definition

The TDRD for Mercury Stabilization (DOE, 1996) indicated that many DOE sites have debris and sludges that are contaminated with mercury. The document also noted that then-existing commercial processes for stabilization of mercury in mixed waste were inadequate, or at least not yet demonstrated. Members of the ATG process development team have produced several commercial proprietary processes that have stabilized metals and organic compounds in soils and sludges for both commercial- and government-sector clients. Once stabilized, the treated waste is usually solidified into a cementitious material to form a high-strength, leach-resistant monolith. Metals stabilized by the ATG team include lead, vanadium, nickel, chromium, chromium (VI), arsenic, copper, cadmium, zinc, and now, mercury. Stabilized organic compounds include polycyclic aromatic hydrocarbons, pentachlorophenol, dioxins, furans, and cyanide.

The recently promulgated UTS for the total concentration of mercury in the leachate from a TCLP is 0.025 mg/L, which is nearly an order of magnitude below the previous standard of 0.20 mg/L. Many

¹ As determined by Environmental Protection Agency (EPA) SW-846 Method 1311 Toxic Characteristic Leaching Procedure (TCLP).



commercial-scale and laboratory-scale tests have satisfied the stricter standard (Conner 1990), but most wastes had less than 5 mg/kg of total mercury, and all but one had less than 20 mg/kg of total mercury.

ATG developed a formulation that stabilizes the most common mercury species for initial mercury concentrations in waste approaching 260 ppm. The performance of the DTC formulation with various chemical species of mercury is described in another report submitted as part of this study (Osborne-Lee 1999). DOE has a considerable volume of waste with mercury concentrations greater than 100 mg/kg. This demonstration examined the correlation between bench-scale tests and full-scale operations and evaluated the reliability of mercury stabilization for DOE wastes with mercury concentrations approaching 260 mg/kg.

The goal in this treatability study was to demonstrate the effective stabilization of mercury and other metals in ion-exchange resin. Effectiveness was judged by the ability of the process to produce treated-sample residues with TCLP leachate mercury concentrations less than 0.025 mg/L and other RCRA metals below the new UTS levels.

ATG System Operation

Materials

The full-scale demonstration test and supporting bench-scale tests were conducted with an ion exchange resin waste [DOE(BJ) R98-099] supplied by DOE's Portsmouth, Ohio, facility. ATG received 160 kg of liquid waste containing less than 5 percent solids. The solids consisted of ion exchange beads and rust from the drums. The DOWEX[®] 1X4 resin had been used in Portsmouth's ion exchange facility to capture technetium in the raffinate waste stream from a uranium recovery process.

The waste appeared to be resin backwash rather than packed beads drained directly from the column. Upon sitting for several days, the rust colored solids settled to the bottom of a container and a clear liquid could be decanted off of the top. After settling, the rust colored suspension accounted for approximately 20 kg of the total waste and had a solids content of 33 grams of solids per 100 grams of waste.

The ion exchange waste contained 1.06 mg/mL of mercury and 680 picocuries per gram (pCi/g) of technetium-99 (⁹⁹Tc). The concentrations of other metals are discussed later in this report. ATG reported the activities of other radionuclides in the resin in a previous report (ATG 1998). The density of the clear liquid was 1.16 gm/mL, indicative of a high dissolved salt concentration. Significant quantities of crystalline salts were visible on the ion exchange beads when the rust colored suspension was evaporated to dryness.

The stabilization reagents tested included proprietary dithiocarbamate (DTC), phosphate, and polymeric reagents, and several generic reagents. The generic reagents used in the bench tests described below included magnesium oxide, calcium carbonate, sodium meta-bisulfite, sodium hydrosulfide, and activated carbon.

Methods

Before proceeding with the full-scale demonstration test, ATG conducted bench-scale tests with the waste ion exchange resin. Based on results from ATG's preliminary mercury-speciation study (Osborne-Lee 1999), DTC was selected as the primary stabilization reagent for these bench-scale tests. One or more of the generic reagents identified above were added to the DTC reagent to create additional formulations. The selection of generic reagents was based on their potential to either protect the DTC from premature inactivation or to reduce the quantity of DTC required. A magnesium oxide and phosphate formulation, from which DTC was omitted, was tested because of the potential of ceramic forming reactions to decrease the final volume of waste created.

Based on the results of the bench-scale tests with 600-g samples of waste, the simple DTC formulation was selected for the demonstration test. Although specified in the work plan, no Synthetic Precipitation



Leaching Procedure (SPLP) tests were conducted on either the untreated or treated wastes. The SPLP test is primarily of interest for solid wastes, not the liquid waste used in this demonstration.

Bench-Scale Test

Seven formulations were bench-tested. Between 70 and 300 grams of formulations were mixed with 600 grams of waste. The order of addition and time of mixing before the addition of other components of the reagents was carefully controlled. The pH of the stabilized mixture was always measured prior to the addition of the solidifying polymer.

In addition to the tests described in the work plan, two formulations were tested on the rusty-colored suspension, described above, after most of the water had been evaporated. Placing approximately 10 liters of the suspension in a 5-gallon pail into an oven at 130°C for 8 to 10 hours evaporated the water. About 2 liters of suspension (sludge) remained after drying.

Demonstration Test

Three 33-kg batches of waste were treated with the DTC formulation. A total of 5.6 kg of the DTC formulation was added to a 33-kg batch of waste. The 33 kilograms of waste represented about one-fifth of the approximately 165-kg waste capacity of the mortar mixer.

The bead size for the polymeric absorbent (< 5-mm mesh) was larger for the demonstration test than for the bench tests (< 1-mm mesh). The larger polymeric beads required several hours to absorb the water and solidify the waste in the first batch of the demonstration test. After the first batch, the polymeric beads were ground in a mill to a mesh size (< 2-mm mesh) that was used for the last two batches. An additional 40% by weight of the polymer weight used in batches two and three was added to the first batch to speed solidification.



SECTION 3

PERFORMANCE

Bench-Scale Results

A detailed description of experimental materials and methods is provided in a work plan,² submitted to the HGWG. The materials, methods, and significant deviations from the work plan were described in the previous section. The results and findings are presented here.

The bench-scale test evaluated seven formulations and identified five that reduced the leaching of mercury from the treated waste below the UTS limit. These same formulations resulted in a small, less than 25 percent increase, in the volume of the treated waste relative to the untreated waste. Temperature and pH changes were minimal for these five formulations. Successful formulations were found, all of which contained the same DTC reagent.

Leach Test Findings

As shown in Table 1, the most successful formulation, DTC alone, reduced the mercury concentration from over 4,000 percent (40 times) of the UTS limit in the untreated waste to 22 percent in the treated waste. With the exception of carbon, addition of other compounds with the DTC reduced the effectiveness of the DTC in stabilizing mercury.

Table 1. Comparison of reduction in leachability of mercury by stabilization formulations in the Allied Technology Group study

Formulation		Treated Waste		
ID	Description	Average TCLP ^a mg/L	% of UTS ^b	Amount stabilized (%)
H	DTC	0.0056	22	99.5
I	DTC & Magnesium Oxide	0.0152	61	98.6
J	DTC & Carbonate	0.0149	60	98.6
K	<i>DTC & Meta-Bisulfite</i>	<i>0.0309</i>	<i>124</i>	<i>97.1</i>
L	DTC & Hydrosulfide	0.0101	40	99.0
N	DTC & Carbon	0.0064	26	99.4
O	<i>Magnesium Oxide & Phosphate</i>	<i>0.111</i>	<i>444</i>	<i>89.5</i>

^a TCLP refers to the toxicity characteristic leaching procedure.

^b UTS refers to the universal treatment standard.

The magnesium oxide and phosphate formulation was 10 times less effective in stabilizing mercury than the carbamate reagent. Formulations containing carbamate stabilized between 97 and 99.5 percent of the mercury whereas the magnesium oxide formulation stabilized only 90 percent of the mercury. The percent stabilized is defined as the percent difference in the concentration of TCLP leachates from treated and untreated samples compared to the concentration in the untreated sample.

² Work plan submitted by ATG in 1997 to the HGWG (reference LMES Subcontract No. 1GX-SX540V-MER02)



Volume Increase Findings

The volume increase resulting from addition of the formulations to the ion exchange waste was small, less than 25 percent, for all but the formulation containing sulfide. Volume increases and other changes in properties resulting from treatment with the formulations are shown in Table 2. The volume increase was the smallest, 10 percent, for the magnesium oxide and phosphate formulation, which sets up into a moderately dense ceramic. Except for the magnesium oxide and phosphate formulation, the volume increase was approximately the same as the weight increase.

Table 2. Changes in properties of stabilized ion exchange waste in Allied Technology Group demonstration

ID	Formulation	Density of treated waste (kg/l)	Weight increase ^a (%)	Volume increase ^b (%)	Change in pH	Temperature change (°C)
H	DTC	1.06	15	24	0.64	0
I	DTC & Magnesium Oxide	1.08	17	24	1.35	0
J	DTC & Carbonate	1.20	30	24	0.56	0
K	DTC & Meta-Bisulfite	1.08	26	33	-2.6	0
L	DTC & Hydrosulfide	1.14	24	24	3.2	0
N	DTC & Carbon	1.15	25	24	0.56	0
O	Magnesium Oxide & Phosphate	1.59	52	10	0.00	26

^a Initial waste volume is 500 mL and initial waste density is 1.16 g/L.

^b Initial pH of raw waste, after adjustment with HCl, is 8.

The small increase in volume for stabilizing and solidifying the ion exchange waste, which is primarily water, is attributable to the enormous absorptive capacity of the polymer. Volume increases of 200–300 percent resulted when more common solidification agents, such as clays, were added to water in preliminary reagent screening tests. In these bench tests, the polymer beads absorbed more than 20 times their weight in water.

Operational Considerations

Except for the formulation containing both DTC and meta-bisulfite, no pH control is likely to be necessary for larger treatment systems. The sharp drop of 2.6 pH units to a mildly acidic pH of 5.4 may have caused this formulation to fail to satisfy the UTS limit for mercury.

Except for the magnesium oxide and phosphate formulation, temperature control is unlikely to be required for larger treatment systems. The ceramic reactions in the magnesium oxide and phosphate formulation gave off sufficient heat to raise the temperature of the nominally 1-liter bench test batch by 26°C. Temperature control is a significant concern when this formulation is used to treat larger batches.

Additional Leach Test Findings

Formulations containing only DTC effectively immobilized mercury in ion exchange resin dried before treatment. Mercury concentrations in leachate from waste treated with two different DTC formulations were 0.0088 and 0.0086 mg/L, which is about one-third of the UTS limit. The effectiveness of the mercury immobilization was independent of the DTC concentration range used in these tests. The mercury leachate concentrations were the same for both formulations even though the DTC concentration of one formulation was twice that of the other. These formulations are identified in the analytical reports as Formulations A and B, with the DTC concentration of Formulation A one-half that of Formulation B. The formulation with DTC alone (Formulation H) was the simplest and most effective for immobilizing mercury.



Therefore, DTC alone (but including a polymeric solidifying reagent) was selected for the demonstration test.

Demonstration Results

The demonstration test showed that treatment with DTC and polymer stabilized the mercury in the untreated waste to the UTS limit with a minimal increase in volume. The treatment also stabilized several other metals, including barium, cadmium, and chromium.

Additional Leach Test Findings

Table 3 shows that leaching of both cadmium and mercury exceeded the UTS limit in the raw waste, but satisfied the limit in the treated waste. For treated waste, the concentration of cadmium in the leachate was closer to the corresponding UTS limit than that of mercury. Cadmium and mercury were present at 48 and 37 percent of their UTS limits respectively. The concentration of chromium in the leachate from the waste was reduced from near the UTS limit to 3 percent of the limit in the treated waste.

Table 3. Reduction in leachability of metals from ion exchange waste after treatment with the Allied Technology Group stabilization process

Metal	Raw Waste Leaching ^a	UTS ^e limit (mg/L)	Treated Waste		
			Average ^d TCLP ^e (mg/L)	% of UTS	% Stabilized
Antimony - Sb	-	1.15	<0.02	<2	-
Arsenic - As	<0.015	5	<0.015	<1	-
Barium - Ba	1.07	21	0.34	2	68
Beryllium - Be	-	1.22	0.00043	0.036	-
Cadmium - Cd	0.371	0.11	0.053	48	86
Chromium - Cr	0.51 ^b	0.6	0.016	3	97
Cobalt - Co	-	NA ^c	0.020	NA	-
Copper - Cu	-	NA	0.0050	NA	-
Lead - Pb	<0.015	0.75	0.019	2	-
Mercury - Hg	1.06	0.025	0.0092	37	99
Molybdenum - Mo	-	NA	<0.005	NA	-
Nickel - Ni	-	11	0.32	3	-
Selenium - Se	<0.015	5.7	0.017	0.3	-
Silver - Ag	0.004	0.14	<0.003	<3	>25
Thallium - Tl	-	0.2	<0.008	<4	-
Vanadium - V	-	1.6	<0.004	<0.3	-
Zinc - Zn	-	4.3	0.63	15	-
TCLP Pass / Fail	Fail	NA	Pass	NA	NA

^a Bold type indicates concentration in untreated waste leachate exceeded UTS regulatory limit.

^b Chromium concentration in untreated waste leachate was slightly less than the UTS limit.

^c NA - Not Applicable.

^d Values for the treated waste are the averages of values for three batches.

^e UTS and TCLP refer to universal treatment standard and toxicity characteristic leaching procedure, respectively.

The average concentration of metals leaching from the three wastes was calculated as the average of the three runs. The range of mercury concentrations in the TCLP from the three treated waste samples was moderate, ranging from 0.0078 to 0.0118 mg/L.



Based on the percent of the metal stabilized, the DTC formulation most effectively stabilized mercury and chromium. The formulation was moderately effective with barium and cadmium. The formulation stabilized 99 percent of the mercury and 97 percent of the chromium.

The volume increase resulting from stabilization of ion exchange waste was small, an average of 16 percent for two runs. Volume and weight increases resulting from treatment are shown in Table 4. Because the density of the treated and untreated waste was similar for these two runs, the volume increase was equal to the weight increase.

Although results from the first run were used in calculating the average concentrations of metals in TCLP leachates, results from this run were not used to calculate the average volume or weight increase. The sub-5 mm mesh size of the polymer beads used in the first run was several times larger than the sub-1 mm mesh size of the polymer beads used in the bench scale study. For Runs 2 and 3, ATG ground the polymer beads to a sub-2 mm mesh size before adding them to the waste. The larger beads appeared to trap air and failed to pack as densely as the smaller beads.

Table 4. Volume changes resulting from treatment of ion exchange waste in Allied Technology Group demonstration

Run	Density of treated waste ^a (kg/L)	Weight increase (%)	Volume increase ^b (%)
1	1.04	18	33
2	1.18	16	14
3	1.16	17	17
Average ^c	1.17	17	16

^a Density of untreated waste is 1.16 kg/L.

^b Volume of untreated waste ranges from 28 to 29 liters.

^c Average calculated from Runs 2 and 3 only as excess polymer was added in run 1.

The time required to stabilize the waste was much larger for the first run than for the second and third runs. The smaller beads in the second and third runs absorbed the free water in 20 minutes as compared to the several hours required for the larger beads. The still smaller beads used in the bench tests absorbed the water in 5 minutes. For the second and third runs, the total elapsed time from the initial addition of the untreated waste to the mortar mixer to the removal of the treated waste was 35 minutes.

With the smaller beads used for the bench tests, the total cycle time could be shortened to 20 minutes. On a 20-minute cycle, the 0.2 m³ (7 ft³) mortar mixer used here could process three 0.16 m³ (5.6 ft³) batches of untreated waste, or 550 kg (1,200 lb), each hour.

At the beginning of the first run, mercury vapors were monitored every minute within the mortar mixer and were never detected, nor were mercury vapors detected when spot monitored during the remainder of the first run and during the other runs. The liquid effectively shielded radioactivity within the waste and no radioactivity was observed with the Ludlum Model 2221 portable scale rate meter.

No significant temperature change was observed during the mixing operation. Addition of the DTC increased the pH of the mixture approximately one-half of a unit from 8.3 to 8.9. The air temperature during the three runs gradually increased from 25.2 to 29.2°C. The mixing speed was constant at 66 rpm throughout all three runs.

A plastic sheet covering the mixer shown in Figure 1 was sufficient to contain the small amount of material thrown off as the mixer blades rotated. When treatment was complete, most of the material



readily dumped from the mixer and the remainder was easily scraped out with a flexible scraper as shown in Figure 2. The final product, shown in Figures.3–5, consisted of small gelatinous particles with dimensions on the order of a few millimeters. There were no noticeable textural differences between the granules produced during the bench tests and those produced during the demonstration tests. When pulled apart, the granules separated cleanly, with no stringy connecting material stretching between them.

Secondary Waste Generation

The only secondary wastes generated by the demonstration test were seventeen 0.6-0.9 kg samples of treated waste (approximately 14 kg total) generated by the bench tests and dunnage. The dunnage consisted of personal protective clothing, cloth wipes, plastic sheets, jars, and pails. Excluding empty waste containers, the demonstration test indicated that 10–20 lb of dunnage would be generated each day during full-scale operation.



Figure 1. Mortar mixer used in Allied Technology Group process for stabilization demonstration.





Figure 2. Emptying mortar mixer during Allied Technology Group demonstration of MER02 stabilization process.

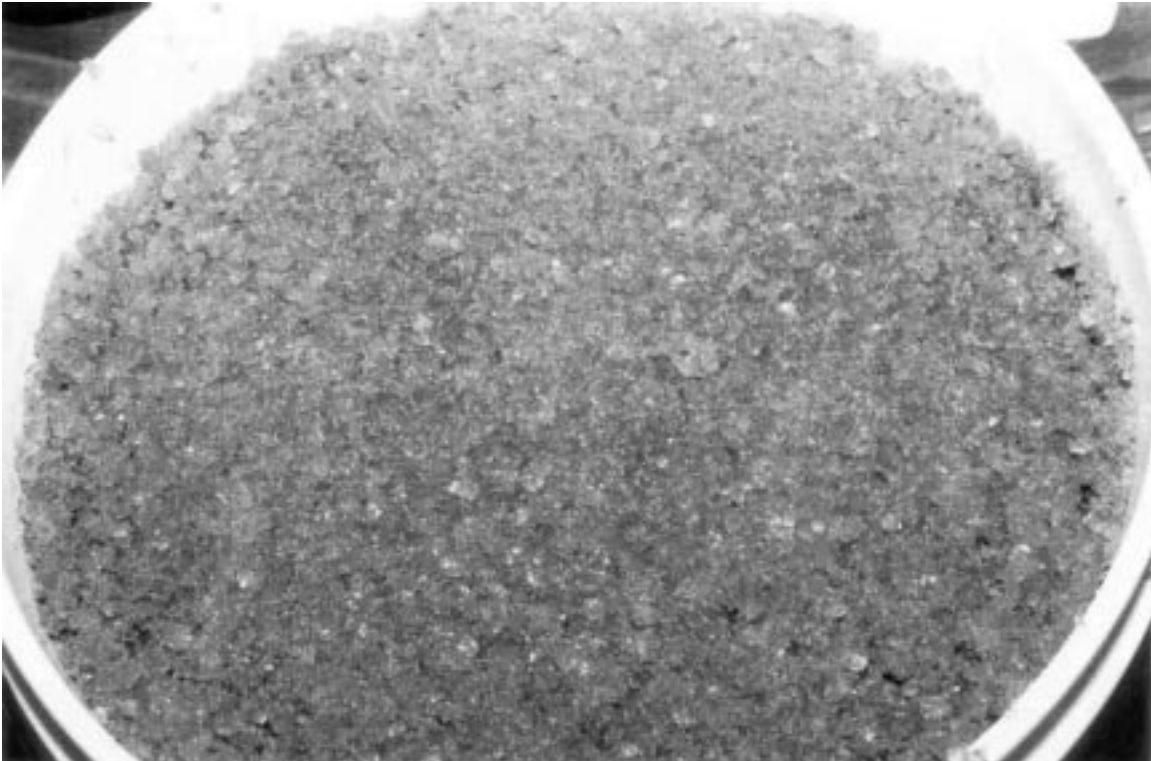


Figure 3. Close-up view of treated ion-exchange resin waste product from the Allied Technology Group stabilization process.



Figure 4. Six numbered pails containing all treated waste from demonstration of the Allied Technology Group stabilization process.





Figure 5. Comparison of waste treatment products from Allied Technology Group stabilization process: demonstration (left) and bench test (right) results.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

Competing Technologies

Baseline Technologies

While RMERC/IMERC has been used to address mercury within waste at concentrations exceeding 260 ppm, there is relatively little work on the effective stabilization of mercury in problematic mercury contaminated mixed wastes at <260 ppm. This need has driven the mission of the HgWG to identify and validate useful industry mercury stabilization technology for DOE mixed wastes. Although RMERC could be applied to mercury in the <260 ppm range, there are both public and regulatory concerns about mercury emissions. In addition, RMERC alone does not address the potential need to stabilize thermal residuals before disposal in a licensed and permitted landfill. Hence, no real baseline technology exists for mercury-contaminated mixed wastes at <260 ppm, although several promising new and developing technologies do exist.

Sulfur polymer cement offers some potential for mercury stabilization. However, this process is sensitive to water content of the subject material and requires elevated temperature for application. For the specific matrix tested in this work, sulfur polymer cement is unlikely to be as useful as other competing technologies, such as the NFS DeHg process, given the high water content and the relatively low decomposition temperature of anion-exchange material.

The MER02 Scope of Work (SOW) specified technology demonstrations to address the deficiencies in technology for treating mercury-contaminated mixed waste. Under the MER02 SOW, a total of three vendors were funded to demonstrate their newly-developed or developing processes on actual mixed wastes. The processes demonstrated by the ATG, Duratek, and NFS represent competing technologies. As newly demonstrated technologies, comparisons of these processes, among themselves and with respect to the baseline, are of particular interest. Important criteria for comparison include (1) performance in treating mercury contaminated mixed waste (<260 ppm), (2) applicability to the target and other waste categories, (3) cost, and (4) risk to workers and the public.

Currently, however, some demonstration findings are still being gathered at the time of this report, such that a full comparison of competing technologies must await a future report. Nevertheless, important criteria for comparison are reported here for the ATG process along with similar information for NFS and Duratek, where available.

Technology Applicability

The stabilization system demonstrated by ATG has the potential to treat most of the low-level streams listed in Table 1 of the MWFA TDRD (MWFA 1996), including aqueous streams designated for the TSCA incinerator and the transportable vitrification system. The hundreds of cubic meters of transuranic (TRU) wastes would require a larger system than tested here and the heterogeneous debris wastes would also require equipment for size reduction.

The ion exchange waste treated by ATG was relatively free of constituents, aside from the target metals that consume the DTC reagent. Studies of required dosages of DTC would be useful to establish whether DTC formulations are suitable for full-scale stabilization for other DOE waste streams. If excessive dosages are required, other studies directed toward finding alternative stabilizers or toward protecting the DTC reagent may be warranted. Previous treatability work (ATG 1998) showed that either sulfide or borohydride formulations were effective with inorganic mercury wastes.



The full-scale system tested in this study is easily portable and well suited for homogeneous streams of liquid, sludge or solid waste. Most waste streams of less than 50 m³ total volume can be processed by the mobile facility in 10 days or less by a crew of two.

For waste streams larger than 50 m³ that contain water amounting to more than a few percent, treatment costs could be reduced substantially by dewatering before solidification. The simplest method of dewatering would be via evaporation in a thermal dryer. For example, barrels containing waste would be placed in a heated enclosure for 48 hours.

Precipitating the mercury and stabilizing only the resulting precipitate often treats hazardous waste water containing mercury. Provided the resulting liquid could be managed as a nonhazardous and nonradioactive waste, precipitation of mercury from a primarily aqueous mixed waste would be less costly than thermal evaporation of the liquid.

This demonstration showed that a transportable stabilization and solidification system is suitable for onsite management of homogeneous streams of liquid, sludge, and solid wastes containing mercury. No federal permits may be required for this transportable treatment unit. If no federal permits are required, permitting of a treatment facility incorporating the transportable unit would be greatly simplified in comparison to the RCRA Part B permitting process for a fixed treatment facility.

Other Competing Technologies

Table 5 summarizes technology features and demonstration results for the three vendors participating in the MER02 mixed waste treatment demonstrations.

NFS Stabilization Technology

NFS developed their process to address a large variety of chemical forms of mercury. The process has been successfully applied to and is useful for a wide selection of waste matrices, including shreddable debris, nonshreddable debris, wastewaters, soils, sludges, and organic compounds.

The NFS was used to successfully demonstrate treatment of elemental mercury waste in a MER01 demonstration (MWFA 1998B) and was also applied to demonstrate the treatment of mixed waste containing mercury in the form of various chemical species (Osborne-Lee 1999). NFS used its process to stabilize inorganic, organic, and complexed forms of mercury at <260 ppm, including elemental mercury, mercuric chloride, mercuric iodide, phenyl-mercuric chloride, mercuric oxide, mercuric cyanide, and mercuric thiocyanate.

Mixed wastes with elemental mercury will require the addition of amalgamation, as well as stabilizing reagents to address the various chemical species of mercury. Soils and sludges containing elemental mercury represent a particular challenge. This is ascribed to potential matrix-mercury interaction effects, which render stabilization less effective. In addition, the elemental mercury contamination within these matrices is unevenly distributed. Therefore, mixing methods become important in dispersing amalgamating/stabilizing reagents to all sites within the matrix that contain the mercury contamination.

Potential commercial applications of the NFS process also exist. Certain select matrices, such as sludges, soils, adsorbents, etc., generated by commercial entities are similar to those within DOE, except without the radiological components.

GTS Duratek Stabilization Technology

Duratek has evaluated the efficacy of Portland cement-based grout for stabilization of sludge and laboratory residues generated at LANL. Bench scale solidification tests were performed at low and high waste loading. Full-scale drum solidification capabilities were demonstrated. The Duratek demonstration was subject to complications due to unexpected characteristics of the waste stream.

The presence of organic compounds, including pesticides, in the sludge specimen created additional processing requirements, including pretreatment such as shredding and thermal treatment. The difficulty



of stabilizing wastes containing a significant amount of organic compounds is well known. The presence of unexpectedly high amounts of radioactivity in the specimen leads in the direction of high volume increases at the low-waste loading necessary to obtain land disposal of the final waste form. These uncertainties make life-cycle cost difficult to project. Likewise, the additional challenge posed by the presence of organic hazardous constituents and high radionuclide concentrations makes comparison of the Duratek technology with those of ATG and NFS unfeasible.



Table 5. Summary of findings from tests by Duratek, Allied Technology Group, and Nuclear Fuel Services on the stabilization of mixed wastes (< 260 ppm Hg)

Comparison factor	GTS Duratek, Inc.	Nuclear Fuel Services, Inc. (NFS)	Allied Technology Group, Inc. (ATG)
Waste type tested	Sludge and laboratory residues from LANL	Ion-exchange resin from Portsmouth, Ohio facility	Ion-exchange resin from Portsmouth, Ohio facility
Process mechanism	In-drum mixer based operation	Standard laboratory glassware operation based in a ventilation hood	Pug mill, mortar mixer, hazardous material enclosure, with ventilated hood and air treatment system
Scale of bench test	0.25–0.35 kg bench scale tests performed	1 kg scoping tests performed	0.6 kg bench tests performed
Scale of demonstration	55-gallon drum (about 200–400 kg)	14 kg batches	33 kg batches (full-scale)
Final waste form	Met UTS limit for Hg. Failed TCLP test for organics and pesticides which were not part of the study	Met UTS limit for Hg. Passes TCLP and UTS tests for Cd, Cu, Zn, Ni, and Cr, which were not part of the study. Modified formulation required for Cr	Met UTS limit for Hg. Formulation used was most effective for Hg and Cr. Moderately effective for Ba and Cd. Ba, Cr, and Cd were not part of the study.
Stabilization process	Portland cement based grout	Uses proprietary formulation of additives and EPA-prescribed agents	Uses dithiocarbamate, or other non-proprietary agents, and a small amount of proprietary liquid
Effect of contaminants on the process	Unexpected high concentration of organic compounds make effective waste form difficult to achieve. Process would have to be optimized for organic contaminants	Fines from resin created filtration challenge. Solved by use of filter aids.	Water <10% tolerated. Other contamination not addressed
Throughput	^a	1,000 lb/hr, per SOW	1,200 lb/hr at full scale
Cost	^a	~\$6/kg at 1,000 lb/hr to \$37/kg at 100 lb/hr.	<\$2 kg at 1,200 lb/hr
Waste acceptance criteria	^a	Both processes produce waste forms that meet current Envirocare Waste Acceptance Criteria (WAC)	
Moisture	Moisture (water in small amounts) is tolerated by all three processes		
Physical characteristics	^a	Waste form characteristics are physically similar	
Regulatory and safety requirements	No additional hazards, safety, or regulatory issues found for either process		



Comparison factor	GTS Duratek, Inc.	Nuclear Fuel Services, Inc. (NFS)	Allied Technology Group, Inc. (ATG)
Summary assessment	a	Better leach performance (in meeting UTS) for more UHCs, but formulations are proprietary	Lower cost, higher waste loadings, less secondary waste, and fewer proprietary reagents

^a Waste specimens tested by ATG, and NFS are very comparable. Duratek sample was very different, thus basis for comparison of three vendor technologies is difficult to achieve. Also, uncertainties in waste characteristics complicate Duratek demonstration, delaying the availability of key results. No comparison is made of Duratek with ATG and NFS at this time.

^b Universal Treatment Standard (UTS). Underlying Hazardous Constituents (UHCs). Waste Acceptance Criteria (WAC).



SECTION 5

COST

Cost Methodology

The full-scale Transportable Mercury Stabilization System is illustrated in Figure 6. Although the small 7 ft³ mortar mixer used in the demonstration test is technically large enough for a full-scale (1,200-lb/hr) facility, a larger 9-ft³ mixer provides more reserve capacity. Because the 9-ft³ mixer also simplifies operational scheduling, the larger mixer has been selected for the full-scale transportable facility.

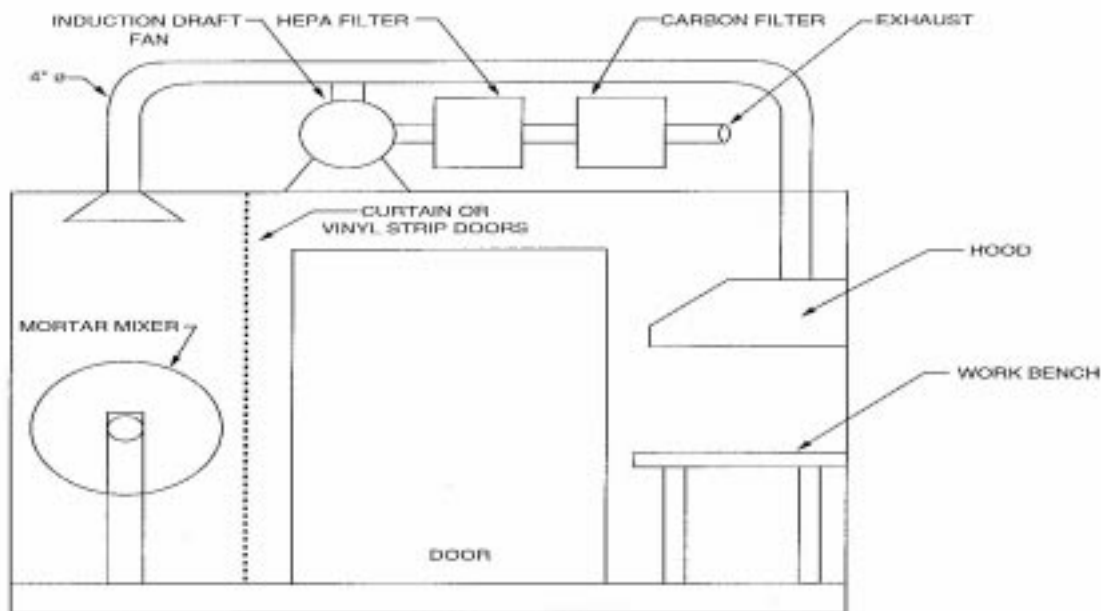


Figure 6. Transportable mercury stabilization system used by Allied Technology Group, Inc.

In addition to the mixer, the stabilization facility also includes a hazardous materials enclosure with an air treatment system, and a hood. The air treatment system includes a HEPA filter and a carbon filter. The air treatment system and hazardous materials enclosure were described in the work plan prepared for this demonstration (ATG 1998). A separate hood and workbench are included for the conduct of treatability studies. Other items of equipment required, but not shown in Figure 1, are a 1,000-kg scale and a hand-operated forklift for raising and lowering the drums. Total capital costs for the system are \$30,000.

Operating costs are in the range of \$95 per hour of operation. The costs include two laborers, health and safety oversight, and management support. Reagent and material costs are based on the nature of the waste and are highly variable. The expected range is from a low of \$50 per ton for a dry, easily stabilized waste to \$900 per ton for a mostly liquid, difficult to treat waste. The cost per ton of reagents for the mostly liquid ion exchange resin waste is in the range of \$550 per ton, of which \$450 is attributable to the polymer resin included to solidify the aqueous matrix.

The life-cycle design and cost basis are summarized in Table 7.



Table 7. Life-cycle design and cost basis for processing mercury mixed waste

Parameter	Design and Cost Basis
Plant life	10 years
Operations	250 days/year, 5 days/week, 8 h/d
Throughput	1,200 lb/h
Treatment process	Full-scale stabilization facility using DTC and polymer beads
Capital costs	Mixer, enclosure, air treatment system with HEPA filter and carbon filter, hood and workbench, scale, and forklift.
Operating costs	Laborers, oversight and management support, reagents, and other materials.
Disposal costs	\$1,000/m ³ (or 862/ton)
Decommissioning costs	Not included.

Taking the capital costs of \$30,000, operating costs over 10 years at full operating capacity, and disposal costs at the assumed rate reported by ATG, the life-cycle unit cost is estimated to be \$1.73/kg. Decontamination and decommissioning costs are not included. Capital costs were not amortized over the life of the facility.

The high cost of the polymeric solidification agent is offset by the reduced costs associated with transportation and disposal of the treated waste. The polymeric agent minimizes the weight and volume of treated waste, especially for mostly aqueous wastes. For example, solidification of 1 m³ of the ion exchange waste with clay would result in at least 2 m³ of treated waste as opposed to 1.16 m³ for solidification with the polymer. Disposal of the reduced volume of waste costs \$750 less when disposal costs are \$1,000 per cubic meter. The \$750 in savings on disposal costs is an excellent return on a \$450 investment in a polymeric solidification agent.

Cost Conclusions

For the steady-state 1,200-lb per hour processing rate specified in the original solicitation for this work, the cost is estimated at \$1.73/kg for wastes similar to that treated in this demonstration. The cost increases to \$3.68/kg when processing at the lower end of the rate range (100 lb/hour).

These cost estimates were based on ATG demonstration results. Actual costs will vary depending upon the: (1) homogeneity of the waste, (2) nature of the matrix being processed, and (3) presence of other hazardous constituents requiring treatment, and other factors.



SECTION 6

REGULATORY/POLICY ISSUES

Regulatory Considerations

No federal permitting may be required for the ATG transportable mercury stabilization system. Federal regulations allow onsite treatment of hazardous waste without a permit under certain conditions. Processing of lead-contaminated soils in a pug mill satisfied these conditions (EPA 1994) as should processing of mercury-contaminated mixed waste in a mortar mixer.

The regulatory/permitting issues related to the use of stabilization technology for treatment of mercury contaminated wastes, are governed by the following safety and health regulations:

- Occupational Safety and Health Administration (OSHA), 29 CFR 1926
 - 1926.28 Personal Protective Equipment
 - 1926.102 Eye and Face Protection
 - 1926.103 Respiratory Protection
- OSHA 29 CFR 1910
 - 1910.132 General Requirements (Personnel Protective Equipment)
 - 1910.133 Eye and Face Protection
 - 1910.134 Respiratory Protection

Disposal requirements/criteria include the following DOT and DOE requirements:

- 49 CFR, Subchapter C, Hazardous Materials Regulation
 - 171 General Information, Regulations, and Definitions
 - 172 Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
 - 173 Shippers—General Requirements for Shipments and Packaging
 - 174 Carriage by Rail
 - 177 Carriage by Public Highway
 - 178 Specifications for Packaging
- 10 CFR 71 Packaging and Transportation of Radioactive Material

If the waste is determined to be hazardous solid waste, the following EPA requirement should be considered:

- 40 CFR, Subchapter 1 Solid Waste

CERCLA Criteria

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has established nine criteria against which alternative treatment approaches are to be judged during the Remedial Investigation/Feasibility Study (RI/ FS) portion of the remediation action. A short explanation of each of the criteria (EPA 1988) and the assessment of ATG's process against it follows.

Overall protection of human health and the environment

This criterion is an evaluation of the overall protectiveness of an alternative and should focus on whether a specific alternative achieves adequate protection and should describe how site risks posed through each pathway being addressed by the FS are eliminated, reduced, or controlled.



In a CERCLA environment, the resulting waste forms from the ATG process will provide improved protection of human health and the environment by reducing the mobility of the elemental mercury. The final waste forms may need to be placed inside another container to further enhance protection.

Compliance with ARARs

This evaluation criteria is used to determine whether each alternative will meet all of its federal and state Applicable or Relevant and Appropriate Requirements (ARARs) that have been identified in previous stages of the RI/ FS process.

The Land Disposal Restrictions (LDRs) are the most likely ARAR to be applied to a CERCLA site dealing with mercury wastes. Regulations under RCRA specify no standard treatment for elemental mercury. ATG's process provides a potential future best practice for this waste type.

Long-term effectiveness and permanence

Alternatives under this criterion are to be evaluated in terms of risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/ or untreated wastes.

The long-term effectiveness of any remediation process has to be judged not only by the efficacy of the actual treatment process, but by how well the process can be applied to the extent of the contamination. Assuming that the mercury waste can be efficiently brought to ATG's equipment, the process should be able to provide environmental protectiveness. Mercury vapor pressure tests to be performed at Oak Ridge National Laboratory (ORNL) will provide a more definitive answer.

Reduction of toxicity, mobility, or volume through treatment

The statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances are to be evaluated under this criterion.

Stabilization with the ATG process, or a similar process, should significantly reduce mercury's mobility in a waste management scenario. In a CERCLA action, further study would be required to assess how the action of bacteria affects the waste form. Secondary containment may be prudent in any case.

Short-term effectiveness

This criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives are met.

As designed and operated, the ATG process should be protective of the community and the workers while not imposing meaningful environmental consequences during its operation.

Implementability

The implementability criterion focuses on the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation.

The process should prove to be viable from the standpoints of both the technical (ability to construct, reliability, and monitoring) and administrative (coordination with other agencies) feasibility, as well as the availability of services and materials.

Cost

The costing procedures found in the *Remedial Action Costing Procedures Manual* are to be the bases for comparing alternatives with regard to costs.

The cost figures to be provided in the future were not based on the rigor detailed in the referenced document above.



State acceptance

This assessment evaluates the technical and administrative issues and concerns the state (or support agency in the case of state-lead sites) may have regarding each of the alternatives.

See “Safety, Risks, Benefits, and Community Reaction” subsection below.

Community Acceptance

Under this criterion, an assessment is made on the issues and concerns the public may have regarding each of the alternatives.

See “Safety, Risks, Benefits, and Community Reaction” subsection below.

Safety, Risks, Benefits, and Community Reaction --- ---

The HgWG, considering eight criteria for the level of risk as associated with mercury stabilization, evaluated other aspects of risk, as follows:

- correctness (technical correctness),
- cost (effectiveness to use),
- permitability (ease of permitting),
- safety,
- sponsorship (commitment by sponsors),
- completeness (ready for use),
- acceptability (to stakeholders),
- timeliness (to meet schedules).

The risk values, established for the MWFA developed technology processes, have been derived from top-level requirements defined in the MWFA Systems Requirements Document. Evaluations of the technology and assignment of risk values were made by a team comprised of HgWG members in consideration of the risk category definitions and performance observations from the demonstration experience. The assessments made are summarized below.

Correctness

This risk category is moderately low. The targeted volume of waste to be treated is not large compared with most other waste types. Prior successes with low-level radioactive wastes, bench-scale tests with mixed wastes, and now largely promising demonstration results indicate that stabilization is a reasonable option for many mercury mixed waste streams. Limitations to stabilization as a stand-alone technology for mercury waste treatment may be overcome by using it in combination with supporting treatment steps.

Cost

This risk category is rated as moderate. The targeted volume to be treated is not large, but the waste possesses diverse characteristics. Oxidation, complexation, and speciation of mercury across various matrices add an element of uncertainty as to the difficulty of successfully stabilizing the bulk of inventory (and future generation) without process modifications. In addition, cost estimates provided by ATG show that stream characteristics greatly influence unit cost.

Permitability

This risk category is rated as very low. The treatment process is simple and based on a well-proven Best Available Demonstrated Technology for nonradioactive mercury waste. The volumes of waste involved are not large enough to pose much likelihood of regulatory problems.



Safety

This risk category is rated as low. While mercury is a hazardous material of some concern and radioactive contamination has the potential to raise additional concern, mercury vapors and leaching appear to be well-controlled by the process and radioactive contamination is low. The stability of the final waste form is key in immobilizing both mercury and radionuclides, thereby minimizing concerns over worker safety, public safety, and environmental protection (Connor 1990).

Sponsorship

This risk category is rated as moderately low. Interest by the sites has been good, and programmatic support for technology development has demonstrated good commitment. There is a small risk that some potential users may find a local or onsite solution for treatment of their mercury wastes.

Completeness

This risk category is rated as moderately low due to the simple, proven nature of stabilization, in consideration of the potential complexity of mercury chemistry and diversity of waste matrices, especially in light of recent successful demonstrations.

Acceptability

This risk category is rated as very low. Stabilization is a process easily identifiable to the public because of the widespread use of cement and concrete. The waste form stability, simplicity, and familiarity to the public that characterize the technology are expected to make for easy public acceptance.

Timeliness

This risk category is rated low. Based on preliminary information received to date from 10 DOE sites, the timeframe for treatment is late FY-99 and FY-00.

Public Participation

The siting of a mixed waste treatment facility of any kind near communities will involve public input. Stakeholders are generally concerned about the type, toxicity, and amount of emissions to be discharged to the atmosphere and the disposal site for the final waste form.

The MWFA Tribal and Public Involvement Resource Team and HgWG initiated activities to involve and gather stakeholder issues, needs, and concerns about mercury treatment technologies. These activities included reviews, articles, and presentations. During November and December of 1997, the chair of the HgWG addressed both the Oak Ridge Local Oversight Committee and the Site Specific Advisory Board (SSAB). The purpose of the November 1997 meetings was to identify issues, needs, and concerns of various Oak Ridge stakeholders regarding technologies that may be applicable to Oak Ridge. The areas emphasized included continuous emission monitors, characterization, input to Technology Performance Reports, and the HgWG. These meetings were interactive, where participants explored the issues and problem-solved collectively. No formal presentations were made, but information was provided and progress on various MWFA projects was discussed. Participants included members of the local oversight committee, the STCG, and the general public.



The SSAB Environmental Technology Group meeting on December 10, 1997, involved providing stakeholder input into various technologies development projects at Oak Ridge. Those they have expressed interest in addressing are:

1. Transportable Vitrification System,
2. TSCA Test Bed for Continuous Emissions Monitors,
3. Mercury Working Group/Mercury Treatment Demonstrations,
4. Removal of Mercury from Liquid Wastes.

A short presentation on the status of each activity was given and the proposed future scopes were discussed.

The MWFA assembled a Technical Requirements Working Group (TRWG); a stakeholder group capable of representing varied Tribal and public perspectives. The TRWG assisted MWFA technical staff in transforming or integrating site-specific issues, needs, and concerns into TDRDs, and providing Tribal and public perspectives to technical staff for identifying and resolving technical issues. The TRWG reviewed and provided recommendations to the MWFA on changes to the Mercury TDRDs.

Lastly, the MWFA Resource Team facilitated tribal and public involvement by issuing an article in the quarterly, July 1997, newsletter highlighting mercury treatment and disposal.



SECTION 7

LESSONS LEARNED

Implementation Considerations

Key lessons learned during this project were as follows:

- The DTC formulation most effectively stabilized mercury and chromium. The formulation was moderately effective with barium and cadmium.
- The volume increase resulting from stabilization of ion exchange waste was small, an average of 16 % for two runs. Larger polymer beads, added to absorb water, appeared to trap air and failed to pack as densely as smaller beads, leading to larger volume increases during treatment. The final treatment formulation used smaller beads.
- The cost of stabilization treatment is reasonable at <\$2/kg. The relatively high cost of the polymeric solidification agent is offset by the reduced costs associated with transportation and disposal of the treated waste. The polymeric agent minimizes the weight and volume of treated waste, especially for mostly aqueous wastes.
- This work shows that UTS levels in TCLP leachate for RCRA metals can be attained for this waste matrix using the ATG stabilization process.



Appendix A

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Appendix B

ACRONYMS AND ABBREVIATIONS

ATG	Allied Technologies Group, Inc. (Fremont, California)
ADA	ADA Technologies (Englewood, Colorado)
ARARs	Applicable or Relevant and Appropriate Requirements
BOIP	Balance of Inventory Procurement (i.e., Broad Spectrum Procurement)
CBD	<i>Commerce Business Daily</i>
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DeHg	A proprietary process by NFS for processing mercury mixed waste (pronounced de'-merk)
DOE	Department of Energy
DOT	Department of Transportation
DTC	Dithiocarbamate, a reagent in a formula for stabilization
Duratek	GTS Duratek, Inc., (Oak Ridge, Tennessee)
EPA	Environmental Protection Agency
HgWG	Mercury Working Group, MWFA
IT	International Technologies, Inc.
ITSR	Innovative Technology Summary Report
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restrictions
LESAT	Lockheed Environmental Systems and Technologies Company
MER01	A solicitation to industry (November 1996) entitled, "Demonstration of the Amalgamation Process for Treatment of Radioactively Contaminated Elemental Mercury Wastes"
MER02	A solicitation to industry (September 1997??) entitled, "Demonstration of the Stabilization Process for Treatment of Radioactively Contaminated Mercury (<260 ppm) Wastes"
MWFA	Mixed Waste Focus Area
NFS	Nuclear Fuel Services, Incorporated (Erwin, TN)
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PPE	personal protection equipment
Ppm	parts per million
QAP	Quality Assurance Plan
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposal
SOW	Scope of Work
SPC	sulfur polymer cement
SPLP	Synthetic Precipitation Leaching Procedure
SSAB	Site Specific Advisory Board
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TDRD	Technology Development Requirements Document
TLV	Threshold Limit Value
TOX	Total organic halide
TRU	transuranic
TRWG	Technical Requirements Working Group
UHC	Underlying hazardous constituent
UTS	Universal Treatment Standard
WAC	Waste Acceptance Criteria

