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SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Technology Demonstration Summary

Babcock & Wilcox Cyclone Furnace Vitrification

A Superfund Innovative Technology Evaluation (SITE) Demonstration of the Babcock & Wilcox Cyclone Furnace Vitrification Technology was conducted in November 1991. This Demonstration occurred at the Babcock & Wilcox (B&W) Alliance Research Center (ARC) in Alliance, OH. The B&W cyclone furnace may be used for thermal treatment of soils contaminated with organics, metals, and radionuclides. The cyclone furnace is designed to destroy organic contaminants and to immobilize metals and radionuclides in a vitrified soil matrix (slag).

For the SITE Demonstration, the cyclone furnace was used to treat a synthetic soil matrix (SSM) spiked with semivolatile organics, metals, and simulated radionuclides. Demonstration Test results indicate that the majority of the nonvolatile metals and radionuclides were retained in the slag. The leachate from the slag complies with the Toxicity Characteristic Leaching Procedure (TCLP) regulatory requirements. The slag also demonstrates extremely low leachability for the spiked simulated radionuclides. Destruction and Removal Efficiencies (DREs) for both spiked organic contaminants exceeded 99.99% with stack gas concentrations below detection limits.

The soil, metals, and simulated radionuclides not retained in the slag exited the furnace with the flue gas and were captured in the baghouse as flyash. The leachate from the flyash did not meet the TCLP regulatory requirements and therefore was considered a hazardous waste. Wash water and rinse water which came in contact with the SSM were also disposed of as hazardous wastes. The quench water used to cool the slag was analyzed and found suitable for discharge to the local POTW.

An economic analysis was conducted to estimate costs for a commercial treatment system utilizing the B&W cyclone furnace vitrification system. This analysis was based on the pilot-scale results from the SITE Demonstration. The economic analysis is for a projected commercial unit capable of treating approximately 3.3 tons per hour (tph) of contaminated soil. The cost to remediate 20,000 tons of contaminated soil using this commercial unit is estimated at $465 per ton if the system is

on-line 80% of the time or $529 per ton if the system is on-line 60% of the time. Treatment costs appear to be competitive with other available technologies.

This Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the SITE program demonstration that is fully documented in two separate reports (see ordering information at back).

Introduction

In response to the Superfund Amendments and Reauthorization Act of 1986 (SARA), the U.S. Environmental Protection Agency's (EPA's) Office of Research and Development (ORD) and Office of Solid Waste and Emergency Response (OSWER) have established a formal program to accelerate the development, demonstration, and use of new or innovative technologies as alternatives to current containment systems for hazardous wastes. This new program is called Superfund Innovative Technology Evaluation or SITE.

The major objective of the SITE Program is to develop reliable performance and cost information for innovative technologies. One such technology is the Babcock & Wilcox (B&W) Cyclone Furnace Vitrification Technology, which was demonstrated over a 2-wk period beginning November 4, 1991 and ending November 16, 1991. The Demonstration was conducted at B&W's Alliance Research Center (ARC) in Alliance, Ohio.

The cyclone furnace system was demonstrated on a SSM provided by the EPA's Risk Reduction Engineering Laboratory (RREL) in Edison, New Jersey. SSMs are well-characterized, clean soils which are spiked with known concentrations of contaminants of concern. For this study, the SSM was spiked with contaminants similar to those found at Superfund sites, Department of Defense (DOD) facilities, and Department of Energy (DOE) facilities: heavy metals, semivolatile organics, and simulated radionuclides. (Simulated radionuclides are non-radioactive metals whose behavior in the cyclone furnace will simulate true radionuclide species.)

The B&W cyclone furnace process is designed to destroy semivolatile organics and immobilize heavy metals and simulated radionuclides in a nonleachable slag. The critical and noncritical objectives were established to evaluate the effectiveness of the process. Critical parameters provided data to support the developer's claims. Noncritical measurements provided additional information on the technology's applicability to other Superfund sites and allowed observation and documentation of any process performance anomalies.

The critical objectives of this SITE Demonstration were to assess the ability of the B&W cyclone vitrification furnace technology to:

- produce a vitrified material (slag) that does not exceed TCLP regulatory levels for cadmium, chromium, or lead
- achieve at least a 10 to 1 ratio (dry weight basis) of slag to flyash
- capture at least 60% (by weight) of the chromium from the dry, untreated SSM in the vitrified slag
- achieve at least a 25% volume reduction in solids when comparing product solid to the untreated SSM
- achieve 99.99% DREs for each organic contaminant spike
- comply with emission limits for nitrogen oxide (NO_x), carbon monoxide (CO), total hydrocarbons (THC), and particulates from the stack as stipulated by 40 CFR 264

The non-critical objectives of this Demonstration were to determine the technology's general applicability and to document process performance by analyzing:

- simulated radionuclide concentrations in stack emissions
- metals concentrations in the baghouse solids, furnace outlet, and slag quench water
- semivolatile organics concentrations in the slag, baghouse solids, and quench water
- leachability of metals in the baghouse solids
- leachability of simulated radionuclides in the slag
- emissions of products of incomplete combustion (PICs)
- ultimate analysis, proximate analysis, ash content, ash fusion temperature, and particle size distribution of the SSM

Process and Facility Description

The Demonstration of the B&W cyclone furnace vitrification technology was performed at B&W's ARC located on a 37.5 acre site containing 230,000 sq ft of office, laboratory, and service facilities.

A 6-million Btu/hr pilot-scale cyclone furnace located at the ARC was used for the SITE Demonstration. This non-mobile cyclone furnace is a scaled-down version of B&W's commercial cyclone boiler and is capable of firing natural gas, oil, or coal. The cyclone furnace is watercooled and simulates the geometry of B&W's single cyclone, front-wall-fired cyclone boiler. The furnace has a horizontal cylinder (barrel) lined with a refractory layer suitable for operation at high temperatures. This unit is designed to achieve very high release rates, temperatures, and turbulence. The cyclone test facility is shown in Figure 1.

The SSM was contained in 55-gal drums. A drum tumbler was used to mix each drum before it was transferred into the feeder tank. The feed SSM was introduced at a nominal feed rate of 170 lb/hr via a soil disperser (atomizer) at the center of the cyclone. The cyclone furnace was fired with natural gas during the Demonstration and preheated combustion air (nominal 800°F) entered the furnace tangentially. Particulate matter from the feed soil is retained along the walls of the furnace by the swirling action of the combustion air and is incorporated into a molten slag layer. Organic material in the soil is incinerated in the molten slag or in the gas phase. The slag exits the furnace from a tap at the cyclone throat at a temperature of approximately 2400°F, then drops into a water-filled quench tank, where it cools and solidifies.

The gas residence time in the furnace is approximately two seconds. The gas exits the cyclone barrel at a temperature of over 3000°F and exits the furnace at a temperature of over 2000°F. A heat exchanger cools stack gases to approximately 200°F before they enter the pulse-jet baghouse. A small portion of the soil exits as flyash in the flue gas and is collected in the baghouse. The cyclone facility is also equipped with a scrubber (a lime spray dryer) to control any acid gases that may be generated. The scrubber was not used for the Demonstration since no chlorinated compounds were spiked in the SSM. The scrubber and baghouse are followed by an induced draft (ID) fan, which draws flue gases into a process stack for release to the ambient air.

SSM Description

The SSM feed was spiked with heavy metals (lead, cadmium, and chromium), semivolatile organics (dimethylphthalate and anthracene), and simulated radionuclides (bismuth, strontium, and zirconium). These spikes were chosen to allow for proper evaluation of the technology without risk to personnel safety while limiting the generation of hazardous products. Contaminant concentrations in the SSM are summarized in Table 1.

Sampling and Monitoring

A total of four runs were conducted over a 3-day period and included a back-

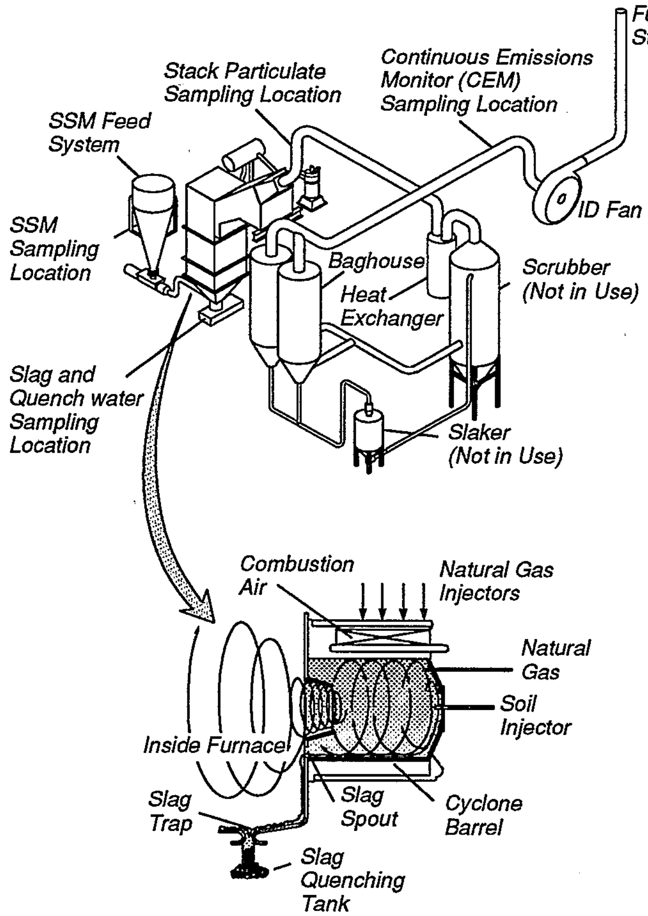

Figure 1. *B & W Cyclone test facility.*

ground run (Run 0) and three test runs (Runs 1A, 2, and 3).

Prior to the firing of SSM, a background run was conducted to establish baseline conditions. For this run, the furnace was fired with natural gas. Air sampling at the stack and furnace outlets was used to determine background concentrations of metals and particulates. Water samples from the quench tank were used to determine background levels of metals. Flyash was collected from the baghouse to determine metals concentrations.

Table 1. *Spiked Components in the SSM*

Analyte	*Conc. (mg/kg)* Average	Range
Heavy Metals		
Lead	*6350*	*3880-7510*
Cadmium	*1250*	*1000-1800*
Chromium	*4300*	*3800-4630*
Simulated Radionuclides		
Bismuth	*4140*	*2810-7205*
Strontium	*3690*	*3300-4080*
Zirconium	*4030*	*3660-5000*
Organic Compounds		
Anthracene	*4340*	*920-7800*
Dimethylphthalate	*8340*	*4800-10000*

The cyclone furnace was fired with natural gas for approximately two hr at the beginning of each test run to preheat the barrel. Soil was then added and the test was begun after the furnace reached steady-state, slag-production conditions (approximately an hour later). During the test runs, which lasted an average of about four hours, sampling of SSM feed, slag, and air emissions was conducted. Quench water was sampled at the beginning and end of each test run. Baghouse solids were sampled after completion of each test run.

Each drum of SSM was sampled immediately after mixing and was then transferred to a screw feeder. The hopper was accessed through an opening sealed by a plexiglas cover and samples of the SSM were drawn out through this opening.

The flue gas was sampled in two locations: immediately downstream of the furnace (prior to the air pollution control equipment) and in the process stack.

A composite sample of flyash was collected from drums located below the baghouse after the completion of each test run. Quench water samples were collected from the quench tank located below the cyclone furnace before and after each test run.

A perforated, galvanized tub ("colander") mounted on wheels was used to collect slag samples from the quench tank located below the furnace slag tap. At the start of each test run, the slag sampling device was placed beneath the furnace slag tap. This was to ensure that the slag produced before the start of the run could be removed from the quench water. Segregation of test slag and non-test slag was essential since total mass of slag produced during each test was needed for several calculations.

Slag samples from the perforated, galvanized tub were composited into galvanized transfer pails, which were covered with aluminum foil to prevent contamination by dust. The slag samples were then transferred from the galvanized buckets to aluminum pans and were air-dried in ovens at ARC's Coal Preparation Laboratory. All slag was air-dried so that the total slag mass generated could be accurately determined. After the dried weight of each sample was determined and recorded, the slag was separated into two categories: slag to be sent to a laboratory for analysis ("analytical slag") and slag to be used for bulk density measurements ("bulk density slag").

Three analytical composite slag samples were collected for each run. After air drying, the analytical slag samples were separately crushed inside cotton/polyester sacks to pass a ⅜-inch screen. The slag was then passed through a splitter to obtain representative samples.

Slag not collected for laboratory analyses was used for bulk density measurements. After the slag was dried, nine cylindrical pieces of slag were handpicked from the array of trays. The length-to-width ratios of the samples ranged from approximately 1.6 to 3.7. These samples were analyzed for leachability of the simulated radionuclides (bismuth, strontium, and zirconium) according to the American Nuclear Society (ANS) 16.1 test method. After sample selection, several bulk density measurements were made for each run.

A maximum number of bulk densities were recorded by overfilling a previously weighed box of known dimensions, striking off the excess with a straightedge, and reweighing the filled box. An average was then determined from the bulk density measurements taken for each run.

Operating conditions related to the efficient performance of the cyclone furnace were controlled and monitored by B&W during all tests, including the background run. Much of the data was acquired and downloaded via a computerized data acquisition system every five min. Parameters monitored in this manner included combustion air flow rate and temperature; soil dispersing air flow rates; oxygen (O_2), CO, and NO_x concentrations at the convection pass; baghouse inlet and outlet temperature; pressure drop across the baghouse; and total heat input. Operating data for the three test runs is summarized as follows:

- cyclone slag temperature ranged from 2360 to 2470 °F.
- total heat input ranged from 4.9 million to 5.1 million Btu/hr.
- nominal soil feed rate remained constant at 170 lb/hr.
- combustion air temperature ranged from 811 to 832 °F.
- temperature of the gas entering the baghouse ranged from 196 to 215 °F; temperature of the gas exiting the baghouse ranged from 185 to 206 °F.

Table 2. *B & W SITE Demonstration Data and Potential Incineration ARARs*

	SITE Demonstration Results—Range	ARARs
TCLP (mg/L)		
Cadmium	0.07-0.18	1.0
Chromium	0.15-0.61	5.0
Lead	0.22-0.39	1.0
DRE (%)		
Anthracene	>99.996->99.998	99.99
Dimethyl-phthalate	>99.996	for each
Particulate matter (gr/dscf at 7% O_2)	0.004-0.0017	0.08
Carbon Monoxide (ppm)	4.8-54.1	<100
Total Hydrocarbons (ppm)	<5.9-18.2	<20
Metals (lb/hr)		
Cd	9.4×10^{-6}-1.5×10^{-4}	a
Cr	2.1×10^{-5}-1.9×10^{-4}	a
Pb	4.8×10^{-5}-7.1×10^{-4}	a
NO_x (ppm)	310-435	b

a Less those established by EPA Guidance on Metal Emissions from Hazardous Waste Incinerators
b Allowable emissions limits established on a case-by-case basis as per the requirements of the Clean Air Act.

Results and Discussion

Table 2 illustrates the cyclone furnace's performance as it relates to Applicable or Relevant and Appropriate Requirements (ARARs).

TCLP analyses were performed on both the feed SSM and the slag to determine if the B&W technology produces a non-leachable slag from a leachable soil.

The TCLP conducted on the feed SSM indicated that cadmium and lead leached from the SSM in quantities significantly above regulatory levels (the cadmium and lead concentrations in the leachate were 49.9 mg/L and 97.3 mg/L, respectively). Following cyclone vitrification, the slag passed the TCLP for these metals. TCLP results are presented in Table 3.

The leachability of the simulated radionuclides from the slag was determined according to ANS 16.1- "American National Standard Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure." The method used to quantify the external surface area of the slag was modified to account for the irregular shape of the slag material. Although all other equations and data reduction procedures remain the same, the method has not been validated for the material in question and the data are, therefore, suspect. The test results suggest, however, that the cyclone furnace may be able to effectively immobilize radionuclides in low-level radioactive wastes.

The percent volume reduction experienced during the Demonstration was determined by comparing the volume of dry SSM introduced into the furnace to the volume of dry slag produced by the furnace. Percent volume reductions were calculated using a method developed by B&W. This method determines bulk density by weighing the soil in a box of known volume. Since this method was used to determine bulk density for the both the SSM and slag, comparisons between the SSM and slag data provide reliable results which agree with field observations and Demonstration Test objectives. These results confirm B&W's claim that an average of 25% reduction in the volume is experienced during treatment.

As the SSM goes through the cyclone furnace, metals partition to the flyash and the slag. Their fates are primarily dependent on their relative volatilities. The nonvolatile metals, such as chromium, strontium, and zirconium, primarily remain in the slag. The more volatile metals, such as bismuth, cadmium, and lead, partition to the flue gas and are collected by the baghouse. During the Demonstration, over 75% (by weight) of the chromium in the SSM was incorporated in the vitrified slag. Approximately 85 and 95% of the strontium and zirconium, respectively, remained in the slag. The more volatile metals (bismuth, cadmium, and lead) had lower retentions of 27, 12, and 29%, respectively. (Data regarding the simulated radionuclides are suspect because the analytical methods have not been validated for these metals. Data are used for informational purposes only.)

Table 3. *TCLP Results (mg/L)*

	Cadmium	Chromium	Lead
Regulatory Limits	1.0	5.0	1.0
Feed			
Run 1	52.0	2.29	90.8
Run 2	63.6	1.77	75.6
Run 3	34.2	3.87	125
Slag			
Run 1	0.11*	0.15	<0.25
Run 2	0.19	0.37	0.39*
Run 3	0.07	0.15	0.29*

** Worst case scenario*

Almost all of the metals which partition to the flue gas are captured by the baghouse. A very small portion of the metals pass through the baghouse and out the stack. As long as these levels do not exceed the furnace's permit limits (as determined by a site-specific risk assessment) no significant changes to emissions treatment need be employed.

Particulate emissions were measured at the cyclone furnace outlet and stack for all Demonstration Tests. Particulate emissions out of the stack averaged 0.008 gr/dscf (corrected to 7% O_2), or 0.001 lb/hr, which is well under the RCRA regulatory limit of 0.08 gr/dscf. Average emissions from the furnace outlet were 0.806 gr/dscf (corrected to 7% O_2), or 6.07 lb/hr. The average removal efficiency of the baghouse was 99.8%.

A slag-to-flyash ratio can be determined by comparison of the stack particulate emissions with the amount of slag produced per hour by the cyclone furnace. The average slag-to-flyash ratio from the Demonstration was 13.7. The slag-to-flyash ratio illustrates that the cyclone furnace is capable of converting the vast majority of a contaminated soil to a non-hazardous slag.

The cyclone furnace achieved greater than 99.99% DREs for the two organic spikes in the feed SSM. Because anthracene and dimethylphthalate are relatively difficult organics to destroy, it is projected that the commercial-scale cyclone furnace will be capable of achieving DREs of 99.99% or greater for all, or nearly all, organics.

The cyclone furnace formed PICs but only at very low concentrations (in the parts per trillion range). Several chlorinated PICs were detected, although no chlorinated organics were spiked in the SSM. Potential sources of chlorine include trace levels in the SSM and in the furnace from previous tests. These trace amounts of chlorine probably caused the formation of the chlorinated volatile organic compounds (VOCs). Higher concentrations of chlorinated VOCs will be present if a feed soil contains chlorinated compounds. Soils contaminated with chlorinated organics would also form hydrogen chloride (HCl) gas, which would have to be controlled by a scrubber.

Throughout each of the Demonstration Tests, CO, CO_2, THC, O_2, and NO_x were monitored continuously to present a real-time image of the combustion process and to determine if regulatory standards were being exceeded. Exhaust gas data is summarized in Table 4.

The O_2 and CO_2 values obtained reflect typical excess air values for a natural gas-fired furnace. The NO_x concentrations in the emissions from the Demonstration were relatively low.

Quench water samples collected before and after each run were analyzed to determine if any of the metals present in the slag or infusible matter leached into the quench water. Analyses of the quench water from the baseline run and the three test runs indicated minimal increases in the concentrations of certain metals during the test runs. Concentrations of cadmium, chromium, lead, and strontium were so close to the detection limits it cannot be determined if any increases or decreases are a result of the process. Concentrations of bismuth and zirconium remained below detection limits throughout the testing period.

Quench water samples collected before and after the second and third test runs were analyzed for anthracene and dimethylphthalate to determine whether these chemicals leached into the quench water. Concentrations of both chemicals remained below method quantitation limits throughout both test runs.

When the Demonstration Tests were complete, the quench water was found to be suitable for discharge to a sanitary sewer and was disposed of in accordance with the terms of B&W's wastewater discharge agreement with its local POTW. Water that came in contact with the SSM (wash and rinse water from Demonstration equipment cleanups) was collected, stored apart from other wastes, and disposed of as a hazardous waste.

An economic analysis has been developed to estimate costs (not including profits) for a commercial treatment system utilizing the B&W cyclone furnace vitrification process. This analysis is based on the results of the SITE Demonstration, which utilized a pilot-scale cyclone furnace vitrification system. The pilot-scale unit operated at a feed rate of 170 lb/hr of contaminated soil and utilized energy at a rate of 5-million Btu/hr. It is projected the commercial unit will be capable of treating approximately 3.3 tph of contaminated soil and will require an energy input of 100-million Btu/hr. The daily feed rate for the pilot-scale system was approximately 2 tpd, while it is projected the commercial system will be capable of treating 80 tpd.

Treatment costs appear to be competitive with other available technologies. The cost to remediate 20,000 tons of contaminated soil using a 3.3 tph cyclone furnace vitrification system is estimated at $465 per ton if the system is on-line 80% of the time or $529 per ton if the system is on-line 60% of the time. Projected unit costs for a smaller site (less than 20,000 tons of contaminated soil) are slightly higher; projected unit costs for a larger site are slightly lower.

Table 4. *Summary of Exhaust Gas Data*

Run No.	*Value*	*Concentration (ppm - dry basis)* NO_x	*CO*	*THC as* C_3H_3	*Concentration, %* CO_2	O_2	*Particulates gr/dscf*	*Flow Rate dscfm*
1	*Average*	*357*	*>6.1*	*<7.4*	*9.2*	*4.9*	*0.0016*	*1259*
	Low	*328*	*4.8*	*<6.9*	*8.8*	*4.6*	—	—
	High	*373*	*>54.1*	*8.4*	*9.5*	*6.5*	—	—
2	*Average*	*338*	*6.9*	*11.3*	*8.9*	*4.9*	*0.0009*	*1208*
	Low	*310*	*6.3*	*8.9*	*8.2*	*4.4*	—	—
	High	*423*	*7.4*	*18.2*	*11.8*	*5.2*	—	—
3	*Average*	*383*	*5.0*	*<6.4*	*9.6*	*4.9*	*0.0003*	*1291*
	Low	*311*	*4.9*	*<5.9*	*9.6*	*4.8*	—	—
	High	*435*	*5.2*	*8.1*	*9.7*	*5.1*	—	—

Conclusions and Recommendations

The B&W cyclone furnace transforms the majority of the hazardous feed with a high inorganic content (such as soils, sludges, and sediments) to a nonleachable, nonhazardous slag. A small portion exits the stack as flyash.

TCLP analyses were performed on both the feed SSM and the slag and it was determined that the B&W technology achieves its critical objective of producing a slag that does not exceed TCLP regulatory levels for cadmium, chromium, or lead.

The method used to determine the leachability of the simulated radionuclides was altered slightly for application to the slag. The altered method has not been validated and the data are therefore suspect. The test results suggest, however, that the cyclone furnace may be able to effectively immobilize radionuclides in low-level radioactive wastes.

A comparison of the volume of the dry untreated SSM and the slag confirms B&W's claim that an average volume reduction of 25% is experienced during cyclone furnace vitrification.

The metals (including simulated radionuclides) contained in the SSM prior to cyclone furnace vitrification were primarily contained in the slag and in the baghouse solids after treatment. The majority of the nonvolatile metals remained in the slag, while the majority of the more volatile metals were found in the baghouse solids. In particular, approximately 75% of the chromium from the SSM is retained in the slag, exceeding the critical objective of retaining at least 60% of the chromium.

Almost all of the metals which partition to the flue gas are captured by the baghouse. A very small portion of the metals pass through the baghouse and out the stack. As long as these levels do not exceed the furnace's permit limits (as determined by a site-specific risk assessment) no significant changes to emission treatment need be employed. Modifications have been proposed which would recirculate the baghouse solids through the furnace, allowing the system additional opportunities to trap the metals within the slag. These modifications would eliminate the need to dispose of or treat the flyash as a hazardous waste.

Because the radionuclides and heavy metals in the slag are nonleachable, the flyash from the baghouse is the primary hazardous waste produced by this process. If a radioactive feed is employed, both the slag and baghouse solids would be radioactive. However, since the radionuclides are expected to be nonleachable, this technology may be used to treat radioactive soils to prevent the migration of radionuclides from a site.

Particulate emissions out of the stack during the Demonstration Tests averaged 0.008 gr/dscf (corrected by 7% O_2), or 0.001 lb/hr, which is well under the RCRA regulatory limit of 0.08 gr/dscf.

The average slag-to-flyash ratio from the Demonstration was 13.7, indicating that the cyclone furnace is capable of converting the vast majority of a contaminated soil to a nonhazardous slag. This also means that the cyclone furnace exceeds its critical objective of achieving a slag-to-flyash ratio of at least 10 to 1.

The cyclone furnace met another critical objective by achieving greater than 99.99% DREs for the two organic spikes in the feed SSM. Because anthracene and dimethylphthalate are relatively difficult organics to destroy, it is projected that the commercial-scale cyclone furnace will be capable of achieving DREs of 99.99% or greater for all or nearly all organics.

Throughout each of the Demonstration Tests, CO, CO_2, THC, O_2, and NO_x were monitored continuously to present a real time image of the combustion process and to determine if regulatory standards were being exceeded. Results indicate that the cyclone furnace should not have difficulty meeting the RCRA limit of 100 parts per million (ppm) for CO. THC emissions, however, are close to the RCRA limit of 20 ppm. Careful monitoring of THC emissions for the cyclone furnace will be required for the unit to operate in compliance. The THC and CO levels measured indicate that effective thermal destruction of the organic compounds was occurring; the O_2 and CO_2 values obtained reflect typical excess air values for a natural gas-fired furnace. The NO_x concentrations in the emissions from the Demonstration were relatively low. A larger unit, however, may emit significant levels of NO_x and may be designated a major source under the Clean Air Act. Allowable emissions of NO_x will be established on a case-by-case basis.

Particulate emissions were measured at both the cyclone furnace outlet and the stack. Emissions out of the stack easily met the RCRA emissions limit of 0.08 gr/dscf corrected to 7% O_2. The furnace achieved its critical objectives for emissions by complying with emission limits for carbon monoxide, THC, and particulates from the stack.

Analyses of the quench water from the baseline run and the three test runs indicated minimal increases in the concentrations of certain metals during the test runs. Concentrations of both anthracene and dimethylphthalate remained below method quantitation limits. When the Demonstration Tests were complete, the quench water was found to be suitable for discharge to a sanitary sewer; it is projected that the quench water from the commercial-scale system will also be suitable for discharge to a sanitary sewer, but this must be determined on a site-specific basis.

Wash water and rinse water from the Demonstration was disposed of as a hazardous waste. The nature of the wash water and rinse water during commercial-scale treatment will be site-specific. It may be a hazardous or radioactive waste at some sites; at other sites it may be suitable for discharge to a sanitary sewer. Note that any wash water, rinse water, or quench water used in the commercial-scale system will create only occasional discharges. It is projected that the commercial-scale system will continuously discharge water from a quench tower, which will use water to cool the flue gas (the pilot-scale system did not include a quench tower). The water from the quench tower should be suitable for discharge to a sanitary sewer.

An economic analysis was con-ducted to estimate costs for a commercial treatment system utilizing the B&W cyclone furnace vitrification system. The economic analysis is for a projected commercial unit capable of treating approximately 3.3 tph of contaminated soil. Projected treatment costs appear to be competitive with other available technologies.

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The complete report, entitled "Technology Evaluation Report: Babcock & Wilcox Cyclone Furnace Vitrification Technology," consists of two volumes:
"Volume I", (Order No. PB92-222215 AS; Cost: $26.00, subject to change)
"Volume II", (Order No. PB92-222223 AS; Cost: $43.00, subject to change).
Both volumes of this report will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

A related report, entitled "Babcock & Wilcox Cyclone Furnace Vitrification Technology: Applications Analysis Report," which discusses application and costs is under development.

The EPA Project Manager can be contacted at:

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