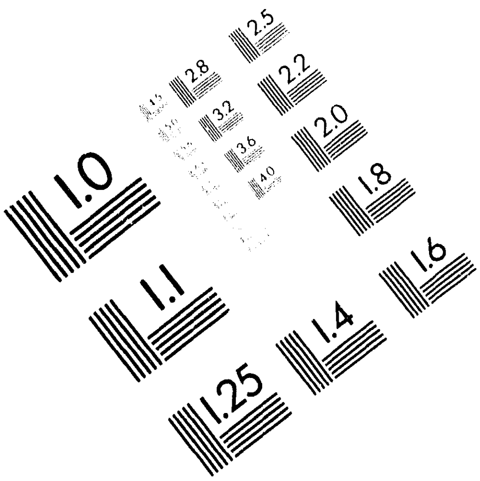
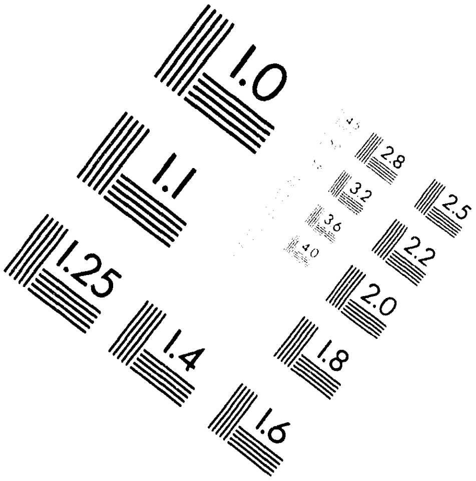


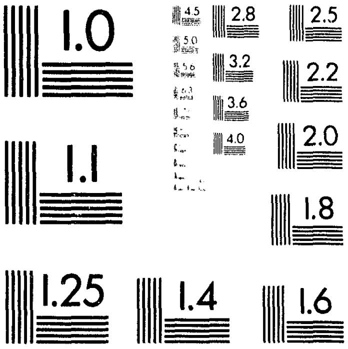
AIIM

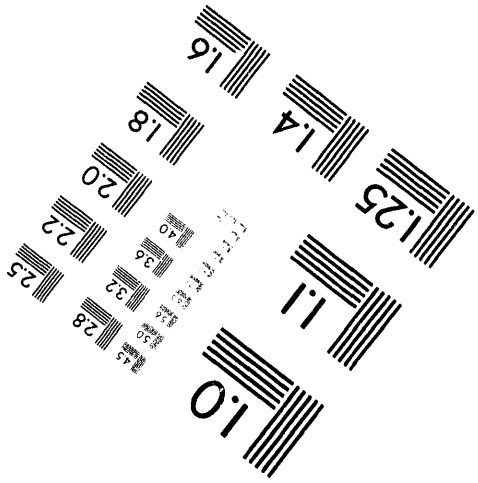
Association for Information and Image Management

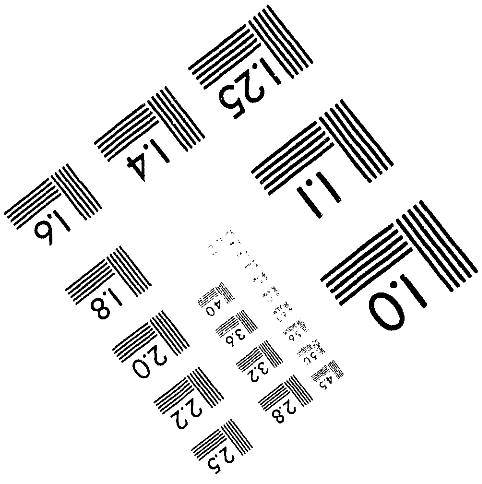
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202









MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

2

PNL-SA-24419

PACIFIC NORTHWEST LABORATORY ENVIRONMENTAL TECHNOLOGIES AVAILABLE FOR DEPLOYMENT

S. C. Slate

July 1994

Handout

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DRAFT

PNL-XXXX

PACIFIC NORTHWEST LABORATORY ENVIRONMENTAL TECHNOLOGIES AVAILABLE FOR DEPLOYMENT

May 1994

Prepared by
Environmental Restoration and
Waste Management Directorate

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

PACIFIC NORTHWEST LABORATORY
ENVIRONMENTAL TECHNOLOGIES
AVAILABLE FOR DEPLOYMENT

Revision Date: May 1994

EXECUTIVE SUMMARY

The Department of Energy created the Office of Environmental Management (EM) to conduct a 30-year plus, multi-billion dollar program to manage the wastes and cleanup the legacy from over fifty years of nuclear material production. Across the DOE System there are thousands of sites containing millions of metric tons of buried wastes and contaminated soils and groundwater. Additionally, there nearly 400,000 m^3 of highly radioactive wastes in underground storage tanks, over 1400 different mixed-waste streams, and thousands of contaminated surplus facilities, some exceeding 200,000 m^2 in size. Costs to remediate all these problems have been estimated to be as much as several hundred billion dollars.

The tremendous technical challenges with some of the problems and the high costs of using existing technologies has led the Department to create the Office of Technology Development (TD) to lead an aggressive, integrated national program to develop and deploy the needed advanced, cost-effective technologies. This program is developing technologies for all major cleanup steps: assessment, characterization, retrieval, treatment, final stabilization, and disposal. Work is focused on the Department's five major problem areas:

- High-Level Waste Tank Remediation
- Contaminant Plume Containment and Remediation
- Mixed Waste Characterization, Treatment, and Disposal
- Contaminated Soils and Buried Wastes
- Facility Transitioning, Decommissioning, and Final Disposal

The TD National Program is very comprehensive, developing hundreds of new technologies through the Department's contractor and National Laboratory systems and through private industry. The new technologies are at various stages of development, ranging from initial concepts requiring fundamental research, to field demonstrations, to being available for final deployment. One of the principal measures of success for the program is how many technologies reach this final stage of development each year. The actual definition of availability for deployment is broad to accommodate the variety of actions being considered. For example, a device to perform an initial screening for contaminants needs less validation testing than a proposed final cleanup action which will permanently alter a contaminated site. General criteria for full availability are being defined at Headquarters to ensure consistency across the National Program. A draft version of these criteria has been prepared and was the starting point for this document.

According to the Headquarters draft document,"EM Technology Development Performance Measures Definitions" (Predecisional Draft 50MEASURE.OOB), a technology is available for deployment if it is a demonstrated improvement over the baseline technology/system, and it includes sufficient information for making a documented selection on

- potential risks and environmental impacts
- life-cycle costs
- expected benefits and disadvantages
- ability to meet normal and off-normal operating requirements
- results from full-scale demonstrations under realistic conditions and
- the acceptability of the technology to regulators and affected stakeholders.

Additionally, the technology or service should have a viable means for delivery, such as an equipment vendor or remediation contractor. It should be noted that being available for deployment does not mean that it may not be necessary to further develop and adapt the technology to meet the operational requirements of various applications.

The purposes of this document are to describe the basis used at PNL to define a deployable technology, as well as the preceding levels of development, and to identify those PNL-developed, environmental technologies which can be considered ready for deployment by private or public users. The PNL basis will build off the general criteria provided by Headquarters. The sections of this document provide details on each of the major criteria which are used to define status of development. (See Author's note.) Each section describes the type and extent of information required and the possible methods for developing the information. The information on the available technologies will be included in the Appendix. More information on the currently listed technologies and new technologies will be added in future revisions of this document. Current plans call for updates to be prepared at least annually.

[AUTHOR'S NOTE: For the purposes of this early version of this report, the generally written Headquarters' criteria were used to identify PNL's deployable technologies. These criteria have not been fully defined or finalized. When completed, they will be the starting point for the sections on development levels and deployment information needs. Further development of this document is dependent on the progress of the Headquarters' effort.]

A summary listing of the technologies which are currently classified as available for deployment is provided in Table 1. This table provides the technology title, a brief description of its function, and the principal technical contact. The Appendix provides two-page summaries on each of these technologies. These summaries provide more details on the target problem, the objectives and functions of the technology, the expected benefits, technological maturity, and commercialization status. More detailed information beyond these summaries is available from the principal technical contact or the central contact specified in each of the summaries. PNL has over 100 other environmental technologies which are being screened against the interim set of criteria. Information on these technologies are available from the central contact listed on the technology summaries.

Table 1: Summaries of Available PNL Technologies

HaloSnif Fiber Optic Spectrochemical Sensor

HaloSnif is fiber-optic sensor system which provides real-time measurement of chlorinated compounds in applications requiring air, gas, or water monitoring. The system uses a plasma excitation approach to excite and monitor the chlorine emission line. The system sensitivity ranges from 5 to 10,000 ppmv.
Khris Olsen, 509-376-4114.

Unsaturated Flow Apparatus Method

The Unsaturated Flow Apparatus (UFA) is a laboratory instrument that simulates the migration of VOCs, microbial nutrients, water, and other substances in the subsurface environment of arid sites. This centrifuge device provides results in hours instead of weeks or months using soil columns.
Judith Wright, 509-372-4747

In Situ Vitrification

In Situ Vitrification (ISV) electrically heats and melts soil contaminated with radioactive, chemical, and organic waste. Organics are destroyed by the heat, other contaminants are immobilized in the solid block of obsidian-like glass that remains after cooling. Field-scale applications have been demonstrated.
John Tixier, Jr., 509-376-8732

On-Site Analysis of Sediments by Stripping Analysis

Stripping Analysis determines concentrations of chromium, uranium, lead, cadmium, copper, and zinc in sediment samples at the field collection site. The compact unit requires 10 amps at 120 VAC to operate and produces data in a short period of time.
Khris Olsen, 509-376-4114

Waste Acid Detoxification and Reclamation (WADR) of Metals

The WADR system removes metals and recovers reusable acid from waste acids from industrial applications. The vacuum distillation system treats many acids, including nitric, hydrochloric, sulfuric, and hydrofluoric acids. The concentrated metal byproduct is often suitable for metal recovery treatment.
Evan O. Jones, (509) 372-0662.

Six-Phase Soil Heating

Electrical heating of the soil enhances the removal of volatile and semivolatile organic compounds from soils. Contaminants are vaporized; vapor pressure forces the contaminants out of the soil, aided by steam from vaporized water. A full scale demonstration removed 99.9% of the chlorinated solvents from 1100 m^3 of humid clay at a depth of 45 feet.
Theresa Bergsman, 509-376-3638

Graphite Electrode DC Arc Furnace

Coaxial graphite electrodes create an arc which treats heterogenous solid wastes. Up to 700 lbs per hour of feedstock is heated to over 1700°C. The resulting slag cools to a glass-like matrix which is extremely durable.
Jeff Surma, 509-376-4905

High Energy Corona

A high energy corona is established in cylinder. Gas contaminated with volatile organic compounds is cleaned while passing through the corona. Oxides of nitrogen (NO_x) and non-aqueous phase liquids are also treatable. The system is build of off-the-shelf components and operates from 60 Hz power. Based on a feed of 400 cu ft per minute contaminated with 2500 ppm of chlorinated solvents, high energy corona saves 50% to 95% of the cost of other accepted treatments.
William Heath, 509-376-0554

Terra-Vit

A low cost melter accepts 15 to 400 tons of contaminated soil, sludge, slurry, and combustible waste per day. Organics are destroyed, and heavy metals and radioactive materials are immobilized in stable, chemically durable glass that will remain intact for millions of years. Different waste streams can be processed by the same melter. A 50 ton-per-day melter was constructed in nine weeks at a cost of $500 k.
Chris Chapman, 509-376-6576

APPENDIX

SUMMARY TECHNOLOGY PROFILES
FOR
PACIFIC NORTHWEST LABORATORY
ENVIRONMENTAL TECHNOLOGIES
AVAILABLE FOR DEPLOYMENT

REVISION DATE: MAY 1994

Summary Technology Profile
Revision Date: 4/25/94

Name of Technology: HaloSnif
DOE Identification Number: RL321105

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: Khris B. Olsen
Phone/Fax: 509-376-4114/509-376-5368

Central Contact: S. C. Slate
Phone/Fax: 509-375-3903/509-375-5963

Target Problem: This technology is targeted toward environmental characterization and cleanup. HaloSnif was developed as a monitoring system capable of providing real-time concentration data for volatile chlorine-containing compounds in air, gas, and water.

Technology Objectives: HaloSnif is a chlorinated compound class-specific sensor system capable of providing real-time measurement capability for numerous environmental and process applications relating to air, gas, or water monitoring. HaloSnif's response is insensitive to moisture and other non-chlorinated compounds present in the sample stream. The most important advantages are response, reversibility of response, and range.

Technology/Process Description: During monitoring operation, HaloSnif operating at sub-ambient pressure (40-torr) continuously draws an air or gas sample through a critical orifice (for aqueous sample streams a sample is drawn across a heated membrane) into the plasma excitation chamber where it is mixed with helium and excited with a radio-frequency signal inductively-coupled to the plasma. The plasma chamber is coupled via a fused silica optical fiber to the signal processor unit. The optical emission of the plasma is filtered with a narrow band pass filter designed to monitor the 837.6 nm emission line from the excited chlorine atom. The intensity of the chlorine emission is directly proportional to the concentration of chlorine containing species in the sample gas. The detection sensitivity for carbon tetrachloride is 4 ppmv. The response of the system is linear from the detection limit to 10,000 ppmv. The detection limit for other chlorine containing compounds can be estimated by determining the ratio of chlorine in the compound of interest to that of carbon tetrachloride.

Data acquisition is achieved using a LabView™ data acquisition software package mounted on a Mackintosh computer system. The data acquisition system is interfaced to the electro-optical signal processing module via a 1 to 10 volt analog output. Real-time concentrations of total chlorinated compounds are displayed on the monitor for observation by on-site personnel. All data is stored in computer memory for post-run processing and analysis.

Summary of Advantages: HaloSnif is a new technology which can provide real-time monitoring capabilities for measuring concentrations of volatile chlorine-containing in gas, air, or water. HaloSnif's most important advantages are response, reversibility of response, and linear range, as explained below.

Instrument Response: HaloSnif is considered a real-time monitor, responding immediately to the presence of volatile chlorine-containing compounds. Equilibration times normally are less than 1 minute to reach 90% of full scale. Short-term (2-4 hours) baseline drift is approximately ± 5 ppm.

Reversibility: HaloSnif's response is completely reversible when the source of chlorinated compound(s) is/are removed. Thus, it is immediately ready for re-use.

Range: HaloSnif's response to chlorinated species is linear from a compound detection limit (i.e., 4 ppm for carbon tetrachloride) to approximately 10,000 ppm.

Technology Maturity: HaloSnif has been successfully demonstrated at DOE's Savannah River Site and Hanford Site. At Savannah River, HaloSnif was used to measure the concentrations of tetrachloroethylene and trichloroethylene in vadose zone monitoring wells and soil gas being extracted for catalytic destruction. At Hanford, HaloSnif was used as a real-time monitor for carbon tetrachloride concentrations in soil gas before and after cleanup with activated charcoal. HaloSnif was interfaced with a cone penetrometer system to provide real-time measurements for carbon tetrachloride concentrations as a function of depth during site characterization activities. HaloSnif was also used to conduct long-term monitoring at several vadose zone test points installed with the cone penetrometer system.

Timing: A solicitation for transferring the HaloSnif technology for commercialization was entered in the May 15, 1993, Commerce Business Daily (CBD). Fifteen firms requested additional information as a result of the CBD solicitation. One firm has expressed interest in licensing the HaloSnif system as a key component for a system used for subsurface characterization activities.

Regulatory Objectives: HaloSnif is not expected to replace any standard method of analysis of environmental samples. Instead it is a tool to be used for field screening areas contaminated with volatile chlorinated compounds.

Industrial Partnerships: The HaloSnif system has been further refined through a joint effort of PNL and Quanta Physik, a small business located in West Palm Beach, Florida. Presently, two units constructed by Quanta Physik have been delivered, tested, and used during field investigation exercises. A third Quanta Physik system has been ordered. Delivery is expected in July 1994.

Intellectual Property: HaloSnif was developed at Pacific Northwest Laboratory (PNL) and is covered under U.S. patent 5,085,599 "Fiber Optics Spectrochemical Emission Sensors" issued in February 1992.

Key Reference Documents:

Anheier, N. C., K. B. Olsen, and J. W. Griffin. 1993. "Fiber-Optic Spectrochemical Emission Sensor: A Detector for Volatile Chlorinated Compounds". Sensors and Actuators B, 11 447-453.

Olsen, K. B., J. W. Griffin, T. C. Kiefer, R. S. Matson, and C. J. Flynn. 1992. "A Fiber-Optic Spectrochemical Emission Sensor as a Detector for Volatile Chlorinated Compounds". ACS Symposium Series 479: Element Specific Chromatographic Detectors by Atomic Emission Spectroscopy; Ed. Peter C. Uden.

Summary Technology Profile
Revision Date: 3/30/94

Name of Technology: Unsaturated Flow Apparatus (UFA) Method
DOE Identification Number: RL321105

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford, and Washington State University (WSU)

Principal Investigator: J. V. Wright, PNL
J. L. Conca, WSU
Phone/Fax: 509-375-4787/509-375-4838

Central Contact: S. C. Slate
Phone/Fax: 509-375-3903/509-375-5963

Target Problem: There is a need for understanding contaminant distribution and migration behavior in subsurface environments at arid sites. In addition, there is a need for remote, in situ, or other onsite methods for increased safety and cost effectiveness for local characterization of contaminants.

Technology Objectives: The unsaturated flow apparatus (UFA) is a laboratory instrument that simulates the migration of VOCs, microbial nutrients, and water in the subsurface environment of arid sites. Instead of taking weeks or years to obtain transport data on unsaturated environments, the UFA can achieve steady state in several hours. This system is a more rapid method of obtaining transport data. The UFA can address any flow transport problem involving almost any fluid in any porous media under almost any condition.

Technology/Process Description: Soil samples are collected using any of the various methods, e.g., cable tool drilling/split spoon sampler technology. The soil or bedrock samples are transferred to a specially designed titanium canister and subjected to as much as 20,000 g in a open-flow centrifugation device. A rotating seal assembly fitted to the canister allows an ultra-low flow pump to deliver liquid or gas to the sample surface during centripetal acceleration. When steady state conditions are reached (within a matter of hours), transport parameters are evaluated, e.g., hydraulic conductivity to measure permeability, diffusion coefficient, and chemical retardation.

The UFA supports the development of restoration technologies such as vapor extraction (e.g., measure vapor migration rates) or bioremediation (e.g., nutrient delivery rates) for unsaturated soils. In addition, the UFA technology is a predictive tool, i.e., "time machine," that can be used 1) to validate the predictive models of subsurface contaminant migration, and 2) to screen the performance of various remediation technologies in the field.

Summary of Advantages: The UFA allows acquisition of data within hours or days rather than months to years. The UFA directly measures transport parameters at water contents well below any existing method, down to water contents of a few percent and hydraulic conductivities down to 10^{-10} cm/s. The UFA improves the predictive capabilities of VOC migration and provides a greater probability of choosing successful restoration strategies. This technology can also be used to do quick screening. The UFA can provide data to describe field conditions, which cannot be easily or quickly obtained under normal conditions.

Technology Maturity: There is no limitation to the use of this technology, provided that the sample can fit into the sample chamber. The UFA is capable of handling any porous media and almost any fluid. One of the major challenges is the preparation of the soil sample, i.e., obtaining undisturbed samples. The UFA uses components with different compositions to allow compatibility with many contaminants. Titanium, teflon, stainless steel, and various co-polymers can be used interchangeably.

After a relatively short period of onsite training with an experienced operator, a new worker may operate the technology alone. At this point, the UFA is able to be run by a unsupervised technician who is able to make many different types of decisions. Although the UFA is a research tool, its operation is simple.

The public may have some knowledge, but not a fundamental understanding, of this technology. There have been several press releases and local television news clips on the UFA. No adverse reactions are anticipated. There may be some question regarding how this technology can accurately simulate the natural environment. The UFA uses pristine soil samples and imposes exact conditions on the soils.

Timing: When matched up against traditional column experiments, the UFA has matched up 100% of the time against those methods. The UFA can achieve results in days. This compares to the months and years that are needed to achieve results with traditional column methods, or in situ analysis.

Initial discussions have also identified modifications that may need to occur for this technology to be used in a radioactive environment.

Regulatory Objectives: It is not anticipated that any environmental regulations impact the UFA. Some discussion with State regulatory officials regarding this technology has occurred over the past 3 years. It is not anticipated that any approvals will be needed to operate this technology.

Industrial Partnerships: A CRADA is in place between Beckman Instruments, Inc., and PNL. Beckman has provided two instruments for PNL use. PNL is using the instruments to refine the UFA Method and to extend the technique to a wide range of porous materials and fluids.

Environmental companies may be very interested in working with PNL to test the performance of their technologies on arid soils. There may be a need to work with principal investigators who are assessing the feasibility of laboratory user facilities for site remediation. Several concerns have made plans to purchase a UFA. The technology may have application to hot cell testing, but further development is needed to design radiation-hardened equipment.
The concrete industry has expressed an interest in UFA to test reactivity of concrete aggregate to alkaline solutions.

The Japanese are very interested in the UFA to study the movement of pore water through bentonite barriers for their waste repository programs, and have purchased a UFA with plans to purchase others.

Intellectual Property: Beckman Instruments, In., developed the rotating seals based on technology to spin oil out of whole rock shales, and has the intellectual property rights.

Reference Documents:

Conca, J. L., and J. V. Wright. 1992. "Direct Determinations of Unsaturated Flow and Transport." In *Proceedings of the 12th Annual Hydrology Days Conference*, p.103-116, Fort Collins, Colorado.

Conca, J. L., and J. V. Wright. 1992. "Flow and Diffusion of Unsaturated Gravel, Soils, and Whole Rock." Applied Hydrogeology, Vol. 1, pp. 5-24. International Association of Hydrogeologists.

Conca, J. L., and J. V. Wright. 1992. "A New Technology for Direct Measurements and Unsaturated Transport." In *Proceedings of the Nuclear and Hazardous Waste Management Spectrum '92 Meeting*, Vol. 2, pp. 1546-1555. American Nuclear Society, Boise, Idaho.

Summary Technology Profile
Revision Date: 4/19/94

Name of Technology: In Situ Vitrification (ISV)
DOE Identification Number: RL331010

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: J. S. Tixier	**Central Contact:** S. C. Slate
Phone/Fax: 509-376-8732/509-372-0867	**Phone/Fax:** 509-375-3903/509-375-5963

Target Problem: In Situ Vitrification targets contaminated soil and underground waste sites for the in place remediation and immobilization of contaminants. These sites may be contaminated or co-contaminated with heavy metals, hazardous organics, and radionuclides.

Technology Objectives: ISV allows for the in place remediation of contaminated soil sites. The ISV process destroys organics through pyrolysis and permanently immobilizes inorganics, heavy metals, and radionuclides in the durable glass and crystalline product.

Technology/Process Description: ISV is a thermal treatment process which uses electricity to melt soils. The process is started with a conductive mixture laid at the surface connecting an array of vertical electrodes. As the electrical power is passed through the starter path the resistance is such that very rapid heating and melting occurs. As power is continually applied heat is transferred from this molten region to the surrounding soil and the melt continues to grow. The off-gas produced in this process is trapped within a hood at the soil surface. This hood directs the gasses to an off-gas treatment system, where any and all contaminants are physically and chemically removed. When the electric current ceases, the molten volume cools and solidifies into a high-integrity block of glass and crystalline material resembling natural obsidian. The technology is applicable to a wide variety of sites and is virtually independent of soil type (sand, silt, clay,etc.) and inclusions (rubber, concrete, metal, wooden materials).

Summary of Advantages: Unique among treatments for hazardous waste, In Situ Vitrification offers numerous benefits compared to alternative technologies:

- Complete destruction/removal of hazardous organics
- Permanent immobilization of hazardous inorganics in the residual glass and crystalline product
- A high quality residual product that consistently passes current U.S. EPA test protocols and consistently meets or exceeds leach test results for HLW glass
- Simultaneous processing of widely varying mixtures of wastes (e.g., organics/inorganics, solids/sludges, refuse)
- Reduction of waste volume by 30 to 80 percent

- Maximum public and occupational safety through eliminating the excavation, packaging, pretreatment, transport, and redisposal of hazardous wastes
- Elimination of waste owner'/generators' exposure to long-term "joint and several" liability associated with offsite disposal

Power can be supplied by local utilities or by diesel-powered generators. Nominal energy requirements of 0.8 kilowatt hours per kilogram of vitrified mass attest to the efficiency of the process.

Technology Maturity: In Situ Vitrification has been demonstrated through field-scale and is currently available for field application at contaminated soil sites. A large-scale system has been operated at rates of up to five tons per hour, producing single melts greater than 1000 tons. The ISV process currently has a depth limitation of approximately 20 feet. Research is continuing on increasing the ISV process' depth capability. ISV technology is applicable to all soil types, with the exception of those low in alkali content (less than 1%). Research is underway on a method to treat soils low in alkaline earth materials. Methods for increasing the ISV melt depth and treating soils low in alkaline earth materials have been demonstrated in engineering-scale tests. Also, the effect on volatile organic compounds is not completely understood and needs to be studied on a case by case basis.

Timing: The technology is currently available for inclusion in feasibility studies, use on DOE sites, and commercial use for contaminated soil sites less than 20 feet deep. It is anticipated that deeper processing depths will be achieved in the near future.

Regulatory Objectives: ISV technology is available for applications involving mixed contaminated soil sites up to a depth of 20 feet. The vitrified block produced has tensile and compressive strengths averaging about ten times that of unreinforced concrete. The vitrified block has excellent chemical durability comparable to that of high-quality laboratory glassware and greater than that of granite and marble. Studies indicate that the glass product on ISV will retain its physical and chemical integrity for geologic time periods.

Industrial Partnerships: ISV technology is currently provided commercially by the Geosafe Corporation, Richland, WA.

Intellectual Property: ISV is a patented technology licensed to Battelle, Pacific Northwest Laboratories by the Department of Energy. Exclusive commercial rights to the ISV technology have been sub-licensed to the Geosafe Corporation. Development of In Situ Vitrification has been funded by the U.S. Department of Energy and several private organizations. U.S. Patent No. 4376598 was issued for the invention in 1983. Numerous additional patents cover subsequent technology improvements.

Key Reference Documents:

Buelt, J. L., C. L. Timmerman, K. H. Oma, V. F. Fitzpatrick, and J. G. Carter. 1987. "In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Application Assessment." PNL-4800, Suppl. 1, Pacific Northwest Laboratory, Richland, Washington.

Callow, R. A., L. E. Thompson, J. R. Weidner, C. A. Loehr, B. P. McGrail, and S. O. Bates. 1991. "In Situ Vitrification Application to Buried Waste: Final Report of Intermediate Field Tests at Idaho National Engineering Laboratory." EGG-WTD-9807, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Luey, J., S. S. Koegler, W. L. Kuhn, P. S. Lowery, and R. G. Winkelman. 1992. "In Situ Vitrification of a Mixed Waste Contaminated Soil Site: The 116-B-6A Crib at Hanford." PNL-8281, Pacific Northwest Laboratory, Richland, Washington.

Spalding, B. P., G. K. Jacobs, N. W. Dunbar, M. T. Naney, J. S. Tixier, and T. D. Powell. 1992. "Tracer-Level Radioactive Pilot-Scale Test of In Situ Vitrification Technology for the Stabilization of Contaminated Soil Sites at ORNL." Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Buelt, J. L., L. E. Thompson. 1992. "The In Situ Vitrification Integrated Program: Focusing an Innovative Solution on Environmental Restoration Needs." Pacific Northwest Laboratory, Richland, Washington.

Summary Technology Profile
Revision Date: 3/31/94

Name of Technology: On-Site Analysis of Sediments By Stripping Analysis
DOE Identification Number: RL321112

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: Khris B. Olsen and Professor Joseph Wang
Phone/Fax: 509-376-4114/509-376-5368

Central Contact: S. C. Slate
Phone/Fax: 509-375-3903/509-375-5963

Topic Category: Improved Sample Collection and Analysis

Target Problem: This technology is targeted for the determination of chromium, uranium, lead, cadmium, copper, and/or zinc concentrations in sediment samples. The objective of technology is to develop the capability to accurately measure the concentrations of the aforementioned metals in soils and sediments.

Technology Objectives: To develop the capability to analyze sediment samples for the aforementioned metal in the field during characterization and remedial activities at hazardous waste sites.

Technology/Process Description: The following processes can be conducted in a mobile field laboratory. Sediment samples are dried and digested in a microwave digestion system. Nitric acid is used as the leachate in the digestion process. Leachate (or digestate) solutions are diluted to 100 ml with distilled or deionized water and analyzed by stripping analysis which includes adsorptive stripping voltammetry (for chromium analysis), stripping voltammetry (for uranium, cadmium, copper, zinc, and/or lead analysis) and/or potentiometric stripping analysis for cadmium, copper, and/or lead analysis). Results of stripping analysis are reported as ppm of dry weight for the metal of interest.

Summary of Advantages: Stripping analysis (SA) is well suit for field screening support. The system is compact, requires minimal electricity (10 amp at 120 VAC), and produces high quality data in a short period of time. Significant cost saving are anticipate using SV to support characterization activities. This cost savings should arise from the ability to screen sediment samples concurrent with field teams' sampling activities. For example, the results from SA can be used to identify when contamination has been encountered during drilling of boreholes. In addition, field screening efforts can be used during a removal action to help delineate when a cleanup level has been achieved for a contaminant of concern.

Timing: This technology is currently available from commercial vendors.

Regulatory Objectives: This technology can aid in meeting cleanup milestones by decreasing significantly the time required for obtaining offsite analytical results.

Industrial Partnerships: Radiometer America has significant interest in extending the applications of stripping analysis into the field as a screening tool for priority metals of concern. Radiometer is the manufacture of the potentiometric stripping system currently being used for method development at PNL and NMSU.

Intellectual Property: None

Reference Documents:

Wang, J. 1985. *Stripping Analysis: Principles, Instrumentation and Applications*. VCH Publishers, Deerfield Beach, Florida.

J. Wang and R. Setiadjii. 1992. "Selective Determination of Trace Uranium by Stripping Voltammetry Following Adsorptive Accumulation of the Uranium-Cuferron Complex." Analytica Chimica Acta 264: 205-211.

J. Wang, J. Lu, and K.B. Olsen. 1992. "Ultratrace Measurements of Chromium." Analyst 117, 1915.

J. Wang, R. Setiadjii, L. Chen, J. Lu, and S. Morton. 1992. "Automated System for On-Line Monitoring of Uranium." Electro-analysis 4, 161.

Reports

K. B. Olsen, J. Wang, and R. Setiadjii. October 1992. "Field Screening of Sediment Samples for Chromium by Stripping Voltammetry." Milestone Report to Sponsor.

Summary Technology Profile
Revision Date: 3/31/94

Name of Technology: Waste Acid Detoxification and Reclamation and Detoxification (WADR)
DOE Identification Number: RL343001

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: E. O. Jones
W. A. Wilcox
Phone/Fax: 509-372-0662/509-372-2310

Central Contact: S. C. Slate
Phone/Fax: 509-375-3903/509-375-5963

Target Problem: Large quantities of metal-bearing spent acids are produced by electroplating, surface finishing, and chemical milling/dissolution operations common to DOE and DoD manufacturing and chemical processes. In addition, spent acids are widespread throughout U.S. private industry with over 15,000 companies generating over 8 billion pounds of metal-bearing spent acids each year and are affected by the problem of disposing of this waste. Typical industrial operations affected by regulatory restrictions and public demand for pollution prevention include: electroplating and surface finishing operations in electronics, aerospace, automotive, metalworking, steel, and defense industries.

Technology Objectives: The objective of the WADR technology is to recover and reuse metal-bearing spent acids. Using simple and proven distillation technology with advanced corrosion-resistant materials and specialty manufacturing, the WADR process concurrently concentrates the metals and recovers clean acid.

Technology/Process Description: Through a combination of simple and proven distillation technology together with advanced corrosion-resistant materials and specialty manufacturing, the WADR process concurrently concentrates the metals and recovers clean acid. Over 90% of the spent acid can be recovered as a reusable product, and the volume of waste to be disposed of is minimized or possibly eliminated. The concentrated metal byproduct is frequently suitable for recovery by metal reclamation companies.

The WADR system processes a variety of spent acids, including nitric, hydrochloric, sulfuric, and hydrofluoric acids. Spent acids can be distilled under vacuum in a simple, compact, corrosion-resistant system to maintain maximum efficiency and reduce risk.

The key attributes of the system are highlighted below:

- Vacuum Operation - Operating under a vacuum lowers fluid temperatures and reduces side-reactions, lengthens the life of the equipment, reduces equipment costs, and allows the use of lower-temperature heat transfer media (e.g., low-temperature steam). In addition, vacuum operation is an inherently safe operation with respect to personnel exposure and environmental releases.

- Advanced Materials of Construction - Dual-laminate equipment combining fluoropolymer liners with reinforced thermosetting plastic (RTP) is lightweight, corrosion resistant, and custom configured.
- No dilution - The WADR process does not use chemicals or water to perform the separation. The entire volume of spent acid is converted to a reusable acid and potentially reclaimable metal byproduct; there is no net increase in the volume of chemicals used or discharged.
- Variety of Acids Rejuvenated - The WADR system is capable of processing a variety of spent acids using the same system.
- Uses Waste Energy for Waste Recovery - The WADR process can use low-temperature waste energy such as low-pressure steam to recover spent acids.
- Flexible and simple operation - The WADR process can be designed to operate as batch, semi-batch, or continuous operation for multiple or single acid streams, and it can be built as a mobile or fixed system. Distillation is a proven technology that is easily and safely operated and maintained with little impact from misoperation or variation in feed compositions.

Summary of Advantages: The baseline treatment technology for metal-bearing spent acids is treatment and disposal in landfills or deep-well injection. Alternative current acid recovery technologies include ion exchange, resin bed exchange, electrodialysis and other membrane separations and electrowinning. Specialized distillation has the advantage of being able to recover clean products from a variety of corrosive concentrated acids using a single process. In contrast with other technologies, vacuum distillation combined with corrosion-resistant materials of construction is simpler, safer, and less expensive.

Technology Maturity: Field application.

Timing: Available for commercial use now.

Regulatory Objectives: The technology complies/meets regulatory obligations to recycle materials prior to treatment and disposal.

Industrial Partnerships: The licensee of the process is Viatec Recovery Systems of Richland, Washington. The spin-off partnership of this DOE-developed technology combines the mechanical design and dual-laminate fabrication skills of Viatec with the design and specialized process knowledge of Pacific Northwest Laboratory.

This technology has broad application, as evidenced by the several hundred inquiries received from private companies in the U.S. and overseas.

Intellectual Property: The intellectual property is specialized knowledge of recovering spent acids using vacuum distillation and advanced fluoropolymer materials of construction. The knowledge is contained in an invention report that may be submitted for a patent.

Key Reference Documents:

Jones, E. O. and K. L. Kensington. 1993. "Spent Acid Recovery Using the WADR Process System." 207th Annual American Chemical Society Conference,
August 22-27, 1993, Chicago, Illinois. PNL-SA-3796A, Pacific Northwest Laboratory, Richland, Washington.

Jones, E. O. 1993. "Waste Acid Detoxification and Reclamation (WADR): Proven Technology and Advanced Materials." American Institute of Chemical Engineers (AIChE) Conference, August 15-18, 1993, Seattle, Washington.

Jones, E. O., W. A. Wilcox and W. Lewis. 1993. "Recovering Spent Acids Using the WADR Process." 19th Environmental Symposia and Exposition, March 22-24, 1993, Albuquerque, New Mexico. PNL-SA-3740, Pacific Northwest Laboratory, Richland, Washington.

Jones, E. O. 1992. "Waste Acid Detoxification and Reclamation." 6th Annual Aerospace Hazardous Waste Minimization Conference, June 25-27, 1992, Seattle, Washington. PNL-SA-19402S, Pacific Northwest Laboratory, Richland, Washington

Jones, E. O. 1990. "Treating Metal-bearing Spent Acids with a Transportable Test System." 11th AESF/EPA Conference on Environmental Control for the Metal Finishing Industry, Orlando, Florida.

Jones, E. O. 1989. "Waste Acid Detoxification and Reclamation (WADR) 1989 Annual Report." PNL-SA-17654, Pacific Northwest Laboratory, Richland, Washington.

Regulatory Objectives: SPSH is available for cleaning soils contaminated with VOCs and SVOCs to regulatory requirements as outlined in the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Compensation and Liability Act (CERCLA). Tests have demonstrated removal of tetrachloroethylene, trichloroethylene, benzene, and naphthalene (approximating gasoline and diesel fuel) to well below regulatory limits.

Industrial Partnerships: PNL is actively seeking licensees for the SPSH technology. SPSH has widespread commercial applications, such as cleanup of gasoline spills, etc. A relationship is being developed with an industrial firm that is expected to culminate in a licensing agreement with PNL for use of SPSH at a large number of sites.

Intellectual Property: On November 14, 1991, a patent was obtained for electrical soil heating (U.S. 4,957,393). A second patent has been allowed and will be issued shortly. A third patent application is being prepared. Applications for foreign rights have also been completed.

Key Reference Documents:

Gauglitz, P. A., J. S, Roberts, T. M. Bergsman, S. M. Caley, W. O. Heath, M. C. Miller, R. W. Moss, R. Schalla, and M. H. Schlender. 1994. "Field Test of Six-Phase Soil Heating at the Savannah River Site." PNL-SA-24002, Pacific Northwest Laboratory, Richland, Washington.

Bergsman, T. M., J. S, Roberts, D. L. Lessor, and W. O. Heath. 1993. "Six Phase Soil Heating to Enhance Removal of Contaminants." PNL-SA-21709, Pacific Northwest Laboratory, Richland, Washington.

Bergsman, T. M., J. S. Roberts, D. L. Lessor, and W. O. Heath. 1993. "Field Test of Six Phase Heating and Evaluation of Engineering Design Code." PNL-SA-21537, Pacific Northwest Laboratory, Richland, Washington.

Heath, W. O., J. S. Roberts, D. E. Lessor, and T. M. Bergsman. 1992. "Engineering Scale-up of Electrical Soil Heating for Soil Decontamination." PNL-SA-20740, Pacific Northwest Laboratory, Richland, Washington.

Summary Technology Profiles
Revision Date: 3/31/94

Name of Technology: Six-Phase Soil Heating
DOE Identification Number: RL331004

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: T. M. Bergsman	**Central Contact:** S. C. Slate
Phone/Fax: 509-376-3638/509-376-1867	**Phone/Fax:** 509-375-3903/509-375-5963

Target Problem: Six-Phase Soil Heating (SPSH) is a technology for thermally enhancing the removal of volatile and semi-volatile organic compounds (VOCs, SVOCs) from soils via soil vapor extraction (SVE).

Technology Objectives: The soil is heated to the soil moisture's boiling point in order to increase the contaminant's vapor pressure thereby increasing its removal rate and to create an in situ source of steam that strips out the less volatile organic compounds that venting alone does not remove. Removal of soil moisture (as steam) also tends to increase the flow permeability of soils, which can further increase the rate of contaminant removal by simultaneous venting.

Technology/Process Description: The six-phase soil heating technique is based on the ability to split conventional three-phase electricity into six separate electrical phases. The six phases are connected to six separate electrodes placed in a circle in the soil. Because each electrode is at a separate phase, each one conducts to all the others. Voltage gradients in the six-phase array are relatively uniform, thus facilitating very uniform heating throughout the volume bounded by the six electrodes. A seventh, electrically neutral pipe is inserted in the center of the hexagon and connected to a vacuum blower in order to vent the soil.

Summary of Advantages: Since electrical soil heating heats the soil internally by passing standard ac electric current through the indigenous soil moisture, clays and silts are heated as effectively as sands. Treatment of a broad range of sites with complex stratigraphy is possible with SPSH. Since the technology uses conventional utility transformers, capital costs are low as compared to high frequency systems.

Technology Maturity: A full-scale demonstration (1100 m^3) was completed at DOE's Savannah River Site. 99.9% removal of chlorinated solvents (tetrachloroethylene and trichloroethylene) from a humid clay at a depth to 45 ft was achieved.

Timing: SPSH is currently available for inclusion in feasibility studies, use on DOE sites, and commercial use.

Summary Technology Profile
Revision Date: 3/31/94

Name of Technology: Graphite Electrode DC Arc Furnace
DOE Identification Number: RL321211

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: J. E. Surma	**Central Contact:** S. C. Slate
Phone/Fax: 509-376-4905/509-376-1867	**Phone/Fax:** 509-375-3903/509-375-5963

Target Problem: The technology is required to treat heterogenous solid wastes.

Technology Objectives: The primary objective is to treat the solid wastes across the DOE complex such as buried waste. It is however applicable to solid and solid liquid mixtures where hazardous organics are present.

Technology/Process Description: The Pacific Northwest Laboratory (PNL), Massachusetts Institute of Technology (MIT), and Electro-Pyrolysis Inc. (EPI) have entered into a collaborative agreement to develop and demonstrate this technology. An earlier bench-scale model, Mark I furnace, was successfully tested in 1992 to demonstrate that surrogate soil and soil mixtures can be converted into iron enriched basalt (IEB), a stable waste form, using DC arc technology. The Mark I furnace was small in size and had very limited batch loading capability.

The Mark II furnace is much larger and has the capability for continuous loading and slag removal at the rate of 500 to 700 lb/h. The furnace features a unique graphite coaxial center electrode that generates heat by arcing between these electrodes, "nontransferred" arc mode, or by arcing between the center electrodes and the positive electrode hearth, "transferred" arc mode. The hearth collects the molten feedstock until it reaches a level of 12 in. It then overflows into a 55-gal drum for slag removal. The furnace can operate in either the submerged arc, which is preferred to limit offgas emissions. or a non-submerged mode.

The furnace interior is inerted with N_2 gas at all times to prolong the electrode life and to provide a cleaner melt. The N_2 system also supplies gas to operate the gate and pusher rod actuators and to inflate the seals. Furnace hot spots such as flanges, supports, and gates are cooled with a recirculating water system. An offgas system, which consists of a quencher, two Venturi scrubbers, recirculation/filter system, and water seal, is provided to condition and clean the offgas.

Summary of Advantages: This technology has been demonstrated to be effective on processing materials with high melting points (i.e., > 1700°C) into a glass like matrix that is extremely durable.

Technology Maturity: Ready for deployment

Timing: The technology is ready now for several applications.

Regulatory Objectives: The technology will be available for implementation in support of DOE cleanup milestones. As stated above the technology is ready for deployment now. With respect to compliance with applicable regulations this technology will meet all current regulations.

Industrial Partnerships: Two industrial partners presently are involved with the technology development effort. Electro-Pyrolysis Inc. (EPI) and T&R Associates both of Wayne, PA have been involved from the inception of this program. EPI is presently pursuing the commercialization of the DC arc furnace technology with KVS a large firm with engineering experience in the deployment of large incineration systems.

Intellectual Property: There is IP that has been developed under this program and technology that was brought into the program by EPI. The DC arc furnace technology is owned by both EPI and T&R associates. The other IP that has been developed under this program involves diagnostics for measuring the emissions from the furnace and an advanced temperature measurement system. Both of these technologies have been patented through MIT and are owned by all parties involved in the program. MIT is currently developing the licensing strategy for these inventions.

Key Reference Documents:

Surma, J. E., D. R. Cohn, D. L. Smatlak, P. Thomas, P. P. Woskov, C. H. Titus, J. K. Wittle, and R. A. Hamilton. 1993. "Graphite Electrode DC Arc Technology Development for Treatment of Buried Wastes." PNL-SA-21891, Pacific Northwest Laboratory, Richland, Washington.

Surma, J. E., C. J. Freeman, T. D. Powell, D. R. Cohn, D. L. Smatlak, P. Thomas, P. P. Woskov, C.H. Titus, J.K. Wittle, and R.A. Hamilton. 1993. "Evaluation of the Graphite Electrode DC Arc Furnace for the Treatment of INEL Buried Wastes." PNL-8525, Pacific Northwest Laboratory, Richland, Washington.

Surma, J. E., D. R. Cohn, P. Thomas, P. P. Woskov, C. H. Titus, J. K. Wittle, and R. A. Hamilton. March 1993. "Graphite Electro de DC Arc Technology Development for Treatment of Buried Wastes." Presented at Waste Management 93, Tucson, Arizona.

Woskov, P. P., D. R. Cohn, D. Y. Rhee, C. H. Titus, J. K. Wittle, J. E. Surma. 1993. "Diagnostics for a Waste Remediation Plasma Arc Furnace." In *Proceedings 6th International Symposium on Laser-Aided Plasma Diagnostics*, p. 260. October 1993, Bar Harbor, Maine.

Woskov, P. P., D. R. Cohn, D. Y. Rhee, C. H. Titus, J. K. Wittle, J. E. Surma. 1993. "Diagnostics for a Waste Remediation Plasma Arc Furnace." PFC/JA-93-28, MIT Plasma Fusion Center Report.

Summary Technology Profile
Revision Date: 4/25/94

Name of Technology: High-Energy Corona
DOE Identification Number: RL321101

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: W. O. Heath	**Central Contact:** S. C. Slate
Phone/Fax: 509-376-0554/509-376-1867	**Phone/Fax:** 509-375-3903/509-375-5963

Target Problem: This technology targets the treatment of airborne VOCs. Primary applications for DOE include treatment of secondary offgases from site cleanup operations and treatment of fugitive organic emissions from waste storage tanks. A below-ground (in-well) application for HEC is also feasible. Potential industrial applications for HEC applications are extremely diverse, running from regulatory compliance for the paint and coatings industry, pharmaceuticals, odor control, parts cleaning and manufacturing, pulp and paper, and fuel-storage depots, to treating cold-start emissions from automobiles, to managing formaldehyde concentrations as a way of curing "sick" buildings, to compact air purification systems for NASA. The HEC technology is also applicable to the direct treatment of non-aqueous phase liquids (NAPLs) without requiring any thermal prevolatilization. The technology appears feasible as a more publicly acceptable alternative to incineration, particularly for the destruction of PCBs.

Technology Objectives: The HEC technology destroys organic waste compounds, forming carbon dioxide, water and halide ions.

Technology/Process Description: The HEC device is shaped like a coaxial cylinder with an inner metal electrode and an outer tube made of glass or metal. An ac electric field is established across the gap between the electrode and the tube to create a low-temperature plasma. To create a uniform plasma throughout the gap, the gap is filled with a dielectric packing material that amplifies and distributes the electrical field. The gas to be treated is simply pulled through the plasma, with destruction of the contaminant molecules occurring in a few seconds. The HEC process is highly energy efficient because treatment occurs as rapidly as in conventional incineration, but occurs near room temperature and pressure. Studies conducted at PNL since 1989 have demonstrated the ability of corona discharges to destroy a wide variety of organic compounds, including benzoic acid, trichloroethylene, perchloroethylene, acrylamide, benzo(a)pyrene, three organic dyes, benzene, heptane, toluene, naphthalene, phenol, chlorophenol, chloronaphthalene, methane, and carbon tetrachloride. Other researchers have demonstrated the reduction of NOx using corona, the destruction of chemical and biological warfare agents, the removal of particulates from gas streams, and the oxidation of many metals including gold. Recent experiments have also demonstrated the ability to destroy liquid-phase organics that are injected directly into the device. When treating halogenated wastes, a secondary scrubber will often be required to remove acid gases.

Summary of Advantages: The main benefit of high-energy corona is its potential for significant savings in the cost (both operating and capital) of treating organic-contaminated gas streams as well as direct treatment of liquid-phase organics. Compared to other advanced oxidation processes, electrically based off-gas treatment is expected to be less sensitive to variations in the type of organic contaminant and variations in inlet stream conditions. Compared to strictly thermal methods (and methods requiring thermal regeneration of catalysts or sorbents) high-energy corona is significantly more energy efficient. Compared to other systems that use nonequilibrium plasma, HEC appears to exhibit superior capital costs on scaleup and very competitive energy and operating costs. Unlike other nonequilibrium-plasma techniques, HEC uses off-the-shelf power supplies that operate at the standard power frequency of 60 Hz, which reduces both capital cost and energy losses associated with high-frequency devices. The HEC process would also be expected to be relatively maintenance-free, safe, and simple to operate. Based on a preliminary analysis of costs for treating VOC-contaminated air, HEC is projected to cost less than all known baseline technologies for dilute airstreams. HEC is projected to cost: 50% of sorption with recovery (which creates a secondary liquid waste); 10% of membrane separation; 8% of catalytic oxidation; and 5% of carbon sorption with regeneration. These figures include an overall 25% added cost for HEC to represent uncertainties associated with a new process. They are based on a stream volume of 400 cfm contaminated with 2500 ppmv total of chlorinated solvents. The cost for treating liquid-phase organics via injection into HEC reactors would be expected to be similar to the cost for treating air on a mass-of-contaminant basis.

Technology Maturity: HEC is available for full-scale DOE and/or commercial demonstration and deployment.

Timing: The HEC technology is now available for inclusion in feasibility studies, initial use on DOE sites and initial commercial use. Costs and performance can be projected for any stream volume.

Regulatory Objectives: The HEC technology would assist site cleanup by providing a cost-effective means of treating secondary offgases requiring treatment prior to atmospheric release. It is available for use now at sites such as Rocky Flats where offgas treatment is key to meeting cleanup objectives. The technology appears to meet all applicable clean air regulations as well as the forthcoming NESHAP regulations that will effect industry initially, then DOE. It is expected to be used for treating manufacturing emissions as well as fugitive storage-tank emissions.

Industrial Partnerships: We have entered license negotiations with three U.S. companies that want to manufacture and market the HEC technology for treating industrial VOC emissions. Battelle will be granting exclusive licenses for specific territories and fields of use. Three other companies have requested status as industrial partners, including Allied Signal for assisting with commercial hardware design, and a second company for assisting with high-voltage engineering.

Intellectual Property: Battelle holds a patent on the HEC technology (U.S. No. 5,254,231) and holds other IP related to scaleup and improved performance that are now being reduced to practice. Further patents are anticipated. The HEC technology was recognized with an R&D 100 Award as "one of the 100 most technologically significant new products of 1993", and was listed No. 1 in the January 1994 issue of Environment Today in the "top ten research projects that could change the face of pollution control."

Key Reference Documents:

Heath, W. O., S. M. Caley, L. M. Peurrung, B. D. Lerner, R. W. Moss. 1994. "Feasibility of In situ Electrical Corona for Soil Detoxification." In Situ Remediation: Scientific Basis for Current and Future Technologies, The Thirty Third Hanford Symposium on Health and the Environment, November 7-11, 1994, Richland, Washington.

Shah, R. R., R. E. Garcia, J. T. Jeffs, J. W. Virden, and W. O. Heath. 1994. "Initial Field Test of High-Energy Corona Process for Treating a Contaminated Soil-Offgas Stream." PNL 9224, Pacific Northwest Laboratory, Richland, Washington.

Heath, W. O., J. W. Virden, R. L. Richardson, and T. M. Bergsman. 1993. "Method and Apparatus for Chemically Altering Fluids in Continuous Flow." U.S. Patent No. 5,254,231.

Virden, J. W., W. O. Heath, S. C. Goheen, M. C. Miller, G. M. Mong, and R. L. Richardson. 1992. "High-Energy Corona for Destruction of Volatile Organic Contaminants in Process Off-Gases." DOE Spectrum '92.

Heath, W. O., S. C. Goheen, M. C. Miller, and R. R. Richardson. 1992. "Investigation of Electric Fields For Low-Temperature Treatment of Soils and Liquids." PNL-SA-20825, Pacific Northwest Laboratory, Richland, Washington.

Summary Technology Profile
Revision Date: 4/23/94

Name of Technology: Terra-Vit, A Low-Cost Melter Technology
DOE Identification Number: TBD

Affiliation: Battelle, Pacific Northwest Laboratory; Hanford

Principal Investigator: C. C. Chapman
Phone/Fax: 509-376-6576/509-376-1867

Central Contact: S. C. Slate
Phone/Fax: 509-375-3903/509-375-5963

Target Problem: This technology is best suited for high-capacity applications that require more than 15 to 400 tons per day of waste to be processed. It has applicability to organic, heavy metal and radioactive contaminated soils, sludges, slurries and combustible solid wastes. Scrap metal content may be as high as 25 weight percent. Possible applications include contaminated soils, retrieved buried waste, debris from D&D facilities, sludges, and combustible low-level, mixed, or TRU trash. The same device can be used for different waste streams at a site. It is typically an above grade, fixed-based processing system. However, the low-cost characteristics of this patented melter allow transportable systems to be contemplated.

Technology Objectives: Destroy organics and immobilize heavy metals and radioactive elements and bind them into the material's molecular structure resulting in a stable, chemically durable glass that will remain intact for millions of years.

Technology/Process Description: The feature of this technology is to minimize capital and operating costs for making a superior waste form; glass. To achieve this compared to conventional glass melters, the melter is constructed with low-cost ores, soils, rock, refractory seconds or other low-cost sources. The melter is oversized, the side walls are sloped and the power electrodes are operated to reduce the temperature and corrosion of the low-cost, molten-pool containment. Units can be rapidly and easily constructed. For example, a 50 ton-per-day melter that is 30 feet in diameter and 16 feet tall was constructed at Hanford in nine weeks at a cost of only $500,000.

Waste materials are fed and accumulated on the top of the molten pool. As the waste settles, the material dries, organics pyrolize, and salts decompose. When residual carbon is present, oxidation air is injected and oxidizes the carbon. Then the material melts. Typically, the molten material convects in the molten pool for one to five days and homogenizes. This ensures good mixing and allows heterogeneous wastes to be processed with minimal characterization. After a long residence time, the glass is discharged to the glass-forming system for disposition.

This is a very versatile, robust melter technology. It can process combustible or non combustible sludges, slurries and solids, or mixtures of these wastes. Campaigns of greatly different wastes can be processed in the same unit. There are essentially no secondary wastes, because materials that escape to the off-gas system are filtered or scrubbed and recycled to the melter.

When electrical energy costs are too high, alternative energy sources can be used to provide the melting energy. Other wastes such as waste wood, plastics, coal or solid waste can be added to the waste to supply the energy. A schematic of an above grade Terra-Vit melter is shown in the following figure.

Summary of Advantages: This technology allows the vitrification process to be cost competitive with many other inferior waste forms. It destroys organics, binds heavy metals and radioactive elements in a material that is stable for millions of years. It provides high volume reduction with very high compressive strength. The process produces little or no secondary wastes.

Technology Maturity: Full demonstration to deployment. Two commercial solid-waste designs have been completed; one for a 50 tpd of MSW bottom ash and one for 25 tpd solid medical waste.

Timing: The technology is available for commercial use.

Regulatory Objectives: The technology is available for cleanup milestones. The process has been demonstrated effective at destroying organics (>99.99%) and satisfies land band leaching requirements for heavy metals with the exception of mercury.

Industrial Partnerships: Four private companies have licensed the technology. The licensing strategy is to license the technology by waste stream and by region. Thus, many additional licenses are envisioned.

Intellectual Property: Patented and owned by Battelle Memorial Institute.

II

DATE FILMED

8/23/94

END