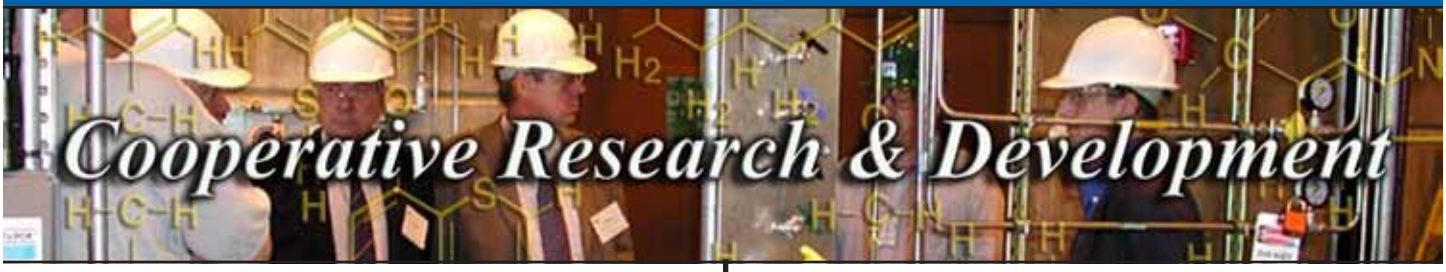
U.S. Department of Energy • Office of Fossil Energy
National Energy Technology Laboratory



Successes

Halogenated Volatile Organic Compound (HVOC) Field Screening

Advanced Research

To support coal and power systems development, NETL's Advanced Research Program conducts a range of pre-competitive research focused on breakthroughs in materials and processes, coal utilization science, sensors and controls, computational energy science, and bioprocessing—opening new avenues to gains in power plant efficiency, reliability, and environmental quality. NETL also sponsors cooperative educational initiatives in University Coal Research, Historically Black Colleges and Universities, and Other Minority Institutions.

Accomplishments

- ✓ Process improvement
- ✓ Cost reduction
- ✓ Greater efficiency
- ✓ Innovative materials

Objectives

The ultimate goal of this effort is to develop and commercialize a field-portable kit for screening halogenated volatile organic compounds (HVOCs) from soil and water samples, in order to provide a streamlined method for testing of brownfield (redevelopment) sites for environmental contamination. The screening tool was based on a commercial refrigerant leak detector that was modified to add a numerical readout, and modified further to provide rapid response and enhanced sensitivity. A method to screen trichloroethylene (TCE)-contaminated soil was developed, and this method was evaluated and approved through the balloting process used by the American Society for Testing and Materials (ASTM) International. A water screening method also was developed, and the ASTM soil screening method was successfully revised to include water screening in 2006.

Project Description/Technology

HVOCs are among the most common contaminants in the United States. They were used extensively in the past as refrigerants, degreasers, dewaxers, fumigants, dry cleaning solvents, and aerosol propellants, with disposal practices that led to their release into the environment. These compounds, such as carbon tetrachloride, trichloroethylene (TCE), and tetrachloroethylene (PCE), also are referred to as dense nonaqueous phase liquids (DNAPLs). Many are still in use as degreasing solvents for equipment cleaning operations in petroleum refining and other industries.

Altogether, HVOCs are the most significant organic contaminants in groundwater associated with disposal sites in the United States. The Environmental Protection Agency (EPA) has identified nearly 70,000 affected industrial and residential sites. The Department of Defense (DoD) has targeted approximately 9,000 military sites for cleanup. Despite the prevalence of HVOCs, screening methods have been costly and problematic. The most common non-halogenated VOC field screening tools do not specifically detect HVOC pollutants.

Under a grant from the U.S. Department of Energy, Office of Fossil Energy (DOE-FE), the University of Wyoming's Western Research Institute (WRI) has worked with the Advanced Research group at the National Energy Technology Laboratory (NETL) to develop and validate

Project Duration

Start Date
11/01/05

End Date
04/30/08

Corporate Co-Sponsor

Bacharach, Inc.
621 Hunt Valley Circle
New Kensington, PA 15068
1-800-736-4666
help@bacharach-inc.com

new methodology and a test kit to screen soil or water samples for HVOCs in field applications. WRI works with NETL on research, development, demonstration, and commercialization of technologies related to energy, environment, and transportation materials.

To commercialize the new screening device, known as the X-Wand®, NETL and WRI joined with Bacharach, Inc., New Kensington, PA, which participated as the corporate co-sponsor for this Jointly Sponsored Research (JSR) task managed by NETL's Advanced Research (AR) Program. Bacharach, the manufacturer and distributor of X-Wand®, manufactures and distributes other advanced equipment for the measurement and detection of gases and liquids. The company has sales and service centers in five countries.

Product Features

The X-Wand® heated diode unit is a modified version of a model H-10PM refrigerant leak detector from Bacharach. It is used to detect halogens released into the air in the "headspace" above a solid or liquid sample. The diode sensor is heated to temperatures between 1,100–1,800 °F. The voltage readout is proportional to a microamp current from the diode, which measures the results from the ionic reaction of the halogen above the sample with alkali metal vapor released by the sensor. An on-board sampling pump provides unrestricted air flow through the sensor at about 0.38 L/minute. A 14-gauge, 4-inch long, blunt stainless steel needle is attached to the wand tip to allow the probe to sample air from various containers. An on-board liquid crystal diode (LCD) voltmeter provides a numerical voltage readout. The unit is equipped with a "zero" knob and a span knob. The zero knob is manually adjusted to provide a zero reading in the absence of HVOCs in air, while the span knob is set to provide a voltage readout of 9–12 V when exposed to a standard 1,000 milligrams per cubic meter (mg/m^3) TCE in air.

X-Wand® makes HVOC detection fast, easy, accurate, and economical. For rapid evaluation of soil or water, this portable, hand-held instrument uses a heated diode sensor of the same type used to detect refrigerant leaks from air conditioners, freezers, and refrigerators. The sensor is selective for halogens, but does not respond to volatile aromatic hydrocarbons such as those in gasoline, and is not affected by water vapor (high relative humidity). The device can be used to screen headspace above either soil or water samples.

Features of the X-Wand® include:

- Distinguishes HVOCs from other VOCs such as gasoline.
- Quickly identifies "hot spots," increasing the efficiency of environmental assessments and cleanup.
- Provides real-time monitoring during and after cleanup.
- Eliminates unnecessary laboratory analyses and costs.
- The detection limit for trichloroethylene (TCE) is about 1 part per billion (ppb) — comparable to that of EPA-approved laboratory methods.
- Operation requires very little training.
- Described in ASTM Standard Method D7203.

A patent on the X-Wand® technology is pending.

X-Wand® HVOC analyzer

Status/Accomplishments

Results from testing during development show that the X-Wand® modified heated diode leak detector can be used to screen HVOC concentrations in both soil and water, with limits comparable to those achieved by the EPA Gas Chromatography/Mass Spectroscopic (GC/MS) laboratory methods. Assuming complete TCE vaporization as a result of heating of the sample, the detection limit for TCE in either soil or water is about 1 microgram per kilogram (µg/kg) (ppb) for a 25-g sample in an 8-oz jar. A variable volume headspace calculation method can be used to compensate for incomplete VOC partitioning between a water sample and air. This calculation is more suited for application to water samples, since there is typically a single coefficient for water and headspace partitioning, whereas soil samples may vary in concentration and composition.

The limit of detection for the heated diode sensor is about 0.1 mg/m^3 TCE in air, while the maximum reading is obtained at about 1,000 mg/m^3. Variability between sensors, and changes in a particular sensor over time, can be compensated for by normalizing sensor readings to a maximum reading at 1,000 mg/m^3 TCE in air, and by providing an additional calibration point at 100 mg/m^3 TCE in air.

ASTM Committee D 34 on Waste Management approved the development of a new draft ASTM standard for screening TCE-contaminated soils using a heated diode sensor. The initial draft method was reviewed and voted on by ASTM Subcommittee D 34.01 and was revised based on reviewer comments. The method was approved as ASTM D 7203-05, Standard Test Method for Screening Trichloroethylene (TCE)-Contaminated Soil Using a Heated Diode Sensor. In 2006, the method was revised to include water screening, and its new title is ASTM D 7203-06, Standard Test Method for Screening Trichloroethylene (TCE)-Contaminated Media Using a Heated Diode Sensor.

Results Summary

The current work has led to development of new, cost-effective commercial technology to rapidly screen for HVOCs in the field. This involved taking existing refrigerant detectors and, with slight hardware modifications and comprehensive analytical method development research, launching them into a new commercial application with significant uses and benefits to the environmental industry. In addition to the demonstrated field screening ability of the instrument, X-Wand® screening data can be used in the laboratory to determine which of two very different EPA Method 5035, Section 7.1.1-approved GC/MS sample preparation and analysis methods should be used when evaluating HVOCs in soil samples: the low concentration closed-system direct purge-and-trap method, which consumes the entire sample in analysis; or the high concentration methanol extraction method, which allows for repeat analysis of methanol aliquots. This is a new and important time and cost saving solution for analytical laboratories, since the screening can now be performed in minutes rather than by a full, costly exploratory analysis of an extra sample.

Sources

Schabron, J.F., S.S. Sorini, J.F. Rovani, Jr., and T.M. Bomstad, "Field Validation of the X-Wand® Sensor Device for Screening Halogenated Volatile Organic Compound (HVOC) Contamination in Water," Report to U.S. Department of Defense, Concurrent Technologies Corp., 2005.

Sorini, S.S., J.F. Schabron, J.F. Rovani, Jr., and T.M. Bomstad, "Development of a Standard Test Method for Screening Trichloroethylene (TCE)-Contaminated Soil Using a Heated Diode Sensor," ASTM International Research Report RR: D34-107, November 2005.

Schabron, J.F., S.S. Sorini, and J.F. Rovani, Jr., "Field Screening for Halogenated Volatile Organic Compounds: The New X-Wand® HVOC Screening Device," WRI Final Report to U.S. Department of Energy Under Cooperative Agreement DE-FC21-98FT40322, 2005.

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States and Localities Impacted

Laramie, WY
New Kensington, PA

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South, Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

Visit the NETL website at:
www.netl.doe.gov

Customer Service:
1-800-553-7681

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Contacts

Robert R. Romanosky
Technology Manager,
Advanced Research
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4721
robert.romanosky@netl.doe.gov

Robie E. Lewis
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4445
robie.lewis@netl.doe.gov

John F. Schabron
Principal Scientist
Western Research Institute
365 North 9th Street
P.O. Box 3395
Laramie, WY 82072-3380
307-721-2445
jfschabr@uwyo.edu

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