TechData Sheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4370

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Destruction of PCBs in Contaminated Soils at Mare Island Navy Base

A Demonstration of In Situ Thermal Desorption Thermal Blankets and Wells

Conducted by:
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RT Environmental Services, Inc., King of Prussia, Pennsylvania

Sponsored by:
Bay Area Defense Conversion Action Team, Oakland, California

Introduction

TerraTherm Environmental Services, Inc. (a subsidiary of Shell Technology Ventures, Inc., Houston, Texas) and RT Environmental Services, Inc., are conducting a field demonstration of in situ thermal desorption (ISTD) sponsored by BADCAT, the Bay Area Defense Conversion Action Team Environmental Technology Partnership. BADCAT is a public/private partnership of the Bay Area Regional Technology Alliance (BARTA), California Environmental Protection Agency (Cal EPA), U. S. Environmental Protection Agency (USEPA), U.S. Navy, Chevron Research and Technology Company, SFSU CAREER/PRO, and other technical experts working to expedite the cleanup and conversion of closing bases in the San Francisco Bay Area through the application of innovative environmental technologies.

The demonstration site is a former electrical shop grease trap at Mare Island Naval Shipyard in Vallejo, California, where oil containing polychlorinated biphenols (PCBs) was washed out of transformers. Liquid waste and sludge were pumped to the grease trap prior to discharge to the industrial wastewater system. The grease trap was subsequently removed and backfilled with soils contaminated with PCBs. Levels as high as 2,200 parts per million (ppm) are present on the site.

Purpose of the Demonstration

The demonstration is designed to further the evidence that the TerraTherm ISTD destroys and removes PCBs to well below 2 ppm. This demonstration will also solidify the cost estimate data to confirm its cost effectiveness.

Advantages of In Situ Thermal Desorption

Shell Research Labs developed the heating technology over the last 25 years as part of its enhanced oil recovery efforts. TerraTherm's in situ thermal desorption technology provides a combination of benefits that are not offered by any one conventional remediation technique:

- Destroys a mix of volatile and semi-volatile organic to very low residual levels
- Destroys most contaminant molecules in situ and others are destroyed or collected in the vapor treatment facility at the surface - carbon dioxide and water vapor are virtually the only air emissions
- Works in both unsaturated and saturated zones, in near surface and deeper contaminated zones, and in heterogeneous soils including low-permeability clays
- Offers cost-effective solutions for difficult cleanup problems
- Provides the fastest in situ remediation alternative
- Operates under and next to roads, structures, foundations, and other heavy, fixed installations
- Operates at any depth achievable by standard drilling techniques
- Limits neighborhood disruption through quiet, very low profile operations
- Lowers long-term liability exposure by leaving little residual contamination

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System Description

There are currently two configurations for TerraTherm's ISTD technology: thermal blankets and thermal wells. Shown in Figure 1 is a conceptual layout of the TerraTherm treatment system and auxiliary components. Figure 2 shows a block diagram of the treatment train.

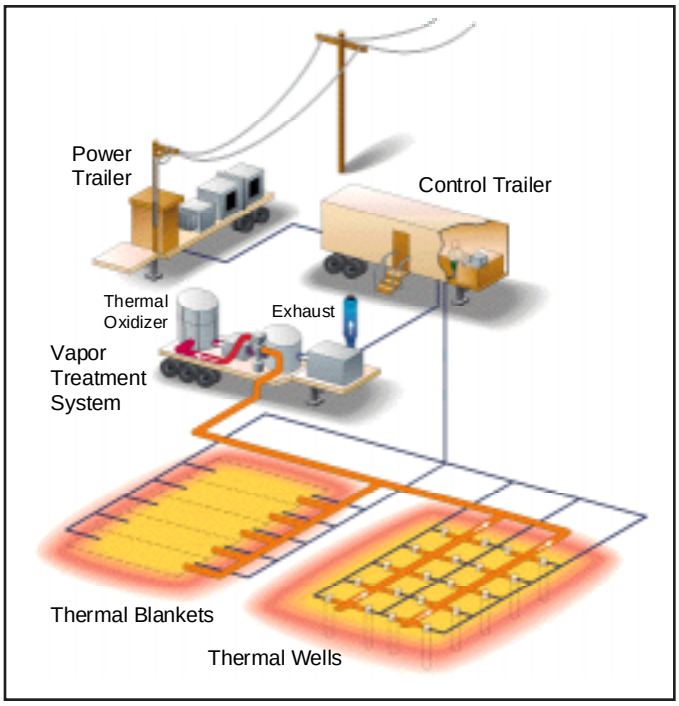

Figure 1. TerraTherm treatment system arrangement.

The thermal blanket works like a large electric blanket and a powerful vacuum cleaner. Thermal blankets, used for near-surface contamination, work to depths up to three feet.

Typically, each blanket is made up of an 8- by 20-foot steel box. Stainless steel webbing is suspended from the bottom of the box. Heating element rods are threaded through the webbing to transfer heat into the soil below the blanket. Several blankets set up side-by-side increase the total area treated at one time. Contaminants are vaporized by heating the soil with the blanket. Contaminated vapors are then drawn out of the soil and through the blanket by a vacuum system. Most contaminants are destroyed in the extremely hot soil near the heat source. Remaining vapors are cleaned in the trailer-mounted vapor treatment system which includes a flameless thermal oxidizer and activated carbon filters.

The flameless thermal oxidizer uses a ceramic matrix heated to 1,800°F which ensures thorough mixing, uniform temperature and consistent residence time. This is in contrast to flame-based systems which may create products of incomplete combustion due to the variable nature of vapor flow through the flame zone. Use of the flameless thermal oxidizer results in extremely high destruction efficiency for off-gas vapors. As a result, there are virtually no products of incomplete combustion emissions. Continuous monitoring ensures that the resulting emissions contain only carbon dioxide and water vapor.

In situ thermal desorption will destroy volatile and semi-volatile organic compounds, including PCBs, chlorinated solvents, pesticides, and petroleum wastes. This technology can also collect and capture some low boiling point metals such as mercury, arsenic, and certain forms of cadmium and lead.

Thermal wells use the same scientific process as thermal blankets, except that heating elements are placed in wellbores drilled on a regular pattern. Typical well spacings can be seven to ten feet. Wells can be drilled vertically into the contaminated zone, possibly as deep as several hundred feet. They may reach horizontally under operating facilities, roadways, and through concrete and other structures. Simulations suggest that thermal wells can work both above and below the water table. Treatment of the saturated zone can be achieved if the treatment zone is dewatered or recharge rates are limited.

Remediation levels and cleanup times can be predicted by computer simulation before the project begins. Monitoring systems and thermocouple probes in the soil are used to measure the progress of the thermal front through the soil. Experience has shown that there is good agreement between the computer predictions and actual results. Pre- and post-treatment samples are used to verify the treatment.

Usually, the very low residual organic contaminants left behind are significantly lower than typical state and federal cleanup levels. In comparison with other technologies, contaminant destruction by in situ thermal desorption is quite complete.

When PCBs and other chlorinated hydrocarbons are destroyed, hydrochloric acid is produced as shown in Figure 3. These acids are stabilized rapidly by precipitation with natural soil elements, principally iron. For example, hydrochloric acid and iron will form iron chloride, which is harmless and very stable. Experience remediating PCBs shows that acid gas emissions typically are very low.

Because this is a thermal process, when treating chlorinated organics there is the possibility of dioxin and furan formation. The ISTD process vaporizes and destroys dioxins and furans at rates faster than they are created. Analysis of post-treatment soil samples show toxic equivalent concentration levels below the background level of 8 parts per trillion for uncontaminated soils.

Previous Demonstrations of Thermal Blankets and Thermal Wells

PCB Contamination at a State Superfund Site in New York

TerraTherm's ISTD remediation was employed at a site which contained PCB contamination as high as 5,000 ppm. Thermal blankets were used and the soil cleanup target levels of less than 2 ppm were achieved. The air emissions were well below New York and EPA regulatory limits and virtually no dust or odors were created.

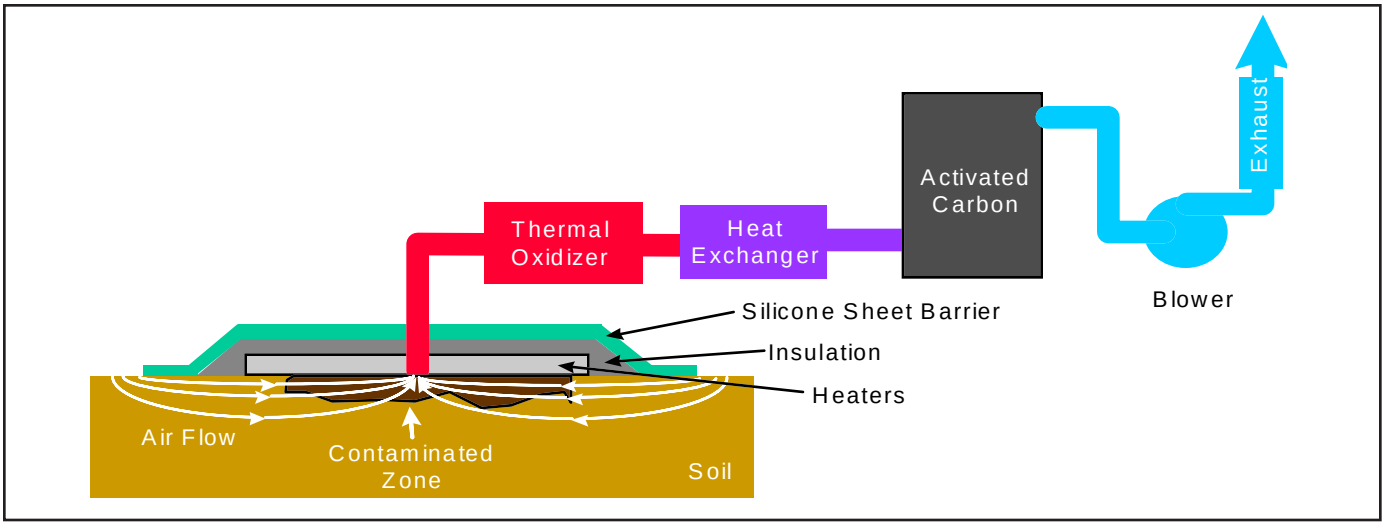

Figure 2. TerraTherm treatment system schematic.

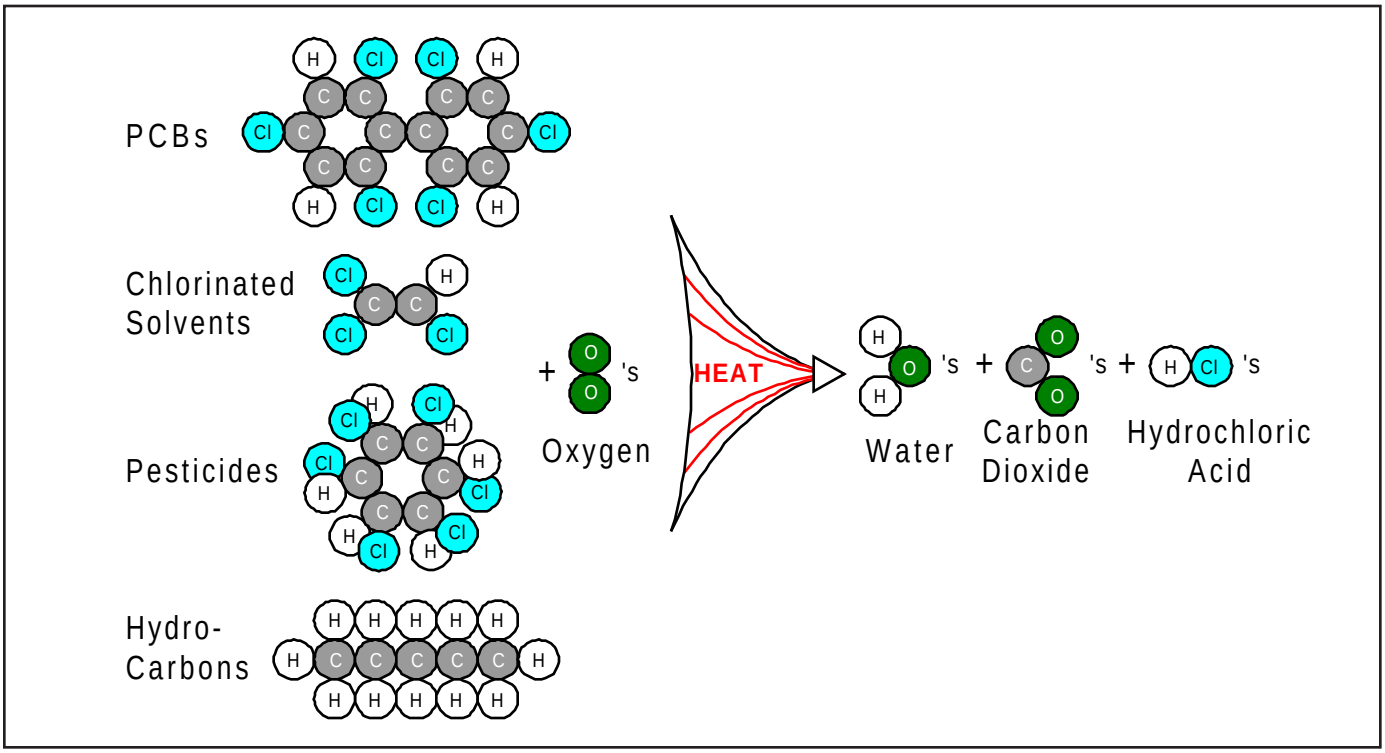

Figure 3. Treatment chemistry.

A total area of 5,000 square feet was treated over the course of ten days. Thermal bankets were used to remediate the site which was previously a drag strip on which PCB-laden oil had been sprayed to eliminate dust. PCB contamination varied in depth from 6 to 18 inches.

The thermal blanket treatment process used temperatures that ranged from 480°F to 840°F during the 10-day remediation operation. The entire remediation process was continuously monitored using a sophisticated computer operation. Temperatures were monitored throughout the remediation process, and soil samples were taken pre- and post-treatment. Both monitoring and soil sampling at the site showed excellent agreement between computer simulations and actual results.

PCB Contamination at a Federal Superfund Site in Missouri

PCB contamination was reduced to well below the remedial objective of 2 ppm, according to preliminary lab results. The six-acre site, formerly a motor and transformer repair and sales business, is contaminated with the PCB Aroclor 1260. The PCB concentrations in the demonstration areas were as high as 19,900 ppm. The EPA Region VII and the responsible parties authorized

the demonstration. Representatives from EPA and the Missouri Department of Natural Resources monitored the demonstration.

Working in tight clay soil, TerraTherm used both thermal blankets and wells. A third test introduced the latest process developed by TerraTherm, the container cleaning system.

A mobile unit consisting of a thermal blanket and a self-contained vapor processing system was used in the first test conducted in March 1997. Preliminary reports show PCB contamination averaging 510 ppm at depths to 6 inches was reduced to well below the remedial objective of 2 ppm. Contamination averaging 3 ppm at depths of 6 to 18 inches was also reduced well below the remedial objective of 2 ppm.

Sixteen thermal wells, reaching depths of 10 feet and operating at temperatures up to 1,900°F, were used in the second test conducted in April 1997. PCB contamination was as high as 19,900 ppm in this area. Preliminary lab reports show results below the remedial objective of 2 ppm. The results are noteworthy considering that the demonstration was conducted during an extremely wet spring and early summer for that part of the country.

Chlorinated Solvent Contamination at a Site in Indiana

Fifteen thermal wells treated a 30- by 30-foot area with 1,1-dichloroethylene (DCE) contamination levels up to 650 parts per billion (ppb) at depths to 12 feet. The wells were heated to 1,500°F, with the area between the wells reaching in excess of 250°F. Because DCE is much more volatile than PCBs, lower temperatures are sufficient. The operation proceeded smoothly despite a very cold and wet winter.

The remediation objective of 80 ppb was easily met according to preliminary sampling. All but one area had non-detectable quantities of the contaminant (1 to 3 ppb) with the single exception at only 9 ppb. Operations will continue at this location on a second larger site.

Results of the demonstrations are summarized in Table 1.

Comparable Cost for Soil Remediation

The cost of in situ thermal desorption depends on a variety of factors such as depth of contamination, soil moisture, and contaminant types. In general, in situ thermal desorption would be cost-competitive for TSCA and RCRA wastes with alternative processes, since excavation, hauling, backfilling, and off-site disposal or incineration would not be required. Also, in many industrial and utility applications, remediation could usually be completed with minimal disruption to ongoing operations, reducing the overall cost impact. A low-cost pilot test using TerraTherm's mobile demonstration unit could be performed on site to provide process efficiency and cost estimates. Where other technologies may reach as low as $1,000 per ton, TerraTherm ISTD treatment costs are estimated to range from $100 to $300 per ton.

For more information about in situ thermal desorption, contact:

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Table 1. Previous Demonstration Treatment Summary

Demonstration Site	Contaminant	Pre-Treatment Concentration	Post-Treatment Concentration	Treatment Goal
New York	PCBs	5,000 ppm	< 2ppm	2 ppm
Missouri	PCBs	19,900 ppm	< 2 ppm	2 ppm
Indiana	DCE	650 ppb	< 9 ppb	80 ppb