United States Environmental Protection Agency

Solid Waste And Emergency Response (OS-220)

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EPA

Innovative Technology

In-Situ Vitrification

TECHNOLOGY DESCRIPTION

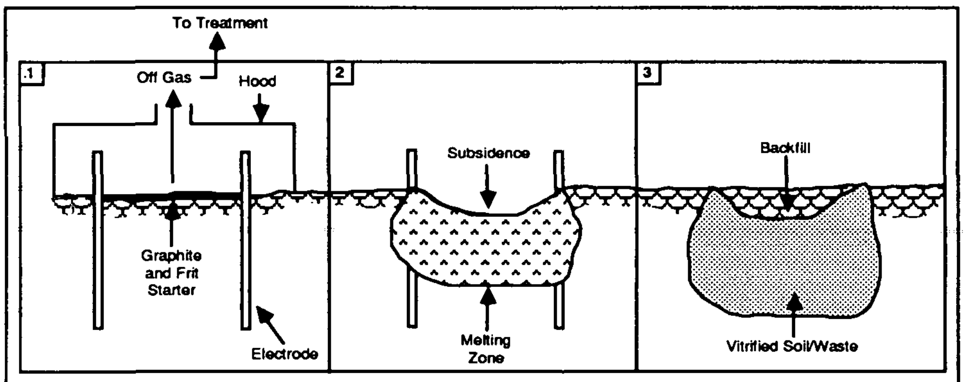
In-situ vitrification (ISV) can be used to treat soils and sludges contaminated with mixtures of various waste types (e.g., radioactive, inorganic, and/or organic). The process electrically melts the waste media, creating an extremely stable glass-like solid.

A schematic diagram of a typical ISV treatment facility is shown in Figure 1. Four electrodes connected to a utility distribution system or to an on-site diesel generator are inserted into the soil. Because soil typically has low electrical conductivity, flaked graphite and glass frit are deposited between electrodes to provide a starter path for the electrical current. As the current flows between electrodes, the adjacent soil is heated to 1600 - 2000°C, well above a typical soil's melting temperature. The graphite starter path eventually burns off and the current is transferred to the now highly conductive melted soil.

Within the melt, organic contaminants are vaporized and pyrolyzed (i.e., thermally decomposed); the pyrolysis products rise to the surface and combust in the presence of oxygen. Non-volatile inorganic elements are dissolved or incorporated into the melt. Volatile metals may vaporize and rise to the surface along with the pyrolysis products. Table 1 lists the effectiveness of ISV on general contaminant groups.

A negatively pressurized hood placed over the process area collects both organic and inorganic gases, which are treated before being released into the atmosphere. An off-gas treatment system is designed to handle conditions at most sites. If necessary, the treatment system may be modified to meet specific site requirements. The off-gas treatment may include any of the following units: a wet scrubber system, a heat exchanger with a glycol cooling system, a heater, a filter, and/or an activated charcoal assembly. The hood draws in large amounts of outside air which helps to oxidize combustible vapors and pyrolysis products. All equipment involved with the ISV process, including the off-gas treatment system, are contained in three mobile trailers.

Figure 1: Schematic Diagram of a Typical In-Situ Vitrification Treatment Facility



Note: adapted from Battelle Pacific Northeast Laboratories, for Booz, Allen & Hamilton Inc

When the treatment is completed, the power is shut off and the equipment (i.e., electrodes and hood) is moved to another treatment area where the treatment process is repeated. Following treatment, the surface of the vitrified area is covered with clean soil, and the melt is allowed to cool slowly, producing an amorphous solid resembling obsidian. Several months are required for the treated area to cool to ambient temperature; however, after four to five days, the melt has cooled sufficiently for equipment to be moved onto the treated area.

The advantages of ISV include the potential ability to destroy, remove, or immobilize all contaminant groups and to reduce the volume of the waste/media being treated. The need for off-gas collection and treatment, however, is a disadvantage.

SITE CHARACTERISTICS AFFECTING TREATMENT FEASIBILITY

Generally, the acceptable levels for treatment of contaminants in soil are 5 to 10 weight percent organics and 5 to 15 weight percent inorganics. Due to the need to consider several other factors (e.g., soil type) in determining feasibility, treatability tests are required.

The ISV process can be used to treat saturated soils; however, the water must be evaporated first, requiring additional energy and further expense. If the soil permeability is high and the soils are recharged by an aquifer, a ground water diversion system may need to be installed, adding additional expense.

Table 1
Effectiveness of In-Situ Vitrification Treatment on General Contaminant Groups for Soil and Sludge

	Treatability Groups	Effectiveness
Organics	Halogenated volatiles	◒
	Halogenated semi-volatiles	◒
	Non-halogenated volatiles	◒
	Non-halogenated semi-volatiles	◒
	PCBs	◒
	Pesticides	◒
	Dioxins/Furans	◒
	Organic cyanides	◒
	Organic corrosives	◒
Inorganics	Volatile metals	◒
	Non-volatile metals	◒
	Asbestos	◒
	Radioactive materials	●
	Inorganic corrosives	◒
	Inorganic cyanides	◒
Reactive	Oxidizers	◒
	Reducers	◒

Demonstrated Effectiveness ● No Expected Effectiveness ○
Potential Effectiveness ◒ Potentially Detrimental X

The presence of significant amounts of buried metals (e.g., drums) may cause shorting between electrodes, therefore, the metal concentration limit is 5 to 16 percent of the melt weight. Additionally, metals cannot occupy more than 90 percent of the continuous linear distance between electrodes. Table 2 lists those factors that affect ISV feasibility.

TECHNOLOGY CONSIDERATIONS

Currently, ISV technology can be used to treat a maximum area of 30 ft. x 30 ft.; the maximum depth of treatment is 30 ft. Note that the maximum mass of contaminated material that can be treated per setting is 800 to 1,000 tons. When processing a 30 ft. x 30 ft. area, the mass limit will be reached before the depth reaches 30 ft.; consequently, it is impossible to reach all three maximums simultaneously. Conversely, the minimum area that can be treated is 10 ft. x 10 ft.; the recommended minimum depth of treatment is 5 to 7 ft.

Most soil types contain sufficient glass-forming materials (e.g., silicon and aluminum oxides) for treatment to be effective; however, it may be necessary to add a fluxing material (e.g., sodium carbonate) to supply adequate amounts of monovalent cations to provide sufficient electric conductivity. During ISV, the soil volume decreases 20 to 40 percent necessitating the backfilling of the subsided area with clean soil.

During full-scale operation, ISV processes 4 to 6 tons of soil per hour, requiring 0.3 to 0.5 kwh per pound of soil. The power level required is 1.9 Mw/phase.

The base price of a typical treatability study, conducted in Geosafe Corporation's laboratory, is estimated to be $25,000. Analytical costs, however, can raise the total cost to between $35,000 and $100,000.

TECHNOLOGY STATUS

Battelle Memorial Institute is exclusively licensed by the U.S. Department of Energy (DOE) to perform ISV. Geosafe Corporation, primarily owned by Battelle, holds the exclusive sublicense to perform ISV commercially. More information concerning Geosafe is found in Table 3. Battelle and Geosafe have cumulatively performed more than 70 tests of various scales for DOE and other clients. At the DOE Hanford Site in Washington State, ISV successfully treated soils contaminated with radioactive wastes.

The ISV process has been selected for evaluation under the SITE Program. Formal demonstration and testing of the process has been postponed until the developer has obtained funding for a demonstration at an appropriate site.

Currently, EPA's Emergency Response Division in Region 5 has selected ISV to treat pesticides, heavy metals, and low-level dioxins. ISV has also been selected to treat contaminated soils at the Ionia Landfill in Region 5 and the Northwest Transformers site in Region 10. The status of ISV application at CERCLA sites is summarized in Table 4.

Table 2
Site-specific Characteristics and Impacts on In-Situ Vitrification Treatment

Characteristics Impacting Process Feasibility	Reasons for Potential Impact	Actions to Minimize Impacts
Presence of ground water	Water affects the efficiency of the vitrification process, limits economic practicality	Dewater before treatment or pump to lower water table
Soil permeability greater than 1 x 10^{-5}cm/sec	Soil is re-saturated faster than water can be evaporated	Install ground water diversion system
Buried metals (e.g., drums), greater than 5 to 15 percent of the melt weight between electrodes	Buried metals can result in a conductive path that would lead to shorting between electrodes	Use feeding electrodes
Loosely packed rubbish and/or buried coal	May start underground fire	Install barrier walls or sheet piling
Combustible liquids, greater than 9,600 lb/yd of depth or 5 to 10 percent by weight	Time-ordered limits to the capacity of the off-gas system to contain combustion gas, (not cumulative capacity)	Increase hood capacity, process at a slower rate, or employ smaller process setting volumes
Combustible solids (e.g., wood), greater than 6,400 lb/yd of depth or 4.7 percent by weight	Time-ordered limits to the capacity of the off-gas system to contain combustion gas, (not cumulative capacity)	Increase hood capacity, process at a slower rate, or employ smaller process setting volumes
Combustible packages (e.g., boxes of clothing packaged for disposal), greater than 32 ft^3	Time-ordered limits to the capacity of the off-gas system to contain combustion gas, (not cumulative capacity)	Increase hood capacity, process at a slower rate, or employ smaller process setting volumes
Volatile metal content and depth	Retention of volatile metals in melt is less near surface than further below	Before treatment, clean soil on top t increase melt depth
Void volumes greater than 152 ft^3	Time-ordered limits to the capacity of the off-gas system to contain combustion gas, (not cumulative capacity)	Increase hood capacity, process at a slower rate, or employ smaller process setting volumes

OFFICE OF RESEARCH AND DEVELOPMENT CONTACTS

Further information regarding the ISV process may be obtained from Steve James, U.S. EPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio 45268, (513) 569-7877 or FTS (684-7877).

Table 3
Vendor Information

Company	Contact	Address
Geosafe Corporation	James Hansen Dale Timmons	303 Parkplace Suite 126 Kirkland, WA 98033 (206) 822-4000
Note: Geosafe Corporation is the exclusive commercial sublicensee of the ISV process.		

Table 4
In-Situ Vitrification Status at CERCLA Sites

SELECTED:		
Region 5 - Ionia Landfill, MI 9/89	Heavy metals, organics in Soil	5000 cubic yards
Region 5 - Parsons/ETM, MI (Removal Action) FY90	Pesticides, heavy metals, low-level dioxins in Soil	Not Pr
Region 10 - Northwest Transformers, WA 9/89	PCBs in Soil	Not Provided