PDHonline Course C170 (2 PDH)

Hazardous and Toxic Waste Disposal Technologies

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2012

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Advantages	Disadvantages
HDPE is low in cost, commercially available, very stable chemically, nonbiodegradable, mechanically tough, and flexible	Requires large capital investments in equipment
Encapsulated waste materials can withstand the mechanical and chemical stresses of a wide range of disposal schemes (e.g., landfill, ocean disposal)	Skilled labor is required to operate molding and fusing equipment
	Drying/dewatering of noncontainerized waste sludges is required for agglomeration/ encapsulation
	Process has yet to be applied on a commercial scale under actual field conditions

d. Data Requirements. Data requirements are similar to those required for solidification/stabilization described in paragraph 4-21.

e. Design Criteria.

(1) It is important to emphasize that encapsulation techniques have only recently advanced from the developmental and testing stages, and no large commercial-scale encapsulation facilities have been designed and operated as yet. It is likely that, as a remedial action, encapsulation will not be an economically feasible alternative compared to other direct waste treatment methods. However, a central solidification/encapsulating waste processing facility may be technically and economically feasible as a predisposal operation at hazardous waste storage and disposal facilities in the near future.

(2) The fabrication of commercial-scale encapsulates of containerized wastes under actual field conditions would require an encapsulation unit that is readily transportable to the storage or disposal site where containerized wastes reside. Where containerized wastes are of volumes smaller than the design capacity of the encapsulation unit, sand or soil may be used to fill voids between the container and encapsulate walls. Where very large volume waste containers require encapsulation (greater than 208 ℓ (55 gallons)), it may be necessary to install compaction operations at the site.

4-20. Low Temperature Thermal Desorption.

a. Process Description.

(1) Low temperature thermal treatment is a process of heating contaminated soil only enough to vaporize volatile organic compounds (VOCs). The gases emitted from the soil are then treated by a subsequent unit operation. The process described here as an example (Patent No. 4,738,206) uses indirect heat to separate the VOCs from the soil and incineration to destroy the VOCs in the gas phase. Maximum soil temperature for this process is 150 ^{0}C. The process was developed by the U.S. Army Environmental Center to treat soils at

military installations contaminated with trichloroethylene, dichloroethylene, tetrachloroethylene, xylene, and other components of solvents and petroleum fuels.

(2) The thermal processor for this system is a Holo-Flite screw conveyor heated by Dowtherm HT hot oil circulating through the shaft, blades, and jacket of the conveyor. A schematic diagram of the system is illustrated in Figure 4-22. Larger scale models may include two thermal processors operated in series with the first processor mounted on top of the second. Maximum temperature for the oil is 350 °C.

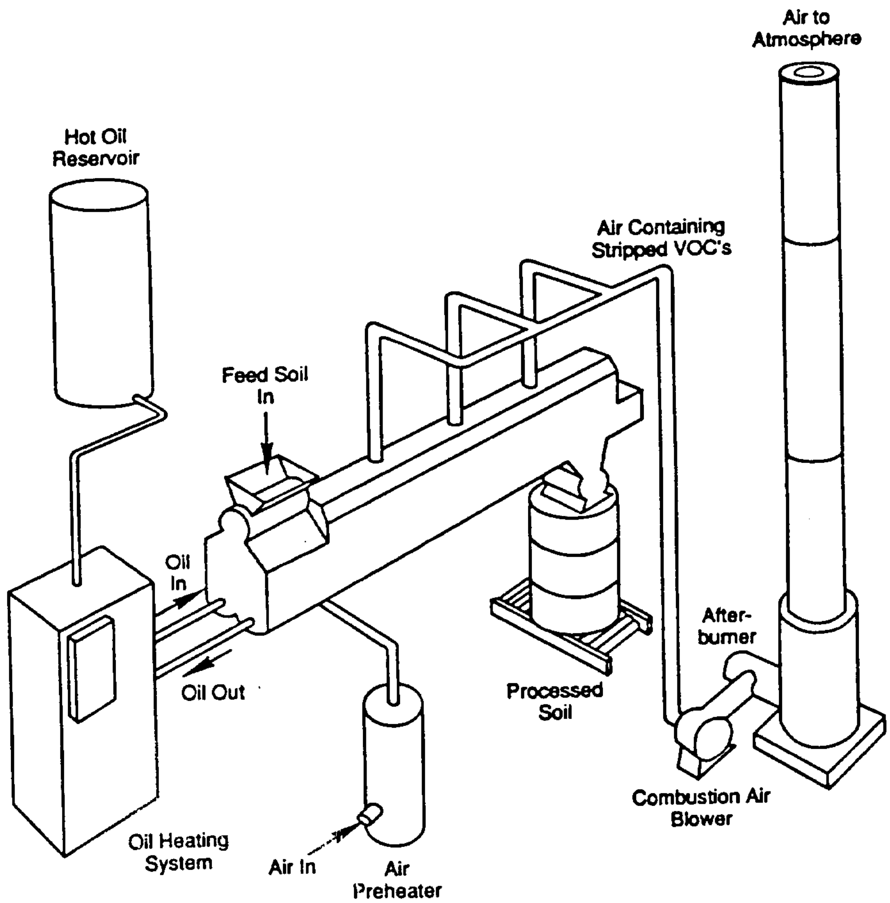

Figure 4-22. Schematic Diagram of a Low Temperature Thermal Treatment System

(3) The vapor stream from the thermal processor consists of the contaminants being removed, water vapor from the soil, and exhaust gases from the hot oil heater. This stream exits at approximately 150 °C (maximum) and flows through a fabric filter, condenser, afterburner, and caustic scrubber system. The fabric filter removes particulate carried over from the processor. The vapor stream then passes through an air-cooled condenser which reduces the temperature to approximately 52 °C. Water and organics condensed reduce the load on the afterburner. The afterburner is a gas-fired, vertical, fume incinerator operating at 980 °C. The afterburner is operated at a minimum of 3 percent excess oxygen. Exhaust from the afterburner is quenched

to approximately 80 ^{0}C. It then passes through a packed bed absorber where acid gases produced in the afterburner are neutralized with a caustic solution.

(4) A liquid stream is produced by the condenser which is water rich but does contain some hydrocarbons. The aqueous phase is separated from the organic phase in an oil-water separator. The aqueous phase is processed through a water treatment system consisting of fabric filters followed by granular activated carbon. This water is then used as makeup water for the scrubber and for dust control on processed soil. The organic phase from the separator may be either drummed for off-site disposal or injected into the afterburner.

(5) A system capable of processing 10 metric tons of soil per hour is mobile and can be transported to a site and assembled. Utilities required for operation are propane or natural gas, electricity, and process water. Discharges from the system include the scrubber stack exhaust, the processed soil, the granular activated carbon, and filter cake, and the organic phase from the water separator. Operation requires eight persons for continuous operation, including a site manager and an instrumentation technician.

b. Applications. Low temperature thermal treatment is capable of remediating soils contaminated with volatile and semivolatile compounds. Greater than 99 percent removal from soils has been demonstrated for trichloroethylene, dichloroethylene, and tetrachloroethylene, 1, 2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, toluene, naphthalene, and xylene. It has potential for application to a number of other volatile and semivolatile organic contaminants in soil.

c. Advantages and Disadvantages. Advantages of low temperature thermal treatment are summarized below:

Advantages	Disadvantages
Fully mobile system for on-site treatment	Limited applicability to higher boiling point organic compounds such as PCBs
Indirect heating provides greater thermal efficiency and reduced emission control requirements	Increased moisture content of soil increases costs
Afterburner destroys contaminants	Particle size reduction and debris removal may be required

d. Data Requirements. Design experience for application of this process to a wide range of soil types and contaminants is limited because of its recent development. Laboratory testing to determine optimum temperatures and retention times for the thermal processor should be conducted to develop the process design for the system. Important soil characteristics are grain size, moisture content, and contaminant concentrations.

(1) Waste characteristics (binding agent selection).

(a) pH.

(b) Buffer capacity.

(c) Water content.

(d) Total organic carbon.

(e) Inorganic and organic constituents.

(2) Treatability tests (cure time, mix).

(a) Leachability.

(b) Strength.

e. Design Criteria. The key design parameters for solidification/stabilization techniques include:

(1) Solidification mixing ratios.

(2) Curing time.

(3) Volume increase of solidified product.

f. Evaluation. The evaluation of these factors is dependent on the solidification technology and the specific waste being treated.

4-22. Thermal Destruction.

a. Process Description. Incineration combusts or oxidizes organic material at very high temperatures. The end products of complete incineration are CO_2, H_2O, SO_2, NO_1, and HCl gases. Emission control equipment (scrubbers, electrostatic precipitators) for particulates, SO^2, NO_x, and products of incomplete oxidation are needed to control emissions of regulated air pollutants. Common types of incinerators most applicable to hazardous waste include:

(1) Rotary kilns.

(2) Multiple hearth.

(3) Fluidized bed.

(4) Liquid injection.

The key features of incineration methods cited previously are summarized in Table 4-20.

Table 4-20. Key Features of Major Types of Incinerators

Type	Process principle	Application	Combustion temp.	Residence time
Rotary kiln	Slowly rotating cylinder mounted at slight incline to horizontal. Tumbling action improves efficiency of combustion	Most organic wastes; well suited for solids and sludges; liquids and gases	810-1,640 °C (1,500-3,000 °F)	Several seconds to several hours
Multiple hearth	Solid feed slowly moves through vertically stacked hearths; gases and liquids feed through side ports and nozzles	Most organic wastes, largely in sewage sludge; well suited for solids and sludges; also handles liquids and gases	760-980 °C (1,400-1,800 °F)	Up to several hours
Liquid injection	Vertical or horizontal vessels; wastes atomized through nozzles to increase rate of vaporization	Limited to pumpable liquids and slurries (750 SSU Saybolt Seconds Universal) or less for proper atomization)	650-1,650 °C (1,200-3,000 °F)	0.1 to 1 sec
Fluidized bed	Wastes are injected into a hot agitated bed of inert granular particles; heat is transferred between the bed material and the water during combustion	Most organic wastes; ideal for liquids, also handles solids and gases	750-870 °C (1,400-1,600 °F)	Seconds for gases and liquids; longer for solids

b. Applications.

(1) Incineration is used for reduction of sludge volume, thereby reducing land requirements for disposal. Incineration can also be used to destroy most organic wastes whether they be gas, liquid, or solid.

(2) Mobile incineration systems have been considered for onsite treatment at hazardous waste sites. The EPA*s Office of Research and Development has completed construction and is in the testing phase of a mobile incineration system. The system was designed to EPA*s PCB destruction specifications to provide state-of-the-art thermal detoxification of long-lived, refractory organic compounds, as well as debris from cleanup operations. Hazardous substances that could be incinerated include compounds containing chlorine and phosphorous--for example, PCB*s, kepone, dioxins, and organophosphate pesticides, which may be in pure form, in sludges, or in soils. A typical mobile incinerator is illustrated in Figure 4-24.

c. Advantages/Disadvantages. The advantages and disadvantages of hazardous waste treatment with incineration are summarized below:

Advantages	Disadvantages
Can destroy a wide range of organic wastes	Thickening and dewatering pretreatment may be required
Can handle gaseous, liquid, and solid wastes	May not be economical for small plants
	Air pollution control measures are required

d. Data Requirements. The principal data requirements for the design of an incineration system are:

(1) Waste constituents and characteristics.

(a) Moisture content.

(b) Volatile materials content.

(c) Ash content.

(d) Ash specific level, specific gravity, or bulk density.

(e) Ash particle size range.

(f) Carbon, hydrogen, oxygen, halide, sulfur, nitrogen, phosphorus content.

(g) Waste specific gravity, viscosity, and melting point.

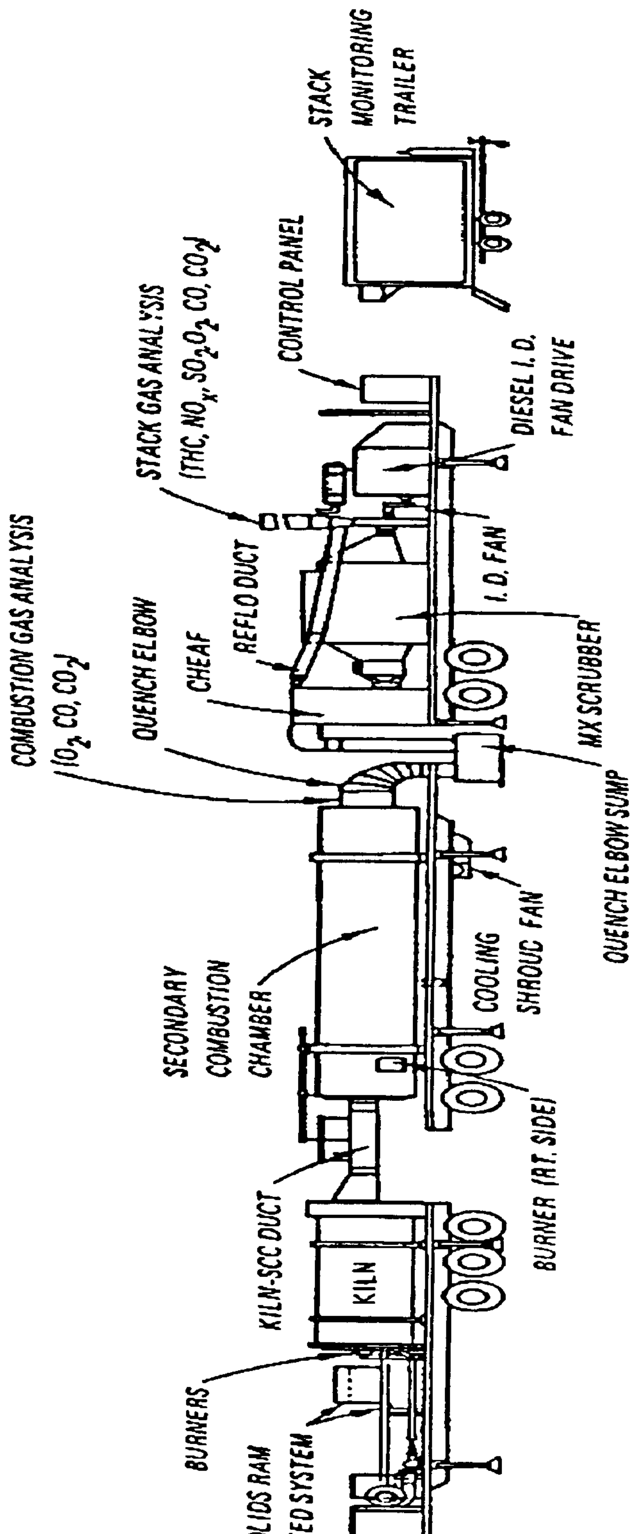

Figure 4-24. EPA Mobile Incineration System

(h) Metal content.

(i) Thermogravimetric analysis.

(j) Suspended and dissolved solids.

(k) Reactive chemical groups.

(l) Flammability, stability, detonation.

(m) Environmental sensitivity.

(n) Toxicity.

(2) Process characterization.

(a) Residence time.

(b) Temperature.

(c) Destruction efficiencies.

(d) Ash residue.

(e) Gaseous effluent.

e. Design Criteria. The design criteria for a fluidized bed furnace (FBF) and a multiple hearth furnace (MHF) are presented in Tables 4-21 and 4-22, respectively. During actual operations some extensive maintenance problems have occurred with air preheaters. Venture scrubbers have also had scaling problems. Screw feeds and screw pump feeds are both subject to jamming because of either overdrying of the sludge feed at the incinerator or because of silt carried into the feed system with the sludge. Fluidized bed furnace systems have had problems with the burnout of spray nozzles or thermocouples in the bed.

Table 4-21. Design Criteria for Fluidized Bed Furnace

Parameter	Design criteria
Bed loading rate	245 to 294 $kg/m^2/hr$ (50 to 60 lb wet solids/ ft^2/hr)
Superficial bed velocity	0.12 to 0.18 m/s (0.4 to 0.6 ft/sec)
Sand effective size	0.2 to 0.3 mm (uniformity coefficient = 1.8)
Operating temperature	760 to 816 °C (1,400 to 1,500 °F) (normal); 1204 °C (2,200 °F (maximum))
Bed expansion	80 to 100 percent
Sand loss	5 percent of bed volume per 300 hr of operation

Table 4-22. Design Criteria for Multiple Hearth Furnace

Parameter	Design criteria
Maximum operating temperature	927 °C (1,700 °F)
Hearth loading rate	29.4 to 49 kg/m^2/hr ((6 to 10 lb wet solids/ ft^2/hr) with a dry solids concentration of 20-40 percent
Combustion airflow	12 to 13 kg/kg dry (12 to 13 lb/lb dry solids
Shaft cooling airflow	1/3 to ½ of combustion airflow
Excess air	75 to 100 percent

4-23. Volume Reduction.

a. Process Description.

(1) Volume reduction as applied to sludges can be termed as thickening or dewatering processes. Thickening of sludge consists of the removal of supernatant, thereby reducing the volume of sludge that will require disposal or treatment. Gravity thickening takes advantage of the difference in specific gravity between the solids and water.

(2) Centrifuges are used to dewater sludges using centrifugal force to increase the sedimentation rate of sludge solids. During the process of centrifugation, if a particle is more dense than the fluid, it will tend to migrate in the direction of the centrifugal force, i.e., toward the periphery of the rotating vessel containing the fluid. If the particle is less dense than the fluid, there will be a tendency for the particle to remain near the center of rotation and the fluid to migrate toward the periphery of the vessel. Either way, particles that were uniformly dispersed throughout the fluid prior to centrifugation would now be concentrated in a specific region of the centrifuge where they can be removed as a more concentrated mixture. In centrifugation, the centrifugal force is analogous to gravitational force in the sedimentation process. In centrifugation, however, forces equal to several thousand times the force of gravity are often generated.

(3) Volume reduction will frequently be required to meet regulatory restraints as applied to disposal of hazardous waste. Disposal costs can be reduced through the use of volume reduction techniques by eliminating nonhazardous free liquids from a waste. Before a hazardous waste can be disposed of at a chemical waste landfill, it must be solidified. Typically the solidification process will add to the total weight and volume and therefore the disposal costs. If the same waste can be separated into a reduced volume of hazardous solid waste and a nonhazardous liquid waste, disposal costs can be lowered significantly.