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EPA

Superfund Engineering Issue

Issues Affecting the Applicability and Success of Remedial/Removal Incineration Projects

RPM/OSC SUMMARY

The Regional Superfund Engineering Forum is a group of EPA professionals, representing EPA's Regional Superfund Offices, committed to the identification and resolution of engineering issues impacting the remediation of Superfund sites. The Forum is supported by and advises the Superfund Technical Support Project.

Incineration has been a recommended method for disposing of hazardous materials, and its use in the Superfund Program is increasing rapidly. It has become one of the most often selected methods for treating hazardous constituents found at Superfund sites. Because of the increased reliance of Superfund decision-makers on incineration, the Engineering Forum has identified the informed evaluation of incineration as a remedy, and issues inherent in its implementation as a high priority. This paper was prepared by the Risk Reduction Engineering Laboratory's (RREL) Engineering and Treatment Technical Support Center, under the technical direction of Laurel Staley (RREL) and Paul Leonard (Region III), with the support of the Superfund Technical Support Project. For further information on this topic please contact Laurel Staley, FTS 684-7863 or (513) 569-7863.

INTRODUCTION

The On-Scene Coordinator (OSC) and/or Remedial Project Manager (RPM) for each Superfund site is responsible for overseeing all activities involved with the cleanup of that site. This includes oversight of Removal Actions (OSC), the Remedial Investigation/Feasibility Study (RI/FS) (RPM), Record of Decision (ROD) (RPM), and remedial design and remedial action (RD/RA) (RPM). This document is intended to familiarize OSCs and RPMs with issues which are important to the successful completion of incineration projects. Use of this document should assist the OSC/RPM in directing the activities of removal/remediation contractors. This report summarizes key pieces of information and lists EPA contacts that can assist the RPM/OSC in making an informed evaluation of the Remedial Design. Although the contents are based on the assumption that the reader is already somewhat familiar with incineration, a list of references is included to assist those who are less familiar with this topic.

Incineration is a proven means of destruction for many organic wastes and should be considered as a possible treatment for the cleanup of most toxic waste sites. The matrix in Figure 1 compares the applicability of incineration for waste treatment with that of other technologies.

An incineration system includes a number of subsystems including the following:

- Waste pretreatment
  - Waste screening
  - Size reduction (grinding)
  - Waste mixing
- Waste feed
  - Belt conveyors
  - Augers
  - Apron feeders
  - Hoppers
  - Chutes
  - Pump (liquids, sludges, oils)
  - Screw conveyors
  - Ram feeder
- Combustion unit
  - Rotary kiln/SCC
  - Liquid injection
  - Fluidized bed
  - Infrared

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Superfund Technical Support Center for Engineering and Treatment

Risk Reduction Engineering Laboratory

Technology Innovation Office
Office of Solid Waste And Emergency Response, U.S. EPA, Washington, DC

Walter W. Kovalisk, Jr., Ph.D.
Director

	Incineration	Pyrolysis	Wet Oxidation	Neutralization	Precipitation	Distillation	Air Stripping/Soil Aeration	Activated Carbon	Evaporating/Dewatering	Phase Separation	Fixation	Extraction/Soil Washing	Membrane Sep./Ion Exch.	Evaporation	Filtration	Activated Sludge	In Situ Biodegradation
Aqueous Wastes																	
Metals	○	×	×	●	●	×	×	○	×	×	×	○	●	●	●	×	×
Highly Toxic Organics	○	○	●	○	○	●	×	●	×	○	×	○	●	●	●	×	×
Volatile Organics	○	○	●	○	○	●	●	●	×	●	×	○	○	×	×	○	○
Toxic Organics	○	○	●	○	○	●	●	●	×	●	×	○	●	×	×	●	●
Radioactive	×	×	×	×	×	×	×	×	×	×	×	×	×	○	●	×	×
Corrosive	○	×	×	●	●	○	×	×	×	×	×	×	×	×	×	×	×
Cyanide	○	○	●	○	○	×	×	×	×	×	×	×	×	×	×	○	×
Pesticide	○	○	●	●	●	●	×	●	×	○	×	○	●	●	●	○	×
Asbestos	×	×	×	○	○	×	×	×	×	×	×	×	○	●	●	×	×
Explosive	○	×	×	×	●	×	×	●	○	●	×	○	●	○	×	○	○
Organic Liquids																	
Metals	○	○	×	●	●	●	×	×	×	●	○	×	×	●	●	×	×
Highly Toxic Organics	●	●	●	×	×	●	×	○	×	○	×	×	×	×	×	×	×
Volatile Organics	●	●	●	×	×	●	×	×	×	○	×	×	×	×	×	×	×
Toxic Organics	●	●	○	×	×	●	×	×	×	○	×	×	×	×	×	×	×
Radioactive	○	×	×	×	○	●	×	×	×	○	○	×	×	○	○	×	×
Corrosive	○	×	×	●	○	●	×	×	×	○	×	×	×	×	×	×	×
Cyanide	●	●	●	×	×	●	×	×	×	○	×	×	×	×	×	×	×
Pesticide	●	●	○	×	×	●	×	×	×	○	×	×	×	×	×	×	×
Sludges/Soils																	
Metals	○	○	×	○	○	×	×	○	●	×	●	●	×	○	×	×	×
Highly Toxic Organics	●	●	●	×	×	●	×	●	●	●	●	○	×	●	●	○	×
Volatile Organics	●	●	●	×	×	●	●	○	●	○	○	○	×	×	×	×	○
Toxic Organics	●	●	●	×	○	○	×	●	●	●	●	○	×	○	○	×	●
Radioactive	○	×	×	×	×	×	×	×	●	●	●	×	×	×	×	×	×
Corrosive	○	×	×	●	×	×	×	×	●	×	●	×	×	×	×	×	×
Cyanide	○	○	●	×	○	○	×	×	●	×	○	×	×	×	×	×	○
Pesticide	●	●	○	×	●	○	×	●	●	○	×	●	●	×	○	×	○
Asbestos	×	×	×	×	×	×	×	×	●	×	●	×	×	×	×	×	×
Explosive	○	○	×	○	×	×	×	●	●	●	●	○	×	×	×	×	○

● Applicable ○ Potentially Applicable × Not Applicable

Sources: Brunner 1988a, U.S. Environmental Protection Agency 1986a.

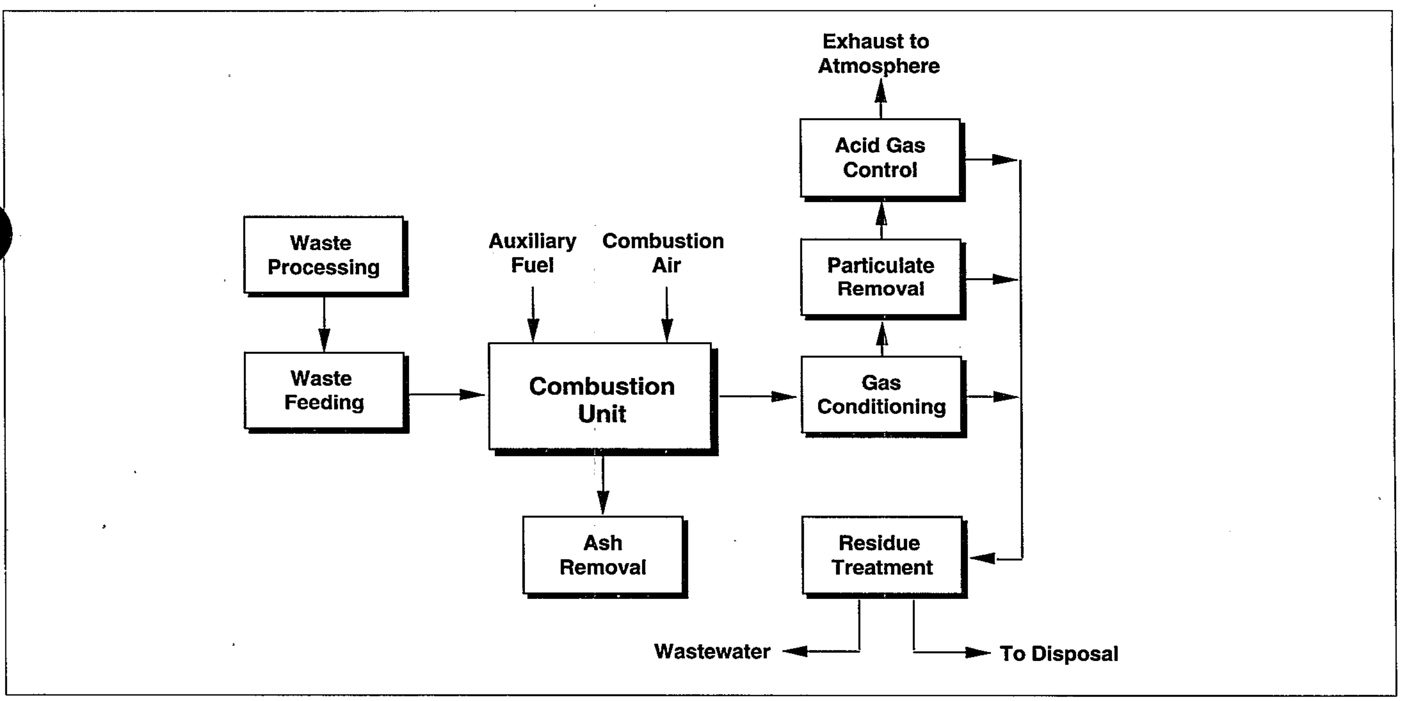
Figure 1. Onsite waste treatment technology matrix.

- Heat recovery (optional - not normally applicable to onsite incineration)

- Air pollution control equipment to treat:
  - Products of incomplete combustion:
    - Minimized in combustion chamber and afterburner. Afterburners can significantly reduce the toxicity of the exhaust gas from an incinerator.
  - Particulate emissions:
    - Venturi scrubber
    - Wet electrostatic precipitator
    - Electrostatic precipitator
    - Quench systems
    - Fabric filter
  - Acid gases:
    - Packed towers
    - Spray towers
    - Spray dryers

- Residue handling and disposal
  - Ash
    - Solidification
    - Use as fill material onsite or offsite disposal
  - Liquids
    - Neutralization
    - Filtration
    - Precipitation (metals)
    - Clarification
    - Carbon adsorption or air stripping (for small amounts of organics which are sometimes recovered in scrubber water)
    - Discharge to a POTW after successful treatment using one of the above four options. Use to cool ash from the Rotary Kiln

Figure 2 presents a schematic diagram of a typical incineration system.



Source: U.S. Environmental Protection Agency 1988b.

Figure 2. Incineration System Concept Fow Diagram

When incineration is considered along with other possible treatment methods, the relative risks involved with the use of each of the technologies should be taken into account. Table 1 shows the total excess lifetime cancer risks that environmental releases from incineration pose to the most exposed individual. These values, which were developed to support the Resource Conservation and Recovery Act (RCRA) hazardous waste incineration regulations, are based on assumptions that included process upsets and covered a wide range of operating conditions. As shown in Table 1, the risks presented by metals are likely to be higher than those presented by Principle Organic Hazardous Constituents (POHCs) and products of incomplete combustion (PICs). The total estimated risk (including metals, POHCs, and PICs) does not exceed 1 in 100,000 and is unlikely to do so as long as the all appropriate incinerator standards are met. This information should be considered in light of the other risks that are associated with a particular superfund site as indicated from any required risk assessments.

The information in this report was obtained through a literature survey and contacts with several EPA representatives experienced in the use of incineration for the cleanup of toxic waste sites and for the treatment of RCRA hazardous wastes.

In addition to the EPA Regional and state technical advisors listed on page 25, the following people can be contacted for specialized information:

Robin Anderson EPA, Washington 202/398-8739	EPA policies and practices, remedial operations
James Cudahy Focus Environmental 615/694-7517	Full-scale, mobile, thermal remediation projects
Paul Lemieux EPA, RTP 919/541-0962	Secondary combustion chamber/afterburner impact on toxic air emissions
Kevin Smith International Technology 615/690-3211	Mobile incinerator markets and technology
Sonya Sasseville EPA, Washington 202/382-3132	EPA policies and practices, RCRA incineration permits
Lionel Vega EPA, Washington 202/475-8988	EPA policies and practices, RCRA incinerator permits
Y.J. Kim EPA Region 5 312/886-6147	National incinerator expert
Dr. Barry Dellinger University of Dayton Research Institute 513-229-2846	POHC and PIC thermal stability
Laurel Staley RREL USEPA, Cincinnati 513-569-7863	Innovative thermal treatment technology

Table 1. Total Excess Lifetime Cancer Risk from Incinerator Emissions to the Maximum Exposed Individual[a]

Emmision Item	*Risk Range*	*Probability statement*
POHCs	10^{-7} to 10^{-10}	1 in 10,000,000 to 1 in 10 billion
PICs	10^{-7} to 10^{-11}	1 in 10,000,000 to 1 in 100 billion
Metals	10^{-5} to 10^{-8}	1 in 100,000 to 1 in 100,000,000
Total	10^{-5} to 10^{-8}	1 in 100,000 to 1 in 100,000,000

[a] Source: Weinberger et al. 1984.

INCINERATION SYSTEM DESIGN, OPERATION, AND PERFORMANCE

A complete discussion of the design, operation, and performance of incineration systems is beyond the scope of this report. Detailed information on any of these topics can be found in the references listed at the end of this report. This information should be useful to the RPM/OSC in obtaining some background and perspective on issues pertaining to the use of incineration. It is the objective of this section, and of the entire report, to provide the RPM/OSC with enough basic information, resource documents, and personal contacts to allow themselves to conduct technical oversight and monitoring of remedial activities. To keep the report as concise as possible, this information is presented in a series of tables, as follows:

Table 2	Design and Operating Characteristics of a Typical Incineration System
Table 3	Typical Design Parameters for Air Pollution Control Equipment on Hazardous Waste Incinerators
Table 4	Summary of Continuous Emission Monitors
Table 5	Typical Automatic Waste Feed Shut Off (AWFSO) Parameters
Table 6	Example Operating Parameters and How They Affect Performance
Table 7	Waste Properties Affecting Incineration System Performance
Table 8	Operating/Failure Modes Leading to the Formation of Excessive Products of Incomplete Combustion (PICs) and Low Destruction and Removal Efficiency (DRE)
Table 9	Reaction Products Observed from Thermal Decomposition of Various Materials in UDRI Flow Reactor Studies
Table 10	Maintenance Checklist for a Rotary Kiln Incinerator

These tables are excerpted from the references listed on pages 27-28. Some values have been updated and additional information has been added, where appropriate, to provide more complete information. These additional values were determined from discussion with various incineration experts during the development of this document. It is suggested that the OSC/RPM seek the advice of some of the experts listed in this document and of the regional RCRA incineration contacts regarding appropriate values for the incinerator to be used at their specific site.

Table 2 focuses on an incineration system with a rotary kiln and a liquid injection unit exhausting into a secondary combustion chamber (afterburner). Other tables in this section also rely heavily on reported information and experiences with rotary kiln incineration systems because these units have been and are scheduled to be used for the treatment of contaminated soils at most Superfund sites. Approximately 0.91 million tons of the 1.3 million tons of contaminated soils and sludges that have been treated or contracted to be treated (approximately 70 percent) by onsite thermal treatment methods have or are projected to be treated by rotary kiln incineration. The remaining tons are fairly evenly split among low- and high-temperature desorption, circulating fluidized bed, and infrared conveyor furnaces (approximately 6 to 9 percent for each type of unit).

Table 3 provides an overview of design parameters for Air Pollution Control Equipment which is typically included in incineration systems. This table is useful as a reference in specifying design criteria for these systems.

Table 4 provides an overview of the continuous emission montitors that are typically used on incinerators. Ranges and typical values are provided. Generally, if continuous emission monitors are within the specified "typical values", the incinerator is probably operating in compliance with applicable or relevant and appropriate requirements (ARARs).

Table 5 is a summary of operating parameters which are required by an operating permit to trigger an automatic cessation of feed. in the event that a safe operating range is exceeded. These precautions may not always be included in incinerator designs, but do help to insure safe operation and compliance with ARARs.

Table 6 is a summary of operating parameters that affect incinerator performance. This is useful general information which should assist the RPM/OSC in reviewing incinerator designs to assure the efficient performance of an incinerator at a particular site.

Table 7 summarizes the physical properties of solid waste which can adversely affect the performance of an incinerator. Waste streams that are difficult to treat can cause frequent shutdowns, thus significantly lengthening the time required to remediate the site. Also, some waste streams can form toxic PICs and should not be incinerated without the use of an afterburner.

Table 8 summarizes failure modes that can result in the incinerator failing to comply with ARARs. These conditions should be avoided.

Table 9 lists some of the PICs that can form from various mixtures of organic compounds. This list is particularly useful in determining what POHCs to designate during a trial burn. In addition, it provides the RPM/OSC with an indication of what organic chemicals may be emitted from an incinerator burning a particular mixture of contaminants under suboptimal conditions.

Finally, Table 10 lists some of the maintenance that must be done on an operating incinerator. This is useful to the RPM/OSC in determining the level of effort required to implement an incineration remedy.

Table 2. Design and Operating Characteristics of a Typical Incineration System[a]

Parameter	Typical values
Rotary kiln	
Operating Temperature, °F	
Ashing kiln	1200 to 1800
Slagging kiln	2200 to 2600
Types of Waste	
Ashing Kiln	• Low BTU waste (e.g., contaminated soils) <5000 BTU/lb • High BTU waste >5000 BTU/lb
Slagging Kiln	• High BTU waste >5000 BTU/lb • Moderate moisture & halogen content • Both drums and drummed wastes
Solids residence time, min	
Ashing kiln	30 to 60
Slagging kiln	60 to 100
Gas residence time, s	1 to 2
Gas velocity through kiln, ft/s	15 to 20
Heat release levels, Btu/ft^3 per h	25,000 to 40,000
Small kiln, million Btu/h	8 to 35
Large kiln, million Btu/h	35 to 100
Kiln loading, % kiln volume	
Ashing kiln	7.5 to 15
Slagging kiln	4 to 6
Kiln operating pressure, in.H_2O	-0.5 to -2.0
Excess air, %	75 to 200
Liquid injection unit	
Operating temperature, °F	1800 to 3100
Residence time, s	Milliseconds to 2.5
Excess air, %	10 to 60
Waste heating value, BTU/lb	≤ 4500
Secondary combustor (afterburner)	
Residence time, s	2
Operating temperature, °F	2200 typical
TSCA wastes	>2250
RCRA wastes	1600 to 2800
Excess air, %	10 to 60

[a] Sources: Tillman, Rossi, and Vick 1990; Schaefer and Albert 1989.

Table 3. Typical Design Parameters for Air Pollution Control Equipment on Hazardous Waste Incinerators[a]

Air pollution control equipment	Typical design parameters
Particulate	
Electrostatic precipitators	SCA = 400-500 ft^2/1000 acfm Gas velocity = 0.2 ft/s
Fabric filters	Pulse jet A/C = 3-4:1 Reverse air A/C = 1.5-2:1
Venturi scrubbers	ΔP = 40-70 in. W.C. L/G = 8-15 gal/1000 acfm
Acid gases	
Packed towers	Superficial velocity = 6-10 ft/s Packing depth = 6-10 ft L/G = 20-40 gal/100 acfm Caustic scrubbing medium, maintaining pH = 6.5 Stoichiometric ratio = 1.05
Spray dryers	Low temperature: Retention time 15-20 sec Outlet temperature 250-450°F Stoichiometric ratio (lime) = 2-4

SCA = specific collection area
A/C = air-to-cloth ratio in units of ft/min
L/G = liquid-to-gas ratio

[a] Source: Buonicore 1990.

Table 4. Summary of Continuous Emission Monitors[a]

Pollutant	Monitor type	Expected concentration range	Available range[b]	Typical value
O_2	Paramagnetic	3-14%	0-25%	8%
CO_2	NDIR[c]	2-14%	0-21%	8%
CO	NDIR[c]	0-100 ppm	0-5000 ppm	40 ppm
NO_x	Chemiluminescent	0-4000 ppm	0-10000 ppm	200 ppm
SO2	Flame photometry	0-4000 ppm	0-5000 ppm	Varies by waste
Organic compounds (THC)	FID[d]	0-20 ppm	0-1000 ppm	<20 ppm

[a] Source: Oppelt 1987. [b] For available instruments only. Higher ranges are possible through dilution. [c] Nondispersion infrared. [d] Flame ionizing detection.

Table 5. Typical Automatic Waste Feed Shut Off (AWFSO) Parameters[a]

Parameter (example value)	Purpose of AWFSO: Excess emissions	Worker safety	Equipment protection
High CO in stack (100 ppm)*	X		
Low chamber temperature* (1400°F for rotary kiln 1700°F for SCC)	X		
High combustion gas flow (Varies by size)	X		
Low pH of scrubber water (4) (e.g. not less than 6.5)	X		
Low scrubber water flow (Varies by size)	X		X
Low scrubber pressure drop (20 inches W.G. for venturi)	X		X
High scrubber temp. (220°F)			X
Low sump levels (variable)			X
High chamber pressure (positive)	X	X	
High chamber temperature (2000°F for rotary kiln, 2600°F for SCC)	X	X	X
Excessive fan vibration	X	X	X
Low burner air pressure (1 psig)	X		
Low burner fuel pressure (3.0 psig for natural gas)	X		
Burner flame loss		X	X
Low oxygen in stack (3 percent)*	X		
Loss of atomizing media	X		
High stack SO2*	X		
High waste feed flow	X		
High Opacity >5%	X		

[a] Source: Oppelt 1987.

* Rolling averages of these parameters can sometimes be used. (Leonard, Paul comments 10/23/90)

Table 6. Example Operating Parameters and How They Affect Performance[a]

Operating parameter	Effect
Temperature	Combustion reaction rates increase with temperature until the rates are limited by mixing. High temperatures can also elevate NOx emissions.
Combustion gas flow rate	For a fixed chamber volume, the waste constitutents remain in the chamber for a shorter time (have a lower residence time) as the flow rate increases. As the combustion gas flow rate increases, gas velocity through the chamber increases. This can result in increased entrainment of solid material (fly ash) and emission of particulates.
Waste feed rate and heat content	As waste feed rate decreases, the heat release in the combustion chamber will decrease and temperature may drop. Waste heat content can affect combustion temperature. Insufficient heat content can result in the need for auxiliary fuel which will adversely affect the economics of the process. Wide variations in heating value of the waste can cause puffing (positive pressure surges) in rotary kilns.
Moisture Content of the Waste	Moisture decreases the heat content of the waste and, as a result, reduces the combustion temperature and efficiency when high moisture waste is burned.
Air input rate	Air supplies oxygen for the combustion reactions. A minimum is needed to achieve complete combustion; however, too much air will lower the temperature (because the air must be heated) and quench combustion reactions due to excessive cooling. The additional air will increase combustion gas flow rate, which then lowers the residence times. Increased air input can increase combustion efficiency by increasing the amount of oxygen available to oxidize organic contamination.
Waste atomization	Atomizing liquid waste into smaller droplets will increase the effectiveness of fuel/air mixing and the burning rate. Waste feed and atomizing fluid (air or steam) flow rates and pressures affect atomization. Suboptimal waste feed and atomizing fluid flows will result in less efficient atomization resulting in the production of larger fuel/waste droplets.
Feed System	Consistent, reliable delivery of waste feed into the incinerator is critical to the efficient operation of an incinerator. The design of appropriate feed systems can be difficult for inconsistent or difficult feed streams.
Mixing/Turbulence	A burner must be selected which induces adequate turbulence into the combustion air/fuel/waste mixture. This promotes good mixing of air and fuel which leads to efficient combustion.

[a] Source: ASME 1988.

Table 7. Waste Properties Affecting Incineration System Performance[a]

Property	Hardware Affected	Operating Parameter Affected	Effect of Performance	Example Feeds of Concern
Heating value	Rotary kiln	Rotary kiln temperature, flue gas residence time	Feed capacity, fuel usage	Plastics, trash
Density	Rotary kiln	Weight of material held by kiln	Feed capacity	Brominated sludge (high density sludge)
Halogen and sulfur content	Quench system, air pollution control equipment design and operation	Pump cavitation, pH control, blowdown rate, particulate emissions	Feed capacity, caustic usage	Trial burn mixture, brominated sludge
Moisture	Feed system		Increased fuel usage to maintain temperature	
Particle size distribution	Cyclone, SCC, ducts, wet electrostatic precipitation (WEP), instrumentation	Kiln draft, particulate emissions excess oxygen control, temperature control	Fouling of duct, cyclone, SCC, process water system, and instruments	Soils, brominated sludge, vermiculite
H:Cl ratio of POHCs[b]	———	Incinerator's ability to thermally destroy POHCs/PICs	As H:Cl ratio decreases, thermal stability of POHCs increases and oxidation of PICs is reduced. Under oxygen starved conditions the tendency to form PICs increases as the N:Cl ratio decreases	C_2Cl_6, C_6I_6, C_2HCl_3, and similar compounds
Any fusion characteristics (determined by chemical characteristics, e.g., alkalis)	Rotary kiln, cyclone, ducts, quench elbow, instrumentation	Kiln draft, temperature, excess O_2 control	Slagging of kiln, plugging of instruments and downstream equipment	Plastic, trash, brominated sludge

Sources: a) Stumbar et al, 1989
b) Taylor and Dellinger, 1988, Tirey, 1990.

Knowing the thermal stability of POHCs and PICs is extremely important to the design of an effective incineration system. The University of Dayton Research Institute (UDRI) has studied the thermal stability of 330 hazardous organic coumponds and has ranked their thermal stability under oxidative and pyrolytic conditions. This database is available in Environmental Science & Technology Volume 24, No. 3 pp. 316-328, 1990. UDRI has also determined the PICs which can be produced from various POHCs under different combustion conditions. The PICs produced from a given POHC vary depending upon whether the atmosphere is oxidative or pyrolytic. Further, mixtures of POHCs produce different PICs than the individual POHCs would alone. Some of UDRI's results are presented in Table 9. Complete results can be obtained in the following references.

Dellinger, B.., Torres, J.L., Rubey, W.A., Hall, D.L., Graham, J.L., and Carnes, R.A. "Determination of the Thermal Stability of Selected Hazardous Organic Compounds," *Hazardous Waste*, Vol. 1, pp. 137-157 (1984)

Taylor, P.H. and Dellinger, B., "Thermal Degradation Characteristics of Chlorinated Methane Mixtures," *Environmental Science & Technology* Vol.22 pp. 438-447 (1988)

Taylor, P.H. and Dellinger, B., "Development of a Thermal Stability Based Ranking of Hazardous Organic Compound Incinerability," *Environmental Science & Technology* Vol. 24, pp. 316-328 (1990).

Dellinger, B., Taylor, P.H., and Tirey, D.A., "Minimizartion and Control of Hazardous Combustion Byproducts," Final Report and Project Summary prepared for U.S. EPA under cooperative agreement CR-813938-01-0, April 1990.

Tirey, D.A., Taylor, P.H., and Dellinger, B., "Products of Incomplete Combustion from the High Temperature Pyrolysis of the Chlorinated Methanes," in *Emissions from Combustion Processes: Origin, Measurement and Control*, pp. 109-120 (Lewis Publishers: Chelsea, MI) 1990.

Table 8. Operating/Failure Modes Leading to the Formation of Excessive Products of Incomplete Combustion (PICs) and Low Destruction and Removal Efficiency[a]

Condition	Results
Low oxygen to fuel/waste ratio	Insufficient oxygen for complete combustion; in many cases, this will reduce POHC DRE and increase propensity for PIC formation
High air/fuel ratio	High air levels and associated gas flows lead to temperature quenching and flameouts.
Low-temperature operation	Many PICs require higher destruction temperature than parent POHCs, thus low destruction efficiency for POHCs and higher PIC emission rates.
Waste surges	Leads to overloading combustion system and incomplete combustion (starved air condition). Also, can lead to fugitive emissions as a result of sudden pressurization of the system. High CO and THC levels can result
Poor gas mixing in combustion chamber due to low turbulence	Optimum combustion of all organics not achieved. PICs can be formed from the onset of pyrolysis within the system. Localized oxygen-starved stoichiometries lower POHC DRE and increase PIC formation. CO levels increase
Poor atomization for liquids	Droplets too large for vaporization in flame zone or droplet trajectories penetrate flame zone.
Injection waste flame impinging on cool surface such as combustion chamber wall	Can cause severe damage to the refractory. Quenches combustion reactants before combustion is complete. PICs and CO levels can increase
Liquid waste flame impinging on cool surface such as combustion chamber wall	This can result in the release of PICs and unburned POHCs into the environment. Refractory can also be damaged
Poorly designed or malfunctioning air pollution control (APC) device or failure of APC	PICs are absorbed on soot particles that are normally collected in the APC system. This condition will increase these particulate emissions. Dioxin formation can occur in this way
Short residence time	Insufficient time for complete burning, most critical when stable PICs are formed from POHC combustion.
High halogen content (e.g. H:Cl ratio too low)	Highly chlorinated POHCs and PICs are more difficult to oxidize than less chlorinated or unchlorinated derivatives

[a] Sources: ASME 1988; Daniels 1989; Dellinger, Taylor, and Tirey 1989. Also, Santoleri 1989

The above table is not all inclusive and appropriate care should be given to make certain that incinerator designs have a minimum of failure modes which could result in PIC formation. As an added precaution, secondary combustion chambers should always be used since they have been shown to reduce the toxicity of organic emissions from incinerators. (Limeux, 1990)

Table 9. Reaction Products Observed from Thermal Decomposition of Various Materials in UDRI Flow Reactor Studies[a]

Parent (POHC)	Product (PIC)	Condition
Carbon Tetrachloride	Tetrachloroethene Hexachloroethane Hexachlorobutadiene	Air atmosphere, t_r* = 2.0 s
Pentachlorobenzene	Hexachlorobenzene	Air atmosphere, t_r = 2.0 s
Chloroform	CCl_4 1,2-$C_2H_2Cl_2$ C_2HCl_3 C_2Cl_4 C_2HCl_5 C_2Cl_2 $C_2H_2Cl_4$ C_3Cl_4 C_4Cl_6 C_6Cl_6	o = 0.67, t_r = 2.0 s
Chloroform	Carbon Tetrachloride Trichloroethene Pentachloroethane Dichloroethyne Tetrachloroethene Tetrachloropropyne 1,1,2,4-Tetrachloro-1-buten-3-yne Hexachlorobutadiene	o=0.76 and Nitrogen atmospheres
Mixture of CCl_4 53% (mole) $CHCl_3$ CH_2Cl_2 CH_3Cl	 CCl_4 33% 7% 7% C_2Cl_2 1,1-$C_2H_2Cl_2$ C_2HCl_3 C_2Cl_4 C_2Cl_6 C_3Cl_4 C_4Cl_4 C_4Cl_6 C_6Cl_6 C_8Cl_8	 Pyrolytic, t_r = 2.0 s $CHCl_3$ CH_2Cl_2 CH_3Cl

[a] This table was excerpted from a table appearing in a UDRI report on PIC minimization entitled Minimization and Control of Hazardous Combustion Byproducts Final Report and Project Summary prepared for U.S. EPA under cooperative agreement CR-813938-01-0 summarizing the results of flow reactor studies conducted at the University of Dayton Research Institute. The complete table can be found in the above listed reference.

Table 10. Maintenance Checklist For A Rotary Kiln Incinerator[a]

Item	Procedure	Frequency
Shredder	Inspect Lubricate	Daily Weekly
Kiln feeder	Inspect Lubricate	Daily Weekly
Kiln burner	Check flame Remove, inspect atomizer	Each shift Quarterly
Other atomizers	Remove, inspect	Quarterly
Kiln speed	Check	Daily
Kiln drive	Inspect Lubricate	Daily Weekly
Kiln refractor	Inspect visually Repair	Each shift As needed
Kiln seals	Inspect Replace	Each shift As needed
Ash gates	Inspect	Daily
Ash conveyor	Inspect Lubricate	Daily Weekly
Afterburner refractory	Inspect visually Repair	Each shift As needed
Afterburner burners	Check flame Remove, inspect atomizer	Each shift quarterly
Quench	Check for leaks Check outlet temperature Remove, inspect atomizers	Each shift Each hour quarterly
Waste heat boiler	Check steam pressure Check pressure drop Inspect tubes	Each hour Each shift Each 6 months
Particulate scrubber	Check pressure drop Check water level Lubricate throat drive	Each shift Each shift Monthly
Absorber	Check pressure drop Inspect packing Remove, inspect nozzles	Each shift Each 6 months quarterly
Fabric filter system	Check pressure drop Inspect bags Lubricate discharge mechanism	Each shift Each 6 months Monthly
Main fan	Check motor amperage Lubricate bearings Check vibration	Daily Weekly Daily
Pumps	Check motor amperage Lubricate Check discharge pressure	Weekly Weekly Daily
Control instruments	Calibrate	Per manufacturer's instructions
Analytical instruments	Calibrate	Daily
Limit controls	Test	Daily
Emergency vent	Test	Quarterly

[a] Source: Brunner 1988b.

INCINERATION EXPERIENCE

Incineration has been a popular method of disposing of unwanted materials for many years. Several incinerator manufacturers such as Combustion Engineering and Vulcan Iron Works have been in business for 100 years. With the advent of RCRA, the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA), and the Superfund Amendments and Reauthorization Act of 1986 (SARA), developments in incineration have evolved with changing environmental concerns. Manufacturers have had to modify their incinerators to ensure complete destruction of all the hazardous constituents found in the variety of mixed wastes on a Superfund site. More commercial facilities were established to deal with the quantity of wastes being generated or found. The concern over transporting wastes from a hazardous waste site to a commercial facility led to the development of mobile treatment technologies, which allowed the waste to be treated onsite and thus prevented the spread of contamination. The full-scale thermal remediation projects included later in this section were all performed onsite with mobile or transportable equipment. When site conditions precluded the use of mobile equipment, commercial facilities were used. The Records of Decision listed in Table 13 all used some form of incineration or thermal treatment. Last, but not least, are the SITE Demonstrations, where new, innovative modifications such as oxygen enrichment are made to the incineration process to develop alternative systems for effectively cleaning the environment.

Onsite Mobile Treatment

When Congress authorized SARA in 1986, one of their goals was to prevent the possible spread of contamination resulting from transportation of untreated wastes. According to SARA, "The offsite transport and disposal of hazardous substances or contaminated materials... should be the least favored alternative remedial action where practicable treatment technologies are available." Because SARA also emphasizes the use of a permanent solution, incineration has become the most used method for treating hazardous waste. Using a mobile incinerator not only satisfies both of the SARA requirements, it provides a proven technology that is capable of quickly and effectively achieving a high level of waste destruction with no long-term liability. Existing technologies have demonstrated the capability of achieving >99.9999% destruction of organics while producing an organic-free ash suitable for backfilling at the site. Because onsite cleanups can be conducted without Federal, state, or local permits, the time required for start-up can usually be reduced.

Even though permits may not be required for onsite cleanups, the substantive technical requirements of a permit must still be met. Offsite commercial incinerators must comply with the "offsite" policy. (OSWER Directive 9330.2-1)

Onsite incineration includes mobile units, which are transported to a site fully operational. A unit is used to treat wastes at one site and, when the job is finished, it is moved to another site. Transportable incinerators are those which are transported to a site and are erected onsite. At some very large sites where the cleanup will require a number of years, it may be feasible to actually build an incinerator onsite. Once, erected they cannot be moved from the site without first being dismantled to some extent. Transportable incinerators are generally larger than mobile units and are best used for long term cleanups in which a relatively large amount of material will be treated. Economic considerations are often the key factor in determining whether, mobile, transportable, fixed or offsite commercial incineration will be used at a given site. Cost for onsite and offsite thermal treatment vary widely. In choosing between onsite and offsite incineration, factors which affect the economics of incineration are the type, physical form, and quantity of contaminants; applicable site cleanup criteria; and the availability of offsite incineration, including the capacity and proximity of the commercial unit, container requirements, and the method of transportation (McCormick and Duke 1989).

Based in part on a survey conducted by McCoy and Associates, Inc. (1989), the following companies offer mobile or transportable thermal treatment of hazardous wastes:

The EPA Regional contacts listed later in this report may have more specific information concerning the capabilities of each vendor.

Chemical Waste Management

3003 Butterfield Road
Oak Brook, IL 60521
Contact: Ray Bock
Phone: (708) 218-1675

Technology: Transportable rotary kiln incinerator
Setup time: 2 monthsWaste/Media: Soils, sludges, and other solids; unit
Typical cost: $200-300/ton can also burn incidental liquids
Limitations: 20-30 tons/hour; 82 million Btu/hour; minimum quantity of 10,000 tons to justify mobilization; 20,000 tons or more preferred

Environmental Systems Co. (ENSCO)

333 Executive Court
Little Rock, Arkansas 72205
Contact: Steve Hardin
Phone: (501) 223-4100

Setup time: 4 to 6 weeks
Typical cost: Varies, depending on waste stream

Technology: MWP-2000 modular incinerator; rotary kiln
Waste/Media: Solids and liquids (RCRA and TSCA)
Limitations: 40 million Btu/hour; no radioactive waste or fluorinated compounds

Harmon Environmental (Williams)

1550 Pumphrey Avenue
Auburn, Alabama 36830
Contact: Bill Webster
Phone: (205) 821-9253

Setup time: 4 hours
Typical cost: $55-75/ton

Technology: Mobile rotary kiln
Waste/Media: Light fuels, diesel, gasoline
Limitations: 8 tons/hour; 24 million Btu

Haztech (Westinghouse Environmental Services)

5304 Panola Industrial Blvd., Suite E
Decatur, Georgia 30035-4013
Contact: Carol Renfroe
Phone: (404) 593-3464

Setup time: 4-6 weeks
Typical cost: $200-300/ton

Technology: Transportable infrared conveyor system
Waste/Media: Organic soils and sludges
Limitations: 100-175 tons/day; feed stream must be chopped/shredded to less than 1-in. pieces

International Technology Corporation

23456 Hawthorne Blvd.
Torrance, California 90505
Contact: Kevin R. Smith
Phone: (615) 690-3211

Setup time: 3 weeks
Typical cost: $150-450/ton

Technology: Hybrid Thermal Treatment System (HTTS); transportable rotary kiln
Waste/Media: Solids, sludges, and liquid wastes, including light contaminated materials up to heavy organics
Limitations: 56 million Btu/hour

Ogden Environmental Services, Inc.

P.O. Box 85178
San Diego, California 92138-5178
Contact: Robert C. Haney
Phone: (619) 455-3045

Setup time: 2-3 weeks
Typical Cost: $100-300/ton

Technology: Transportable circulating-bed combustor
Waste/Media: Soils, sludges, and liquids containing hazardous and toxic constituents including PCBs, hydrocarbons, oil, and munitions

O.H. Materials Corp.

16406 U.S. Route 244 East
Findlay, Ohio 45840
Contact: Greg McCartney
Phone: (419) 423-3526

Setup time: 7 days
Typical cost: $150-250/ton

Technology: Mobile infrared hazardous waste incinerator
Waste/Media: Soils, sludges, and sediments contaminated with halogenated and nonhalogenated organics
Limitations: 200 tons/day; limited to solid/semisolid waste media

Thermodynamics Corporation

P.O. Box 369
Bedford Hills, New York 10507
Contact: Mark Wolstencroft
Phone: (914) 666-6066

Setup time: 2 days
Typical cost: $400/ton
(depends onsite and material)

Technology: Mobile rotary-kiln incinerator
Waste/Media: Handles all mediums
Limitations: 9 million Btu/hour (however, larger unit may be available in the future); solids must be crushed or shredded to 1-in. size

VESTA Technology, Ltd.

1670 West McNab Road
Ft. Lauderdale, Florida 33309

Contact: Tricia P. Jack
Phone: (305) 978-1300

Setup time: 8 hours; 24-48 hours

Typical cost: $450-750/ton;
$250-600/ton

Technology: Mobile rotary-kiln incinerator (small or large unit)
Waste/Media: Liquids, solids, and sludges
Limitations: 8 million Btu/hour; 12 million Btu/hour; cannot handle heavy metals, arsenic, or mercury

Waste-Tech Services, Inc.

18400 W. 10th Avenue
Golden, Colorado 80401

Contact: John Wurster
Phone: (303) 279-9712

Setup time: 3 days
Typical cost: $700/ton

Technology: Trailer-mounted fluidized-bed incinerator
Waste/Media: Solids, liquids, sludges, slurries, soils, and gases; halogenated and nonhalogenated wastes
Limitations: 1.5 million Btu/hour; 600 pounds/hour; solid wastes with greater than 3-cubic-inch particle size require size-reduction pretreatment step

Weston Services, Inc.

Weston Way
West Chester, Pennsylvania 19380

Contact: John W. Noland
Phone: (215) 430-3103

Setup time: 6 weeks
Typical cost: $250/ton

Technology: Transportable Incineration System (TIS); rotary kiln
Waste/Media: Hazardous soils, sludges, and liquids
Limitations: 7 tons/hour; 20 million Btu/hour in kiln and 20 million Btu/hour in afterburner

Offsite Commercial Facilities

Although onsite treatment is the preferred remediation method for Superfund wastes, site conditions might preclude the use of mobile or transportable incinerators. (OSWER Directive 9355.3-01) In these cases, the wastes must be transported to a commerical incinerator which is in compliance with the "offsite-policy". Currently, only 9 companies, operating 14 commerical facilities in 8 states, are capable of handling the wide spectrum of wastes that might be found at a CERCLA site. Current information regarding these facilities' compliance with the "offsite-policy" should be obtained prior to use. The following list contains the companies, incinerator location, and type of incinerator used:

Chemical Waste Management, Inc.

Incinerator location: Port Arthur, TX — Phone: 800/843-3604, 409/736-2821
Technology: Rotary kiln

Incinerator Location: Sauget, IL — Phone: 800/843-3604, 618/271-2804
Technology: Rotary kiln

Incinerator Location: Chicago, IL — Phone: 800/843-3604, 312/646-5700
Technology: Rotary kiln

ENSCO, Inc.

Incinerator Location: El Dorado, AK — Phone: 501/223-4160
Technology: Liquid injection, Rotary kiln

GSX/Thermal Oxidation Corporation

Incinerator Location: Roebuck, SC — Phone: 803/576-1085
Technology: Liquid injection

L.W.D., Inc. *

Incinerator Location: Calvert City, KY — Phone: 502/395-8313
Technology: Liquid injection, Rotary kiln

Olin Chemicals

Incinerator Location: Brandenburg, KY — Phone: 800/227-7592, 502/422-2101
Technology: Liquid injection

Rhone-Poulenc Basic Chemical Company

Incinerator Location: Baton Rouge, LA — Phone: 713/688-9311
Technology: Liquid injection

Incinerator Location: Houston, TX — Phone: 713/683-3314, 713/683-3315
Technology: Liquid injection

Rollins Environmental Services, Inc.

Incinerator Location: Baton Rouge, LA — Phone: 504/778-1234
Technology: Liquid injection, Rotary kiln

Incinerator Location: Bridgeport, NJ — Phone: 609/467-3105
Technology: Liquid injection, Rotary kiln

Incinerator Location: Deer Park, TX — Phone: 713/930-2300

Technology: Liquid injection, Rotary kiln, Rotary reactor
Ross Incineration Services, Inc.

Incineration Location: Grafton, Ohio   Phone: 216/748-2171
Technology: Liquid injection, Rotary kiln

ThermalKEM, Inc.

Incinerator Location: Rock Hill, SC   Phone: 803/328-9690
Technology: Fixed hearth

*(Contact Betty Willis, EPA Region IV, regarding the permit status of this incinerator. She can be reached at FTS 257-3433)

Incinerator Manufacturers

Incinerators can be distinguished from each other primarily by the design of their combustion chambers. Each type operates under a specific set of conditions designed to achieve maximum efficiency for the quantity and type of wastes it will handle. Many of the major incinerator manufacturers conduct extensive onsite demonstrations of their incinerator equipment to ensure maximum operating efficiency. Table 11 lists the manufacturers of the major incinerator types. These firms can be contacted individually for further information (see listing following table).

Table 11. Manufacturers of Incinerators[a]

Hearth incinerators	Liquid injection incinerators	Rotary kiln incinerators	Fluidized bed incinerators
Basic Environmental Engineering	Brulé	Boliden Allis, Inc.	CE Raymond
Bayco	Burn-Zol	CE Raymond	Dorr Oliver
Burn-Zol	Coen Co.	Deutsche-Babcock	Fuller Company
Cleaver-Brooks	Hirt Combustion Engineers	Environmental Elements Corp.	Sur-Lite
Econo-Therm Energy Systems, Inc.	McGill, Inc.	Fuller Company	
Epcon Industrial Systems, Inc.	Met-Pro Corp.	Industronics, Inc.	
Int'l Waste Ind.	Peabody Int'l	Int'l Waste Energy Systems	
Kennedy Van Saun	Prenco, Inc.	Kennedy Van Saun Corp.	
	Process Combustion	ThermAll, Inc.	
	Sur-Lite	U.S. Smelting Furnace	
	Trane Thermal	vonRoll, Ltd.	
	John Zink Co.	Vulcan Iron Works	

a Source: U.S. Environmental Protection Agency 1986b.

The locations and telephone numbers of the manufacturers listed in Table 11 are as follows:

Basic Environmental Engineering, Inc.
Glen Ellyn, IL
(312) 469-5340

Bayco Industries of California
San Leandro, CA
(415) 562-6700

Boliden Allis, Inc.
Milwaukee, WI
(414) 475-2690

Brulé C.E. & E., Inc.
Blue Island, IL
(312) 388-7900

Burn-Zol Corporation
Dover, NJ
(209) 931-1297

CE Raymond
Combustion Engineering, Inc.
Lisle, IL
(708) 971-2500

Cleaver-Brooks
Milwaukee, WI
(414) 962-0100

Coen Company
Burlingame, CA
(415) 697-0440

Deutsche-Babcock
(Ford, Bacon & Davis)
Salt Lake City, UT
(801) 583-3773

Dorr Oliver, Inc.
Stamford, CT
(203) 358-3741

Econo-Therm Energy Systems Corp.
Tulsa, OK
1-800-322-7867

Environmental Elements Corp.
Baltimore, MD
(301) 368-7166

EPCON Industrial Systems, Inc.
The Woodlands, TX
(713) 353-2319

Fuller Company
Bethlehem, PA
(215) 264-6011

Hirt Combustion Engineers
Montebello, CA
(213) 728-9164

Industronics, Inc.
S. Windsor, CT
(203) 289-1551

International Waste Energy Systems, Inc.
St. Louis, MO
(314) 389-7275

International Waste Industries
Blue Bell, PA
(215) 643-2100

Kennedy Van Saun Corp.
Danville, PA
(717) 275-3050

McGill, Inc.
Tulsa, OK
(918) 445-2431

Met-Pro Corp.
Harleysville, PA
(215) 723-6751

Peabody International Corporation
Stamford, CT
(203) 327-7000

Prenco, Inc.
Madison Heights, MI
(313) 399-6262

Process Combustion
Pittsburgh, PA
(412) 655-0955

Sur-Lite Corporation
Santa Fe Springs, CA
(213) 693-0796

ThermAll, Inc.
Peapack, NJ
(201) 234-1776

Trane Thermal Company
Conshohocken, PA
(215) 828-5400

U.S. Smelting Furnace
Belleville, IL
(618) 233-0129

vonRoll, Ltd.
Cranford, NJ
(201) 272-1555

Vulcan Iron Works, Inc.
Wilkes-Barre, PA
(717) 822-2161

John Zink Co.
P.O. Box 702220
Tulsa, OK 74170
(918) 747-1371

Full-Scale, Onsite Thermal Remediation Projects

Mobile and transportable thermal treatment methods are being used at several contaminated sites throughout the United States. Table 12, adapted from a list developed by James Cudahy of Focus Environmental, contains information about completed, ongoing, or contracted full-scale commercial cleanups in the United States using mobile or transportable thermal equipment. In this context, a mobile thermal treatment system is defined as a truck or skid-mounted system which takes two weeks or less for field erection and minimal foundations; a transportable system requires more than two weeks of field erection and substantial foundations. The list does not contain any pilot-scale remediation efforts or fixed-treatment methods (such as cement kilns or commercial incinerators). Of those reporting onsite problems, materials handling ranked the highest, followed by the weather. More details on each site can be obtained by contacting the responsible EPA Regional Office and the contractor.

Table 12. Full-Scale Onsite Thermal-Remediation Projects [a]

Contractor	Site name, location, state	Site size, tons	Source of contamination/ indicator compound	Contaminant concentration in treated soil, mg/kg	Combustion equipment	Thermal capacity, 10^6 Btu/h	APC equipment	Particulate emissions, gr/dscf at 7% O_2	Project status
Boliden Allis	Oak Creek, Oak Creek, WI	50,000	Dye manufacturing/naphthylamine	<0.5	Rotary kiln	40	Spray tower, baghouse	<0.01	Finished
Canonie	Ottati & Goss, Kingston, NH	8,000	Volatile organics	<0.2	Low-temperature direct desorber	55	Baghouse, carbon, scrubber	<0.03	Finished
Canonie	Canon Bridgewater, Bridgewater, MA	6,500	Solvent recycling/ total VOC	<0.1	Low-temperature direct desorber	55	Baghouse, carbon, scrubber		Contracted
Canonie	South Kearney, South Kearney, NJ	18,000	Solvent recycling/ volatile organics		Low-temperature direct desorber	55	Baghouse, carbon, scrubber		Finished
Canonie	McKin, Gray, ME	18,000	Waste treatment and disposal/ trichloroethylene	<0.1	Low-temperature direct desorber	55	Baghouse, carbon, scrubber	<0.03	Finished
Chem Waste	Confidential, Northeast	35,000	PCB spills/PCBs	<2.0	High-temperature indirect desorber		Condensation, carbon		Contracted
ENSCO	Union Carbide, Seadrift, TX		Chemical manufacturing		Rotary kiln	35	Steam ejector scrubber		Contracted
ENSCO	Lenz Oil, Lemont, IL	26,000	Hydrocarbons	<5.0	Rotary kiln	35	Steam ejector scrubber	0.006	Finished
ENSCO	Sydney Mines, Brandon, FL	10,000	Waste-oil lagoon/ hydrocarbons	<5.0	Rotary kiln	35	Steam ejector scrubber		Finished
ENSCO	NCBC, Gulfport, MS	22,000	Herbicide storage/ dioxin	<15 ppt	Rotary kiln	35	Steam ejector scrubber	0.017	Finished
ENSCO	Bridgeport Rental, Bridgeport, NJ	100,000	Used-oil recycling/PCBs		Rotary kiln	100	Steam ejector scrubber		Contracted

Table 12. Full-Scale Onsite Thermal-Remediation Projects (continued)

Contractor	Site name, location, state	Site size, tons	Source of contamination/ indicator compound	Contaminant concentration in treated soil, mg/kg	Combustion equipment	Thermal capacity, 10^6 Btu/h	APC equipment	Particulate emissions, gr/dscf at 7% O_2	Project status
GDC Engineering	Rubicon, Geismar, LA	52,000	Chemical manufacturing		Infrared conveyor furnace		Waterloo scrubber		Contracted
Harmon (Williams)	Bog Creek, Howell Twp., NJ	22,500			Rotary kiln	82	Cyclone, baghouse, packed bed		Contracted
Harmon (Williams)	Confidential, AL	600	Gasoline tank leak/petroleum hydrocarbons	<100.0	Low temperature direct desorber	21	Baghouse		Contracted
Harmon (Williams)	Prentiss Creosote, Prentiss, MS	9,200	Wood treatment/ PAHs	<2.0	Rotary kiln	82	Cyclone, baghouse, packed bed	0.011	Finished
IT Corporation	Motco, Lamarque, TX	80,000	Styrene tar disposal pits/PCBs		Rotary kiln	56	Hydrosonics tandem scrubber		Contracted
IT Corporation	Cornhusker AAP, Grand Island, NE	45,000	Munitions plant redwater pits/ trinitrotoluene	<1.34	Rotary kiln	56	Hydrosonics tandem scrubber		Ongoing
IT Corporation	Louisiana AAP, Minden, LA	100,000	Munitions plant redwater lagoon/ trinitrotoluene	<1.3	Rotary kiln	56	Hydrosonics tandem scrubber		Ongoing
IT Corpora–tion	Sikes Pits, Crosley, TX	341,000	Chemical dump-ing/hydrocarbons, metals	<100	HTDS-SK rotary kiln	56	Hydrosonics tandem scrubber	<0.08	Contracted
Kimmina	LaSalle, LaSalle, IL	69,000	PCB capacitor manufacturing/ PCBs	<2.0	Rotary kiln	100	Baghouse, packed bed		Contracted
Ogden	Confidential, Sacramento, CA	22,500			Circulating fluid bed	10	Baghouse		Contracted

Table 12. Full-Scale Onsite Thermal-Remediation Projects (continued)

Contractor	Site name, location, state	Site size, tons	Source of contamination/ indicator compound	Contaminant concentration in treated soil, mg/kg	Combustion equipment	Thermal capacity, 10^6 Btu/h	APC equipment	Particulate emissions, gr/dscf at 7% O_2	Project status
Ogden	Swanson River, Kenai, AK	80,000	Oil pipeline compressor oil/ PCBs	<0.1	Circulating fluid bed	10	Baghouse	<0.05	Ongoing
Ogden	Stockton, Stockton,CA	16,000	Underground tank oil leak.total hydrocarbons	<1.0	Circulating fluid bed	10	Baghouse	<0.08	Ongoing
O.H. Materials	Gas station, Cocoa, FL	1,000	Petroleum tank leak/benzene, toluene, xylene	<0.01	Low-temperature direct desorber	12	Venturi	0.011	Finished
O.H. Materials	Rail yard, PA	1,500	Repetitive spills/diesel oil	<100.0	Low-temperature direct desorber	20	Cyclone, venturi		Finished
O.H. Materials	Twin City AAP, New Brighton, MN	2,000	Munitions plants/ PCBs	<2.0	Infrared conveyor furnace	30	Venturi, packed bed		Finished
O.H. Materials	Rail yard, PA	1,300	Diesel tank spill/ diesel oil	<100.0	Low-temperature direct desorber	20	Cyclone, venturi		Finished
O.H. Materials	Florida Steel, Indiantown, FL	18,000	Steel mill used oils/PCBs	<2.0	Infrared conveyor furnace	30	Venturi, packed bed	0.056	Finished
O.H. Materials	Rail yards, Cleveland, OH	1,500	Petroleum hydrocarbons	<50.0	Low-temperature direct desorber	20	Cyclone, venturi	0.039	Finished
Site Recl. Systems	Koch Chemical, KS	700	Tank bottoms/ toluene, xylene		Low-temperature direct desorber	47	Baghouse		Contracted
Site Recl. Systems	Gulf Oil, multiple sites, FL	18,000	Benzene, toluene, xylene	<1.0	Low-temperature direct desorber	25	Baghouse		Contracted

Table 12. Full-Scale Onsite Thermal-Remediation Projects (continued)

Contractor	Site name, location, state	Site size, tons	Source of contamination/ indicator compound	Contaminant concentration in treated soil, mg/kg	Combustion equipment	Thermal capacity, 10^6 Btu/h	APC equipment	Particulate emissions, gr/dscf at 7% O_2	Project status
Site Recl. Systems	Sun Oil, multiple sites				Low-temperature direct desorber	25	Baghouse		Contracted
Soil Remediation Co.	Multiple sites, SC	3,000	Gas and oil leaks, spills/petroleum hydrocarbons	<50.0	Low-temperature direct desorber	48	Cyclone, baghouse		Finished
Soiltech	Waukegan Harbor, Waukegan, IL	20,000	Marine motor manufacturing/ PCBs		High-temperature in direct desorber	14	Baghouse, cyclone, scrubber		Contracted
TDI Services	Chevron Refinery, El Segundo, CA	30,000	API sludges	BDAT	High-temperature indirect desorber		Condensation, carbon		Contracted
Thermodynamics Corp.	S. Crop Services, Delray Beach, FL	1,800	Crop-dusting operation/ pentachlorophenol	0.003	Rotary kiln	7	Wet scrubber	0.035	Finished
U.S. Waste Thermal Proc.	Gas station, Temecula, CA	1,000	Petroleum tank leak/total hydrocarbons	<10.0	Infrared conveyor furnace	10	Calvert scrubber	0.008	Finished
U.S. Waste Thermal Proc.	CA	7,500	Total hydrocarbons		Infrared conveyor furnace	10	Calvert scrubber		Contracted
U.S. Waste Thermal Proc.	San Bernardino, CA	540	Total hydrocarbons	<10.0	Infrared conveyor furnace	10	Calvert scrubber		Finished
Vertac Site Contractors	Vertac, Jacksonville, AR	6,500	Chemical manu-facturing/dioxins		Rotary kiln	35	Spray dryer, baghouse, scrubber	0.08	Contracted
VESTA	Nyanza, Ashland, MA	1,000	Dye manufactur-ing/nitrobenzene		Rotary kiln	8	Wet scrubber	0.02	Finished

Table 12. Full-Scale Onsite Thermal-Remediation Projects (continued)

Contractor	Site name, location, state	Site size, tons	Source of contamination/ indicator compound	Contaminant concentration in treated soil, mg/kg	Combustion equipment	Thermal capacity, 10^6 Btu/h	APC equipment	Particulate emissions, gr/dscf at 7% O_2	Project status
VESTA	Rocky Boy, Havre, MT	1,800	Wood treatment/ pentachlorophenol		Rotary kiln	12	Wet scrubber		Contracted
VESTA	S. Crop Services, Delray Beach, FL	1,800	Crop-dusting operation/DDT	<0.2	Rotary kiln	12	Wet scrubber	0.03	Finished
VESTA	American Crossarm, Chehalis, WA	900	Wood treatment/ dioxin	<0.001	Rotary kiln	12	Wet scrubber	0.011	Finished
VESTA	Fort A.P. Hill, Bowling Green, VA	200	Army Base/dioxin	<0.001	Rotary kiln	12	Wet scrubber	0.02	Finished
Westinghouse/ Haztech	Peak Oil, Tampa, FL	7,000	Used oil recycling/PCBs	<1.0	Infrared conveyor furnace	30	Wet scrubber	,0.08	Finished
Westinghouse/ Haztech	LaSalle, LaSalle, IL	30,000	Transformer reconditioning/ PCBs	<2.0	Infrared conveyor furnace	30	Wet scrubber	<0.08	Finished
Weston	Revenue, Springfield, IL	1,000	PAHs	<0.33	Low-temperature indirect desorber	12	Baghouse		Finished
Weston	Tinker AFB, Oklahoma City, OK	1,000	Aircraft maintenance trichloroethylene		Low-temperature indirect desorber	12	Baghouse, wet scrubber		Finished
Weston	Paxton Avenue, Chicago, IL	16,000	Waste lagoon/ RCRA constituents		Rotary kiln	35	Baghouse, packed bed		Contracted
Weston	Lauder Salvage, Beardstown, IL	8,500	Metal scrap salvage/PCBs	<2.0	Rotary kiln	35	Baghouse, packed bed	0.02	Finished

[a]Source: Cudahy and Troxler 1990.

Records of Decision

The Superfund RODs for fiscal years (FYs) 1985 through 1988 indicate the increasing use of incineration as a remediation method. In 1984, only 8.0 percent of the total number of RODs (including action memos, enforcement decision documents, and negotiation documents) involved incineration. In 1989, 30 percent of the source control RODs that selected treatment specified incineration/thermal destruction as all or part of the remediation effort. More than half of those were for onsite treatment (U.S. EPA 1990).

The RODs listed in Table 13 all recommended the use of incineration/thermal destruction as part of the site remediation. More information on any of these sites can be obtained by requesting a full copy of the ROD from any EPA library or by contacting the appropriate EPA Regional Office.

SITE Program

In response to a requirement of SARA, the EPA established a program called the Superfund Innovative Technology Evaluation (SITE) Program to encourage the development and use of innovative technologies to clean up hazardous waste sites. Two of the major components of the SITE Program are the Emerging Technologies Program and the Demonstration Program. During the Emerging Technologies Program, the basic concepts of a new technology are validated through bench and pilotscale testing. If the technology shows promise, it may advance to the Demonstration Program. Along with other technologies selected through annual solicitation, the performance of these technologies is evaluated under field conditions. Reports discussing the procedures, sampling and analytical data, results, etc., are prepared after each step. When the demonstration is completed, an Applications Analysis Report is prepared to evaluate all the information available on a particular process and to analyze the applicability of the process to other sites, waste types, and media. Also, each year EPA publishes a document describing all the technologies that have been evaluated under the SITE Program. Further information on the SITE Program can be obtained from:

Robert A. Olexsey, Division Director
Superfund Technology Demonstration Division
513/569-7861 FTS: 684-7861

Stephen C. James, Chief
SITE Demonstration & Evaluation Branch
513/569-7877 FTS: 684-7877

Norma M. Lewis, Chief
Emerging Technology Section
513/569-7665 FTS: 6847665

John F. Martin, Chief
Demonstration Section
513/569-7758 FTS: 684-7758

Table 13. Superfund Records Of Decision Recommending the Use Of Incineration/Thermal Destruction For Site Remediation

Region I

Ottati and Goss
Re-Solve, Inc.
Davis Liquid Waste
Cannon Engineering Corp.
Rose Disposal Pit
Charles George Landfill No. 3
Pinette's Salvage Yard
Wells G&H
Baird & McGuire
O'Connor Company Site
Norwood PCBS
W. R. Grace

Region II

Volney Landfill
Williams Property
Renora, Inc.
Brewster Wellfield
Ewan Property
Reich Farms
KinBuc Landfill
Bog Creek Farm
Claremont Polychemical
Fulton Terminals
Pepe Field
Port Washington Landfill
Vineland State School

Region III

Ordnance Works Disposal
Douglassville Disposal
Westline Site
Wildcat Landfill
Southern Maryland Wood
Berks Sand Pit
Drake Chemical Pit
Avtex Fibers, Inc.
Tyson Dump No. 1
MW Manufacturing Site
Douglassville Disposal

Region IV

Geiger (C&M Oil) Site
Tower Chemical
Martin MariettaSodyeco
Zellwood Groundwater
Chemtronics, Inc.
Alpha Chemical Corp.
Celanese Corp. Shelby Fiber
Amnicola Dump
Aberdeen Pesticide Dumps
Newsom Brothers Old Reichold
Carolawn
Smith's Farm Brooks

Region V

Laskin/Poplar Oil
Liquid Disposal
Seymour Recycling Corp.
Pristine, Inc.
LaSalle Electrical Utilities
Forest Waste Disposal
Belvidere Municipal Landfill
Summit National Disposal Service
Fort Wayne Reduction
Laskin/Poplar Oil
Wedzeb Enterprises, Inc.
Ninth Avenue Dump
Miami County Incinerator
Alsco Anaconda
Cliff/Dow Dump
Cross Brothers Pail Recycling
Big D Campground
Twin City Army Ammo Plant

Region VI

Hardage/Criner
Cleve Reber
Bayou Bonfouca
Brio Refinery Co., Inc.
Koppers Co.
South Cavalcade Street
Gurley Pit
Sheridan Disposal Services
Motco, Inc.
United Creosoting Co.

Region VII

Minker/Stout/Romaine
Times Beach
Hastings Groundwater

Region VIII

Broderick Wood Products Co.
Libby Groundwater
Woodbury Chemical Co.
Sand Creek Industrial

Region IX

Lorentz Barrel and Drum Co.

Region X

Pacific Hide & Fur
Northwest Transformer

Federal Laws

Section 121 of CERCLA requires that any Superfund action that results in a hazardous substance or contaminant remaining onsite attain a level of control that is at least equivalent to any Federal standard, criteria, or limitation considered applicable or relevant and appropriate (ARARs). Applicable requirements are those standards, criteria, or limitations that address a specific hazardous substance, pollutant, action, location, or other circumstance at a site. Relevant and appropriate requirements are those standards, criteria, or limitations that deal with problems or situations sufficiently similar to those encountered at the site to be considered both relevant and appropriate.

CERCLA actions conducted entirely onsite must comply only with the substantive requirements of ARARs, not the administrative requirements. Thus, CERCLA exempts any onsite action from having to obtain a Federal, state, or local permit; however, the action is not exempt from complying with the substantive portions of the same laws that the permits enforce. Remedial actions that use offsite facilities during the cleanup must comply with both the substantive and the administrative portions of all legally applicable requirements. Also, these actions must be conducted only at facilities that are in compliance with all applicable Federal and state requirements.

Remedial actions also must consider nonregulatory guidance manuals or advisories issued by Federal or state agencies. These "to-be-considered" (TBC) materials are important because they provide interpretation and analysis of ARARs.

ARARs can be chemical-specific, location-specific, or action-specific. Chemical-specific ARARs, such as the RCRA or the Safe Drinking Water Act Maximum Contaminant Levels (MCLs), and location-specific ARARs, such as Wetlands or Wilderness area standards, are too site-specific to be dealt with here. More information on these subjects can be obtained from the document entitled *CERCLA Compliance With Other Laws Manual: Interim Final,* which is listed in the selected bibliography of guidance and resource documents (see page 27).

Action-specific ARARS are standards or requirements related to technology- or activity-based remedial alternatives, such as incineration. Table 14 lists potential ARARs that <u>are</u> applicable to onsite incineration as a CERCLA remedial action under EPA's HSWA omnibus authority. As new statutes are passed or regulations promulgated, other action-specific requirements will need to be added to this list. The proposed amendments to the hazardous waste incinerator regulations (55 FR 17862, April 27, 1990) and the proposed procedures and technical requirements for corrective action at waste management sites (55 FR 30798, July 27, 1990) will be important potential ARARs when promulgated.

State Laws

State regulations that are more stringent than Federal standards must also be met during CERCLA actions if they are identified in a timely manner by the state and if they meet the criteria of being promulgated, generally applicable, and legally enforceable. Whether the state is the lead or the support agency, it is solely responsible for identifying potential state ARARs and documenting the particular sections that are applicable to the site under remediation. The EPA, however, always retains the responsibility for the final decision on the applicability or the possible waiver of ARARs. Examples of state laws that are potential ARARs include:

- ***Siting Requirements:*** Most states have locational standards that are more restrictive than the Federal regulations and that are specific to a site's topographic, hydrologic, or geologic characteristics. Remedial activities, such as the use of a mobile incinerator, could be subject to siting limitations established for that type of facility or that area if those limitations are based on the protection of human health and the environment.

- **Discharge of Toxic Pollutants to Surface Waters:** The Clean Water Act required states to adopt numeric criteria for the discharge or presence of toxic pollutants applicable to the water body and sufficient to protect the designated use. A proposed discharge of incineration scrubber water into surface water could be in conflict with state regulations.

- **Cleanup Standards:** States may enact more stringent cleanup standards than those required under Federal law. For example, under Federal law cleanup of releases of hazardous substances must leave no more than 25 ppm polychlorinated biphenyls (PCBs) in the area; however, under Texas law, cleanups must leave no more than 1 ppm.

Generally, CERCLA actions need not comply with local laws; however, the laws may be part of a regional plan enforceable by the state and, as such, are potential state ARARs. Table 14 lists potential incineration ARARs.

State standards are an integral part of determining the remediation alternatives and the level of control. The public comment period is not the time to identify conflicts between a selected remedial action and a state regulation. The document CERCLA Compliance with Other Laws Manual, Part II, contains detailed information on identifying and complying with state ARARS.

TABLE 14. POTENTIAL INCINERATION ARARS[a,b]

Prerequisite for Applicability	Requirement	Citation
RCRA		
RCRA hazardous waste	Analyze the waste feed to determine physical and chemical composition limits.	40 CFR 264.341
	Dispose of all hazardous waste and residues, including ash, scrubber water, and scrubber sludge, according to applicable requirements.	40 CFR 264.351
	(Note: No further requirements for wastes that are listed as hazardous solely because they exhibit one or more of the characteristics of ignitability, corrosivity, reactivity or because they fail the TCLP leaching test and a waste analysis demonstrates no Appendix VIII constituent is present that might reasonably be expected to be present.) Such wastes may also be exempted if Appendix VIII constituents are not present at significant levels.l	40 CFR 264.340
	Performance standards:	
	Achieve a destruction and removal efficiency (DRE) of 99.99 percent for each principal organic hazardous constituent designated in the waste feed and 99.9999 percent for dioxins and PCB contaminated liquids.	
	Reduce hydrogen chloride emissions to 1.8 kg/hr or to 1 percent of the HCl in the stack gas before entering any pollution control device.	
	No release of particulates >180 mg/dscm (0.08 gr/dscf) corrected to 7% Oxygen.	
	Emissions of CO must be <100 ppm and emissions of THC must be <20 ppm corrected to 7% Oxygen.	RCRA Omnibus Authority
	Metals emissions less than those established using the tiered approach outlined in the document "Guidance on Metal and HCl Emissions for Hazardous Waste Incinerators" August 1989.	
	Trial Burn Requirements	40 CFR 270.62
	All residues must meet the RCRA Land Disposal Restrictions	40 CFR 268
	Control fugitive emissions by:	
	Keeping combustion zone sealed; or Maintaining combustion-zone pressure lower than atmospheric pressure.	40 CFR 264.345
	Use automatic cutoff system to stop waste feed when operating conditions deviate or exceed established limits.	40 CFR 264.345
	Monitor various parameters during operation, including combustion temperature, waste feed rate, indication of combustion gas velocity, and carbon monoxide in stack gas.	40 CFR 264.347
CAA		
Air emissions	Remediation activities must comply with the National Ambient Air Quality Standards (NAAQS). Compliance should be determined in cooperation with the appropriate state government agency. An air permit from the state may be required.	40 CFR 50

TABLE 14. POTENTIAL INCINERATION ARARS[a,b] (Cont.)

Prerequisite for Applicability	Requirement	Citation
TSCA		
Liquid PCBs at concentration of 50 ppm or greater.	Performance standards:	40 CFR 761.70
	2-second residence time at 1200°C (±100°C) and 3 percent excess oxygen in stack gas; or	
	1.5-second residence time at 1600°C and 2 percent excess oxygen in stack gas.	
	Combustion efficiency of at least 99.90 percent.	
	DRE>99.9999%	
	Rate and quantity of PCBs fed to the combustion system shall be measured and recorded at regular intervals of no longer than 15 minutes.	40 CFR 761.70
	Temperature of incineration shall be continuously measured and recorded.	40 CFR 761.70
	Flow of PCBs to incinerator must stop automatically whenever the combustion temperature drops below specified temperature."	40 CFR 761.70
	Monitoring must occur:	40 CFR 761.70
	When the incinerator is first used or modified; monitoring must measure for O_2, CO, CO_2, oxides of nitrogen, HCl, RCl, PCBs, total particulate matter.	40 CFR 761.70
	Whenever PCBs are being incinerated, the O2, CO, CO2, oxides of nitrogen and CO levels must be continuously checked; CO2 must be periodically checked.	
	Water scrubbers must be used for HCl control.	40 CFR 761.70
Non-liquid PCBs, PCB articles, PCB equipment, and PCB containers at concentrations of 50 ppm or greater.	Mass air emissions from the incinerator shall be no greater than 0.001g PCB per kg of the PCBs entering the incinerator (99.9999 percent DRE).	40 CFR 761.70
	Requirements as listed for liquid PCBs.	40 CFR 761.70
FIFRA	Performance standards:	
Organic pesticides, except organic mercury, lead, cadmium, and arsenic (recommended).	2-second residence time at 1000°C (or equivalent that will assure complete destruction).	40 CFR 165.8 40 CFR 165.1
	Meet requirements of CAA relating to gaseous emissions.	40 CFR 165.8
	Dispose of liquids, sludges, or solid residues in accordance with applicable Federal, State, and local pollution control requirements.	40 CFR 165.8
Metallo-organic pesticides, except mercury, lead, cadmium, or arsenic compounds (recommended).	Chemically or physically treat pesticides to recover heavy metals; incinerate in same manner as organic pesticides.	40 CFR 165.8
Combustible containers that formerly held organic or metallo-organic pesticides, except organic mercury, lead, arsenic, and cadmium (recommeded).	Incinerate in same manner as organic pesticides.	40 CFR 165.9
OSHA		
Remediation activities	All remediation activities must comply with the policies and programs established for worker safety.	29 CFR 1910 29 CFR 1926

[a] Source: U.S. Environmental Protection Agency 1988a and 1989a.

[b] The regulations cited herein may contain special provisions or variances applicable to the specific site under remediation. In all circumstances the actual regulations should be consulted before any decisions are formulated.

COST OF INCINERATION

Incineration costs will vary significantly from site to site. Unfortunately, costs are often sources of controversy during site remediation. The relatively high cost of incineration often eliminates it as a treatment option. This being the case, it is very important to conduct an accurate cost assessment. Since detailed cost estimation is not within the scope of this document, the RPM/OSC is urged to work in close coordination with the RCRA incineration contacts in each Region during the development of cost estimates for incineration projects. To provide some preliminary background information on this topic, the following information is provided.

The cost of an incineration system varies with several factors, including:

- System capacity
- Types of feedstocks being fed
- Regime (i.e., slagging vs. ashing)
- Length-to-diameter (L/D) ratio for rotary kilns
- Type of solids discharge system
- Type and capacity of afterburner
- Type of auxiliary fuel used
- Regulatory climate

These costs in turn affect the cost of waste treatment by incineration. Table 15 presents the estimated costs of incinerating contaminated soils in both onsite and offsite incineration systems. These costs do not include transportation, storage, or removal of the soil from the ground. The total cost of waste treatment would vary considerably from site to site, and any estimate should include the following (Evans 1990):

- Site preparation
- Permitting and regulatory requirements
- Capital equipment
- Startup
- Labor
- Consumables and supplies
- Utilities
- Effluent treatment and disposal
- Residuals/waste shipping and handling
- Analytical services
- Maintenance and modifications
- Demobilization

Table 15. Typical Costs of Incineration of Contaminated Soils[a,b]

	Incineration system capacity (tons/h)	Unit cost ($/ton)
Centralized rotary kiln system	Commercial unit	300 to 650
Onsite incineration		
Small site (<5,000 tons)	<5	1000 to 1500
Medium site (5,000 to 10,000 tons)	5 to 10	300 to 800
Large site (>30,000 tons)	>10	100 to 400

[a] Estimated costs are in 1988 dollars. They do not include the cost of transportation, removal of soils from the ground, or storage.

[b] Sources: Cudahy, Decicco, and Troxler 1987; Tillman, Rossi, and Vick 1990; U.S. Environmental Protection Agency 1988.

SOURCES OF INFORMATION

Technical Specialists

Communication between the RPM, the EPA Regional office, and the corresponding state environmental office is critical. **More importantly, communication with the RCRA incineration experts and technical contacts in each Regional office who have extensive incineration expertise is vital to the success of remedial/removal activities involving incineration.** Any remediation plans involving an incinerator should be sent to the Regional RCRA incinerator permit office for review. Getting this office involved early in the remediation selection process can prevent costly delays later. Each Regional office has an incinerator expert available as a technical specialist to advise and assist the RPM. Many states also have technical contacts with extensive experience in incineration. The following is a list of the EPA Headquarters and Regional incinerator experts and the corresponding state expert. If a state does not have an incinerator expert on their staff, the RPM is referred to the Regional office.

Contact		FTS	Commercial
Headquarters			
Sonya Sasseville, Chief Alternative Technology and Support Section		382-3132	202/382-3132
Lionel Vega, Incineration Permit Assistance		475-8988	202/475-8988
Region I.			
Stephen Yee		833-1644	617/573-9644
John Podgurski		833-1673	617/573-9673
Connecticut	George Dews		203/566-2264
Maine	See Regional contact.		
Massachusetts	Stephen Dresszen		617/292-5832
New Hampshire	See Regional contact.		
Rhode Island	Beverly Migllore		401/277-2797
Vermont	See Regional contact.		
Region II.			
John Brogard		264-8682	212/264-8682
Clifford Ng (Puerto Rico)		264-9579	212/264-9579
New Jersey	Thomas Sherman		609/292-1250
New York	James Dolen		518/457-6934
Region III.			
Gary Gross		597-7940	215/597-7940
Delaware	Ken Weiss		302/736-3689
Dist. of Columbia	Angelo Tompros		202/783-3194
Maryland	Alvin Bowles		301/631-3343
Pennsylvania	Joe Hayes		717/787-7381
Virginia	Karol Akers		804/225-2496
West Virginia	Robert Weser		304/348-4022
Region IV.			
Betty Willis		257-3433	404/347-3433
Alabama	Clyde Shearer		205/271-7700
Florida	John Griffith		904/488-0300
Georgia	Bill Mundy		404/656-2833
Kentucky	Mohammed Alauddin		502/564-6716
Mississippi	Steve Spengler		601/961-5171
N. Carolina	Bill Hamner		919/733-2178
S. Carolina	David Wilson		803/734-5200
Tennessee	Jackie Okoree-Baah		615/741-3424
Region V.			
Y. J. Kim		886-6147	312/886-6147
Juana Rojo (Illinois)		886-0990	312/886-0990
Gary Victorine (Indiana)		886-1479	312/886-1479
Lorna Jereza (Michigan)		353-5110	312/353-5110
Wen Haung (Minnesota)		886-6191	312/886-6191
Thelma Codina (Ohio)		886-6181	312/886-6181
Wen Haung (Wisconsin)		886-6191	312/886-6191
Illinois	Robert Watson		217/785-8410
Indiana	Elaine Greg		317/232-8866
Michigan	Steve Buda		517/373-2730
Minnesota	Fred Jenness		612/297-1792

Contact		FTS	Commercial
Ohio	Bob Babik		614/644-2949
Wisconsin	Ed Lynch		608/266-3084
Region VI.			
Henry Onsgard		655-6785	214/655-6785
Jim Sales (Texas)		655-6785	214/655-6785
Stan Burger (Arkansas, Louisiana, Oklahoma, New Mexico)		655-6785	214/655-6785
Arkansas	Mike Bates		501/562-7444
Louisiana	Karen Fisher		504/342-4685
New Mexico	Dr. Elizabeth Gordon		505/827-2934
Oklahoma	Catherine Sharp		405/271-7062
Texas	Wayne Harry		512/463-8173
Region VII.			
Joe Galbraith		276-7057	913/551-7057
Luetta Flournoy (Iowa)		276-7058	913/551-7653
Iowa	See Regional contact.		
Kansas	John Ramsey		913/296-1610
Missouri	John Doyle		314/751-3176
Nebraska	Glen Dively		402/471-4176
Region VIII.			
Nat Miullo		330-1500	303/330-1500
Colorado	Neal Kolwey		303/331-4830
Montana	See Regional contact.		
N. Dakota	See Regional contact.		
S. Dakota	See Regional contact.		
Utah	Connie Nakahara		801/538-6170
Wyoming	See Regional contact.		
Region IX.			
Larry Bowerman		484-1471	415/744-1471
Arizona	Al Roesler		602/257-2249
California	Sangat Kals		916/324-9611
Region 1	Eric Hong		916/855-7726
Region 2	Don F. Murphy		415/540-3969
Region 3	Gautum Guha		818/567-3123
Region 4	Anand Rege		213/590-4896
Hawaii	Les Segunda		808/548-8837
Nevada	Don Gross		702/885-5872
Region X.			
Cathy Massimino		399-4153	206/442-4153
Alaska	David Ditraglia		907/465-2671
Idaho	Jay Skabo		208/334-5879
Oregon	Ed Chiong		503/229-5326
Washington	Cindy Gilder		206/438-7019

GUIDANCE AND RESOURCE DOCUMENTS

EPA Hazardous Waste Incineration Guidance Series

Volume I: Guidance Manual for Hazardous Waste Incinerator Permits. SW-966, July 1983. NTIS: PB84-100577 (update expected late 1990)

Volume II: Guidance on Setting Permit Conditions and Reporting Trial Burn Results. EPA-625/6-89-019, January 1989.

Volume III: Hazardous Waste Incineration Measurement Guidance Manual. EPA-625/6-89-021, June 1989. NTIS: PB90-182759.

Volume IV: Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators. 1989 Draft Report.

Volume V: Guidance on PIC Controls for Hazardous Waste Incinerators. 1989 Draft Report.

Volume VI: Proposed Methods for Measurement of CO, O2, THC, HCl, and Metals at Hazardous Waste Incinerators. 1989 Draft Report.

Other EPA Resource Documents

CERCLA Compliance with Other Laws Manual: Interim Final. EPA 540/G-89-006. August 1988.

CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements. EPA 540/G-89-009, August 1989.

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA: Interim Final. EPA 540/G-89-004. October 1988.

Engineering Handbook for Hazardous Waste Incineration. SW-889, September 1981. NTIS: PB81-248163. (update expected late 1990).

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