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Project Summary

Hazardous Waste Combustion in Industrial Processes: Cement and Lime Kilns

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The full report summarizes the results of several studies relating to hazardous waste combustion in cement and lime kilns. The tests included in this study are four kilns tested by the U.S. Environmental Protection Agency (EPA), four kilns tested by State agencies or the kiln operator, two Canadian tests, and one Swedish test. The predominant types of wastes tested included chlorinated organic compounds, aromatic compounds, and metal-contaminated waste oil. The kiln types include lime kilns and cement kilns, which included the dry, wet, and preheated processes. Fabric filters and electrostatic precipitators (ESPs) were the pollution control devices used in these processes, and the primary fuels included coal, coke, coal/coke, fuel oil, and natural gas/coke.

The parameters examined in this study were Destruction and Removal Efficiency (DRE) of the Principal Organic Hazardous Constituents, particulate and HCl emissions, metals, and the effect of burning hazardous waste on SO_2, NO_x, and CO emissions. The primary conclusion of this study is that DREs of 99.99% or greater can be obtained in properly operating calcining kilns. Particulate matter can increase when chlorinated wastes are burned in a kiln equipped with an electrostatic precipitator. Those kilns equipped with fabric filters showed no change in emissions.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

With the passage of the Hazardous and Solid Waste Amendments of 1984, more categories of liquid hazardous wastes will be banned from land disposal facilities. At the same time, energy intensive industries are increasingly seeking to find new sources of less expensive fuel. Because many industrial waste products can be readily used as fuels and some hazardous wastes can be economically processed and made into fuels, a market based on hazardous waste has been developing in the United States. If reprocessed waste liquids do contain significant quantities of toxic metals, halogenated materials, or PCBs, and have a high heating value, they can be economically substituted for coal, coke, oil or natural gas in many industrial processes. There are many examples of high temperature industrial furnaces and processes which already burn hazardous waste as supplemental fuel: cement kilns (both wet and dry processes), lime and dolomite kilns, clay processing kilns, steel blast furnaces, phosphate rock calciners and dryers, iron ore dryers, brick and tile tunnel kilns, mineral wool furnaces and glass melt furnaces.

In particular, there has been a great deal of interest in the use of cement kilns for the disposal of industrial wastes as supplemental fuel for several reasons: 1)

the production process is highly energy intensive; fuel savings may translate into a competitive advantage; 2) kiln temperatures are higher (2700°F) and gas residence times are longer (6-10 seconds) than those encountered in most hazardous waste incinerators; 3) cement product quality is relatively insensitive to addition of most waste trace impurities.

A US EPA study, published in 1982, recommended that the Agency conduct a full assessment of the use of waste organic materials as supplemental fuel in cement kiln[1]. As a result of that recommendation, the Agency began a field test program at facilities using hazardous waste as fuel. In addition to these EPA field tests, results from test burns reported by other investigators are incorporated in this study. A summary of the tests used in this assessment and a description of each site is listed in Table 1. The data generated by these studies are being used to assess health and environmental risks, develop regulations, and define reasonable operating limits.

Using the data from all test sites listed in Table 1, the full report is intended to evaluate the effectiveness of the calcining process in destroying the waste, to determine any significant change in criteria pollutant emissions, and to measure HCl emissions from the process when burning chlorinated wastes.

Particulate Matter

Most of the tests conducted at kilns using electrostatic precipitators exhibited little change in particulate emissions when burning hazardous wastes. A summary of the data for each test is listed in Table 2. The major exceptions are tests during which there were either process equipment malfunctions or high amounts of chlorine being fed to the kiln. The latter tests have led to the conclusion that substantial chlorine input (>6 kg Cl/Mg clinker) to a kiln can lead to greater particulate emissions in kilns equipped with electrostatic precipitators.

Destruction and Removal Efficiencies for Principal Organic Hazardous Constitutents

Cement kilns, burning hazardous wastes as a fuel, will have to meet, in the near future, Federal regulations for incinerators. Specifically, with regard to the Principal Organic Hazardous Constituents (POHCs), the facility must achieve a destruction and removal efficiency (DRE) of 99.99% for each designated POHC.

The DRE is determined as follows:

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100\%$$

where:

W_{in} = mass feed rate of a specific POHC in waste feed stream

W_{out} = mass flow rate of the same POHC in exhaust emissions to the atmosphere

Table 3 summarizes the results of the tests for which DRE was determined. In general, the results show that cement kilns, when well operated, can achieve destruction and removal efficiencies equal to those achieved by well designed and well operated hazardous waste incinerators.

Conventional Pollutants and Hydrogen Chloride Emissions

The process materials in the cement and lime manufacturing process are, by their nature, very alkaline. This property enables the process to adsorb acid gases, such as HCl, generated in the combustion of chlorinated organics. For the most part, the data shows that for typical amounts of chlorinated waste fed to these processes, HCl emissions are lower than the 1.8 kg/hr limit specified by the incinerator regulations. HCl removal efficiencies, based on stack gas measurements, were greater than 99%.

The criteria pollutants, CO, SO_2 and NO_x were measured in six of the nine tests evaluated. Significant changes in pollutant emissions were noted from test to test, but were not related to the use of hazardous waste as a fuel. Normal fluctuations in fuel, combustion air flow and air preheater temperature are responsible for changes in the observed pollutant emissions.

Lead Emissions

Lead emissions and the lead content of process waste dust increase when hazardous waste, contaminated with significant quantities of lead, are burned. However, baseline emissions (no waste being burned) of lead are very low to begin with and, although emissions do increase with waste burning, more than 99 percent of the lead entering the process is captured by the process materials and the resulting emission rat are not significant.

Conclusions

Field tests conducted at nine ceme and lime producing facilities burni hazardous wastes indicate that POH DREs generally exceed 99.99 perce under good operating conditions. Crite pollutant emissions (SO_2, NO_x,CO) we not significantly affected by was burning. HCl and lead emissio increased with waste burning, b emission rates were not significa Particulate emissions increase w increasing chlorine content of the wa in facilities equipped with ESPs. Cont of particulate from kilns equipped w baghouses is not a significant problem.

Reference

(1) Hazelwood, D., et al, 19 Assessment of Waste Fuel Use Cement Kilns, U S. Environmen Protection Agency, 1982.

Table 1. *Summary of Cement and Lime Kiln Tests*

	Plant	Date	Process	APCD	Fuel	Wastes
1	St. Lawrence Cement Mississauga, ON	1974 1975-76	Dry Wet	ESP ESP	Fuel Oil Fuel Oil	Waste oil Chlorinated organics
2	Stora Vika Sweden	1978	Wet	ESP	Coal	Chlorinated organics, PCBs, Freon 113
3	Marquette Cement Oglesby, IL	1981	Dry	ESP	Coal	Hydrocarbon solvents (<5% chlorine)
4	San Juan Cement Puerto Rico	1981-82	Dry	Baghouse	Fuel Oil	Chlorinated organics
5	Alpha Cement Cementon, NY	1982	Wet	ESP	Coal	Solvents
6	General Portland Lebec, CA	1982	Dry	Baghouse	Coal	Hydrocarbon solvents
7	General Portland Paulding, OH	1983	Wet	ESP	Coal	Hydrocarbon solvents, Freon 113
8	Lone Star Industries Oglesby, IL	1983	Dry	ESP	Coal/Coke	Hydrocarbon solvents, Freon 113
9	Rockwell Lime Manitowoc, WI	1983	Lime	Baghouse	Coke	Hydrocarbon solvents

Table 2. *Summary of Particulate Emission Data*

Plant	Test Condition	Particulate Emission gr/scf	lb/hr	lb/ton[3]	Chloride Input to Kiln (kg/Mg)
St. Lawrence	Chlorinated aliphatics[1]	0 21	123	3	4.0
	Chlorinated aromatics	0 286	45	1 1	5 5
	PCBs	0.078	44	1 1	2 5
	Baseline	0 038	21	0 5	-
	Lubricating oil	0.064	83	0 7	-
	Baseline	0.107	139	1.1	-
Rockwell Lime	Waste	0 016	2.2	0 26	2 7
	Baseline	0.013	2.0	0 24	-
Stora Vika	Aliphatics	0 039	21	0 88	4 4
	Baseline	0.009	4 7	0.21	0
	PCBs	0.024	12.7	0.53	3 6
	Baseline	0 011	5.9	0.25	0
	Chlorophenols & Phenoxyacids	0 058	30 9	1.36	0 95
	Baseline	0.014	7.7	0.34	0
	Freon 113	0 062	33 3	1 39	1 7
	Baseline	0 022	11 7	0 49	0
Marquette	Waste solvents	0.014	58	21	1 1
	Baseline	0 093	80	20 8	-
Alpha Cement	Solvents	0 041	44	0 8	-
	Baseline	0 050	53	1 1	-
San Juan	Wastes	0 043	22.4	0 66	5.5
	Baseline	0 041	21 7	0.64	-
General Portland Paulding	Wastes	0 030	18 9	0.65	2 2
	Baseline	0 030	19 6	0.64	0.2
Lone Star	Waste[2]	0.17	116	2 0	1 2
	Baseline				0.2

[1]Process upset during test.
[2]ESP malfunctioned during test.
[3]lb of particulate emitted per ton of product material (cement).

Table 3. *Summary of DRE Data*

Plant	Waste Component	Destruction Efficiency
St. Lawrence Cement	Chlorinated aliphatics	>99.990
	Chlorinated aromatics	>99.989
	PCBs	>99.986
Stora Vika	Methylene chloride	>99.995
	Trichloroethylene	>99.9998
	All chlorinated hydrocarbons	>99.988
	PCB	>99 99998
	Chlorinated phenols	>99 99999
	Phenoxy acids	>99.99998
	Freon 113	>99 99986
San Juan Cement	Methylene chloride	93.292-99.997
	Trichloromethane	92.171-99 96
	Carbon tetrachloride	91.043-99.996
Los Robles (General Portland)	Methylene chloride	>99 99
	1,1,1-Trichloroethane	99.99
	1,3,5-Trimethylbenzene	>99.95
	Xylene	>99 99
Paulding (General Portland)	Methylene chloride	99 956-99.998
	Freon 113	>99.999
	Methyl ethyl ketone	99.978-99.997
	1,1,1-Trichloroethane	99.991-99.999
	Toluene	99 940-99.988
Oglesby (Lone Star)	Methylene chloride	99.94-99.99
	Freon 113	99 999
	Methyl ethyl ketone	99 997-99.999
	1,1,1-Trichloroethane	>99 999
	Toluene	99 986-99.998
Rockwell Lime	Methylene chloride	99.9947-99 9995
	Methyl ethyl ketone	99.9992-99.9997
	1,1,1-Trichloroethane	99.9955-99.9982
	Trichloroethylene	99.997 -99 9999
	Tetrachloroethylene	99 997 -99.9999
	Toluene	99.995 -99.998

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The complete report, entitled "Hazardous Waste Combustion in Industrial Processes: Cement and Lime Kilns" (Order No. PB 88-126 412/AS; Cost: $14.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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