DIOXIN EMISSIONS FROM SOIL BURNING INCINERATORS

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Abstract

The U.S. Environmental Protection Agency (EPA) hazardous waste combustion strategy recommends that total polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) stack emissions from facility trial burns not exceed 30 nanograms per dry standard cubic meter (ng/dscm). EPA's recently proposed Hazardous Waste Combustion Rule contains a 0.2 ng/dscm emissions standard for PCDD/PCDFs, when measured on toxic equivalency (TEQ) basis. Measured PCDD/PCDF emissions from soil burning mobile incinerators at 16 sites were evaluated for both total dioxin/furans and dioxin/furan TEQ emissions. Seventy-five percent of the units met the 30 ng/dscm total dioxins limit, but less than 40 percent met the proposed 0.2 ng/dscm TEQ regulatory standard. At one site, 18 separate stack tests for dioxins were performed in less than two years. In each case, the TEQ emissions were well below 0.2 ng/dscm. Average total dioxin emissions varied by about 200-fold over the sampling events, while average dioxin-TEQ emissions varied by about 13-fold.

Introduction

Combustion of waste has been identified as a significant source for formation of dioxins. In November 1994, EPA issued a final *Strategy for Hazardous Waste Minimization and Combustion*[1] recommending that total PCDD/PCDF stack emissions measured during facility trial burns not exceed 30 ng/dscm. In April 1996, EPA issued the proposed Hazardous Waste Combustion Rule [2] calling for emissions of the 17 potentially toxic PCDDs and PCDFs not to exceed 0.2 ng/dscm TEQs @ 7% oxygen (0_2). These potentially toxic PCDDs and PCDFs are congeners having 4 to 8 chlorine substituents with chlorine atoms occupying the 2,3,7, and 8 positions of the aromatic ring structure.

On-site incineration of contaminated soils has historically been a preferred method of remediation at hazardous waste sites containing difficult to destroy compounds. This paper summarizes and evaluates dioxin/furan stack emissions data from 16 sites at which incineration of contaminated soils and other debris in mobile units were conducted, and also presents information on their design and the significant contaminants in the soil at each site.

Experimental Methods

Readily available trial burn and other emission testing reports for soil incineration facilities [3-20] were obtained. Only results of congener-specific testing were considered. Typically, three test runs were performed to make a test series. The data for each congener from each test run were estimated as ng/dscm corrected to 7% 0_2. The excess air corrections to 7% 0_2 considered any oxygen enrichment used in the incinerator when applicable. Standardized emission values for each congener were then

averaged for the test runs in an emission test series. Values below the detection limit were assumed to be one-half the detection limit. In addition, the TEQ of those congener-specific values (as 2,3,7,8-TCDD) and the total dioxins and furans (with 4 through 8 chlorines) were also calculated

The presented data were collected from test programs, primarily trial burns, in which "worst case" operating conditions, soil contaminant levels and maximum feed rates were obtained. In addition, data from field and trip blank samples were not used for emission rate corrections. Therefore, the presented data represent the average maximum emissions results from a test series. Ten of the 16 test results were from soil incineration facilities using the same type of incineration and air pollution control equipment (rotary kiln, secondary combustion chamber, baghouse and scrubber). In addition, the results of 18 test series over a 2 year period were available for one facility (Baird McGuire). The results of the 18 test series (one trial burn and 17 periodic test programs) were analyzed as a group to assess the variation in dioxin emissions and profile at one facility over time.

Results and Discussion

Table 1 presents data on the combustion technology and air pollution control equipment used at each site, as well as the chemical nature of the soil contamination. The incineration units at five of the sites burned wastes containing polychlorinated biphenyls (PCBs). At four of the sites, dioxins were either the primary contaminants of concern or one of a group of contaminants.

Table 2 shows the measured dioxin stack emissions at each site, both with respect to total emissions and TEQ emissions. These emission values were calculated from the averages of the test runs for the homologue groups and for each of the 17 congeners of concern. Average total PCDD/PCDF stack emissions from units at 12 of the sites were below the recommended 30 ng/dscm level. Average dioxin TEQ emissions, however, were below 0.2 ng/dscm at only six of the sites (all were less than 0.1 ng/dscm). At the remaining 10 sites, including the 4 exceeding the 30 ng/dscm level, TEQ emissions ranged from 0.21 to 2.91 ng/dscm. None of the units burning PCB-contaminated soil met the 0.2 ng/dscm TEQ emissions level. These results indicate that a significant fraction of soil-burning incinerators could have problems meeting a future emissions limit of 0.2 ng/dscm. Because of the limited data available and the similarities in data variation, no conclusions could be drawn regarding differences in emissions related to incineration or air pollution control technologies.

At the Baird McGuire Superfund site in Massachusetts, 18 separate stack sampling test series were performed over an 18-month period. Table 3 shows the minimum, average and maximum emissions from these sampling events for each of the 17 individual congeners of concern, for the congener classes containing a specific number of chlorine atoms, for total PCDDs/PCDFs, and for dioxin TEQs. Average dioxin TEQ emissions calculated from congener-specific values ranged from a low of 0.0023 ng/dscm to a high of 0.031 ng/dscm. Average total PCDD/PCDF emissions calculated as homologue specific values ranged from 0.017 ng/dscm to 3.6 ng/dscm. The variation among TEQ emissions (~13-fold) from independent sampling events was significantly less than the variation of results among total PCDD/PCDF measurements (~200-fold).

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Table 1: Summary Characteristics of Soil Incineration Units

Site	Combustion Equipment[a]	APC Equipment[b]	Primary Soil Contaminants[c]	Permitted Feed Rate (Tons/hr)
American Creosote [3]	RK, SCC	BH, SB	PAH, Phenols, VOC	16
Baird McGuire [4,5]	RK, SCC	BH, SB	Chlordane, Dieldrin, PAH, Arsenic, PCDD/PCDF	26.2
Coal Creek [6]	RK, SCC	BH, SB	PCB, Metals	4.9
Laskin Poplar [7]	RK, SCC	BH, SB	PCB, Tars, Oils, PAH, PCDD/PCDF	5.4
Lindsley Lumber [8]	IR, SCC	SB	PCP, Metals, Naphthalene	7.1
Times Beach [9,10]	RK, SCC	WESP, SB	PCDD/PCDF	41.7
F.T. Rose [11]	RK, SCC	CY, SB	PCB	51.8
Sanders Aviation [12]	RK, SCC	BH, SB	Toxaphene, DDT, DDE	12.5
Woods Industries [13]	RK, SCC	BH, SB	DDT, Dieldrin, Hexachlorobenzene	25.5
Southern Ship [14]	RK, SCC	SB	PAH	28.5
Rocky Boy [15]	RK, SCC	SB	PCP	2.25
University of Minnisota-Rosemount Research Center [16]	RK, SCC	BH, SB	PCB, Lead	6.2
Old Midlands Products [17]	RK, SCC	BH, SB	PCP, PCDD/PCDF	16.25
Bog Creek Farms [18]	RK, SCC	BH, SB	Unknown	17.6
Blackfeet Post and Pole [19]	RK, SCC	SB	PCP	1.85
Crab Orchard National Wildlife Refuge [20]	RK, SCC	CY, BH, SB	PCB, Cadmium, Lead	51.5

a RK - Rotary Kiln
SCC - Secondary Combustion Chamber
IR - Infrared Kiln

b BH - Baghouse
SB - Scrubber
WESP - Wet Electrostatic Precipitator
CY - Cyclone

c PAH - Polynuclear Aromatic Hydrocarbons
VOC - Volatile Organic Compounds
PCB - Polychlorinated Biphenyls
PCDD/PCDF - Polychlorinated Dibenzo-p-dioxins/furans
PCP - Pentachlorophenol

Table 2: Summary of Soil Incinerator Test Results

Site	Test Date(s)	2,3,7,8-TCDD TEQ (ng/dscm @ 7% O_2)	Total PCDD/PCDF (ng/dscm @ 7% O_2)
American Creosote [3]	December 1996	0.859	53.5
Baird McGuire [4,5]	January 1995 (Trial Burn) July 1995-January 1997 (Periodic Tests)	0.008	0.3
Coal Creek [6]	January 1994	0.284	7.0
Laskin Poplar [7]	January 1992	1.70	71.9
Lindsley Lumber [8]	November 1991	1.16	28.2
Times Beach [9, 10]	November 1995 and January 1997	0.030	0.8
F.T. Rose [11]	October 1993	1.50	44.3
Sanders Aviation [12]	September 1995	0.086	3.0
Woods Industries [13]	May 1995	0.008	0.8
Southern Ship [14]	December 1995	0.010	0.2
Rocky Boy [15]	June 1990	0.218	4.6
University of Minnisota-Rosemount Research Center [16]	March 1993	0.343	9.2
Old Midlands Products [17]	May 1992	0.324	23.5
Bog Creek Farms [18]	April 1990	0.057	2.7
Blackfeet Post and Pole [19]	September 1990	2.91	92.1
Crab Orchard National Wildlife Refuge [20]	September 1996	0.311	17.3

Table 3: Summary of Dioxin/Furan Emissions from the Baird McGuire Soil Incineration Unit Over Time[4,5]

Compound Name	Minimum of Test Series (ng/dscm @ 7% O_2)	Average of Test Series (ng/dscm @ 7% O_2)	Maximum of Test Series (ng/dscm @ 7% O_2)
	AVERAGE OF TEST SERIES VALUES		
PCDD/PCDF			
2378-TCDD	8.88E-04	2.54E-03	9.05E-03
Total TCDD	1.08E-03	1.24E-02	1.68E-01
12378-PeCDD	6.38E-04	2.82E-03	1.17E-02
Total PeCDD	1.43E-03	2.07E-02	3.20E-01
123478-HxCDD	1.58E-03	3.29E-03	1.49E-02
123678-HxCDD	4.91E-04	2.24E-03	1.07E-02
123789-HxCDD	5.95E-04	2.80E-03	1.49E-02
Total HxCDD	1.28E-03	4.75E-03	1.80E-02
1234678-HpCDD	1.32E-03	1.53E-02	1.70E-01
Total HpCDD	1.32E-03	2.04E-02	2.60E-01
Total OCDD	6.16E-03	1.45E-01	2.26E+00
Total PCDD	1.16E-02	2.03E-01	2.54E+00
2378-TCDF	5.82E-04	2.30E-03	1.32E-02
Total TCDF	5.82E-04	6.64E-03	5.17E-02
12378-PeCDF	4.95E-04	1.84E-03	5.25E-03
23478-PeCDF	4.97E-04	2.02E-03	5.92E-03
Total PeCDF	5.72E-04	7.27E-03	5.35E-02
123478-HxCDF	6.70E-04	2.78E-03	8.24E-03
123678-HxCDF	4.71E-04	1.99E-03	6.76E-03
234678-HxCDF	6.49E-04	2.36E-03	4.77E-03
123789-HxCDF	3.22E-03	6.23E-03	9.10E-03
Total HxCDF	3.14E-03	1.15E-02	3.88E-02
1234678-HpCDF	8.29E-04	5.26E-03	2.75E-02
1234789-HpCDF	9.79E-04	2.49E-03	4.79E-03
Total HpCDF	8.98E-04	1.01E-02	1.13E-01
Total OCDF	9.77E-04	2.82E-02	2.81E-01
Total PCDF	1.13E-02	6.37E-02	3.46E-01
TOTAL PCDD/PCDF	2.32E-02	2.67E-01	2.84E+00
2,3,7,8-TCDD TEQ	3.11E-03	7.86E-03	2.28E-02
	CALCULATED FROM CONGENER-SPECIFIC VALUES		
2,3,7,8-TCDD TEQ	2.34E-03	7.86E-03	3.09E-02
TOTAL PCDD	1.13E-02	2.03E-01	3.03E+00
TOTAL PCDF	6.17E-03	6.37E-02	5.38E-01
TOTAL PCDD/PCDF	1.74E-02	2.67E-01	3.56E+00