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Project Summary

Lime and Cement Industry Particulate Emissions: Source Category Report Volume I. Lime Industry

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The objective of this study was to develop particulate emission factors based on cutoff size for inhalable particles for the lime industry. After review of available information characterizing particulate emissions from lime plants, the data were summarized and rated in terms of reliability. Size specific emission factors were developed from these data for the major processes used in the manufacture of lime. A detailed process description was presented with emphasis on factors affecting the generation of emissions. A replacement for Section 8.15 (Lime Manufacturing) of EPA report AP-42, A Compilation of Air Pollutant Emissions Factors, was prepared, containing the size specific emission factors developed during this program.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, 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).

Introduction

The purpose of this program was to summarize the best available information on emissions of inhalable particulate matter in the lime industry. The main objective of the program was to develop reliable size specific emission factors for the various processes used in the production of lime. Both uncontrolled and controlled emission factors are presented in the report. The uncontrolled factors represent emissions which would result if the particulate control device (baghouse, scrubber, etc.) were bypassed, and the controlled factors represent emissions emanating from a particular type of control system. The size-specific emission factors are generally based on the results of simultaneous sampling conducted at the inlet and outlet of the control device(s), utilizing a variety of particle sizing techniques. Other objectives of this program were to present current information on the lime industry as well as prepare a replacement for Section 8.15 in EPA report AP-42, "A Compilation of Air Pollutant Emissions Factors."

The above objectives were met by a thorough literature search which included:

- Data from inhalable particulate characterization program,
- Fine Particle Emissions Inventory System (FPEIS),
- AP-42 background file at EPA's Office of Air Quality Planning and Standards (OAQPS),
- Midwest Research Institute files, and
- Various industry sources (e.g., National Lime Association).

The emission data contained in 45 reference documents were reviewed, analyzed, summarized, and ranked according to the criteria established by OAQPS, as published in the EPA report, "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections," April 1980. After ranking the data, emission factors were calculated using the highest quality data

TABLE 1. *Emission Factors for Lime Manufacturing*[a]

	Emission Factor Rating: B							
	Particulate[b]		Nitrogen oxides		Carbon monoxide		Sulfur dioxide	
Source	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Crushers, screens, conveyors, storage piles, unpaved roads, etc.	c	c	Neg	Neg	Neg	Neg	Neg	Neg
Rotary kilns[d]								
Uncontrolled[e]	180	350	1.4	2.8	1	2	f	f
Large diameter cyclone	81	160	1.4	2.8	1	2	f	f
Multiple cyclone	42	83	1.4	2.8	1	2	f	f
Electrostatic precipitator[g]	2.4	4.8	1.4	2.8	1	2	h	h
Venturi scrubber	2.4	4.8	1.4	2.8	1	2	h	h
Gravel bed filter[g]	0.53[i]	1.1[i]	1.4	2.8	1	2	h	h
Multiclone and venturi scrubber[g]	0.44	0.87	1.4	2.8	1	2	h	h
Baghouse	0.45[i]	0.89[i]	1.4	2.8	1	2	h	h
Cyclone and baghouse	0.055	0.11	1.4	2.8	1	2	h	h
Vertical kilns								
Uncontrolled	4	8	NA	NA	NA	NA	NA	NA
Calcimatic kilns[k]								
Uncontrolled	25	50	0.1	0.2	NA	NA	NA	NA
Multiple cyclone	3	6	0.1	0.2	NA	NA	NA	NA
Secondary dust collection[l]	NA	NA	0.1	0.2	NA	NA	NA	NA
Fluidized bed kilns	m	m	NA	NA	NA	NA	NA	NA
Product coolers								
Uncontrolled	20[n]	40[n]	Neg	Neg	Neg	Neg	Neg	Neg
Hydrators (atmospheric)[p]								
Wet scrubber	0.05	0.1	Neg	Neg	Neg	Neg	Neg	Neg
Crusher, screen, hammermill								
Baghouse	0.0005	0.001	Neg	Neg	Neg	Neg	Neg	Neg
Final screen								
Baghouse	0.0004	0.0008	Neg	Neg	Neg	Neg	Neg	Neg
Uncontrolled truck loading								
Limestone								
Open truck	0.75	1.5	Neg	Neg	Neg	Neg	Neg	Neg
Closed truck	0.38	0.76	Neg	Neg	Neg	Neg	Neg	Neg
Lime - closed truck	0.15[i]	0.30[i]	Neg	Neg	Neg	Neg	Neg	Neg

[a] Factors for kilns and coolers are per unit of lime produced. Divide by 2 to obtain factors per unit of limestone feed to the kiln. Factors for hydrators are per unit of hydrated lime produced. Multiply by 1.25 to obtain factors per unit of lime feed to the hydrator. Neg = negligible. NA = not available.

[b] Emission Factor Rating = D.

[c] Factors for these operations are presented in Sections 8.20 and 11.2 of AP-42.

[d] For coal fired rotary kilns only.

[e] No particulate control except for settling that may occur in stack breeching and chimney base.

[f] Sulfur dioxide may be estimated by a material balance using fuel sulfur content.

[g] Combination coal/gas-fired rotary kilns only.

[h] When scrubbers are used, <5% of the fuel sulfur will be emitted as SO_2 even with high sulfur coal. When other secondary collection devices are used, about 20% of the fuel sulfur will be emitted as SO_2 with high sulfur fuels, and <10% with low sulfur fuels.

[i] Emission Factor Rating = E.

[j] Emission Factor Rating = C.

[k] Calcimatic kilns generally have stone preheaters. Factors are for emissions after the kiln exhaust passes through a preheater.

[l] Fabric filters and venturi scrubbers have been used on calcimatic kilns. No data are available on particulate emissions after secondary control.

[m] Fluidized bed kilns must have sophisticated dust collection equipment for process economics, hence particulate emissions will depend on efficiency of the control equipment installed.

[n] Some or all cooler exhaust typically is used in kiln as combustion air. Emissions will result only from that fraction not recycled to kiln.

[p] Typical particulate loading for atmospheric hydrators following water sprays or wet scrubbers. Limited data suggest particulate emissions from pressure hydrators may be approximately 1 kg/Mg (2 lb/ton) of hydrate produced, after wet collectors.

available. The quality of the data used to develop each emission factor is indicated by the emission factor rating.

Process control system operating data as well as general industry information were also obtained and summarized as general background information. It was not part of this program to provide detailed engineering analyses, product specifications, or detailed evaluations of trends in the industry.

Summary of Results

Particulate emissions are generated from various activities at a lime plant including stone extraction, stone processing, calcination, pulverization, and hydration. The kiln potentially represents the largest single contribution to process-related particulate emissions in a lime plant. Fugitive dust emissions from open sources (i.e., unpaved roads) are also a major contributor but are not specifically treated in this report except for emissions from product loading.

Some sort of particulate control is generally applied to most kilns. Rudimentary fallout chambers and cyclone separators are commonly used for control of larger particles. Fabric and gravel bed filters, wet (commonly venturi) scrubbers, and electrostatic precipitators are used for secondary control. Cyclones, fabric filters, and wet scrubbers have been used on product coolers for particulate control. Hydrator emissions are low because water sprays or wet scrubbers are usually installed to prevent product loss in the exhaust gases. Other particulate sources in lime plants include primary and secondary crushers, mills, screens, mechanical and pneumatic transfer operations, storage piles, and roads.

The total mass controlled and uncontrolled emission factors for lime manufacturing are presented in Table 1. The size-specific controlled and uncontrolled emission factors for rotary lime kilns are presented in Table 2. The size-specific uncontrolled emission factors for product loading are presented in Table 3. Size-specific emission factors for other lime manufacturing processes are not included in the report due to insufficient data.

Table 2. *Summary of Size Specific Emission Factors for Rotary Lime Kilns*[a]

Emission Factor Rating: D

	Cumulative mass % ≦ stated particle size[b]				*Cumulative particulate emission factor ≦ stated size*[c]							
					Uncontrolled rotary kilns		*Rotary kiln with multiclone*[d]		*Rotary kiln with ESP*[e]		*Rotary kiln with cyclone and baghouse*[f]	
Particle size (μmA)	*Uncontrolled rotary kiln*	*Rotary kiln with multiclone*[d]	*Rotary kiln with ESP*[e]	*Rotary kiln with cyclone and baghouse*[f]	*kg/Mg*	*lb/ton*	*kg/Mg*	*lb/ton*	*kg/Mg*	*lb/ton*	*kg/Mg*	*lb/ton*
2.5	*1.4*	*6.1*	*14*	*27*	*2.6*	*5.2*	*2.6*	*5.2*	*0.34*	*0.68*	*0.02*	*0.03*
5.0	*2.9*	*9.8*	*NA*	*NA*	*5.2*	*10*	*4.1*	*8.2*	*NA*	*NA*	*NA*	*NA*
10.0	*12*	*16*	*50*	*55*	*21*	*42*	*6.9*	*14*	*1.2*	*2.4*	*0.03*	*0.06*
15.0	*31*	*23*	*62*	*73*	*56*	*110*	*9.7*	*19*	*1.5*	*3.0*	*0.04*	*0.08*
Total mass emission factor[g]					*180*	*350*	*42*	*83*	*2.4*	*4.8*	*0.055*	*0.11*

[a] *Coal-fired rotary kilns. Numbers rounded to two significant figures. ESP = electrostatic precipitator. NA = not available.*
[b] *Aerodynamic diameter.*
[c] *Unit weight of particulate matter/unit weight of lime produced.*
[d] *Emission Factor Rating = E.*
[e] *For combination coal/natural gas fired rotary kilns.*
[f] *For rotary kiln with cyclone collector followed by baghouse.*
[g] *PM_{10} emission factor data is not available for baghouse, venturi scrubber, simple cyclone and other control technologies used for rotary lime kilns.*

Table 3. *Uncontrolled Fugitive Particulate Emission Factors For Product Loading*[a]

	Total particulate[b]		*Inhalable particulate*[c]		*Fine particulate*[d]		
Type of loading operation	*kg/Mg*	*lb/ton*	*kg/Mg*	*lb/ton*	*kg/Mg*	*lb/ton*	*Emission factor rating*
Pulverized limestone into open bed trucks	*0.75*	*1.5*	*0.51*	*1.0*	*0.13*	*0.26*	*D*
Pulverized limestone into tank trucks	*0.38*	*0.76*	*0.29*	*0.58*	*0.043*	*0.086*	*D*
Glass lime into tank trucks	*0.15*	*0.30*	*0.062*	*0.12*	*0.0080*	*0.016*	*E*

[a] *Factors are for mass of pollutant/mass of product loaded. Numbers rounded to two significant figures.*
[b] *Particles <~300 μmA (aerodynamic diameter).*
[c] *Particles <15 μmA (aerodynamic diameter).*
[d] *Particles <2.5 μmA (aerodynamic diameter).*

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The complete report, entitled "Lime and Cement Industry Particulate Emissions: Source Category Report—Volume I. Lime Industry," (Order No. PB 87-103 628/AS; Cost: $22.95, subject to change) will be available only from:
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