11.20 Lightweight Aggregate Manufacturing

11.20.1 Process Description[1,2]

Lightweight aggregate is a type of coarse aggregate that is used in the production of lightweight concrete products such as concrete block, structural concrete, and pavement. The Standard Industrial Classification (SIC) code for lightweight aggregate manufacturing is 3295; there currently is no Source Classification Code (SCC) for the industry.

Most lightweight aggregate is produced from materials such as clay, shale, or slate. Blast furnace slag, natural pumice, vermiculite, and perlite can be used as substitutes, however. To produce lightweight aggregate, the raw material (excluding pumice) is expanded to about twice the original volume of the raw material. The expanded material has properties similar to natural aggregate, but is less dense and therefore yields a lighter concrete product.

The production of lightweight aggregate begins with mining or quarrying the raw material. The material is crushed with cone crushers, jaw crushers, hammermills, or pugmills and is screened for size. Oversized material is returned to the crushers, and the material that passes through the screens is transferred to hoppers. From the hoppers, the material is fed to a rotary kiln, which is fired with coal, coke, natural gas, or fuel oil, to temperatures of about 1200°C (2200°F). As the material is heated, it liquefies and carbonaceous compounds in the material form gas bubbles, which expand the material; in the process, volatile organic compounds (VOC) are released. From the kiln, the expanded product (clinker) is transferred by conveyor into the clinker cooler where it is cooled by air, forming a porous material. After cooling, the lightweight aggregate is screened for size, crushed if necessary, stockpiled, and shipped. Figure 11.20-1 illustrates the lightweight aggregate manufacturing process.

Although the majority (approximately 90 percent) of plants use rotary kilns, traveling grates are also used to heat the raw material. In addition, a few plants process naturally occurring lightweight aggregate such as pumice.

11.20.2 Emissions And Controls[1]

Emissions from the production of lightweight aggregate consist primarily of particulate matter (PM), which is emitted by the rotary kilns, clinker coolers, and crushing, screening, and material transfer operations. Pollutants emitted as a result of combustion in the rotary kilns include sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), and VOCs. Chromium, lead, and chlorides also are emitted from the kilns. In addition, other metals including aluminum, copper, manganese, vanadium, and zinc are emitted in trace amounts by the kilns. However, emission rates for these pollutants have not been quantified. In addition to PM, clinker coolers emit CO_2 and VOCs. Emission factors for crushing, screening, and material transfer operations can be found in AP-42 Section 11.19.

Some lightweight aggregate plants fire kilns with material classified as hazardous waste under the Resource Conservation and Recovery Act. Emission data are available for emissions of hydrogen chloride, chlorine, and several metals from lightweight aggregate kilns burning hazardous waste. However, emission factors developed from these data have not been incorporated in this AP-42 section because the magnitude of emissions of these pollutants is largely a function of the waste fuel composition, which can vary considerably.

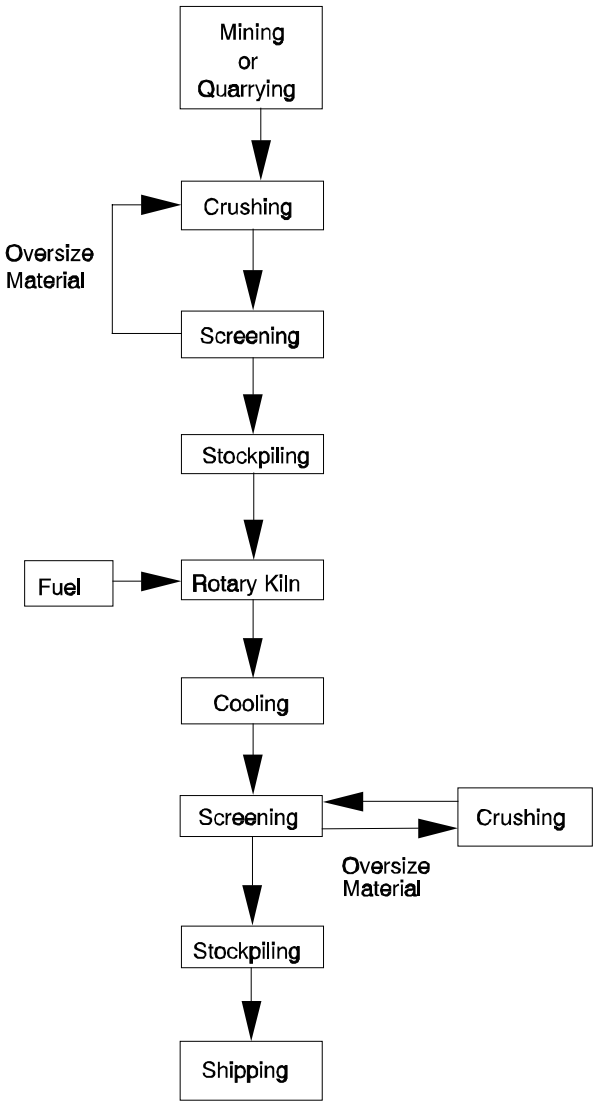

Figure 11.20-1. Process flow diagram for lightweight aggregate manufacturing.

Emissions from rotary kilns generally are controlled with wet scrubbers. However, fabric filters and electrostatic precipitators (ESP) are also used to control kiln emissions. Multiclones and settling chambers generally are the only types of controls for clinker cooler emissions.

Tables 11.20-1 and 11.20-2 summarize uncontrolled and controlled emission factors for PM emissions (both filterable and condensable) from rotary kilns and clinker coolers. Emission factors for SO_x, NO_x, CO, and CO_2 emissions from rotary kilns are presented in Tables 11.20-3 and 11.20-4, which also include an emission factor for CO_2 emissions from clinker coolers. Table 11.20-5 presents emission factors for total VOC (TVOC) emissions from rotary kilns. Size-specific PM emission factors for rotary kilns and clinker coolers are presented in Table 11.20-6.

Table 11.20-1 (Metric Units). EMISSION FACTORS FOR LIGHTWEIGHT AGGREGATE PRODUCTION[a]

Process	Filterable[b]				Condensable PM[c]			
	PM		PM-10		Inorganic		Organic	
	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING
Rotary kiln	65[d]	D	ND		0.41[e]	D	0.0080[f]	D
Rotary kiln with scrubber	0.39[g]	C	0.15[h]	D	0.10[h]	D	0.0046[h]	D
Rotary kiln with fabric filter	0.13[i]	C	ND		0.070[j]	D	ND	
Rotary kiln with ESP	0.34[k]	D	ND		0.015[k]	D	ND	
Clinker cooler with settling chamber	0.14[l]	D	0.055[l]	D	0.0085[l]	D	0.00034[l]	D
Clinker coller with multiclone	0.15[m]	D	0.060[m]	D	0.0013[m]	D	0.0014[m]	D

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on cascade impaction particle size distribution.
[c] Condensable PM is that PM collected in the impinger portion of a PM sampling train.
[d] References 3,7,14. Average of 3 tests that ranged from 6.5 to 170 kg/Mg.
[e] References 3,14.
[f] Reference 3.
[g] References 3,5,10,12-14.
[h] References 3,5.
[i] References 7,14,17-19.
[j] Reference 14.
[k] References 15,16.
[l] References 3,6.
[m] Reference 4.

Table 11.20-2 (English Units). EMISSION FACTORS FOR LIGHTWEIGHT AGGREGATE PRODUCTION[a]

Process	Filterable[b]				Condensable PM[c]			
	PM		PM-10		Inorganic		Organic	
	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING
Rotary kiln	130[d]	D	ND		0.82[e]	D	0.016[f]	D
Rotary kiln with scrubber	0.78[g]	C	0.29[h]	D	0.19[h]	D	0.0092[h]	D
Rotary kiln with fabric filter	0.26[i]	C	ND		0.14[j]	D	ND	
Rotary kiln with ESP	0.67[k]	D	ND		0.031[k]	D	ND	
Clinker cooler with settling chamber	0.28[l]	D	0.11[l]	D	0.017[l]	D	0.00067[l]	D
Clinker cooler with multiclone	0.30[m]	D	0.12[m]	D	0.0025[m]	D	0.0027[m]	D

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on cascade impaction particle size distribution.
[c] Condensable PM is that PM collected in the impinger portion of a PM sampling train.
[d] References 3,7,14. Average of 3 tests that ranged from 13 to 340 lb/ton.
[e] References 3,14.
[f] Reference 3.
[g] References 3,5,10,12-14.
[h] References 3,5.
[i] References 7,14,17-19.
[j] Reference 14.
[k] References 15,16.
[l] References 3,6.
[m] Reference 4.

Table 11.20-3 (Metric Units). EMISSION FACTORS FOR LIGHTWEIGHT AGGREGATE PRODUCTION[a]

Process	SO_x		NO_x		CO		CO_2	
	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING	kg/Mg Of Feed	EMISSION FACTOR RATING
Rotary kiln	2.8[b]	C	ND		0.29[c]	C	240[d]	C
Rotary kiln with scrubber	1.7[e]	C	1.0[f]	D	ND		ND	
Clinker cooler with dry multicyclone	ND		ND		ND		22[g]	D

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data.
[b] References 3,4,5,8.
[c] References 17,18,19.
[d] References 3,4,5,12,13,14,17,18,19
[e] References 3,4,5,9.
[f] References 3,4,5.
[g] Reference 4.

Table 11.20-4 (English Units). EMISSION FACTORS FOR LIGHTWEIGHT AGGREGATE PRODUCTION[a]

Process	SO_x		NO_x		CO		CO_2	
	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING	lb/ton Of Feed	EMISSION FACTOR RATING
Rotary kiln	5.6[b]	C	ND		0.59[c]	C	480[d]	C
Rotary kiln with scrubber	3.4[e]	C	1.9[f]	D	ND		ND	
Clinker cooler with dry multicyclone	ND		ND		ND		43[g]	D

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data.
[b] References 3,4,5,8.
[c] References 17,18,19.
[d] References 3,4,5,12,13,14,17,18,19
[e] References 3,4,5,9.
[f] References 3,4,5.
[g] Reference 4.

Table 11.20-5 (Metric And English Units). EMISSION FACTORS FOR LIGHTWEIGHT AGGREGATE PRODUCTION[a]

Process	TVOCs		
	kg/Mg Of Feed	lb/ton Of Feed	EMISSION FACTOR RATING
Rotary kiln	ND	ND	D
Rotary kiln with scrubber	0.39[b]	0.78[b]	D

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data.
[b] Reference 3.

Table 11.20-6 (Metric And English Units). PARTICULATE MATTER SIZE-SPECIFIC EMISSION FACTORS FOR EMISSIONS FROM ROTARY KILNS AND CLINKER COOLERS[a]

EMISSION FACTOR RATING: D

Diameter, micrometers	Cumulative % Less Than Diameter	Emission Factor	
		kg/Mg	lb/ton
Rotary Kiln With Scrubber[b]			
2.5	35	0.10	0.20
6.0	46	0.13	0.26
10.0	50	0.14	0.28
15.0	55	0.16	0.31
20.0	57	0.16	0.32
Clinker Cooler With Settling Chamber[c]			
2.5	9	0.014	0.027
6.0	21	0.032	0.063
10.0	35	0.055	0.11
15.0	49	0.080	0.16
20.0	58	0.095	0.19
Clinker Cooler With Multiclone[d]			
2.5	19	0.029	0.057
6.0	31	0.047	0.093
10.0	40	0.060	0.12
15.0	48	0.072	0.14
20.0	53	0.080	0.16

[a] Emission factors based on total feed.
[b] References 3,5.
[c] References 3,6.
[d] Reference 4.

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