11.3 Bricks And Related Clay Products

11.3.1 Process Description

The manufacture of brick and related products such as clay pipe, pottery, and some types of refractory brick involves the mining, grinding, screening, and blending of the raw materials, and the forming, cutting or shaping, drying or curing, and firing of the final product.

Surface clays and shales are mined in open pits. Most fine clays are found underground. After mining, the material is crushed to remove stones and is stirred before it passes onto screens for segregation by particle size.

To start the forming process, clay is mixed with water, usually in a pug mill. The 3 principal processes for forming bricks are stiff mud, sort mud, and dry press. In the stiff mud process, sufficient water is added to give the clay plasticity, and bricks are formed by forcing the clay through a die. Wire is used in separating bricks. All structural tile and most brick are formed by this process. The soft mud process is usually used with clay too wet for the stiff mud process. The clay is mixed with water to a moisture content of 20 to 30 percent, and the bricks are formed in molds. In the dry press process, clay is mixed with a small amount of water and formed in steel molds by applying pressure of 3.43 to 10.28 megapascals (500 to 1500 pounds per square inch). A typical brick manufacturing process is shown in Figure 11.3-1.

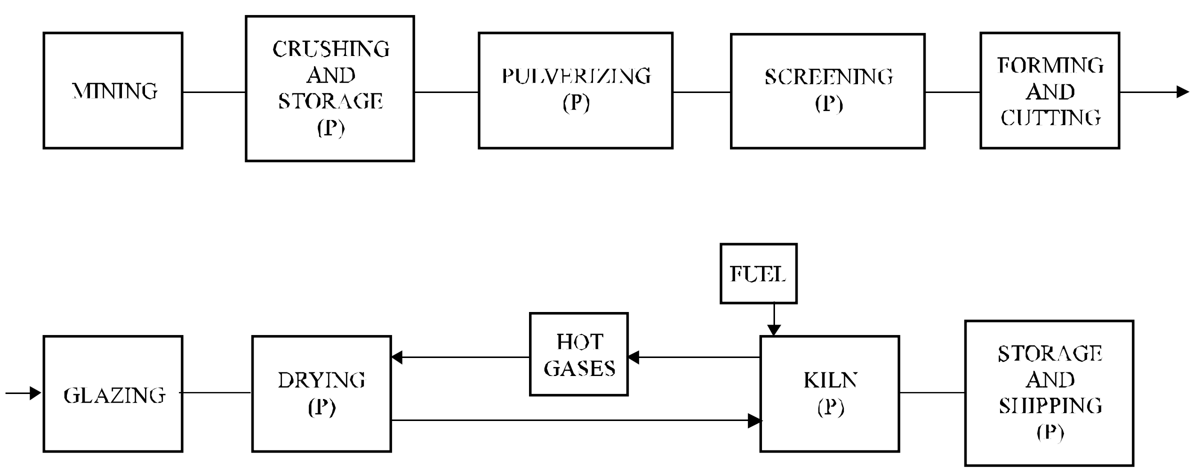

Figure 11.3-1. Basic flow diagram of brick manufacturing process.
(P = a major source of particulate emissions.)

Wet clay units that have been formed are almost completely dried before firing, usually with waste heat from kilns. Many types of kilns are used for firing brick, but the most common are the downdraft periodic kiln and the tunnel kiln. The periodic kiln is a permanent brick structure with a number of fireholes where fuel enters the furnace. Hot gases from the fuel are drawn up over the bricks, down through them by underground flues, and out of the oven to the chimney. Although lower heat recovery makes this type less efficient than the tunnel kiln, the uniform temperature distribution leads to a good quality product. In most tunnel kilns, cars carrying about 1200 bricks travel on rails through the kiln at the rate of one 1.83-meter (6-foot) car per hour. The fire zone is located near the middle of the kiln and is stationary.

In all kilns, firing takes place in 6 steps: evaporation of free water, dehydration, oxidation, vitrification, flashing, and cooling. Normally, gas or residual oil is used for heating, but coal may be used. Total heating time varies with the type of product; for example, 22.9-centimeter (9-inch) refractory bricks usually require 50 to 100 hours of firing. Maximum temperatures of about 1090°C (2000°F) are used in firing common brick.

11.3.2 Emissions And Controls[1,3]

Particulate matter is the primary emission in the manufacture of bricks. The main source of dust is the materials handling procedure, which includes drying, grinding, screening, and storing the raw material. Combustion products are emitted from the fuel consumed in the dryer and the kiln. Fluorides, largely in gaseous form, are also emitted from brick manufacturing operations. Sulfur dioxide may be emitted from the bricks when temperatures reach or exceed 1370°C (2500°F), but no data on such emissions are available.[4]

A variety of control systems may be used to reduce both particulate and gaseous emissions. Almost any type of particulate control system will reduce emissions from the material handling process, but good plant design and hooding are also required to keep emissions to an acceptable level.

The emissions of fluorides can be reduced by operating the kiln at temperatures below 1090°C (2000°F) and by choosing clays with low fluoride content. Satisfactory control can be achieved by scrubbing kiln gases with water, since wet cyclonic scrubbers can remove fluorides with an efficiency of 95 percent or higher.

Tables 11.3-1 and 11.3-2 present emission factors for brick manufacturing without controls. Table 11.3-3 presents data on particle size distribution and emission factors for uncontrolled sawdust-fired brick kilns. Table 11.3-4 presents data on particle size distribution and emission factors for uncontrolled coal-fired tunnel brick kilns. Table 11.3-5 presents data on particle size distribution and emission factors for uncontrolled screening and grinding of raw materials for brick and related clay products. Figure 11.3-2, Figure 11.3-3, and Figure 11.3-4 present a particle size distribution for Tables 11.3-3, 11.3-4, and 11.3-5 expressed as the cumulative weight percent of particles less than a specified aerodynamic diameter (cut point), in micrometers (µm).

Table 11.3-1 (Metric Units). EMISSION FACTORS FOR BRICK MANUFACTURING WITHOUT CONTROLS[a]

EMISSION FACTOR RATING: C

Process	Particulates	Sulfur Oxides	Carbon Monoxide	Volatile Organic Compounds		Nitrogen Oxides	Fluorides[b]
				Nonmethane	Methane		
Raw material handling[c]							
Drying	35	ND	ND	ND	ND	ND	ND
Grinding	38	ND	ND	ND	ND	ND	ND
Storage	17	ND	ND	ND	ND	ND	ND
Brick dryer[d]							
Coal/gas fired	0.006A	0.55S	ND	ND	ND	0.33	ND
Curing and firing[e]							
Tunnel kiln							
Gas fired	0.012	Neg	0.03	0.0015	0.003	0.09	0.5
Oil fired	0.29	1.98S	0.06	0.0035	0.013	0.525	0.5
Coal fired	0.34A	3.65S	0.71	0.005	0.003	0.73	0.5
Coal/gas fired	0.16A	0.31S	ND	ND	ND	0.81	ND
Sawdust fired	0.12	ND	ND	ND	ND	ND	ND
Periodic kiln							
Gas fired	0.033	Neg	0.075	0.005	0.01	0.25	0.5
Oil fired	0.44	2.93S	0.095	0.005	0.02	0.81	0.5
Coal fired	9.42	6.06S	1.19	0.01	0.005	1.18	0.5

[a] Expressed as units per unit weight of brick produced, kilograms per megagram (kg/Mg). One brick weighs about 2.95 kg. ND = no data. A = % ash in coal. S = % sulfur in fuel. Neg = negligible.
[b] References 3,6-10.
[c] Based on data from Section 11.7, "Ceramic Clay Manufacturing" in this publication. Because of process variation, some steps may be omitted. Storage losses apply only to that quantity of material stored.
[d] Reference 12.
[e] References 1,5,12-16.

Table 11.3-2 (English Units). EMISSION FACTORS FOR BRICK MANUFACTURING WITHOUT CONTROLS[a]

EMISSION FACTOR RATING: C

Process	Particulates	Sulfur Oxides	Carbon Monoxide	Volatile Organic Compounds		Nitrogen Oxides	Fluorides[b]
				Nonmethane	Methane		
Raw material handling[c]							
Drying	70	ND	ND	ND	ND	ND	ND
Grinding	76	ND	ND	ND	ND	ND	ND
Storage	34	ND	ND	ND	ND	ND	ND
Brick dryer[d]							
Coal/gas fired	0.012A	1.10S	ND	ND	ND	0.66	ND
Curing and firing[e]							
Tunnel kiln							
Gas fired	0.023	Neg	0.06	0.003	0.006	0.18	1.0
Oil fired	0.59	3.95S	0.12	0.007	0.025	1.05	1.0
Coal fired	0.67A	7.31S	1.43	0.01	0.006	1.45	1.0
Coal/gas fired	0.31A	0.62S	ND	ND	ND	1.61	ND
Sawdust fired	0.24	ND	ND	ND	ND	ND	ND
Periodic kiln							
Gas fired	0.065	Neg	0.15	0.01	0.02	0.50	1.0
Oil fired	0.88	5.86S	0.19	0.01	0.04	1.62	1.0
Coal fired	18.84	12.13S	2.39	0.02	0.015	2.35	1.0

[a] Expressed as units per unit weight of brick produced, pounds per ton (lb/ton). One brick weighs about 6.5 pounds. ND = no data. A = % ash in coal. S = % sulfur in fuel. Neg = negligible.
[b] References 3,6-10.
[c] Based on data from Section 11.7, "Ceramic Clay Manufacturing" in this publication. Because of process variation, some steps may be omitted. Storage losses apply only to that quantity of material stored.
[d] Reference 12.
[e] References 1,5,12-16.

Table 11.3-3 (Metric Units). PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED SAWDUST-FIRED BRICK KILNS[a]

EMISSION FACTOR RATING: E

Aerodynamic Particle Diameter (µm)	Cumulative Weight % ≤ Stated Size	Emission Factor[b] (kg/Mg)
2.5	36.5	0.044
6.0	63.0	0.076
10.0	82.5	0.099
	Total particulate emission factor	0.12[c]

[a] Reference 13.
[b] Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of brick produced.
[c] Total mass emission factor from Table 11.3-1.

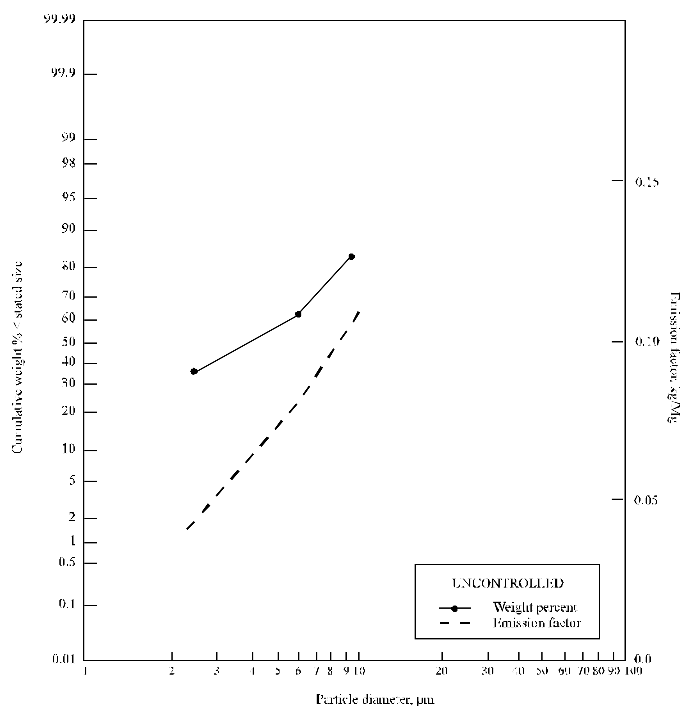

Figure 11.3-2. Cumulative weight percent of particles less than stated particle diameters for uncontrolled sawdust-fired brick kilns.

Table 11.3-4 (Metric Units). PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED COAL-FIRED TUNNEL BRICK KILNS[a]

EMISSION FACTOR RATING: E

Aerodynamic Particle Diameter (µm)	Cumulative Weight % ≤ Stated Size	Emission Factor[b] (kg/Mg)
2.5	24.7	0.08A
6.0	50.4	0.17A
10.0	71.0	0.24A
	Total particulate emission factor	0.34A[c]

[a] References 12,17.
[b] Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of brick produced. A = % ash in coal. (Use 10% if ash content is not known.)
[c] Total mass emission factor from Table 11.3-1.

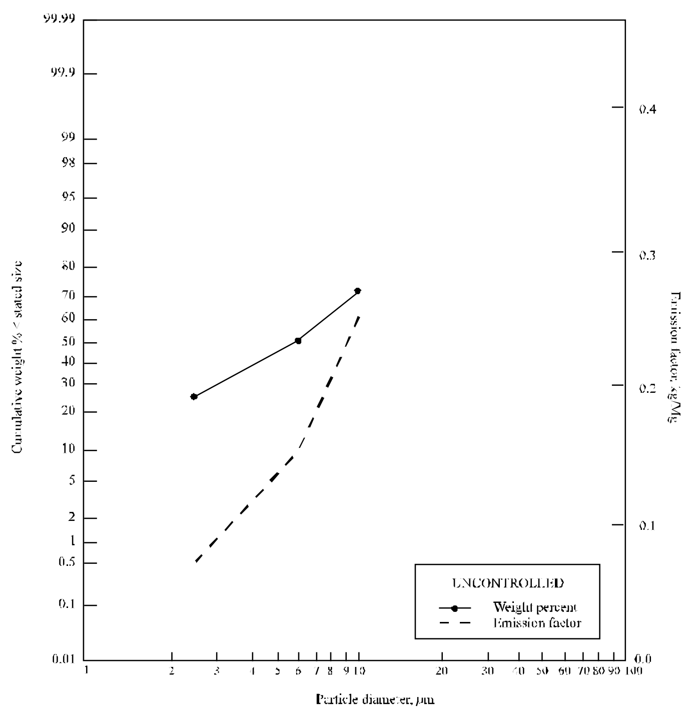

Figure 11.3-3. Cumulative weight percent of particles less than stated particle diameters for uncontrolled coal-fired tunnel brick kilns.

Table 11.3-5 (Metric Units). PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED SCREENING AND GRINDING OF RAW MATERIALS FOR BRICK AND RELATED CLAY PRODUCTS[a]

EMISSION FACTOR RATING: E

Aerodynamic Particle Diameter (µm)	Cumulative Weight % ≤ Stated Size	Emission Factor[b] (kg/Mg)
2.5	0.2	0.08
6.0	0.4	0.15
10.0	7.0	2.66
	Total particulate emission factor	38[c]

[a] References 11,18.
[b] Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of raw material processed.
[c] Total mass emission factor from Table 11.3-1.

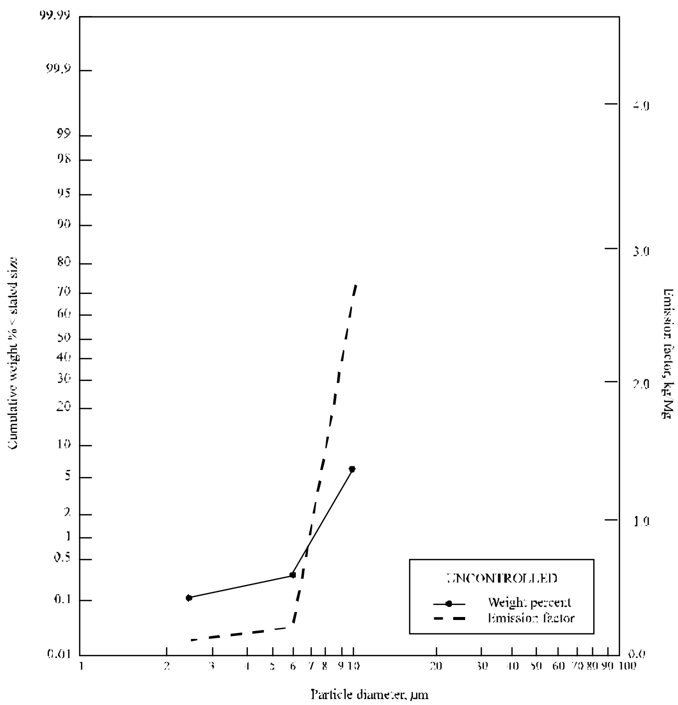

Figure 11.3-4. Cumulative weight percent of particles less than stated particle diameters for uncontrolled screening and grinding of raw materials for brick and related clay products.

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