Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP42 Section:	11.3
Reference:	3
Title:	Compilation Of Air Pollutant Emission Factors, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1986.

8.3 BRICKS AND RELATED CLAY PRODUCTS

8.3.1 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 three principal processes for forming brick are stiff mud, soft 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 8.3-1.

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 six 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.

8.3.2 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]

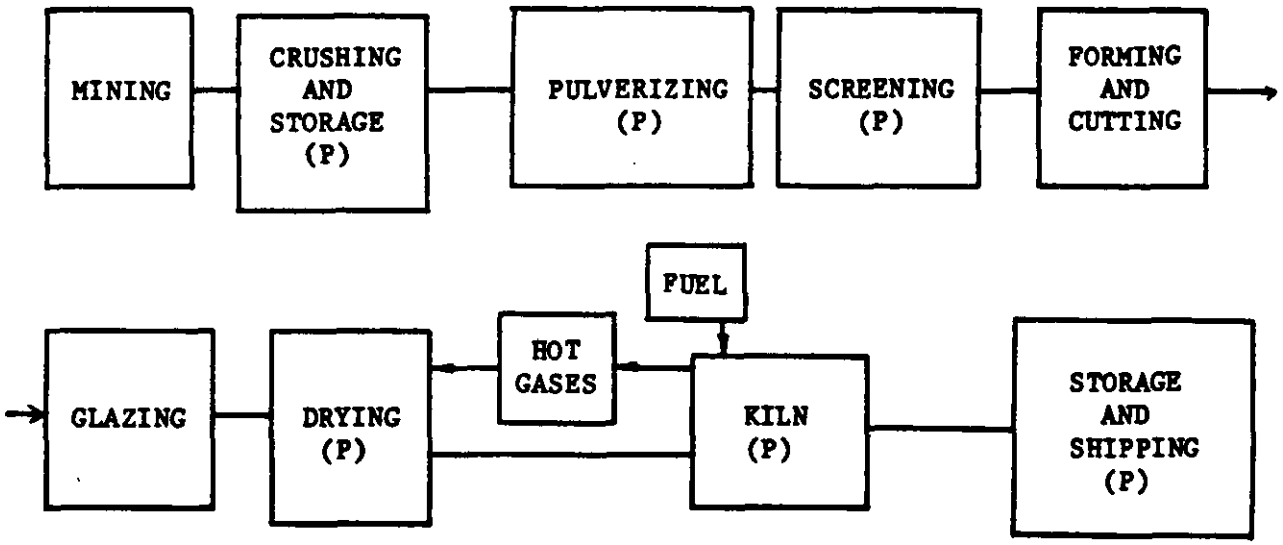

Figure 8.3-1. Basic flow diagram of brick manufacturing process. (P = a major source of particulate emissions)

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.

Table 8.3-1 presents emission factors for brick manufacturing without controls. Table 8.3-2 presents data on particle size distribution and emission factors for uncontrolled sawdust fired brick kilns. Table 8.3-3 presents data on particle size distribution and emission factors for uncontrolled coal fired tunnel brick kilns.

TABLE 8.3-1. EMISSION FACTORS FOR BRICK MANUFACTURING WITHOUT CONTROLS[a]

EMISSION FACTOR RATING: C

Process	Particulates		Sulfur oxides		Carbon monoxide		Volatile Organic Compounds: Nonmethane		Volatile Organic Compounds: Methane		Nitrogen oxides		Fluorides[b]	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Raw material handling[c]														
Drying	35	70	-	-	-	-	-	-	-	-	-	-	-	-
Grinding	38	76	-	-	-	-	-	-	-	-	-	-	-	-
Storage	17	34	-	-	-	-	-	-	-	-	-	-	-	-
Brick dryer[d]														
Coal/gas fired	0.006A	0.012A	0.55S	1.10S	-	-	-	-	-	-	0.33	0.66	-	-
Curing and firing[e]														
Tunnel kiln														
Gas fired	0.012	0.023	Neg	Neg	0.03	0.06	0.0015	0.003	0.003	0.006	0.09	0.18	0.5	1.0
Oil fired	0.29	0.59	1.98S	3.95S	0.06	0.12	0.0035	0.007	0.013	0.025	0.525	1.05	0.5	1.0
Coal fired	0.34A	0.67A	3.65S	7.31S	0.71	1.43	0.005	0.01	0.003	0.006	0.73	1.45	0.5	1.0
Coal/gas fired	0.16A	0.31A	0.31S	0.62S	-	-	-	-	-	-	0.81	1.61	-	-
Sawdust fired	0.12	0.24	-	-	-	-	-	-	-	-	-	-	-	-
Periodic kiln														
Gas fired	0.033	0.065	Neg	Neg	0.075	0.15	0.005	0.01	0.01	0.02	0.25	0.50	0.5	1.0
Oil fired	0.44	0.88	2.93S	5.86S	0.095	0.19	0.005	0.01	0.02	0.04	0.81	1.62	0.5	1.0
Coal fired	9.42	18.84	6.06S	12.13S	1.19	2.39	0.01	0.02	0.005	0.01	1.18	2.35	0.5	1.0

[a]Expressed as units per unit weight of brick produced. One brick weighs about 2.95 kg (6.5 pounds). Dash = No data. A = % ash in coal. S = % sulfur in fuel. Neg = negligible.
[b]References 3, 6-10.
[c]Based on data from Section 8.7 on 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 8.3-2. 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 8.3-1.

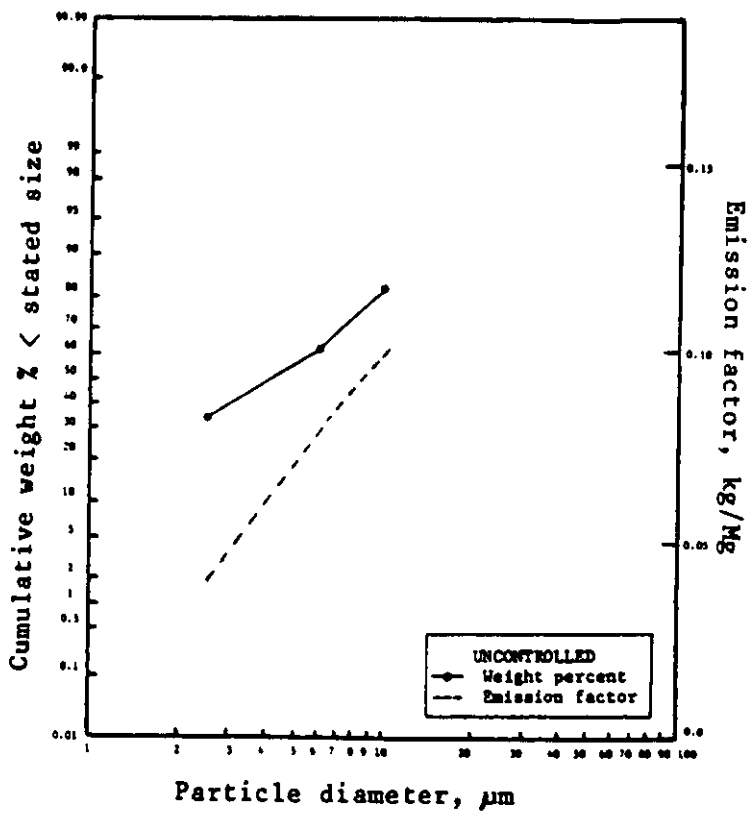

Figure 8.3-2. Cumulative weight percent of particles less than stated particle diameters for uncontrolled sawdust fired brick kilns.

TABLE 8.3-3. 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 8.3-1.

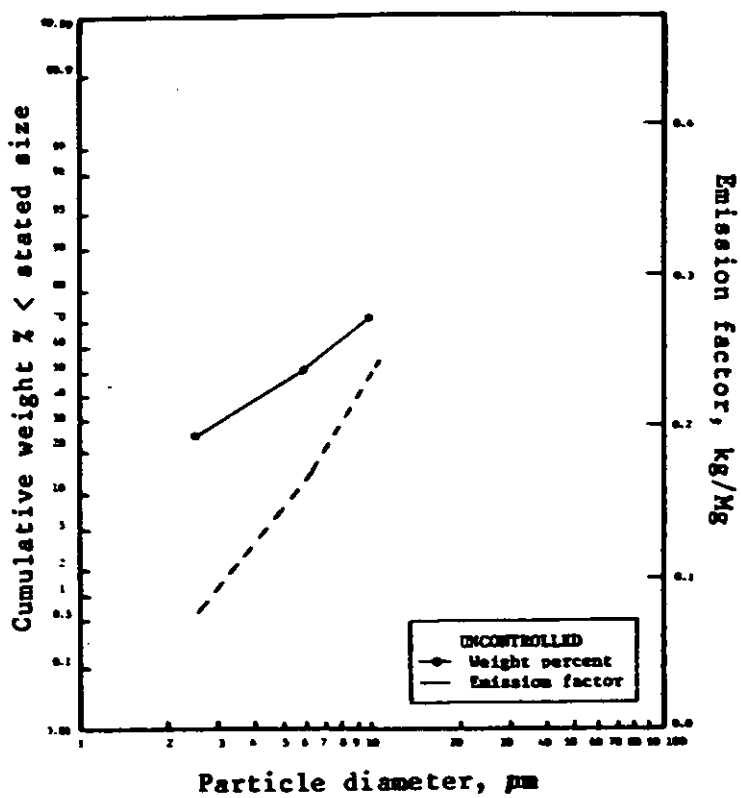

Figure 8.3-3. Cumulative weight percent of particles less than stated particle diameters for uncontrolled coal fired tunnel brick kilns

TABLE 8.3-4. PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED SCREENING AND GRINDING OF RAW MATERIALS FOR BRICKS 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 8.3-1.

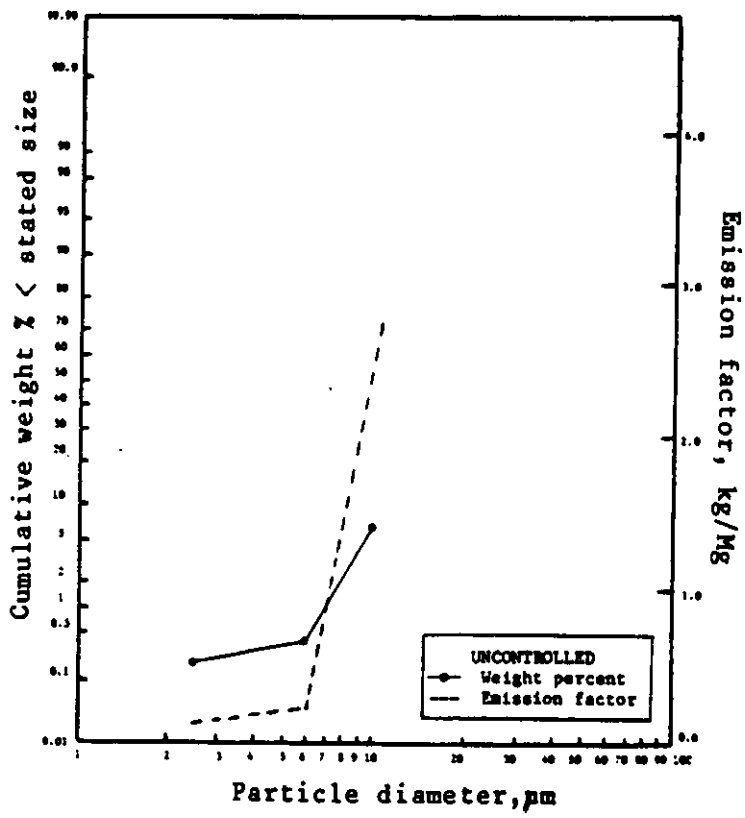

Figure 8.3-4. Cumulative weight percent of particles less than stated particle diameters for uncontrolled screening and grinding of raw materials for bricks and related clay products.

References for Section 8.3

1. Air Pollutant Emission Factors, APTD-0923, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1970.

2. "Technical Notes on Brick and Tile Construction", Pamphlet No. 9, Structural Clay Products Institute, Washington, DC, September 1961.

3. Unpublished control techniques for fluoride emissions, U. S. Department Of Health And Welfare, Washington, DC, May 1970.

4. M. H. Allen, "Report on Air Pollution, Air Quality Act of 1967 and Methods of Controlling the Emission of Particulate and Sulfur Oxide Air Pollutants", Structural Clay Products Institute, Washington, DC, September 1969.

5. F. H. Norton, Refractories, 3rd Ed, McGraw-Hill, New York, 1949.

6. K. T. Semrau, "Emissions of Fluorides from Industrial Processes: A Review", Journal Of The Air Pollution Control Association, 7(2):92-108, August 1957.

7. Kirk-Othmer Encyclopedia of Chemical Technology, Vol 5, 2nd Edition, John Wiley and Sons, New York, 1964.

8. K. F. Wentzel, "Fluoride Emissions in the Vicinity of Brickworks", Staub, 25(3):45-50, March 1965.

9. "Control of Metallurgical and Mineral Dusts and Fumes in Los Angeles County", Information Circular No. 7627, Bureau Of Mines, U. S. Department Of Interior, Washington, DC, April 1952.

10. Notes on oral communication between Resources Research, Inc., Reston, VA and New Jersey Air Pollution Control Agency, Trenton, NJ, July 20, 1969.

11. H. J. Taback, Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin, PB 293 923/AS, National Technical Information Service, Springfield, VA, February 1979.

12. Building Brick and Structural Clay Industry - Lee Brick and Tile Co., Sanford, NC, EMB 80-BRK-1, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1980.

13. Building Brick and Structural Clay Wood Fired Brick Kiln - Emission Test Report - Chatham Brick and Tile Company, Gulf, North Carolina, EMB-80-BRK-5, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1980.

14. R. N. Doster and D. J. Grove, Stationary Source Sampling Report: Lee Brick and Tile Co., Sanford, NC, Compliance Testing, Entropy Environmentalists, Inc., Research Triangle Park, NC, February 1978.

15. R. N. Doster and D. J. Grove, Stationary Source Sampling Report: Lee Brick and Tile Co., Sanford, NC, Compliance Testing, Entropy Environmentalists, Inc., Research Triangle Park, NC, June 1978.

16. F. J. Phoenix and D. J. Grove, Stationary Source Sampling Report - Chatham Brick-and Tile Co., Sanford, NC, Particulate Emissions Compliance Testing, Entropy Environmentalists, Inc., Research Triangle Park, NC, July 1979.

17. Fine Particle Emissions Information System, Series Report No. 354, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1983.