Emission Factor Documentation for AP-42
Section 11.3

BRICK AND STRUCTURAL CLAY PRODUCT MANUFACTURING

Final Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group

EPA Contract 68-D2-0159
Work Assignment No. 4-02

MRI Project No. 4604-02

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Research Triangle Park, NC 27711

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NOTICE

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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under Contract No. 68-D2-0159, Work Assignment Nos. 3-01 and 4-02. Mr. Ron Myers was the requester of the work.

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August 1997

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1. INTRODUCTION

The document *Compilation of Air Pollutant Emission Factors* (AP-42) has been published by the U. S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by EPA to respond to new emission factor needs of EPA, State and local air pollution control programs, and industry.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors usually are expressed as the weight of pollutant divided by the unit weight, volume, distance, or duration of the activity that emits the pollutant. The emission factors presented in AP-42 may be appropriate to use in a number of situations, such as making source-specific emission estimates for areawide inventories for dispersion modeling, developing control strategies, screening sources for compliance purposes, establishing operating permit fees, and making permit applicability determinations. The purpose of this report is to provide background information from test reports and other information to support revisions to AP-42 Section 11.3, Bricks and Related Clay Products.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the brick and structural clay product manufacturing industry. It includes a characterization of the industry, a description of the different process operations, a characterization of emission sources and pollutants emitted, and a description of the technology used to control emissions resulting from these sources. Section 3 is a review of emission data collection (and emission measurement) procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details how the revised AP-42 section was developed. It includes the review of specific data sets, a description of how candidate emission factors were developed, and a summary of changes to the AP-42 section. Section 5 presents the AP-42 Section 11.3, Brick and Structural Clay Product Manufacturing. The name of the section was changed to more accurately define the source category.

2. INDUSTRY DESCRIPTION

2.1 INDUSTRY CHARACTERIZATION[1,2]

The brick and structural clay products industry is made up primarily of facilities that manufacture structural brick from clay, shale, or a combination of the two. These facilities are classified under standard industrial classification (SIC) code 3251, brick and structural clay tile. Facilities that manufacture structural clay products, such as clay pipe, adobe brick, chimney pipe, flue liners, drain tiles, roofing tiles, and sewer tiles, are classified under SIC code 3259, structural clay products, not elsewhere classified.

In 1992, approximately 220 facilities manufactured brick and structural clay tile, with a total value of shipments of about $1.1 billion. Approximately 65 facilities produced other structural clay products, with a total value of shipments of about $126 million. North Carolina, Ohio, South Carolina, and Texas were the leading brick and structural clay tile producing States, while California and Ohio were the leading producers of other structural clay products. In 1990, approximately 77 percent of all brick manufacturing plants used natural gas (120 of the 152 plants that responded to a survey used natural gas) as the primary fuel for firing kilns, with the remainder of the plants using sawdust (15 plants) and coal (16 plants). One plant used fuel oil, and 31 plants had fuel oil available as a backup fuel. The trend in the industry is towards natural gas-fired kilns.

2.2 PROCESS DESCRIPTION[3-6]

The manufacture of brick and structural clay products involves mining, grinding, screening and blending of the raw materials followed by forming, cutting or shaping, drying, firing, cooling, storage, and shipping of the final product. A typical brick manufacturing process is shown in Figure 2-1.

The raw materials used in the manufacture of brick and structural clay products include surface clays and shales, which are mined in open pits. The moisture content of the raw material varies among plants, from a low of about 3 percent to a high of about 15 percent. Some facilities have on-site mining operations, while others bring in raw material by truck or rail. The raw material is typically loaded by truck or front-end loader into a primary crusher for initial size reduction. The material is then conveyed to a grinding room, which houses several grinding mills and banks of screens that produce a fine material that is suitable for forming bricks or other products. Types of grinding mills typically used include dry pan grinders, roller mills, and hammermills. From the grinding room, the material is conveyed to storage silos or piles, which typically are enclosed. The material is then either conveyed to the mill room for brick forming or conveyed to a storage area.

Most brick are formed by the stiff mud extrusion process, although brick are also formed using the soft mud and dry press processes (there may be no plants in the U.S. currently using the dry press process). A typical stiff mud extrusion line begins with a pug mill, which mixes the ground material with water and discharges the mixture into a vacuum chamber. Some facilities mix additives such as barium carbonate, which prevents sulfates from rising to the surface of the brick, with the raw material prior to extrusion. The moisture content of the material entering the vacuum chamber is typically between 14 and 18 percent. The vacuum chamber removes air from the material, which is then continuously augured or extruded through dies. The resulting continuous "column" is lubricated with oil or other lubricant to reduce friction during extrusion. If specified, various surface treatments, such as manganese dioxide, iron oxide, and iron chromite can be applied at this point. These treatments are used to add color or texture to the product. A wire-cutting machine is used to cut the column into individual bricks, and then the bricks are mechanically

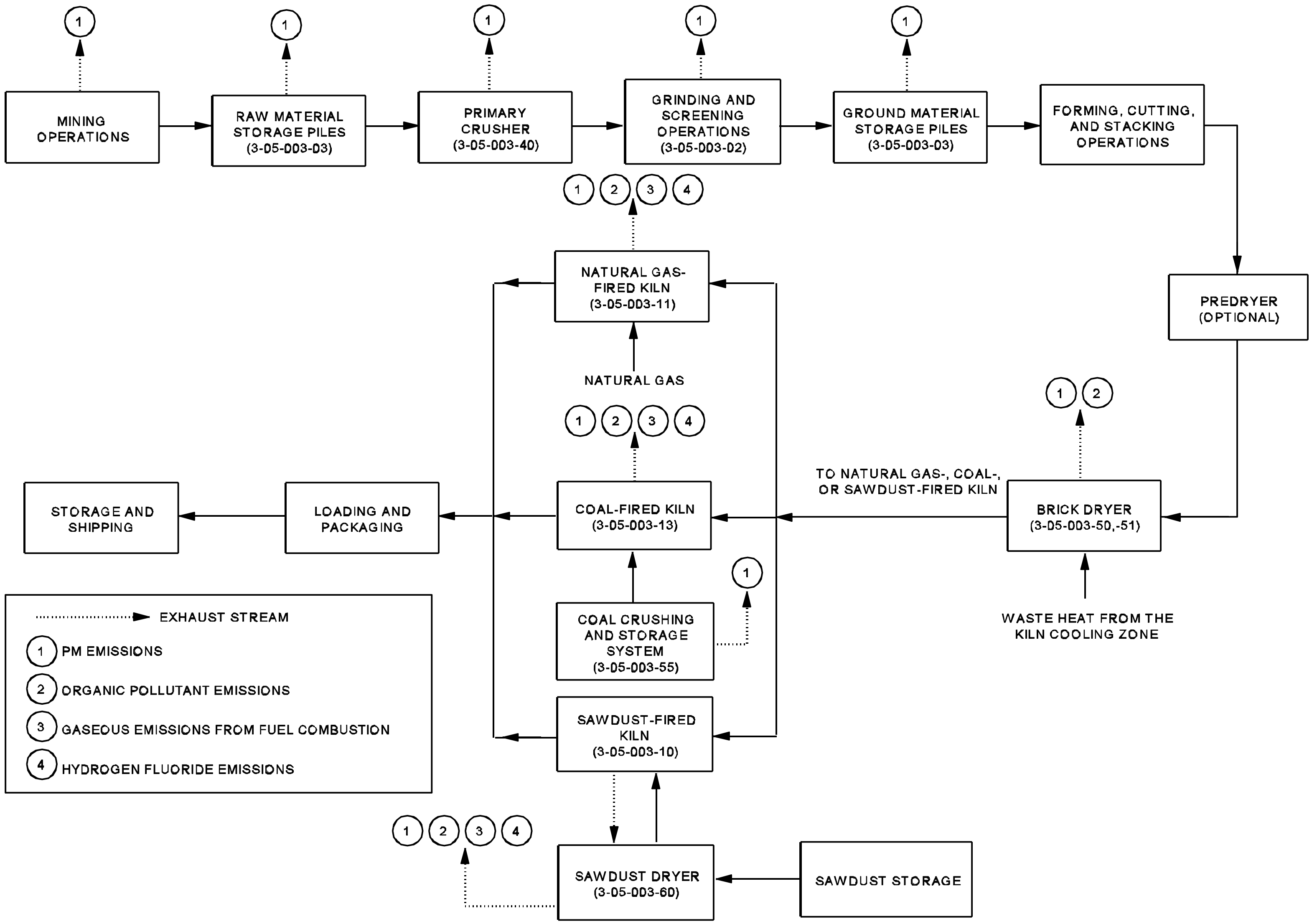

Figure 2-1. Typical brick manufacturing process.

or hand set onto kiln cars. All structural tile and most brick are formed by this process. Prior to stacking, some facilities mechanically process the unfired bricks to create rounded imperfect edges that give the appearance of older worn brick.

The soft mud process is usually used with clay that is too wet for stiff mud extrusion. In a pug mill, the clay is mixed with water to a moisture content of 20 to 30 percent, and the bricks are formed in molds and are dried before being mechanically stacked onto kiln cars. 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 1,500 pounds per square inch).

Following forming and stacking, the brick-laden kiln cars enter a predryer or a holding area and are then loaded into the dryer. Dryers typically are heated to about 204°C (400°F) using waste heat from the cooling zone of the kiln. However, some plants heat dryers with gas or other fuels. Dryers may be in-line or totally separate from the kiln. From the dryer, the bricks enter the kiln. The most common type of kiln used for firing brick is the tunnel kiln, although some facilities operate downdraft periodic kilns or other types of kilns. A typical tunnel kiln ranges from about 104 meters (m) (340 feet [ft]) to 152 m (500 ft) in length and includes a dryer, a firing zone, and a cooling zone. The firing zone typically is maintained at a maximum temperature of about 1090°C (2000°F). During firing, small amounts of excess fuel are sometimes introduced to the kiln atmosphere, creating a reducing atmosphere that adds color to the surface of the bricks. This process is called flashing. After firing, the bricks enter the cooling zone, where they are cooled to near ambient temperatures before leaving the tunnel kiln. The bricks are then stored and shipped.

A periodic kiln is a permanent brick structure with a number of fireholes through which fuel enters the furnace. Hot gases from the fuel are first drawn up over the bricks, then down through them by underground flues, and then out of the kiln to the stack.

In all kilns, firing takes place in six steps: evaporation of free water, dehydration, oxidation, vitrification, flashing, and cooling. Natural gas is the fuel most commonly used for firing, followed by coal and sawdust. Some plants have fuel oil available as a backup fuel. Most natural gas-fired plants that have a backup fuel use vaporized propane as the backup fuel. For most types of brick, the entire drying, firing, and cooling process takes between 20 and 50 hours.

Flashing is used to impart color to bricks by adding uncombusted fuel (other materials such as zinc, used tires, or used motor oil are also reportedly used) to the kiln to create a reducing atmosphere. Typically, flashing takes place in a "flashing zone" that follows the firing zone, and the bricks are rapidly cooled following flashing. In tunnel kilns, the uncombusted fuel or other material typically is drawn into the firing zone of the kiln and is burned.

2.3 EMISSIONS[3,7-12]

Emissions from brick manufacturing facilities include particulate matter (PM), PM less than or equal to 10 microns in aerodynamic diameter (PM-10), PM less than or equal to 2.5 microns in aerodynamic diameter (PM-2.5), sulfur dioxide (SO_2), sulfur trioxide (SO_3), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), metals, total organic compounds (TOC) (including methane, ethane, volatile organic compounds [VOC], and some hazardous air pollutants [HAP]), and fluorides. Factors that may affect emissions include raw material composition and moisture content, kiln fuel type, kiln operating parameters, and plant design. Emissions from the manufacture of other structural clay products are expected to be similar to emissions from brick manufacturing.

The primary sources of PM, PM-10, and PM-2.5 emissions are the raw material grinding and screening operations and the kilns. Other sources of PM emissions include sawdust dryers used by plants with sawdust-fired kilns, coal crushing systems used by plants with coal-fired kilns, and fugitive dust sources such as paved roads, unpaved roads, and storage piles.

Combustion products, including SO_2, NO_x, CO, and CO_2, are emitted from fuel combustion in brick kilns and some brick dryers. Brick dryers that are heated with waste heat from the kiln cooling zone are not usually a source of combustion products because kilns are designed to prevent combustion gases from entering the cooling zone. Some brick dryers have supplemental gas burners that produce small amounts of NO_x, CO, and CO_2 emissions. These emissions are sensitive to the condition of the burners. The primary source of SO_2 emissions from most brick kilns is the raw material, which may contain sulfur compounds. Some facilities use raw material with a high sulfur content, and have higher SO_2 emissions than facilities that use low-sulfur raw material. In addition, some facilities use additives that contain sulfates, and these additives may contribute to SO_2 emissions. Figure 2-2 shows the sulfur content (in ppm) of soil samples taken from locations throughout the United States. The samples, which were taken at a depth of about 20 cm, are not specific to clays and shales used for brick manufacturing, but they provide insight into regional variations in the sulfur content of soils. The sulfur content of the soil samples ranges from less than 0.08 percent to 4.8 percent and averages 0.16 percent.

Organic compounds, including methane, ethane, VOC, and some HAP, are emitted from both brick dryers and kilns. These compounds also are emitted from sawdust dryers used by facilities that fire sawdust as the primary kiln fuel. Organic compound emissions from brick dryers may include contributions from the following: (1) petroleum-based or other products in those plants that use petroleum-based or other lubricants in extrusion, (2) light hydrocarbons within the raw material that vaporize at the temperatures encountered in the dryer, and (3) incomplete fuel combustion in dryers that use supplemental burners in addition to waste heat from the kiln cooling zone. Organic compound emissions from kilns are the result of volatilization of organic matter contained in the raw material and kiln fuel.

Hydrogen fluoride (HF) and other fluoride compounds are emitted from kilns as a result of the release of the fluorine compounds contained in the raw material. Fluorine typically is present in brick raw materials in the range of 0.01 to 0.06 percent. As the green bricks reach temperatures of 500° to 600°C (930° to 1110°F), the fluorine in the raw material forms HF and other fluorine compounds. Much of the fluorine is released as HF. Because fluorine content in clays and shales is highly variable, emissions of HF and other fluoride compounds vary considerably depending on the raw material used. Figure 2-3 shows the fluorine content (in ppm) of soil samples taken from locations throughout the United States. The samples, which were taken at a depth of about 20 cm, are not specific to clays and shales used for brick manufacturing, but they provide insight into regional variations in the fluorine content of soils. The fluorine content of the soil samples ranges from less than 0.001 percent to 0.37 percent and averages 0.043 percent.

2.4 EMISSION CONTROL TECHNOLOGY[3-6]

A variety of control systems may be used to reduce PM emissions from brick manufacturing operations. Grinding and screening operations are sometimes controlled by fabric filtration systems, although many facilities process raw material with a relatively high moisture content (greater than 10 percent) and do not use add-on control systems. Most tunnel kilns are not equipped with control devices, although fabric filters or wet scrubbers are sometimes used for PM removal. Particulate matter

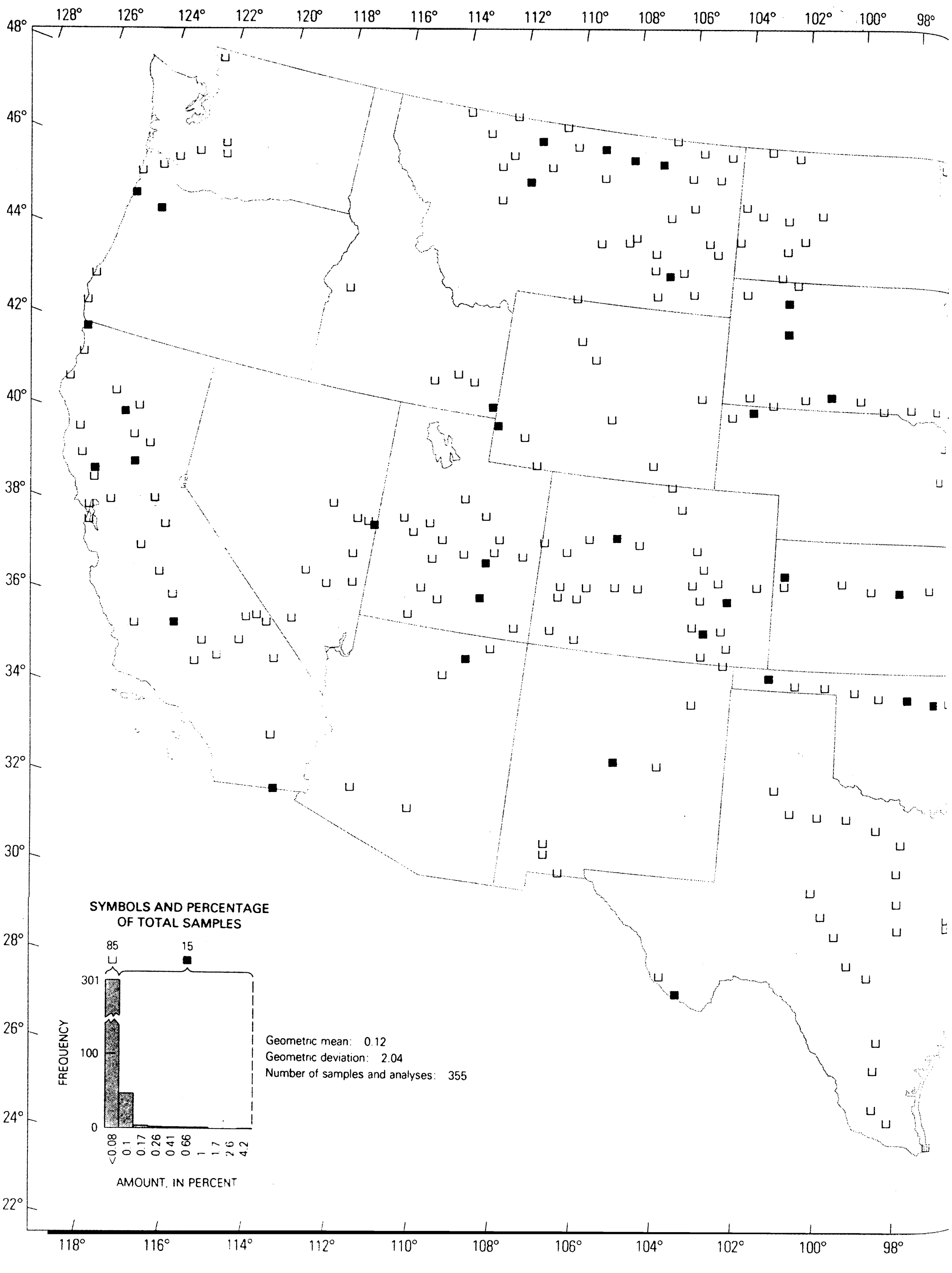

Figure 2-2. Sulfur content of soils.[22]

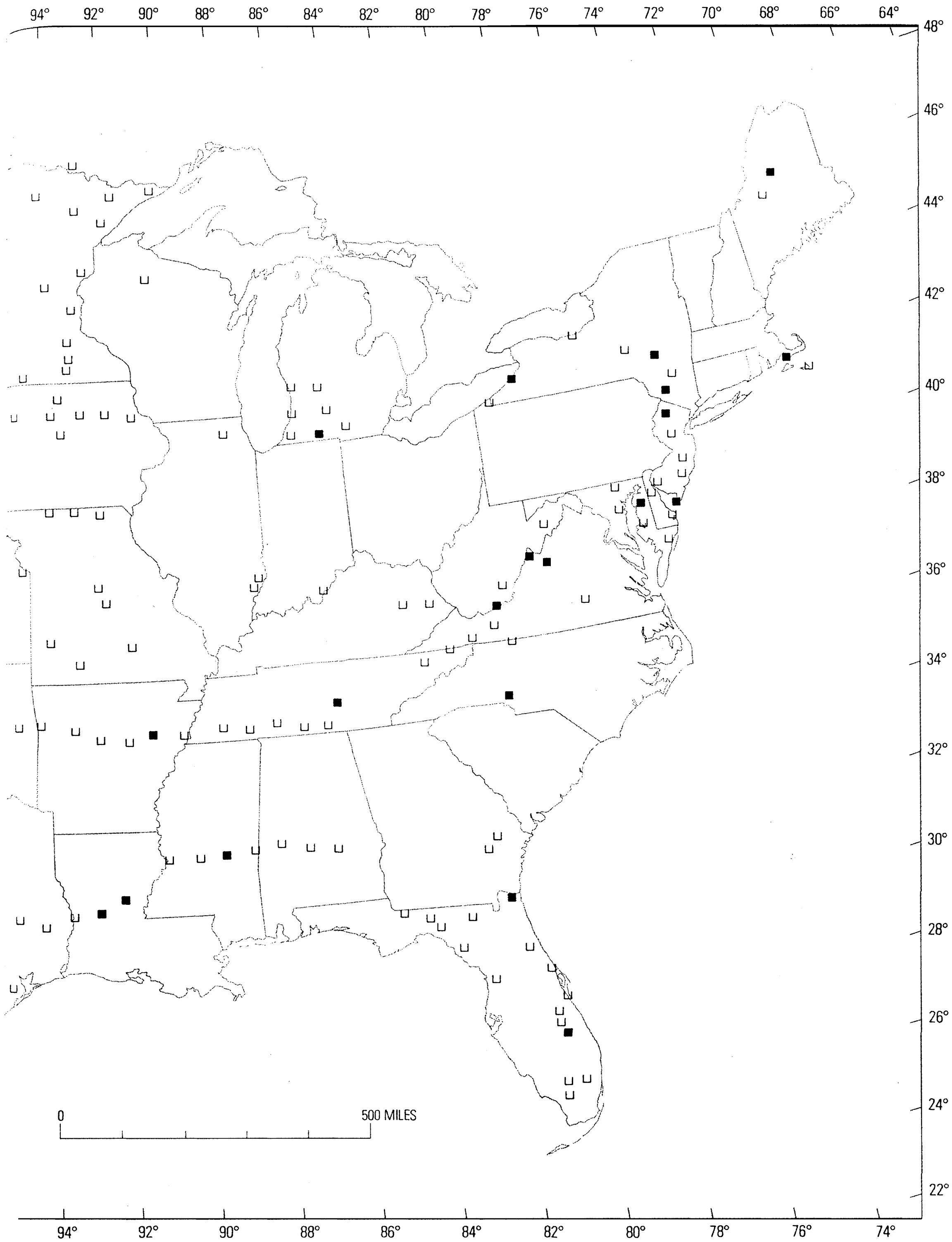

Figure 2-2. (continued)

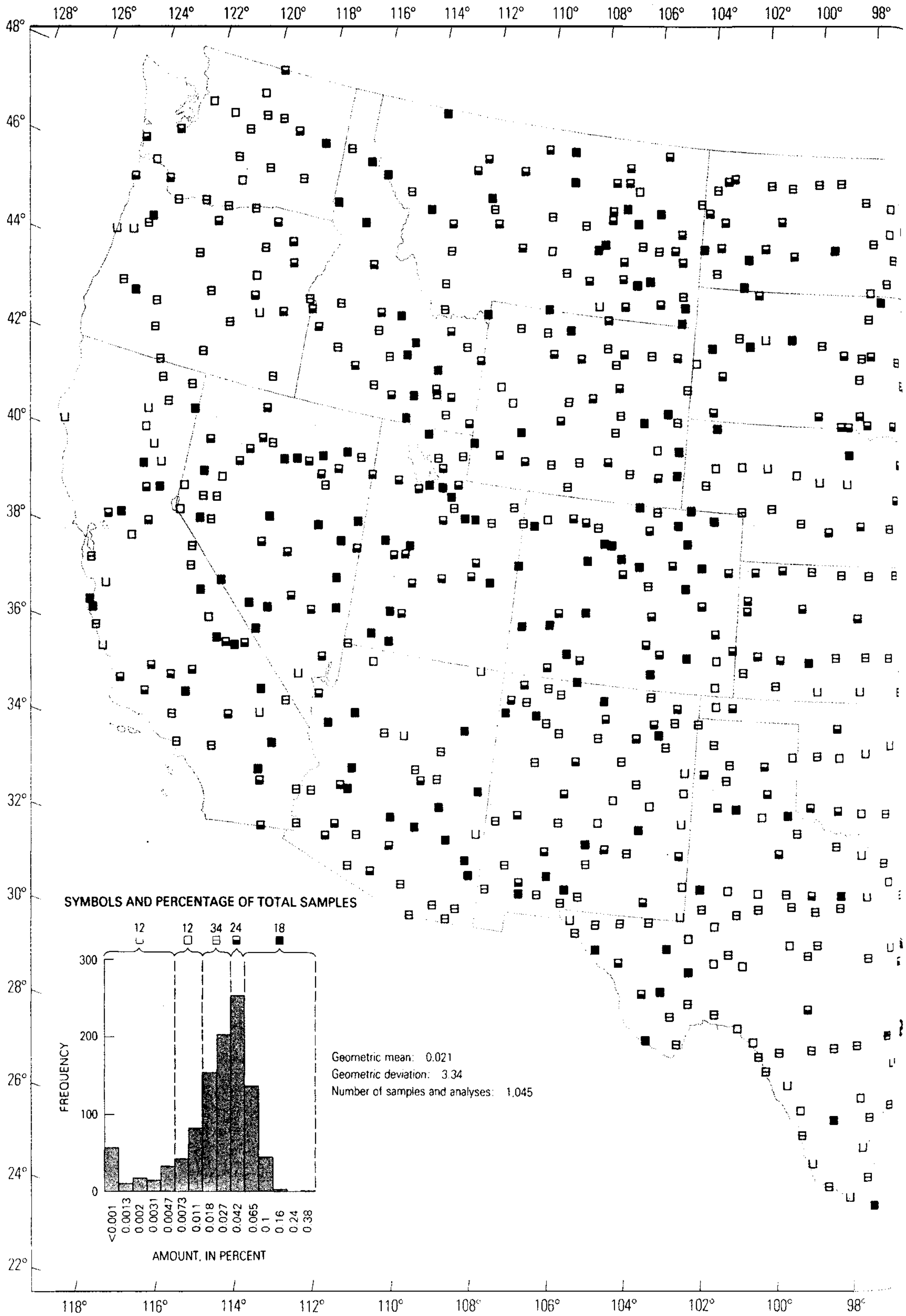

Figure 2-3. Fluorine content of soils.[22]

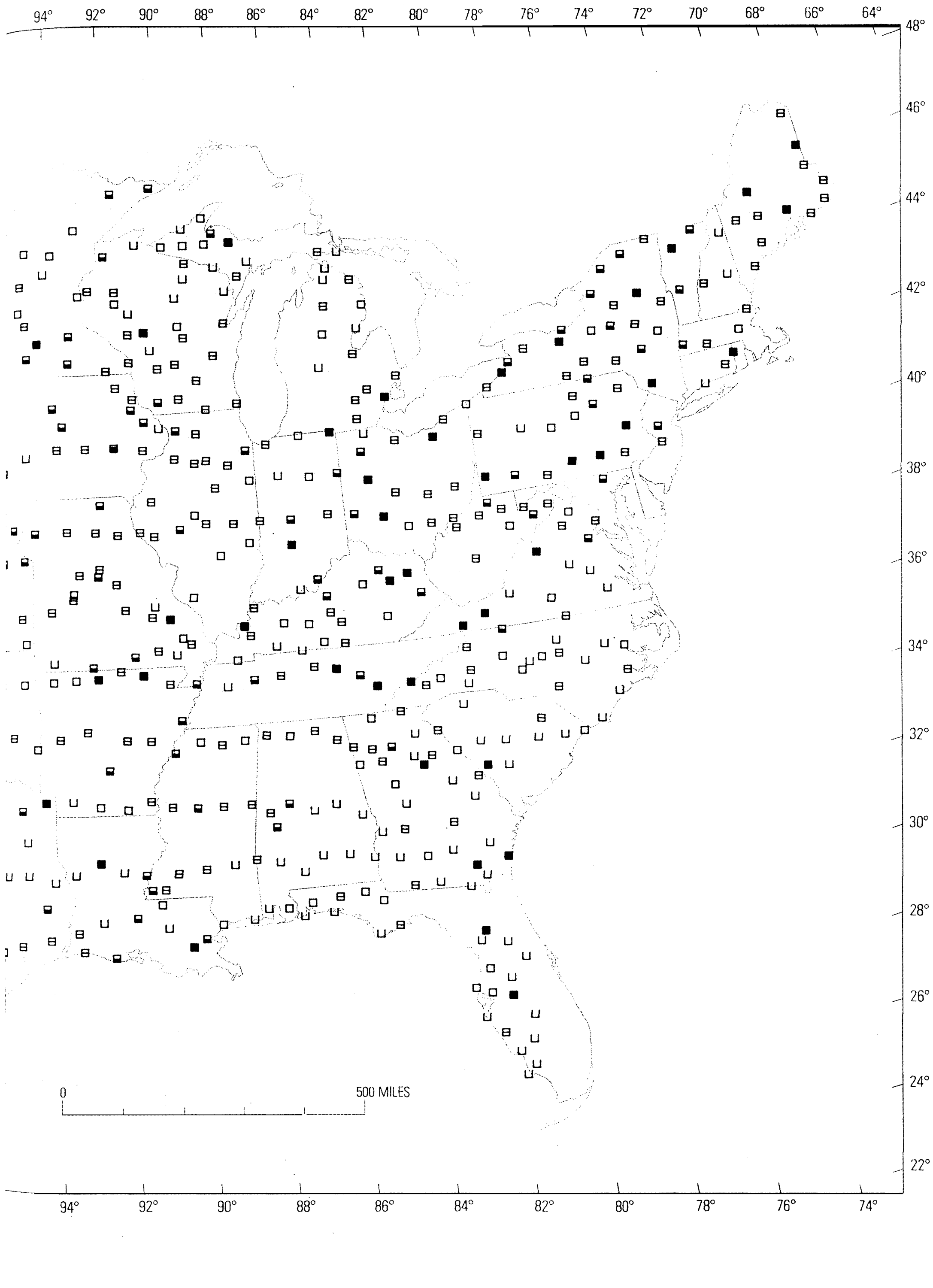

Figure 2-3. (continued)

emissions from fugitive sources such as paved roads, unpaved roads, and storage piles can be controlled using wet suppression techniques.

Gaseous emissions from brick dryers and kilns typically are not controlled using add-on control devices. However, dry scrubbers that use limestone as a sorption medium are sometimes used to control HF emissions; control efficiencies of 95 percent or higher have been reported at one plant operating this type of scrubber. Also, wet scrubbers are used at one facility. These scrubbers, which use a soda ash and water solution as the scrubbing liquid, provide effective control of HF and SO_2 emissions. Test data show that the only high-efficiency packed tower wet scrubber operating in the U.S. (at brick plants) achieves control efficiencies greater than 99 percent for SO_2 and total fluorides. A unique "medium-efficiency" wet scrubber operating at the same plant has demonstrated an 82 percent SO_2 control efficiency.

Process controls are also an effective means of controlling kiln emissions. For example, facilities with coal-fired kilns typically use a low-sulfur, low-ash coal to minimize SO_2 and PM emissions. In addition, research is being performed on the use of additives (such as lime) to reduce HF and SO_2 emissions.

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6. Written communication from B. Shrager, Midwest Research Institute, Cary, NC, to R. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1993.

7. D. A. Brosnan, "Monitoring For Hydrogen Fluoride Emissions", *Ceramic Industry*, July 1994.

8. *Emission Testing at a Structural Brick Manufacturing Plant--Final Emission Test Report for Testing at Belden Brick Company, Plant 6, Sugarcreek, Ohio,* U. S. Environmental Protection Agency, Research Triangle Park, NC, February 1995.

9. *Final Test Report for U. S. EPA Test Program Conducted At General Shale Brick Plant, Johnson City, TN*, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 1993.

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3. GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained from a number of sources within the Office of Air Quality Planning and Standards (OAQPS) and from outside organizations. The AP-42 background files located in the Emission Factors and Inventory Group (EFIG) were reviewed for information on the industry, processes, and emissions. The Factor Information and Retrieval (FIRE), Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF), and VOC/PM Speciation Data Base Management System (SPECIATE) data bases were searched by SCC code for identification of the potential pollutants emitted and emission factors for those pollutants. A general search of the Air CHIEF CD-ROM also was conducted to supplement the information from these data bases.

Information on the industry, including number of plants, plant location, and annual production capacities, was obtained from the *Census of Manufactures*, and other sources. The Aerometric Information Retrieval System (AIRS) data base also was searched for data on the number of plants, plant location, and estimated annual emissions of criteria pollutants. A number of sources of information were investigated specifically for emission test reports and data. A search of the Test Method Storage and Retrieval (TSAR) data base was conducted to identify test reports for sources within the brick and structural clay product manufacturing industry. Copies of these test reports were obtained from the files of the Emissions Monitoring and Analysis Division (EMAD). The EPA library was searched for additional test reports. Using information obtained on plant locations, State and Regional offices were contacted about the availability of test reports. Publications lists from the Office of Research and Development (ORD) and Control Technology Center (CTC) were also searched for reports on emissions from the brick and structural clay product manufacturing industry. In addition, representative trade associations, including the Brick Institute of America and the Brick Association of the Carolinas, were contacted for assistance in obtaining information about the industry and emissions.

To screen out unusable test reports, documents, and information from which emission factors could not be developed, the following general criteria were used:

1. Emission data must be from a primary reference:

a. Source testing must be from a referenced study that does not reiterate information from previous studies.

b. The document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document. If the exact source of the data could not be determined, the document was eliminated.

2. The referenced study should contain test results based on more than one test run. If results from only one run are presented, the emission factors must be down rated.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 DATA QUALITY RATING SYSTEM[1]

As part of the analysis of the emission data, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were excluded from consideration:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front half with EPA Method 5 front and back half);

3. Test series of controlled emissions for which the control device is not specified;

4. Test series in which the source process is not clearly identified and described; and

5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Test data sets that were not excluded were assigned a quality rating. The rating system used was that specified by EFIG for preparing AP-42 sections. The data were rated as follows:

A—Multiple tests that were performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in EPA reference test methods, although these methods were used as a guide for the methodology actually used.

B—Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C—Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D—Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent to which such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data are documented in the report, and any variations in the sampling and process operation are noted. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM[1]

The quality of the emission factors developed from analysis of the test data was rated using the following general criteria:

A = Excellent. Emission factor is developed primarily from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.

B = Above average. Emission factor is developed primarily from A- or B-rated test data from a moderate number of facilities. Although no specific bias is evident, is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

C = Average. Emission factor is developed primarily from A-, B-, and C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

D = Below average. Emission factor is developed primarily from A-, B- and C-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.

E = Poor. Factor is developed from C- and D-rated test data from a very few number of facilities, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

The use of these criteria is somewhat subjective and depends to an extent upon the individual reviewer. Details of the rating of each candidate emission factor are provided in Section 4.

REFERENCE FOR SECTION 3

1. *Procedures for Preparing Emission Factor Documents* EPA-454/R-95-015, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1997.

4. REVIEW OF SPECIFIC DATA SETS

4.1 INTRODUCTION

Emission factors for brick manufacturing operations (grinding rooms, brick dryers, natural gas-, coal-, and sawdust-fired tunnel kilns, and sawdust dryers) were developed using data from 28 test reports and 1 summary report. Five additional test reports, References 11, 16, and 26 through 28, were not used for emission factor development for several reasons. The test methodology described in Reference 11 is not valid. Insufficient process data are provided in Reference 16. Reference 26 provides summary data for testing of a week-long batch kiln cycle, and three 1-hour test runs were conducted. This test did not characterize emissions for the entire kiln cycle, and the data are not useful for emission factor development. References 27 and 28 provide summary data for two tests conducted at the same facility (not the same kiln, but a similar kiln) described in Reference 2. The data from References 27 and 28 are not used for emission factor development because only summary data are provided, and the data are not consistent with the fully documented data from Reference 2. Reviews of two additional documents, References 31 and 36, are also included in this report, although the documents were not used for emission factor development.

In addition to the new information, the references from the 1986 AP-42 section were reviewed, and the references that contain original test data are discussed in the following section. Emission factors for structural clay product manufacturing were developed using data from two reports.

4.2 REVIEW OF SPECIFIC DATA SETS

4.2.1 Reference 1

This test report documents an emission test conducted on November 8-12, 1993, at the Belden Brick Corporation Plant 6 in Sugarcreek, Ohio. The test was sponsored by EPA and was conducted to develop emission factors for grinding and screening, brick drying, and brick firing operations. The grinding room was tested for filterable PM and PM-10 emissions prior to and following the fabric filtration system that controls grinding room emissions. A natural gas-fired brick dryer was tested for emissions of TOC, methane, and ethane. A natural gas-fired tunnel kiln was tested for emissions of filterable PM, PM-10, condensible PM, CO, NO_x, SO_2, CO_2, HF, hydrochloric acid (HCl), chlorine (Cl_2), TOC, methane, ethane, metals, and speciated VOC and semi-volatile organic compounds (SVOC). All of the pollutants were measured using EPA reference test methods.

The grinding room was tested for uncontrolled and controlled filterable PM and PM-10 emissions. The inlet and outlet of the grinding room fabric filtration system were tested using EPA Method 5 and 201A sampling trains. Three test runs were conducted at the fabric filter inlet, and two test runs were conducted at the outlet. Only two runs were conducted at the outlet because light grain loadings necessitated long (6 to 7 hour) test runs. The inlet measurements were taken upstream of two small ducts that tied into the main duct just before the baghouse, but the dust loading carried by these two small ducts is believed to be minimal in comparison to the rest of the system. The average raw material moisture content (following the grinding operations) was 3.9 percent, and the average silt content was 16.9 percent. These grinding room emission data are assigned an A rating. Reference test methods were used, no problems were reported, and sufficient detail was provided in the report. A mass balance (using the grinding room fabric filter catch) was performed to determine uncontrolled filterable PM emissions from the grinding room, but the results of this test are believed to be biased high. Therefore, the mass balance data are not rated for use in developing emission factors.

The brick dryer (heated with waste heat from the kiln cooling zone and a supplemental gas burner) was tested for TOC, methane, and ethane emissions. The natural gas burner in the dryer was malfunctioning during the testing. Therefore, the results of these tests are not used for emission factor development and the data are not rated. However, Belden retested the dryer for TOC and CO emissions after the malfunctioning burner was fixed, and the data from the retest are presented in Appendix F of this report. These data are assigned a B rating because they are based on a single continuous test run.

Most of the data from the kiln test are assigned an A rating. The data for several of the organic pollutants measured with the volatile organic sampling train (VOST) are assigned a B rating because the measured concentrations for one or two test runs were either below the method quantitation limit or above the calibration range. In such cases, the concentrations were estimated. Data for unvalidated organic compounds measured with VOST and semi-VOST are downrated one letter grade. In addition, high background concentrations of several metals (antimony, cadmium, cobalt, lead, and selenium) may have biased the metals analysis. The data for these metals are downrated to C. Also, arsenic and beryllium were not detected during any test run, and emissions of these metals are estimated as one-half of the detection limit. These data are rated C.

After reviewing the test results, it became apparent that Belden is not a typical brick manufacturing facility. The raw material is mined from a coal seam (in conjunction with coal mining activities) and contains higher percentages of sulfur, several metals, and some organic pollutants than materials typically used for manufacturing brick. Also, Belden uses natural gas from a well in combination with public utility natural gas, and the gas may contain impurities. The emission data for SO_2 and several metals, including chromium, cobalt, mercury, and nickel, were unexpectedly higher than other available data for brick kilns. Therefore, data for each pollutant were examined for potential biases caused by the atypical materials; much of the data from this test were not used for emission factor development.

4.2.2 Reference 2

This test report documents an emission test conducted on July 26-31, 1992, at the General Shale Products Corporation brick plant in Johnson City, Tennessee. The test was sponsored by EPA and was conducted to develop emission factors for grinding and screening, brick drying, and brick firing operations. The grinding room was tested for emissions of filterable PM and PM-10 emissions following the fabric filtration system that controls grinding room emissions. The brick dryer, which is heated with waste heat from the cooling section of the kiln, was tested for emissions of TOC, methane, and ethane. Kiln A (one of two coal-fired tunnel kilns operating at the facility) was tested for emissions of filterable PM, PM-10, condensible PM, CO, NO_x, CO_2, HF, TOC, methane and ethane, metals, and speciated VOC and SVOC. The kiln was equipped with supplemental gas burners, which facilitate coal combustion.

All of the pollutants, except for methane and ethane, were measured using EPA reference test methods. Methane and ethane emissions were quantified by modifying an EPA Method 25A sampling system with an activated charcoal filter, which removed all hydrocarbons except for methane and ethane prior to analysis. This modified Method 25A test was conducted before each Method 25A test run on the dryer, and before and after each Method 25A run on the kiln. Several of the compounds detected by the semi-VOST and VOST were either below the method quantitation limit or above the calibration range. These compounds include: chloromethane, trichlorfluoromethane, carbon disulfide, acetone, 2-butanone, benzene, toluene, m-/p-xylene, 1,1-dichloroethane, dibenzofuran, 1,4-dichlorobenzene, 2-methylnaphthalene, diethylphthalate, and butylbenzylphthalate. The values for these compounds were estimated and are footnoted in the test report. In addition, emissions of several pollutants were not detected during one or more test runs. Emissions for nondetect runs were estimated as one-half of the detection limit for each pollutant (for each run). These pollutants (number of nondetect runs) are: chloromethane (one run), carbon disulfide (one run), chloroform (all three runs), vinyl acetate (all three runs), 1,1,1-trichloroethane (all three runs), carbon tetrachloride (all three runs), trichloroethane (all three runs), tetrachloroethane (all three runs), 2-hexanone (all three runs), styrene (all three runs), 2-methylphenol (all three runs), dimethylphthalate (all three runs), dibenzofuran (two runs), 1,4-dichlorobenzene (one run), butylbenzylphthalate (one run), and di-n-octylphthalate (one run).

The grinding room was tested for filterable PM and PM-10 emissions. The grinding room fabric filter exhaust stack was tested using EPA Method 5 and 201A sampling trains. The raw material moisture content was between 8.1 and 10.8 percent, and the average silt content was about 17.1 percent. These data are assigned an A rating. The reference test methods were used, no problems were reported, and sufficient detail was provided.

Most of the data from the kiln and brick dryer tests are assigned an A rating. The data for TOC and methane/ethane emissions from the kiln are assigned a B rating because the Run 3 methane/ethane measurement was higher than the Run 3 TOC measurement. The data for several of the organic pollutants measured by VOST are assigned a B rating because the measured concentrations in one or more test runs were either below the method quantitation limit or above the calibration range. In such cases, the concentrations were estimated. In addition, data for unvalidated compounds measured with the VOST and semi-VOST are downrated one letter grade, data for compounds not detected in one of three test runs are downrated one letter grade, and data for compounds not detected in two or three test runs are rated C.

4.2.3 Reference 3

This test report documents an emission test conducted on March 9, 1993 at the Chattahoochee Brick Company in Atlanta, Georgia. The test was sponsored by General Shale Products Corporation and was conducted to provide baseline emission data for emissions from brick kilns. Uncontrolled emissions of SO_2, NO_x, CO, CO_2, and total hydrocarbons from the kiln and the brick dryer were quantified using EPA Methods 6C, 7E, 10, 3 (with an Orsat gas analyzer), and 25A, respectively. A single 90-minute continuous test was conducted, with monitor readings recorded every 30 seconds. The testing indicated that SO_2, NO_x, CO, and CO_2 are not emitted from the brick dryer, which is heated with waste heat from the cooling section of the kiln. The primary fuel fired in the kiln was a low-sulfur (1.09 percent), low-ash (4.38 percent) coal, and supplemental natural gas provided about 22 percent of the heat in the kiln. Data to determine both the green brick feed and fired brick (production) process rates were provided in the report.

A rating of A was assigned to all of the test data. The report included adequate detail, the methodology appeared to be sound, and no problems were reported.

4.2.4 Reference 4

This test report documents an emission test conducted on October 27 through November 6, 1992 at the Pine Hall Brick Plant in Madison, North Carolina. The test was sponsored by EPA and was conducted to develop emission factors for the primary crushing, grinding and screening, brick firing, and sawdust drying operations. The primary crusher and the grinding room were tested for filterable PM and PM-10 emissions, and two kilns and one sawdust dryer were tested for emissions of filterable PM, PM-10, condensible PM, CO, NO_x, CO_2, total fluorides, HF, TOC, metals, and speciated VOC and SVOC. In addition, particle size analyses were performed at the kiln and sawdust dryer outlets. Process data are provided in an attachment to the report and are based on tons of material processed (primary crusher, grinding room) and tons of brick produced (kiln and sawdust dryer). In the report, the sampling point at which the kiln emissions were tested is referred to as the sawdust dryer inlet because the sawdust dryer is heated using the kiln exhaust. The sawdust dryer outlet A and outlet B results represent emissions from both the kiln and the sawdust dryer.

All of the pollutants were measured using EPA reference test methods. Several problems were noted during the testing, including: (1) isokinetic problems encountered during the total fluoride testing at the kiln and sawdust dryer outlets; (2) isokinetic problems with the first particle sizing run at the kiln outlet (four runs were conducted); (3) the sawdust dryer outlet A NO_x monitor exceeded the calibration drift limit during Run 3 of the multiple metals train and Runs 1 and 3 of semi-VOST and VOST; (4) in the analysis of the semi-VOST and VOST samples, several of the detected compounds were either below the method quantitation limit or above the calibration range (the values for these compounds were estimated and the results are footnoted in the test report); (5) the impinger fractions for semi-VOST Runs 1 and 2 (outlet B) were mislabeled during analysis; however, the two fractions were analyzed separately and found to be similar; and (6) the first test on the primary crusher was not valid because air flow through the crusher was not measured and the filter was not centered in the sampler.

The primary crusher was tested for total suspended particulate (TSP) and PM-10 emissions using ambient monitors. The crusher was enclosed on the discharge side (except for the area immediately surrounding the conveyor exit) and was completely open on the charging side. A total air flow meter was used to approximate the air flow rate into the building at the conveyor exit side of the crusher. Flow rates were calculated by multiplying the air flow meter reading (in feet) by the area of the face of the meter (in square feet) and dividing by the total measurement time. These data are not rated for use in developing emission factors because the air flow rates are approximated, and it is likely that additional air was flowing through the building through the conveyor opening at the discharge side.

The grinding room was tested for filterable PM and PM-10 emissions. Emissions were tested by ducting two of the three exhaust fans (located near the top of the building) to ground level, where EPA Method 5 and 201A sampling trains were used to quantify emissions. The third exhaust fan was turned off during testing. The raw material moisture content was between 13 and 14.2 percent, and the average silt content was about 4.5 percent. The opening for the third exhaust fan was not covered during testing, and during part of the first test run, a bay door was left open, possibly allowing PM emissions to leave the building. These data are assigned a B rating. Reference test methods were used, no problems were reported, and sufficient detail was provided. However, it is possible that emissions were exiting the grinding room through the third exhaust fan opening throughout the test or through the bay door during the first run.

The kiln and sawdust dryer tests were conducted according to EPA reference test methods and most of the data are assigned an A rating. The total fluoride data are not rated because the first run (outlet) was not isokinetic, only one of the two outlet ducts was tested, a meter box malfunctioned during testing, and the results were significantly lower than the HF test results (which are supported by the results of a mass balance test conducted by Clemson University). The data for several of the organic pollutants measured with VOST are assigned a B rating because the measured concentrations were either below the method quantitation limit or above the calibration range. In such cases, the concentrations were estimated. In addition, data for unvalidated compounds measured with the VOST and semi-VOST are downrated one letter grade. Data for ketone emissions are assigned a C rating because ketone recovery from the VOST is erratic.

4.2.5 Reference 5

This test report documents an emission test conducted on March 3, 1992 at Belden Brick Plant 3 in Sugarcreek, Ohio. The test was sponsored by Belden Brick and was conducted for compliance purposes. Uncontrolled emissions of filterable PM, SO_2, NO_x, and CO_2 from the No. 1 kiln were quantified using EPA Methods 5, 6, 7, and 3 (with an Orsat gas analyzer), respectively. Three test runs were conducted at the kiln stack. The fuel fired in the kiln was natural gas. Process data were provided in the report, but the basis of these data (feed or product) was not specified. The process data are assumed to represent fired brick production.

A rating of B was assigned to all of the test data. The report included adequate detail, the methodology appeared to be sound, and no problems were reported. However, the basis for the process data is not specified in the report.

4.2.6 Reference 6

This test report documents an emission test conducted on October 17-19, 1990 at the General Shale Products Corporation facility in Marion, Virginia. The test was sponsored by General Shale and was conducted for compliance purposes. Uncontrolled emissions of filterable PM and CO_2 from the kilns 6B and 28 were quantified using EPA Methods 5 and 3 (with a Fyrite gas analyzer), respectively. Three test runs were conducted at each kiln stack. The primary fuel fired in the kiln was a low-sulfur (0.83 percent), low-ash (2.86 percent) coal, and supplemental natural gas provided 16 percent of the heat for kiln 6B and 7.5 percent for kiln 28. Data to determine the green brick (feed) rates for both kilns are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratios of the weights of fired bricks and green bricks for the respective kilns, which were 0.833 (kiln 6B) and 0.813 (kiln 28).

A rating of A was assigned to the filterable PM test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the PM test methodology appeared to be sound, and no problems were reported. The CO_2 data are downrated to C because of the relative inaccuracy of Fyrite gas analyzers.

4.2.7 Reference 7

This test report documents an emission test conducted on October 16, 1990 at the General Shale Products Corporation facility in Glascow, Virginia. The test was sponsored by General Shale and was conducted for compliance purposes. Uncontrolled emissions of filterable PM and CO_2 from kiln No. 21 were quantified using EPA Methods 5 and 3 (with a Fyrite analyzer), respectively. Three test runs were conducted at the kiln stack. The primary fuel fired in the kiln was a low-sulfur, low-ash coal (percentages of sulfur and ash in the coal are not included in the report), and supplemental natural gas provided about 8 percent of the heat for the kiln. Data to determine the green brick feed rates for the kiln are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratio of the weights of a fired brick and a green brick, which was 0.778 for the test.

A rating of A was assigned to the filterable PM test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the PM test methodology appeared to be sound, and no problems were reported. The CO_2 data are downrated to C because of the relative inaccuracy of Fyrite gas analyzers.

4.2.8 Reference 8

This test report documents an emission test conducted on July 21, 1989 at Belden Brick Plant 3 in Sugarcreek, Ohio. The test was sponsored by Belden Brick and was conducted for compliance purposes. Uncontrolled emissions of filterable PM, SO_2, NO_x, and CO_2 from the No. 1 kiln were quantified using EPA Methods 5, 6, 7, and 3 (Orsat), respectively. Three test runs were conducted at the kiln stack. The fuel fired in the kiln was natural gas. The kiln tested is the same kiln as that discussed in Reference 5. Process data were provided in the report, but the basis of these data (feed or product) was not specified. The process data are assumed to represent fired brick production.

A rating of B was assigned to all of the test data. The report included adequate detail, the methodology appeared to be sound, and no problems were reported. However, the basis for the process data is not specified in the report.

4.2.9 Reference 9

This test report documents an emission test conducted on December 2, 1986 at the General Shale Products Corporation facility in Mooresville, Indiana. The test was sponsored by General Shale and was conducted for compliance purposes. Uncontrolled emissions of SO_2 and CO_2 from kiln No. 20 and the kiln No. 20 brick dryer were quantified using EPA Methods 6 and 3 (with a Fyrite gas analyzer), respectively. Normally, brick dryers are not expected to emit SO_2 or CO_2. Therefore, General Shale was contacted to determine the cause of these emissions. Apparently, the dryer stack was venting emissions from the kiln during the test. Therefore, kiln emissions are calculated as the sum of the dryer stack emissions and the kiln stack emissions. Three test runs were conducted at the kiln stack and at the dryer stack. The fuel fired in the kiln was a low-sulfur (1.05 percent), low-ash (3.35 percent) coal. Data to determine the green brick feed rates for the kiln are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratio of the weights of a fired brick and a green brick, which was 0.792 for the test.

A rating of A was assigned to the SO_2 test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the SO_2 test methodology appeared to be sound, and no problems were reported. Because of the relative inaccuracy of Fyrite gas analyzers, the CO_2 data are downrated to C.

4.2.10 Reference 10

This test report documents an emission test conducted on April 22, 1986 at the General Shale Products Corporation facility in Knoxville, Tennessee. The test was sponsored by General Shale and was conducted for compliance purposes. Uncontrolled emissions of filterable PM and CO_2 from kiln No. 7B were quantified using EPA Methods 5 and 3 (with a Fyrite gas analyzer), respectively. Three test runs were conducted at the kiln stack. The fuel fired in the kiln was a low-sulfur (1.18 percent), low-ash (4.31 percent) coal. Data to determine the green brick feed rates for the kiln are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratio of the weights of a fired brick and a green brick, which was 0.895 for the test.

A rating of A was assigned to the filterable PM test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the filterable PM test methodology appeared to be sound, and no problems were reported. Because of the relative inaccuracy of Fyrite gas analyzers, the CO_2 data are downrated to C.

4.2.11 Reference 12

This test report documents an emission test conducted on October 11, 1983 at the General Shale Products Corporation facility in Kingsport, Tennessee. The test was sponsored by General Shale and was conducted for compliance purposes. Uncontrolled emissions of filterable PM and CO_2 from kiln No. 15 were quantified using EPA Methods 5 and 3 (with a Fyrite analyzer), respectively. Four test runs were conducted at the kiln stack. The primary fuel fired in the kiln was a low-sulfur (0.79 percent), low-ash coal (3.22 percent), and supplemental natural gas provided about 21 percent of the heat for the kiln. Data to determine the green brick feed rates for the kiln are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratio of the weights of a fired brick and a green brick, which was 0.837 for the test.

A rating of A was assigned to the filterable PM test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the PM test methodology appeared to be sound, and no problems were reported. Because of the relative inaccuracy of Fyrite gas analyzers, the CO_2 data are downrated to C.

4.2.12 Reference 13

This test report documents an emission test conducted on July 21, 1982 at the General Shale Products Corporation facility in Kingsport, Tennessee. The test was sponsored by General Shale and was conducted for compliance purposes. Emissions of filterable PM and CO_2 following the kiln No. 29 fabric filtration system were quantified using EPA Methods 5 and 3 (with a Fyrite analyzer), respectively. Three test runs were conducted at the fabric filter outlet stack. The fuel fired in the kiln was a low-sulfur (0.78 percent), low-ash coal (4.91 percent). Data to determine the green brick feed rates for the kiln are provided in the report. General Shale was contacted for the additional data (fired brick weight) needed to determine the brick production rates. To determine the brick production rates, the green brick feed rates were multiplied by the ratio of the weights of a fired brick and a green brick, which was 0.818 for the test. In addition to the kiln test, two filterable PM test runs were conducted at the outlet of the fabric filter that controlled emissions from the coal crusher. Coal throughput data are not provided in the report, and the data could not be used for emission factor development.

A rating of A was assigned to the filterable PM test data, and a rating of C was assigned to the CO_2 data. The report included adequate detail, the PM test methodology appeared to be sound, and no problems were reported. Because of the relative inaccuracy of Fyrite gas analyzers, the CO_2 data are downrated to C.

4.2.13 Reference 14

This test report documents an emission test conducted on August 19, 1980 at the Chatham Brick and Tile Company brick plant in Gulf, North Carolina. The test was sponsored by EPA for use in developing new source performance standards. Two sawdust-fired kilns (one using natural gas for flashing) were tested for CO_2 emissions using EPA Method 3 (with an Orsat gas analyzer). In addition, a particle size analysis was performed on emissions from the kiln that was not performing flashing. An Anderson Mark III cascade impactor was used to perform two particle size tests. This cascade impactor is assumed to include a cyclone prior to the impactor, like the impactor used in the Reference 15 emission test. The CO_2 measurements did not include volumetric flow measurements for each test run; therefore, these data could not be used for emission factor development.

The particle size data are assigned a B rating because only two test runs were performed. The report included adequate detail, the test methodology appeared to be sound, and no problems were reported.

4.2.14 Reference 15

This test report documents an emission test conducted on January 9-12, 1980 at the Lee Brick and Tile Company brick plant in Sanford, North Carolina. The test was sponsored by EPA for use in developing new source performance standards. A coal-fired tunnel kiln was tested while processing both low-ash and high-ash coal. However, only a single test run was conducted while high-ash coal was used, and these data are not considered useful for emission factor development. During firing of low-ash coal, filterable PM and condensible inorganic PM emissions were measured using three EPA Method 5 test runs on each of three kiln stacks (north, south, and bottom stacks venting emissions from one kiln) and one brick dryer stack. In addition, EPA Method 3 (with an Orsat gas analyzer) was used to quantify CO_2 emissions during each PM run, and a particle size analysis was performed at the north and south kiln stacks using a cascade impactor. The cascade impactor includes a cyclone prior to the impactor. Sulfur dioxide and NO_x emissions were measured using single EPA Method 6 and 7 tests, respectively, at each kiln stack and the dryer stack. Production rates are provided in the report.

The filterable PM, condensible inorganic PM, particle size, and CO_2 data are assigned an A rating. The report included adequate detail, the test methodology appeared to be sound, and no problems were reported. The SO_2 and NO_x data are not rated because only one test run was conducted for each.

4.2.15 Reference 17

This test report documents a compliance test conducted on June 18, 1991, at the Acme Brick Company facility in Sealy, Texas. A natural gas-fired brick kiln and a brick dryer were tested for filterable PM (kiln only), total fluorides, SO_2, and CO_2 emissions using EPA Methods 5, 13, 6, and 3 (with Fyrite gas analyzer), respectively. Dryer emissions were not controlled, and kiln emissions were controlled by a dry packed bed scrubber (designed for HF control) that used 1/8 to 3/8 inch diameter limestone as the scrubbing media. The scrubber is assumed to provide a small degree of PM removal in addition to effectively controlling total fluorides emissions. The scrubber is assumed to have no significant effect on the SO_2 and CO_2 emission measurements. The SO_2 data from the dryer were added to the kiln SO_2 data because SO_2 emissions are not likely to result from brick drying. Process rates are provided (16 cars per day), and Acme has specified that each kiln car carried 14,400 bricks that weighed 4 lb each. The raw material processed at this facility has an unusually high fluorine content, and the packed bed scrubber is unique in the brick manufacturing industry in the United States.

The filterable PM, total fluorides, and SO_2 data from this report are assigned an A rating. The test methodology was sound, adequate detail about the testing was provided, and no problems were reported. The CO_2 data are assigned a C rating because of the relative inaccuracy of Fyrite gas analyzers.

4.2.16 Reference 18

This test report documents an emission compliance test conducted on January 24, 1978 at the Lee Brick and Tile Company brick plant in Sanford, North Carolina. A coal-fired tunnel kiln was tested for filterable PM emissions using EPA Method 5. In addition, EPA Method 3 (with an unspecified gas analyzer) was used to quantify CO_2 emissions during the PM testing. A single test run was conducted on each of two stacks, and process rates were provided (in tons of brick produced plus tons of coal used per hour). The amount of coal used is not reported separately from the process rate. Therefore, actual brick production rates cannot be calculated.

The data from this report are not rated because only one test run was conducted on each stack.

4.2.17 Reference 19

This test report documents an emission compliance test conducted on February 9, 1978 at the Lee Brick and Tile Company brick plant in Sanford, North Carolina. A coal-fired tunnel kiln was tested for filterable PM emissions using EPA Method 5. Three test runs were conducted on each of two stacks that vented kiln emissions, and process rates were provided in tons of brick produced per hour.

The data from this report are assigned a C rating because the report does not contain any raw data sheets, and the data presented are incomplete.

4.2.18 Reference 20

This test report documents an emission compliance test conducted on June 29, 1978 at the Lee Brick and Tile Company brick plant in Sanford, North Carolina. A coal-fired tunnel kiln was tested for filterable PM emissions using EPA Method 5. Three test runs were conducted on each of two stacks that vented kiln emissions, and process rates were provided in tons of brick produced plus tons of coal burned per hour. The amount of coal used is not reported separately from the process rate. Therefore, actual brick production rates cannot be calculated.

The data from this report are not rated because the report presents only the mass emission rates and production rates, and does not contain a summary of emission data or raw data sheets. Also, the production rates are presented in units that are inconsistent with production rates provided in other reports.

4.2.19 Reference 21

This test report documents an emission compliance test conducted on July 18 and 19, 1979 at the Chatham Brick and Tile Company brick plant in Sanford, North Carolina. A sawdust-fired tunnel kiln was tested for filterable PM emissions using EPA Method 5. Three test runs were conducted on each of two stacks that vented kiln emissions, and process rates were provided in tons of brick produced per hour. Emissions of CO_2 were measured during a single EPA Method 3 test run (gas analyzer not specified).

The PM data from this report are assigned an A rating. The test methodology was sound, adequate detail is provided in the report, and no problems were reported. The CO_2 data are not rated because only one Method 3 test run was conducted.

4.2.20 Reference 22

This reference documents the results of a test program conducted on October 17 and 18, 1995, at Triangle Brick in Merry Oaks, North Carolina. Filterable PM, condensible inorganic and organic PM, PM-10, metals, SO_2, NO_x, CO, THC, and CO_2 emissions were measured using EPA Methods 5, 202, 201A, 6C, 7E, 10, 25A, and 3A (Orsat analyzer). The test was conducted to determine emission factors to be used by the Brick Association of North Carolina.

During testing, the bricks produced included no facing material or other additives; consequently, the emissions measured were a result of fuel combustion or were released from the raw material. Brick production rates were recorded during testing, but are not included in the report. The test coordinator, Mr. William Colby, was contacted to obtain the process rates. A copy of the contact report is included in the final test report located in the AP-42 file.

The following pollutants were not detected during any test run: methane, beryllium, cobalt, and mercury. Emissions of these pollutants are estimated as one-half of the detection limit for each pollutant and each run.

Most of the data from this report are assigned an A rating. The test methodology was sound, no problems were reported, and adequate detail was provided in the report. The data for pollutants that were not detected are assigned a C rating because the emissions are estimated as described in the previous paragraph.

4.2.21 Reference 23

This reference includes a summary of emission testing conducted by the Center for Engineering Ceramic Manufacturing at Clemson University and original test data sheets for several of the tests. The tests were conducted at six facilities (seven kilns). All of the tests included HF or total fluoride measurements, and some of the tests included measurements of HCl, SO_2, SO_3, and filterable PM. Reviews of the individual tests are presented in the following paragraphs.

A test was conducted on November 8, 1995, at Boral Brick, Kiln No. 5, in Augusta, Georgia. A natural gas-fired kiln was tested for HF and HCl (EPA Method 26A), filterable PM (EPA Method 5), and SO_2/ SO_3 (EPA Method 8) emissions. Sawdust was added to the brick bodies, but did not appear to effect emissions. The data from this test are assigned a B rating. The test methodology was sound, no problems were reported, and adequate (although not extensive) detail about the process and testing was provided.

A test was conducted on February 10 and 11, 1993, at Boral Brick in Phenix City, Alabama. A natural gas-fired kiln was tested for HF and HCl (EPA Method 26A), total fluoride (EPA Method 13B), and SO_2/ SO_3 (EPA Method 8) emissions. The data from this test are assigned a C rating. The test methodology was sound, but little documentation about the process and testing was provided.

A test was conducted from July 6 through 8, 1993, at Boral Brick (formerly Isenhour Brick) in Salisbury, North Carolina. A sawdust-fired kiln (and sawdust dryer) was tested for HF and HCl (EPA Method 26A), filterable PM (EPA Method 5), and SO_2/ SO_3 (EPA Method 8) emissions. Although little process information was provided, MRI and EPA visited this plant (in 1992) and are familiar with the operations. The data from this test are assigned a B rating. The test methodology was sound, no problems were reported, and adequate (although not extensive) detail about the process and testing was provided. The filterable PM data from this test are not comparable to other available data because of the configuration of the kiln and sawdust dryer.

A test was conducted from July 6 through 8, 1993, at Endicott Clay Products in Fairbury, Nebraska. A brick kiln (unspecified fuel) was tested for total fluoride (EPA Method 13B) emissions. The data from this test are assigned a C rating. The test methodology was sound, but little documentation about the process and testing was provided.

A test was conducted on August 31 and September 1, 1993, at Redlands Brick in East Windsor, Connecticut. A natural gas-fired kiln was tested for HF and HCl (EPA Method 26A) and SO_2/ SO_3 (EPA Method 8) emissions. The data from this test are assigned a C rating. The test methodology was sound, but little documentation about the process and testing was provided.

A test was conducted on December 20, 1994, at Richtex Brick, Plant No. 4 in Columbia, South Carolina. A natural gas-fired brick kiln was tested for total fluoride (EPA Method 13B) emissions. All of the test runs were between 114 percent and 116 percent isokinetic, but the average emission from the test are consistent with total fluoride measurements from other facilities. The data from this test are assigned a C rating because of the isokinetic variation. Adequate documentation about the process and testing was provided.

A test was conducted at Richtex Brick, Plant No. 2, in Columbia, South Carolina. A coal-fired kiln was tested for HF (EPA Method 26A) emissions. Other pollutants may have been measured, but original data sheets were not available for this test. The data from this test are assigned a C rating. The test methodology was sound, but no documentation about the process and testing was provided.

A test was conducted at Richtex Brick, Plant No. 4, in Columbia, South Carolina. A natural gas-fired kiln was tested for HF (EPA Method 26A) emissions. Other pollutants may have been measured, but original data sheets were not available for this test. The summary document states that this was a special test to reduce HF emissions. The data from this test are not rated because the process was modified to reduce emissions, but no documentation of the modifications or testing was provided.

4.2.22 Reference 24

This reference documents measurements of uncontrolled filterable PM, total fluorides, SO_2, and CO_2 emissions from a natural gas-fired tunnel kiln used to manufacture structural clay tile. The test was conducted in September 1993 to demonstrate compliance with local regulations. Filterable PM, total fluorides, SO_2, and CO_2 emissions were measured using EPA Methods 5, 13B, 6, and 3 (with Orsat analyzer for CO_2 analysis), respectively. Process rates were provided on the basis of production.

The manufacturing process consists of forming tile from a clay blend, spraying a color pigment on the outside surface, drying the tile to a moisture content of 5 to 6 percent, then firing the tile in a tunnel kiln at a temperature of about 1120°C (2050°F). The kiln cycle (tile retention time in the kiln) was 73 hours. The sulfur content of the unfired tile averages about 0.19 percent at this facility.

The data from this report are assigned a B rating. The test methodology was sound and no problems were reported, but the report did not contain sufficient detail to warrant a higher rating.

4.2.23 Reference 25

This reference documents measurements of uncontrolled filterable PM, SO_2, and CO_2 emissions from a natural gas-fired tunnel kiln used to manufacture structural clay tile. The test was conducted in February 1988 to demonstrate compliance with local regulations. Filterable PM, SO_2, and CO_2 emissions were measured using EPA Methods 5, 6, and 3 (with Orsat analyzer for CO_2 analysis), respectively. Process rates were provided on the basis of production. No other process information is provided in the report.

The data from this report are assigned a B rating. The test methodology was sound and no problems were reported, but the report did not contain sufficient detail to warrant a higher rating.

4.2.24 Reference 29

This reference documents emission tests conducted on several different processes at Interstate Brick in West Jordan, Utah. The tests were conducted on December 5-7, 1994. Emissions of PM-10 were measured at the primary crusher fabric filter outlet and the Extrusion Line 3 and Line 4 fabric filter outlets. Emissions of SO_2, NO_x, and CO_2 were measured at the Tunnel Kiln No. 3 scrubber inlet and the Tunnel Kiln No. 4 scrubber inlet. Emissions of filterable PM, condensible organic PM, condensible inorganic PM, PM-10, total fluorides, SO_2, NO_x, and CO_2 were measured at the Tunnel Kiln No. 4 scrubber outlet. All of the tests included three test runs using EPA reference test methods.

The primary crusher test runs were all about 150 percent isokinetic, and the acceptable limit of isokinetic variation for EPA Method 201A is ±20 percent. High isokinetics indicate that the emission measurements are probably biased low. Because of this potential bias, these data are assigned a D rating and should be considered a low estimate of PM-10 emissions from fabric filter-controlled primary crushers. A process rate of 100 tons per hour of raw material throughput was recorded during testing.

The extrusion lines at Interstate Brick are controlled by fabric filters. Particulate matter emissions are primarily a result of a material drop point prior to the pug mill. Additives, such as manganese dioxide (325 mesh size) and barium carbonate, are sometimes added to the mixture and may contribute to PM emissions. Two of the three Extrusion Line 3 test runs were slightly above 120 percent isokinetic (Run 1--123 percent, Run 3--128 percent). However, the emission measurements from these two runs are comparable to the measurements during Run 2, which met the isokinetic requirements of Method 201A. Because no bias is indicated, these data are assigned a B rating. A process rate of 21.9 tons per hour of material processed was recorded during testing.

All of the three Extrusion Line 4 test runs were above 170 percent isokinetic. The emission measurements from this test are slightly lower than the measurements from the Line 3 test discussed above. However, the isokinetics indicate that a large bias is possible, and the data are assigned a D rating. A process rate of 21.9 tons per hour of material throughput was recorded during testing.

The test conducted at the Tunnel Kiln No. 3 scrubber inlet is not valid because a letter provided by Interstate Brick states that the volumetric flow rates measured during the test are incorrect.

Tunnel Kiln No. 4 is a natural gas-fired kiln equipped with a medium-efficiency scrubber designed to remove SO_2 and fluoride emissions from the kiln exhaust. The scrubber uses a soda-ash/water solution (maintained at pH 7) as the scrubbing media. A process rate of 12 tons per hour of fired brick produced was recorded during testing. The average sulfur and fluorine contents of the unfired brick produced by Interstate Brick are 0.0866 percent weight and 0.0944 percent weight. The Tunnel Kiln No. 4 test data are assigned an

A rating. The test methodology was sound, the report contains sufficient detail, and no problems were reported.

4.2.25 Reference 30

This reference documents an emission test conducted on Tunnel Kiln No. 3 at Interstate Brick in West Jordan, Utah. The testing was conducted on October 31, 1995. Emissions of filterable PM, condensible organic PM, condensible inorganic PM, total fluorides, SO_2, NO_x, CO, and CO_2 were measured at the kiln scrubber inlet and outlet. All of the tests included three test runs using EPA reference test methods.

Tunnel Kiln No. 3 is a natural gas-fired kiln equipped with a high-efficiency packed tower type scrubber designed to remove SO_2 and fluoride emissions from the kiln exhaust. The scrubber uses a soda-ash/water solution as the scrubbing media. A process rate of 13.2 tons per hour of fired brick produced was recorded during testing. The average sulfur and fluorine contents of the unfired brick produced by Interstate Brick are 0.0866 percent weight and 0.0944 percent weight. The test data are assigned an A rating. The test methodology was sound, the report contains sufficient detail, and no problems were reported.

4.2.26 Reference 31

This reference is Exhibit A provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document provides an estimate of uncontrolled PM emissions from grinding rooms. The estimate is based on data obtained by EPA during the November 1993 emission test conducted at Belden Brick. Ambient PM monitors were stationed upwind and downwind of the grinding room, and inside the grinding room. The document estimates the percentage of grinding room PM emissions that leave the building by subtracting the upwind (background) concentration from the downwind concentration, and dividing the difference by the inside concentration. The calculated percentage then was multiplied by the "uncontrolled" emission rate of the grinding room (measured at the inlet of the fabric filter that controls grinding room emissions), to calculate an emission rate for PM the leaves the building.

The methodology presented is somewhat similar to the upwind-downwind method of sampling fugitive PM. The upwind-downwind method requires the use of sampling instruments at a minimum of two downwind distances and three crosswind distances. The number of required upwind instruments depends on the degree of isolation of the emission source (i.e., the absence of interference from other sources upwind). The net downwind concentrations (i.e., downwind minus upwind) are used as input to dispersion equations to backcalculate the PM emission rate required to generate the pollutant concentration measured. A number of meteorological parameters must be concurrently reported for input to the dispersion equation. At a minimum, the wind direction and speed must be recorded on-site.

The monitoring conducted upwind and downwind of the Belden Brick grinding room was conducted for background information purposes and was not designed to calculate emission rates from the building. In particular, meteorological data were not collected during the test, and the concentrations measured by only one downwind monitor cannot be assumed to represent the entire plume emanating from the grinding operations. Therefore, the data presented are not rated and are not used for emission factor development.

4.2.27 Reference 32

This reference is Exhibit B provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a test report that documents emission testing conducted on a sawdust-fired brick kiln at Boral Bricks, Isenhour Division, in Salisbury, NC, on October 6, 1995. Tests for CO and CO_2 were conducted at two stacks that vent emissions from the No. 6 kiln and a third stack that vents emissions from the sawdust dryer (which is heated with a portion of the kiln exhaust). The sawdust dryer exhaust was ducted to a cyclone prior to the exhaust stack. Three test runs were conducted at each stack, and EPA reference test methods were used. The results of the three tests were summed to determine the total emissions from the kiln and sawdust dryer. Fired brick production rates are included in the report.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.28 Reference 33

This reference includes Exhibits C and D provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a test report that documents emission testing conducted on two natural gas-fired brick kilns at Boral Bricks, Inc., in Smyrna, Georgia, on August 27 and 28, 1996. Emissions of filterable PM, total fluorides, TOC, methane (not detected during any test run), SO_2, CO, NO_x, and CO_2 at the exhaust stacks of tunnel kiln Nos. 1 and 2. All of the tests included three valid runs using EPA reference test methods (Method 13B for total fluorides). Fired brick production rates are provided in an attachment to the report.

Several mistakes were found in the Method 25A test data for TOC emissions. In the report, the concentrations were not corrected to a dry basis before calculating the emission rates. Also, the first reading for Run 1 on Kiln No. 2 was 7 ppm on the data recorder, but was recorded as zero in the calculations. These errors were corrected before these data were used for emission factor development. The TOC emission rates presented in this background report differ from the emission rates presented in the report because of the corrections that were made. Also, the TOC data were reported "as carbon" in the report and were converted to an "as propane" basis for use in developing emission factors.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.29 Reference 34

This reference is Exhibit E provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a test report that documents emission testing conducted on two natural gas-fired brick kilns at Boral Bricks, Inc., in Henderson, TX, on February 15, 1996. Emissions of filterable PM, condensable inorganic PM, total fluorides, SO_2, SO_3, NO_x, and CO_2 at the exhaust stack of the dry scrubber that controls emissions from tunnel kiln Nos. 1 and 2. All of the tests included three valid runs (six CO_2 runs) using EPA reference test methods (Method 13B for total fluorides). Fired brick production rates are provided in the report.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.30 Reference 35

This reference is Exhibit F provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a test report that documents emission testing conducted on two natural gas-fired brick kilns at Boral Bricks, Inc., in Henderson, TX, on February 15, 1996. Emissions of filterable PM, condensable inorganic PM, total fluorides, SO_2, SO_3, NO_x, and CO_2 at the exhaust stack of the dry scrubber that controls emissions from tunnel kiln Nos. 1 and 2. Total fluoride emissions were also measured prior to the scrubber. All of the tests included three valid runs using EPA reference test methods (Method 13B for total fluorides). Fired brick production rates are provided in an attachment to the report. The scrubber demonstrated a fluoride removal efficiency of about 93.5 percent during the test.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.31 Reference 36

This reference is Exhibit G provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a memo summarizing the approach suggested for all Boral plants in estimating emissions from pneumatic control devices in operation. It suggests assuming a constant exhaust grain loading for pneumatic devices. This memo also states that if operations are uncontrolled, emissions should be based on production rates (draft AP-42 factor) and should incorporate a building removal efficiency where applicable.

For emission inventory purposes, an emission factor that is associated with production is needed to estimate emissions from the industry as a whole. For a specific facility that needs to estimate emissions from grinding rooms, the proposed method should provide a better estimate than the AP-42 emission factor. The information from this memo was not used for emission factor development.

4.2.32 Reference 37

This reference is Exhibit H provided by the BIA following the (December 1996 to February 1997) external review of the draft background report and AP-42 Section 11.3. The document is a test report that documents emission testing conducted on a sawdust-fired brick kiln at Statesville Brick Company, in Statesville, North Carolina, on November 29, 1994. Tests for CO and CO_2 were conducted at a stack that vents emissions from the No. 6 kiln and a stack that vents emissions from the sawdust dryer (which is heated with a portion of the kiln exhaust). The sawdust dryer exhaust was ducted to a cyclone prior to the exhaust stack. Three test runs were conducted at each stack, and EPA reference test methods were used. The results of the three tests were summed to determine the total emissions from the kiln and sawdust dryer. Fired brick production rates are included in the report.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.33 Reference 38

This reference documents and emission testing conducted on the tunnel kiln and brick dryers at Marseilles Brick Venture, Ltd., in Marseilles, Illinois, on August 29 and 30, 1994. The brick dryers are independent tunnels that are each about 200 ft long and are heated with waste heat from the kiln cooling zone and supplemental gas burners. The raw material used to form the bricks included 17 percent shale and 83 percent fire clay mixture. The tunnel kiln is a 498 ft natural gas-fired kiln that holds 36 kiln cars. The cooling zone includes a rapid cool zone where the brick is cooled from approximately 1930°F to about 1300°F by injecting ambient air directly on the brick. The kiln and dryers were tested for filterable PM, NO_x, CO, CO_2, TOC, SO_2, and SO_3 emissions. Three test runs were conducted for each pollutant and EPA reference test methods were used. During testing, the kiln was operating on a 15 car per day production schedule; this equates to 11.97 tons per hour of fired brick produced. For the dryers, the process rate was estimated using the assumption that each dryer provided half of the brick that was produced. Sulfur dioxide, TOC, and NO_x emissions were not detected during the dryer tests (SO_2 and TOC were each detected by one of six dryer test runs). Although SO_3 was detected during the dryer tests, the data were added to the kiln SO_3 data because SO_3 emissions are not likely to result from brick drying.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.34 Reference 39

This reference documents and emission testing conducted on the tunnel kiln and brick dryers at Marseilles Brick Venture, Ltd., in Marseilles, Illinois, on May 10 and 11, 1994. The brick dryers are independent tunnels that are each about 200 ft long and are heated with waste heat from the kiln cooling zone and supplemental gas burners. The raw material used to form the bricks included 80 percent shale and 20 percent fire clay mixture. The tunnel kiln is a 498 ft natural gas-fired kiln that holds 36 kiln cars. The cooling zone includes a rapid cool zone where the brick is cooled from approximately 1930°F to about 1300°F by injecting ambient air directly on the brick. The kiln and dryers were tested for filterable PM, NO_x, CO, CO_2, TOC, SO_2, and SO_3 emissions. Three test runs were conducted for each pollutant and EPA reference test methods were used. During testing, the kiln was operating on a 12 car per day production schedule; this equates to 9.58 tons per hour of fired brick produced. For the dryers, the process rate was estimated using the assumption that each dryer provided half of the brick that was produced. Sulfur dioxide emissions were not detected during the dryer tests. Although SO_3 was detected during four of six dryer test runs, the data were added to the kiln SO_3 data because SO_3 emissions are not likely to result from brick drying.

The data from this report are assigned an A rating. The test methodology was sound, adequate detail was provided, and no problems were reported.

4.2.35 Review of FIRE and SPECIATE Data Base Emission Factors

The FIRE and SPECIATE data bases do not contain any new emission factors for brick and structural clay product manufacturing operations.

4.3 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

Emission factors for grinding and screening, brick dryers, coal-fired kilns, natural gas-fired kilns, sawdust-fired kilns, and sawdust-fired kilns followed by sawdust dryers were developed using data from the references described in Section 4.2 of this document. These data are presented in Table 4-1, the emission factor data combination is shown in Table 4-2, and a summary of the candidate emission factors is presented in Table 4-3. Particle size distribution data are shown in Tables 4-4 and 4-5. Sections 4.3.1 through 4.3.13 present detailed descriptions, by pollutant, of the data combination and emission factor

TABLE 4-1. SUMMARY OF TEST DATA FOR BRICK AND STRUCTURAL CLAY PRODUCT MANUFACTURING[a]

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Grinding room[b]	Filterable PM	3	A	5.4-10.5	8.5	1
Grinding room[b]	Filterable PM-10	3	A	0.51-0.55	0.53	1
Grinding room[b]	Filterable PM	2	NR	16-18	17	1
Grinding room with fabric filter[b]	Filterable PM	2	A	0.0043-0.0061	0.0052	1
Grinding room with fabric filter[b]	Filterable PM-10	2	A	0.0011-0.0012	0.0011	1
Natural gas-fired kiln	Arsenic[c]	3	C	$1.7x10^{-5}$-$1.9x10^{-5}$	$1.8x10^{-5}$	1
Natural gas-fired kiln	Beryllium[c]	3	C	$3.4x10^{-7}$-$3.6x10^{-7}$	$3.4x10^{-7}$	1
Natural gas-fired kiln	Cadmium	3	C	$1.0x10^{-5}$-$5.7x10^{-5}$	$3.3x10^{-5}$	1
Natural gas-fired kiln	Chromium	3	A	0.0035-0.0151	0.0075	1
Natural gas-fired kiln	Cobalt	3	C	$5.2x10^{-5}$-0.00020	0.00011	1
Natural gas-fired kiln	Mercury	3	A	$7.0x10^{-5}$-0.00023	0.00016	1
Natural gas-fired kiln	Manganese	3	A	0.00043-0.0013	0.00073	1
Natural gas-fired kiln	Nickel	3	A	0.0017-0.0082	0.0042	1
Natural gas-fired kiln	Lead	3	C	$6.3x10^{-5}$-$9.8x10^{-5}$	$7.9x10^{-5}$	1
Natural gas-fired kiln	Antimony	3	C	$1.4x10^{-5}$-$2.7x10^{-5}$	$2.2x10^{-5}$	1
Natural gas-fired kiln	Selenium	3	C	0.00027-0.00051	0.00036	1
Natural gas-fired kiln	Chloromethane	3	B	$9.0x10^{-5}$-0.0017	0.00067	1
Natural gas-fired kiln	Chloroethane	3	B	$1.9x10^{-6}$-0.0013	0.00057	1
Natural gas-fired kiln	Iodomethane	3	B	$1.4x10^{-5}$-0.00019	$9.3x10^{-5}$	1
Natural gas-fired kiln	Acetone	3	C	0.0012-0.0026	0.0017	1
Natural gas-fired kiln	Carbon disulfide	3	B	$2.7x10^{-5}$-$5.3x10^{-5}$	$4.1x10^{-5}$	1
Natural gas-fired kiln	2-butanone	3	C	0.00011-0.00034	0.00022	1
Natural gas-fired kiln	1,1,1-Trichloroethane	3	B	$6.6x10^{-7}$-$8.3x10^{-6}$	$4.7x10^{-6}$	1
Natural gas-fired kiln	Benzene	3	B	0.0012-0.0045	0.0029	1
Natural gas-fired kiln	2-Hexanone	3	C	$3.0x10^{-6}$-0.00015	$8.5x10^{-5}$	1
Natural gas-fired kiln	Tetrachloroethene	3	A	$4.7x10^{-7}$-$4.1x10^{-6}$	$2.8x10^{-6}$	1
Natural gas-fired kiln	Toluene	3	B	0.00012-0.00018	0.00016	1
Natural gas-fired kiln	Ethylbenzene	3	B	$3.6x10^{-5}$-$5.5x10^{-5}$	$4.4x10^{-5}$	1
Natural gas-fired kiln	Styrene	3	B	$2.6x10^{-6}$-$4.7x10^{-5}$	$2.0x10^{-5}$	1
Natural gas-fired kiln	m-/p-Xylene	3	B	$5.5x10^{-5}$-$8.0x10^{-5}$	$6.7x10^{-5}$	1
Natural gas-fired kiln	o-Xylene	3	B	$4.7x10^{-5}$-$6.9x10^{-5}$	$5.8x10^{-5}$	1
Natural gas-fired kiln	Phenol	3	A	$6.3x10^{-5}$-0.00010	$8.6x10^{-5}$	1
Natural gas-fired kiln	1,4-dichlorobenzene	3	B	$3.7x10^{-5}$-$7.0x10^{-5}$	$4.8x10^{-5}$	1

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural gas-fired kiln	Naphthalene	3	C	$4.6x10^{-5}$-$8.8x10^{-5}$	$6.5x10^{-5}$	1
Natural gas-fired kiln	2-methylnaphthalene	3	B	$3.7x10^{-5}$-$8.0x10^{-5}$	$5.7x10^{-5}$	1
Natural gas-fired kiln	Diethylphthalate	3	B	0.00013-0.00041	0.00024	1
Natural gas-fired kiln	Di-n-butylphthalate	3	B	0.00010-0.00022	0.00014	1
Natural gas-fired kiln	Butylbenzylphthalate	3	B	$1.5x10^{-5}$-$2.2x10^{-5}$	$1.8x10^{-5}$	1
Natural gas-fired kiln	Bis(2-ethylhexy)phthalate	3	C	0.00059-0.0037	0.0020	1
Natural gas-fired kiln	SO_2	3	A	2.4-3.3	3.0	1
Natural gas-fired kiln	NO_x	3	A	0.71-1.0	0.91	1
Natural gas-fired kiln	CO	3	A	1.0-1.2	1.1	1
Natural gas-fired kiln	CO_2	3	A	720-830	770	1
Natural gas-fired kiln	TOC as methane	3	A	0.050-0.10	0.081	1
Natural gas-fired kiln	Methane	3	A	0.072-0.11	0.084	1
Natural gas-fired kiln	Filterable PM[d]	3	A	0.35-0.46	0.42	1
Natural gas-fired kiln	Filterable PM[e]	3	A	0.32-0.65	0.47	1
Natural gas-fired kiln	Filterable PM[f]	3	B	0.23-0.35	0.30	1
Natural gas-fired kiln	Filterable PM-10	3	A	0.066-0.26	0.13	1
Natural gas-fired kiln	Condensible inorganic PM	3	A	2.9-3.3	3.1	1
Natural gas-fired kiln	Condensible organic PM	3	A	0.18-1.1	0.51	1
Natural gas-fired kiln	Hydrogen fluoride	3	A	0.27-0.32	0.30	1
Natural gas-fired kiln	Hydrochloric acid	3	A	0.017-0.020	0.018	1
Natural gas-fired kiln	Chlorine	3	A	0.0012-0.0016	0.0013	1
Brick dryer with supplemental gas burner	TOC as methane	1	B	NA	0.18	1
Brick dryer with supplemental gas burner	CO	1	B	NA	0.44	1
Grinding room with fabric filter[b]	Filterable PM	3	A	0.0042-0.012	0.0072	2
Grinding room with fabric filter[b]	Filterable PM-10	3	A	0.0028-0.0093	0.0052	2
Brick dryer--waste heat	TOC as propane	3	A	0.058-0.062	0.060	2
Brick dryer--waste heat	Methane/ethane as propane	3	A	0.023-0.034	0.028	2
Brick dryer--waste heat	TNMOC as propane	3	A	0.026-0.039	0.032	2
Coal-fired kiln[g]	Filterable PM	6	A	0.62-0.76	0.67	2
Coal-fired kiln[g]	Filterable PM-10	3	A	0.38-0.51	0.45	2
Coal-fired kiln[g]	Condensible inorganic PM	3	A	0.067-0.19	0.12	2

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Coal-fired kiln[g]	Condensible organic PM	3	A	0.029-0.068	0.048	2
Coal-fired kiln[g]	CO_2	9	A	210-300	270	2
Coal-fired kiln[g]	Antimony	3	A	$1.3x10^{-5}$-$1.5x10^{-5}$	$1.4x10^{-5}$	2
Coal-fired kiln[g]	Arsenic	3	A	$1.3x10^{-4}$-$1.4x10^{-4}$	$1.3x10^{-4}$	2
Coal-fired kiln[g]	Beryllium	3	A	$1.4x10^{-5}$-$1.7x10^{-5}$	$1.6x10^{-5}$	2
Coal-fired kiln[g]	Cadmium	3	A	$2.2x10^{-6}$-$4.3x10^{-6}$	$3.3x10^{-6}$	2
Coal-fired kiln[g]	Chromium	3	A	$7.2x10^{-5}$-$8.7x10^{-5}$	$7.8x10^{-5}$	2
Coal-fired kiln[g]	Lead	3	A	$7.7x10^{-5}$-$9.1x10^{-5}$	$8.6x10^{-5}$	2
Coal-fired kiln[g]	Manganese	3	A	$4.5x10^{-5}$-$4.8x10^{-5}$	$4.7x10^{-5}$	2
Coal-fired kiln[g]	Mercury	3	A	$8.8x10^{-5}$-$1.0x10^{-4}$	$9.6x10^{-5}$	2
Coal-fired kiln[g]	Nickel	3	A	$1.6x10^{-4}$-$2.0x10^{-4}$	$1.7x10^{-4}$	2
Coal-fired kiln[g]	Phosphorus	3	A	$5.3x10^{-4}$-$5.8x10^{-4}$	$5.5x10^{-4}$	2
Coal-fired kiln[g]	Selenium	3	A	$4.2x10^{-4}$-$5.2x10^{-4}$	$4.6x10^{-4}$	2
Coal-fired kiln[g]	CO	3	A	0.87-0.94	0.90	2
Coal-fired kiln[g]	NO_x	3	A	0.66-0.75	0.71	2
Coal-fired kiln[g]	Hydrogen fluoride	3	A	0.060-0.24	0.13	2
Coal-fired kiln[g]	TOC as propane	3	B	0.066-0.23	0.14	2
Coal-fired kiln[g]	Methane/ethane as propane	3	B	0.094-0.11	0.10	2
Coal-fired kiln[g]	Chloromethane[h]	3	B	$4.8x10^{-5}$-$1.7x10^{-4}$	$1.1x10^{-4}$	2
Coal-fired kiln[g]	Bromomethane	3	A	$2.2x10^{-5}$-$2.6x10^{-5}$	$2.4x10^{-5}$	2
Coal-fired kiln[g]	Trichlorofluoromethane	3	B	$3.5x10^{-6}$-$3.0x10^{-5}$	$1.4x10^{-5}$	2
Coal-fired kiln[g]	Carbon disulfide[h]	3	C	$5.0x10^{-8}$-$3.4x10^{-6}$	$2.3x10^{-6}$	2
Coal-fired kiln[g]	Acetone	3	C	$3.9x10^{-4}$-$9.3x10^{-4}$	$6.8x10^{-4}$	2
Coal-fired kiln[g]	Methylene chloride	3	C	0-$2.4x10^{-6}$	$8.0x10^{-7}$	2
Coal-fired kiln[g]	Chloroform[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	Vinyl acetate[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	2-butanone	3	C	$2.0x10^{-4}$-$2.9x10^{-4}$	$2.5x10^{-4}$	2
Coal-fired kiln[g]	1,1,1-trichloroethane[c]	3	C	NA	BDL ($1.7x10^{-5}$)	2
Coal-fired kiln[g]	Carbon tetrachloride[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	Benzene	3	B	$2.8x10^{-4}$-$3.0x10^{-4}$	$2.9x10^{-4}$	2
Coal-fired kiln[g]	Trichloroethane[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	Toluene	3	C	$2.0x10^{-4}$-$3.1x10^{-4}$	$2.5x10^{-4}$	2
Coal-fired kiln[g]	Tetrachloroethane[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	2-hexanone[c]	3	C	NA	BDL ($8.2x10^{-7}$)	2

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Coal-fired kiln[g]	Ethylbenzene	3	B	$1.8x10^{-5}$-$2.7x10^{-5}$	$2.1x10^{-5}$	2
Coal-fired kiln[g]	M-/p-xylene	3	C	$9.2x10^{-5}$-$1.8x10^{-4}$	$1.3x10^{-4}$	2
Coal-fired kiln[g]	O-xylene	3	B	$3.6x10^{-5}$-$6.3x10^{-5}$	$4.7x10^{-5}$	2
Coal-fired kiln[g]	Styrene[c]	3	C	NA	BDL ($1.0x10^{-7}$)	2
Coal-fired kiln[g]	Chloroethane	3	B	$1.0x10^{-5}$-$1.4x10^{-5}$	$1.1x10^{-5}$	2
Coal-fired kiln[g]	1,1-dichloroethane	3	C	$7.7x10^{-7}$-$1.3x10^{-5}$	$5.0x10^{-6}$	2
Coal-fired kiln[g]	Chlorobenzene	3	B	$1.4x10^{-5}$-$2.4x10^{-5}$	$2.1x10^{-5}$	2
Coal-fired kiln[g]	Phenol	3	A	0-$5.7x10^{-5}$	$3.5x10^{-5}$	2
Coal-fired kiln[g]	Naphthalene	3	A	0-$1.7x10^{-5}$	$6.9x10^{-6}$	2
Coal-fired kiln[g]	2-methylphenol[c]	3	C	NA	BDL ($2.2x10^{-6}$)	2
Coal-fired kiln[g]	Dimethylphthalate[c]	3	C	NA	BDL ($7.8x10^{-7}$)	2
Coal-fired kiln[g]	Dibenzofuran[j]	3	C	$2.9x10^{-7}$-$4.2x10^{-7}$	$3.6x10^{-7}$	2
Coal-fired kiln[g]	Di-n-butylphthalate	3	A	0-0	0	2
Coal-fired kiln[g]	Bis(2-ethylhexy)phthalate	3	C	0-$1.2x10^{-4}$	$4.9x10^{-5}$	2
Coal-fired kiln[g]	1,4-dichlorobenzene[h]	3	C	$6.9x10^{-7}$-$4.8x10^{-6}$	$3.2x10^{-6}$	2
Coal-fired kiln[g]	Isophorone	3	B	$1.1x10^{-6}$-$8.7x10^{-5}$	$3.0x10^{-5}$	2
Coal-fired kiln[g]	Benzoic acid	3	B	$1.6x10^{-4}$-$3.9x10^{-4}$	$2.5x10^{-4}$	2
Coal-fired kiln[g]	2-methylnaphthalene	3	C	$1.3x10^{-6}$-$2.5x10^{-6}$	$1.7x10^{-6}$	2
Coal-fired kiln[g]	Diethylphthalate	3	C	$7.9x10^{-7}$-$2.4x10^{-6}$	$1.4x10^{-6}$	2
Coal-fired kiln[g]	Butylbenzylphthalate[h]	3	C	$1.2x10^{-6}$-$1.3x10^{-6}$	$1.2x10^{-6}$	2
Coal-fired kiln[g]	Di-n-octylphthalate[h]	3	C	$7.9x10^{-6}$-$1.4x10^{-5}$	$1.2x10^{-5}$	2
Brick dryer--waste heat	SO_2	1	A	NA	0	3
Brick dryer--waste heat	TOC as propane	1	A	NA	0.036	3
Coal-fired kiln[g]	CO_2	1	A	NA	300	3
Coal-fired kiln[g]	SO_2[k]	1	A	NA	1.2	3
Coal-fired kiln[g]	NO_x	1	A	NA	0.30	3
Coal-fired kiln[g]	CO	1	A	NA	0.70	3
Coal-fired kiln[g]	TOC as propane	1	A	NA	0.011	3
Primary crusher[b]	Filterable PM-10	2	NR	$9.3x10^{-8}$-$1.3x10^{-7}$	$1.1x10^{-7}$	4
Grinding room[b]	Filterable PM	3	B	0.016-0.031	0.025	4
Grinding room[b]	Filterable PM-10	3	B	0.0019-0.0032	0.0023	4
Sawdust-fired kiln	Filterable PM	3	A	0.28-0.34	0.30	4
Sawdust-fired kiln	Filterable PM-10	3	A	0.20-0.22	0.21	4
Sawdust-fired kiln	Condensible inorganic PM	3	A	0.14-0.23	0.20	4

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Sawdust-fired kiln	Condensible organic PM	3	A	0.066-0.11	0.081	4
Sawdust-fired kiln	CO_2	9	A	470-630	540	4
Sawdust-fired kiln	Antimony[j]	3	C	$3.6x10^{-6}$-$1.2x10^{-5}$	$6.3x10^{-6}$	4
Sawdust-fired kiln	Arsenic	3	A	$4.5x10^{-5}$-$5.5x10^{-5}$	$5.1x10^{-5}$	4
Sawdust-fired kiln	Beryllium	3	A	$5.3x10^{-7}$-$1.1x10^{-6}$	$7.2x10^{-7}$	4
Sawdust-fired kiln	Cadmium	3	A	$6.2x10^{-6}$-$2.9x10^{-5}$	$1.7x10^{-5}$	4
Sawdust-fired kiln	Chromium	3	A	$3.3x10^{-5}$-$7.1x10^{-5}$	$5.3x10^{-5}$	4
Sawdust-fired kiln	Lead	3	A	$1.7x10^{-4}$-$4.8x10^{-4}$	$3.3x10^{-4}$	4
Sawdust-fired kiln	Manganese	3	A	0.0010-0.036	0.013	4
Sawdust-fired kiln	Mercury	3	A	$5.4x10^{-6}$-$1.5x10^{-5}$	$9.9x10^{-6}$	4
Sawdust-fired kiln	Nickel	3	A	$2.1x10^{-5}$-$4.7x10^{-5}$	$3.4x10^{-5}$	4
Sawdust-fired kiln	Phosphorus	3	A	0.0011-0.0018	0.0014	4
Sawdust-fired kiln	Selenium	3	A	$2.2x10^{-5}$-$1.2x10^{-4}$	$5.6x10^{-5}$	4
Sawdust-fired kiln	CO	9	A	2.9-3.5	3.2	4
Sawdust-fired kiln	NO_x	9	A	0.39-0.44	0.41	4
Sawdust-fired kiln	Total fluorides	3	NR	0.0028-0.19	0.070	4
Sawdust-fired kiln	Hydrogen fluoride	3	A	0.21-0.64	0.46	4
Sawdust-fired kiln	TOC as propane	3	A	0.053-0.060	0.057	4
Sawdust-fired kiln	Acetone	3	C	$1.7x10^{-4}$-$7.7x10^{-4}$	$3.9x10^{-4}$	4
Sawdust-fired kiln	Acrylonitrile[j]	3	C	$9.0x10^{-6}$-$2.7x10^{-5}$	$1.5x10^{-5}$	4
Sawdust-fired kiln	Benzene	3	B	$4.0x10^{-4}$-$5.8x10^{-4}$	$5.2x10^{-4}$	4
Sawdust-fired kiln	Bromomethane	3	A	$3.4x10^{-5}$-$7.1x10^{-5}$	$5.0x10^{-5}$	4
Sawdust-fired kiln	2-butanone[c]	3	C	NA	BDL ($6.6x10^{-6}$)	4
Sawdust-fired kiln	Carbon disulfide	3	C	$1.3x10^{-5}$-$2.0x10^{-5}$	$1.6x10^{-5}$	4
Sawdust-fired kiln	Carbon tetrachloride[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Chloroform[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Chloromethane	3	B	$1.4x10^{-4}$-0.0010	$6.8x10^{-4}$	4
Sawdust-fired kiln	Ethylbenzene	3	C	$6.0x10^{-6}$-$1.3x10^{-5}$	$8.5x10^{-6}$	4
Sawdust-fired kiln	2-hexanone[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Iodomethane	3	B	$1.6x10^{-4}$-$2.3x10^{-4}$	$2.0x10^{-4}$	4
Sawdust-fired kiln	Methylene chloride	3	B	$4.1x10^{-6}$-$1.0x10^{-5}$	$7.5x10^{-6}$	4
Sawdust-fired kiln	M-/p-xylene	3	C	$1.1x10^{-5}$-$5.0x10^{-5}$	$2.9x10^{-5}$	4
Sawdust-fired kiln	O-xylene[j]	3	C	$1.8x10^{-6}$-$5.4x10^{-6}$	$3.8x10^{-6}$	4
Sawdust-fired kiln	Styrene[c]	3	C	NA	BDL ($4.4x10^{-7}$)	4

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Sawdust-fired kiln	Tetrachloroethane[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Toluene	3	C	$6.5x10^{-5}$-$1.3x10^{-4}$	$1.1x10^{-4}$	4
Sawdust-fired kiln	1,1,1-trichloroethane[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Trichloroethane[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Trichlorofluoromethane	3	B	$4.6x10^{-6}$-$7.0x10^{-6}$	$5.8x10^{-6}$	4
Sawdust-fired kiln	Vinyl acetate[c]	3	C	NA	BDL ($3.0x10^{-7}$)	4
Sawdust-fired kiln	Bis(2-ethylhexy)phthalate	3	B	$1.9x10^{-5}$-$3.9x10^{-5}$	$2.9x10^{-5}$	4
Sawdust-fired kiln	Dibenzofuran[h]	3	B	$1.0x10^{-9}$-$3.5x10^{-5}$	$1.5x10^{-5}$	4
Sawdust-fired kiln	Dimethylphthalate[j]	3	C	$1.0x10^{-9}$-$3.1x10^{-5}$	$1.0x10^{-5}$	4
Sawdust-fired kiln	Di-n-butylphthalate[j]	3	C	$1.0x10^{-9}$-$1.8x10^{-5}$	$6.1x10^{-6}$	4
Sawdust-fired kiln	2-methylphenol[c]	3	C	NA	BDL ($2.0x10^{-9}$)	4
Sawdust-fired kiln	Naphthalene[j]	3	C	$1.0x10^{-9}$-$1.0x10^{-3}$	$3.4x10^{-4}$	4
Sawdust-fired kiln	Phenol[h]	3	B	$1.0x10^{-9}$-$1.9x10^{-4}$	$7.2x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Filterable PM	3	A	1.3-1.4	1.3	4
Sawdust-fired kiln and sawdust dryer	Filterable PM-10	3	A	0.22-0.29	0.25	4
Sawdust-fired kiln and sawdust dryer	Condensible inorganic PM	3	A	0.0037-0.022	0.013	4
Sawdust-fired kiln and sawdust dryer	Condensible organic PM	3	A	0.011-0.088	0.043	4
Sawdust-fired kiln and sawdust dryer	CO_2	9	A	420-480	460	4
Sawdust-fired kiln and sawdust dryer	Antimony[j]	3	C	$2.7x10^{-6}$-$3.0x10^{-6}$	$2.8x10^{-6}$	4
Sawdust-fired kiln and sawdust dryer	Arsenic	3	A	$1.7x10^{-5}$-$2.5x10^{-5}$	$2.1x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Beryllium[h]	3	A	$8.7x10^{-8}$-$5.7x10^{-7}$	$3.1x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	Cadmium	3	A	$1.9x10^{-5}$-$2.6x10^{-5}$	$2.2x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Chromium	3	A	$3.0x10^{-5}$-$8.1x10^{-5}$	$4.8x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Lead	3	A	$9.0x10^{-6}$-$2.6x10^{-4}$	$1.2x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Manganese	3	A	$3.6x10^{-4}$-$5.8x10^{-4}$	$4.8x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Mercury	3	A	$7.2x10^{-6}$-$1.7x10^{-5}$	$1.1x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Nickel	3	A	$2.3x10^{-5}$-$4.9x10^{-5}$	$3.4x10^{-5}$	4

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Sawdust-fired kiln and sawdust dryer	Phosphorus[j]	3	A	$4.2x10^{-4}$-$7.3x10^{-4}$	$5.5x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Selenium	3	A	$3.7x10^{-5}$-$5.5x10^{-5}$	$4.7x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	CO	9	A	2.8-3.2	3.0	4
Sawdust-fired kiln and sawdust dryer	NO_x	9	A	0.31-0.34	0.32	4
Sawdust-fired kiln and sawdust dryer	Total fluorides	2	NR	0.010-0.031	0.020	4
Sawdust-fired kiln and sawdust dryer	Hydrogen fluoride	3	A	0.071-0.32	0.18	4
Sawdust-fired kiln and sawdust dryer	TOC as propane	3	A	0.093-0.26	0.18	4
Sawdust-fired kiln and sawdust dryer	Acetone	3	C	$9.3x10^{-4}$-0.0012	0.0010	4
Sawdust-fired kiln and sawdust dryer	Acrylonitrile[h]	3	C	$1.5x10^{-5}$-$2.6x10^{-5}$	$1.9x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Benzene	3	B	$5.2x10^{-4}$-$6.0x10^{-4}$	$5.6x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Bromomethane[h]	3	A	$3.1x10^{-5}$-$5.6x10^{-5}$	$4.4x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	2-butanone[h]	3	C	$6.7x10^{-5}$-$4.4x10^{-4}$	$2.2x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Carbon disulfide	3	C	$1.7x10^{-5}$-$2.0x10^{-5}$	$1.8x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Carbon tetrachloride[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Chloroform[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Chloromethane	3	B	0.0013-0.0015	0.0014	4
Sawdust-fired kiln and sawdust dryer	Ethylbenzene	3	C	$8.2x10^{-6}$-$1.2x10^{-5}$	$1.0x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	2-hexanone[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Iodomethane	3	A	$2.2x10^{-4}$-$2.7x10^{-4}$	$2.4x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Methylene chloride	3	B	$2.8x10^{-5}$-$1.3x10^{-4}$	$6.2x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	M-/p-xylene	3	C	$1.9x10^{-5}$-$4.1x10^{-5}$	$2.9x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	O-xylene	3	C	$5.6x10^{-6}$-$8.8x10^{-6}$	$7.3x10^{-6}$	4

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Sawdust-fired kiln and sawdust dryer	Styrene[c]	3	C	NA	BDL ($4.2x10^{-6}$)	4
Sawdust-fired kiln and sawdust dryer	Tetrachloroethane[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Toluene	3	C	$4.2x10^{-4}$-$4.4x10^{-4}$	$4.3x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	1,1,1-trichloroethane[c]	3	C	NA	BDL ($5.2x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Trichloroethane[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Trichlorofluoromethane[h]	3	B	$4.5x10^{-6}$-$1.5x10^{-5}$	$1.0x10^{-6}$	4
Sawdust-fired kiln and sawdust dryer	Vinyl acetate[c]	3	C	NA	BDL ($3.8x10^{-7}$)	4
Sawdust-fired kiln and sawdust dryer	Bis(2-ethylhexy)phthalate[h]	3	C	$7.4x10^{-5}$-$2.7x10^{-4}$	$1.4x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Dibenzofuran[c]	3	C	NA	BDL ($2.4x10^{-9}$)	4
Sawdust-fired kiln and sawdust dryer	Dimethylphthalate[c]	3	C	NA	BDL ($2.4x10^{-9}$)	4
Sawdust-fired kiln and sawdust dryer	Di-n-butylphthalate[h]	3	C	$5.2x10^{-6}$-$2.4x10^{-5}$	$1.6x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	2-methylphenol[c]	3	C	NA	BDL ($2.4x10^{-9}$)	4
Sawdust-fired kiln and sawdust dryer	Naphthalene[c]	3	C	NA	BDL ($2.4x10^{-9}$)	4
Sawdust-fired kiln and sawdust dryer	Phenol[h]	3	B	$3.5x10^{-5}$-$1.4x10^{-4}$	$1.0x10^{-4}$	4
Natural gas-fired kiln	Filterable PM	3	B	0.27-0.36	0.32	5
Natural gas-fired kiln	CO_2	3	B	410-470	440	5
Natural gas-fired kiln	SO_2	3	B	0.32-0.37	0.35	5
Natural gas-fired kiln	NO_x	3	B	0.25-0.32	0.29	5
Coal-fired kiln[g]	Filterable PM	3	A	1.9-2.3	2.1	6
Coal-fired kiln[g]	CO_2	3	C	400-450	420	6
Coal-fired kiln[g]	Filterable PM	3	A	0.58-0.89	0.76	6
Coal-fired kiln[g]	CO_2	3	C	130-200	170	6
Coal-fired kiln[g]	Filterable PM	3	A	0.50-0.90	0.73	7
Coal-fired kiln[g]	CO_2	3	C	140-260	200	7
Natural gas-fired kiln	Filterable PM	3	B	0.25-0.34	0.28	8
Natural gas-fired kiln	CO_2	3	B	180-250	210	8
Natural gas-fired kiln	SO_2	3	B	0.31-0.37	0.35	8

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural gas-fired kiln	NO_x	3	B	0.24-0.30	0.27	8
Coal-fired kiln	SO_2	3	A	1.0-1.3	1.2	9
Coal-fired kiln	CO_2	3	C	59-66	62	9
Coal-fired kiln	Filterable PM	3	A	0.79-0.90	0.86	10
Coal-fired kiln	CO_2	3	C	250-250	250	10
Coal-fired kiln	Filterable PM	4	A	0.81-1.0	0.90	12
Coal-fired kiln	CO_2	4	C	400-530	470	12
Coal-fired kiln with fabric filter	Filterable PM	3	A	0.038-0.051	0.043	13
Coal-fired kiln	CO_2	3	C	480-610	550	13
Brick dryer--waste heat	Condensible inorganic PM	3	A	0.055-0.16	0.11	15
Brick dryer--waste heat	Filterable PM	3	A	0.054-0.11	0.073	15
Coal-fired kiln	Condensible inorganic PM	3	A	0.11-0.14	0.13	15
Coal-fired kiln	Filterable PM	3	A	1.6-1.7	1.6	15
Coal-fired kiln	CO_2	3	A	280-320	300	15
Natural gas-fired kiln with dry scrubber	Filterable PM	3	A	0.21-0.26	0.23	17
Natural gas-fired kiln with dry scrubber	Total fluorides	3	A	0.0035-0.0044	0.0040	17
Natural gas-fired kiln with dry scrubber	SO_2	3	A	0.64-0.66	0.65	17
Natural gas-fired kiln with dry scrubber	CO_2	3	C	340-450	370	17
Brick dryer	SO_2	3	A	0.022-0.027	0.024	17
Coal-fired kiln	Filterable PM	1	NR	NA	3.8	18
Coal-fired kiln	CO_2	1	NR	NA	370	18
Coal-fired kiln	Filterable PM	3	C	2.5-3.1	2.9	19
Coal-fired kiln	Filterable PM	3	NR	1.6-2.2	1.9	20
Sawdust-fired kiln	Filterable PM	3	A	0.29-0.44	0.38	21
Sawdust-fired kiln	CO_2	3	NR	640-670	650	21
Natural gas-fired kiln	Antimony	3	A	$0-1.9x10^{-4}$	$6.4x10^{-5}$	22
Natural gas-fired kiln	Arsenic	3	A	$7.6x10^{-6}-5.0x10^{-5}$	$2.3x10^{-5}$	22
Natural gas-fired kiln	Beryllium	3	C	$2.1x10^{-7}-2.2x10^{-7}$	$2.1x10^{-7}$	22
Natural gas-fired kiln	Cadmium	3	A	$3.3x10^{-6}-7.1x10^{-6}$	$5.8x10^{-6}$	22
Natural gas-fired kiln	Chromium	3	A	$1.7x10^{-5}-2.3x10^{-5}$	$2.1x10^{-5}$	22
Natural gas-fired kiln	Cobalt	3	C	$2.1x10^{-6}-2.2x10^{-6}$	$2.1x10^{-6}$	22
Natural gas-fired kiln	Lead	3	A	$1.2x10^{-5}-2.3x10^{-4}$	$8.6x10^{-5}$	22

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural gas-fired kiln	Manganese	3	A	$7.7x10^{-5}$-$9.9x10^{-5}$	$8.5x10^{-5}$	22
Natural gas-fired kiln	Mercury	3	C	$4.9x10^{-6}$-$5.3x10^{-6}$	$5.0x10^{-6}$	22
Natural gas-fired kiln	Nickel	3	A	$4.4x10^{-6}$-$1.9x10^{-5}$	$1.3x10^{-5}$	22
Natural gas-fired kiln	Selenium	3	A	$4.0x10^{-5}$-$4.6x10^{-5}$	$4.3x10^{-5}$	22
Natural gas-fired kiln	Methane	3	C	0.0033-0.0036	0.0034	22
Natural gas-fired kiln	CO	3	A	0.56-0.59	0.58	22
Natural gas-fired kiln	CO_2	3	A	230-230	230	22
Natural gas-fired kiln	NO_x	3	A	0.12-0.13	0.13	22
Natural gas-fired kiln	SO_2	3	A	0.056-0.074	0.063	22
Natural gas-fired kiln	TOC as propane	3	A	0.068-0.071	0.069	22
Natural gas-fired kiln	Filterable PM	3	A	0.031-0.039	0.035	22
Natural gas-fired kiln	Filterable PM	3	B	0.061-0.072	0.066	22
Natural gas-fired kiln	Filterable PM-10	3	A	0.045-0.053	0.049	22
Natural gas-fired kiln	Condensible inorganic PM	3	A	0.13-0.20	0.17	22
Natural gas-fired kiln	Condensible organic PM	3	A	0.0-0.022	0.012	22
Natural gas-fired kiln	Hydrogen fluoride	3	B	0.81-0.90	0.85	23[m]
Natural gas-fired kiln	Filterable PM	6	B	0.14-0.19	0.17	23[m]
Natural gas-fired kiln	HCl	3	B	0.40-0.44	0.41	23[m]
Natural gas-fired kiln	SO_2	3	B	0.99-1.0	0.99	23[m]
Natural gas-fired kiln	SO_3	3	B	0.24-0.34	0.28	23[m]
Natural gas-fired kiln	Hydrogen fluoride	3	C	0.14-0.26	0.22	23[n]
Natural gas-fired kiln	Total fluorides	3	C	0.35-0.39	0.37	23[n]
Natural gas-fired kiln	HCl	3	C	0.058-0.12	0.097	23[n]
Natural gas-fired kiln	SO_3	3	C	0.045-0.050	0.048	23[n]
Natural gas-fired kiln	SO_2	3	C	0.22-0.24	0.23	23[n]
Sawdust-fired kiln	Hydrogen fluoride	3	B	0.25-0.30	0.28	23[p]
Sawdust-fired kiln	HCl	3	B	0.043-0.069	0.057	23[p]
Sawdust-fired kiln	SO_2	3	B	0.52-0.56	0.54	23[p]
Sawdust-fired kiln	SO_3	3	B	0.040-0.063	0.051	23[p]
Sawdust-fired kiln	Filterable PM	3	B	0.94-1.2	1.1	23[p]
Unspecified fuel-fired kiln	Total fluorides	2	C	0.23-0.24	0.23	23[q]
Natural gas-fired kiln	Hydrogen fluoride	3	D	0.57-0.69	0.63	23[r]
Natural gas-fired kiln	HCl	3	C	0.23-0.29	0.26	23[r]
Natural gas-fired kiln	SO_2	3	C	0.60-0.69	0.65	23[r]

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural gas-fired kiln	SO_3	3	C	0.025-0.056	0.038	23[r]
Natural gas-fired kiln	Total fluorides	3	C	0.41-0.48	0.44	23[s]
Coal-fired kiln	Hydrogen fluoride	3	C	0.18-0.22	0.20	23[t]
Natural gas-fired kiln	Hydrogen fluoride	2	NR	0.23-0.24	0.23	23[u]
Natural gas-fired kiln firing structural clay tile	Filterable PM	3	B	1.4-2.0	1.7	24
Natural gas-fired kiln firing structural clay tile	Total fluorides	3	B	0.62-0.65	0.64	24
Natural gas-fired kiln firing structural clay tile	SO_2	3	B	7.1-8.2	7.7	24
Natural gas-fired kiln firing structural clay tile	CO_2	3	B	680-740	710	24
Natural gas-fired kiln firing structural clay tile	Filterable PM	3	B	0.37-0.40	0.39	25
Natural gas-fired kiln firing structural clay tile	SO_2	3	B	2.4-3.2	2.9	25
Natural gas-fired kiln firing structural clay tile	CO_2	3	B	240-290	270	25
Primary crusher with fabric filter[v]	PM-10	3	D	$5.6x10^{-4}$-$6.3x10^{-4}$	$5.9x10^{-4}$	29
Extrusion line with fabric filter	PM-10[w]	3	B	0.0025-0.0049	0.0036	29
Extrusion line with fabric filter	PM-10[w]	3	D	0.0018-0.0039	0.0027	29
Natural gas-fired kiln	SO_2[x]	3	A	4.5-6.5	5.7	29
Natural gas-fired kiln	NO_x	3	A	0.21-0.28	0.24	29
Natural gas-fired kiln	CO_2	3	A	470-570	530	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	SO_2[x]	3	A	0.86-1.1	1.0	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	NO_x	3	A	0.20-0.25	0.23	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	CO_2	3	A	470-570	530	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	Filterable PM	3	A	0.48-0.92	0.70	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	Condensible organic PM	3	A	0.010-0.015	0.013	29
Natural-gas fired kiln with medium-efficiency scrubber[y]	Condensible inorganic PM	3	A	0.014-0.015	0.014	29

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural-gas fired kiln with medium-efficiency scrubber[y]	Total fluorides[x]	3	A	0.16-0.21	0.18	29
Natural gas-fired kiln	SO_2[x]	3	A	1.8-2.0	2.0	30
Natural gas-fired kiln	NO_x	3	A	0.77-0.81	0.79	30
Natural gas-fired kiln	CO	3	A	2.7-2.8	2.7	30
Natural gas-fired kiln	CO_2	3	A	320-350	340	30
Natural gas-fired kiln	Filterable PM	3	A	0.10-0.11	0.11	30
Natural gas-fired kiln	Condensible organic PM	3	A	0.0034-0.0065	0.0049	30
Natural gas-fired kiln	Condensible inorganic PM	3	A	0.0019-0.0034	0.0027	30
Natural gas-fired kiln	Total fluorides[x]	3	A	1.5-2.6	2.1	30
Natural-gas fired kiln with high-efficiency scrubber[z]	SO_2[x]	3	A	0.0043-0.0061	0.0049	30
Natural-gas fired kiln with high-efficiency scrubber[y]	NO_x	3	A	0.18-0.23	0.21	30
Natural-gas fired kiln with high-efficiency scrubber[y]	CO	3	A	2.3-2.7	2.4	30
Natural-gas fired kiln with high-efficiency scrubber[y]	CO_2	3	A	430-470	450	30
Natural-gas fired kiln with high-efficiency scrubber[z]	Filterable PM	3	A	0.11-0.13	0.12	30
Natural-gas fired kiln with high-efficiency scrubber[z]	Condensible organic PM	3	A	0.00074-0.0011	0.00086	30
Natural-gas fired kiln with high-efficiency scrubber[z]	Condensible inorganic PM	3	A	0.00040-0.0019	0.0011	30
Natural-gas fired kiln with high-efficiency scrubber[z]	Total fluorides[x]	3	A	0.0011-0.0015	0.0013	30
Sawdust-fired kiln and sawdust dryer	CO	3	A	1.2-1.3	1.2	32
Sawdust-fired kiln and sawdust dryer	CO_2	3	A	500-510	510	32
Natural gas-fired kiln[aa]	Filterable PM	6	A	0.33-0.76	0.49	33
Natural gas-fired kiln[aa]	Total fluorides	6	A	0.022-0.063	0.047	33
Natural gas-fired kiln[aa]	TOC as propane	6	A	0.00074-0.031	0.011	33
Natural gas-fired kiln[aa]	SO_2	6	A	1.2-1.7	1.5	33
Natural gas-fired kiln[aa]	CO_2	6	A	300-330	310	33

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Natural gas-fired kiln[aa]	NO_x	6	A	0.20-0.22	0.21	33
Natural gas-fired kiln[aa]	CO	6	A	0.72-0.86	0.80	33
Natural gas-fired kiln with dry scrubber[bb]	Filterable PM	3	A	0.24-0.39	0.32	34
Natural gas-fired kiln with dry scrubber[bb]	Condensable inorganic PM	3	A	0.017-0.19	0.12	34
Natural gas-fired kiln with dry scrubber[bb]	Total fluorides	3	A	0.054-0.058	0.056	34
Natural gas-fired kiln with dry scrubber[bb]	CO_2	6	A	290-330	310	34
Natural gas-fired kiln with dry scrubber[bb]	SO_2	3	A	0.98-1.0	1.0	34
Natural gas-fired kiln with dry scrubber[bb]	SO_3	3	A	0.032-0.046	0.037	34
Natural gas-fired kiln with dry scrubber[bb]	NO_x	3	A	0.24-0.27	0.26	34
Natural gas-fired kiln with dry scrubber[cc]	Filterable PM	3	A	0.38-0.44	0.41	35
Natural gas-fired kiln with dry scrubber[cc]	Condensable inorganic PM	3	A	0.029-0.099	0.072	35
Natural gas-fired kiln with dry scrubber[cc]	Total fluorides	3	A	0.044-0.046	0.045	35
Natural gas-fired kiln with dry scrubber[cc]	CO_2	6	A	290-320	310	35
Natural gas-fired kiln with dry scrubber[cc]	NO_x	3	A	0.32-0.35	0.34	35
Natural gas-fired kiln	Total fluorides	3	A	0.64-0.74	0.69	35
Sawdust-fired kiln and sawdust dryer	CO	3	A	0.53-0.66	0.59	37
Sawdust-fired kiln and sawdust dryer	CO_2	3	A	460-480	470	37
Brick dryer (No. 1) with supplemental gas burner	Filterable PM	3	A	0.027-0.11	0.070	38
Brick dryer (No. 1) with supplemental gas burner	TOC as propane	3	NR	ND-0.034	0.011	38
Brick dryer (No. 1) with supplemental gas burner	SO_2	3	NR	ND	ND	38
Brick dryer (No. 1) with supplemental gas burner	CO_2	3	A	47-90	70	38
Brick dryer (No. 1) with supplemental gas burner	CO	3	A	0.077-0.20	0.12	38

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Brick dryer (No. 1) with supplemental gas burner	NO_x	3	NR	ND	ND	38
Brick dryer (No. 2) with supplemental gas burner	Filterable PM	3	A	0.032-0.045	0.040	38
Brick dryer (No. 2) with supplemental gas burner	TOC as propane	3	NR	ND	ND	38
Brick dryer (No. 2) with supplemental gas burner	SO_2	3	NR	ND-0.013	0.0044	38
Brick dryer (No. 2) with supplemental gas burner	CO_2	3	A	60-81	67	38
Brick dryer (No. 2) with supplemental gas burner	CO	3	A	0.039-0.063	0.054	38
Brick dryer (No. 2) with supplemental gas burner	NO_x	3	NR	ND	ND	38
Natural gas-fired kiln[dd]	Filterable PM	3	A	0.95-1.8	1.3	38
Natural gas-fired kiln[dd]	TOC as propane	3	A	0.060-0.077	0.067	38
Natural gas-fired kiln[dd]	SO_2	3	A	10-11	10	38
Natural gas-fired kiln[dd]	CO_2	3	A	220-230	220	38
Natural gas-fired kiln[dd]	CO	3	A	0.79-0.89	0.83	38
Natural gas-fired kiln[dd]	SO_3 (includes dryer SO_3 measurements)	3	A	0.028-0.081	0.049	38
Natural gas-fired kiln[dd]	NO_x	3	A	0.077-0.17	0.14	38
Brick dryer (No. 1) with supplemental gas burner	Filterable PM	3	A	0.078-0.20	0.14	39
Brick dryer (No. 1) with supplemental gas burner	TOC as propane	3	A	0.081-0.19	0.14	39
Brick dryer (No. 1) with supplemental gas burner	SO_2	3	NR	ND	ND	39
Brick dryer (No. 1) with supplemental gas burner	CO_2	3	A	65-80	74	39
Brick dryer (No. 1) with supplemental gas burner	CO	3	A	0.11-0.39	0.27	39
Brick dryer (No. 1) with supplemental gas burner	NO_x	3	A	0.054-0.27	0.14	39

TABLE 4-1. (continued)

Source	Pollutant	No. of test runs	Data rating	Emission factor range, lb/ton	Average emission factor, lb/ton	Ref. No.
Brick dryer (No. 2) with supplemental gas burner	Filterable PM	3	A	0.025-0.16	0.071	39
Brick dryer (No. 2) with supplemental gas burner	TOC as propane	3	A	0.066-0.11	0.083	39
Brick dryer (No. 2) with supplemental gas burner	SO_2	3	NR	ND	ND	39
Brick dryer (No. 2) with supplemental gas burner	CO_2	3	A	69-77	72	39
Brick dryer (No. 2) with supplemental gas burner	CO	3	A	0.22-0.31	0.28	39
Brick dryer (No. 2) with supplemental gas burner	NO_x	3	A	0.035-0.074	0.056	39
Natural gas-fired kiln[ee]	Filterable PM	3	A	0.41-0.48	0.44	39
Natural gas-fired kiln[ee]	TOC as propane	3	A	0.070-0.085	0.080	39
Natural gas-fired kiln[ee]	SO_2	3	A	4.0-4.5	4.3	39
Natural gas-fired kiln[ee]	CO_2	3	A	160-170	170	39
Natural gas-fired kiln[ee]	CO	3	A	0.71-0.76	0.73	39
Natural gas-fired kiln[ee]	SO_3 (includes dryer SO_3 measurements)	3	A	0.20-0.30	0.26	39
Natural gas-fired kiln[ee]	NO_x	3	A	0.25-0.28	0.26	39

a Emission factor units are lb of pollutant per ton of brick produced, unless noted. To convert from lb/ton to kg/Mg, multiply by 0.5. NA = not applicable. NR = not rated. ND = not detected.
b Emission factor units are lb of pollutant per ton of raw material throughput.
c BDL = below detection limit. Pollutant was not detected during any test run. Detection limit shown in parentheses.
d Measured simultaneously with Method 26A train.
e Measured simultaneously with Method 29 train.
f Based on Method 201A sampling train.
g Kiln fired by coal and supplemental natural gas.
h Emission factor includes data from one nondetect run (emissions estimated as one-half of the detection limit).
j Emission factor includes data from two nondetect runs (emissions estimated as one-half of the detection limit).
k 1.09 percent sulfur in coal
m Boral Bricks, Kiln No. 5, Augusta, Georgia. Clay bodies contained sawdust.
n Boral Bricks, Phenix City, Alabama.
p Boral Bricks, Salisbury, North Carolina. Emissions measured at two kiln stacks and one sawdust dryer stack.
q Endicott Brick, Fairbury, Nebraska.
r Redlands Brick, East Windsor Hill, Connecticut.
s Richtex Brick, Kiln No. 4, Columbia, South Carolina.
t Richtex Brick, Kiln No. 2, Columbia, South Carolina.
u Richtex Brick, Kiln No. 4, Columbia, South Carolina. Special test to reduce HF emissions. Control method not documented in Reference 23.
v Because of superisokinetic sampling, this emission factor is probably a low estimate of emissions from this source.

TABLE 4-1. (continued)

[w] PM-10 emissions from conveyor drop point and from the addition of fine (325-mesh) manganese dioxide and barium carbonate powders to the raw material.
[x] Raw material with high sulfur and fluorine content.
[y] Medium-efficiency scrubber using a soda-ash/water solution (maintained at pH 7) as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants.
[z] High-efficiency packed-bed scrubber using a soda-ash/water solution as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants.
[aa] Average of data from Kiln 1 and Kiln 2 at Boral Bricks, Smyrna, Georgia.
[bb] Same kilns as Reference 35.
[cc] Same kilns as Reference 34.
[dd] Raw material is 17 percent shale and 83 percent fire clay.
[ee] Raw material is 80 percent shale and 20 percent fire clay.

TABLE 4-2. EMISSION FACTOR DEVELOPMENT FOR BRICK AND STRUCTURAL CLAY PRODUCT MANUFACTURING[a]

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Coal-fired kiln[b]	Hydrogen fluoride	3	A	0.13	0.17 (D)	2
Coal-fired kiln	Hydrogen fluoride	3	C	0.20		23[c]
Natural gas-fired kiln	Hydrogen fluoride (total fluorides ÷ 1.6)	6	A	0.047 ÷ 1.6 = 0.029	0.37 (C) σ = 0.23 n = 11 range = 0.82	33
Unspecified fuel-fired kiln	Hydrogen fluoride (total fluorides ÷ 1.6)	2	C	0.23 ÷ 1.6 = 0.14		23[j]
Natural gas-fired kiln	Hydrogen fluoride	3	C	0.23		23[d]
~~Natural gas-fired kiln~~	~~Hydrogen fluoride~~	~~2~~	~~NR~~	~~0.23~~		~~23[e]~~
Natural gas-fired kiln	Hydrogen fluoride (total fluorides ÷ 1.6)	3	C	0.44 ÷ 1.6 = 0.28		23[k]
Sawdust-fired kiln	Hydrogen fluoride	3	B	0.28		23[f]
Natural gas-fired kiln	Hydrogen fluoride	3	A	0.30		1
Natural gas-fired kiln firing struct. clay tile	Hydrogen fluoride (total fluorides ÷ 1.6)	3	B	0.64 ÷ 1.6 = 0.40		24
Natural gas-fired kiln	Hydrogen fluoride (total fluorides ÷ 1.6)	3	A	0.69 ÷ 1.6 = 0.43		35
Sawdust-fired kiln	Hydrogen fluoride	3	A	0.46		4
Natural gas-fired kiln	Hydrogen fluoride	3	C	0.63		23[g]
Natural gas-fired kiln	Hydrogen fluoride	3	B	0.85		23[h]
Natural gas-fired kiln	Total fluorides	3	NA	1.6 x candidate HF factor = 0.59	0.59 (E)	23[d]
Natural gas-fired kiln	Total fluorides[m]	3	A	2.1	2.1 (NR)	30
Natural gas-fired kiln with medium-efficiency scrubber[n]	Total fluorides[m]	3	A	0.18	0.18 (C)	29
Natural gas-fired kiln with high-efficiency scrubber[p]	Total fluorides[m]	3	A	0.0013	0.0013 (C)	30
Natural gas-fired kiln with dry scrubber	Total fluorides	3	A	0.0040	0.028 (C)	17
Natural gas-fired kiln with dry scrubber	Total fluorides	6	A	0.051		34,35
Natural gas-fired kiln	HCl	3	A	0.018	0.17 (D) σ = 0.16 n = 5 range = 0.39	1
Sawdust-fired kiln	HCl	3	B	0.057		23[f]
Natural gas-fired kiln	HCl	3	C	0.097		23[d]
Natural gas-fired kiln	HCl	3	C	0.26		23[g]
Natural gas-fired kiln	HCl	3	B	0.41		23[h]
Coal-fired kiln	Methane/ethane as propane	3	B	71% of TOC	59% of TOC, 0.037 (E)	2
Natural gas-fired kiln	Methane	3	C	4.9% of TOC		22
Natural gas-fired kiln	Methane	3	A	100% of TOC		1

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Coal-fired kiln	TOC as propane	1	A	0.011	0.062 (C) σ = 0.044 n = 7 range = 0.13	3
Natural gas-fired kiln	TOC as propane	6	A	0.011		33
Natural gas-fired kiln	TOC as propane	6	A	0.074		38,39
Coal-fired kiln	TOC as propane	3	B	0.14		2
Natural gas-fired kiln	TOC as propane	3	A	0.069		22
Natural gas-fired kiln	TOC as propane	3	A	0.074		1
Sawdust-fired kiln	TOC as propane	3	A	0.057		4
Coal-fired kiln[b]	Antimony	3	A	$1.4x10^{-5}$	$2.7x10^{-5}$ (D)	2
Natural gas-fired kiln	Antimony	3	C	$2.2x10^{-5}$		1
Natural gas-fired kiln	Antimony	3	A	$6.4x10^{-5}$		22
Sawdust-fired kiln	Antimony[q]	3	C	$6.3x10^{-6}$		4
Coal-fired kiln[b]	Arsenic	3	A	$1.3x10^{-4}$	$1.3x10^{-4}$ (E)	2
Natural gas-fired kiln	Arsenic	3	A	$2.3x10^{-5}$	$3.1x10^{-5}$ (D)	22
Sawdust-fired kiln	Arsenic	3	A	$5.1x10^{-5}$		4
Natural gas-fired kiln	Arsenic[r]	3	C	$1.8x10^{-5}$		1
Coal-fired kiln[b]	Beryllium	3	A	$1.6x10^{-5}$	$1.6x10^{-5}$ (E)	2
Natural gas-fired kiln	Beryllium[r]	3	C	$2.1x10^{-7}$	$4.2x10^{-7}$ (D)	22
Natural gas-fired kiln	Beryllium[r]	3	C	$3.4x10^{-7}$		1
Sawdust-fired kiln	Beryllium	3	A	$7.2x10^{-7}$		4
Sawdust-fired kiln	Cadmium	3	A	$1.7x10^{-5}$	$1.5x10^{-5}$ (D)	4
Natural gas-fired kiln	Cadmium	3	C	$3.3x10^{-5}$		1
Coal-fired kiln[b]	Cadmium	3	A	$3.3x10^{-6}$		2
Natural gas-fired kiln	Cadmium	3	A	$5.8x10^{-6}$		22
Natural gas-fired kiln	Chromium	3	A	0.0075	0.0075 (NR)	1
Natural gas-fired kiln	Chromium	3	A	$2.1x10^{-5}$	$5.1x10^{-5}$ (D)	22
Sawdust-fired kiln	Chromium	3	A	$5.3x10^{-5}$		4
Coal-fired kiln[b]	Chromium	3	A	$7.8x10^{-5}$		2
Natural gas-fired kiln	Cobalt	3	C	0.00011	0.00011 (NR)	1
Natural gas-fired kiln	Cobalt[r]	3	C	$2.1x10^{-6}$	$2.1x10^{-6}$ (E)	22
Sawdust-fired kiln	Lead	3	A	$3.3x10^{-4}$	$1.5x10^{-4}$ (D)	4
Natural gas-fired kiln	Lead	3	C	$7.9x10^{-5}$		1
Natural gas-fired kiln	Lead	3	A	$8.6x10^{-5}$		22
Coal-fired kiln[b]	Lead	3	A	$8.6x10^{-5}$		2

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Sawdust-fired kiln	Manganese	3	A	0.013	0.013 (E)	4
Natural gas-fired kiln	Manganese	3	A	0.00073	$2.9x10^{-4}$ (D)	1
Coal-fired kiln[b]	Manganese	3	A	$4.7x10^{-5}$		2
Natural gas-fired kiln	Manganese	3	A	$8.5x10^{-5}$		22
Natural gas-fired kiln	Mercury	3	A	0.00016	0.00016 (NR)	1
Coal-fired kiln[b]	Mercury	3	A	$9.6x10^{-5}$	$9.6x10^{-5}$ (E)	2
Natural gas-fired kiln	Mercury[r]	3	C	$5.0x10^{-6}$	$7.5x10^{-6}$ (D)	22
Sawdust-fired kiln	Mercury	3	A	$9.9x10^{-6}$		4
Natural gas-fired kiln	Nickel	3	A	0.0042	0.0042 (NR)	1
Coal-fired kiln[b]	Nickel	3	A	$1.7x10^{-4}$	$7.2x10^{-5}$ (D)	2
Natural gas-fired kiln	Nickel	3	A	$1.3x10^{-5}$		22
Sawdust-fired kiln	Nickel	3	A	$3.4x10^{-5}$		4
Sawdust-fired kiln	Phosphorus	3	A	0.0014	$9.8x10^{-4}$ (E)	4
Coal-fired kiln[b]	Phosphorus	3	A	$5.5x10^{-4}$		2
Natural gas-fired kiln	Selenium	3	C	0.00036	$2.3x10^{-4}$ (D)	1
Coal-fired kiln[b]	Selenium	3	A	0.00046		2
Natural gas-fired kiln	Selenium	3	A	$4.3x10^{-5}$		22
Sawdust-fired kiln	Selenium	3	A	$5.6x10^{-5}$		4
Natural gas-fired kiln	SO_2	3	A	0.063	0.67 (C) σ = 0.44 n = 9 range = 1.5	22
Natural gas-fired kiln	SO_2	3	C	0.23		23[d]
Natural gas-fired kiln	SO_2	3	B	0.35		5,8
Sawdust-fired kiln	SO_2	3	B	0.54		23[f]
Natural gas-fired kiln	SO_2	3	C	0.65		23[g]
Natural gas-fired kiln with dry scrubber	SO_2	3	A	0.67		17
Natural gas-fired kiln	SO_2	3	B	0.99		23[h]
Natural gas-fired kiln with dry scrubber	SO_2	3	A	1.0		34
Natural gas-fired kiln	SO_2	6	A	1.5		33

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Natural gas-fired kiln firing high-sulfur material	SO_2[m]	3	A	2.0	5.1 (D) σ = 2.9 n = 7 range = 8.0	30
Natural gas-fired kiln firing structural clay tile	SO_2	3	B	2.9		25
Natural gas-fired kiln firing high-sulfur material	SO_2	3	A	3.0		1
Natural gas-fired kiln firing high-sulfur material	SO_2	3	A	4.3		39
Natural gas-fired kiln firing high-sulfur material	SO_2[m]	3	A	5.7		29
Natural gas-fired kiln firing structural clay tile	SO_2	3	B	7.7		24
Natural gas-fired kiln firing high-sulfur material	SO_2	3	A	10		38
Natural-gas fired kiln with medium-efficiency scrubber[n]	SO_2[m]	3	A	1.0	1.0 (C)	29
Natural-gas fired kiln with high-efficiency scrubber[p]	SO_2[m]	3	A	0.0049	0.0049 (C)	30
Natural gas-fired kiln with dry scrubber	SO_3	3	A	0.037	0.11 (D) σ = 0.11 n = 7 range = 0.24	34
Natural gas-fired kiln	SO_3	3	C	0.038		23[g]
Natural gas-fired kiln	SO_3	3	C	0.048		23[d]
Natural gas-fired kiln	SO_3	3	A	0.049		38
Sawdust-fired kiln	SO_3	3	B	0.051		23[f]
Natural gas-fired kiln	SO_3	3	A	0.26		39
Natural gas-fired kiln	SO_3	3	B	0.28		23[h]
Brick dryers with supplemental gas burners	CO	12	A	0.18	0.31 (E)	38,39
Brick dryer with supplemental gas burner	CO	1	B	0.44		1
Brick dryer--waste heat from coal-fired kiln	Condensible inorganic PM	3	A	0.11	0.11 (E)	15
Brick dryer--waste heat from coal-fired kiln	Filterable PM	3	A	0.073	0.077 (E)	15
Brick dryers with supplemental gas burners	Filterable PM	12	A	0.080		38,39
Brick dryer--waste heat	Methane/ethane as propane	3	A	47% of TOC[s]	0.043 (E)	2

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Brick dryer--waste heat	TOC as propane	1	A	0.036	0.048 (E)	3
Brick dryer--waste heat	TOC as propane	3	A	0.060		2
Brick dryers with supplemental gas burners	TOC as propane	6	A	0.11	0.14 (E)	39
Brick dryer with supplemental gas burner	TOC as propane	1	B	0.16		1
Brick dryers with supplemental gas burners	CO_2	12	A	71	71 (E)	38,39
Brick dryers with supplemental gas burners	NO_x	6	A	0.098	0.098 (E)	39
Brick dryers with supplemental gas burners	SO_3	12	A	0.020	0.020 (NR)	38,39
Coal-fired kiln[b]	1,1-dichloroethane	3	C	5.0×10^{-6}	5.0×10^{-6} (E)	2
Coal-fired kiln[b]	1,1,1-trichloroethane[r]	3	C	BDL (1.7×10^{-5})	BDL (E)	2
Coal-fired kiln[b]	1,4-dichlorobenzene[t]	3	C	3.2×10^{-6}	3.2×10^{-6} (E)	2
Coal-fired kiln[b]	2-butanone	3	C	2.5×10^{-4}	2.5×10^{-4} (E)	2
Coal-fired kiln[b]	2-hexanone[r]	3	C	BDL (8.2×10^{-7})	BDL (E)	2
Coal-fired kiln[b]	2-methylnaphthalene	3	C	1.7×10^{-6}	1.7×10^{-6} (E)	2
Coal-fired kiln[b]	2-methylphenol[r]	3	C	BDL (2.2×10^{-6})	BDL (E)	2
Coal-fired kiln[b]	Acetone	3	C	6.8×10^{-4}	6.8×10^{-4} (E)	2
Coal-fired kiln[b]	Benzene	3	B	2.9×10^{-4}	2.9×10^{-4} (E)	2
Coal-fired kiln[b]	Benzoic acid	3	B	2.5×10^{-4}	2.5×10^{-4} (E)	2
Coal-fired kiln[b]	Bis(2-ethylhexy)phthalate	3	C	4.9×10^{-5}	4.9×10^{-5} (E)	2
Coal-fired kiln[b]	Bromomethane	3	A	2.4×10^{-5}	2.4×10^{-5} (E)	2
Coal-fired kiln[b]	Butylbenzylphthalate[t]	3	C	1.2×10^{-6}	1.2×10^{-6} (E)	2
Coal-fired kiln[b]	Carbon disulfide[t]	3	C	2.3×10^{-6}	2.3×10^{-6} (E)	2
Coal-fired kiln[b]	Carbon tetrachloride[r]	3	C	BDL (1.0×10^{-7})	BDL (E)	2
Coal-fired kiln[b]	Chlorobenzene	3	B	2.1×10^{-5}	2.1×10^{-5} (E)	2
Coal-fired kiln[b]	Chloroethane	3	B	1.1×10^{-5}	1.1×10^{-5} (E)	2
Coal-fired kiln[b]	Chloroform[r]	3	C	BDL (1.0×10^{-7})	BDL (E)	2
Coal-fired kiln[b]	Chloromethane[t]	3	B	1.1×10^{-4}	1.1×10^{-4} (E)	2
Coal-fired kiln[b]	CO	1	A	0.70	0.80 (D)	3
Coal-fired kiln[b]	CO	3	A	0.90		2

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Coal-fired kiln	CO_2	3	C	62	300 (C)	9
Coal-fired kiln[b]	CO_2	3	C	170		6
Coal-fired kiln[b]	CO_2	3	C	200		7
Coal-fired kiln	CO_2	3	C	250		10
Coal-fired kiln[b]	CO_2	9	A	270		2
Coal-fired kiln[b]	CO_2	1	A	300		3
Coal-fired kiln	CO_2	3	A	300		15
~~Coal-fired kiln~~	~~CO_2~~	~~1~~	~~NR~~	~~370~~		~~18~~
Coal-fired kiln[b]	CO_2	3	C	420		6
Coal-fired kiln	CO_2	4	C	470		12
Coal-fired kiln	CO_2	3	C	550		13
Natural gas-fired kiln	Condensible inorganic PM	6	A	0.0019	0.48 (D)	30
Natural gas-fired kiln with dry scrubber	Condensable inorganic PM	6	A	0.096		34,35
Coal-fired kiln[b]	Condensible inorganic PM	3	A	0.12		2
Coal-fired kiln	Condensible inorganic PM	3	A	0.13		15
Natural gas-fired kiln	Condensible inorganic PM	3	A	0.17		22
Natural gas-fired kiln	Condensible inorganic PM	3	A	3.1		1
Sawdust-fired kiln	Condensible inorganic PM	3	A	0.20		4
Natural-gas fired kiln with medium-efficiency scrubber[n]	Condensible inorganic PM	3	A	0.014		29
Coal-fired kiln[b]	Condensible organic PM	3	A	0.048	0.11 (D)	2
Natural gas-fired kiln	Condensible organic PM	3	A	0.012		22
Natural gas-fired kiln	Condensible organic PM	3	A	0.51		1
Sawdust-fired kiln	Condensible organic PM	3	A	0.081		4
Natural gas-fired kiln	Condensible organic PM	6	A	0.0029		30
Natural-gas fired kiln with medium-efficiency scrubber[n]	Condensible organic PM	3	A	0.013		29
Coal-fired kiln[b]	Di-n-butylphthalate	3	A	0	0 (E)	2
Coal-fired kiln[b]	Di-n-octylphthalate[t]	3	C	$1.2x10^{-5}$	$1.2x10^{-5}$ (E)	2
Coal-fired kiln[b]	Dibenzofuran[q]	3	C	$3.6x10^{-7}$	$3.6x10^{-7}$ (E)	2
Coal-fired kiln[b]	Diethylphthalate	3	C	$1.4x10^{-6}$	$1.4x10^{-6}$ (E)	2
Coal-fired kiln[b]	Dimethylphthalate[r]	3	C	BDL ($7.8x10^{-7}$)	BDL (E)	2
Coal-fired kiln[b]	Ethylbenzene	3	B	$2.1x10^{-5}$	$2.1x10^{-5}$ (E)	2

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Coal-fired kiln[b]	Filterable PM	6	A	0.67	1.2 (A)	2
Coal-fired kiln[b]	Filterable PM	3	A	0.73		7
Coal-fired kiln[b]	Filterable PM	3	A	0.76		6
Coal-fired kiln	Filterable PM	3	A	0.86		10
Coal-fired kiln	Filterable PM	4	A	0.90		12
~~Coal-fired kiln~~	~~Filterable PM~~	~~3~~	~~NR~~	~~1.9~~		~~20~~
Coal-fired kiln[b]	Filterable PM	3	A	2.1		6
Coal-fired kiln	Filterable PM	6	A,C	2.3		15,19
~~Coal-fired kiln~~	~~Filterable PM~~	~~1~~	~~NR~~	~~3.8~~		~~18~~
Coal-fired kiln[b]	Filterable PM-10	3	A	63% of filt. PM[u]	0.76 (D)	2,15
Coal-fired kiln[b]	Isophorone	3	B	3.0x10^{-5}	3.0x10^{-5} (E)	2
Coal-fired kiln[b]	M-/p-xylene	3	C	1.3x10^{-4}	1.3x10^{-4} (E)	2
Coal-fired kiln[b]	Methylene chloride	3	C	8.0x10^{-7}	8.0x10^{-7} (E)	2
Coal-fired kiln[b]	Naphthalene	3	A	6.9x10^{-6}	6.9x10^{-6} (E)	2
Coal-fired kiln[b]	NO_x	1	A	0.30	0.51 (D)	3
Coal-fired kiln[b]	NO_x	3	A	0.71		2
Coal-fired kiln[b]	O-xylene	3	B	4.7x10^{-5}	4.7x10^{-5} (E)	2
Coal-fired kiln[b]	Phenol	3	A	3.5x10^{-5}	3.5x10^{-5} (E)	2
Coal-fired kiln	SO_2	3	A	1.2	1.2 (D)	9
Coal-fired kiln[b]	SO_2[v]	1	A	1.2		3
Coal-fired kiln[b]	Styrene[r]	3	C	BDL (1.0x10^{-7})	BDL (E)	2
Coal-fired kiln[b]	Tetrachloroethane[r]	3	C	BDL (1.0x10^{-7})	BDL (E)	2
Coal-fired kiln[b]	Toluene	3	C	2.5x10^{-4}	2.5x10^{-4} (E)	2
Coal-fired kiln[b]	Trichloroethane[r]	3	C	BDL (1.0x10^{-7})	BDL (E)	2
Coal-fired kiln[b]	Trichlorofluoromethane	3	B	1.4x10^{-5}	1.4x10^{-5} (E)	2
Coal-fired kiln[b]	Vinyl acetate[r]	3	C	BDL (1.0x10^{-7})	BDL (E)	2
Coal-fired kiln with fabric filter	Filterable PM	3	A	0.043	0.043 (E)	13
Extrusion line with fabric filter[w]	PM-10	3	B	0.0036	0.0036 (E)	29
~~Extrusion line with fabric filter[w]~~	~~PM-10~~	~~3~~	~~D~~	~~0.0027~~		~~29~~
Grinding room with fabric filter[x]	Filterable PM	2	A	0.0052	0.0062 (E)	1
Grinding room with fabric filter[x]	Filterable PM	3	A	0.0072		2

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Grinding room with fabric filter[x]	Filterable PM-10	2	A	0.0011	0.0032 (E)	1
Grinding room with fabric filter[x]	Filterable PM-10	3	A	0.0052		2
Grinding room (14% moisture)[x]	Filterable PM	3	B	0.025	0.025 (E)	4
Grinding room (3.9% moisture)[x]	Filterable PM	3	A	8.5	8.5 (E)	1
~~Grinding room (3.9% moisture)[x]~~	~~Filterable PM~~	~~2~~	~~NR~~	~~17~~		~~1~~
Grinding room (14% moisture)[x]	Filterable PM-10	3	B	0.0023	0.0023 (E)	4
Grinding room (3.9% moisture)[x]	Filterable PM-10	3	A	0.53	0.53 (E)	1
Natural gas-fired kiln	1,1,1-Trichloroethane	3	B	4.7×10^{-6}	4.7×10^{-6} (E)	1
Natural gas-fired kiln	1,4-dichlorobenzene	3	B	4.8×10^{-5}	4.8×10^{-5} (E)	1
Natural gas-fired kiln	2-methylnaphthalene	3	B	5.7×10^{-5}	5.7×10^{-5} (E)	1
Natural gas-fired kiln	2-butanone	3	C	0.00022	0.00022 (E)	1
Natural gas-fired kiln	2-Hexanone	3	C	8.5×10^{-5}	8.5×10^{-5} (E)	1
Natural gas-fired kiln	Acetone	3	C	0.0017	0.0017 (E)	1
Natural gas-fired kiln	Benzene	3	B	0.0029	0.0029 (E)	1
Natural gas-fired kiln	Bis(2-ethylhexy)phthalate	3	C	0.0020	0.0020 (E)	1
Natural gas-fired kiln	Butylbenzylphthalate	3	B	1.8×10^{-5}	1.8×10^{-5} (E)	1
Natural gas-fired kiln	Carbon disulfide	3	B	4.1×10^{-5}	4.1×10^{-5} (E)	1
Natural gas-fired kiln	Chlorine	3	A	0.0013	0.0013 (E)	1
Natural gas-fired kiln	Chloroethane	3	B	0.00057	0.00057 (E)	1
Natural gas-fired kiln	Chloromethane	3	B	0.00067	0.00067 (E)	1
Natural gas-fired kiln	CO	3	A	0.58	1.2 (C)	22
Natural gas-fired kiln	CO	6	A	0.78		38,39
Natural gas-fired kiln	CO	6	A	0.80		33
Natural gas-fired kiln	CO	3	A	1.1		1
Natural gas-fired kiln	CO	6	A	2.6		30

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Natural gas-fired kiln	CO_2	6	A	200	400 (B)	38,39
Natural gas-fired kiln	CO_2	3	A	230		22
Natural gas-fired kiln firing structural clay tile	CO_2	3	B	270		25
Natural gas-fired kiln	CO_2	6	A	310		33
Natural gas-fired kiln with dry scrubber	CO_2	12	A	310		34,35
Natural gas-fired kiln	CO_2	6	B	330		5,8
Natural gas-fired kiln[y]	CO_2	6	A	395		30
Natural gas-fired kiln with dry scrubber	CO_2	3	C	370		17
Natural gas-fired kiln[y]	CO_2	6	A	530		29
Natural gas-fired kiln firing structural clay tile	CO_2	3	B	710		24
Natural gas-fired kiln	CO_2	3	A	770		1
Natural gas-fired kiln	Di-n-butylphthalate	3	B	0.00014	0.00014 (E)	1
Natural gas-fired kiln	Diethylphthalate	3	B	0.00024	0.00024 (E)	1
Natural gas-fired kiln	Ethylbenzene	3	B	4.4×10^{-5}	4.4×10^{-5} (E)	1
Natural gas-fired kiln	Filterable PM	6	A,B	0.051	0.37 (C)	22
Natural gas-fired kiln	Filterable PM	6	B	0.17		23[h]
Natural gas-fired kiln with dry scrubber	Filterable PM	3	A	0.23		17
Natural gas-fired kiln	Filterable PM	6	B	0.30		5,8
Natural gas-fired kiln with dry scrubber	Filterable PM	6	A	0.37		34,35
Natural gas-fired kiln	Filterable PM	9	A	0.40		1
Natural gas-fired kiln	Filterable PM	6	A	0.49		33
Natural gas-fired kiln[y]	Filterable PM	6	A	0.11		30
Natural-gas fired kiln with medium-efficiency scrubber[n]	Filterable PM	3	A	0.70		29
Natural gas-fired kiln	Filterable PM	6	A	0.88		38,39
Natural gas-fired kiln firing structural clay tile	Filterable PM	3	B	0.39	1.0 (E)	25
Natural gas-fired kiln firing structural clay tile	Filterable PM	3	B	1.7		24
Natural gas-fired kiln	Filterable PM-10	3	A	75% of filt. PM	0.28 (E) 75% of filt. PM	22
~~Natural gas-fired kiln~~	~~Filterable PM-10~~	~~3~~	~~A~~	~~33% of filt. PM~~		~~1~~
Natural gas-fired kiln	Iodomethane	3	B	9.3×10^{-5}	9.3×10^{-5} (E)	1
Natural gas-fired kiln	m-/p-Xylene	3	B	6.7×10^{-5}	6.7×10^{-5} (E)	1

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Natural gas-fired kiln	Naphthalene	3	C	$6.5x10^{-5}$	$6.5x10^{-5}$ (E)	1
Natural gas-fired kiln	NO_x	3	A	0.13	0.35 (C)	22
Natural gas-fired kiln	NO_x	6	A	0.20		38,39
Natural gas-fired kiln	NO_x	6	A	0.21		33
Natural gas-fired kiln with dry scrubber	NO_x	6	A	0.30		34,35
Natural gas-fired kiln	NO_x	6	B	0.28		5,8
Natural gas-fired kiln	NO_x	3	A	0.91		1
Natural gas-fired kiln[y]	NO_x	6	A	0.24		29
Natural gas-fired kiln[y]	NO_x	6	A	0.50		30
Natural gas-fired kiln	o-Xylene	3	B	$5.8x10^{-5}$	$5.8x10^{-5}$ (E)	1
Natural gas-fired kiln	Phenol	3	A	$8.6x10^{-5}$	$8.6x10^{-5}$ (E)	1
Natural gas-fired kiln	Styrene	3	B	$2.0x10^{-5}$	$2.0x10^{-5}$ (E)	1
Natural gas-fired kiln	Tetrachloroethene	3	A	$2.8x10^{-6}$	$2.8x10^{-6}$ (E)	1
Natural gas-fired kiln	Toluene	3	B	0.00016	0.00016 (E)	1
~~Primary crusher[x]~~	~~Filterable PM-10~~	~~2~~	~~NR~~	~~$1.1x10^{-7}$~~		~~4~~
Primary crusher with fabric filter[x,z]	Filterable PM-10	3	D	$5.9x10^{-4}$	$5.9x10^{-4}$ (E)	29
Sawdust-fired kiln	1,1,1-trichloroethane[r]	3	C	BDL ($3.0x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln	2-butanone[r]	3	C	BDL ($6.6x10^{-6}$)	BDL (E)	4
Sawdust-fired kiln	2-hexanone[r]	3	C	BDL ($3.0x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln	2-methylphenol[r]	3	C	BDL ($2.0x10^{-9}$)	BDL (E)	4
Sawdust-fired kiln	Acetone	3	C	$3.9x10^{-4}$	$3.9x10^{-4}$ (E)	4
Sawdust-fired kiln	Acrylonitrile[q]	3	C	$1.5x10^{-5}$	$1.5x10^{-5}$ (E)	4
Sawdust-fired kiln	Benzene	3	B	$5.2x10^{-4}$	$5.2x10^{-4}$ (E)	4
Sawdust-fired kiln	Bis(2-ethylhexy)phthalate	3	B	$2.9x10^{-5}$	$2.9x10^{-5}$ (E)	4
Sawdust-fired kiln	Bromomethane	3	A	$5.0x10^{-5}$	$5.0x10^{-5}$ (E)	4
Sawdust-fired kiln	Carbon disulfide	3	C	$1.6x10^{-5}$	$1.6x10^{-5}$ (E)	4
Sawdust-fired kiln	Carbon tetrachloride[r]	3	C	BDL ($3.0x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln	Chloroform[r]	3	C	BDL ($3.0x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln	Chloromethane	3	B	$6.8x10^{-4}$	$6.8x10^{-4}$ (E)	4
Sawdust-fired kiln[aa]	CO	3	A	0.59	1.6 (D)	37
Sawdust-fired kiln[aa]	CO	3	A	1.2		32
Sawdust-fired kiln[aa]	CO	18	A	3.1		4

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Sawdust-fired kiln[aa]	CO_2	18	A	500	490 (D)	4
Sawdust-fired kiln[aa]	CO_2	3	A	470		37
Sawdust-fired kiln[aa]	CO_2	3	A	510		32
~~Sawdust-fired kiln~~	~~CO_2~~	~~3~~	~~NR~~	~~650~~		~~21~~
Sawdust-fired kiln	Di-n-butylphthalate[q]	3	C	6.1x10^{-6}	6.1x10^{-6} (E)	4
Sawdust-fired kiln	Dibenzofuran[t]	3	B	1.5x10^{-5}	1.5x10^{-5} (E)	4
Sawdust-fired kiln	Dimethylphthalate[q]	3	C	1.0x10^{-5}	1.0x10^{-5} (E)	4
Sawdust-fired kiln	Ethylbenzene	3	C	8.5x10^{-6}	8.5x10^{-6} (E)	4
Sawdust-fired kiln	Filterable PM	3	A	0.30	0.34 (D)	4
Sawdust-fired kiln	Filterable PM	3	A	0.38		21
Sawdust-fired kiln and sawdust dryer (parallel)	Filterable PM	3	B	1.1	1.1 (NR)	23[f]
Sawdust-fired kiln	Filterable PM-10	3	A	70% of filt. PM	77% of filt. PM 0.26 (D)	4
Sawdust-fired kiln	Filterable PM-10	2	B	84% of filt. PM		14
Sawdust-fired kiln	Iodomethane	3	B	2.0x10^{-4}	2.0x10^{-4} (E)	4
Sawdust-fired kiln	M-/p-xylene	3	C	2.9x10^{-5}	2.9x10^{-5} (E)	4
Sawdust-fired kiln	Methylene chloride	3	B	7.5x10^{-6}	7.5x10^{-6} (E)	4
Sawdust-fired kiln	Naphthalene[q]	3	C	3.4x10^{-4}	3.4x10^{-4} (E)	4
Sawdust-fired kiln[aa]	NO_x	18	A	0.37	0.37 (E)	4
Sawdust-fired kiln	O-xylene[q]	3	C	3.8x10^{-6}	3.8x10^{-6} (E)	4
Sawdust-fired kiln	Phenol[t]	3	B	7.2x10^{-5}	7.2x10^{-5} (E)	4
Sawdust-fired kiln	Styrene[r]	3	C	BDL (4.4x10^{-7})	BDL (E)	4
Sawdust-fired kiln	Tetrachloroethane[r]	3	C	BDL (3.0x10^{-7})	BDL (E)	4
Sawdust-fired kiln	Toluene	3	C	1.1x10^{-4}	1.1x10^{-4} (E)	4
~~Sawdust-fired kiln~~	~~Total fluorides~~	~~3~~	~~NR~~	~~0.070~~		~~4~~
Sawdust-fired kiln	Trichloroethane[r]	3	C	BDL (3.0x10^{-7})	BDL (E)	4
Sawdust-fired kiln	Trichlorofluoromethane	3	B	5.8x10^{-6}	5.8x10^{-6} (E)	4
Sawdust-fired kiln	Vinyl acetate[r]	3	C	BDL (3.0x10^{-7})	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	1,1,1-trichloroethane[r]	3	C	BDL (5.2x10^{-7})	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	2-butanone[t]	3	C	2.2x10^{-4}	2.2x10^{-4} (E)	4
Sawdust-fired kiln and sawdust dryer	2-hexanone[r]	3	C	BDL (3.8x10^{-7})	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	2-methylphenol[r]	3	C	BDL (2.4x10^{-9})	BDL (E)	4

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Sawdust-fired kiln and sawdust dryer	Acetone	3	C	0.0010	0.0010 (E)	4
Sawdust-fired kiln and sawdust dryer	Acrylonitrile[t]	3	C	$1.9x10^{-5}$	$1.9x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Antimony[q]	3	C	$2.8x10^{-6}$	$2.8x10^{-6}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Arsenic	3	A	$2.1x10^{-5}$	$2.1x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Benzene	3	B	$5.6x10^{-4}$	$5.6x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Beryllium[t]	3	A	$3.1x10^{-7}$	$3.1x10^{-7}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Bis(2-ethylhexy)phthalate[t]	3	C	$1.4x10^{-4}$	$1.4x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Bromomethane[t]	3	A	$4.4x10^{-5}$	$4.4x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Cadmium	3	A	$2.2x10^{-5}$	$2.2x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Carbon disulfide	3	C	$1.8x10^{-5}$	$1.8x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Carbon tetrachloride[r]	3	C	BDL ($3.8x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Chloroform[r]	3	C	BDL ($3.8x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Chloromethane	3	B	0.0014	0.0014 (E)	4
Sawdust-fired kiln and sawdust dryer	Chromium	3	A	$4.8x10^{-5}$	$4.8x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Condensible inorganic PM	3	A	0.013	0.013 (E)	4
Sawdust-fired kiln and sawdust dryer	Condensible organic PM	3	A	0.043	0.043 (E)	4
Sawdust-fired kiln and sawdust dryer	Di-n-butylphthalate[t]	3	C	$1.6x10^{-5}$	$1.6x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Dibenzofuran[r]	3	C	BDL ($2.4x10^{-9}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Dimethylphthalate[r]	3	C	BDL ($2.4x10^{-9}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Ethylbenzene	3	C	$1.0x10^{-5}$	$1.0x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Filterable PM	3	A	1.3	1.3 (E)	4
Sawdust-fired kiln and sawdust dryer	Filterable PM-10	3	A	0.25	0.25 (E)	4
Sawdust-fired kiln and sawdust dryer	Hydrogen fluoride	3	A	0.18	0.18 (E)	4

TABLE 4-2. (continued)

Source	Pollutant	No. of test runs	Data rating	Single facility emission factor, lb/ton	Candidate emission factor, lb/ton (rating)	Ref. No.
Sawdust-fired kiln and sawdust dryer	Iodomethane	3	A	$2.4x10^{-4}$	$2.4x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Lead	3	A	$1.2x10^{-4}$	$1.2x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	M-/p-xylene	3	C	$2.9x10^{-5}$	$2.9x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Manganese	3	A	$4.8x10^{-4}$	$4.8x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Mercury	3	A	$1.1x10^{-5}$	$1.1x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Methylene chloride	3	B	$6.2x10^{-5}$	$6.2x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Naphthalene[r]	3	C	BDL ($2.4x10^{-9}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Nickel	3	A	$3.4x10^{-5}$	$3.4x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	O-xylene	3	C	$7.3x10^{-6}$	$7.3x10^{-6}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Phenol[t]	3	B	$1.0x10^{-4}$	$1.0x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Phosphorus[q]	3	A	$5.5x10^{-4}$	$5.5x10^{-4}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Selenium	3	A	$4.7x10^{-5}$	$4.7x10^{-5}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Styrene[r]	3	C	BDL ($4.2x10^{-6}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Tetrachloroethane[r]	3	C	BDL ($3.8x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	TOC as propane	3	A	0.18	0.18 (E)	4
Sawdust-fired kiln and sawdust dryer	Toluene	3	C	$4.3x10^{-4}$	$4.3x10^{-4}$ (E)	4
~~Sawdust-fired kiln and sawdust dryer~~	~~Total fluorides~~	~~2~~	~~NR~~	~~0.020~~		~~4~~
Sawdust-fired kiln and sawdust dryer	Trichloroethane[r]	3	C	BDL ($3.8x10^{-7}$)	BDL (E)	4
Sawdust-fired kiln and sawdust dryer	Trichlorofluoromethane[t]	3	B	$1.0x10^{-6}$	$1.0x10^{-6}$ (E)	4
Sawdust-fired kiln and sawdust dryer	Vinyl acetate[r]	3	C	BDL ($3.8x10^{-7}$)	BDL (E)	4

TABLE 4-2. (continued)

[a] Emission factor units are lb of pollutant per ton of brick produced, unless noted. To convert from lb/ton to kg/Mg, multiply by 0.5. NA = not applicable. NR = not rated. Data that are crossed out are not used for emission factor development.

[b] Kiln fired by coal and supplemental natural gas.

[c] Richtex Brick, Kiln No. 2, Columbia, South Carolina.

[d] Boral Brick, Phenix City, Alabama.

[e] Richtex Brick, Kiln No. 4, Columbia, South Carolina. Special test to reduce HF emissions. Method of reduction not documented in Reference 23.

[f] Boral Brick, Salisbury, North Carolina.

[g] Redlands Brick, East Windsor, Connecticut.

[h] Boral Brick, Kiln No. 5, Augusta, GA. Clay bodies contained sawdust.

[j] Endicott Brick, Fairbury, Nebraska.

[k] Richtex Brick, Kiln No. 4, Columbia, South Carolina.

[m] Raw material with high sulfur and fluorine content.

[n] Medium-efficiency scrubber using a soda-ash/water solution (maintained at pH 7) as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants.

[p] High-efficiency packed-bed scrubber using a soda-ash/water solution as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants.

[q] Emission factor includes data from two nondetect runs (emissions estimated as one-half of the detection limit).

[r] Pollutant not detected during all three test runs (detection limit shown in parentheses).

[s] Methane as a percentage of TOC measured during same test. The candidate emission factor is calculated by multiplying this percentage by the candidate TOC emission factor for this source.

[t] Emission factor includes data from one nondetect run (emissions estimated as one-half of the detection limit).

[u] PM-10 as a percentage of filterable PM measured during same test. The candidate emission factor is calculated by multiplying this percentage by the candidate filterable PM emission factor for this source.

[v] 1.09 percent sulfur in coal.

[w] PM-10 emissions from conveyor drop point and from the addition of fine (325-mesh) manganese dioxide and barium carbonate powders to the raw material.

[x] Emission factor units are lb of pollutant per ton of raw material throughput.

[y] Includes measurements taken before and after a scrubber that does not control CO, CO_2, filterable PM, or NO_x emissions.

[z] Because of superisokinetic sampling, this emission factor is probably a low estimate of emission from this source.

[aa] Includes measurements following a sawdust dryer heated with the exhaust stream from a sawdust-fired kiln.

TABLE 4-3. SUMMARY OF EMISSION FACTORS FOR BRICK AND STRUCTURAL CLAY PRODUCT MANUFACTURING[a]

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Coal-fired kiln	Hydrogen fluoride	2	D	0.13-0.20	0.17	2,23
Natural gas- or sawdust-fired kiln	Hydrogen fluoride	11	C	0.029-0.85	0.37	1,4,23, 24,33,35
Natural gas- or sawdust-fired kiln	Total fluorides	1	E	1.6 x candidate HF factor	0.59	23
Brick kiln with medium-efficiency scrubber[b]	Total fluorides	1	C	NA	0.18	29
Brick kiln with high-efficiency scrubber[c]	Total fluorides	1	C	NA	0.0013	30
Brick kiln with dry scrubber[d]	Total fluorides	2	C	0.0040-0.051	0.028	17,34,35
Brick kiln	HCl	5	D	0.018-0.41	0.17	1,23
Brick kiln	Methane	3	E	59% of candidate TOC factor	0.037	1,2,22
Brick kiln	TOC as propane	7	C	0.011-0.14	0.062	1-4,22, 33,38,39
Brick kiln	Antimony	4	D	$6.3x10^{-6}$-$6.4x10^{-5}$	$2.7x10^{-5}$	1,2,4,22
Coal-fired kiln	Arsenic	1	E	NA	$1.3x10^{-4}$	2
Sawdust or natural gas-fired kiln	Arsenic	3	D	$1.8x10^{-5}$-$5.1x10^{-5}$	$3.1x10^{-5}$	1,4,22
Coal-fired kiln	Beryllium	1	E	NA	$1.6x10^{-5}$	2
Sawdust or natural gas-fired kiln	Beryllium	3	D	$2.1x10^{-7}$-$7.2x10^{-7}$	$4.2x10^{-7}$	1,4,22
Brick kiln	Cadmium	4	D	$3.3x10^{-6}$-$3.3x10^{-5}$	$1.5x10^{-5}$	1,2,4,22
Brick kiln	Chromium	3	D	$2.1x10^{-5}$-$7.8x10^{-5}$	$5.1x10^{-5}$	2,4,22
Brick kiln	Cobalt	1	E	NA	$2.1x10^{-6}$	22
Brick kiln	Lead	4	D	$7.9x10^{-5}$-$3.3x10^{-4}$	$1.5x10^{-4}$	1,2,4,22
Sawdust-fired kiln[e]	Manganese	1	E	NA	0.013	4
Natural gas or coal-fired kiln	Manganese	3	D	$4.7x10^{-5}$-$7.3x10^{-4}$	$2.9x10^{-4}$	1,2,22
Coal-fired kiln	Mercury	1	E	NA	$9.6x10^{-5}$	2
Natural gas- or sawdust-fired kiln	Mercury	2	D	$5.0x10^{-6}$-$9.9x10^{-6}$	$7.5x10^{-6}$	4,22
Brick kiln	Nickel	3	D	$1.3x10^{-5}$-$1.7x10^{-4}$	$7.2x10^{-5}$	2,4,22
Sawdust- or coal-fired kiln	Phosphorus	2	E	$5.5x10^{-4}$ - 0.0014	$9.8x10^{-4}$	2,4
Brick kiln	Selenium	4	D	$4.3x10^{-5}$-$4.6x10^{-4}$	$2.3x10^{-4}$	1,2,4,22
Natural gas- or sawdust-fired kiln	SO_2	9	C	0.063-1.5	0.67	5,8,17, 22,23, 33,34

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Natural gas-fired kiln firing high-sulfur material	SO_2	7	D	2.0-10	5.1	1,24,25, 29,30, 38,39
Natural gas-fired kiln with medium-efficiency scrubber	SO_2	1	C	NA	1.0	29
Natural gas-fired kiln with high-efficiency scrubber	SO_2	1	C	NA	0.0049	30
Natural gas- or sawdust-fired kiln	SO_3	7	D	0.037-0.28	0.11	23,34, 38,39
Brick kiln	Condensible inorganic PM	8	D	0.0019-3.1	0.48	1,2,4,15, 22,29,30, 34,35
Brick kiln	Condensible organic PM	6	D	0.0029-0.51	0.11	1,2,4,22, 29,30
Brick dryer with supplemental gas burner	CO	2	E	0.18-0.44	0.31	1,38,39
Brick dryer--waste heat from coal-fired kiln	Condensible inorganic PM	1	E	NA	0.11	15
Brick dryer	Filterable PM	2	E	0.073-0.080	0.077	15,38,39
Brick dryer--waste heat	Methane/ethane as propane	1	E	47% of candidate TOC factor	0.043	2
Brick dryer--waste heat	TOC as propane	2	E	0.036-0.060	0.048	2,3
Brick dryer--supplemental gas burner	TOC as propane	2	E	0.11-0.16	0.14	1,39
Brick dryer with supplemental gas burner	CO_2	1	E	NA	71	38,39
Brick dryer with supplemental gas burner	NO_x	1	E	NA	0.098	39
Coal-fired kiln	1,1-dichloroethane	1	E	NA	5.0×10^{-6}	2
Coal-fired kiln	1,1,1-trichloroethane	1	E	NA	BDL 1.7×10^{-5}	2
Coal-fired kiln	1,4-dichlorobenzene	1	E	NA	3.2×10^{-6}	2
Coal-fired kiln	2-butanone	1	E	NA	2.5×10^{-4}	2
Coal-fired kiln	2-hexanone	1	E	NA	BDL 8.2×10^{-7}	2
Coal-fired kiln	2-methylnaphthalene	1	E	NA	1.7×10^{-6}	2
Coal-fired kiln	2-methylphenol	1	E	NA	BDL 2.2×10^{-6}	2
Coal-fired kiln	Acetone	1	E	NA	6.8×10^{-4}	2
Coal-fired kiln	Benzene	1	E	NA	2.9×10^{-4}	2
Coal-fired kiln	Benzoic acid	1	E	NA	2.5×10^{-4}	2
Coal-fired kiln	Bis(2-ethylhexy)phthalate	1	E	NA	4.9×10^{-5}	2
Coal-fired kiln	Bromomethane	1	E	NA	2.4×10^{-5}	2
Coal-fired kiln	Butylbenzylphthalate	1	E	NA	1.2×10^{-6}	2

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Coal-fired kiln	Carbon disulfide	1	E	NA	$2.3x10^{-6}$	2
Coal-fired kiln	Carbon tetrachloride	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln	Chlorobenzene	1	E	NA	$2.1x10^{-5}$	2
Coal-fired kiln	Chloroethane	1	E	NA	$1.1x10^{-5}$	2
Coal-fired kiln	Chloroform	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln	Chloromethane	1	E	NA	$1.1x10^{-4}$	2
Coal-fired kiln	CO	2	D	0.70-0.90	0.80	2,3
Coal-fired kiln	CO_2	10	C	62-550	300	2,3,6,7, 9,10,12, 13,15
Coal-fired kiln	Di-n-butylphthalate	1	E	NA	0	2
Coal-fired kiln	Di-n-octylphthalate	1	E	NA	$1.2x10^{-5}$	2
Coal-fired kiln	Dibenzofuran	1	E	NA	$3.6x10^{-7}$	2
Coal-fired kiln	Diethylphthalate	1	E	NA	$1.4x10^{-6}$	2
Coal-fired kiln	Dimethylphthalate	1	E	NA	BDL $7.8x10^{-7}$	2
Coal-fired kiln	Ethylbenzene	1	E	NA	$2.1x10^{-5}$	2
Coal-fired kiln	Filterable PM	7	A	0.67-2.3	1.2	2,6,7,10, 12,15,19
Coal-fired kiln	Filterable PM-10	2	D	0.42-1.4	0.76	2,15
Coal-fired kiln	Isophorone	1	E	NA	$3.0x10^{-5}$	2
Coal-fired kiln	M-/p-xylene	1	E	NA	$1.3x10^{-4}$	2
Coal-fired kiln	Methylene chloride	1	E	NA	$8.0x10^{-7}$	2
Coal-fired kiln	Naphthalene	1	E	NA	$6.9x10^{-6}$	2
Coal-fired kiln	NO_x	2	D	0.30-0.71	0.51	2,3
Coal-fired kiln	O-xylene	1	E	NA	$4.7x10^{-5}$	2
Coal-fired kiln	Phenol	1	E	NA	$3.5x10^{-5}$	2
Coal-fired kiln	SO_2	2	D	1.2-1.2	1.2	3,9
Coal-fired kiln	Styrene	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln	Tetrachloroethane	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln	Toluene	1	E	NA	$2.5x10^{-4}$	2
Coal-fired kiln	Trichloroethane	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln	Trichlorofluoromethane	1	E	NA	$1.4x10^{-5}$	2
Coal-fired kiln	Vinyl acetate	1	E	NA	BDL $1.0x10^{-7}$	2
Coal-fired kiln with fabric filter	Filterable PM	1	E	NA	0.043	13
Extrusion line with fabric filter[f]	Filterable PM-10	1	E	NA	0.0036	29

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Grinding room with fabric filter[g]	Filterable PM	2	E	0.0052-0.0072	0.0062	1,2
Grinding room with fabric filter[g]	Filterable PM-10	2	E	0.0011-0.0052	0.0032	1,2
Grinding room (14% moisture)[g]	Filterable PM	1	E	NA	0.025	4
Grinding room (3.9% moisture)[g]	Filterable PM	1	E	NA	8.5	1
Grinding room (14% moisture)[g]	Filterable PM-10	1	E	NA	0.0023	4
Grinding room (3.9% moisture)[g]	Filterable PM-10	1	E	NA	0.53	1
Natural gas-fired kiln	1,1,1-Trichloroethane	1	E	NA	$4.7x10^{-6}$	1
Natural gas-fired kiln	1,4-dichlorobenzene	1	E	NA	$4.8x10^{-5}$	1
Natural gas-fired kiln	2-methylnaphthalene	1	E	NA	$5.7x10^{-5}$	1
Natural gas-fired kiln	2-butanone	1	E	NA	0.00022	1
Natural gas-fired kiln	2-hexanone	1	E	NA	$8.5x10^{-5}$	1
Natural gas-fired kiln	Acetone	1	E	NA	0.0017	1
Natural gas-fired kiln	Benzene	1	E	NA	0.0029	1
Natural gas-fired kiln	Bis(2-ethylhexy)phthalate	1	E	NA	0.0020	1
Natural gas-fired kiln	Butylbenzylphthalate	1	E	NA	$1.8x10^{-5}$	1
Natural gas-fired kiln	Carbon disulfide	1	E	NA	$4.1x10^{-5}$	1
Natural gas-fired kiln	Chlorine	1	E	NA	0.0013	1
Natural gas-fired kiln	Chloroethane	1	E	NA	0.00057	1
Natural gas-fired kiln	Chloromethane	1	E	NA	0.00067	1
Natural gas-fired kiln	CO	5	C	0.58-2.6	1.2	1,22,30, 33,38,39
Natural gas-fired kiln	CO_2	11	B	200-770	400	1,5,8,17, 22,24,25, 29,30, 33-35,38, 39
Natural gas-fired kiln	Di-n-butylphthalate	1	E	NA	0.00014	1
Natural gas-fired kiln	Diethylphthalate	1	E	NA	0.00024	1
Natural gas-fired kiln	Ethylbenzene	1	E	NA	$4.4x10^{-5}$	1
Natural gas-fired kiln	Filterable PM	10	C	0.051-0.88	0.37	1,5,8,17, 22,23,29, 30,33-35,38,39
Natural gas-fired kiln firing structural clay tile	Filterable PM	2	E	0.39-1.7	1.0	24,25

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Natural gas-fired kiln	Filterable PM-10	1	E	75% of candidate filt. PM factor	0.28	22
Natural gas-fired kiln	Iodomethane	1	E	NA	$9.3x10^{-5}$	1
Natural gas-fired kiln	m-/p-Xylene	1	E	NA	$6.7x10^{-5}$	1
Natural gas-fired kiln	Naphthalene	1	E	NA	$6.5x10^{-5}$	1
Natural gas-fired kiln	NO_x	8	C	0.13-0.91	0.35	1,5,8,22, 29,30,33- 35,38,39
Natural gas-fired kiln	o-Xylene	1	E	NA	$5.8x10^{-5}$	1
Natural gas-fired kiln	Phenol	1	E	NA	$8.6x10^{-5}$	1
Natural gas-fired kiln	Styrene	1	E	NA	$2.0x10^{-5}$	1
Natural gas-fired kiln	Tetrachloroethene	1	E	NA	$2.8x10^{-6}$	1
Natural gas-fired kiln	Toluene	1	E	NA	0.00016	1
Primary crusher with fabric filter[g]	Filterable PM-10	1	E	NA	$5.9x10^{-4}$	29
Sawdust-fired kiln	1,1,1-trichloroethane	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	2-butanone	1	E	NA	BDL $6.6x10^{-6}$	4
Sawdust-fired kiln	2-hexanone	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	2-methylphenol	1	E	NA	BDL $2.0x10^{-9}$	4
Sawdust-fired kiln	Acetone	1	E	NA	$3.9x10^{-4}$	4
Sawdust-fired kiln	Acrylonitrile	1	E	NA	$1.5x10^{-5}$	4
Sawdust-fired kiln	Benzene	1	E	NA	$5.2x10^{-4}$	4
Sawdust-fired kiln	Bis(2-ethylhexy)phthalate	1	E	NA	$2.9x10^{-5}$	4
Sawdust-fired kiln	Bromomethane	1	E	NA	$5.0x10^{-5}$	4
Sawdust-fired kiln	Carbon disulfide	1	E	NA	$1.6x10^{-5}$	4
Sawdust-fired kiln	Carbon tetrachloride	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	Chloroform	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	Chloromethane	1	E	NA	$6.8x10^{-4}$	4
Sawdust-fired kiln[h]	CO	3	D	0.59-3.1	1.6	4,32,37
Sawdust-fired kiln[h]	CO_2	3	D	470-510	490	4,32,37
Sawdust-fired kiln	Di-n-butylphthalate	1	E	NA	$6.1x10^{-6}$	4
Sawdust-fired kiln	Dibenzofuran	1	E	NA	$1.5x10^{-5}$	4
Sawdust-fired kiln	Dimethylphthalate	1	E	NA	$1.0x10^{-5}$	4
Sawdust-fired kiln	Ethylbenzene	1	E	NA	$8.5x10^{-6}$	4
Sawdust-fired kiln	Filterable PM	2	D	0.30-0.38	0.34	4,21
Sawdust-fired kiln	Filterable PM-10	2	D	0.23-0.29	0.26	4,14
Sawdust-fired kiln	Iodomethane	1	E	NA	$2.0x10^{-4}$	4

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Sawdust-fired kiln	M-/p-xylene	1	E	NA	$2.9x10^{-5}$	4
Sawdust-fired kiln	Methylene chloride	1	E	NA	$7.5x10^{-6}$	4
Sawdust-fired kiln	Naphthalene	1	E	NA	$3.4x10^{-4}$	4
Sawdust-fired kiln[h]	NO_x	1	E	NA	0.37	4
Sawdust-fired kiln	O-xylene	1	E	NA	$3.8x10^{-6}$	4
Sawdust-fired kiln	Phenol	1	E	NA	$7.2x10^{-5}$	4
Sawdust-fired kiln	Styrene	1	E	NA	BDL $4.4x10^{-7}$	4
Sawdust-fired kiln	Tetrachloroethane	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	Toluene	1	E	NA	$1.1x10^{-4}$	4
Sawdust-fired kiln	Trichloroethane	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln	Trichlorofluoromethane	1	E	NA	$5.8x10^{-6}$	4
Sawdust-fired kiln	Vinyl acetate	1	E	NA	BDL $3.0x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	1,1,1-trichloroethane	1	E	NA	BDL $5.2x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	2-butanone	1	E	NA	$2.2x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	2-hexanone	1	E	NA	BDL $3.8x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	2-methylphenol	1	E	NA	BDL $2.4x10^{-9}$	4
Sawdust-fired kiln and sawdust dryer	Acetone	1	E	NA	0.0010	4
Sawdust-fired kiln and sawdust dryer	Acrylonitrile	1	E	NA	$1.9x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Antimony	1	E	NA	$2.8x10^{-6}$	4
Sawdust-fired kiln and sawdust dryer	Arsenic	1	E	NA	$2.1x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Benzene	1	E	NA	$5.6x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Beryllium	1	E	NA	$3.1x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	Bis(2-ethylhexy)phthalate	1	E	NA	$1.4x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Bromomethane	1	E	NA	$4.4x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Cadmium	1	E	NA	$2.2x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Carbon disulfide	1	E	NA	$1.8x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Carbon tetrachloride	1	E	NA	BDL $3.8x10^{-7}$	4

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Sawdust-fired kiln and sawdust dryer	Chloroform	1	E	NA	BDL 3.8×10^{-7}	4
Sawdust-fired kiln and sawdust dryer	Chloromethane	1	E	NA	0.0014	4
Sawdust-fired kiln and sawdust dryer	Chromium	1	E	NA	4.8×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Condensible inorganic PM	1	E	NA	0.013	4
Sawdust-fired kiln and sawdust dryer	Condensible organic PM	1	E	NA	0.043	4
Sawdust-fired kiln and sawdust dryer	Di-n-butylphthalate	1	E	NA	1.6×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Dibenzofuran	1	E	NA	BDL 2.4×10^{-9}	4
Sawdust-fired kiln and sawdust dryer	Dimethylphthalate	1	E	NA	BDL 2.4×10^{-9}	4
Sawdust-fired kiln and sawdust dryer	Ethylbenzene	1	E	NA	1.0×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Filterable PM	1	E	NA	1.3	4
Sawdust-fired kiln and sawdust dryer	Filterable PM-10	1	E	NA	0.25	4
Sawdust-fired kiln and sawdust dryer	Hydrogen fluoride	1	E	NA	0.18	4
Sawdust-fired kiln and sawdust dryer	Iodomethane	1	E	NA	2.4×10^{-4}	4
Sawdust-fired kiln and sawdust dryer	Lead	1	E	NA	1.2×10^{-4}	4
Sawdust-fired kiln and sawdust dryer	M-/p-xylene	1	E	NA	2.9×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Manganese	1	E	NA	4.8×10^{-4}	4
Sawdust-fired kiln and sawdust dryer	Mercury	1	E	NA	1.1×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Methylene chloride	1	E	NA	6.2×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	Naphthalene	1	E	NA	BDL 2.4×10^{-9}	4
Sawdust-fired kiln and sawdust dryer	Nickel	1	E	NA	3.4×10^{-5}	4
Sawdust-fired kiln and sawdust dryer	O-xylene	1	E	NA	7.3×10^{-6}	4
Sawdust-fired kiln and sawdust dryer	Phenol	1	E	NA	1.0×10^{-4}	4
Sawdust-fired kiln and sawdust dryer	Phosphorus	1	E	NA	5.5×10^{-4}	4

TABLE 4-3. (continued)

Source	Pollutant	No. of sources tested	Emission factor rating	Emission factor range, lb/ton	Candidate emission factor, lb/ton	Ref. Nos.
Sawdust-fired kiln and sawdust dryer	Selenium	1	E	NA	$4.7x10^{-5}$	4
Sawdust-fired kiln and sawdust dryer	Styrene	1	E	NA	BDL $4.2x10^{-6}$	4
Sawdust-fired kiln and sawdust dryer	Tetrachloroethane	1	E	NA	BDL $3.8x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	TOC as propane	1	E	NA	0.18	4
Sawdust-fired kiln and sawdust dryer	Toluene	1	E	NA	$4.3x10^{-4}$	4
Sawdust-fired kiln and sawdust dryer	Trichloroethane	1	E	NA	BDL $3.8x10^{-7}$	4
Sawdust-fired kiln and sawdust dryer	Trichlorofluoromethane	1	E	NA	$1.0x10^{-6}$	4
Sawdust-fired kiln and sawdust dryer	Vinyl acetate	1	E	NA	BDL $3.8x10^{-7}$	4

[a] Emission factor units are lb of pollutant per ton of brick produced, unless noted. To convert from lb/ton to kg/Mg, multiply by 0.5. NA = not applicable. NR = not rated. Data that are crossed out are not used for emission factor development. BDL = below detection limit.

[b] Medium-efficiency scrubber using a soda-ash/water solution (maintained at pH 7) as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants. This scrubber is not a standard air pollution control device.

[c] High-efficiency packed-bed scrubber using a soda-ash/water solution as the scrubbing media. This scrubber is designed to reduce SO_2 and fluoride emissions, but is not expected to control other pollutants.

[d] Dry scrubber using limestone as the sorption medium.

[e] The facility uses a manganese surface treatment on the bricks. The manganese emission factor for coal- and natural gas-fired kilns is a better estimate for sawdust-fired kilns firing bricks that do not have a manganese surface treatment.

[f] PM-10 emissions from conveyor drop point and from the addition of fine (325-mesh) manganese dioxide and barium carbonate powders to the raw material.

[g] Emission factor units are lb of pollutant per ton of raw material throughput.

[h] Includes measurements following a sawdust dryer heated with the exhaust stream from a sawdust-fired kiln.

TABLE 4-4. SUMMARY OF PARTICLE SIZE DISTRIBUTION DATA FOR FILTERABLE PM EMISSIONS FROM KILNS

Source	Aerodynamic diameter, microns	Percent of PM emissions less than or equal to stated particle size	Reference No.
Sawdust-fired kiln[a]	10	73	4
	2.5	60	4
	1	57	4
Sawdust-fired kiln[a]	10	84	14
	2.5	36	14
	1	30	14
Sawdust-fired kiln[b]	10	67	4
Coal-fired kiln[a]	10	58	15
	2.5	23	15
	1	9.8	15
Coal-fired kiln[b]	10	67	2

[a]Based on a particle size distribution test performed using cascade impactors.
[b]Based on a comparison of PM-10 (measured using EPA Method 201A) and filterable PM (measured using EPA Method 5) emissions.

TABLE 4-5. AVERAGE PARTICLE SIZE DISTRIBUTION FOR FILTERABLE PM EMISSIONS FROM KILNS[a]

Source	Aerodynamic diameter, microns	Percent of PM emissions less than or equal to stated particle size	Reference No.
Sawdust-fired kiln	10[b]	75	4, 14
	2.5	48	4, 14
	1	44	4, 14
Coal-fired kiln	10[b]	63	2, 15
	2.5	23	15
	1	9.8	15

[a]Particle size distribution based on cascade impactor tests unless noted.
[b]Based on cascade impactor particle size distribution and a comparison of PM-10 (measured using EPA Method 201A) and filterable PM (measured using EPA Method 5) emissions.

development. The emission factors are expressed in units of mass of pollutant per mass of brick produced, unless noted in the text.

4.3.1 <u>Filterable PM</u>

An emission factor for uncontrolled filterable PM emissions from grinding rooms processing relatively dry (moisture content of about 3.9 percent) raw material was developed using A-rated data from Reference 1. The emission factor is 4.2 kg/Mg (8.5 lb/ton) of raw material throughput. This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for uncontrolled filterable PM emissions from grinding rooms processing wet (moisture content of about 14 percent) raw material was developed using B-rated data from Reference 4. The emission factor is 0.012 kg/Mg (0.025 lb/ton) of raw material throughput. This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for fabric filter-controlled filterable PM emissions from grinding rooms was developed using data from two A-rated tests. Raw material moisture content did not appear to affect the magnitude of emissions following the control device. The data range from 0.0026 kg/Mg (0.0052 lb/ton) to 0.0036 kg/Mg (0.0072 lb/ton) and average 0.0031 kg/Mg (0.0062 lb/ton). This candidate emission factor is assigned an E rating because it was developed using data from only two tests.

An emission factor for uncontrolled filterable PM emissions from brick dryers (heated with waste heat from the cooling section of a coal-fired kiln or from a dryer with supplemental gas burners) was developed using A-rated data from two tests. The data range from 0.037 kg/Mg (0.073 lb/ton) to 0.040 kg/Mg (0.080 lb/ton) and average 0.039 kg/Mg (0.077 lb/ton) of bricks produced. This emission factor is assigned an E rating because it was developed using data from only two tests.

An emission factor for uncontrolled filterable PM emissions from coal-fired kilns was developed using A-rated data from emission tests conducted on seven different kilns and C-rated data from a test conducted on one of the same kilns. The data range from 0.34 kg/Mg (0.67 lb/ton) to 1.1 kg/Mg (2.3 lb/ton) and average 0.60 kg/Mg (1.2 lb/ton). This candidate emission factor is assigned an A rating because it was developed using A-rated data from tests conducted at 7 of about 20 domestic facilities that use coal as the primary fuel for firing brick kilns.

An emission factor for uncontrolled filterable PM emissions from natural gas-fired kilns was developed using A- and B-rated test data from tests conducted on 10 kilns. References 5 and 8 document tests conducted on the same kiln, as do References 34 and 35 and References 38 and 39. The data from these tests were first averaged and then combined with the average of three filterable PM tests documented in Reference 1, two tests documented in Reference 22, two tests documented in Reference 30, and single tests documented in References 17, 23, and 29. The kilns in References 17, 34, and 35 were controlled by dry scrubbers that did not appear to reduce PM emissions. One of the Reference 30 tests was conducted at the outlet of a packed bed scrubber that did not control PM emissions. The data range from 0.025 kg/Mg (0.051 lb/ton) to 0.44 kg/Mg (0.88 lb/ton) and average 0.19 kg/Mg (0.37 lb/ton). This candidate emission factor is assigned a C rating because it is based on data from 10 of more than 100 facilities that use natural gas as the primary fuel for firing brick kilns.

An emission factor for uncontrolled filterable PM emissions from sawdust-fired kilns was developed using A-rated data from two tests. The data range from 0.15 kg/Mg (0.30 lb/ton) to 0.19 kg/Mg (0.38 lb/ton) and average 0.17 kg/Mg (0.34 lb/ton). This candidate emission factor is assigned a D rating because it is based on data from 2 of about 20 facilities that use sawdust as the primary fuel for firing brick kilns.

An emission factor for uncontrolled filterable PM emissions from a sawdust-fired kiln and sawdust dryer was developed using A-rated data from a single test. The emission factor is 0.67 kg/Mg (1.3 lb/ton). This emission factor is applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. This emission factor is assigned an E rating because it is based on data from a single test.

An emission factor for fabric filter-controlled filterable PM emissions from coal-fired kilns was developed using A-rated data from a single test. The emission factor is 0.022 kg/Mg (0.043 lb/ton). This emission factor is assigned an E rating because it is based on data from a single test.

An emission factor for uncontrolled filterable PM emissions from natural gas-fired kilns firing structural clay tile was developed using B-rated data from two tests. The data range from 0.20 kg/Mg (0.39 lb/ton) to 0.85 kg/Mg (1.7 lb/ton) and average 0.50 kg/Mg (1.0 lb/ton). This candidate emission factor is assigned an E rating because it is based on only two tests.

4.3.2 Filterable PM-10

An emission factor for uncontrolled filterable PM-10 emissions from coal-fired kilns was developed using A-rated data from an EPA Method 201A test and a particle sizing test in conjunction with the filterable PM emission factor for coal-fired kilns discussed above. The data indicate that about 63 percent of filterable PM emissions are less than or equal to 10 microns in aerodynamic diameter. Therefore, the average filterable PM emission factor was multiplied by 0.63 to determine the filterable PM-10 emission factor of 0.38 kg/Mg (0.76 lb/ton). This candidate emission factor is assigned a D rating because the PM-10 data represent data from 2 of about 20 facilities that use coal as the primary fuel for firing brick kilns.

An emission factor for fabric filter-controlled filterable PM-10 emissions from primary crushers was developed using D-rated data from a single test. The data are D-rated because of superisokinetic sampling, which should cause the data to underestimate actual emissions. the emission factor is 0.00030 kg/Mg (0.00059 lb/ton). This emission factor is assigned an E rating because it is based on D-rated data from a single test. The magnitude of this factor appears to be reasonable.

An emission factor for uncontrolled filterable PM-10 emissions from grinding rooms processing relatively dry (moisture content of about 3.9 percent and 16.9 percent silt content) raw material was developed using A-rated data from Reference 1. The emission factor is 0.27 kg/Mg (0.53 lb/ton) of raw material throughput. This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for uncontrolled filterable PM-10 emissions from grinding rooms processing wet (moisture content of about 14 percent and 4.6 percent silt content) raw material was developed using B-rated data from Reference 4. The emission factor is 0.0011 kg/Mg (0.0023 lb/ton) of raw material throughput. This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for fabric filter-controlled filterable PM-10 emissions from grinding rooms was developed using data from two A-rated tests. Raw material moisture content did not appear to affect the magnitude of emissions following the control device. The data range from 0.00057 kg/Mg (0.0011 lb/ton) to

0.0026 kg/Mg (0.0052 lb/ton) and average 0.0016 kg/Mg (0.0032 lb/ton) of raw material throughput. This candidate emission factor is assigned an E rating because it was developed using data from only two tests.

An emission factor for uncontrolled filterable PM-10 emissions from natural gas-fired kilns was developed using A-rated filterable PM-10 test data from a single test in conjunction with A- and B-rated filterable PM test data from twelve tests conducted on seven kilns. Additional PM-10 test data from Reference 1 indicate that about 33 percent of filterable PM emissions are less than or equal to 10 microns in aerodynamic diameter. However, this percentage is not consistent with other available PM-10 data for kilns using different fuels and is not used for emission factor development. The Method 201A test from Reference 22 indicates that about 75 percent of filterable PM emissions are PM-10 (percentage based on the PM-10 measurement divided by the sum of the PM-10 measurement and the cyclone catch from the 201A sampling train). Therefore, the candidate filterable PM emission factor for natural gas-fired kilns was multiplied by 0.75 to determine the filterable PM-10 emission factor of 0.14 kg/Mg (0.28 lb/ton). This candidate emission factor is assigned an E rating because it is based on a single test.

An emission factor for uncontrolled filterable PM-10 emissions from sawdust-fired kilns was developed from an EPA Method 201A test and a particle sizing test in conjunction with the filterable PM emission factor for sawdust-fired kilns. The data indicate that about 77 percent of filterable PM emissions are less than or equal to 10 microns in aerodynamic diameter. Therefore, the average filterable PM emission factor was multiplied by 0.77 to determine the filterable PM-10 emission factor of 0.13 kg/Mg (0.26 lb/ton). This candidate emission factor is assigned a D rating because the PM-10 data represent emissions from 2 of about 20 facilities that use sawdust as the primary fuel for firing brick kilns.

An emission factor for uncontrolled filterable PM-10 emissions from a sawdust-fired kiln and sawdust dryer was developed using A-rated data from a single test. The emission factor is 0.13 kg/Mg (0.25 lb/ton). This emission factor is applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. This emission factor is assigned an E rating because it is based on data from a single test.

An emission factor for fabric filter-controlled filterable PM-10 emissions from an extrusion line was developed using B-rated data from a single test. The emission factor is 0.0018 kg/Mg (0.0036 lb/ton). This factor is not applicable to typical extrusion lines, but is based on data from a line processing very fine additives and relatively dry raw material. Also, the line includes a conveyor drop point. This emission factor is assigned an E rating because it is based on data from a single test.

4.3.3 Condensible PM

An emission factor for uncontrolled condensible inorganic PM emissions from brick dryers heated with waste heat from the cooling section a coal-fired kiln was developed using A-rated data from a single test. The emission factor is 0.054 kg/Mg (0.11 lb/ton) of raw material throughput. This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for uncontrolled condensible inorganic PM emissions from coal-, natural gas-, and sawdust-fired kilns was developed using A-rated data from eight tests. The data for these different fuel types were combined because the data indicate that, although emissions are highly variable, the fuel type is not a significant factor in the magnitude of emissions. The data range from 0.00095 kg/Mg (0.0019 lb/ton) to 1.6 kg/Mg (3.1 lb/ton) and average 0.24 kg/Mg (0.48 lb/ton). This candidate emission factor is assigned a D rating because the data are highly variable. Emission measurements taken at a scrubber outlet are averaged with the uncontrolled data because the scrubber is not expected to control condensible PM emissions.

An emission factor for uncontrolled condensible organic PM emissions from coal-, natural gas-, and sawdust-fired kilns was developed using A-rated data from six tests. The data for these different fuel types were combined because the data indicate that, although emissions are highly variable, the fuel type is not a significant factor in the magnitude of emissions. The data range from 0.0015 kg/Mg (0.0029 lb/ton) to 0.26 kg/Mg (0.51 lb/ton) and average 0.055 kg/Mg (0.11 lb/ton). This candidate emission factor is assigned a D rating because it is based on data that range over two orders of magnitude. Emission measurements taken at a scrubber outlet are averaged with the uncontrolled data because the scrubber is not expected to control condensible PM emissions.

Emission factors for uncontrolled condensible organic and inorganic PM emissions from a sawdust-fired kiln and sawdust dryer were developed using A-rated data from a single test. The condensible organic PM emission factor is 0.022 kg/Mg (0.043 lb/ton), and the condensible inorganic PM emission factor is 0.0064 kg/Mg (0.013 lb/ton). These emission factors are applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. These candidate emission factors are assigned E ratings because they are based on data from a single test.

4.3.4 Total Organic Compounds

An emission factor for uncontrolled TOC (as propane) emissions from brick dryers heated with waste heat from the kiln cooling zone was developed using A-rated data from two tests. The data range from 0.018 kg/Mg (0.036 lb/ton) to 0.030 kg/Mg (0.060 lb/ton) and average 0.024 kg/Mg (0.048 lb/ton). This candidate emission factor is assigned an E rating.

An emission factor for uncontrolled TOC (as propane) emissions from brick dryers heated with waste heat and supplemental gas burners was developed using A- and B-rated data from two tests. The data range from 0.055 kg/Mg (0.11 lb/ton) to 0.080 kg/Mg (0.16 lb/ton) and average 0.068 kg/Mg (0.14 lb/ton). This candidate emission factor is assigned an E rating.

An emission factor for uncontrolled TOC (as propane) emissions from brick kilns (including natural gas-, coal-, and sawdust-fired kilns) was developed using A-rated data from six tests and B-rated data from one test. The data range from 0.0055 kg/Mg (0.011 lb/ton) to 0.070 kg/Mg (0.14 lb/ton) and average 0.031 kg/Mg (0.062 lb/ton). This emission factor is assigned a C rating.

An emission factor for uncontrolled TOC (as propane) emissions from a sawdust-fired kiln and sawdust dryer was developed using A-rated data from a single test. The emission factor is 0.090 kg/Mg (0.18 lb/ton). This emission factor is applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. This emission factor is assigned an E rating because it is based on data from a single test.

4.3.5 Volatile Organic Compounds

The VOC emission factors presented in the revised AP-42 section were calculated by subtracting the methane and ethane factors from the TOC factors, and then subtracting available factors for other identified non-reactive compounds (acetone, methylene chloride, trichloroethane, trichlorofluoromethane, and 1,1,1-trichloroethane).

4.3.6 Methane and Ethane

An emission factor for uncontrolled methane/ethane emissions from brick dryers was developed using A-rated data from a single test. The data indicate that 47 percent of TOC emissions are methane/ ethane. Therefore, the candidate TOC emission factor was multiplied by 0.47 to calculate a methane/ ethane emission factor of 0.022 kg/Mg (0.043 lb/ton). This emission factor is assigned an E rating because it was developed using data from a single test.

An emission factor for uncontrolled methane (as propane) emissions from brick kilns (data included natural gas- and coal-fired kilns) was developed using A-rated data from one test, B-rated data from one test, and C-rated data from one test. The data range from 4.9 percent of TOC emissions to 100 percent of TOC emissions (measured during the same test) and average 59 percent of TOC emissions. This percentage is multiplied by the candidate TOC emission factor for brick kilns to calculate an emission factor 0.019 kg/Mg (0.037 lb/ton). This emission factor is assigned an E rating because of the large discrepancy in the percentages of methane measured during the tests. This emission factor is assumed to apply to all kilns, although data are not available for methane emissions from sawdust-fired kilns.

4.3.7 Carbon Monoxide

An emission factor for uncontrolled CO emissions from brick dryers heated with waste heat from the kiln cooling zone and a supplemental natural gas burner was developed using A- and B-rated data from two tests. The data range from 0.090 kg/Mg (0.18 lb/ton) to 0.22 kg/Mg (0.44 lb/ton) and average 0.16 kg/Mg (0.31 lb/ton) of dried bricks produced. This emission factor is assigned an E rating because it is based on data from only two tests.

An emission factor for uncontrolled CO emissions from coal-fired kilns was developed using A-rated data from two tests. The data range from 0.35 kg/Mg (0.70 lb/ton) to 0.45 kg/Mg (0.90 lb/ton) and average 0.40 kg/Mg (0.80 lb/ton). This candidate emission factor is assigned a D rating because it was developed using A-rated data from tests conducted at 2 of about 20 domestic facilities that use coal as the primary fuel for firing brick kilns.

An emission factor for uncontrolled CO emissions from natural gas-fired kilns was developed using A-rated data from six tests conducted on five kilns. The data range from 0.29 kg/Mg (0.58 lb/ton) to 1.3 kg/Mg (2.6 lb/ton) and average 0.60 kg/Mg (1.2 lb/ton). This emission factor is assigned a C rating because it is based on data from five of more than 100 facilities that use natural gas as the primary fuel for firing brick kilns.

An emission factor for uncontrolled CO emissions from sawdust-fired kilns was developed using A-rated data from four tests conducted on three kilns. Two tests from Reference 4 included a test of the kiln exhaust and a test conducted following a sawdust dryer that was heated with the kiln exhaust. The sawdust dryer did not significantly effect CO emissions from the kiln. The data range from 0.30 kg/Mg (0.59 lb/ton) to 1.6 kg/Mg (3.1 lb/ton) and average 0.80 kg/Mg (1.6 lb/ton). This candidate emission factor is assigned a D rating.

4.3.8 Carbon Dioxide

An emission factor for uncontrolled CO_2 emissions from brick dryers with supplemental gas burners was developed using A-rated data from two tests conducted on the same kiln. The candidate emission factor is 36 kg/Mg (71 lb/ton). This candidate emission factor is assigned an E rating because it is based on data from a single kiln.

An emission factor for uncontrolled CO_2 emissions from coal-fired kilns was developed using A-rated data from three tests and C-rated data from seven tests. The data range from 31 kg/Mg (62 lb/ton) to 230 kg/Mg (550 lb/ton) and average 150 kg/Mg (300 lb/ton). This candidate emission factor is assigned a C rating because C-rated data were used.

An emission factor for uncontrolled CO_2 emissions from natural gas-fired kilns was developed using A-rated data from nine tests conducted on seven kilns, B-rated data from two tests performed on the same kiln (References 5 and 8), and B- and C-rated data from two tests. The data are first averaged by kiln (data from References 5 and 8 are averaged, as are the data from References 34 and 35, and the data from References 38 and 39), and then averaged with the data from the other tests. The data range from 100 kg/Mg (200 lb/ton) to 390 kg/Mg (770 lb/ton) and average 200 kg/Mg (400 lb/ton). This candidate emission factor is assigned a B rating because it is based on data from twelve kilns at eleven facilities that use natural gas as the primary fuel for firing brick kilns.

An emission factor for uncontrolled CO_2 emissions from sawdust-fired kilns was developed using A-rated data from four tests conducted on three kilns. Two tests from Reference 4 included a test of the kiln exhaust and a test conducted following a sawdust dryer that was heated with the kiln exhaust. The sawdust dryer did not significantly effect CO_2 emissions from the kiln. The data range from 240 kg/Mg (470 lb/ton) to 260 kg/Mg (510 lb/ton) and average 250 kg/Mg (490 lb/ton). This candidate emission factor is assigned a D rating.

4.3.9 Nitrogen Oxides

An emission factor for uncontrolled NO_x emissions from brick dryers with supplemental gas burners was developed using A-rated data from a single test. The candidate emission factor is 0.049 kg/Mg (0.098 lb/ton). This candidate emission factor is assigned an E rating because it is based on data from a single test.

An emission factor for uncontrolled NO_x emissions from coal-fired kilns was developed using A-rated data from two tests. The data range from 0.15 kg/Mg (0.30 lb/ton) to 0.35 kg/Mg (0.71 lb/ton) and average 0.25 kg/Mg (0.51 lb/ton). This candidate emission factor is assigned a D rating because it was developed using A-rated data from tests conducted at 2 of about 20 domestic facilities that use coal as the primary fuel for firing brick kilns.

An emission factor for uncontrolled NO_x emissions from natural gas-fired kilns was developed using A- and B-rated data from eleven tests conducted on eight kilns. References 5 and 8 document tests on the same kiln, as do References 34 and 35, and References 38 and 39. The data are first averaged by kiln, and then are averaged with the data from the other tests. The data range from 0.065 kg/Mg (0.13 lb/ton) to 0.45 kg/Mg (0.91 lb/ton) and average 0.18 kg/Mg (0.35 lb/ton). This emission factor is assigned a C rating because it is based on data from 7 of more than 100 facilities that use natural gas as the primary fuel for firing brick kilns.

An emission factor for uncontrolled NO_x emissions from sawdust-fired kilns was developed using A-rated data from two tests conducted on the same kiln. One of the tests was conducted following a sawdust dryer that was heated with the kiln exhaust. The sawdust dryer did not significantly effect NO_x emissions from the kiln. The emission factor is 0.18 kg/Mg (0.37 lb/ton). This emission factor is assigned an E rating because it is based on data from a single facility.

4.3.10 Sulfur Dioxide

An emission factor for uncontrolled SO_2 emissions from coal-fired kilns was developed using A-rated data from two tests. The data range from 0.57 kg/Mg (1.2 lb/ton) to 0.61 kg/Mg (1.2 lb/ton) and average 0.59 kg/Mg (1.2 lb/ton). This candidate emission factor is assigned a D rating because it was developed using A-rated data from tests conducted at 2 of about 20 domestic facilities that use coal as the primary fuel for firing brick kilns.

An emission factor for uncontrolled SO_2 emissions from sawdust- and natural gas-fired kilns was developed using A-rated data from four tests, B-rated data from four tests, two of which were performed on the same kiln (References 5 and 8), and C-rated data from two tests. The data from References 5 and 8 were averaged first and then averaged with the other data. The data range from 0.032 kg/Mg (0.063 lb/ton) to 0.75 kg/Mg (1.5 lb/ton) and average 0.34 kg/Mg (0.67 lb/ton). This candidate emission factor is assigned a C rating because it is based on data from 9 of more than 100 facilities that use natural gas as the primary fuel for firing brick kilns. Several additional tests (References 1, 24, 25, 29, 30, 38, and 39) were not used in calculating the candidate emission factor because the raw material sulfur content was considerably higher than is typical, and the test results are not considered representative of typical firing operations.

An emission factor for uncontrolled SO_2 emissions from natural gas-fired kilns firing high-sulfur (one facility documented an average sulfur content of 0.087 percent) material was developed using A-rated data from five tests and B-rated data from two tests. The data range from 1.0 kg/Mg (2.0 lb/ton) to 5.0 kg/Mg (10 lb/ton) and average 2.6 kg/Mg (5.1 lb/ton). This candidate emission factor is assigned a D rating because the tests generally did not document the raw material sulfur content.

Emission factors were developed for wet scrubber-controlled SO_2 emissions from natural gas-fired kilns firing high-sulfur material. A factor of 0.50 kg/Mg (1.0 lb/ton) was developed for a kiln equipped with a medium-efficiency scrubber using a soda-ash/water solution as the scrubbing media. A factor of 0.0025 kg/Mg (0.0049 lb/ton) was developed for a kiln equipped with a high-efficiency packed-bed scrubber using a soda-ash/water solution as the scrubbing liquid. The medium-efficiency scrubber demonstrated a control efficiency of 82 percent, and the high-efficiency scrubber demonstrated a control efficiency of 99.8 percent. The emission factors are assigned C ratings because, although only single tests were performed, the units are unique within the industry.

4.3.11 Sulfur Trioxide

An emission factor for uncontrolled SO_3 emissions from sawdust- or natural gas-fired kilns was developed using A-rated data from three tests, B-rated data from two tests, and C-rated data from two tests. The data range from 0.019 kg/Mg (0.037 lb/ton) to 0.14 kg/Mg (0.28 lb/ton) and average 0.055 kg/Mg (0.11 lb/ton). This candidate emission factor is assigned a D rating because the data range over almost an order of magnitude.

4.3.12 Hydrogen Fluoride

An emission factor was developed for HF emissions from coal-fired kilns using A- and C-rated data from two tests. The data range from 0.065 kg/Mg (0.13 lb/ton) to 0.10 kg/Mg (0.20 lb/ton) and average 0.083 kg/Mg (0.17 lb/ton). This candidate emission factor is assigned a D rating. Most factors that are based on only two tests are assigned an E rating, but the rating for this factor was improved one letter grade because the two kilns represent almost 10 percent of coal-fired brick kilns.

An emission factor for uncontrolled HF emissions from natural gas or sawdust-fired brick kilns was developed using data from four A-rated, three B-rated, and four C-rated emission tests. These data are aggregated because, based on the test data, the magnitude of HF emissions from natural gas- and sawdust-fired kilns is similar. The data range from 0.015 kg/Mg (0.029 lb/ton) to 0.43 kg/Mg (0.85 lb/ton) and average 0.19 kg/Mg (0.37 lb/ton). Several of the tests actually documented total fluoride emissions, and the total fluoride results were divided by 1.6 to estimate HF emissions. The "1.6" factor was taken from the only available test that documented both HF and total fluorides from the same kiln. This candidate emission factor is assigned a C rating.

An emission factor for uncontrolled HF emissions from a sawdust-fired kiln and sawdust dryer was developed using A-rated data from a single test. The emission factor is 0.089 kg/Mg (0.18 lb/ton), and is presented separately from the other HF data because data from Reference 4 indicate that the sawdust dryer removes about 60 percent of the HF from the exhaust stream. This emission factor is applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. This emission factor is assigned an E rating because it is based on data from a single test.

4.3.13 Total Fluorides

An emission factor for uncontrolled total fluoride emissions from brick kilns was developed using C-rated data from one test, which indicated that uncontrolled total fluoride emissions are 1.6 times higher than HF emissions. Therefore, the candidate emission factor for HF was multiplied by 1.6 to develop an emission factor of 0.30 kg/Mg (0.59 lb/ton) for total fluorides. This emission factor is assigned an E rating because it is based on data from a single test.

An emission factor for total fluoride emissions from natural gas-fired kilns controlled with dry packed bed scrubbers was developed using A-rated data from three tests conducted on two kilns. The data range from 0.0020 kg/Mg (0.0040 lb/ton) to 0.025 kg/Mg (0.051 lb/ton) and average 0.014 kg/Mg (0.028 lb/ton). This emission factor is assigned a C rating because it is based on data from most of the dry scrubbers currently used to control HF emissions from brick kilns.

An emission factor for medium-efficiency wet scrubber-controlled total fluoride emissions from brick kilns was developed using data from one A-rated test. The scrubber used a soda-ash/water solution (maintained at pH 7) as the scrubbing media. The emission factor is 0.0090 kg/Mg (0.18 lb/ton). This emission factor is assigned a C rating because the source tested is the only domestic brick kiln that uses this type of scrubber.

An emission factor for high-efficiency wet scrubber-controlled total fluoride emissions from brick kilns was developed using data from one A-rated test. The packed-bed wet scrubber used a soda-ash/water solution (maintained at pH 7) as the scrubbing media. The emission factor is 0.00065 kg/Mg (0.0013 lb/ton). This emission factor is assigned a C rating because the source tested is the only domestic brick kiln that uses this type of scrubber.

4.3.14 Hydrochloric Acid

An emission factor for uncontrolled HCl emissions from natural gas-fired kilns was developed using A-rated data from one test, B-rated data from two tests, and C-rated data from two tests. The data range from 0.0090 kg/Mg (0.018 lb/ton) to 0.21 kg/Mg (0.41 lb/ton) and average 0.065 kg/Mg (0.17 lb/ton). This emission factor is assigned a D rating because of the wide range of data.

4.3.15 Metals

Emission factors for arsenic, antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, manganese, nickel, phosphorus, and selenium emissions from brick kilns were developed using data from four tests. Two of the tests were conducted on natural gas-fired kilns, one test was conducted on a coal-fired kiln, and one test was conducted on a sawdust-fired kiln. The emissions of each metal measured during the tests were compared to determine which data should be combined.

Data from all four tests are combined for antimony, cadmium, lead, and selenium because there are insignificant differences in emissions of these metals from kilns firing the various fuel types. The emission factors for these pollutants are assigned D ratings.

Data from three tests (representing all three fuel types) are combined for chromium and nickel. The emission factors for these pollutants are assigned D ratings. The data for chromium and nickel from Reference 1 are not used for emission factor development because they appear to be high (by a factor of about 100) due to the atypical raw material used by the facility.

Data from three tests (representing natural gas- and sawdust-fired kilns) are combined for arsenic, beryllium, and mercury (two tests). The emission factors for these pollutants are assigned D ratings. The data for arsenic, beryllium, and mercury from coal-fired kilns are presented separately because they are an order of magnitude or more higher than the data for natural gas- and sawdust-fired kilns. The emission factors for these pollutants are assigned E ratings because they are based on single tests.

Data from three tests (representing natural gas and coal-fired kilns) are combined for manganese. The emission factor for this pollutant is assigned a D rating. The manganese data from sawdust-fired kilns are presented separately because they are about two orders of magnitude higher than the other manganese data. However, manganese emissions are probably not caused by sawdust combustion, but result from the use of a brick surface treatment that contains manganese. The emission factor for this pollutant is assigned an E rating and is footnoted as being representative of operations using manganese surface treatments.

Data for cobalt were only reported for natural gas-fired kilns, and data from one of the two tests are not used for emission factor development because high background concentrations are reported in the test report (Reference 1). The emission factor for this pollutant is assigned an E rating. Cobalt emissions are assumed to result from the raw material; therefore, the cobalt emission factor is assumed to represent emissions from kilns firing natural gas, coal, or sawdust.

Data from two tests (representing sawdust- and coal-fired kilns) are combined for phosphorus. The emission factor for this pollutant is assigned an E rating.

Emission factors for arsenic, beryllium, cadmium, chromium, mercury, manganese, nickel, lead, phosphorus, and selenium emissions from a sawdust-fired kiln and a sawdust dryer were developed from A-rated data from a single test. No other metals were detected during testing. These emission factors are applicable to facilities that vent the kiln exhaust into a rotary drum sawdust dryer, through cyclones for sawdust recovery, and then to the atmosphere. The emission factors for these metals are assigned an E rating because they are based on a single test.

4.3.16 Volatile and Semivolatile Organic Compounds

Emission factors for speciated VOC and SVOC were developed for natural gas-, coal-, and sawdust-fired kilns. In addition, emission factors for VOC and SVOC emissions from a sawdust-fired kiln and sawdust dryer were developed. These emission factors are all based on single tests and are all assigned E ratings because they are based on single tests. Factors that are reported as "zero" are based on tests with mesurements that were lower than the blank measurements.

4.4 SUMMARY OF CHANGES TO AP-42 SECTION

4.4.1 Section Narrative

The section narrative was expanded to include a more complete description of brick and structural clay product manufacturing processes and was revised to reflect current industry practices. In addition, the process flow diagram was modified to be consistent with the process description, and Source Classification Codes (SCC) were added to the figure. The particle size figures were removed from the section. Finally, comments from industry were addressed prior to finalizing the report. A copy of the comment and response log is provided in Appendix A.

4.4.2 Emission Factors

The emission factor and particle size distribution tables were completely revised to incorporate the newly developed emission factors and new particle size data. Also, all of the emission factors that were based on the AP-42 fuel combustion emission factors were removed from the section. The emission factor ratings are, for the most part, lower than in the previous section, but are based on more stringent criteria. The emission factors were developed with higher quality data than the old emission factors.

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5. PROPOSED AP-42 SECTION

The proposed AP-42, Section 11.3, Brick and Structural Clay Product Manufacturing, is presented on the following pages as it would appear in the document.