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Office Of Air Quality Planning And Standards Research Triangle Park, NC 27711

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Air

Economic Impact Analysis for the Proposed Clay Minerals Processing NESHAP

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ACRONYMS

CAA	Clean Air Act
EIA	Economic Impact Analysis
EPA	United States Environmental Protection Agency
HAPs	Hazardous Air Pollutants
HCl	Hydrogen Chloride (also known as Hydrochloric Acid)
HF	Hydrogen Fluoride
ISEG	Innovative Strategies and Economics Group
MACT	Maximum Achievable Control Technology
NESHAP	National Emission Standards for Hazardous Air Pollutants
NAICS	North American Industrial Classification Code
OAQPS	Office of Air Quality, Planning, and Standards
RFA	Regulatory Flexibility Act
SBREFA	Small Business Regulatory Enforcement Fairness Act
SIC	Standard Industrial Classification
VOS	Value of Shipments

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1 INTRODUCTION

Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA or the Agency) is developing National Emissions Standards for Hazardous Air Pollutants (NESHAP) to control emissions released from the domestic processing of clay minerals. Clay minerals processing entails the mining and preparation of clay material for use as an input to a variety of end products. The processing of clay results in emissions of hazardous air pollutants (HAPs). The NESHAP which this economic impact analysis (EIA) addresses is scheduled to be proposed in mid-2001. The Innovative Strategies and Economics Group (ISEG) of the Office of Air Quality Planning and Standards (OAQPS) has developed this analysis in support of the evaluation of impacts associated with the clay minerals processing NESHAP.

1.1 Scope and Purpose

This report evaluates the economic impacts of pollution control requirements on clay minerals processing operations. The Clean Air Act (CAA) was designed to protect and enhance the nation's air resources and Section 112 of the CAA establishes the authority to control HAP emissions. A large percentage of the HAP compounds released from clay minerals processing operations are hydrogen fluoride (HF) and hydrogen chloride (HCl). To reduce emissions of these and other HAPs, the Agency establishes maximum achievable control technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT standards can be based. The MACT floor is set by the average emissions limitation achieved by the best performing 12 percent of sources in a category or subcategory when that category or subcategory contains at least 30 sources. The estimated costs for individual clay minerals processing facilities to comply with these standards are inputs to the economic impact analysis presented in this report.

1.2 Organization of the Report

The economic impact analysis is organized into four sections. Section 2 provides a profile of the industry which includes a description of the producers and consumers of clay minerals. This section also presents available market data and trends in the industry, including domestic production, foreign trade, and apparent U.S. consumption. Section 3 describes the facility-level costs of complying with this NESHAP and Section 4 provides facility-, market-, and society-level impacts of complying with this rule. Small business considerations are made in Section 5 as required by the Regulatory Flexibility Act (RFA) of 1980 which was modified by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996.

2 INDUSTRY PROFILE

The industry profile is organized as follows: Section 2.1 describes the stages and costs of clay minerals processing, as well as the types of emissions released during each of the processing stages. Section 2.2 explains the various uses and consumers of clay minerals, as well as the substitutable inputs for clay minerals. Section 2.3 provides a summary profile of the clay minerals processing industry, including a description of the manufacturing facilities and the companies that own them.

Clay minerals are common inputs to a variety of products such as pottery, bricks, sanitaryware, dinnerware, tiles, structural products, lightweight aggregate, and other materials used in construction. They can also be used as fillers and extenders in cosmetics, fertilizers, pet litter, and animal feed. Clay refers to fine-grained materials from the earth that have a plastic-like composition when wet. The pliable nature of wet clay allows it to be molded and shaped. Clay will harden and retain its shape when it is dried through heat exposure. If the clay material is glazed before it is dried, it becomes fireproof and waterproof. These characteristics make clay an attractive input to the production of the products listed above.

Six major clay categories exist: ball clay, common clay and shale, fuller's earth, kaolin, fire clay, and bentonite. The various types of clays are used in the production of different final goods, however, there is some substitutability between them as inputs. Ball clay, a plastic sedimentary clay, is primarily used in tile and sanitaryware production. Common clay has a relatively high iron content and turns red when fired, while shale is a fine-grained sedimentary rock with a thin, friable structure. These two are used in the production of brick, cement, and lightweight aggregate. Fuller's earth, an absorbent clay mineral that lacks plasticity, is a common input to absorbent materials such as pet litter. Kaolin is a pure white clay used mainly in the paper industry. Fire clay is able to withstand extremely high temperatures and therefore is used primarily in refractories. Last is bentonite, which is formed from volcanic ash and is an absorbent aluminum silicate clay. It, like fuller's earth, is used in the production of absorbent materials and foundry sand.

The mining and processing of these clay minerals fall under a few different industries. The Standard Industrial Classification (SIC) codes of these industries are:

- **SIC 1455** - Kaolin and Ball Clay;
- **SIC 1459** - Clay, Ceramic, and Refractory Minerals, not elsewhere classified (n.e.c.); and
- **SIC 3295** - Minerals and Earths, Ground or Otherwise Treated.

These correspond to the following North American Industrial Classification System (NAICS) codes:

- **NAICS 212324** - Kaolin and Ball Clay Mining;
- **NAICS 212325** - Clay, Ceramic, and Refractory Minerals Mining; and
- **NAICS 327992** - Ground or Treated Mineral Earth Manufacturing.

Processing the six different categories of clay minerals entails similar steps. The primary HAPs emitted during the processing of clay minerals are hydrogen fluoride (HF) and hydrogen chloride (HCl) and the major source of these emissions is the calciners used during the treatment stage of processing. Other HAP emissions are a function of the clay minerals and the additives used during their processing.

2.1 Production Overview

This section provides a description of clay minerals processing. Section 2.1.1 describes the stages involved in the processing of clay minerals, while Section 2.1.2 briefly discusses the emissions released from these operations. Section 2.1.3 addresses the costs associated with clay minerals processing and last, Section 2.1.4 provides average market values of the six categories of clay minerals.

2.1.1 Stages of Production

The production processes of clay minerals differ across the six clay categories, however, they are similar enough that a general description can be provided. After the description of the general processing procedure of clay minerals, the specific processes used for each clay type are explained in more detail. Information in this section was taken from EPA's *Emission Factor Documentation on Clay Processing* (1995).

As Figure 2-1 shows, there are several steps involved in the mining and processing of clay minerals that can then be used as inputs. In general, clay minerals are:

- **extracted** by open-pit methods or mined from underground;
- **reduced** in size through crushing, grinding, and screening;
- **treated** mechanically and chemically; and
- **packaged** for shipping and/or storage.

Clay minerals are first extracted from the ground using various types of equipment, such as power shovels, front-end loaders, backhoes, and shale planers. Some kaolin is also extracted through hydraulic mining and dredging. Most clay minerals are mined by open-pit methods, however a high percentage of fire clay is mined underground relative to other clays. Higher quality fire clay is found deep underground, thus making open-pit mining for this clay type less common. Once the clays are mined, they are transported to plants for processing.

Processing begins with the crushing, grinding, and screening of the clay minerals. Depending on the how the clay minerals are going to be used in production, they may go through up to three crushing stages during processing. The primary crushing and grinding reduces the size of the clay minerals from up to one meter down to a few centimeters in diameter using jaw or gyratory crushers. Secondary crushing is accomplished through the use of rotating pan crushers, cone crushers, smooth roll crushers, toothed roll crushers, and hammer mills. In this stage, the size of the clay material is reduced to 3 millimeters or less in diameter. Clays may even be required to go through a third crushing and grinding stage, in which ball, rod, or pebble mills are used. After the crushing of the clay minerals, they are passed through screens to determine if they have been satisfactorily reduced in size. Screens are set up in a sloping, multi-deck fashion and are mechanically or electromagnetically vibrated as the clay minerals pass through. If they do not pass through, they are crushed further until they are able to pass through the screens.

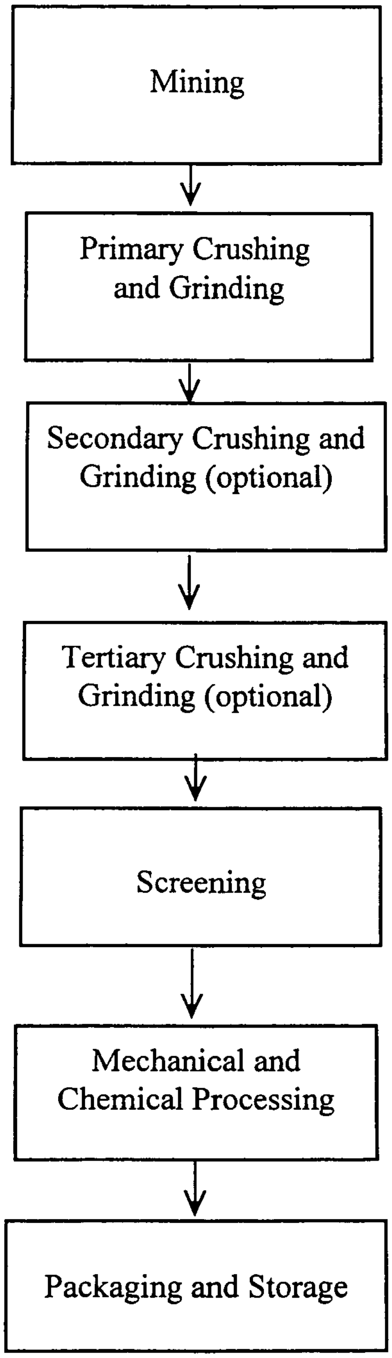


Figure 2-1. Clay Minerals Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

Crushing, grinding, and screening operations do not significantly alter the chemical and mineralogical properties of clay minerals, but since they are used in a variety of applications, they must be mechanically and chemically treated. The processes, which prepare the clay minerals for use as inputs, include blunging, extrusion, drying, and calcining. Blunging is a process by which the clay material is mixed with water in a pug mill. The clay may next be extruded through dies and then dried using rotary, fluid bed, and vibrating grate dryers. Certain clays require calcining, which is accomplished with rotary or flash calciners.

2.1.1.1 Ball Clay Processing

Figure 2-2 shows a flow diagram of the processing steps of ball clay. Ball clay has a moisture content of approximately 28 percent, so after it is mined, it is stored in sheds to dry. When the moisture content decreases to about 22 percent, it is then ready to be processed. Ball clay is shredded into pieces 1.3 to 2.5 centimeters thick using a disintegrator instead of being crushed and screened. This material is either ground using a hammermill or dried in rotary or vibrating dryers. If the ball clay is ground, it is next mixed with water and is ready for shipping in the form of a slurry. Otherwise, the ball clay is dried until it reaches a moisture content of 8 to 10 percent. This dried clay is then ground in a roller mill and is ready for shipping. This ground ball clay can also be mixed with water and shipped in the form of a slurry as well.

2.1.1.2 Common Clay and Shale Processing

As shown in Figure 2-3, the processing of common clay and shale follows the processing steps of clay minerals in general. The mined common clay and shale is first crushed and screened. If material is oversized, it is returned to the crushers until the material is small enough to pass through the screens. At this stage the common clay and shale may be dried to reduce its moisture content for some applications or it may require blunging, extrusion, and firing for other applications. Last, the clay material passes through a final grinding and screening stage and then is packed for shipping and storage.

2.1.1.3 Fuller's Earth Processing

The processing flow diagram for fuller's earth is shown in Figure 2-4. Fuller's earth initially passes through two crushing stages to reduce the material to the required size. The crushed material is then blunged in a pug mill and then may be dried and/or calcined. If dried, the moisture content of the fuller's earth is reduced from approximately 45 percent to between 0 to 10 percent. Calcining fuller's earth will also reduce the moisture content.

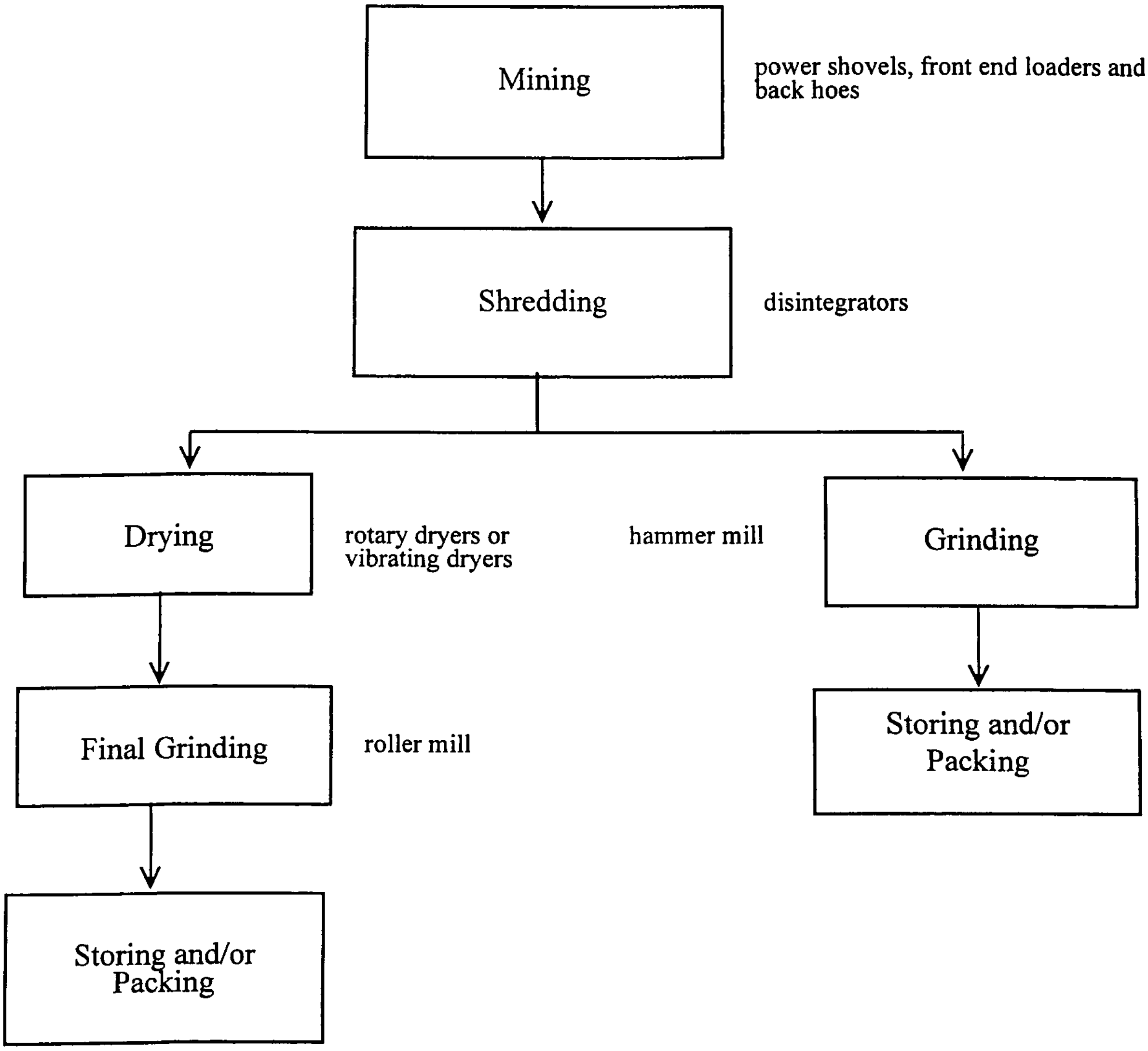


Figure 2-2. Ball Clay Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

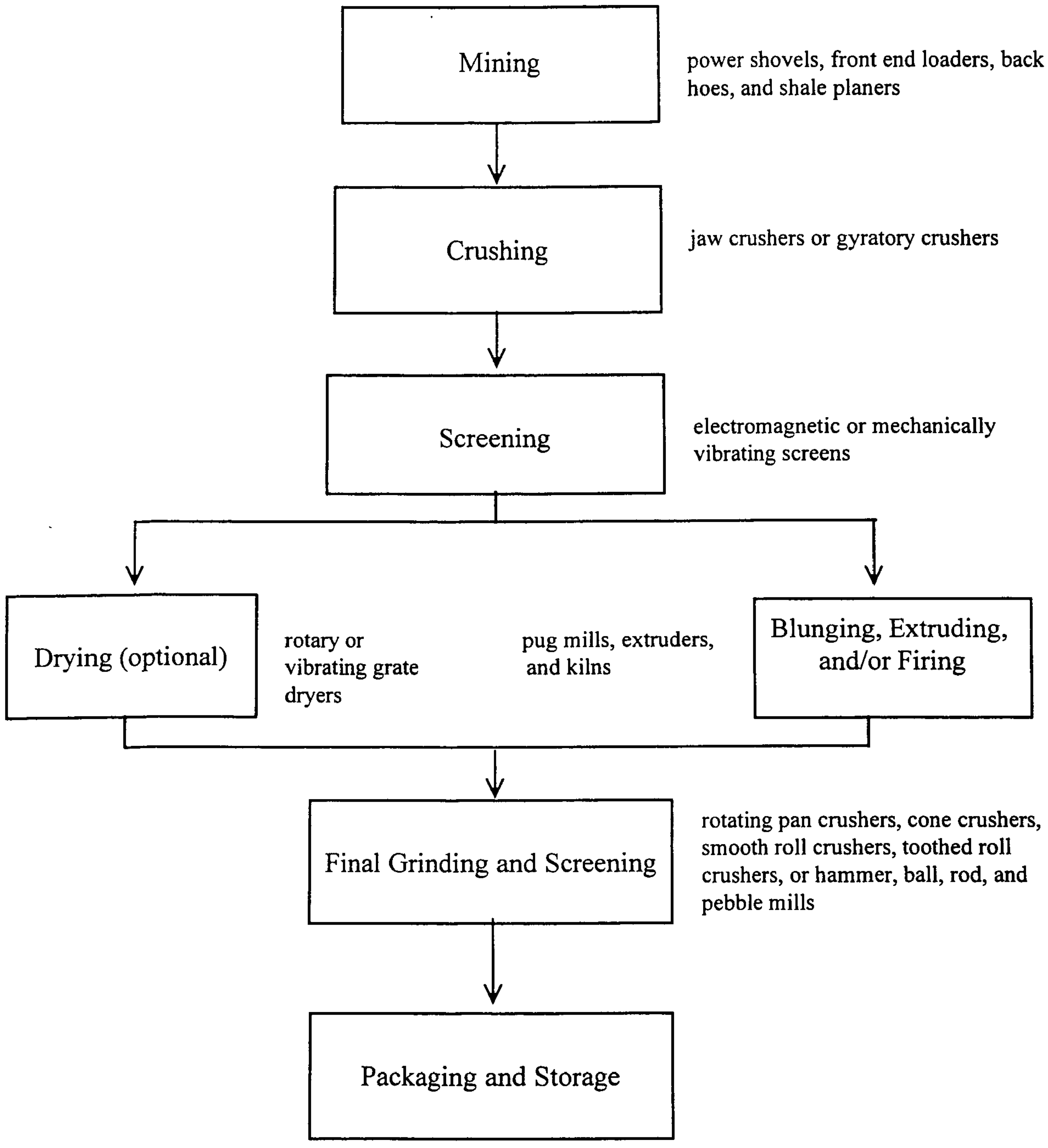


Figure 2-3. Common Clay and Shale Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

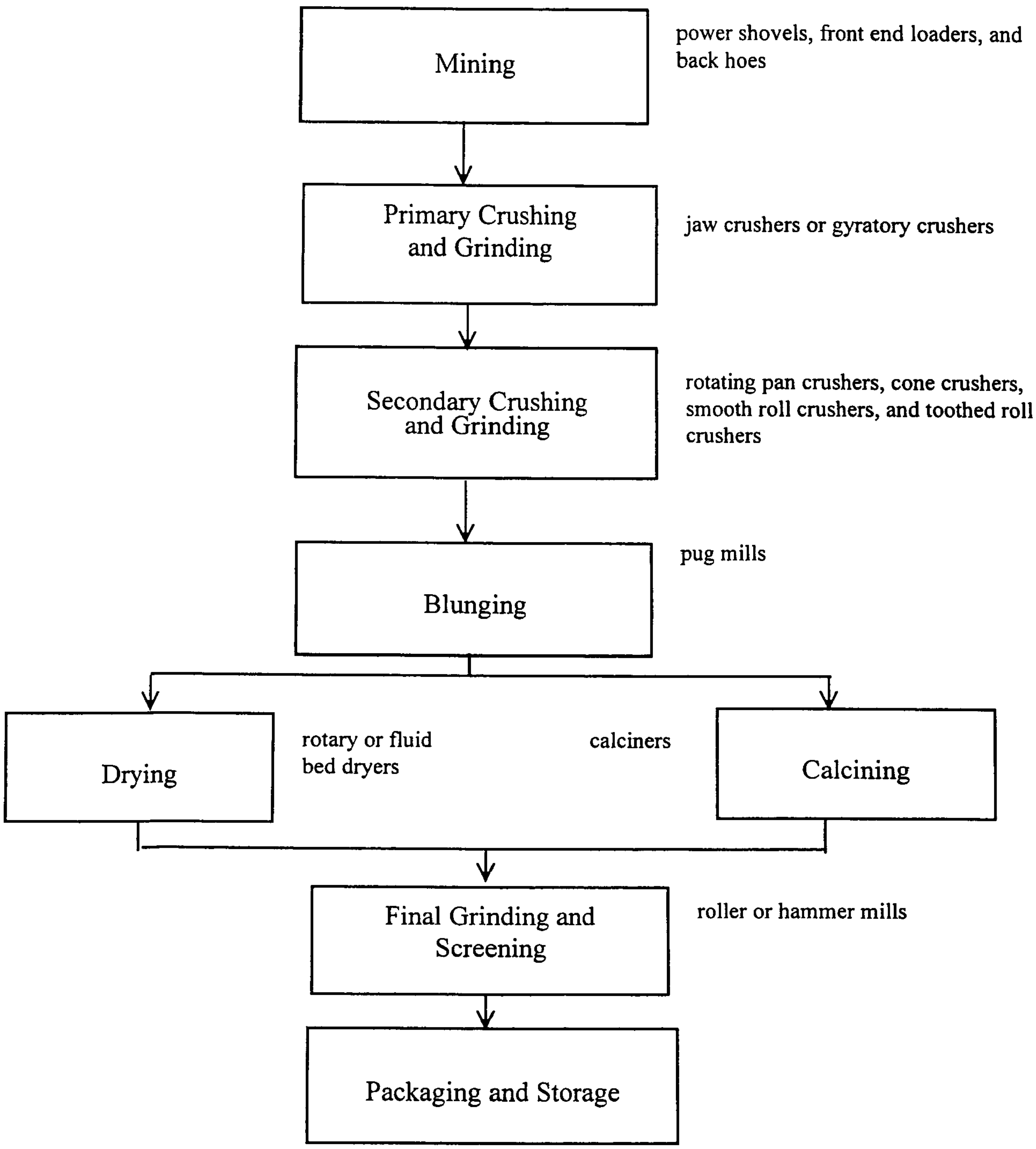


Figure 2-4. Fuller's Earth Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

Once the clay material is calcined, it proceeds to a final grinding stage which is accomplished using roller or hammer mills. The ground material is then screened for size and is ready for shipping.

2.1.1.4 Kaolin Processing

The processing of kaolin depends on the end product it will be used for. Kaolin may be processed through a dry or wet method. Kaolin that is processed through the dry method is used to produce sanitaryware, rubber products, and paper filling. The wet process is used when kaolin is being prepared as an input for paper coating. Figure 2-5 illustrates both the dry and wet production processes of kaolin.

The dry process is a bit simpler than the wet process. In the dry process, kaolin is first crushed and then dried in rotary dryers. The dried material is then pulverized and air-floated to remove impurities and grit. The kaolin is next screened to ensure it has been reduced to the proper size and then is packed for shipping.

In the wet process, kaolin is crushed and then blunged in a pug mill to produce a slurry. It may then be chemically treated through a bleaching process for purification. Physical or magnetic methods may also be used to purify the clay material. This refined slurry is then dried and screened for size. The kaolin that passes through the screen proceeds to the calcining stage and is then ready for storage and shipping.

2.1.1.5 Fire Clay Processing

When fire clay is first mined, it is stockpiled in order to allow the clay material to become weathered. The weathering of fire clay involves freezing and thawing which helps to break up the material for processing. This process also improves the plastic-like composition of the clay. The fire clay is now prepared for processing and at this point, has a moisture content of 10 to 15 percent. The fire clay is now crushed and ground and then it can either be dried or calcined.

For certain applications, the fire clay is dried in order to reduce the moisture content to less than 7 percent. This is accomplished through the use of rotary and vibrating grate dryers. The other option is to calcine the material which not only eliminates moisture, but also reduces the amount of organic material. When calcined, a chemical reaction occurs between the alumina and silica that is present in the fire clay. This in turn results in a harder, denser material that can be crushed more easily. Last, the dried or calcined fire clay is

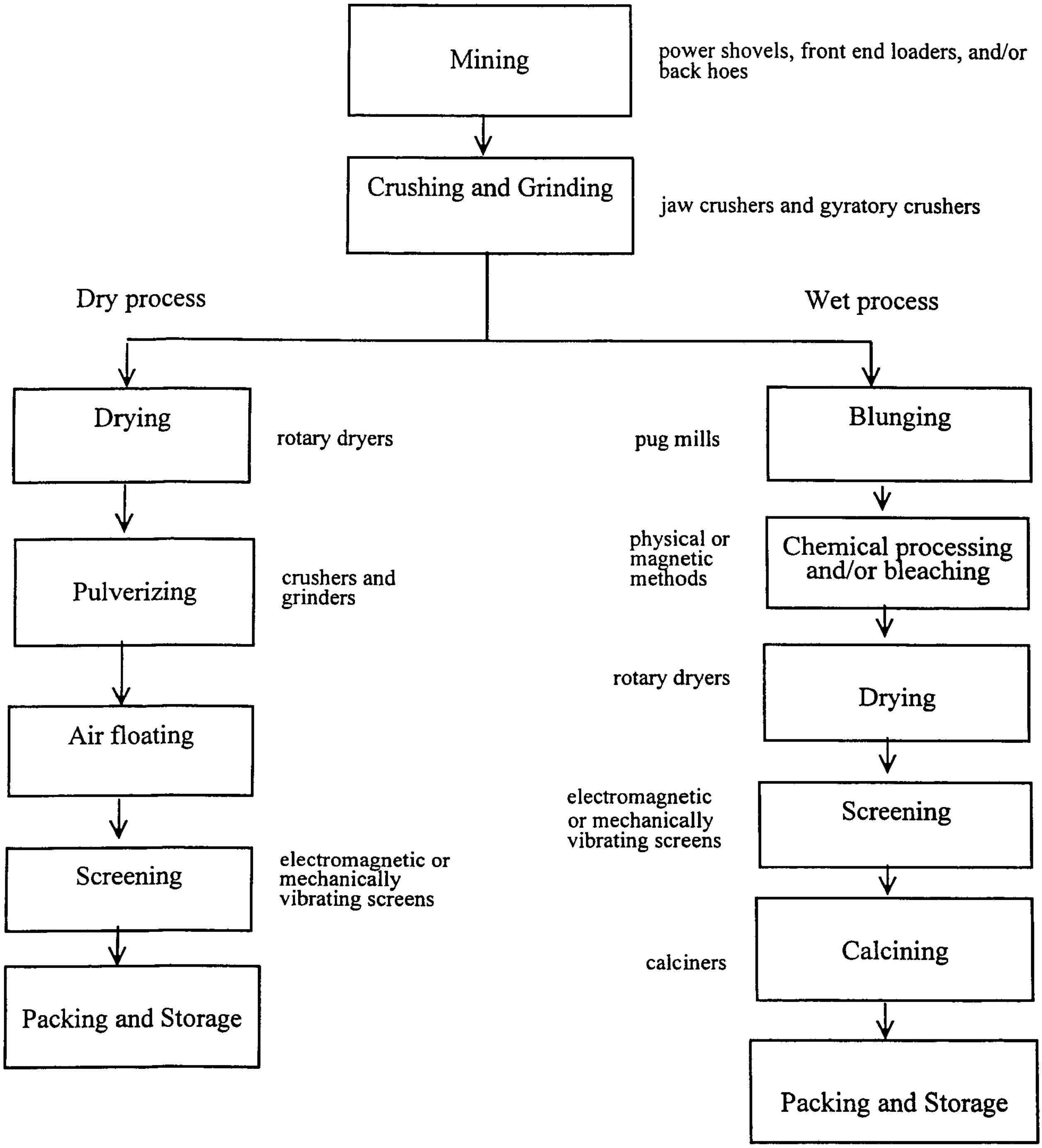


Figure 2-5. Kaolin Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

crushed and screened again. The fire clay that passes through the screens is now ready for packing and shipping. A flow diagram of the fire clay processing can be found in Figure 2-6.

2.1.1.6 Bentonite Processing

When bentonite is first mined and stockpiled, its moisture content is often too high to begin processing immediately. If the moisture content of mined bentonite is between 30 to 35 percent, it is plowed to help it air dry to a moisture content of 16 to 18 percent. This lower-moisture bentonite is then crushed to reduce the size of the clay material to pieces that are less than 2.5 centimeters in size. It is screened to ensure that it has been reduced to the correct size. The screened material is then dried in rotary or fluid bed dryers to reduce the moisture content to 7 to 8 percent. The dried material proceeds to a final crushing using roller or hammer mills and then is screened again. Figure 2-7 displays a flow diagram of bentonite processing.

2.1.2 Emissions from the Processing of Clay Minerals

Clay minerals processing results in emissions of HAPs and other pollutants. These pollutants include particulate matter (PM) , carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x), and the hazardous air pollutants hydrogen fluoride (HF) and hydrogen chloride (HCl). Trace amounts of the HAP metals beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), antimony (Sb), and selenium (Se) may also be present in raw clay material and released in particulate form as it is processed; however available data indicate that total HAP metals are only equal to less than one-tenth of one percent of the PM emitted from plant sites that process clay minerals. All dry mechanical processes, such as crushing, grinding, screening, materials handling, and materials transfer operations result in PM emissions. Fuel combustion at the dryers result in the emissions of CO, CO_2, NO_x, and SO_x while HF and HCl emissions arise from the calciners.

2.1.3 Costs of Production

This section discusses the costs of processing clay minerals. There are several types of costs involved, such as:

- **capital expenditures**, including the costs of mining and processing equipment;
- **energy costs**, which are the costs of electricity and fuels used to process clay;

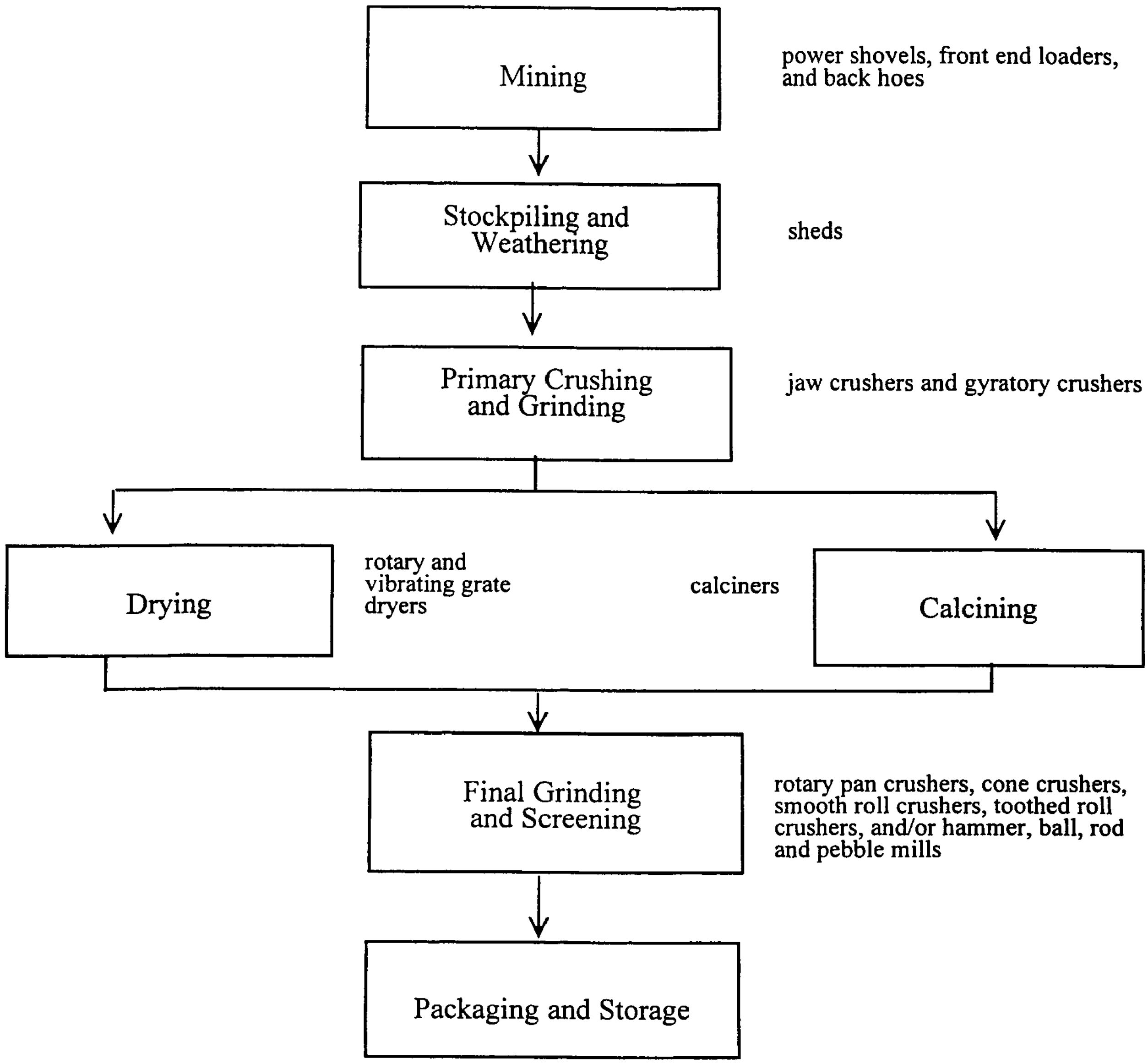


Figure 2-6. Fire Clay Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

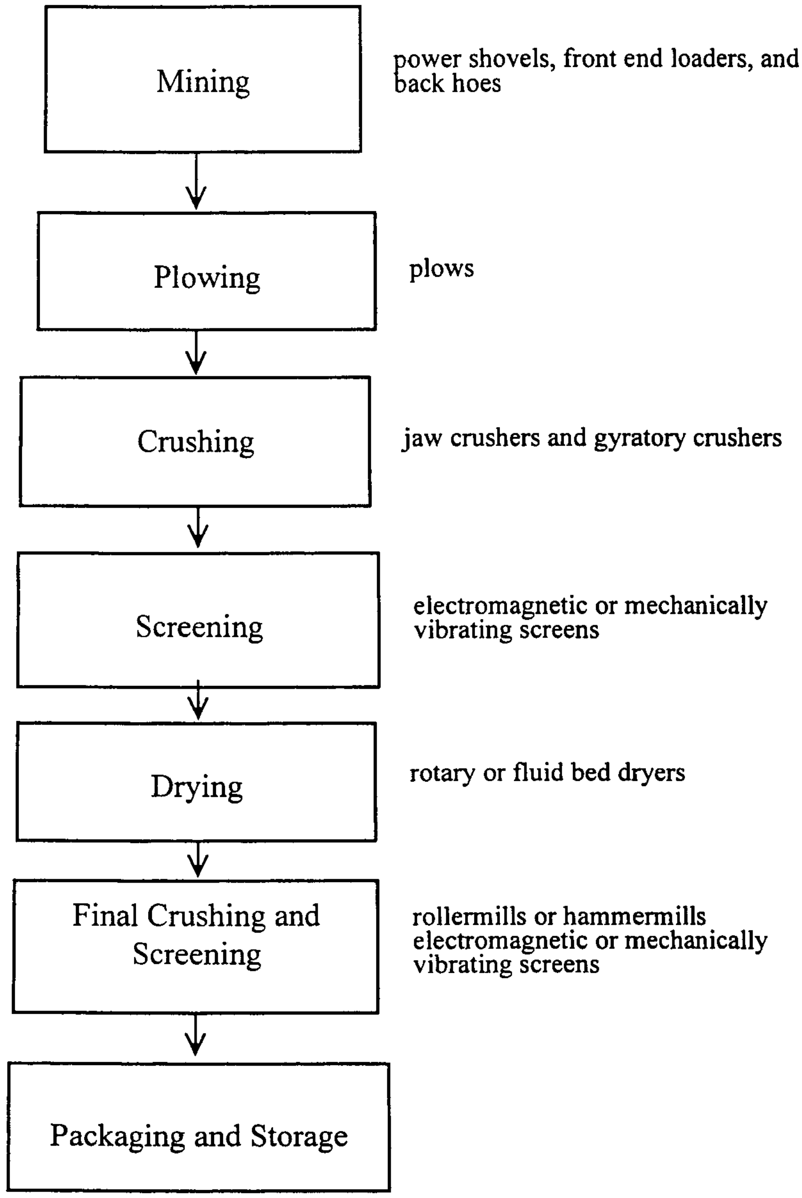


Figure 2-7. Bentonite Processing Flow Diagram

Source: U.S. Environmental Protection Agency. 1995. *Emission Factor Documentation for AP-42, Section 11.25*, "Clay Processing: Final Report."

- **labor costs**, including the costs associated with employees wages and benefits; and
- **the cost of materials**, which are the costs of tangible inputs such as additives.

Table 2-1 shows the 1997 production costs of processing clay minerals and Table 2-2 provides these costs as a share of the value of shipments (VOS) for the three SIC-defined clay minerals processing industries. For the Kaolin and Ball Clay industry (SIC 1455), the Clay, Ceramic, and Refractory Minerals, n.e.c. industry (SIC 1459), and the Minerals and Earths, Ground or Otherwise Treated industry (SIC 3295), the cost of materials in 1997 account for the largest share of costs in each industry, followed by labor costs. As shown in Tables 2-1 and 2-2, the cost of materials are $264.4 million, or almost 29 percent of the industry's value of shipments for SIC 1455. For SIC 1459, the cost of materials are $194.2 million. This is equal to 31 percent of this industry's value of shipments. Last is SIC 3295, which has a cost of materials equal to $793.6 million, or 34 percent of this industry's value of shipments.

Table 2-1. 1997 Production Costs for the Clay Minerals Processing Industries

Costs ($\$10^6$)	SIC 1455	SIC 1459	SIC 3295
Labor Costs	$141.31	$118.31	$355.09
Capital Expenditures	$76.43	$72.21	$138.02
Cost of Materials	$264.38	$194.17	$793.64
Energy Costs	$99.15	$62.28	$137.01
Sum of Costs	$581.27	$446.97	$1,423.76
Value of Shipments	$917.29	$618.26	$2,316.94

Source: U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Manufacturing Industry Series*, "Kaolin and Ball Clay Mining."
U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Mining Industry Series*, "Clay and Ceramic and Refractory Minerals Mining."
U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Mining Industry Series*, "Ground or Treated Mineral and Earth Manufacturing."

Table 2-2. 1997 Costs as Shares of the Value of Shipments (VOS) for the Clay Minerals Processing Industries

Costs as a Share of the VOS	SIC 1455	SIC 1459	SIC 3295
Labor Costs Share	15.41%	19.14%	15.33%
Capital Expenditures Share	8.33%	11.68%	5.96%
Cost of Materials Share	28.82%	31.41%	34.25%
Energy Costs Share	10.81%	10.07%	5.91%
Sum of Costs Share	63.37%	72.29%	61.45%

Source: U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Manufacturing Industry Series*, "Kaolin and Ball Clay Mining."
U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Mining Industry Series*, "Clay and Ceramic and Refractory Minerals Mining."
U.S. Department of Commerce, Bureau of the Census. 1999. *1997 Economic Census, Mining Industry Series*, "Ground or Treated Mineral and Earth Manufacturing."

Labor costs for SIC 1455 and SIC 3295 are slightly above 15 percent of the value of shipments for each of these industries and they are just over 19 percent for SIC 1459. Energy costs and capital expenditures account for smaller shares of the production costs for these industries. The 1997 average earnings per hour of production workers was $15.96 for SIC 1455, was $14.55 for SIC 1459, and was $15.08 for SIC 3295.

2.2 Uses, Consumers, and Substitutes

Processed clay is not a final good, but rather is an intermediate good used as an input to the production of various construction and building materials, ceramics and pottery, and adhesives, fillers, and extenders. The following section describes the end uses, consumers, and substitutes of processed clay material. In Section 2.2.1, the various uses for the six major types of clay minerals are described. Section 2.2.2 identifies the intermediate and final consumers of clay material. Last, the different products that can act as substitutes for clay are described in Section 2.2.3.

2.2.1 End Uses of Clay Minerals

In 1996, 43.2 million metric tons of clay minerals were processed in the United States. The main use of these clay minerals was as inputs to the production of various intermediate and final goods. Some of the intermediate goods that clays are used to produce include brick, tile, paint, structural clay products, sanitaryware, and lightweight aggregate. Many of these products are used in the construction of homes, buildings, and structures. Clay is also used as an input to the production of final goods such as pottery, pet litter, cosmetics, paper, and dinnerware.

Clay has a variety of characteristics that make it an attractive input for the products mentioned above. Because clay is pliable when wet, it can be easily molded and shaped. When clay dries, it acts as an absorbent which is why it is the main input in the production of pet litter. Clay that is dried also becomes fireproof, thus making it a desirable input to the manufacture of roof, floor, and wall tiles. If clay is glazed and fired, it is rendered waterproof and non-absorbent. This makes clay a common input to the production of sanitaryware, such as lavatories, sinks, and bathtubs, and dinnerware, such as plates, bowls, and saucers. Clay sanitaryware and dinnerware do not absorb germs and can be cleaned with ease.

Table 2-3 shows the total quantity of each clay type processed and each clay type's share of the total quantity of the domestic clays processed in the U.S. in 1996. Of the various clay minerals, common clay and shale makes up over 60 percent of the total quantity of clay minerals produced domestically. This clay type represents the largest share of the total quantity. Since common clay and shale is the main input to the production of bricks, cement, and lightweight aggregate, a majority of the clay that is processed in the U.S. goes towards the production of construction materials. The clay type with the second largest share is kaolin, which makes up over 21 percent of the total quantity. Kaolin is used in a diverse set of applications. The other clay minerals represent smaller shares of the total quantity of clay minerals processed in 1996.

Table 2-3. Domestic Quantities, Shares, and Prices of Processed Clay Minerals in 1996

Clay Minerals	Quantity (10^3 metric tons)	Share of Total Quantity	Price
Ball Clay	935	2.2%	$44.81
Common Clay and Shale	26,200	60.7%	$5.50
Fuller's Earth	2,600	6.0%	$106.92
Kaolin	9,180	21.3%	$119.83
Fire Clay	505	1.2%	$21.19
Bentonite	3,740	8.7%	$35.83
Total	**43,160**	**100.0%**	**NA**

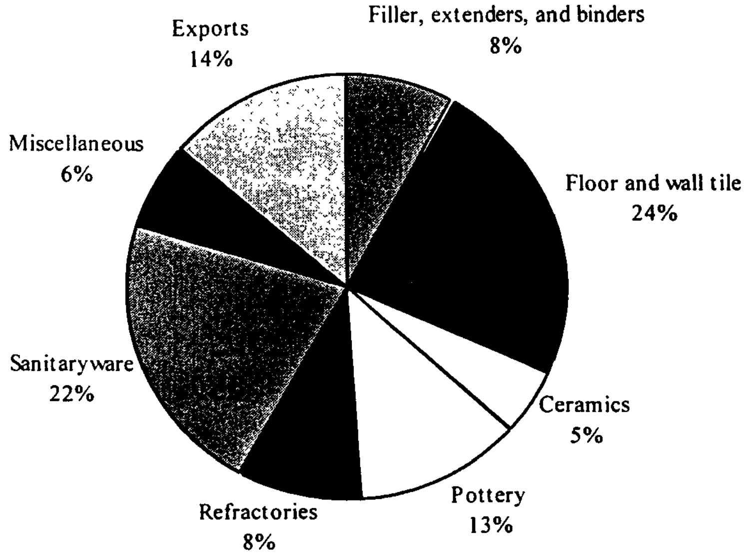
Notes: NA means not applicable

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

Table 2-3 also shows the prices of the various clay minerals in 1996. The most expensive of the clay minerals is kaolin, followed closely by fuller's earth. The least expensive clay is common clay and shale. The cost of the clay minerals affect the prices of the products they are used to produce. For example, bricks and lightweight aggregate are inexpensive relative to dinnerware and sanitaryware. This is because common clay and shale, the main clay input to construction materials, is much cheaper than ball clay and kaolin which are used to produce fine china, sinks, bathtubs, and other bathroom accessories.

The different types of clay minerals are used in various applications, however, there is some overlap in the products for which the different clay materials can be used. In the figures that follow, the proportions of each clay type used in different applications are shown for each type of clay. The share of each clay type that is exported is also portrayed in these figures.

Figure 2-8 illustrates the end uses and the shares of ball clay used in each of its applications. Of the 935 thousand metric tons of ball clay processed in 1996, 24 percent was used to produce floor and wall tile, while 22 percent was used for sanitaryware. Other uses of ball clay include pottery, refractories, and fillers, extenders, and binders. Exports of ball clay were equal to about 14 percent of the total quantity of ball clay processed in 1996.

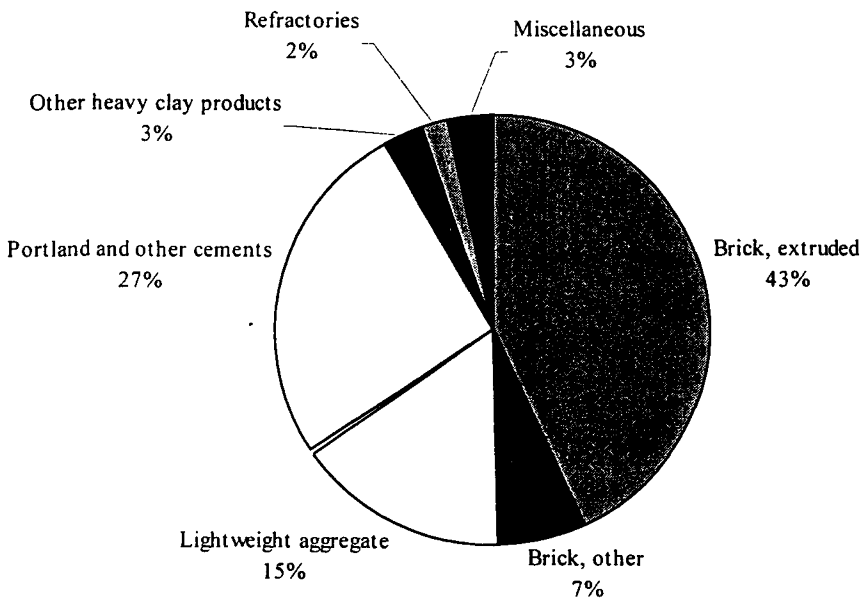


935,000 Metric Tons of Ball Clay

Figure 2-8. Distribution of Ball Clay by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

Common clay and shale is used almost exclusively as an input to the production of building materials. Below, Figure 2-9 shows that extruded brick accounts for the largest share of the total common clay and shale processed in 1996 (43 percent) followed by Portland and other cements (27 percent) and lightweight aggregate (15 percent). The additional uses for common clay and shale are for various other types of building materials. Of all of the clay minerals, common clay and shale is the only one which is not exported from the U.S.

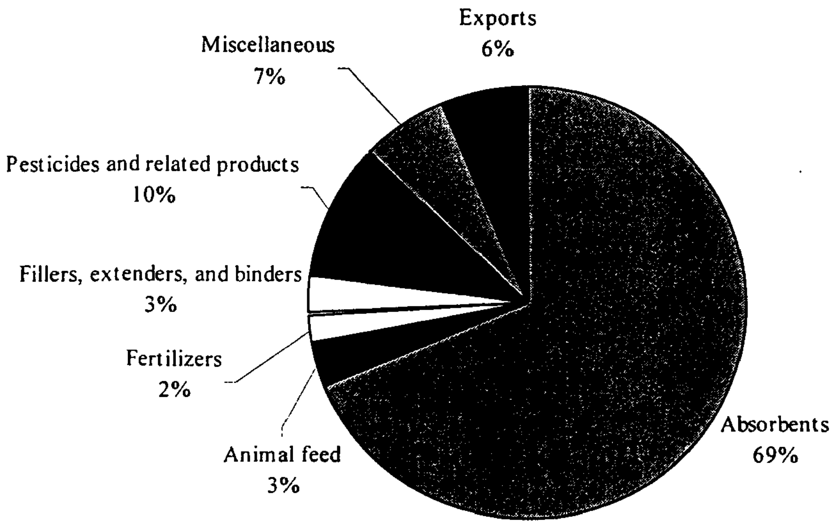


26,200,000 Metric Tons of Common Clay and Shale

Figure 2-9. Distribution of Common Clay and Shale by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1*. U.S. Geological Survey. U.S. Government Printing Office.

A majority of the fuller's earth that was processed in 1996 went towards absorbents (69 percent), as shown in Figure 2-10. The main type of absorbent that fuller's earth is used for is pet litter. The second largest end use of fuller's earth is as an input to pesticides and related products (10 percent). Other end products that use smaller shares of fuller's earth, such as animal feed and fillers, extenders, and binders, are also presented.

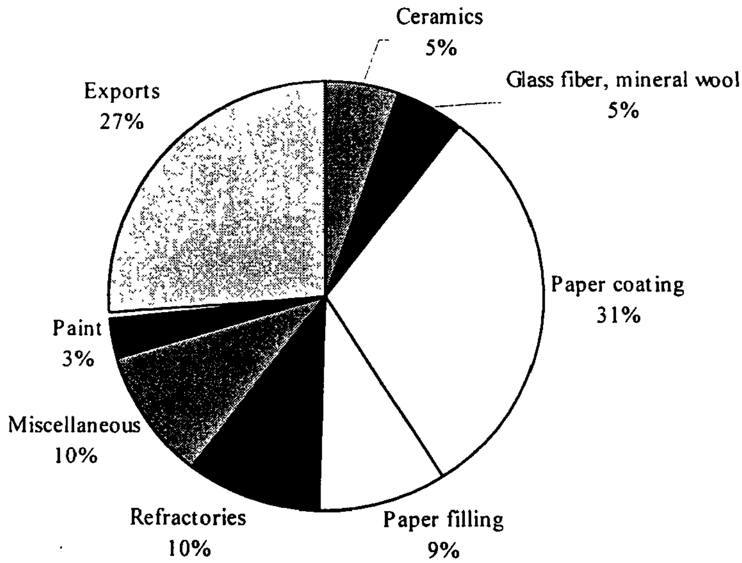


2,610,000 Metric Tons of Fuller's Earth

Figure 2-10. Distribution of Fuller's Earth by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

Of the 9 million metric tons of kaolin processed in the U.S. in 1996, 31 percent was used for paper coating. This is the end use in which the largest share of kaolin was used. Kaolin was also used as an input to refractories (10 percent) as well as paper filling (9 percent). As Figure 2-11 shows, kaolin is an input to a variety of end products. Because of its versatility, a relatively large share of kaolin is exported abroad.

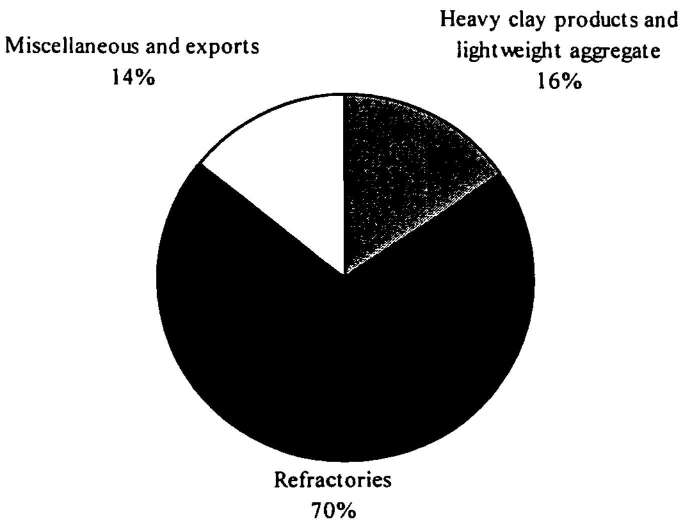


9,180,000 Metric Tons of Kaolin

Figure 2-11. Distribution of Kaolin by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

While kaolin is one of the most versatile clay inputs, fire clay is one of the least (see Figure 2-12 below). It also represents the smallest share of all of the clay types processed in 1996 (1.2 percent). Even though fire clay represents the smallest clay category, it still is a valuable input. The characteristic that makes fire clay unique is its ability to withstand extremely high temperatures relative to other clay minerals. For this reason, it's main use is as an input to refractories. As shown in Figure 2-12, 70 percent of all of the fire clay domestically processed in 1996 was used for refractories. The other major use was as an input to heavy clay products and lightweight aggregate.

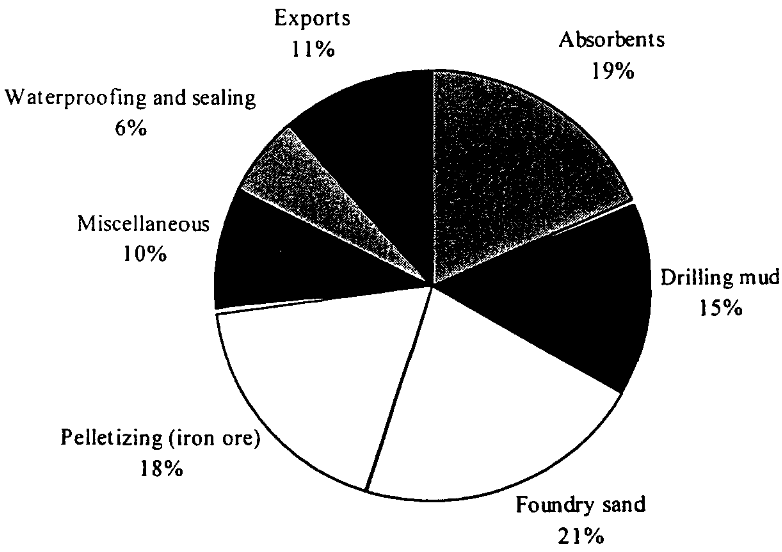


505,000 Metric Tons of Fire Clay

Figure 2-12. Distribution of Fire Clay by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

One of the main uses of bentonite is as an absorbent, however, this is not the most major use of this clay. As shown in Figure 2-13, the most common use of bentonite is as an input to foundry sand. Of the 3.7 million metric tons of bentonite processed in 1996 in the U.S., 21 percent went towards the production of foundry sand, 19 percent went towards absorbents, 18 percent went towards the pelletizing of iron ore, and 15 percent went towards drilling mud.



3,740,000 Metric Tons of Bentonite

Figure 2-13. Distribution of Bentonite by End Use: 1996

Source: Virta, Robert. 1998. "Clays," In: *Minerals Yearbook, Metals and Minerals 1996: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

2.2.2 Consumers of Clay Minerals

There are several types of consumers of clay, but virtually all of the immediate consumers purchase clay material as an input for production. The types of clay producers purchase depends on what they produce. The producers of clay-based construction and building materials are the major purchasing group of common clay and shale, since the main application of this clay is as an input to cement, brick, and lightweight aggregate. Building material producers also purchase ball clay to use as an input to floor, wall, and roofing tile, and limited amounts of fire clay for use in heavy clay products and lightweight aggregate. Once these clay-based building products are produced, they are then sold to construction companies and contractors who then use these products to build homes, buildings, and structures.

Producers of pet litter and oil and grease absorbents are the main purchasers of the clay fuller's earth. This clay is characterized as the most absorbent. In addition, these producers also purchase bentonite to use in the production of their absorbent products. The paper manufacturers are one of the major purchasers of kaolin, since this clay is commonly used as a paper coating and filler. The producers in the paper industry find kaolin the only suitable clay to use for paper manufacturing. Other immediate consumers of kaolin include china and fine dinnerware producers. Sanitaryware producers use ball clay to produce sinks, drinking fountains, and flush tanks since this type of clay is completely non-absorbent and maintains a uniform color when glazed and fired. The main type of clay used by refractories is fire clay, due to its ability to withstand heat.

Clay is minerals are used in such a wide array of products, that virtually all consumers purchase products which contain clay. Clay minerals are found in pottery, ceramics, paints, cosmetics, fertilizers, homes, absorbents, sanitaryware, and a host of other products. Once these products are produced, they are then sold to their final consumers. Final consumers are said to have an indirect demand for clay minerals since they purchase products produced using clay as an input, but not clay material in is raw form.

2.2.3 Substitutes for Clay Minerals

Several substitutes exist for the various clay minerals but for many products, the six clay categories are substitutable. For example, fuller's earth and bentonite can both be used as absorbents, kaolin and fire clay are both used in refractories, ball clay and fuller's earth are common inputs to binders, fillers, and extenders, kaolin and ball clay are used to produce ceramics, and common clay and shale and fire clay are both used in heavy clay products and lightweight aggregate. Aside from these, there are other materials that are used as substitutes for clay minerals in the production of several intermediate and final goods.

One of the main applications of ball clay is sanitaryware. Alternative materials that can be used to produce sinks, flush tanks, and drinking fountains include stainless or enameled steel, enameled cast iron, plastics, fiberglass, and marble. Many of these alternatives possess similar characteristics as ball clay, such as fire- and water-resistance and non-absorbency of harmful germs and bacteria, thus making them suitable inputs for sanitaryware production. Sanitaryware prices differ based on the type of material used in production. In general, plastics and fiberglass are relatively cheap, while cast iron and marble are more expensive.

Aside from sanitaryware, ball clay is also used to produce floor and wall tile. In this application, no suitable substitutes exist for ball clay. There are alternatives to floor and wall tiling however. Instead of tiles, floors and walls can be covered with wood, linoleum, vinyl, marble, or plaster. Each of these alternatives to tiling has advantages and disadvantages relative to clay. For example, vinyl and linoleum are relatively cheap, but they are not as durable. Wood is considered by many an attractive floor covering relative to tiling, but it may be subject to wood rot or pests. Marble is also a highly valued floor and wall covering, but is much more expensive.

Common clay and shale's main application is as an input to brick and other building materials. Common clay and shale is the only available input to the production of bricks, therefore in this application, there is no substitute. There are substitutes to brick as a material used for the exterior walls of buildings and structures however. Aluminum and vinyl siding can be nailed to the exterior of homes, buildings, and structures. Siding protects homes from weather, fire, and pests, as does brick, but it is relatively weak as an insulator. Wood or hardboard is another common building material that can be used for home exteriors. It can painted over or it can be left as it is. In contrast, brick is not often painted over, but rather left in its natural state. Stucco, a combination of sand, cement, and water, is a third possible material to use for the exterior of homes. It is the sturdiest of the three substitute materials listed here, but over time, it develops cracks unless it is properly maintained.

As an input, fuller's earth is predominantly used in pet litter and as an oil and grease absorbent. Bentonite is a substitute for fuller's earth in these applications because it is similar in composition to this clay type.

Kaolin is a clay with many uses, but there are substitutes for some of its applications. One use of kaolin is as an extender, but fuller's earth, serves this function as well. Kaolin is also used as a paper filler, and a substitute for this application exists as well. Talc, often used to in baby powder, is another material used as a paper filler. Of the talc consumed in the U.S., about one-fifth is used by the paper industry. While talc is a good substitute for kaolin in this application, it is still not as competitive as kaolin in this industry.

The predominant use of fire clay is as an input to refractories. Kaolin is also used in this application though not to the same extent. Another substitute for fire clay in refractories is pyrophyllite because of its ability to withstand extremely high temperatures. In 1997, the largest increase in consumption of pyrophyllite was for refractory use. This seems to indicate that pyrophyllite is becoming increasingly competitive with fire clay in refractories.

As previously mentioned, bentonite is an alternative input to absorbents. This is not its only application however. Bentonite is also used in iron ore pelletizing, foundry sands, and drilling muds. Substitutes for bentonite in drilling muds are the hormite clays. Hormite clays are actually thought to be superior to bentonite in this application because they are less sensitive to salt, thus allowing them to produce a higher mud yield. As inputs to drilling muds, the hormite clays may be superior, but bentonite is relatively cheaper.

2.3 Industry Organization

This report addresses the economic impacts of pollution control requirements on facilities that process clay minerals. Because there are costs associated with the control of HAPs, it is important to determine how the industry may be affected. This section provides an description of the clay mining and processing industry at both the facility-level and the company-level. Section 2.3.1 first provides an overview of the market structure of the clay minerals processing industry. Section 2.3.2 characterizes the processing facilities in this industry, while the parent companies of these facilities are described in Section 2.3.3. Last, Section 2.3.4 provides data on domestic processing, foreign trade, and apparent consumption of the various clay minerals.

2.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used in production are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and the Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The concentration ratios and the Herfindahl-Hirschman index are calculated using the sales data of the parent companies that own the clay mining and processing facilities. Table 2-4 provides the four- and eight-firm concentration ratios (CR4 and CR8, respectively), as well as the HHI for the clay minerals mining and processing industry. The CR4, the percentage of sales of the top four companies in the industry, was approximately 69 percent while the CR8 was almost 85 percent. These ratios seem to indicate that the industry is concentrated to some degree.

Table 2-4. Measures of Market Concentration for the Clay Minerals Mining and Processing Industry

Total Sales ($\$10^6$)	CR4	CR8	HHI
$12,020.12	68.6%	84.5%	1655

Notes: CR4 and CR8 are the concentration ratios of the top 4 and 8 firms in the industry (by sales) respectively. HHI refers to the Herfindahl-Hirschman Index, which is the sum of squared market shares for each company in a given industry. Total sales data for the parent companies are from the years 1997 and 1998.

Sources: Dun and Bradstreet. Dun and Bradstreet Market Identifiers Electronic Database. 1999.
Dun and Bradstreet. Dun and Bradstreet Financial Records Plus Electronic Database. 1999.
Dun and Bradstreet. Dun and Bradstreet Canadian Market Identifiers Electronic Database. 1999.

The criteria for evaluating the HHIs are based on the 1992 Department of Justice's Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries are more likely to be price takers, while those in more concentrated industries have more ability to influence market prices. Taken together, these data indicate that the clay minerals and mining industry is moderately concentrated.

2.3.2 Clay Minerals Processing Facilities

There are currently 76 clay mineral processing facilities in the United States. Most of them process a single type of clay but five of the facilities process two types of clays. Table 2-5 shows the number of facilities that process each type of clay. The clay type processed at the largest number of plants is kaolin, followed by bentonite. Fuller's earth is only processed at two facilities. Of the 76 facilities, one did not indicate the type of clay they process.

Table 2-5. Number of Facilities That Process the Different Types of Clay Minerals

Clay Mineral	Number of Facilities
Ball Clay	11
Common Clay and Shale	6
Fuller's Earth	5
Kaolin	31
Fire Clay	7
Bentonite	13
Other Minerals	6

Note: The number of facilities sums to 79 because five facilities process more than one type of clay and one of the facilities did not indicate the type of clay they process.

Source: U.S. Environmental Protection Agency. 1999. Memorandum from Midwest Research Institute to Jeff Telander, Emissions Standards Division, Office of Air Quality Planning and Standards, "Preliminary Industry Characterization Data Inputs for ISEG, Clay Minerals Processing Facilities," September 21.

The table shows that six facilities process other types of minerals. This category is a composite of several minor mineral categories which include bauxite, mullite, kyanite, and catalysts. While there are facilities included in this report that do process these minor mineral types, they have not been discussed in detail because these minerals are not clays.

The size of facilities depends on whether or not they are integrated or non-integrated. Integrated facilities include clay mining operations, while non-integrated facilities conduct clay processing operations only. These non-integrated facilities must purchase their clay minerals from a mining facility and then process them to prepare them for sale. While most facilities do include clay mining pits, they are not necessarily located in the same place as the processing facilities. Usually though, they are located near sources of clay minerals so that the cost of transporting them to the processing facilities is kept low. Thus, the location of the 76 facilities is determined by where clay minerals can be found. These facilities are located across 20 different states. Georgia has a disproportionately high number of facilities with 25. The rest of the states contain 5 facilities or less. Table 2-6 lists the states in which the facilities are located along with the number of facilities in each state.

2.3.3 Companies

The Agency identified 34 ultimate parent companies (listed in Appendix A) that currently own and operate the 76 potentially affected facilities within this source category. Two of the 76 facilities are jointly owned by companies. Sales and employment data for these owning entities were obtained from either their survey response or one of the following secondary sources:

- Canadian Dun's Market Identifiers (Dun & Bradstreet, 1999)
- Dun's Market Identifiers (Dun & Bradstreet, 1999)
- Dun's Financial Record Plus (Dun & Bradstreet, 1999)
- Hoover's Company Profiles Online (Hoover's Companies & Industries, 2001)
- Kompass USA (Kompass International, 1999)
- Securities and Exchange Commission's 10-K Company Reports (1999)
- Standard and Poors Register-Corporate (Standard & Poors Corp., 1999)

Table 2-6. **Location of Potentially Affected Facilities by State**

State	Number of Facilities
Alabama	1
Arkansas	3
California	4
Florida	3
Georgia	25
Illinois	1
Indiana	1
Kansas	1
Kentucky	3
Michigan	1
Missouri	4
Mississippi	4
North Carolina	1
Ohio	3
South Carolina	2
South Dakota	3
Tennessee	5
Texas	5
Virginia	1
Wyoming	5
Total	76

Source: U.S. Environmental Protection Agency. 1999. Memorandum from Midwest Research Institute to Jeff Telander, Emissions Standards Division, Office of Air Quality Planning and Standards, "Preliminary Industry Characterization Data Inputs of Clay Minerals Processing Facilities," September 21.

Annual sales and employment data were available for 33 of the 34 companies (97 percent). The average (median) sales of companies reporting data were $372.3 million ($50.0 million). This includes revenues from operations other than clay minerals mining and processing operations. The average (median) employment for these companies was 1,402 (350) workers.

The top four companies in annual sales for the year 1997[1] are:

- Engelhard Corporation - $3.63 billion with 6,872 employees;
- Clorox Company, Incorporated - $2.74 billion with 6,600 employees;
- Imerys - $2.63 billion with 11,948 employees; and
- J.M. Huber Corporation - $1.23 billion with 6,000 employees.

These companies can also be grouped into small and large categories using Small Business Administration (SBA) general size standard definitions for SIC codes. There are ten different SIC codes, which correspond to a total of sixteen different NAICS codes across the ultimate parent companies owning these facilities. The SBA defines a business as small based on the number of employees . For these NAICS codes, the small business definition ranges between 100 to 500 employees or $5 million in sales. Using these size standards and available data, the Agency has identified 16 small businesses, or 44 percent of all companies within this source category. The annual average (median) sales for these companies are $26.7 million ($14.8 million), and the average (median) employment for these companies is 125 employees (90 employees).

2.3.4 Market Data and Trends

This section presents historical market data for the clay minerals markets. Data were obtained from the *U.S. Geological Survey's Minerals Yearbook* (1997). Table 2-7 provides historical market data on the clay minerals processed and sold domestically, including the total quantity, value, foreign trade, and apparent consumption for the years 1993 through 1997 and Tables 2-8 through 2-13 provide this same data for each clay type.

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[1] Annual sales for these firms are from the year 1997 with the exception of Imerys, where data from the year 2000 are presented.

As shown in Table 2-7, the average annual growth rate of the quantity of domestically processed clay minerals over the years 1993 to 1997 is 0.8 percent. The quantity of all clay minerals increased from 40.7 million metric tons in 1993 to a peak of 43.1 million metric tons in the years 1995 and 1996. The quantity of processed clays then decreased to 42.0 million metric tons in 1997. The value of the clay minerals was at its lowest in 1993 at $1.47 million and it reached its peak in 1995 with a value of $1.73 million, which corresponds with the quantities of clays produced in these years. Note, however, that the same quantity of clays was produced in 1995 and 1996, but the total value of these clay minerals was lower in 1996. In 1995, the value per metric ton was $40.14, while in 1996 the value per metric ton was $39.68.

Table 2-7. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Domestically Processed Clay Minerals ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	40,700	$1,470,000	4,150	39	36,589
1994	42,000	$1,590,000	4,620	36	37,416
1995	43,100	$1,730,000	4,680	35	38,455
1996	43,100	$1,710,000	4,830	45	38,315
1997	42,000	$1,670,000	5,080	64	36,984
Average Annual Growth Rates					
1993 - 1997	0.8%	3.4%	5.3%	15.1%	0.3%

Note: Data for quantity, total value, and exports is rounded to three significant digits while data for imports is rounded to two significant digits. Data reflect the information provided in U.S. Geological Survey (1999) and may not be equal to the sum of the total quantities of each individual clay type.

Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

The average annual growth rates of imports and exports are 15.1 percent and 5.3 percent, respectively. The average annual growth rate of clay imports shows that the amount of clay minerals coming to the U.S. has increased over the years 1993 to 1997, but these imports do not represent a significant share of the clay minerals consumed in the U.S. A measure of the U.S. reliance on imports can be calculated as the ratio of imports to apparent consumption. In 1996, this ratio is only equal to 0.1 percent. The reason why the average annual growth rate for imports appears so large is because there were significant increases in clay mineral imports from 1995 to 1996 and from 1996 to 1997, as shown in Table 2-7. The average annual growth rate of exports is smaller than it is for imports, but the U.S. exports a larger quantity of clay minerals than it imports. The ratio of exports to the total quantity of clays processed in the U.S. can be calculated to measure how much of what is processed in the U.S. is sold abroad. The ratio of exports to total quantity processed in the U.S. for 1996 is equal to 11.2 percent.

As shown in Table 2-8, both the quantity and value of ball clay showed a net increase over the 1993 to 1997 time period. The average annual growth rates of the domestic quantities processed and consumed are 3.7 percent and 0.8 percent, respectively. The low

Table 2-8. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Ball Clay ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	911	$38,500	NA	NA	NA
1994	1,020	$44,900	81	.84	939.8
1995	993	$45,500	28	1.37	966.4
1996	935	$41,900	80	1.4	856.4
1997	1,040	$48,100	91	.82	949.8
Average Annual Growth Rates					
1994 - 1997	3.7%	6.2%	44.7%	8.3%	0.8%

Note: Data for quantity, total value, exports, and imports is rounded to three significant digits.
NA = not available.
Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

average annual growth rate for apparent U.S. consumption is likely caused by the anomalous drop in the apparent consumption of ball clay in 1996. In that year, the U.S. processed and consumed the smallest quantities of ball clay over the time period covered. However, a closer examination of the consumption data reveals that there was a rise in the quantity of ball clay consumed from 1996 to 1997. This provides supporting evidence for the claim that the domestic market for ball clay is growing.

Table 2-9 provides market data for the common clay and shale market over the years 1993 to 1997. Foreign trade data are not presented for common clay and shale because this clay type isn't generally exported and data on imports are unavailable. Since import data are unavailable, apparent consumption of common clay and shale cannot be calculated. We can, however, examine the quantity of common clay and shale produced domestically and draw comparisons to the other clays. Relative to ball clay, larger quantities of common clay and shale are processed in the U.S. The average quantity of ball clay produced per year was approximately 980 thousand metric tons while the average quantity of common clay and shale processed per year over the same period was approximately 25.5 million metric tons.

Table 2-9. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Common Clay and Shale ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value
1993	25,300	$137,000
1994	25,800	$137,000
1995	25,600	$151,000
1996	26,200	$144,000
1997	24,500	$149,000
Average Annual Growth Rates		
1993 - 1997	-0.7%	2.3%

Note: Data for quantity and total value are rounded to three significant digits.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume I.* U.S. Geological Survey. U.S. Government Printing Office.

In fact, as shown earlier in Table 2-3, common clay and shale makes up the largest category of the clay minerals market. Even though the absolute amounts of common clay and shale are relatively large, the average annual growth rate of the quantity processed is negative (-0.7 percent). The negative growth rate seems to indicate a shrinking market for common clay and shale, however this result is driven by the reduction in the quantity of common clay and shale processed between the years 1996 and 1997. After reaching a peak quantity of 26.2 million metric tons in 1996, the quantity of common clay and shale processed in 1997 fell to its lowest level (24.5 million metric tons). The average annual growth rate of the total value of common clay and shale for this time period is 2.3 percent. The total value of common clay and shale was at its lowest in 1993 and 1994 and it reached its peak in 1995.

Like common clay and shale, the data for fuller's earth in Table 2-10 also indicates a shrinking market. The average annual growth rates for quantity and apparent consumption are both negative, although the rate is much more negative for apparent consumption. The quantity of fuller's earth processed in the U.S. has steadily decreased every year between 1995 and 1997, with the largest reduction in quantity occurring between 1996 and 1997.

Table 2-10. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Fuller's Earth ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	2,480	$230,000	NA	NA	NA
1994	2,640	$244,000	74	1.44	2,567.4
1995	2,640	$269,000	63	.10	2,577.1
1996	2,600	$278,000	112	.37	2,488.4
1997	2,370	$255,000	144	3.50	2,229.5
Average Annual Growth Rates					
1993 - 1997	-1.0%	2.9%	30.5%	344.7%	-4.5%

Note: Data for quantity, total value, exports, and imports is rounded to three significant digits.
NA = not available
Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

In contrast, the quantity exported has shown an increasing trend. Since imports are not very large for fuller's earth, or for any clay mineral for that matter, the apparent consumption of fuller's earth has steadily declined over this time period. Exports and imports do not constitute a large share of the quantity of fuller's earth that is processed or consumed, but the average annual growth rates of the shipments of this clay mineral are extremely high. The growth rate of exports was 78 percent from 1995 to 1996, therefore skewing the average annual growth rate up to over 30 percent. For imports, the growth rate between 1996 and 1997 was 854 percent. This enormous rise in the import quantity of fuller's earth from one year to the next drives the high average annual growth rate for imports overall. Just as in the case of the data for all clay minerals, the average annual growth rates show significant increases in exports and imports. However, the absolute quantities of these shipments are small in comparison to the total domestic quantities of fuller's earth that are processed and consumed.

Table 2-11 below displays the quantity, value, foreign trade, and apparent consumption data for kaolin. Of the different types of clays, kaolin is the most expensive.

Table 2-11. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Kaolin ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	8,830	$957,000	NA	NA	NA
1994	8,770	$1,020,000	3,180	10.8	5,600.8
1995	9,480	$1,110,000	3,240	12	6,252
1996	9,180	$1,100,000	3,240	13	5,953.7
1997	9,410	$1,040,000	3,380	30.4	6,060.4
Average Annual Growth Rates					
1993 - 1997	1.7%	2.3%	2.1%	49.1%	2.9%

Note: Data for quantity, total value, exports, and imports is rounded to three significant digits.
NA = not available
Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

It has an average value of $114.42 per metric ton and its annual total value exceeded $1 billion for the years 1994 through 1997. According to Table 2-11, the market for kaolin has grown. There has been a general increasing trend in the quantity of kaolin processed and the average annual growth rate of apparent consumption between 1994 and 1997 is 2.9 percent. The quantity of kaolin exported has held steady and it makes up a significant share of the domestic quantity processed. In fact, of the kaolin processed in the U.S. for the year 1996, over 35 percent was exported. The quantity of kaolin imported makes up a very small share of the kaolin consumed in the U.S. Imports in 1996 made up less than 1 percent of the apparent consumption for that year.

Of all of the clay minerals, fire clay represents the smallest share of the whole clay minerals market (1.2 percent). Table 2-12 provides evidence of the relatively small quantity of fire clay produced annually. The average annual quantity of fire clay produced over the years 1993 to 1997 is 530,400 metric tons. Even though the absolute quantity of fire clay produced is small, the market has grown over the years 1993 to 1997. The average annual

Table 2-12. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Fire Clay ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	459	$11,500	NA	NA	NA
1994	456	$11,600	225	1.03	232
1995	583	$12,800	281	1.35	303.4
1996	505	$10,700	295	0.36	210.4
1997	649	$9,450	222	0.70	427.1
Average Annual Growth Rates					
1993 - 1997	10.6%	-4.2%	1.7%	-41.1%	34.4%

Note: Data for quantity, total value, exports, and imports is rounded to three significant digits.
NA = not available
Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume I*. U.S. Geological Survey. U.S. Government Printing Office.

growth rates for the quantity processed and the apparent consumption of fire clay are 10.6 percent and 34.4 percent, respectively. The relatively high growth rates are a result of the large increases in the amount processed and the amount consumed from 1996 to 1997. The annual growth rate for the amount of fire clay processed between the two years is 28.5 percent and it is over 103 percent for apparent consumption over these years.

The market data for bentonite, the last clay mineral covered in this report, can be found in Table 2-13. Data for the year 1997 shows that the quantity, total value, exports, imports, and apparent consumption of bentonite are largest for this year over the time period examined. This provides evidence to show recent growth in the bentonite market. The average annual growth rates of the quantity processed and the apparent consumption of bentonite also provide evidence of a growing market for this clay mineral. Both growth rates are quite high. Foreign trade of bentonite has also increased over the time period examined. The average annual growth rate of imports is extremely high, 64.6 percent, but the quantity of imports is not a significant share of the amount of bentonite consumed in the U.S.

Table 2-13. Historical Quantity (metric tons), Value, Foreign Trade, and Apparent Consumption of Bentonite ($\$10^3$): 1993 - 1997

Year	Quantity	Total Value	Exports	Imports	Apparent Consumption
1993	2,870	$102,000	NA	NA	NA
1994	3,290	$136,000	768	2.1	2,524.1
1995	3,820	$138,000	733	3.1	3,090.1
1996	3,740	$134,000	746	7.5	3,001.5
1997	4,020	$169,000	850	7.6	3,177.6
Average Annual Growth Rates					
1993 - 1997	9.0%	14.5%	3.7%	64.6%	8.5%

Note: Data for quantity, total value, exports, and imports is rounded to three significant digits.
NA = not available
Apparent Consumption = Total Value - Exports + Imports.

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume I.* U.S. Geological Survey. U.S. Government Printing Office.

Table 2-14 presents historical price data on each of the six different clay minerals. The difference is the price of clay minerals has a direct impact on the prices of clay-based products sold. Kaolin, often used for find dinnerware, is the most expensive type of clay. The average value of kaolin is $114 per metric ton. The next most expensive type of clay is fuller's earth, whose average value is just over $100. Fuller's earth, as mentioned earlier, is used to produce absorbents. The mid-priced clays are ball clay, bentonite, and fire clay, with average values ranging from about $45 to $23. In comparison to fuller's earth and kaolin, these clays are three to five times less expensive. The least expensive clay is common clay and shale, which is primarily used for lightweight aggregate, brick, and cement.

Table 2-14. Historical Data on the Price per Metric Ton of Clay Minerals: 1993 - 1997

Year	Ball Clay	Common Clay/Shale	Fuller's Earth	Kaolin	Fire Clay	Bentonite
1993	$42.26	$5.42	$92.74	$108.38	$25.05	$35.54
1994	$44.02	$5.31	$92.42	$116.31	$25.44	$41.34
1995	$45.82	$5.90	$101.89	$117.09	$21.95	$36.13
1996	$44.81	$5.50	$106.92	$119.83	$21.19	$35.83
1997	$46.25	$6.08	$107.59	$110.52	$14.56	$42.04
Average	$44.63	$5.64	$100.32	$114.42	$21.64	$38.17
Average Annual Growth Rates						
1993-1997	2.3%	3.2%	3.9%	0.6%	-11.7%	5.1%

Source: Virta, Robert. 1999. "Clays," In: *Minerals Yearbook, Metals and Minerals 1997: Volume 1.* U.S. Geological Survey. U.S. Government Printing Office.

Table 2-14 also shows that the value of these clays have generally increased over the 1993 to 1997 time period. Average annual growth rates range from a low of -11.7 percent for fire clay to 5.1 percent for bentonite. The negative growth rate of the price of fire clay is explained by its continual decline over the 1993 to 1997 time period. Its price only increased once, and just slightly, from 1993 to 1994. The average annual growth rate of the price of bentonite is the highest of the six clays, however a closer examination of the data in Table

2–14 shows that its price seemed to increase and then decrease from year to year. In other words, there was no general increasing trend in bentonite's value over this time period. The average growth rate of kaolin's price was less than one percent. Also interesting to not is that kaolin's price initially increased by 7 percent from 1993 to 1994 and continued to steadily increase through 1996. However in 1997, its price fell by close to 12 percent. The prices of the other clays seemed to show general increasing trends over the time period presented here.

3 ENGINEERING COST ANALYSIS

When clay minerals are processed, emissions of HF and HCl are released from the calciners. To control these emissions, EPA has developed emission standards for these HAPs under the authority of Section 112 of the CAA. This section explains how the nationwide estimate of compliance costs associated with the clay minerals processing NESHAP was developed. Section 3.1 first provides a general explanation of the regulatory costs, while Section 3.2 describes which facilities face positive compliance costs associated with this rule. This section also presents the nationwide compliance cost estimate for the clay minerals processing NESHAP.

3.1 Regulatory Costs Description

A facility may have to purchase and install two types of equipment to comply with this NESHAP. First, they may have to purchase equipment to control the emissions they release (if the equipment they currently operate does not meet the MACT floor), and then additional equipment may have to be purchase for the monitoring, recordkeeping, and recording (MRR) of emissions. Regardless of whether equipment is purchased for emissions control or for MRR, three types of costs may be incurred when equipment is installed and operated in a facility: capital costs, testing costs, and operating and maintenance (O&M) costs. Capital costs are the lump-sum costs that are incurred when capital equipment is purchased and installed. Testing costs are those costs incurred when measuring initial performance of monitoring equipment. O&M costs are those costs associated with the upkeep and operation of the capital equipment.

To estimate the annual burden of these costs on facilities, the lump-sum capital costs associated with both the emission control and MRR and the lump-sum performance testing costs are converted to streams of annualized costs. The total capital costs are generally annualized using a 7 percent discount rate over the expected life of the capital equipment.

Added to the annualized capital costs and annualized testing costs are the annual costs of operating and maintaining the capital equipment. The costs faced by each facility affected by the regulation are then summed to develop the nationwide compliance cost estimate associated with the regulation.

3.2 Affected Facilities

The clay minerals processing facilities potentially impacted by this regulation are those that are major sources of HAPs and those that operate calciners in clay minerals processing plants. Of the 76 identified clay minerals processing facilities (described earlier in Section 2.3.2), it is estimated that four will face positive compliance costs associated with this proposed rule. The four facilities, three of which are owned by one company and the last one by another, all possess and operate the necessary control equipment (i.e., wet scrubbers) to meet the proposed standards. These facilities will, however, face costs related to the installation and operation of monitoring, recordkeeping, and recording (MRR) equipment and initial performance testing. The proposed monitoring requirements for calciners equipped with wet scrubbers include MRR of the following scrubber parameters:

- pH of the scrubber liquid effluent;
- liquid flow rate; and
- pressure drop or fan amperage.

One of the four facilities already monitors scrubber liquid flow rate and fan amperage, therefore the estimated costs for this facility excludes the costs associated with the MRR of these parameters. The cost estimate faced by the other three facilities, which are all owned by one company, was developed by including the cost of monitoring all three parameters.

The cost estimates associated with this NESHAP are presented in Table 3-1. The total nationwide costs are the sum of the costs across all four clay minerals processing facilities, and as the table shows, the total annual costs associated with this regulation is equal to $65,085 (baseline year 2000). This total annual cost is made up exclusively of MRR and initial testing costs, since the potentially affected clay minerals processing facilities operate the necessary emission control equipment to meet the proposed standards.

Table 3.1. Monitoring, Recordkeeping, and Recording Costs for Clay Minerals Processing Facilities

Number of Facilities	Total Capital [a]	Annualized Capital [b]	Annualized Testing	Annual O&M	Total Annual MRR Costs
3	$5,716	$812	$3,400	$12,098	$16,310
1	$4,949	$703	$3,400	$12,052	$16,155
Nationwide Total	**$22,097**	**$1,515**	**$13,400**	**$48,346**	**$65,085**

Notes: [a] Total capital cost is the sum of the costs of two pieces of equipment: one for emissions monitoring and the other for recordkeeping and reporting.

[b] Annualized capital cost is the sum of annual capital costs associated with monitoring equipment and the annual capital costs associated with recordkeeping and recording equipment. The lifetimes of these equipment may not be the same.

Source: U.S. Environmental Protection Agency. 2001. Memorandum from Midwest Research Institute to Steve Shedd, Emissions Standards Division, Office of Air Quality Planning and Standards, "Facility-specific Costs and Environmental Impacts for Use in the Economic Analyses for the Clay Minerals Processing NESHAP," February 2.

4 ECONOMIC IMPACT ANALYSIS

In the economic impact analysis, the Agency typically examines how facilities will directly (through the imposition of compliance costs) or indirectly (through a change in market prices) affect the entire U.S. industry. Generally speaking, the implementation of a proposed rule will increase the costs of production at affected plants. These costs will vary across facilities depending on their physical characteristics, baseline controls, and the regulatory standards that are set. The response by producers to these additional costs determine the economic impacts of the regulation. Specifically, the cost of the regulation may induce some owners to change their current operating rates or to close their operations. These choices affected, and in turn are affected by, the market prices for the products manufactured or processed by the affected facilities.

Typically, our economic analyses take several data elements to input to a model that determines changes in market prices, output, and total social cost (via the change in producer and consumer surplus). However, the impacts of this rule are not likely to produce any measurable changes in an economic model of the clay minerals processing industry because only 4 facilities out 76 are estimated to face costs associated only with MRR activities and the nationwide total compliance cost represents an almost infinitesimal share of total market revenues.

We can conclude in general that because a model of the market is not likely to show any changes resulting from the costs imposed by this regulation, the market as a whole will not show adjustments in price and production and affected producers will not be able to recover any of the compliance costs incurred by raising prices. Likewise, while production levels at some of the affected facilities may lower due to the increase in cost of production, other facilities will compensate for this change such that overall industry production will not change.

Rather than perform a full market analysis, the analysis takes a closer look at the firm-level impacts if we assume all costs will be absorbed by the owner of the clay mineral processing facility. We do this by determining the percentage of revenues that the compliance cost will consume. Using data collected from one of the sources listed in Section 2.3.2, we found that the four affected facilities are owned by 2 ultimate parent firms and we were able to obtain revenue and employment data for both of these firms. Table 4-1 presents the companies, number of facilities, total annual costs, annual sales, and calculated share of costs to revenues for these firms. As shown, the compliance costs as a percentage of firm revenues for both firms are less than 0.01 percent. The impacts presented by this rule are likely to be minimal on the two firms owning the affected facilities.

Table 4-1. Company Compliance Costs, Annual Sales, and Cost-to-Sales Ratios: 2000

Company ID	Number of Facilities	Compliance Costs	Annual Sales ($\$10^6$)	Cost-to-Sales Ratio (%)
A	3	$48,930	$509.8	<.01%
B[a]	1	$16,155	$602.4	<.01%

Notes: [a] Annual sales for Company B are for 1997, the most recent publicly available data.

5 SMALL BUSINESS ANALYSIS

This regulatory action will potentially affect the economic welfare of the owners of clay mineral processing facilities. The ownership of these facilities ultimately falls on private individuals who may be owner/operators that directly conduct the business of the firms, or more commonly, on investors or stockholders that employ others to conduct the business of the firm on their behalf (i.e., privately or public corporations). The individuals that manage these facilities have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with the regulation ultimately rests with the facility managers; however, the owners must bear the financial consequence of the decisions. Environmental regulations like this rule potentially affect all businesses, large and small, but small businesses may have special problems in complying with federal regulations.

The Regulatory Flexibility Act (RFA) of 1980 requires that special consideration be given to small entities affected by federal regulation. The RFA was amended in 1996 by the Small Business Regulatory Enforcement Fairness Act (SBREFA) to strengthen the RFA's analytical and procedural requirements. The RFA and SBREFA require the preparation of a regulatory flexibility analysis for any rule that would have a significant impact on a substantial number of small entities, or a disproportionate impact on small entities.

This section identifies the businesses that will be affected by this rule and provides a preliminary screening-level analysis to assist in determining whether the rule is likely to impose a significant or disproportionate burden on small entities and whether a regulatory flexibility analysis is required under the RFA. The screening-level analysis employed here is a "sales test," which computes the annualized compliance costs as a share of sales for each company.

These companies can also be grouped into small and large categories using Small Business Administration (SBA) general size standard definitions for NAICS codes. The SBA defines a small business in terms of the employment or annual sales of the owning entity. These thresholds vary by industry and are evaluated based on the industry classification (NAICS codes) of the impacted facilities. For the NAICS codes representing the companies owning clay minerals processing facilities, the small business definition ranges from100 to 500 employees or $5 million in annual sales. Based on the SBA definitions, the Agency identified 16 of the companies as small (47.1 percent) and 17 as large (50.0 percent) (See

Appendix A for a detailed listing). Data for one company was unavailable, and therefore no size determination could be made.

Only two companies own facilities with positive costs of compliance and both of these companies are considered large based on SBA small size standards. The cost-to-sales ratios for these firms are less than 0.01 percent. Based on this information, we conclude that there will no impact on small entities from this NESHAP.

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APPENDIX A: SUMMARY CLAY MINERALS PROCESSING COMPANY DATA

Table A-1. Summary Data for Companies Operating Clay Minerals Processing Facilities

Company Name	Facilities	Employees	Sales ($\$10^6$)	Small Business
Amcol International Corp.	6	NR	NR	N
BMI France	1	75	113.7	Y
Burgess Pigment Co., Inc.	1	NR	NR	Y
C-E Minerals, Inc.	3	NR	NR	Y
Christy Refactories Company LLC	1	NR	NR	Y
Clorox Co., Inc.	3	NR	NR	N
Engelhard Corp.	6.5	NR	NR	N
Franklin Industries, Inc.	1	350	40	N
GEO Drilling Fluids, Inc.	2	NR	NR	Y
Global Industrial Technologies, Inc.	4	4,262	602.4	N
H.C. Spinks Clay Co., Inc.	2	NR	NR	Y
Hecla Mining Co., Inc.	6	NR	NR	N
Imerys	3.5	11,948	2,632.90	N
ITC	0.5	NA	NA	
J.M. Huber Corp.	3.5	NR	NR	N
Justin Industries	3	3,826	509.8	N
Kyanite Mining Corp.	1	NR	NR	Y
Laporte, Inc.	1	NR	NR	N

Company Name	Facilities	Employees	Sales ($\$10^6$)	Small Business
MFM Delaware, Inc.	1	NR	NR	Y
Morganite North America, Inc.	1	NR	NR	N
Mud Brothers, Inc.	1	NR	NR	Y
National Refractories Holding Co.	1	NR	NR	N
North American Refractories Co., Inc.	2	NR	NR	N
Oil Dri Corp.	3	705	160.3	N
Old Hickory Clay Co., Inc.	2	NR	NR	Y
Resco Products Co., Inc.	1	NR	NR	Y
Rovin Ceramics, Inc.	1	NR	NR	Y
Standard Industrial Minerals, Inc.	1	NR	NR	Y
Sud-Chemie North America, Inc.	2	NR	NR	N
Thiele Kaolin Co., Inc.	2	NR	NR	N
United Clays, Inc.	4	NR	NR	Y
Wilkinson Kaolin Associates Ltd.	1	NR	NR	Y
Wyo-Ben, Inc.	3	NR	NR	Y
Zemex Corp.	1	NR	NR	N
Total	**76**	**55,875**	**$14,390**	**16**

Note: NR means Not Reported. Employment and sales data from Dun & Bradstreet are considered proprietary and are therefore not reported in Table A-1. Data from publicly available sources are, however, presented here. All of the data, reported and unreported, were used to develop the economic impact analysis.
Data presented in this table are generally for the years 1997 and 1998, the latest information available at the time the data were collected. However, more recent data were retrieved for Imerys (1999), Justin Industries (1999), and Oil Dri Corp. (2000).
Englehard Corp. and ITC own a facility together in a joint venture, as do Imerys and J.M. Huber Corp. For this reason, these corporations are listed as owning 0.5 of these jointly owned facilities.

TECHNICAL REPORT DATA

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) is developing a National Emissions Standard for Hazardous Air Pollutants (NESHAP) to control emissions released from the domestic processing of clay minerals. In the baseline year of analysis (1997), 34 companies owned and operated 76 facilities that produce process clay minerals. EPA estimated that four of these facilities owned by two parent companies will incur costs associated with this proposed rule. These four facilities all possess and operate the necessary control equipment (wet scrubbers), but they will face costs related to the installation and operation of monitoring, recordkeeping, and reporting equipment.

The total annual costs of the rule are estimated to be $65 thousand. The costs are estimated to be less than 0.01 percent of sales for both parent companies. No facilities are projected to close, and no change in employment is expected.

The economic impacts of this rule on small businesses is also examined pursuant to the Small Business Regulatory Enforcement Fairness Act (SBREFA) and the Regulatory Flexibility Act. According to the Small Business Administration's definition of a small business in the clay minerals processing source category, there are 16 companies identified as small and 17 as large. None of the facilities owned by the 16 small companies are expected to incur regulatory costs, hence there will be no anticipated impact on small entities from this NESHAP.

17. KEY WORDS AND DOCUMENT ANALYSIS

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