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EPA Office of Compliance Sector Notebook Project

Profile of the Stone, Clay, Glass, and Concrete Products Industry

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Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
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This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be **purchased** from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included at the end of this document.

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Electronic versions of all Sector Notebooks are available on the EPA Enviroene Bulletin Board and via Internet on the Enviroene World Wide Web. Downloading procedures are described in Appendix A of this document.

Cover photograph by Steve Delaney, EPA.

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EPA/310-R-95-018.	Transportation Equipment Cleaning Industry	Virginia Lathrop	564-7057

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STONE, CLAY, GLASS, AND CONCRETE PRODUCTS
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LIST OF ACRONYMS

AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation
NO_X - Nitrogen Oxide
NPDES - National Pollution Discharge Elimination System (CWA)

STONE, CLAY, GLASS, AND CONCRETE PRODUCTS
(SIC 32)
LIST OF ACRONYMS (CONT'D)

NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement and Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

STONE, CLAY, GLASS, AND CONCRETE PRODUCTS (SIC 32)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water, and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, States, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate, and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or States may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages State and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested States may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with State and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. Introduction to the Stone, Clay, Glass, and Concrete Products Industry

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the Stone, Clay, Glass, and Concrete Products industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes.

II.A. Introduction, Background, and Scope of the Notebook

This profile pertains to the Stone, Clay, Glass, and Concrete Products Industry as classified within Standard Industrial Classification (SIC) code 32. The Bureau of Census delineates the industrial groups within SIC code 32 as follows:

SIC 321 - Flat Glass
SIC 322 - Glass and Glassware, Pressed or Blown
SIC 323 - Glass Products, made of Purchased Glass
SIC 324 - Cement, Hydraulic
SIC 325 - Structural Clay Products
SIC 326 - Pottery and Related Products
SIC 327 - Concrete, Gypsum, and Plaster Products
SIC 328 - Cut Stone and Stone Products
SIC 329 - Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products.

The intent of this profile is to provide an overview of the Stone, Clay, Glass, and Concrete Products Industry, providing data on its size and distribution and highlighting production processes and associated pollution outputs, and to address environmental compliance and enforcement issues associated with the industry. The profile does not provide a rigorous analysis of each industrial group within SIC code 32. Greater emphasis is placed on the stone, clay, glass, and concrete industries due to their size and environmental impacts. This profile does not address mining of the raw materials used to manufacture stone, clay, glass, and concrete products. Refer to the separate Sector Notebook entitled *Profile of the Non-Fuel, Non-Metal Mining Industry* for additional information on mineral extraction.

II.B. Characterization of the Stone, Clay, Glass, and Concrete Products Industry

The firms within SIC code 32 are quite diverse in terms of geographic distribution, facility size, and the types of products manufactured. Firms within the Stone, Clay, Glass, and Concrete Products Industry are dispersed across the United States. All rely on mined materials (such as stone, clay, and sand) for production inputs, but the means of production and the types of products produced vary substantially, from glass candlesticks to marble monuments. The general characteristics of the industry are illustrated by the following four subsections.

II.B.1. Industry Size and Geographic Distribution

Variation in facility counts occur across data sources due to many factors, including reporting and definitional differences. This document does not attempt to reconcile these differences, but rather reports the data as they are maintained by each source.

Industry Size

The Stone, Clay, Glass, and Concrete Products Industry consists of approximately 16,000 establishments and employs nearly 470,000 people. It ranks 16th among the major industrial groups (SIC codes 20-39) in terms of total number of employees and 8th in terms of total number of establishments.

Exhibit 1 illustrates the facility size distribution for the industry based on the latest complete U.S. Census Bureau data (1992).

Exhibit 1
Facility Size Distribution of Industry

Industry	SIC Code	Total Employees	Total Number of Facilities	Employees per Facility
Flat Glass	321	11,900	44	270
Glass and Glassware, Pressed or Blown	322	66,200	543	122
Products of Purchased Glass	323	55,500	1,558	36
Cement, Hydraulic	324	17,000	237	72
Structural Clay Products	325	31,100	587	53
Pottery and Related Products	326	35,900	1,084	33

Exhibit 1 (cont'd)
Facility Size Distribution of Industry

Industry	SIC Code	Total Employees	Total Number of Facilities	Employees per Facility
Concrete, Gypsum, and Plaster Products	327	174,200	9,653	18
Cut Stone and Stone Products	328	12,000	917	13
Miscellaneous Nonmetallic Mineral Products	329	65,900	1,662	40
Totals	32	469,900	16,285	29

Source: Compiled from official 1992 statistics of the U.S. Bureau of the Census.

Cut Stone and Stone Products: The Bureau of Census reports 12,000 employees in the Cut Stone and Stone Products Industry in 1992, down one percent from 12,500 in 1987. According to the U.S. Bureau of Mines, the Dimension Stone industry employed 14,000 people in 1993, including 10,900 engaged in finishing operations, which fall within the Cut Stone and Stone Products industry.

Structural Clay Products: Employment in the Structural Clay Products sector fell 10 percent between 1987 and 1992, from 34,100 to 31,100. The greatest decreases occurred within the Brick and Structural Clay Tile and the Structural Clay Products subgroups, where employment fell 14 percent and 19 percent, respectively (Bureau of Census).

Glass: In the U.S., the glass container industry consists of 70 facilities and more than 30,000 employees. According to the Glass Packaging Institute, the industry is experiencing downsizing. The industry produces 41 billion glass containers in the U.S. annually; 64 percent are clear, 23 percent are amber, and 13 percent are green (Glass Packaging Institute, 1995). According to Dr. Blake of the Glass Technical Institute, container glass holds the largest market in the glass industry. The U.S. Flat Glass industry is one of the world's four largest producers of flat glass, along with France, Japan, and the United Kingdom. The U.S. Flat Glass Industry consisted of an estimated 1,100 companies, 1,300 establishments, and 56,000 employees in 1993, according to the U.S. International Trade Commission. An estimated 35 percent of flat glass industry shipments are from firms that produce flat glass by melting raw materials (primary producers). The remaining 65 percent of shipments are from firms that produce flat glass from purchased glass (secondary producers) (1993).

Concrete, Gypsum, and Plaster Products: The Concrete, Gypsum, and Plaster Products Industry employed 174,200 people in 1992, down 14 percent from 203,000 in 1987.

Cement: Based on 1992 industry data, the Cement Industry was composed of 237 establishments, including 120 cement-producing plants (Cement, 1992). Multiplant operations were being run by 18 companies. Total employment in the cement industry was 17,000, down from 19,100 in 1992 (Bureau of Census).

Geographic Distribution

According to U.S. Census data for 1987, the Stone, Clay, Glass, and Concrete Products industry is widely dispersed, with every State reporting the existence of an industry establishment. The five largest States in terms of number of establishments are California (1,651), Texas (1,160), Florida (908), Ohio (889), and Pennsylvania (852).

Exhibit_2 illustrates the number of industry establishments per State as recorded by the U.S. Census for 1987.

Exhibit 2
Geographic Distribution of Stone, Clay, Glass, and Concrete Products Industry
Source: Compiled from official 1987 statistics of the U.S. Bureau of the Census.

Cut Stone and Stone Products: The U.S. Bureau of Mines reports that in 1993, dimension stone was produced by 162 companies in 35 States, including Puerto Rico. Leading States in terms of tonnage were Georgia, Indiana, and Massachusetts, together accounting for 39 percent of the U.S. total. States with the largest number of employees in the Dimension Stone Industry were Georgia with 2,100, Vermont with 1,700, Minnesota with 1,250, North Carolina with 850, Texas with 700, and Indiana with 650.

Structural Clay Products: Establishments engaged in the manufacture of structural clay products are widely dispersed, however, a few States account for the majority of the industry's employment. Leading States include California, Ohio, Pennsylvania, and Texas.

Glass: Glass container manufacturing facilities are located in 27 States in the U.S., including California, Illinois, Pennsylvania, and New Jersey (Glass Packaging Institute, 1995). Production facilities for flat glass exist throughout the U.S. to minimize the shipping costs of raw materials and finished products. California, Michigan, North Carolina, Ohio, and Pennsylvania are the major production areas of flat glass. The primary-producer industry (glass products from manufactured glass) is relatively concentrated, with 13 of 84 establishments accounting for 76 percent of U.S. shipments. The secondary-producer industry (glass products from purchased glass) is less concentrated, with 17 of 1,429 establishments accounting for 28 percent of U.S. shipments (U.S. International Trade Commission, 1993).

Concrete: Concrete production is relatively concentrated within the United States. In 1993, 49 percent of domestic concrete production came from the following six States in descending order: California, Texas, Pennsylvania, Michigan, Missouri, and Alabama (U.S. Bureau of Mines).

Cement: The cement industry consists of 49 companies which operate cement-producing plants in 38 States and Puerto Rico. States that rank among the top cement producers are California, Texas, Pennsylvania, Michigan, Missouri, and Alabama (U.S. Bureau of Mines).

II.B.2. Product Characterization

The Stone, Clay, Glass, and Concrete Products Industry generates a broad array of products, primarily through physical modification of mined materials. The industry includes establishments engaged in the manufacturing of flat glass and other glass products, cement, structural clay products, pottery, concrete and gypsum products, cut stone, abrasive and asbestos products, and other products. The following is an overview of the characteristics of stone, clay, glass, and concrete products.

Stone

The term stone is applied to rock that is cut, shaped, broken, crushed, or otherwise physically modified for commercial use. Establishments covered under SIC code 328 (Cut Stone and Stone Products) are those engaged primarily in cutting, shaping, and finishing stone for building and other miscellaneous uses. The cutting of stones at the quarry (when not associated with further physical modifications) is classified as mining, and is not covered within SIC code 32 or this profile.

The primary type of stone covered within SIC code 32 is dimension stone. Dimension stone refers to blocks of rock that are cut and milled to specified sizes, shapes, and surface finishes. Only a small fraction of rock occurrences have the qualities demanded for dimension stone. The stone must be obtainable in large, sound blocks, free from blemishes, and generally must have a uniform texture. The principle types of dimension stone used in construction are granite, marble, limestone, slate, and sandstone. Flagging is a type of dimension stone used for stepping stones, walkways, and terraces. Soapstone is used for acid proof laboratory equipment, aquariums, and chemical tank linings. Slate differs from other dimension stone because it can be split into thin sheets of any thickness. Slate is used in roofing, blackboards, and floor tile. Of the total dimension stone produced in 1993, 49 percent was granite, 29 percent was limestone, 11 percent was sandstone, three percent was slate, three percent was marble, and five percent was other. In 1993, dimension stone was used in ashlar (dressed stone for facing a wall of rubble or brick), 17 percent; curbing, 15 percent; rough blocks for monuments, 13 percent; rough blocks for building and construction, 12 percent; dressed monumental stone, 12 percent; and other uses, 31 percent (U.S. Bureau of Mines).

Clay

Clay consists of the finest-grain particles in a sediment, soil, or rock, and a rock or a deposit containing a large component of clay-size material. Clay can be composed of any inorganic materials, such as clay minerals, allophane, quartz, feldspar, zeolites, and iron hydroxides, that possess a sufficiently fine grain size. Along with organic matter, water, and air, clays are one of the four main components of soil. Physical properties of clay include plasticity when wet, the ability to form colloidal suspensions when dispersed in water, and the tendency to clump together (flocculate) and settle out in saline water.

Establishments that fall within the Structural Clay Products Industry (SIC code 325) are primarily engaged in using different types of clay and other additives to manufacture brick and structural clay tile, ceramic wall and floor tile, clay firebrick and other heat-resisting products, and clay sewer pipe. The mining of clay used to make structural clay products is not included within SIC code 32.

The U.S. Bureau of Mines categorizes clay into six groups: ball clay; bentonite; common clay and shale; fire clay; fuller's earth; and kaolin. Ball clay is a plastic, white-firing clay that has a high degree of strength as well as plasticity. Principal ball clay markets in 1992 were pottery, floor and wall tile, and sanitary ware. Bentonite is a clay composed mainly of smectite minerals. The three major uses of bentonite in 1992 were drilling mud, foundry sand, and iron ore pelletizing. Common clay and shale contain mixtures of differing proportions of clay, including illite, chlorite, kaolinite, and montmorillonite, plus other nonclay materials. The largest user of these clays is the structural clay products industry, which manufactures brick, drain tile, sewer pipe, conduit tile, glazed tile, and terra cotta. Fire clays can withstand very high temperatures and consist mainly of kaolinite. These clays are used in commercial refractory products such as firebrick and block. Fuller's earth, either the attapulgite-type or montmorillonite-type, is used in pet waste absorbents, oil and grease absorbents, and pesticide carriers. Kaolin has many industrial applications because it has good covering or hiding power when used as a pigment, is soft and nonabrasive, has low conductivity of heat and electricity, and is inexpensive. Major domestic uses for kaolin in 1992 were paper coating, paper filling, fiberglass, paint, rubber, brick, and portland cement.

Glass

Glass is defined as a material made by cooling certain molten materials so that they do not crystallize but remain in an uncrystallized state, their viscosity increasing to such high values that, for all practical purposes, they are solid. Materials having this ability to cool without crystallizing are relatively rare, silica being the most common example.

The glass industry covered under SIC code 32 consists of a wide variety of manufacturing establishments, including firms engaged in primary glass manufacturing and others which create products from purchased glass. Container glass, flat glass, and fiberglass manufacturers are among the most economically significant firms in the primary glass industry.

The glass container industry produces three major products: food, beer, and beverage containers. Other markets for glass containers include: liquor; wine; medicine and health; toiletries and cosmetics; and chemical, household, and industrial products (U.S. Department of Commerce, May 1995).

The flat glass industry (SIC code 321) produces four main products: tempered glass, laminated glass, glass mirrors, and insulating units. Tempered glass is a type of safety glass typically produced by the thermal process, in which heating and subsequent rapid cooling produce surface and interior stresses in the glass that make it stronger than ordinary glass. Laminated glass consists of two or more layers of glass separated by, and bonded to, thin sheets of plastic that prevent the glass from shattering when broken. The automobile industry is the largest market for laminated glass. Glass mirrors are produced by cleaning the glass and coating it on one side with an adhesive, reflective, and binding compound. Insulating units consist of two or more parallel separated panes of glass joined at the edges by metal seals or by fusing the edges, with the space between the panes either evacuated or filled with dry air or another gas. Insulating units are used to reduce surface condensation, to reduce sound transmission, and for thermal insulation.

The fiberglass industry (SIC code 3296) produces two main products: textile fiberglass (electrical glass), and insulation fiberglass. Textile fiberglass is used in the production of fireproof cloth, and insulation fiberglass is used in thermal and acoustical insulation. SIC code 32 also covers glass and glassware establishments which produce bowls, goblets, lenses, jars, tableware, and other products which are pressed, blown, or shaped from glass produced in the same establishment (SIC code 322). Facilities which manufacture products made of purchased glass, such as furniture, mirrors, windows, table tops, and laboratory glassware, fall under SIC code 323.

Concrete

The term concrete refers to a product formed from two principle components: aggregate and paste. Aggregate, which can be either natural or man made, consists of various grades of sand, gravel, crushed stone, or slag. The paste is composed of cement, water, and sometimes entrained air. The cement paste makes up approximately 25 to 40 percent by volume of concrete. Some concrete mixtures include hydrochloric acid, acetone, styrene, glycol ethers, or butyl benzyl phtalate as additives. Manufacturers utilize different combinations of pastes and aggregates to produce grades of concrete which vary in terms of cost, strength, durability, and rigidity. The successful use of concrete in structures has come about from the addition of steel reinforcements. Reinforced concrete is now one of the most common materials from which structures (such as buildings and bridges) are built.

The many types of products fashioned from concrete include brick, architectural blocks, chimneys, columns, paving materials, foundations, curbing, and storage tanks. Firms within SIC code 327 both produce ready-mixed concrete, which is unhardened concrete material, and fashion a multitude of concrete products, such as those listed above.

One subcategory of the concrete, gypsum, and plaster products industry is lime manufacturing. Lime is the product of high temperature calcination of limestone.

Major uses of lime are metallurgical (steel, copper, gold, aluminum, and silver), environmental (flute gas desulfurization, water softening and pH control, sewage-sludge stabilization, hazardous waste treatment, and acid neutralization), and construction (soil stabilization, asphalt additive, and masonry lime).

Cement

Cement is a powder produced from a variety of materials, including alumina, silica, limestone, clay, and iron oxides. It is used as a binding agent, most often as a component of mortar or concrete.

Manufacturers within SIC code 324 produce several types of cement. Among the most common types are portland cement, white cement, and masonry cement. Approximately 97 percent of the cement used in the manufacture of concrete is portland cement, which consists primarily of a kiln-fired, fused powder, known as clinker, that is ground and combined with small amounts of gypsum or a similar material. Portland cement is produced in five grades designed to lend certain properties to the concrete. White cement, which is made from iron-free materials of exceptional purity, usually limestone, china clay or kaolin, and silica, is primarily used to manufacture decorative concrete. Masonry cement, produced by adding limestone to portland cement, is a hydraulic cement used as a component of mortar for masonry construction.

II.B.3. Economic Trends

This section highlights economic trends in the Stone, Clay, Glass, and Concrete Products Industry based on a comparison of 1992 and 1987 Bureau of Census data (unless otherwise noted). The term “value added” as used in the following descriptions is a measure of manufacturing activity derived by subtracting total variable costs (such as cost of raw materials, supplies, fuel, etc.) from the total value of shipments for a given industrial sector. Value added is considered to be the best value measure available for comparing the relative economic importance of manufacturing across industries and geographic areas.

Cut Stone and Stone Products: The value added by cut stone and stone products manufacturers increased by 33 percent between 1987 and 1992, from $450 million to $600 million. In addition, total wages and total value of shipments increased, by approximately 17 and 16 percent, respectively.

Since 1980, a movement back to the use of stone in buildings has occurred because of the rising energy costs associated with stone substitutes, such as concrete, glass, brick, stainless steel, aluminum, and plastics. Consumption of dimension stone increased slightly between 1992 and 1993 to 1.24 million tons, valued at $217 million. Over the same period, the average price for dimension stone decreased from $182 to $176 per ton (U.S. Bureau of Mines).

Clay and Structural Clay Products: The value of shipments from the Structural Clay Products Industry climbed moderately from 1987 to 1992, from $2.81 to $2.86 billion, while the value added by manufacturers held at $740 million.

Glass: According to the *1993 Industrial Outlook*, glass container manufacturing is a five billion dollar industry.

The total value of shipments from the Flat Glass Industry fell over 38 percent between 1987 and 1992, while the value added by flat glass manufacturers declined by over 22 percent. Employment and total wages also declined significantly over this period.

Prices of flat glass and flat glass products fell each year from 1988 until 1992. However, the decline was only one percent from 1991 to 1992, compared with two to six percent in previous years. During the first part of 1993, prices rose two percent compared with 1992. It is expected that prices will remain constant, with minor downward adjustments as manufacturers engage in price competition to increase gross sales and retain market share.

The high transportation costs associated with glass products mitigate against extensive trade. U.S. companies are able to expand into foreign markets by acquiring or establishing foreign plants, thus reducing transportation costs (U.S. International Trade Commission).

Concrete, Gypsum, and Plaster Products: Value added by concrete, gypsum, and plaster products manufacturers fell over seven percent from 1987 to 1992, from close to $11.8 billion to just under $11 billion. The value of shipments, number of employees, and total wages also sagged during this five-year period.

Cement: Between 1987 and 1992, the value added by the Hydraulic Cement Industry fell close to eight percent while total wages held steady, according to Bureau of Census data. According to the U.S. Department of Interior Bureau of Mines Industry Surveys, U.S. cement shipments in 1993 totaled about 86.4 million short tons, up from about 82.7 million short tons in 1992. Cement consumption in 1994 was expected to increase approximately ten percent to roughly 94 million short tons, largely because of increased highway and other public works construction.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the Stone, Clay, Glass, and Concrete Products Industry, including the materials and equipment used and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

III.A. Industrial Processes in the Stone, Clay, Glass, and Concrete Products Industry

The processes used to create stone, clay, glass, and concrete products primarily involve physical conversion of earthen materials by sorting, mixing, grinding, heating, and cooling. This section provides an overview of commonly-employed processes within the industry, broken down by product categories (stone, clay, glass, and concrete) rather than by specific industries within SIC code 32. The mining of the raw materials, while integrally related to the manufacture of stone, clay, glass, and concrete products, is outside the scope of this profile and is not addressed in the following discussion.

Stone

The manufacture of stone products involves cutting and finishing granite, limestone, marble, slate, sandstone, and other materials obtained from the quarry. Dimension stone is prepared for its various uses in mills equipped with saws, polishing machines, and other equipment similar to that found in metal and woodworking shops. Stone-sawing equipment includes large circular saws three meters or more in diameter, some with diamond inserts and others with abrasives; diamond circular saws of smaller size, and reciprocating diamond-bladed or loose-abrasive gang saws. Various types of diamond and other equipment are used for smoothing, polishing, edging, and decorating the finished stone products (U.S. Bureau of Mines).

Clay

The manufacture of clay products involves the conditioning of basic clay ores by a series of processes. These include separation and concentration of clay minerals by screening, floating, wet and dry grinding, and blending of desired ore varieties; followed by forming; cutting or shaping; drying or curing; and firing of the final product. In general, processing clay does not alter its chemical or mineralogical characteristics. Exhibit 3 illustrates the fundamental stages of the clay manufacturing process.

Exhibit 3

Basic Flow Diagram of Clay Manufacturing Process

Source: AP-42, 1986.

Clay manufacturers use different techniques to produce clay products, such as brick, other structural clay products, pottery products, and ceramic tiles. Bricks and related clay products, such as building tiles, paving brick, and chimney blocks, are produced from a clay/water mixture. The three principle processes for manufacturing brick are the stiff mud, soft mud, and dry press methods. In the stiff mud process, water is added to give the clay plasticity, and the bricks are formed by forcing the clay through a wire die. All structural tile and most types of brick are formed by the stiff mud process. The soft mud process utilizes clay with a high moisture content. The clay is mixed with water and the bricks are then formed in molds. In the dry press process, clay is mixed with a small amount of water and formed in steel molds by applying pressure of 500 to 1500 pounds per square inch (AP-42, 1986).

The dominant process in manufacturing structural clay products is extrusion. The three stages of extrusion are pugging, tearing, and extrusion. The dry material is fed into a trough, sprayed with water, and cut and kneaded (pugged) by rotating knives into a homogeneous mixture. The resulting plastic mass is forced into a de-airing chamber where a vacuum is maintained. Following de-airing, the material is forced through a die having the appropriate cross section (extrusion) and cut into correct lengths. The structural clay products are then thermally treated in a tunnel kiln and cooled with fans.

Pottery products, such as stoneware, earthenware, and garden pottery, are made of crude clay. To manufacture pottery products, soft plastic forming is used to process plastic clays with 20-30 percent water and certain additives, which may include barium compounds and aluminum oxide. Jiggering is a soft plastic process used to form ware with symmetrical circular cross sections. The raw materials are prepared by blunging and filter pressing. They are mixed in a blunger, which is a vertical cylindrical tank with horizontal blades or paddles attached to a vertical shaft. The homogeneous mixture, called a slip, is then filter pressed to remove excess water prior to soft plastic forming. The slip is then de-aired, forced through a die with the desired cross section, and cut into slugs. The slug is placed in a mold of either the inside or outside of the ware and pressed onto the mold. High-pressure air is used to separate the ware from the mold. The product is then thermally treated using a tunnel kiln, and slowly cooled with fans.

Ceramic tile manufacturing involves the conditioning of two basic raw materials: kaolinite and montmorillonite. These clays are refined by separation and bleaching, and are then blended, formed, and kiln-dried.

Glass

Nearly all glass produced commercially is one of five basic types: soda-lime, lead, fused silica, borosilicate, and 96 percent silica. Silica forms the basis of most commercially important glasses. Silica by itself makes a good glass, but its high melting point (3133°F or 1723°C) and its high viscosity in the liquid state make it difficult to melt and work. Soda is therefore added to silica, in such forms as sodium carbonate or nitrate, to lower its melting temperature to a more convenient level. Unfortunately, the resulting glass has no chemical durability and is soluble even in water. Lime is added to increase glass durability, thus yielding the basic soda-lime-silica glass composition used for most common glass articles.

Production of glass involves five main procedures: mixing, melting, forming, annealing, and finishing. These procedures generally apply to all types of commercial glass formation. The two principle kinds of mixing are wet mixing and batch agglomeration. Glass with a large silicon dioxide content is wet mixed in a pan-type mixer, which is first dry-blended and then wet-blended by adding small amounts of water. Glasses with high lead oxide are mixed by batch agglomeration, whereby batch particles are coated with each other using the smearing action of a Muller-type mixer. The mixed batch is delivered to a melting unit through a feeder. Wet mixing and batch agglomeration are attractive mixing methods because they prevent dusting, control air pollution, ensure homogeneity, and increase melting efficiency and glass quality.

The type of melting unit employed depends on the quantity and quality of glass to be processed. For small production and special glass, melting is performed in pot furnaces or crucibles containing up to two tons of glass. In large factories, a dozen or so pot furnaces may be heated by one central furnace. Larger batches are melted in large covered furnaces or tanks to which heat is supplied by a flame. For high quality glass, small continuous melting tanks are used to process low volumes of material. Large quantities of high quality glass are melted in continuous regenerative furnaces that recover waste heat from burned gases. Flat glass furnaces provide a larger amount of quality glass and are longer than furnaces used by glass container manufacturers. Although glass tanks are fired by gas or oil, auxiliary heating with electricity is common in the United States. After the glass has melted, the molten glass is taken from the tanks to the forming operation.

Forming is different for each type of glass product. Container glass products such as glass bottles and jars are sometimes mouth blown, but are typically formed with automatic machines. In automatic processes, a stream of glass is cut by shears into individual gobs, which are fed to a blank mold. The gob is then formed into a rough blank, or parison, by either a plunger or compressed air; at this stage the bottle opening is shaped. The blank mold opens and is then transferred to the final or blow mold, where it is blown into shape using an air compressor. Pressing is used to form flat items such as lenses and plates by pressing the glass between a plunger and a mold. Drawing and casting are forming processes which involve pouring molten glass into a mold. The molds for the glass containers resemble the containers (Glass Packaging Institute, 1995).

Once formed, all glass articles need to be slowly cooled or annealed, usually in a long oven called a lehr. The purpose of annealing is to reduce the internal stresses which can crack the glass during cooling. Internal stresses are created because of temperature variations throughout the piece; different parts of the glass become rigid at different times.

The two types of finishing processes are mechanical and chemical. Mechanical processes include cutting, drilling, grinding, and polishing. Chemical treatments are used to alter the strength, appearance, and durability of the product. Acid-polishing is performed with a mixture of hydrofluoric and sulfuric acids to alter the strength or durability of the glass. Chemically strengthened glass is formed by immersing the product into a potassium nitrate bath. The larger potassium ion replaces the sodium ion which produces a surface compression layer. Chemical strengthening is an expensive process which is most often used in the production of large screen television faceplates. Frosting and etching are performed with dilute hydrofluoric acid. Commercial glass contains oxides, such as aluminum and magnesium oxides, and other ingredients to help in oxidizing, finishing, or decolorizing. For example, Pyrex glass contains boron oxide which allows it to withstand rapid temperature changes, optical glass contains lead oxide which gives it a high index of refraction, and stained glass is colored by adding metallic oxides to the molten glass. Once finished, the glass products are cleaned using several agents, including aqueous solvents (chromic and sulfuric acid mixtures, detergent solutions), organic solvents (used alone or mixed with commercial cleansers), and hydrocarbon or halocarbon solvents (removal of nonpolar organic compounds).

Exhibit 4 Typical Glass Manufacturing Process

Source: AP-42, 1986.

Flat glass is typically made by the float process. The raw materials used in this process include silica sand, soda ash, limestone, dolomite, cullet (scrap glass), and small amounts of other materials. These materials are proportioned to meet certain physical characteristics, mixed, and fed into the melting tank, where temperatures of about 1,600°C reduce the material to glass. Coloring agents may be added at this time to produce differing degrees of translucence. The molten glass is then fed as a continuous ribbon from the furnace into a bath of molten tin where it floats (glass is lighter than tin) and is fire polished. The ribbon of glass leaves the float bath and enters the annealing lehr where it is gradually cooled to prevent flaw-causing stresses. The glass is then cut. At this point, the glass may be packaged and sent to a customer, immediately subjected to further processing, or sent to storage for inventory or future processing. Additional processing often involves coating glass with thin layers of metal or chemical compounds that absorb infrared light or improve the reflecting qualities of the glass.

Glass fiber manufacturing involves the high-temperature conversion of raw materials into a homogeneous melt, followed by the fabrication of this melt into glass fibers. The two basic types of glass fiber products, textile and wool, are created by similar processes. Glass fiber production can be separated into three phases: raw materials handling, glass melting and refining, and glass fiber forming and finishing. The primary component of glass fiber is sand, but it also includes varying quantities of feldspar, sodium sulfate, boric acid, and other materials. These materials are conveyed to and from storage piles by belts, screws, and bucket elevators. In the glass melting furnace, the raw materials are heated and transformed through a series of chemical reactions into molten glass. Glass fibers are made from the molten glass by one of two methods. In the rotary spin process, which dominates the fiberglass industry, centrifugal force causes molten glass to flow through small holes in the wall of a rapidly rotating cylinder to create fibers that are broken into pieces by an air stream. The flame attenuation process utilizes gravity to force molten glass through small orifices to create threads which are attenuated, or stretched to the point of breaking by hot air and/or flame. After the glass fibers are created (by either process), they are sprayed with a chemical resin to hold them together, collected on a conveyor belt in the form of a mat, cured, and packaged (AP-42, 1986).

Concrete and Cement

Concrete is formed by mixing hydraulic cement, water, and aggregate materials (sand, gravel, or crushed stone). At concrete batching plants, the cement is elevated to storage silos pneumatically or by bucket elevator. The sand and coarse aggregate are transferred to elevated bins by front-end loader, crane, conveyor belt, or bucket elevator. From these elevated bins, the cement and aggregate are fed by gravity or screw conveyor to weigh hoppers which combine the proper amounts of each material. Concrete batching plants then store, convey, measure, and discharge the ready-mixed concrete into trucks for transport to a job site (AP-42, 1986).

The distribution of the aggregate particle sizes and the relative proportion of cement, aggregate, and water determine the workability and durability of concrete. The most important variables affecting the strength of concrete at a given age are the water/cement ratio and the degree of compaction.

Hydraulic cement, one of the principle components of concrete, is generally made from aluminum and silica as found in clay or shale and from a calcareous material such as limestone or chalk. To make hydraulic cement, the raw materials are ground, mixed, heated, and fused in a rotary kiln, cooled, and finally reduced to a fine powder. Exhibit 5 illustrates the typical cement production process.

Exhibit 5
Basic Cement Production Process

Source: Report to Congress on Cement Kiln Dust, 1993.

Cement is manufactured in five kiln types: wet process, dry process, preheater, precalciner, and semidry process kilns. The same raw materials are used in wet and dry process kilns, however, the moisture content and processing techniques differ, as do the kiln designs. Wet process kilns must be longer in order to dry the wet mix, or slurry, which is fed into the kiln. Dry process kilns produce high temperature exit gases which can be use to generate electrical power. Preheater, precalciner, and semidry process kilns are less common devices, and differ from wet and dry process kilns in terms of kiln length, process inputs, operating temperature, fuel efficiency, and other factors. Processes that take place within each type of kiln include drying and preheating, which includes evaporation of free water and dehydration of clay minerals; calcining, which is the process of decomposing carbon compounds; and burning, which fuses the calcined materials.

The fused cement nodule formed within a cement kiln is known as clinker. The most common method of cooling the clinker is a traveling grate which is cooled by the ambient air. The cooled clinker is transferred to storage or mixed with four to six percent gypsum. This gypsum/clinker mixture is then ground to produce a homogeneous cement powder which is typically sent to a bulk storage area and then shipped by truck or rail.

Most of the hydraulic cement produced in the U.S. is portland cement, a crystalline compound formed primarily of metallic oxides such as calcium carbonate and aluminum, iron, and silicon oxides. Portland cement is produced in an inclined rotary kiln. The mix enters the kiln at the elevated end, opposite from the burner. Materials are moved slowly and continuously to the lower end as they are heated, and different chemical reactions occur as the temperature increases. Portland cement is then produced by grinding the clinker with approximately five percent gypsum to a fine powder. At this stage, various additives may be introduced to produce specialty portland cements, such as masonry cement.

III.B. Raw Material Inputs and Pollution Outputs

Although the stone, clay, glass, and concrete products industry produces a wide array of products, the pollution outputs for this industry are generally limited to particulate emissions, certain solid wastes associated with raw material handling and plant maintenance, and wastewater resulting from the mixing, melting, and refining of raw materials, and the finishing of the final product. Processes in this industry often entail the heating and mixing of materials in a kiln and the use of water as a cooling agent or as an ingredient in making the final product. The fuel used to operate a kiln is itself a source of pollution. The following subsections describe the types of pollution outputs generated in manufacturing of products made of stone, clay, glass, and concrete (See Exhibit 7).

Stone

The manufacture of cut stone and stone products generates fugitive dusts, wastewater, and plant maintenance waste. To create products made of stone, the shape of the stone must be altered through cutting, shaping, and finishing, which can release fugitive dust. For a given type of stone, the chemical composition of the dust generated tends to be rather homogeneous, since its ancestry is the rock formation from which the stone was taken. Process wastewater is also generated through its use as cooling water during the cutting process. Plant maintenance wastes include waste oil from stone processing equipment.

Clay

The wastes generated from manufacturing structural clay products result mainly from handling raw materials, particulate emissions, plant maintenance, and pollution control equipment. Raw materials become wastes when they are spilled, off-spec, or out of date. Significant processing losses occur with kaolin and fuller's earth. About 40 percent of the kaolin and 30 percent of the fuller's earth delivered to the processing plants is discarded. Waste material from processing consists mostly of off-grade clays and small quantities of feldspar, iron-bearing minerals, mica, and quartz.

Various phases of the clay production process generate particulate emissions. The main source of dust is the materials handling process, which includes pulverizing, screening, and storing the raw material. Exhibit 6 illustrates the phases of the clay manufacturing process, during which major particulate emissions occur.

Exhibit 6
Particulate Emissions from Clay Manufacturing

(P) indicates a major source of particulate emissions.
Source: AP-42, 1986.

Pollution control wastes from the clay industry include dust accumulated in baghouses and the solid residues from wet scrubbers used to treat nitrogen oxide emissions. Plant maintenance waste consists primarily of waste oil, which is generated from many types of mechanical equipment.

Wastes generated during the manufacturing of pottery products comes mainly from the use of paints, glazes, and finishes. These materials may be solvent- or water-based, with varying heavy metal content. Where solvent-based finishes are used, solvents are used to clean the paint line and application equipment. The sludge waste generated from this cleaning is typically managed off-site by a solvent recycler or is recovered for fuel blending. When water-based finishes are used, the paint line and equipment are cleaned with water. Depending on the location of the plant and content of this waste, the wastewater discharge may be subject to regulation due to the presence of heavy metals. In addition, the sludge accumulated prior to discharge may be a hazardous waste due to heavy metal content (sludges generated in the pottery industry commonly contain traces of glaze which may contain lead, mercury, and boron).

Certain pottery manufacturers also generate dry powder waste from pollution control equipment. The sludge generated from equipment washing is commonly from glaze lines, glaze mills, glaze tanks and containers, and wet filters. About 10 percent (by weight) of the glaze used ends up in sludges. It is estimated that for each square meter of tile surfaced glazed, 100 grams of glaze waste is generated.

Manufacturers of clay products often use sintering to drive off entrained volatile matter from the clay. Because it is desirable for the clay to contain a sufficient amount of volatile matter so that the resultant aggregate will not be too heavy, it is sometimes necessary to mix the clay with finely pulverized coke prior to sintering. The addition of pulverized coke presents an emissions problem because sintering coke-impregnated clay produces more particulate emissions than the sintering of natural clay.

Glass

Waste generated in the glass industry can be categorized into three groups: 1) materials handling waste, 2) pollution control equipment waste, and 3) plant maintenance waste. Materials handling waste includes the waste generated during the receiving and transfer of raw materials at the facility for storage or processing, including raw materials that are rendered unusable when spilled during receiving or transfer.

Emissions control equipment at glass manufacturing plants generates waste residues from the pollutants produced and captured during the melting, forming, and finishing steps of the manufacturing process. The melting of raw materials to produce glass creates air emissions consisting of particulates, nitrogen oxides, and sulfur oxides generated from the combustion of fuel and the evaporation or dissociation of raw materials. Emissions are also generated during the forming and finishing of glass products as a result of thermal decomposition of lubricants.

Glass plants may also remove pollutants through the use of aqueous media, filters, and precipitators. A quench reactor, which reacts sulfur dioxide from furnace emissions with water and sodium carbonate, is an example of an aqueous emission control device. When the water evaporates upon contact with flue gases, a solid residue results. The residue may contain selenium, chromium, cadmium, cobalt, lead, and sodium sulfate. Arsenic, which is used in glass manufacturing for glass decolorizing, and stannic acid, a lubricant used to coat glass bottles to prevent breakage and which produces hydrochloric acid when it thermally decomposes, are usually removed by reaction with aqueous media, or physically captured by filters or precipitators. Glass manufacturers may use baghouse filters to capture particulate emissions. Baghouse dust residue can often be recycled back into the manufacturing process. To control nitrogen oxide emissions, a method called selective noncatalytic reduction (SNCR) has been used. SNCR reduces flue gas nitrogen oxide through a reaction with ammonia in a temperature range of 1700-1900°F. The ammonia may be supplied as anhydrous ammonia, aqueous ammonia, or urea. At temperatures above 1900°F, the oxidation of ammonia and nitrogen oxide increases and SNCR may actually increase levels of nitrogen oxide. At temperatures below 1700°F, nitrogen oxide reduction falls off and ammonia breakthrough increases, leading to the potential for a visible ammonium-chloride plume.

Glass plant maintenance wastes include waste oil and solvents generated in the forming process, furnace slag, and refractory wastes. During the forming process, oil is used in the forming machines and often contaminates the water that keeps the machines cool. TCA (1,1,1-trichloroethane) may also be used during the forming process to remove a thin layer of graphite coating that is applied to the glass forms or molds. When the coating is too thick or lumpy, the mold is sprayed with TCA, which readily dissolves and removes the graphite coating and evaporates. Furnace slag consists of chunks of unused molten glass which collect in the incinerator portion of the furnace. The composition of the slag is primarily magnesium oxide and sodium sulfate. Another type of plant maintenance waste is water-based glue, which is applied with a gun to glass packaging boxes. The water used to clean the glue guns is typically discharged to the plant's sewer system. Glue that has solidified in its container typically goes to a municipal landfill.

Fiberglass manufacturers also produce materials handling waste, pollution control waste, and plant maintenance waste. As in other glass manufacturing, the major air emission problem associated with fiberglass production is related to the melting and refining furnace operation. The emissions from this operation include fine particulates, including calcium carbonate, sodium fluoride, sodium fluorosilicate, silica, calcium fluoride, aluminum silicate, sodium sulfate, and boron oxides. Gases emitted include fluorides, sulfur oxides, nitrogen oxides, boric acid, carbon dioxide, and water vapor.

Much of the glass in the waste stream is not generated during the manufacturing process, but results from disposal of used glass products. Approximately 13.2 million tons of glass waste are generated annually. Food and beverage containers make up over 90 percent of this amount; the remaining 10 percent comes from products like cookware and glassware, home furnishings, and plate glass. Glass constitutes 6.7 percent of the municipal solid waste stream.

Concrete

Concrete batching generates particulate emissions, paint wastes, and plant maintenance wastes. Particulate emissions which occur in concrete batching consist primarily of cement dust, but some sand and gravel dust emissions also occur. Dust emissions most often occur during the unloading and conveying of concrete and aggregates at manufacturing plants and during the loading of dry-batched concrete mix. Another source of particulate emissions is the traffic of heavy equipment over unpaved or dusty surfaces in and around the plant. Particulate control techniques include the enclosure of dumping and loading areas and of conveyors and elevators, the use of filters on storage bin vents, and the use of water sprays to prevent dust from occurring.

Manufacturers who apply finishes to concrete products generate various paint wastes. When solvent-based paints are used, the spray guns and application equipment must be cleaned with solvent, producing spent solvent waste. The type of coating system used determines the type of solvent used. For example, if the coating system uses TCA, TCA must also be used to clean the equipment. When water-based coatings are used, wastewater from equipment cleaning will be generated. Other wastes generated by concrete plants include equipment and repair wastes, including waste oil generated from vehicle maintenance operations.

The production of lime results in several types of pollutants. Air emissions associated with lime manufacturing include particulate matter from crushing, screening, and calcining of the limestone and combustion products from the kilns. Nitrogen oxides, carbon monoxide, and sulfur dioxide are all produced in lime kilns. Methods of emission control include wet scrubbers (particle control using liquid such as water), baghouses (particle control using filtration fabric), cyclones (particles forced into a cyclone-shaped vortex), and electrostatic precipitators (particle control using electrical forces).

Cement

Pollution outputs from cement manufacturing plants include process waste, primarily cement kiln dust; air emissions; wastewater; plant maintenance waste, such as waste oil from equipment lubrication; and research and laboratory waste. Cement kiln dust is the largest waste stream from cement plants. It is commonly collected in baghouses installed in the grinders and is disposed of as non-hazardous waste. To provide a factual basis for determining the appropriate future regulatory status of cement kiln dust, EPA has conducted extensive research into the characteristics of cement kilns and presented its findings in a 1993 Report to Congress on Cement Kiln Dust. EPA determined that the major constituents of cement kiln dust are alumina, silica, metallic oxides, and clay (the primary constituents of cement itself). Cement kiln dust may also contain trace amounts of organic chemicals, such as dioxins and furans; heavy metals, such as cadmium, lead, and selenium; and certain radionuclides.

Cement plants also generate particulate and gaseous air emissions. Sources of particulate emissions include raw material storage, grinding and blending, clinker production, finish grinding, and packaging. The largest emission source within cement plants is the kiln operation, which includes the feed system, the fuel firing system, and the clinker cooling and hauling system. The kiln generates nitrogen oxides, sulfur oxides, carbon monoxide, and hydrocarbons as part of the normal combustion of fuel used to supply heat for cement kilns and drying operations. Cement kilns also emit particulate matter, trace metals, and certain organic compounds (AP-42, 1991).

The cement manufacturing process also generates wastewater from the cooling of process equipment and from the recovery of cement kiln dust through wet scrubbing of kiln stack emissions. The pollutants contained in raw wastewater are principally dissolved solids (potassium and sodium hydroxide, chlorides, and sulfates), suspended solids (calcium carbonate), and waste heat. The main control and treatment methods for wastewater involve recycling and reusing wastewater. The devices employed include cooling towers or ponds, settling ponds, containment ponds, and clarifiers. Cooling towers or ponds are used to reduce the temperature of water used in cooling process equipment. Settling ponds are used to reduce the concentration of suspended solids. Containment ponds are used to dispose of waste kiln dust. Clarifiers are used to separate solids.

Plant maintenance waste at cement plants comes from machinery used in production of the clinker and finishing and grinding operations. This machinery generates a variety of waste oils and other lubrication waste. Certain cement manufacturers have in-house laboratories to conduct product testing and research, which may produce solid and/or hazardous wastes.

Exhibit 7
Process Material Input/Pollutant Output

Process	Material Input	Air Emissions	Process Wastes	Other Waste

Concrete Product Manufacturing	Cement, sand, gravel, limestone, aggregate material	Cement dust, sand and gravel dust, constituents from burning of fuel	Total dissolved solids (potassium and sodium hydroxide), total suspended solids (calcium carbonate), pH, waste heat	Equipment and repair waste, paint wastes
Cement Manufacturing	Lime, silica sand, alumina, iron, gypsum, by-products (fly ash, metal smelting slags, mill scale)	Cement kiln dust, constituents from burning of fuel, particulate matter, sulfur dioxide, trace metals, organic compounds	Total dissolved solids (potassium and sodium hydroxide), total suspended solids (calcium carbonate), pH, waste heat	Cement kiln dust, waste oil, laboratory wastes, waste oil
Glass Product Manufacturing	Silica sand, soda ash, limestone, cullet, oxides	Particulates, fluorides, fugitive dust, sulfur dioxide	Total dissolved solids, total suspended solids, pH, heavy metals	Materials handling waste, furnace slag, waste oil
Clay Product Manufacturing	Kaolinite clay, montmorillonite clay, glazes containing heavy metals	Particulates, fluorides, acid gases	Total dissolved solids, total suspended solids, pH	Materials handling waste, fired and unfired scrap, waste oil, paint wastes
Stone Product Manufacturing	Dimension stone	Particulate emissions	Wastewater containing dust	Waste rock, waste oil

Sources: Compiled from Environmental Sources and Emissions Handbook, Air Pollution Engineering Manual, and McGraw-Hill Encyclopedia of Science & Technology.

III.C. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (EPA) requires facilities to report information about the management of TRI chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R beginning with the 1991 reporting year. The data summarized below cover the years 1992-1995 and is meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention compliance assistance activities.

While the quantities reported for 1992 and 1993 are estimates of quantities already managed, the quantities reported for 1994 and 1995 are projections only. The EPA requires these projections to encourage facilities to consider future waste generation and source reduction of those quantities as well as movement up the waste management hierarchy. Future-year estimates are not commitments that facilities reporting under TRI are required to meet.

Exhibit 8 shows that the stone, clay, and concrete products industry managed about 1.18 billion pounds of production-related waste (total quantity of TRI chemicals in the waste from routine production operations) in 1993 (column B). Column C reveals that of this production-related waste, 2.3% was either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases by the total quantity of production-related waste. In other words, about 96% of the industry's TRI wastes were managed on-site through recycling, energy recovery, or treatment as shown in columns D, E and F, respectively. The majority of waste that is released or transferred off-site can be divided into portions that are recycled off-site, recovered for energy off-site, or treated off-site as shown in columns G, H, and I, respectively. The remaining portion of the production-related wastes (2.2%), shown in column J, is either released to the environment through direct discharges to air, land, water, and underground injection, or it is disposed off-site.

From the yearly data presented below it is apparent that the portion of TRI wastes reported as recycled on-site has remained fairly constant and the portions treated or managed through energy recovery on-site have generally decreased between 1992 and 1995 (projected).

Exhibit 8
Source Reduction and Recycling Activity for SIC 32

A	B	C	D	E	F	G	H	I	J
Year	**Production Related Waste Volume (10^6lbs.)***	% Reported as Released and Transferred	**On-Site**			**Off-Site**			**Remaining Releases and Disposal**
			% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	
1992	1,259	3.6%	7.52%	73.83%	15.65%	0.21%	0.33%	0.34%	2.21%
1993	1,186	2.3%	8.59%	67.14%	20.76%	0.26%	0.52%	0.50%	2.23%
1994	1,212	—	8.55%	68.40%	20.37%	0.19%	0.16%	0.23%	2.10%
1995	1,449	—	7.38%	73.23%	17.16%	0.15%	0.24%	0.13%	1.72%