AP42 Section: 11.31

Title: Comments to Abrasives Manufacturing Section

1993

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DRAFT

SEP 2 1993

Mr. Allen Wherry
Manager, Grinding Wheel Institute
30200 Detroit Road
Cleveland, Ohio 44145

Dear Mr. Wherry:

As you may know, the Emission Inventory Branch of the U. S. Environmental Protection Agency (EPA) is in the process of updating the document *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (known more commonly as AP-42). As part of this process, we are now seeking comments on the draft sections that are to be included in this update of AP-42.

Chapter eight of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.31, Abrasive Products Manufacturing, and the corresponding background report for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and background report and would send us your comments. It would also be helpful if you could distribute copies of the enclosed section and background report to members of your association for their review. Unfortunately, we are on a very tight schedule, and it is important that we have all comments by October 22, 1993.

The emission factors presented in AP-42 generally are based upon results from validated tests or other emission evaluations that are similar to EPA reference test methods. As a result, revisions to the emission factors presented in AP-42 sections must be supported by equivalent documentation. If you disagree with any emission factors presented in the enclosed AP-42 section or have additional supporting documentation, we would appreciate your providing either a copy of the documentation or information on how we can obtain copies of the supporting documentation.

We appreciate your cooperation and look forward to receiving your comments. If you have any questions, I can be reached by telephone at (919) 541-5407 or by fax at (919) 541-0684.

Sincerely,

Ronald E. Myers
Emission Factors and Methodologies Section
Emission Inventory Branch

2 Enclosures

OAQPS/TSD/EIB:RMyers, rm 455B, 4201 Bldg., 541-5407, MD-14
(MRI/RMarinshaw/LKaufman/677-0249/09/01/93)

IDENTICAL LETTER SENT TO THE FOLLOWING ADDRESSEES:

Mr. Ted Giese
Business Manager
Abrasive Engineering Society
108 Elliott Drive
Butler, Pennsylvania 16001
Mr. Giese
8.31, Abrasive Products Manufacturing
October 15, 1993

Ms. Susan Young
Account Executive
Coated Abrasives Manufacturers' Institute
1300 Sumner Avenue
Cleveland, Ohio 44115-2851
Ms. Young
8.31, Abrasive Products Manufacturing
October 15, 1993

GRINDING WHEEL INSTITUTE / ABRASIVE GRAIN ASSOCIATION
30200 DETROIT ROAD • CLEVELAND, OHIO 44145-1967 • (216) 899-0010 • FAX (216) 892-1404 • TELEX 98-5559
WHERRY ASSOCIATES, MANAGERS

September 15, 1993

Mr. Ronald E. Myers
United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Myers,

It was nice talking to you by phone the other day. As I mentioned, we have a meeting of the Environmental & Occupational Safety Committee scheduled for the 23rd of September, and at which time, we will address you letter and its contents.

We will be in further contact with you after that session.

Very truly yours,

Allen P. Wherry

ALLEN P. WHERRY

APW:ra
cc: Brenda Pinkleton

NOTE:
THESE COMMENTS WERE INADVERTENTLY OVERLOOKED WHEN FINALIZING THE AP-42 SECTION / BACKGROUND REPORT. WHEN THIS SECTION IS NEXT REVISED THESE COMMENTS SHOULD BE INCORPORATED.

7/6/94

GRINDING WHEEL INSTITUTE / ABRASIVE GRAIN ASSOCIATION
30200 DETROIT ROAD • CLEVELAND, OHIO 44145-1967 • (216) 899-0010 • FAX (216) 892-1404 • TELEX 98-5559
WHERRY ASSOCIATES, MANAGERS

October 22, 1993

Mr. Ronald E. Myers
United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Myers:

This is a summary of changes/revisions to the EPA's emission report. Please note also, the handwritten changes on the enclosure. Comments were gathered from our various experts, hence the 'I would...'.

1. Second full paragraph beginning "Resin-bonded wheels..., (page 9)" I would change the word mixture after the wheel is pressed to "pressed mixture". The fourth and fifth sentence should read, "During the curing period, the pressed mixture first softens and then hardens as the oven reaches curing temperature. After cooling, the pressed mixture retains its cured hardness.

The Shellac (last paragraph) should be re-written as follows;

Shellac bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a mixer. Next, wheels are hot or cold pressed depending on product design and are generally molded with a slight degree of oversize to allow for shrinkage during the cure. After pressing, the wheels are set in quartz sand and baked anywhere from 1 to 3 days depending on product (300 degrees F). The finishing and inspection process are similar to those for other types of wheels.

SiC
1. Delete "arc" from ... resistance arc furnace" ... in paragraph 1.
2. Sawdust and salt are optional in furnace mix.
3. Black SiC is made from old, partially ? mix and new mix. Green is made from all new mix.
4. Voltages start as high as 500 and drop to 200.
5. Core temperatures reaches 2400°F).

Alumina
1. The description is for brown fused alumina, not for white. White fused alumina starts with a pure alumina, not bauxite.
2. Some alumina is cooled as pig. Some is cast as igots which gives smaller crystal structure and means crushing small chunks.

Grinding Wheels
Magnesium oxychloride has been used as a bond, but apparently very limited in application.

If you have any questions, please contact me directly.

Sincerely,

J. J. WHERRY

JJW:ra

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mark-up copy

Emission Factor Documentation for AP-42 Section 8.31

Abrasives Manufacturing

Draft Report

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

August 24, 1993

EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 8.31
Abrasives Manufacturing

1. INTRODUCTION

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

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

1. Estimates of areawide emissions;

2. Estimates of emissions for a specific facility; and

3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information from test reports and other information to support preparation of AP-42 Section 8.31, Abrasives Manufacturing.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the bonded abrasive products industry. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from the manufacture of bonded abrasive products. Section 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details the development of pollutant emission factors for the draft AP-42 section. It includes the review of specific data sets and the results of data analysis. Section 5 presents the AP-42 Section 8.31, Abrasives Manufacturing.

2. INDUSTRY DESCRIPTION[1]

The abrasives industry is composed of approximately 400 companies engaged in several separate industries: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. The abrasive grain industry manufactures abrasive grains for use by the other abrasive industries to manufacture abrasive products. The bonded abrasives industry is very diversified and includes the production of grinding stones and wheels, cutoff saws for masonry and metals, and other products. Coated abrasive products manufacturers include those facilities that produce large rolls of abrasive-coated fabric or paper, known as jumbo rolls, and those facilities that manufacture belts and other products from jumbo rolls for end use.

The Standard Industrial Classification (SIC) code for abrasives manufacturing is 3291, which is the code for abrasive products. This SIC code encompasses abrasive grain production, coated and bonded abrasive products manufacturing, and several related industries. There is currently no Source Classification Code (SCC) for the industry. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

2.1 PROCESS DESCRIPTION[1-6]

The process description is broken into three distinct segments discussed in the following sections: production of the abrasive grains, production of bonded abrasive products, and production of coated abrasive products.

Abrasive Grain Manufacturing

The most commonly used abrasive materials are aluminum oxides and silicon carbide. These synthetic materials account for as much as 80 to 90 percent of the total quantity of abrasive grains produced domestically. Other materials used for abrasive grains are cubic boron nitride (CBN), synthetic diamonds, and several naturally occurring minerals such as garnet and emery. Cubic boron nitride is used for machining the hardest steels to precise forms and finishes. The largest application of synthetic diamonds has been in wheels for grinding carbides and ceramics. Natural diamonds are used primarily in diamond tipped drill bits and saw blades for cutting or shaping rock, concrete, grinding wheels, glass, quartz, gems, and high-speed tool steels. Other naturally occurring abrasive

materials (including garnet, emery, silica sand, and quartz) are used in finishing wood, leather, rubber, plastics, glass, and softer metals.

The following paragraphs describe the production of aluminum oxide, silicon carbide, CBN, and synthetic diamond.

1. Silicon carbide. Silicon carbide (SiC) is manufactured in a resistance arc furnace, which is a refractory enclosure, typically 3 meters (m) (10 feet [ft]) high, 3 m (10 ft) wide, and up to 12 m (40 ft) long with a carbon graphite electrode entering the furnace at both ends. The furnace is charged with a mixture of approximately 60 percent silica sand and 40 percent finely ground petroleum coke. A small amount of sawdust is added to the mix to increase its porosity so that the carbon monoxide gas formed during the process can escape freely. Common salt is added to the mix to serve two purposes. First, it acts as a catalyst to promote the carbon-silicon reaction. Second, it assists in the purification of the silicon carbide because it combines with impurities in the sand and coke to form chlorides, which can then be eliminated from the mix by volatilization. The furnace is half filled with this mixture then a core of granular carbon (graphite), which serves as an electrical conductor, is laid down between the two electrodes in the ends of the furnace. The furnace is then completely filled. Some furnaces may contain as much as 90,000 kilograms (kg) (200,000 pounds [lb]) of mix which could yield up to 11,000 kg (25,000 lb) of silicon carbide.

Approximately 300 volts is applied to the electrodes for up to 36 hours, over which time the voltage drops to 200 volts. During the heating period, the furnace core reaches approximately 2200°C (4000°F), at which point a large portion of the load crystallizes. After a prescribed period at the target temperature, the furnace is cooled for about 24 hours, and then the side walls of the furnace are removed to expose the charge. At the end of the run, the furnace contains a core of loosely knit silicon carbide crystals surrounded by unreacted or partially reacted raw materials. The silicon carbide crystals are removed to begin processing into abrasive grains. The center core of graphite is usually saved to be reused, as is the partially reacted or unreacted mixture.

2. Aluminum oxide. Fused aluminum oxide (Al_2O_3) is produced in pot-type electric-arc furnaces with capacities of several tons. Before processing, bauxite, the crude raw material, is calcined at about 950°C (1740°F) to remove both free and combined water. The bauxite is then mixed with ground coke (about 3 percent) and iron borings (about 2 percent). The coke is added to

reduce the impurities in the bauxite to the elemental state. The iron combines with the reduced impurities to produce, after solidification, a magnetic "button" at the bottom of the furnace.

The bottom of an open cylindrical pot furnace is covered with carbon bricks. The sides are left uncovered and are cooled by water jets once the furnace is in operation. The furnace is half filled with the bauxite mixture and two or three vertical electrodes are lowered into the furnace. A starter charge of metallurgical coke is placed between the electrodes and the mixture. An electric current is applied and the intense heat, on the order of 2000°C (3700°F), melts the bauxite and reduces the impurities which settle to the bottom of the furnace. As the fusion process continues, more bauxite mixture is added until the furnace is full. The electrodes are automatically raised and lowered to maintain the correct temperature. This melting period may last from 16 to 36 hours, after which the furnace is left to cool for several days. The furnace is then emptied and the outer impure layer is stripped off. The core of aluminum oxide is then removed to be processed into abrasive grains.

3. Cubic boron nitride. Cubic boron nitride production requires extremely high temperatures and pressures comparable to those required for diamond manufacture. Cubic boron nitride is synthesized in crystal form from hexagonal boron nitride, which is composed of atoms of boron and nitrogen. The hexagonal boron nitride is combined with a catalyst such as metallic lithium at temperatures in the range of 1650°C (3000°F) and pressures of up to 6,895,000 kilopascals (kPa) (1,000,000 pounds per square inch [psi]). The intense heat and pressure in the presence of the catalyst causes the nitrogen atom to donate an electron to a boron atom which then forms a chemical bond to the nitrogen atom and forms a very strong crystalline structure similar to that of diamond.

Dick Sioui

4. Synthetic diamond. Synthetic diamond was first produced when iron sulfide, in a graphite tube closed with tantalum end disks, was subjected to a pressure of 9,653,000 kPa (1,400,000 psi) and 1600°C (2900°F) for several minutes. Now, industrial diamond is manufactured using pressures in the range of 5,571,000 to 13,100,000 kPa (808,000 to 1,900,000 psi) at temperatures in the range of 1400° to 2500°C (2500° to 4500°F). The catalyst solvent metal interface is crucial. Iron was first used, and subsequently chromium, cobalt, magnesium, nickel, platinum, rhodium, ruthenium, and tantalum have been used successfully. Variations in temperature, solvent, and pressure produce different types of diamond. Thus, crystals may be tailored for the optimum combination of size, shape, surface, and crystal structure for specific applications.

Abrasive Grain Processing

Abrasive grains for both bonded and coated abrasive products are made by graded crushing and close sizing of either natural or synthetic abrasives. Raw abrasive materials first are crushed by primary crushers and are then reduced to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]), by jaw crushers. Final crushing is usually accomplished with roll crushers which break up the small pieces into a usable range of sizes. The crushed abrasive grains are then separated into specific grade sizes by passing them over a series of screens. Grains are washed in classifiers to remove slimes, dried, passed through magnetic separators to remove iron-bearing material, and then the grains are again closely sized on screens. This careful sizing is necessary to prevent contamination of grades by coarser grains. Sizes finer than 0.10 millimeter (mm) (250 grit) are separated by hydraulic flotation and sedimentation or by air classification. Figure 2-1 presents a process flow diagram for abrasive grain processing.

Bonded Abrasive Products Manufacturing

The grains in bonded abrasive products are held together by one of six types of bonds: vitrified or ceramic (which accounts for more than 50 percent of all grinding wheels); resinoid (synthetic resin); rubber; shellac; silicate of soda; or oxychloride of magnesium. Figure 2-2 presents a process flow diagram for the manufacturing of vitrified bonded abrasive products.

Measured amounts of prepared abrasive grains are moistened and mixed with porosity media and bond material. Porosity media are used for creating voids in the finished wheels and consist of filler materials, such as paradichlorobenzene (moth ball crystals) or walnut shells, that are vaporized during firing. Feldspar and clays generally are used as bond materials in vitrified wheels. The mix is moistened with water or another temporary binder to make the wheel stick together after it is pressed. The mix is then packed and uniformly distributed into a steel grinding wheel mold, and compressed in a hydraulic press under pressures varying from 1,030 to 69,000 kPa (150 to 10,000 psi). If there is a pore inducing media in the mix, such as paradichlorobenzene, it is removed in a steam autoclave. Prior to firing, smaller wheels are dried in continuous dryers; larger wheels are dried in humidity-controlled, intermittent dry houses.

Most vitrified wheels are fired in continuous tunnel kilns in which the molded wheels ride through the kiln on a moving belt. However, large wheels are often fired in bell or periodic kilns.

OPTIONAL, BUT NOT NECESSARY

① NATURAL ABRASIVES ARE USED ONLY IN SELECTED COATED ABRASIVE PRODUCTS.
② OCCASIONALLY, MAN-MADE ABRASIVES WILL BE SENT THROUGH A "CALCINER" TO REMOVE EXCESS SULFUR. THE CALCINER — A GAS FIRED ROTARY KILN — DRIVES OFF SULFUR AS SO_x.

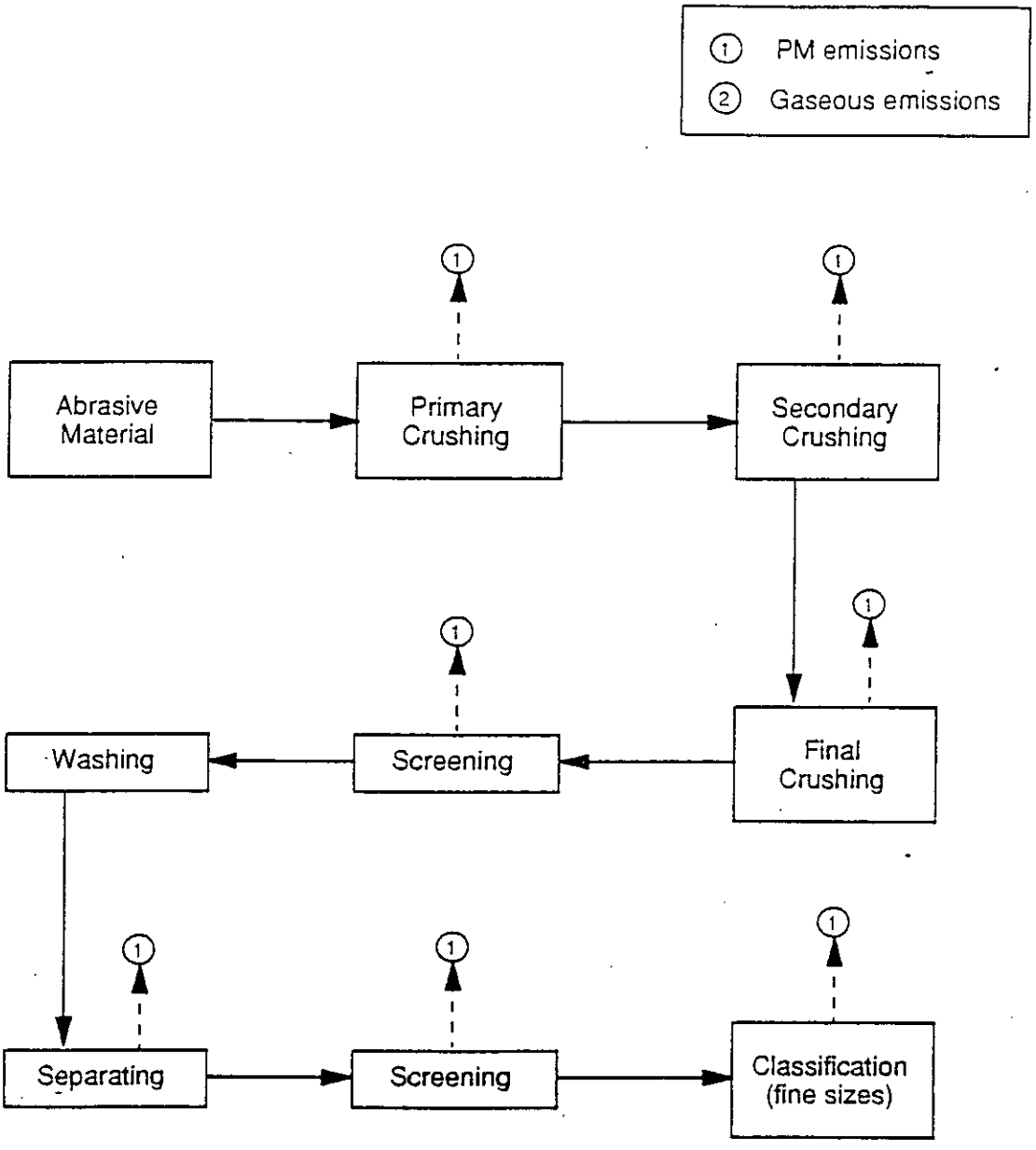

Figure 2-1. Process flow diagram for abrasive grain processing.

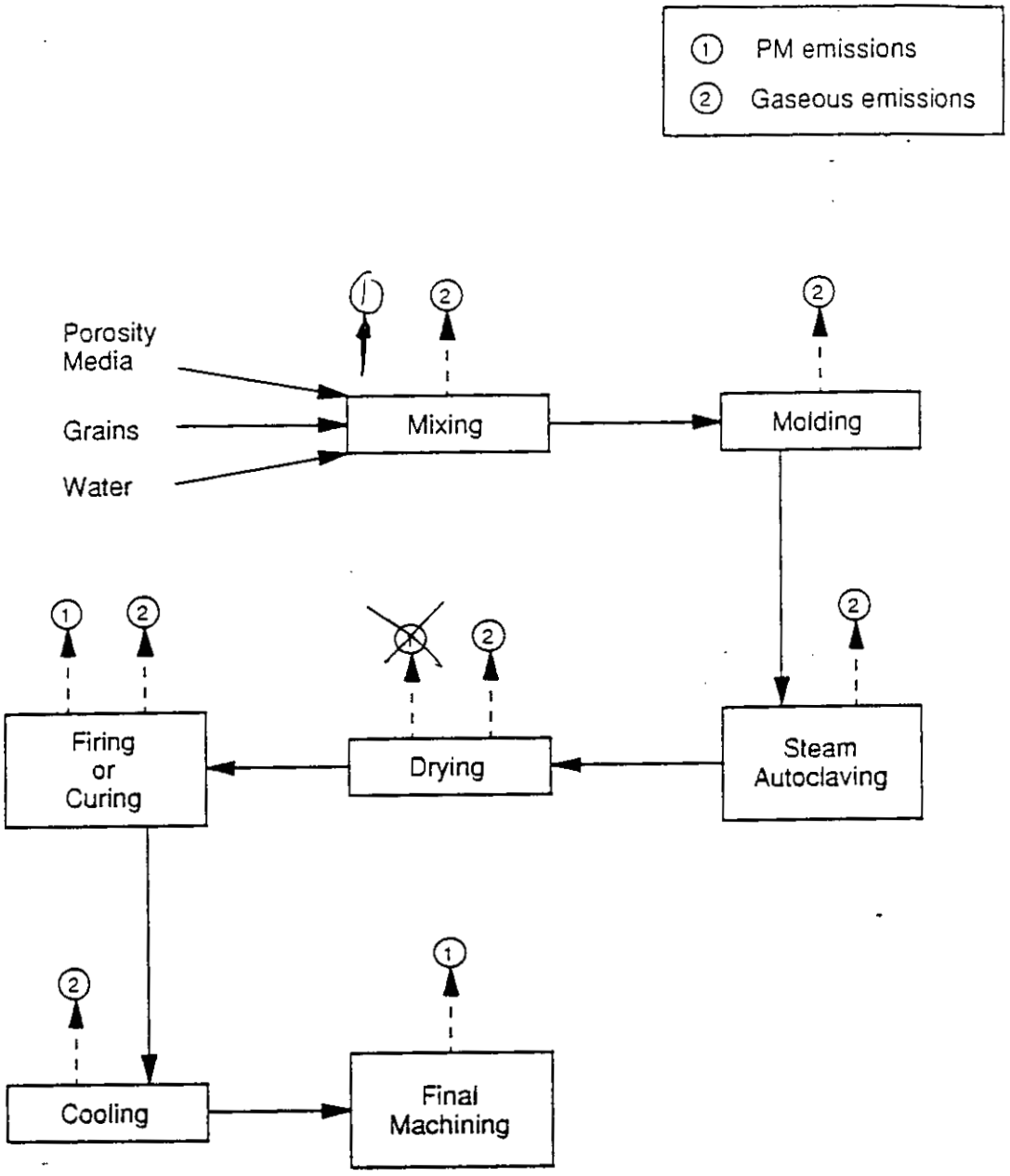

Figure 2-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.

In the firing process, the wheels are brought slowly to temperatures approaching 1400°C (2500°F) for as long as several days, depending on the size of the grinding wheels, ~~and the charge~~. This slow temperature ramp fuses the clay bond mixture so that each grain is surrounded by a hard glass-like bond that has high strength and rigidity. The wheels are then removed from the kiln and slowly cooled.

After cooling, the wheels are checked for distortion, shape, and size. The wheels are then machined to final size, balanced, and ~~o~~verspeed tested to ensure operational safety. Occasionally wax, ~~a~~nd oil, rosin, or sulfur are applied to improve the cutting effectiveness of the wheel.

Resin-bonded wheels are produced similarly to vitrified wheels, except that the bond material is a resin. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C (300° to 400°F) for a period of from 12 hours to 4 or 5 days, depending on the size of the wheel. During the curing period, the mixture first softens and then hardens as the oven reaches curing temperature. After cooling, the ~~m~~mixture retains its cured hardness. The remainder of the production process is similar to that for vitrified wheels.

Rubber-bonded wheels are produced by selecting the abrasive grain, sieving it, and kneading the grain into a natural or synthetic rubber. Sulfur is added as a vulcanizing agent and then the mix is rolled between steel calendar rolls to form a sheet of the required thickness. The grinding wheels are cut out of the rolled sheet to a specified diameter and hole size. Scraps are kneaded, rolled, and cut out again. Then the wheels are vulcanized in molds under pressure in ovens at approximately 150° to 175°C (300° to 350°F). The finishing and inspection processes are similar to those for other types of wheels.

Shellac-bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a steam-heated mixer, which thoroughly coats the grain with the bond material (shellac). Wheels 3 mm (0.125 in) thick or less are molded to exact size in heated steel molds. Thicker wheels are hot-pressed in steel molds. After pressing, the wheels are set in quartz sand and baked for a few hours at approximately 150°C (300°F). The finishing and inspection processes are similar to those for other types of wheels.

In addition to grinding wheels, bonded abrasives are formed into blocks, bricks, and sticks for sharpening and polishing stones such as oil stones, scythe stones, razor and cylinder hones. Curved abrasive blocks and abrasive segments are manufactured for grinding or polishing curved surfaces. Abrasive segments can also be combined into large wheels such as pulpstones. Rubber pencil and ink erasers contain abrasive grains; similar soft rubber wheels, sticks and other forms are made for finishing soft metals.

Coated Abrasive Products Manufacturing — Refer to Ralph Kenon - Troy

Coated abrasives consist of sized abrasive grains held by a film of adhesive to a flexible backing. The backing may be film, cloth, paper, vulcanized fiber, or a combination of these materials. Various types of resins, glues, and varnishes are used as adhesives or bonds. ~~The glue is typically animal hide glue.~~ The resins and varnishes are generally liquid phenolics or ureas, but depending on the end use of the abrasive, they may be modified to yield shorter or longer drying times, greater strength, more flexibility, or other required properties. Figure 2-3 presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, typically 1.3 m (52 in) wide and 46 m (150 ft) long, passing through a printing press which imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Then the backing receives the first application of adhesive bond, the "make" coat, in a carefully regulated film, varying in concentration and quantity according to the particle size of the abrasive to be bonded. Next, the selected abrasive grains are applied either by a mechanical or an electrostatic method. Virtually all of the abrasive grain used for coated abrasive products is either silicon carbide or aluminum oxide, augmented by small quantities of natural garnet or emery for woodworking, and minute amounts of diamond or CBN.

In mechanical application, the abrasive grains are poured in a controlled stream onto the adhesive-impregnated backing, or the impregnated backing is passed through a tray of abrasive thereby picking up the grains. In the electrostatic method, the adhesive-impregnated backing is passed adhesive-coated side down over a tray of abrasive grains, while at the same time passing an electric current through the abrasive. The electrostatic charge induced by the current causes the grains to imbed upright in the wet bond on the backing. In effect the sharp cutting edges of the grain are bonded perpendicular to the backing. It also causes the individual grains to be spaced more

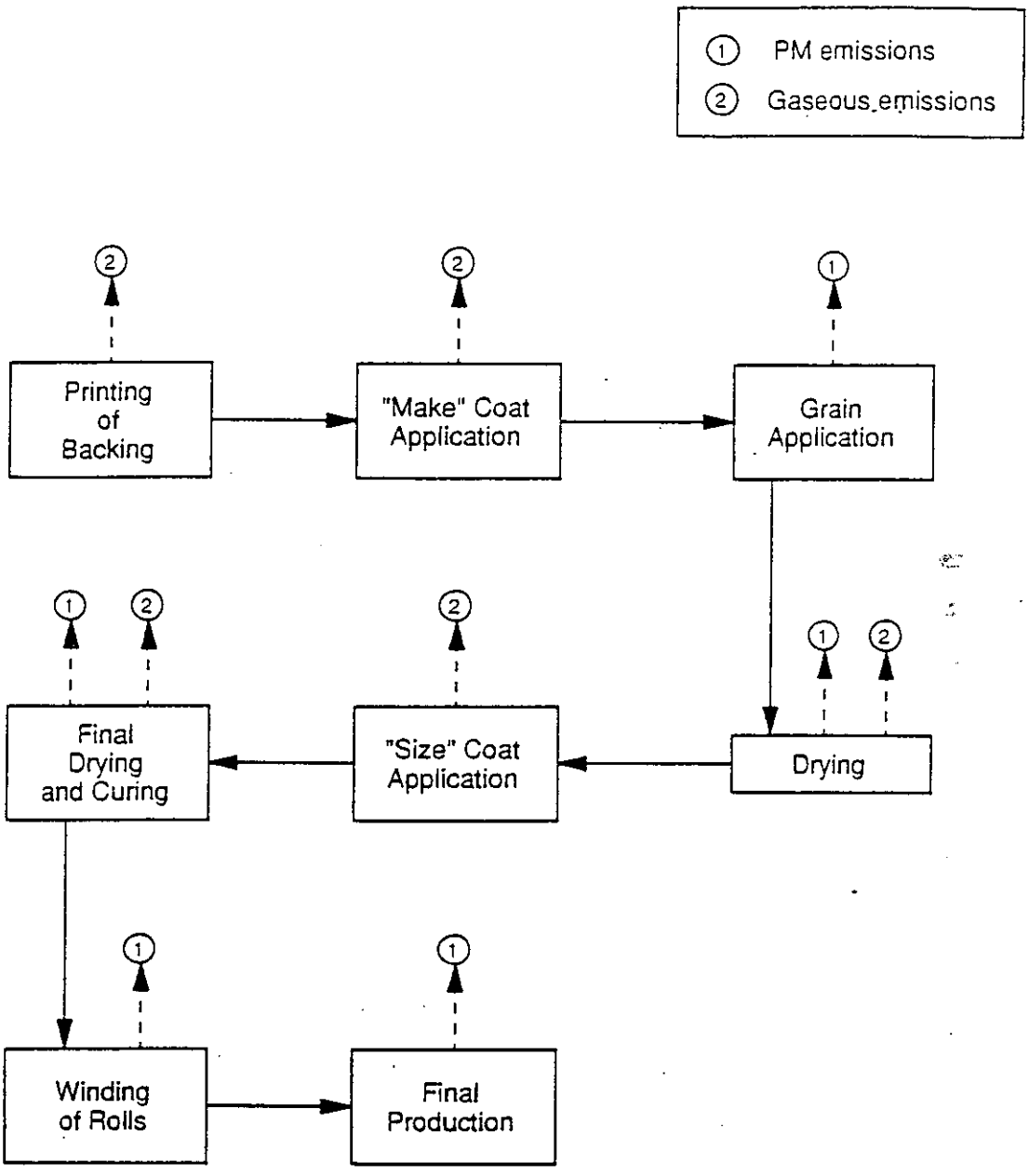

Figure 2-3. Process flow diagram for the manufacturing of coated abrasive products.

evenly due to individual grain repulsion. The amount of abrasive grains deposited on the backing can be controlled extremely accurately by adjusting the abrasive stream and manipulating the speed of the backing sheet through the abrasive.

After the abrasive is applied, the product is carried by a festoon conveyor system through a drying chamber to the sizing unit, where a second layer of adhesive, called the size coat, is applied. The size coat unites with the make coat to anchor the abrasive grains securely. The coated material is then carried by another longer festoon conveyor through the final drying and curing chamber in which the temperature and humidity are closely controlled to insure uniform drying and curing. When the bond is properly dried and cured, the coated abrasive is wound into jumbo rolls and stored for subsequent conversion into marketable forms of coated abrasives. Finished coated abrasives are available as sheets, rolls, belts, discs, bands, cones, and many other specialized forms.

2.2 EMISSIONS[1]

Little information is available on emissions from the manufacturing of abrasive grains and products. However, based on similar processes in other industries, some assumptions can be made about the types of emissions that are likely to result from abrasives manufacturing.

Emissions from the production of synthetic abrasive grains, such as aluminum oxide and silicon carbide, are likely to consist primarily of particulate matter (PM), PM less than 10 micrometers (PM-10) and carbon monoxide (CO) from the furnaces. ~~The PM~~ and PM-10 emissions are likely to consist of filterable, inorganic condensible, and organic condensible PM. The addition of salt and sawdust to the furnace charge for silicon carbide production is likely to result in emissions of chlorides and volatile organic compounds (VOC's). Aluminum oxide processing takes place in an electric arc furnace and involves temperatures up to 2600°C with raw materials of bauxite ore, silica, coke, iron borings, and a variety of minerals that include chromium oxide, cryolite, pyrite, and silane. This processing is likely to emit fluorides, sulfides, and metal constituents of the feed material.

The primary emissions from abrasive grain processing consist of PM and PM-10 from the crushing, screening, and classifying operations. Particulate matter also is emitted from materials handling and transfer operations.

Emissions generated in the production of bonded abrasive products may involve a small amount of dust generated by handling the loose abrasive, but careful control of sizes of abrasives particles limits the amount of fine particulate that can be entrained in the ambient air. However, for products made from finer grit sizes--less than 0.13 mm (200 grit)--PM emissions may be a significant problem. The main emissions from production of grinding wheels are generated during the curing of the bond structure for wheels. Heating ovens or kilns emit various types of VOC's depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Vitrified products produce some emissions as filler materials included to provide voids in the wheel structure are vaporized. Curing resins or rubber that is used in some types of bond systems also produce emissions of VOC's. Another small source of emissions may be vaporization during curing of portions of the chloride- and sulfur-based materials that are included within the bonding structure as grinding aids.

Emissions that may result from the production of coated abrasive products consist primarily of VOC's from the curing of the resin bonds and adhesives used to coat and attach the abrasive grains to the fabric or paper backing. Emissions from dryers and curing ovens also may include products of combustion, such as CO, CO_2, NO_x, and SO_x, in addition to filterable and condensible PM. Emissions that come from conversion of large rolls of coated abrasives into smaller products such as sanding belts consist of PM and PM-10. In addition, some VOC's may be emitted as a result of the volatilization of adhesives used to form joints in those products.

2.3 CONTROL TECHNOLOGY

Little information is available on the types of controls used by the abrasives industry to control emissions. However, it is assumed that conventional devices such as cyclones, scrubbers, fabric filters, and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

REFERENCES FOR SECTION 2

1. Telephone communication from Ted Giese, Abrasive Engineering Society, to R. Marinshaw, Midwest Research Institute, Cary, NC, March 1, 1993.

2. Stuart C. Salmon, Modern Grinding Process Technology, McGraw-Hill, Inc., New York, 1992.

3. Richard P. Hight, "Abrasives," Industrial Minerals and Rocks, Volume 1, Society of Mining Engineers, New York, NY, 1983.

4. Richard L. McKee, Machining With Abrasives, Van Nostrand Reinhold Company, New York, 1982.

5. Kenneth B. Lewis, and William F. Schleicher, The Grinding Wheel, 3rd edition, The Grinding Wheel Institute, Cleveland, OH, 1976.

6. Coated Abrasives-Modern Tool of Industry, 1st edition, Coated Abrasives Manufacturers' Institute, McGraw-Hill Book Company, Inc., New York, 1958.

3. GENERAL DATA REVIEW AND ANALYSIS

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained from a number of sources within the Office of Air Quality Planning and Standards (OAQPS) and from outside organizations. The docket for the development of new source performance standards (NSPS) for calciners and dryers in the mineral industries was reviewed for information on the industry, processes, and emissions. The Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF) and VOC/PM Speciation Data Base Management System (SPECIATE) data bases were searched by SCC for identification of the potential pollutants emitted and emission factors for those pollutants. A general search of the Air CHIEF CD-ROM also was conducted to supplement the information from these two data bases.

Information on the industry, including number of plants, plant location, and annual production capacities, was obtained from the Minerals Yearbook and Census of Manufactures. The Aerometric Information Retrieval System (AIRS) data base also was searched for data on the number of plants, plant location, and estimated annual emissions of criteria pollutants.

A number of sources of information were investigated specifically for emission test reports and data. A search of the Test Methods Storage and Retrieval (TSAR) data base was conducted to identify test reports for sources within the sand and gravel processing industry. Copies of these test reports were obtained from the files of the Emission Measurement Branch (EMB). The EPA library was searched for additional test reports. A list of plants that have been tested within the past 5 years was compiled from the AIRS data base. Using this information and information obtained on plant location from the Minerals Yearbook and Census of Manufactures, State and Regional offices were contacted about the availability of test reports. However, the information obtained from these offices was limited. Publications lists from the Office of Research and Development (ORD) and Control Technology Center (CTC) were also searched for reports on emissions from the sand and gravel processing industry. In addition, representative trade associations were contacted for assistance in obtaining information about the industry and emissions.

To reduce the amount of literature collected to a final group of references from which emission factors could be developed, the following general criteria were used:

1. Emission data must be from a primary reference:

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

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

2. The referenced study must contain test results based on more than one test run.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions. A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 EMISSION DATA QUALITY RATING SYSTEM

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3 EMISSION FACTOR QUALITY RATING SYSTEM

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

A--Excellent: Developed only from A-rated test data from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B--Above average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. The source category is specific enough so that variability within the source category population may be minimized.

C--Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D--Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E--Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

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

REFERENCES FOR SECTION 3

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections (Draft), Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 6, 1992.

4. AP-42 SECTION DEVELOPMENT

4.1 DEVELOPMENT OF SECTION NARRATIVE

The draft AP-42 section is a new section addressing abrasives manufacturing. The new section is based on information gathered from the references cited, and includes a description of the industry, process diagrams, and emission factors for specific process emission points.

4.2 POLLUTANT EMISSION FACTOR DEVELOPMENT

Two test reports were documented and reviewed in the process of developing the section on abrasive manufacturing. These reports are described in the following paragraphs. The emission factors developed from these references are presented in Table 4-1.

4.2.1 Review of Specific Data Sets

4.2.1.1 Reference 1. This report documents measurements of filterable PM from a rotary dryer used to remove water from copper and boiler slag for use as sand blasting grit. The purpose of the emission test was to demonstrate compliance with State regulations. The test was conducted in March 1992. Process rates were provided on the basis of raw material feed. The dryer emissions are controlled with a fabric filter.

Particulate matter emissions were measured using EPA Method 5 and two test runs were conducted. Carbon dioxide concentrations were measured with Fyrite analyzers, but were not presented in the report. Emission factors were developed only for filterable PM.

The emission data for filterable PM are rated C. The test methodology appears to be sound and no problems were reported. However, because only two runs were conducted, and the report lacked complete documentation of the test, a higher rating is not warranted.

4.2.1.2 Reference 2. This report documents measurements of filterable PM, metals, and CO_2 from a rotary kiln used to remove water from copper and boiler slag for use as sand blasting grit. The purpose of the emission test was to demonstrate compliance with State regulations. The

test was conducted in November 1988. Process rates were provided on the bases of raw material feed. The dryer emissions are controlled with a venturi scrubber.

Particulate matter emissions were measured using EPA Method 5. Only one run was conducted, therefore the emission factor developed from the data is unrated and was not incorporated in the draft AP-42 section. Orsat analysis was used to measure carbon dioxide concentrations in the exhaust. Metal emissions were measured using EPA Method 12 and two test runs were conducted. Emission factors were developed for 10 metals and CO_2.

The emission data for metals and CO_2 are rated C. The test methodologies appear to be sound and no problems were reported. However, because the process rates are given as ranges rather than as specific figures, only two test runs were conducted, and the report lacked complete documentation of the test, a higher rating is not warranted.

4.2.2 Review of XATEF and SPECIATE Data Base Emission Factors

No relevant information was found in these data bases.

4.2.3 Results of Data Analysis

Emission factors were developed from Reference 1 for filterable PM emissions from rotary dryers controlled by a fabric filter. Because the PM data from this reference are rated C, the emission factor for filterable PM emissions from rotary dryers is rated E.

Emission factors were developed from Reference 2 for CO_2 and 10 metals. Because the CO_2 and metals emission data from this reference are rated C, the emission factors for CO_2 and metals from rotary dryers are rated E.

The emission factors developed for abrasive manufacturing are presented in Table 4-2.

TABLE 4-1. SUMMARY OF TEST DATA FOR ABRASIVE MANUFACTURING ROTARY DRYERS--DRYING COPPER AND BOILER SLAG FOR SAND BLASTING GRIT

Type of control	Pollutant	No. of test runs	Data rating	Emission factor		Ref. No.
				Range kg/Mg (lb/ton)	Average kg/Mg (lb/ton)	
Fabric filter	Filterable PM	2	C	0.0070 - 0.0075 (0.014 - 0.015)	0.0073 (0.0145)	1
Wet scrubber	Filterable PM	1	C	NA	0.09 (0.18)	2
Wet scrubber	Antimony	2	C	4.0E-05 - 4.05E-05 (8.0E-05 - 8.1E-05)	4.03E-05 (8.05E-05)	2
Wet scrubber	Arsenic	2	C	0.00012 - 0.00012 (0.00024 - 0.00024)	0.00012 (0.00024)	2
Wet scrubber	Beryllium	2	C	4.1E-06 - 4.1E-06 (8.2E-06 - 8.2E-06)	4.1E-06 (8.2E-06)	2
Wet scrubber	Lead	2	C	0.0019 - 0.0025 (0.0038 - 0.0049)	0.0022 (0.0044)	2
Wet scrubber	Cadmium	2	C	0.00041 - 0.00055 (0.00081 - 0.0011)	0.00048 (0.00096)	2
Wet scrubber	Chromium	2	C	0.00019 - 0.00026 (0.00037 - 0.00052)	0.00023 (0.00045)	2
Wet scrubber	Manganese	2	C	2.4E-05 - 3.7E-05 (4.7E-05 -7.4E-05)	3.05E-05 (6.1E-05)	2
Wet scrubber	Mercury	2	C	8.5E-07 - 8.5E-07 (1.7E-06 - 1.7E-06)	8.5E-07 (1.7E-06)	2
Wet scrubber	Thallium	2	C	4.0E-05 - 4.05E-05 (8.0E-05 - 8.1E-05)	4.03E-05 (8.05E-05)	2
Wet scrubber	Nickel	2	C	0.0012 - 0.0014 (0.0023 - 0.0028)	0.0013 (0.0026)	2
Wet scrubber	CO_2	3	C	20 - 23 (39 - 46)	22 (43)	2

how does boiler slag correlate to abrasive manufacture with sand, coke, aluminum ore, etc.

TABLE 4-2. SUMMARY OF EMISSION FACTORS DEVELOPED FOR ABRASIVE MANUFACTURING

Process	Type of control	Pollutant	No. of tests	Average emission factor, kg/Mg (lb/ton)	Emission factor rating	Ref. Nos.
Rotary dryer: sand blasting grit	Fabric filter	Filterable PM	1	0.0073 (0.0145)	E	1
Rotary dryer: sand blasting grit	Wet scrubber	Antimony	1	4.03E-05 (8.05E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Arsenic	1	0.00012 (0.00024)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Beryllium	1	4.1E-06 (8.2E-06)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Lead	1	0.0022 (0.0044)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Cadmium	1	0.00048 (0.00096)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Chromium	1	0.00023 (0.00045)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Manganese	1	3.05E-05 (6.1E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Mercury	1	8.5E-07 (1.7E-06)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Thallium	1	4.03E-05 (8.05E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Nickel	1	0.0013 (0.0026)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	CO_2	1	22 (43)	E	2

WAS A "SAMPLE BLANK" SUBMITTED, SOME- SUCH AS THALLIUM MANGANESE LEAD — DO NOT EXIST IN CONCENTRATIONS ABOVE A FRACTION OF A PART-PER-MILLION

REFERENCES FOR SECTION 4

1. Source Sampling Report: Measurement of Particulates Rotary Dryer, MDC Corporation, Philadelphia, PA, Applied Geotechnical and Environmental Service Corp., Valley Forge, PA, March 18, 1992.

2. Source Sampling Report for Measurement of Particulate and Heavy Metal Emissions, MDC Corporation, Philadelphia, PA, Gilbert/Commonwealth, Inc., Reading, PA, November 1988.

5. DRAFT AP-42 SECTION 8.31

8.31 ABRASIVES MANUFACTURING

8.31.1 General[1]

The abrasives industry is composed of approximately 400 companies engaged in several separate industries: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. The abrasive grain industry manufactures abrasive grains for use by the other abrasive industries to manufacture abrasive products. The bonded abrasives industry is very diversified and includes the production of grinding stones and wheels, cutoff saws for masonry and metals, and other products. Coated abrasive products manufacturers include those facilities that produce large rolls of abrasive-coated fabric or paper, known as jumbo rolls, and those facilities that manufacture belts and other products from jumbo rolls for end use.

The Standard Industrial Classification (SIC) code for abrasives manufacturing is 3291, which is the code for abrasive products. This SIC code encompasses abrasive grain production, coated and bonded abrasive products manufacturing, and several related industries. There is currently no Source Classification Code (SCC) for the industry. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

8.31.2 Process Description[1-6]

The process description is broken into three distinct segments discussed in the following sections: production of the abrasive grains, production of bonded abrasive products, and production of coated abrasive products.

Abrasive Grain Manufacturing

The most commonly used abrasive materials are aluminum oxides and silicon carbide. These synthetic materials account for as much as 80 to 90 percent of the total quantity of abrasive grains produced domestically. Other materials used for abrasive grains are cubic boron nitride (CBN), synthetic diamonds, and several naturally occurring minerals such as garnet and emery. Cubic boron

nitride is used for machining the hardest steels to precise forms and finishes. The largest application of synthetic diamonds has been in wheels for grinding carbides and ceramics. Natural diamonds are used primarily in diamond tipped drill bits and saw blades for cutting or shaping rock, concrete, grinding wheels, glass, quartz, gems, and high-speed tool steels. Other naturally occurring abrasive materials (including garnet, emery, silica sand, and quartz) are used in finishing wood, leather, rubber, plastics, glass, and softer metals.

The following paragraphs describe the production of aluminum oxide, silicon carbide, CBN, and synthetic diamond.

1. Silicon carbide. Silicon carbide (SiC) is manufactured in a resistance arc furnace charged with a mixture of approximately 60 percent silica sand and 40 percent finely ground petroleum coke. A small amount of sawdust is added to the mix to increase its porosity so that the carbon monoxide gas formed during the process can escape freely. Common salt is added to the mix to promote the carbon-silicon reaction and to remove impurities in the sand and coke. During the heating period, the furnace core reaches approximately 2200°C (4000°F), at which point a large portion of the load crystallizes. At the end of the run, the furnace contains a core of loosely knit silicon carbide crystals surrounded by unreacted or partially reacted raw materials. The silicon carbide crystals are removed to begin processing into abrasive grains.

2. Aluminum oxide. Fused aluminum oxide (Al_2O_3) is produced in pot-type electric-arc furnaces with capacities of several tons. Before processing, bauxite, the crude raw material, is calcined at about 950°C (1740°F) to remove both free and combined water. The bauxite is then mixed with ground coke (about 3 percent) and iron borings (about 2 percent). An electric current is applied and the intense heat, on the order of 2000°C (3700°F), melts the bauxite and reduces the impurities which settle to the bottom of the furnace. As the fusion process continues, more bauxite mixture is added until the furnace is full. The furnace is then emptied and the outer impure layer is stripped off. The core of aluminum oxide is then removed to be processed into abrasive grains.

3. Cubic boron nitride. Cubic boron nitride is synthesized in crystal form from hexagonal boron nitride, which is composed of atoms of boron and nitrogen. The hexagonal boron nitride is combined with a catalyst such as metallic lithium at temperatures in the range of 1650°C (3000°F) and pressures of up to 6,895,000 kilopascals (kPa) (1,000,000 pounds per square inch [psi]).

4. Synthetic diamond. Synthetic diamond is manufactured by subjecting graphite in the presence of a metal catalyst to pressures in the range of 5,571,000 to 13,100,000 kPa (808,000 to 1,900,000 psi) at temperatures in the range of 1400° to 2500°C (2500° to 4500°F).

Abrasive Grain Processing

Abrasive grains for both bonded and coated abrasive products are made by graded crushing and close sizing of either natural or synthetic abrasives. Raw abrasive materials first are crushed by primary crushers and are then reduced to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]), by jaw crushers. Final crushing is usually accomplished with roll crushers which break up the small pieces into a usable range of sizes. The crushed abrasive grains are then separated into specific grade sizes by passing them over a series of screens. Grains are washed in classifiers to remove slimes, dried, passed through magnetic separators to remove iron-bearing material, and then the grains are again closely sized on screens. This careful sizing is necessary to prevent contamination of grades by coarser grains. Sizes finer than 0.10 millimeter (mm) (250 grit) are separated by hydraulic flotation and sedimentation or by air classification. Figure 8.31-1 presents a process flow diagram for abrasive grain processing.

Bonded Abrasive Products Manufacturing

The grains in bonded abrasive products are held together by one of six types of bonds: vitrified or ceramic (which accounts for more than 50 percent of all grinding wheels); resinoid (synthetic resin); rubber; shellac; silicate of soda; or oxychloride of magnesium. Figure 8.31-2 presents a process flow diagram for the manufacturing of vitrified bonded abrasive products.

Measured amounts of prepared abrasive grains are moistened and mixed with porosity media and bond material. Porosity media are used for creating voids in the finished wheels and consist of filler materials, such as paradichlorobenzene (moth ball crystals) or walnut shells, that are vaporized during firing. Feldspar and clays generally are used as bond materials in vitrified wheels. The mix is moistened with water or another temporary binder to make the wheel stick together after it is pressed. The mix is then packed and uniformly distributed into a steel grinding wheel mold, and compressed in a hydraulic press under pressures varying from 1,030 to 69,000 kPa (150 to 10,000 psi). If there is a pore inducing media in the mix, such as paradichlorobenzene, it is removed

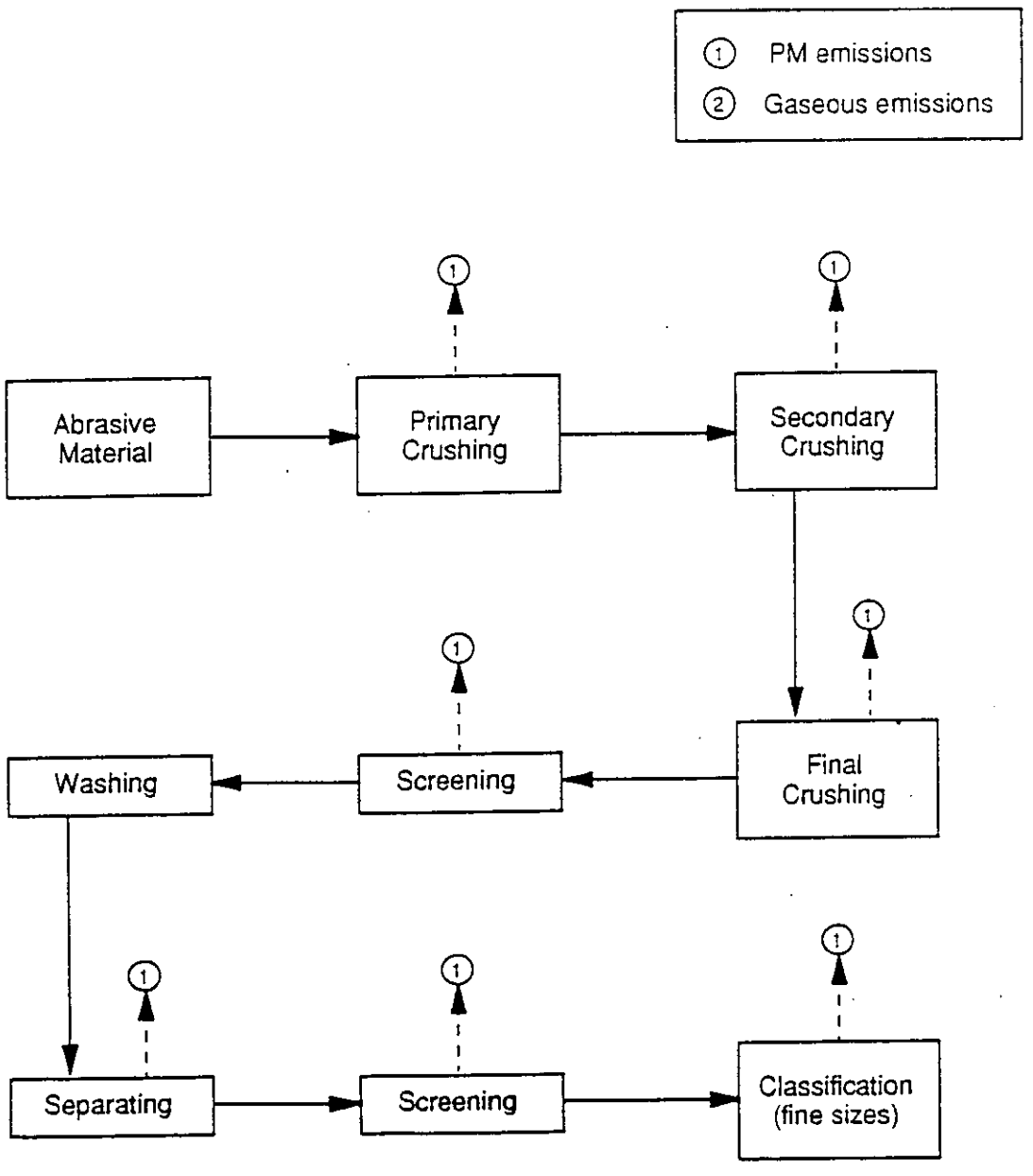

Figure 8.31-1. Process flow diagram for abrasive grain processing.

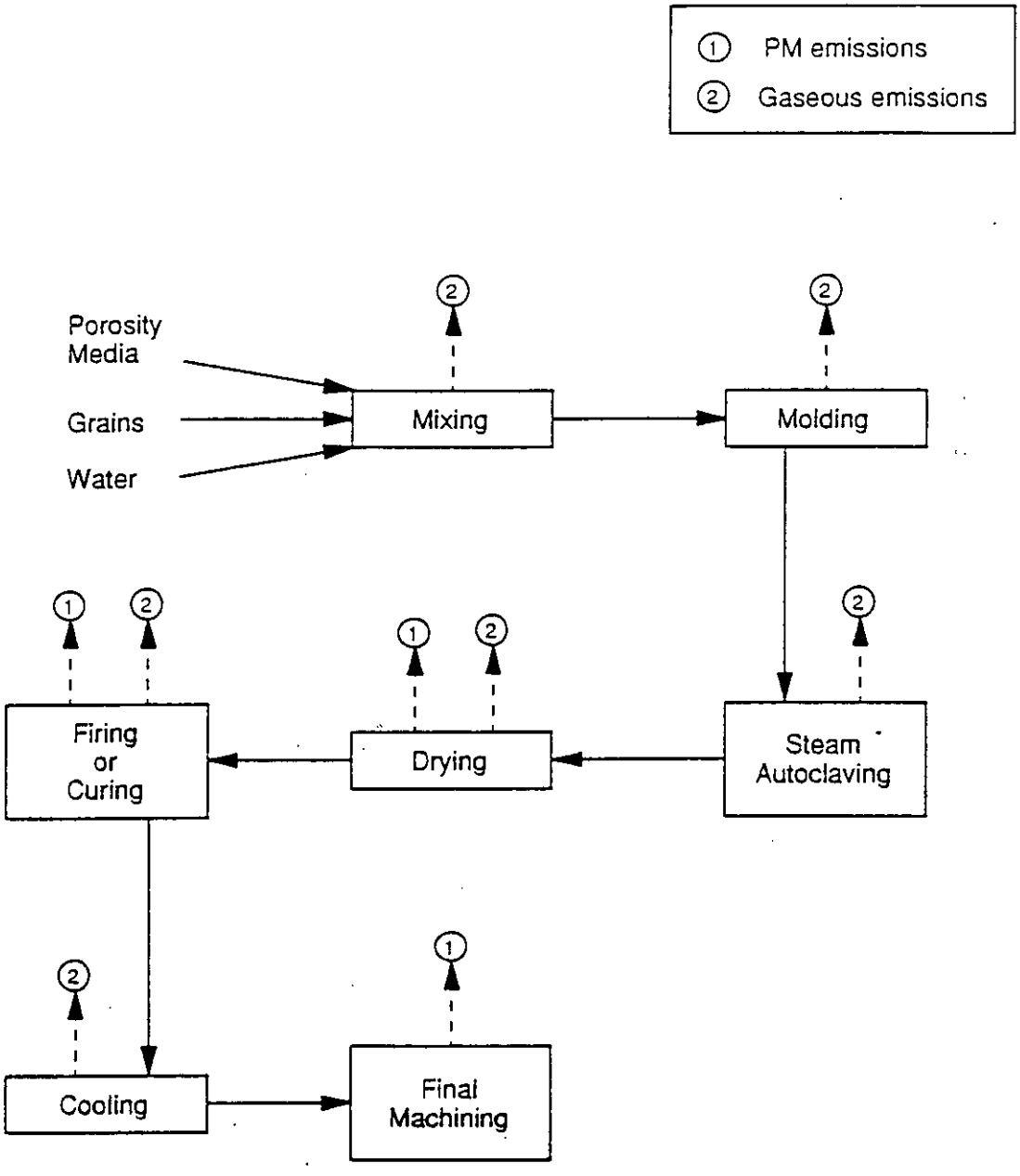

Figure 8.31-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.

in a steam autoclave. Prior to firing, smaller wheels are dried in continuous dryers; larger wheels are dried in humidity-controlled, intermittent dry houses.

Most vitrified wheels are fired in continuous tunnel kilns in which the molded wheels ride through the kiln on a moving belt. However, large wheels are often fired in bell or periodic kilns. In the firing process, the wheels are brought slowly to temperatures approaching 1400°C (2500°F) for as long as several days, depending on the size of the grinding wheels and the charge. This slow temperature ramp fuses the clay bond mixture so that each grain is surrounded by a hard glass-like bond that has high strength and rigidity. The wheels are then removed from the kiln and slowly cooled.

After cooling, the wheels are checked for distortion, shape, and size. The wheels are then machined to final size, balanced, and overspeed tested to ensure operational safety. Occasionally wax and oil, rosin, or sulfur are applied to improve the cutting effectiveness of the wheel.

Resin-bonded wheels are produced similarly to vitrified wheels, except that the bond material is a resin. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C (300° to 400°F) for a period of from 12 hours to 4 or 5 days, depending on the size of the wheel. During the curing period, the mold first softens and then hardens as the oven reaches curing temperature. After cooling, the mold retains its cured hardness. The remainder of the production process is similar to that for vitrified wheels.

Rubber-bonded wheels are produced by selecting the abrasive grain, sieving it, and kneading the grain into a natural or synthetic rubber. Sulfur is added as a vulcanizing agent and then the mix is rolled between steel calendar rolls to form a sheet of the required thickness. The grinding wheels are cut out of the rolled sheet to a specified diameter and hole size. Scraps are kneaded, rolled, and cut out again. Then the wheels are vulcanized in molds under pressure in ovens at approximately 150° to 175°C (300° to 350°F). The finishing and inspection processes are similar to those for other types of wheels.

Shellac-bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a steam-heated mixer,

which thoroughly coats the grain with the bond material (shellac). Wheels 3 mm (0.125 in) thick or less are molded to exact size in heated steel molds. Thicker wheels are hot-pressed in steel molds. After pressing, the wheels are set in quartz sand and baked for a few hours at approximately 150°C (300°F). The finishing and inspection processes are similar to those for other types of wheels.

In addition to grinding wheels, bonded abrasives are formed into blocks, bricks, and sticks for sharpening and polishing stones such as oil stones, scythe stones, razor and cylinder hones. Curved abrasive blocks and abrasive segments are manufactured for grinding or polishing curved surfaces. Abrasive segments can also be combined into large wheels such as pulpstones. Rubber pencil and ink erasers contain abrasive grains; similar soft rubber wheels, sticks and other forms are made for finishing soft metals.

Coated Abrasive Products Manufacturing

Coated abrasives consist of sized abrasive grains held by a film of adhesive to a flexible backing. The backing may be film, cloth, paper, vulcanized fiber, or a combination of these materials. Various types of resins, glues, and varnishes are used as adhesives or bonds. The glue is typically animal hide glue. The resins and varnishes are generally liquid phenolics or ureas, but depending on the end use of the abrasive, they may be modified to yield shorter or longer drying times, greater strength, more flexibility, or other required properties. Figure 8.31-3 presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, typically 1.3 m (52 in.) wide and 46 m (150 ft) long, passing through a printing press which imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Then the backing receives the first application of adhesive bond, the "make" coat, in a carefully regulated film, varying in concentration and quantity according to the particle size of the abrasive to be bonded. Next, the selected abrasive grains are applied either by a mechanical or an electrostatic method. Virtually all of the abrasive grain used for coated abrasive products is either silicon carbide or aluminum oxide, augmented by small quantities of natural garnet or emery for woodworking, and minute amounts of diamond or CBN.

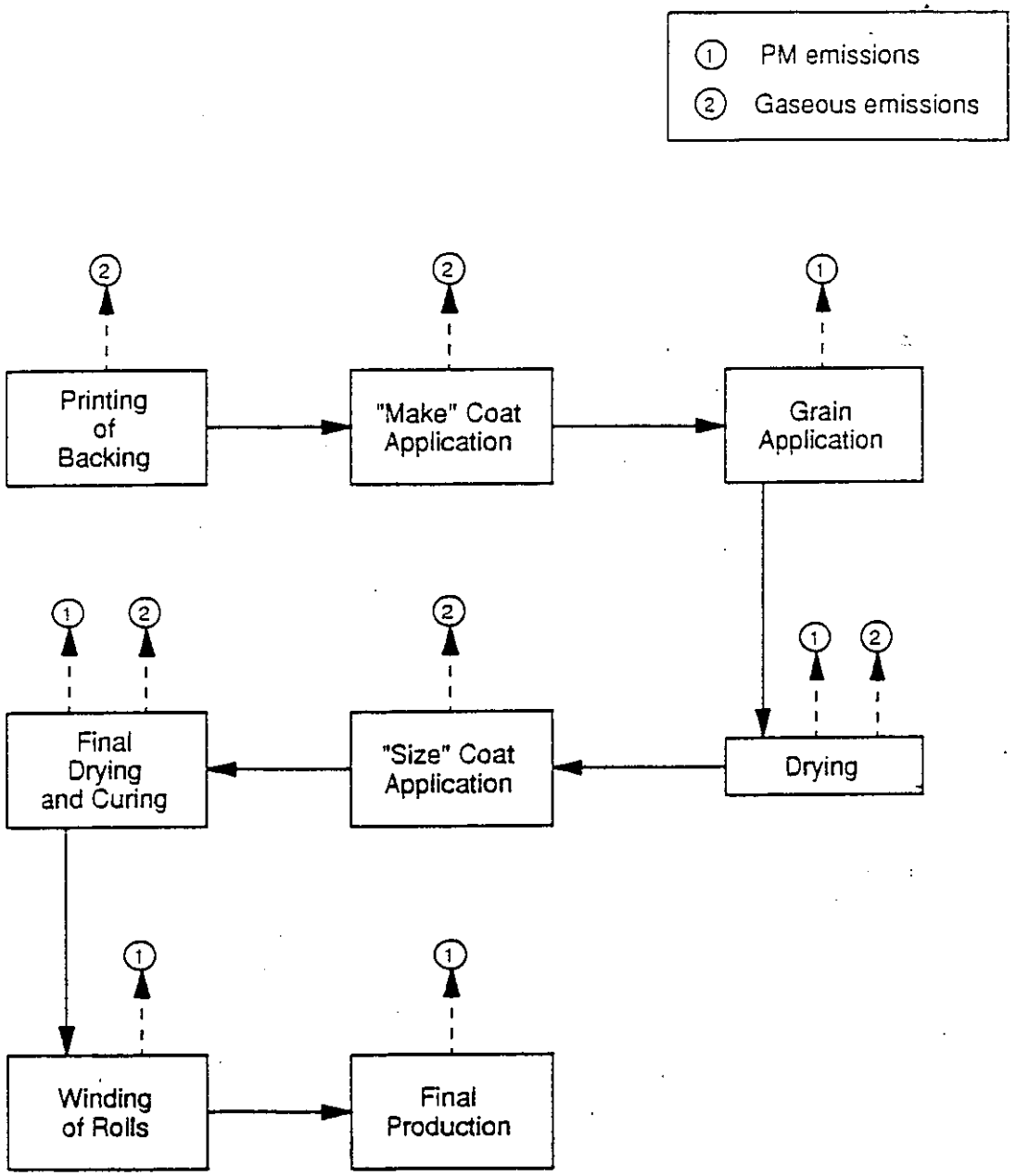

Figure 8.31-3. Process flow diagram for the manufacturing of coated abrasive products.

In mechanical application, the abrasive grains are poured in a controlled stream onto the adhesive-impregnated backing, or the impregnated backing is passed through a tray of abrasive thereby picking up the grains. In the electrostatic method, the adhesive-impregnated backing is passed adhesive-coated side down over a tray of abrasive grains, while at the same time passing an electric current through the abrasive. The electrostatic charge induced by the current causes the grains to imbed upright in the wet bond on the backing. In effect the sharp cutting edges of the grain are bonded perpendicular to the backing. It also causes the individual grains to be spaced more evenly due to individual grain repulsion. The amount of abrasive grains deposited on the backing can be controlled extremely accurately by adjusting the abrasive stream and manipulating the speed of the backing sheet through the abrasive.

After the abrasive is applied, the product is carried by a festoon conveyor system through a drying chamber to the sizing unit, where a second layer of adhesive, called the size coat, is applied. The size coat unites with the make coat to anchor the abrasive grains securely. The coated material is then carried by another longer festoon conveyor through the final drying and curing chamber in which the temperature and humidity are closely controlled to insure uniform drying and curing. When the bond is properly dried and cured, the coated abrasive is wound into jumbo rolls and stored for subsequent conversion into marketable forms of coated abrasives. Finished coated abrasives are available as sheets, rolls, belts, discs, bands, cones, and many other specialized forms.

8.31.3 Emissions and Controls[1]

Little information is available on emissions from the manufacturing of abrasive grains and products. However, based on similar processes in other industries, some assumptions can be made about the types of emissions that are likely to result from abrasives manufacturing.

Emissions from the production of synthetic abrasive grains, such as aluminum oxide and silicon carbide, are likely to consist primarily of particulate matter (PM), PM less than 10 micrometers (PM-10) and carbon monoxide (CO) from the furnaces. The PM and PM-10 emissions are likely to consist of filterable, inorganic condensible, and organic condensible PM. The addition of salt and sawdust to the furnace charge for silicon carbide production is likely to result in emissions of chlorides and volatile organic compounds (VOC's). Aluminum oxide processing takes place in an electric arc furnace and involves temperatures up to 2600°C with raw materials of bauxite ore, silica,

coke, iron borings, and a variety of minerals that include chromium oxide, cryolite, pyrite, and silane. This processing is likely to emit fluorides, sulfides, and metal constituents of the feed material.

The primary emissions from abrasive grain processing consist of PM and PM-10 from the crushing, screening, classifying, and drying operations. Particulate matter also is emitted from materials handling and transfer operations. Tables 8.31-1 and 8.31-2 present emission factors for CO_2 emissions from grain drying operations in metric and English units, respectively, and Tables 8.31-3 and 8.31-4 present emission factors for filterable PM emissions from grain drying in metric and English units. Table 8.31-5 presents emission factors developed from the results of a metals analysis conducted on a rotary dryer controlled by a wet scrubber.

Emissions generated in the production of bonded abrasive products may involve a small amount of dust generated by handling the loose abrasive, but careful control of sizes of abrasives particles limits the amount of fine particulate that can be entrained in the ambient air. However, for products made from finer grit sizes--less than 0.13 mm (200 grit)--PM emissions may be a significant problem. The main emissions from production of grinding wheels are generated during the curing of the bond structure for wheels. Heating ovens or kilns emit various types of VOC's depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Vitrified products produce some emissions as filler materials included to provide voids in the wheel structure are vaporized. Curing resins or rubber that is used in some types of bond systems also produce emissions of VOC's. Another small source of emissions may be vaporization during curing of portions of the chloride- and sulfur-based materials that are included within the bonding structure as grinding aids.

Emissions that may result from the production of coated abrasive products consist primarily of VOC's from the curing of the resin bonds and adhesives used to coat and attach the abrasive grains to the fabric or paper backing. Emissions from dryers and curing ovens also may include products of combustion, such as CO, CO_2, NO_x, and SO_x, in addition to filterable and condensible PM. Emissions that come from conversion of large rolls of coated abrasives into smaller products such as sanding belts consist of PM and PM-10. In addition, some VOC's may be emitted as a result of the volatilization of adhesives used to form joints in those products.

Little information is available on the types of controls used by the abrasives industry to control emissions. However, it is assumed that conventional devices such as cyclones, scrubbers, fabric filters, and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

TABLE 8.31-1. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor.

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	22[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-2. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	43[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-3. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.0073[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-4. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.015[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-5. (METRIC AND ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

Ratings (A-E) Follow Each Emission Factor

Source (SCC)	Metal	Emission factor		Rating	Ref.
		kg/Mg	lb/ton		
Rotary dryer: sand blasting grit, with wet scrubber	Antimony	4.0E-05	8.1E-05	E	8
	Arsenic	0.00012	0.00024	E	8
	Beryllium	4.1E-06	8.2E-06	E	8
	Lead	0.0022	0.0044	E	8
	Cadmium	0.00048	0.00096	E	8
	Chromium	0.00023	0.00045	E	8
	Manganese	3.1E-05	6.1E-05	E	8
	Mercury	8.5E-07	1.7E-06	E	8
	Thallium	4.0E-05	8.1E-05	E	8
	Nickel	0.0013	0.0026	E	8

[a]Emission factors in kg/Mg (lb/ton) of grit fed into dryer.

REFERENCES FOR SECTION 8.31

1. Telephone communication from Ted Giese, Abrasive Engineering Society, to R. Marinshaw, Midwest Research Institute, Cary, NC, March 1, 1993.

2. Stuart C. Salmon, Modern Grinding Process Technology, McGraw-Hill, Inc., New York, 1992.

3. Richard P. Hight, "Abrasives," Industrial Minerals and Rocks, Volume 1, Society of Mining Engineers, New York, NY, 1983.

4. Richard L. McKee, Machining With Abrasives, Van Nostrand Reinhold Company, New York, 1982.

5. Kenneth B. Lewis, and William F. Schleicher, The Grinding Wheel, 3rd edition, The Grinding Wheel Institute, Cleveland, OH, 1976.

6. Coated Abrasives-Modern Tool of Industry, 1st edition, Coated Abrasives Manufacturers' Institute, McGraw-Hill Book Company, Inc., New York, 1958.

7. Source Sampling Report: Measurement of Particulates Rotary Dryer, MDC Corporation, Philadelphia, PA, Applied Geotechnical and Environmental Service Corp., Valley Forge, PA, March 18, 1992.

8. Source Sampling Report for Measurement of Particulate and Heavy Metal Emissions, MDC Corporation, Philadelphia, PA, Gilbert/Commonwealth, Inc., Reading, PA, November 1988.

COATED ABRASIVES
MANUFACTURERS' INSTITUTE

THOMAS ASSOCIATES, INC., *Managing Director*

September 14, 1993

To The
SAFETY AND INDUSTRIAL HEALTH COMMITTEE

SUBJECT: Air Pollutant Emission Factors

Attached, from EPA, is an updated draft document "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources". The portion of the document which is attached is Chapter 8, which addresses the mineral products area.

EPA is requesting comments on the draft section by October 22, 1993.

We have been asked to distribute the attached and since we do not have specific contact names for environmental matters, it is being sent directly to the members of the Safety and Industrial Health Committee.

Sincerely,

SUSAN M. YOUNG

SMY:tr
cami
Enc.
cc Ron Myers,
Environmental Protection Agency

1300 Sumner Avenue, Cleveland, Ohio 44115-2851 • (216) 241-7333 • FAX (216) 241-0105

SEP 10 1993

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

SEP 7 1993

Ms. Susan Young
Account Executive
Coated Abrasives Manufacturers' Institute
1300 Sumner Avenue
Cleveland, Ohio 44115-2851

Dear Ms. Young:

As you may know, the Emission Inventory Branch of the U. S. Environmental Protection Agency (EPA) is in the process of updating the document *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (known more commonly as AP-42). As part of this process, we are now seeking comments on the draft sections that are to be included in this update of AP-42.

Chapter eight of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.31, Abrasive Products Manufacturing, and the corresponding background report for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and background report and would send us your comments. It would also be helpful if you could distribute copies of the enclosed section and background report to members of your association for their review. Unfortunately, we are on a very tight schedule, and it is important that we have all comments by October 22, 1993.

The emission factors presented in AP-42 generally are based upon results from validated tests or other emission evaluations that are similar to EPA reference test methods. As a result, revisions to the emission factors presented in AP-42 sections must be supported by equivalent documentation. If you disagree with any emission factors presented in the enclosed AP-42 section or have additional supporting documentation, we would appreciate your providing either a copy of the documentation or information on how we can obtain copies of the supporting documentation.

We appreciate your cooperation and look forward to receiving your comments. If you have any questions, I can be reached by telephone at (919) 541-5407 or by fax at (919) 541-0684.

Sincerely,

Ronald E. Myers
Emission Factors and Methodologies Section
Emission Inventory Branch

2 Enclosures

Emission Factor Documentation for AP-42 Section 8.31

Abrasives Manufacturing

Draft Report

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

August 24, 1993

EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 8.31
Abrasives Manufacturing

1. INTRODUCTION

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

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

1. Estimates of areawide emissions;

2. Estimates of emissions for a specific facility; and

3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information from test reports and other information to support preparation of AP-42 Section 8.31, Abrasives Manufacturing.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the bonded abrasive products industry. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from the manufacture of bonded abrasive products. Section 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details the development of pollutant emission factors for the draft AP-42 section. It includes the review of specific data sets and the results of data analysis. Section 5 presents the AP-42 Section 8.31, Abrasives Manufacturing.

2. INDUSTRY DESCRIPTION[1]

The abrasives industry is composed of approximately 400 companies engaged in several separate industries: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. The abrasive grain industry manufactures abrasive grains for use by the other abrasive industries to manufacture abrasive products. The bonded abrasives industry is very diversified and includes the production of grinding stones and wheels, cutoff saws for masonry and metals, and other products. Coated abrasive products manufacturers include those facilities that produce large rolls of abrasive-coated fabric or paper, known as jumbo rolls, and those facilities that manufacture belts and other products from jumbo rolls for end use.

The Standard Industrial Classification (SIC) code for abrasives manufacturing is 3291, which is the code for abrasive products. This SIC code encompasses abrasive grain production, coated and bonded abrasive products manufacturing, and several related industries. There is currently no Source Classification Code (SCC) for the industry. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

2.1 PROCESS DESCRIPTION[1-6]

The process description is broken into three distinct segments discussed in the following sections: production of the abrasive grains, production of bonded abrasive products, and production of coated abrasive products.

Abrasive Grain Manufacturing

The most commonly used abrasive materials are aluminum oxides and silicon carbide. These synthetic materials account for as much as 80 to 90 percent of the total quantity of abrasive grains produced domestically. Other materials used for abrasive grains are cubic boron nitride (CBN), synthetic diamonds, and several naturally occurring minerals such as garnet and emery. Cubic boron nitride is used for machining the hardest steels to precise forms and finishes. The largest application of synthetic diamonds has been in wheels for grinding carbides and ceramics. Natural diamonds are used primarily in diamond tipped drill bits and saw blades for cutting or shaping rock, concrete, grinding wheels, glass, quartz, gems, and high-speed tool steels. Other naturally occurring abrasive

materials (including garnet, emery, silica sand, and quartz) are used in finishing wood, leather, rubber, plastics, glass, and softer metals.

The following paragraphs describe the production of aluminum oxide, silicon carbide, CBN, and synthetic diamond.

1. Silicon carbide. Silicon carbide (SiC) is manufactured in a resistance arc furnace, which is a refractory enclosure, typically 3 meters (m) (10 feet [ft]) high, 3 m (10 ft) wide, and up to 12 m (40 ft) long with a carbon graphite electrode entering the furnace at both ends. The furnace is charged with a mixture of approximately 60 percent silica sand and 40 percent finely ground petroleum coke. A small amount of sawdust is added to the mix to increase its porosity so that the carbon monoxide gas formed during the process can escape freely. Common salt is added to the mix to serve two purposes. First, it acts as a catalyst to promote the carbon-silicon reaction. Second, it assists in the purification of the silicon carbide because it combines with impurities in the sand and coke to form chlorides, which can then be eliminated from the mix by volatilization. The furnace is half filled with this mixture then a core of granular carbon (graphite), which serves as an electrical conductor, is laid down between the two electrodes in the ends of the furnace. The furnace is then completely filled. Some furnaces may contain as much as 90,000 kilograms (kg) (200,000 pounds [lb]) of mix which could yield up to 11,000 kg (25,000 lb) of silicon carbide.

Approximately 300 volts is applied to the electrodes for up to 36 hours, over which time the voltage drops to 200 volts. During the heating period, the furnace core reaches approximately 2200°C (4000°F), at which point a large portion of the load crystallizes. After a prescribed period at the target temperature, the furnace is cooled for about 24 hours, and then the side walls of the furnace are removed to expose the charge. At the end of the run, the furnace contains a core of loosely knit silicon carbide crystals surrounded by unreacted or partially reacted raw materials. The silicon carbide crystals are removed to begin processing into abrasive grains. The center core of graphite is usually saved to be reused, as is the partially reacted or unreacted mixture.

2. Aluminum oxide. Fused aluminum oxide (Al_2O_3) is produced in pot-type electric-arc furnaces with capacities of several tons. Before processing, bauxite, the crude raw material, is calcined at about 950°C (1740°F) to remove both free and combined water. The bauxite is then mixed with ground coke (about 3 percent) and iron borings (about 2 percent). The coke is added to

reduce the impurities in the bauxite to the elemental state. The iron combines with the reduced impurities to produce, after solidification, a magnetic "button" at the bottom of the furnace.

The bottom of an open cylindrical pot furnace is covered with carbon bricks. The sides are left uncovered and are cooled by water jets once the furnace is in operation. The furnace is half filled with the bauxite mixture and two or three vertical electrodes are lowered into the furnace. A starter charge of metallurgical coke is placed between the electrodes and the mixture. An electric current is applied and the intense heat, on the order of 2000°C (3700°F), melts the bauxite and reduces the impurities which settle to the bottom of the furnace. As the fusion process continues, more bauxite mixture is added until the furnace is full. The electrodes are automatically raised and lowered to maintain the correct temperature. This melting period may last from 16 to 36 hours, after which the furnace is left to cool for several days. The furnace is then emptied and the outer impure layer is stripped off. The core of aluminum oxide is then removed to be processed into abrasive grains.

3. Cubic boron nitride. Cubic boron nitride production requires extremely high temperatures and pressures comparable to those required for diamond manufacture. Cubic boron nitride is synthesized in crystal form from hexagonal boron nitride, which is composed of atoms of boron and nitrogen. The hexagonal boron nitride is combined with a catalyst such as metallic lithium at temperatures in the range of 1650°C (3000°F) and pressures of up to 6,895,000 kilopascals (kPa) (1,000,000 pounds per square inch [psi]). The intense heat and pressure in the presence of the catalyst causes the nitrogen atom to donate an electron to a boron atom which then forms a chemical bond to the nitrogen atom and forms a very strong crystalline structure similar to that of diamond.

4. Synthetic diamond. Synthetic diamond was first produced when iron sulfide, in a graphite tube closed with tantalum end disks, was subjected to a pressure of 9,653,000 kPa (1,400,000 psi) and 1600°C (2900°F) for several minutes. Now, industrial diamond is manufactured using pressures in the range of 5,571,000 to 13,100,000 kPa (808,000 to 1,900,000 psi) at temperatures in the range of 1400° to 2500°C (2500° to 4500°F). The catalyst solvent metal interface is crucial. Iron was first used, and subsequently chromium, cobalt, magnesium, nickel, platinum, rhodium, ruthenium, and tantalum have been used successfully. Variations in temperature, solvent, and pressure produce different types of diamond. Thus, crystals may be tailored for the optimum combination of size, shape, surface, and crystal structure for specific applications.

Abrasive Grain Processing

Abrasive grains for both bonded and coated abrasive products are made by graded crushing and close sizing of either natural or synthetic abrasives. Raw abrasive materials first are crushed by primary crushers and are then reduced to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]), by jaw crushers. Final crushing is usually accomplished with roll crushers which break up the small pieces into a usable range of sizes. The crushed abrasive grains are then separated into specific grade sizes by passing them over a series of screens. Grains are washed in classifiers to remove slimes, dried, passed through magnetic separators to remove iron-bearing material, and then the grains are again closely sized on screens. This careful sizing is necessary to prevent contamination of grades by coarser grains. Sizes finer than 0.10 millimeter (mm) (250 grit) are separated by hydraulic flotation and sedimentation or by air classification. Figure 2-1 presents a process flow diagram for abrasive grain processing.

Bonded Abrasive Products Manufacturing

The grains in bonded abrasive products are held together by one of six types of bonds: vitrified or ceramic (which accounts for more than 50 percent of all grinding wheels); resinoid (synthetic resin); rubber; shellac; silicate of soda; or oxychloride of magnesium. Figure 2-2 presents a process flow diagram for the manufacturing of vitrified bonded abrasive products.

Measured amounts of prepared abrasive grains are moistened and mixed with porosity media and bond material. Porosity media are used for creating voids in the finished wheels and consist of filler materials, such as paradichlorobenzene (moth ball crystals) or walnut shells, that are vaporized during firing. Feldspar and clays generally are used as bond materials in vitrified wheels. The mix is moistened with water or another temporary binder to make the wheel stick together after it is pressed. The mix is then packed and uniformly distributed into a steel grinding wheel mold, and compressed in a hydraulic press under pressures varying from 1,030 to 69,000 kPa (150 to 10,000 psi). If there is a pore inducing media in the mix, such as paradichlorobenzene, it is removed in a steam autoclave. Prior to firing, smaller wheels are dried in continuous dryers; larger wheels are dried in humidity-controlled, intermittent dry houses.

Most vitrified wheels are fired in continuous tunnel kilns in which the molded wheels ride through the kiln on a moving belt. However, large wheels are often fired in bell or periodic kilns.

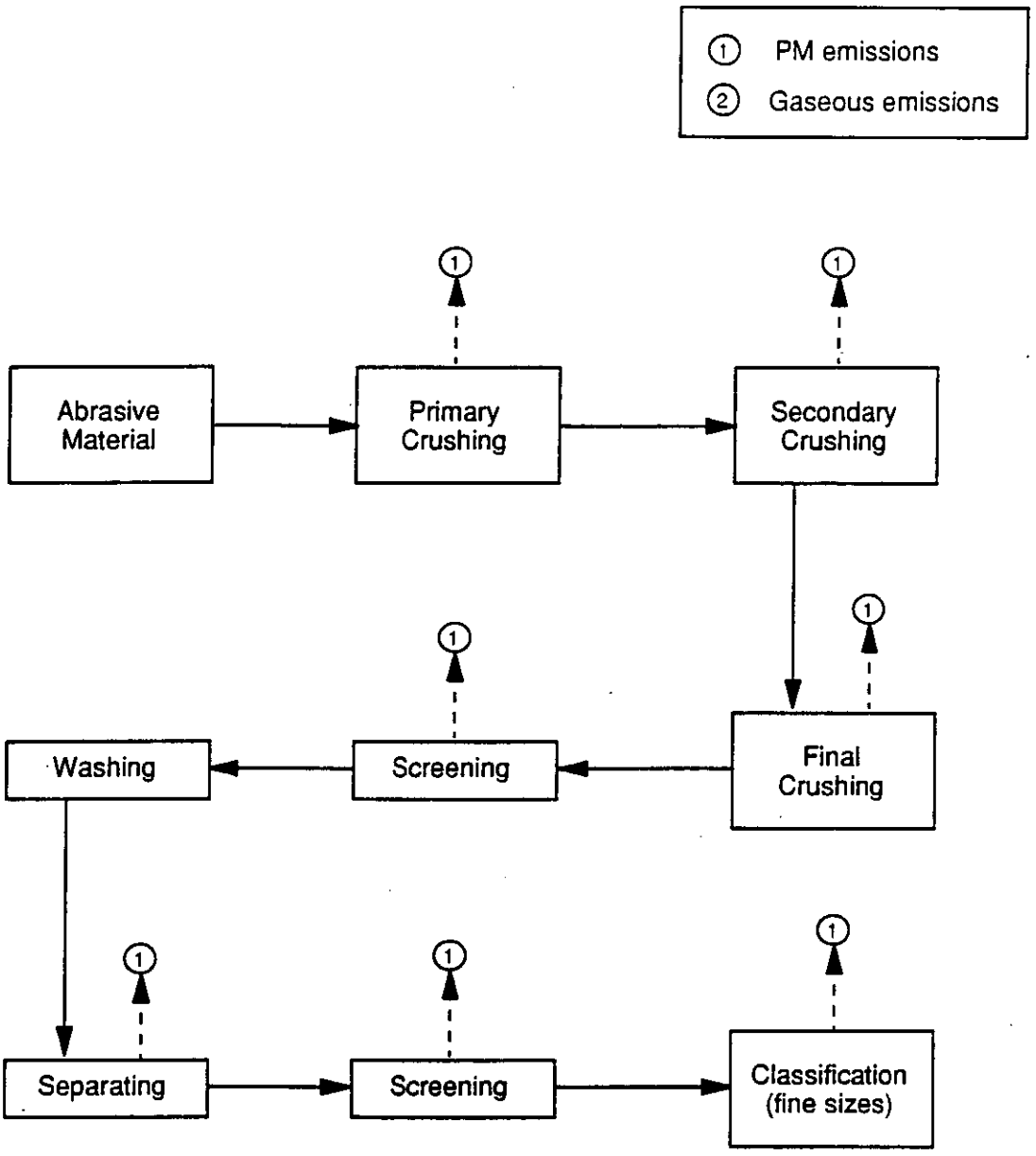

Figure 2-1. Process flow diagram for abrasive grain processing.

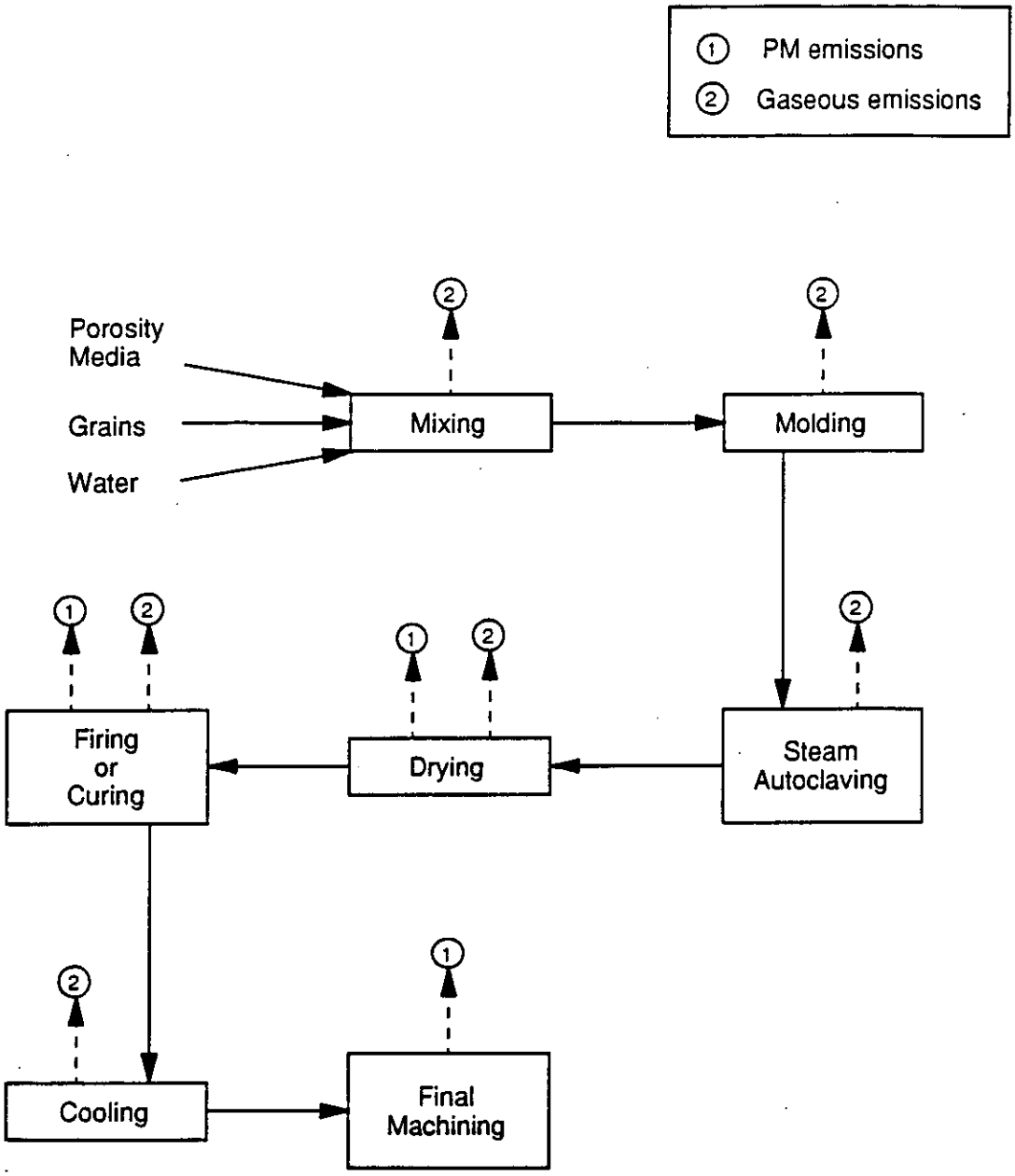

Figure 2-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.

In the firing process, the wheels are brought slowly to temperatures approaching 1400°C (2500°F) for as long as several days, depending on the size of the grinding wheels and the charge. This slow temperature ramp fuses the clay bond mixture so that each grain is surrounded by a hard glass-like bond that has high strength and rigidity. The wheels are then removed from the kiln and slowly cooled.

After cooling, the wheels are checked for distortion, shape, and size. The wheels are then machined to final size, balanced, and overspeed tested to ensure operational safety. Occasionally wax and oil, rosin, or sulfur are applied to improve the cutting effectiveness of the wheel.

Resin-bonded wheels are produced similarly to vitrified wheels, except that the bond material is a resin. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C (300° to 400°F) for a period of from 12 hours to 4 or 5 days, depending on the size of the wheel. During the curing period, the mold first softens and then hardens as the oven reaches curing temperature. After cooling, the mold retains its cured hardness. The remainder of the production process is similar to that for vitrified wheels.

Rubber-bonded wheels are produced by selecting the abrasive grain, sieving it, and kneading the grain into a natural or synthetic rubber. Sulfur is added as a vulcanizing agent and then the mix is rolled between steel calendar rolls to form a sheet of the required thickness. The grinding wheels are cut out of the rolled sheet to a specified diameter and hole size. Scraps are kneaded, rolled, and cut out again. Then the wheels are vulcanized in molds under pressure in ovens at approximately 150° to 175°C (300° to 350°F). The finishing and inspection processes are similar to those for other types of wheels.

Shellac-bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a steam-heated mixer, which thoroughly coats the grain with the bond material (shellac). Wheels 3 mm (0.125 in) thick or less are molded to exact size in heated steel molds. Thicker wheels are hot-pressed in steel molds. After pressing, the wheels are set in quartz sand and baked for a few hours at approximately 150°C (300°F). The finishing and inspection processes are similar to those for other types of wheels.

In addition to grinding wheels, bonded abrasives are formed into blocks, bricks, and sticks for sharpening and polishing stones such as oil stones, scythe stones, razor and cylinder hones. Curved abrasive blocks and abrasive segments are manufactured for grinding or polishing curved surfaces. Abrasive segments can also be combined into large wheels such as pulpstones. Rubber pencil and ink erasers contain abrasive grains; similar soft rubber wheels, sticks and other forms are made for finishing soft metals.

Coated Abrasive Products Manufacturing

Coated abrasives consist of sized abrasive grains held by a film of adhesive to a flexible backing. The backing may be film, cloth, paper, vulcanized fiber, or a combination of these materials. Various types of resins, glues, and varnishes are used as adhesives or bonds. The glue is typically animal hide glue. The resins and varnishes are generally liquid phenolics or ureas, but depending on the end use of the abrasive, they may be modified to yield shorter or longer drying times, greater strength, more flexibility, or other required properties. Figure 2-3 presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, typically 1.3 m (52 in) wide and 46 m (150 ft) long, passing through a printing press which imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Then the backing receives the first application of adhesive bond, the "make" coat, in a carefully regulated film, varying in concentration and quantity according to the particle size of the abrasive to be bonded. Next, the selected abrasive grains are applied either by a mechanical or an electrostatic method. Virtually all of the abrasive grain used for coated abrasive products is either silicon carbide or aluminum oxide, augmented by small quantities of natural garnet or emery for woodworking, and minute amounts of diamond or CBN.

In mechanical application, the abrasive grains are poured in a controlled stream onto the adhesive-impregnated backing, or the impregnated backing is passed through a tray of abrasive thereby picking up the grains. In the electrostatic method, the adhesive-impregnated backing is passed adhesive-coated side down over a tray of abrasive grains, while at the same time passing an electric current through the abrasive. The electrostatic charge induced by the current causes the grains to imbed upright in the wet bond on the backing. In effect the sharp cutting edges of the grain are bonded perpendicular to the backing. It also causes the individual grains to be spaced more

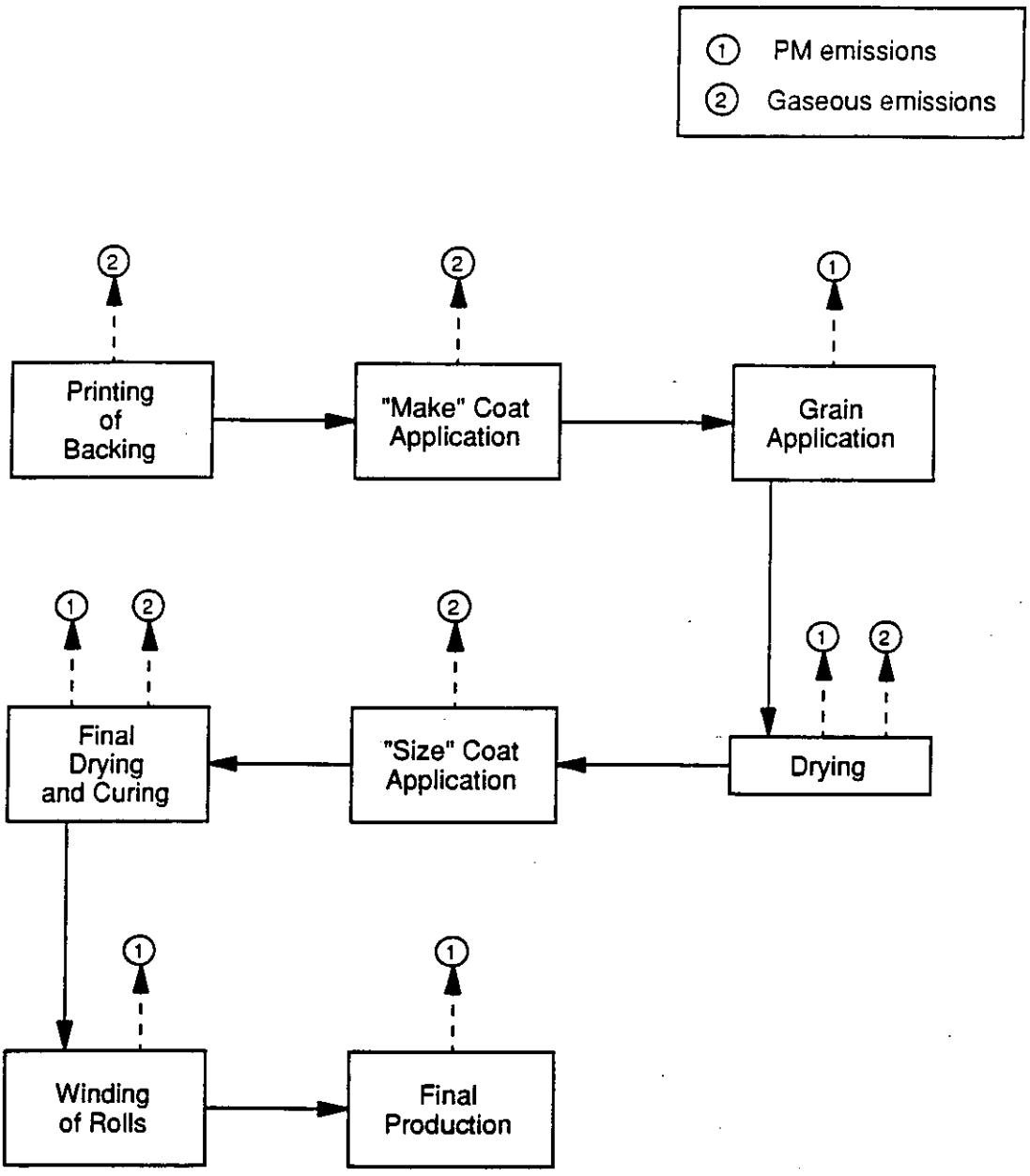

Figure 2-3. Process flow diagram for the manufacturing of coated abrasive products.

evenly due to individual grain repulsion. The amount of abrasive grains deposited on the backing can be controlled extremely accurately by adjusting the abrasive stream and manipulating the speed of the backing sheet through the abrasive.

After the abrasive is applied, the product is carried by a festoon conveyor system through a drying chamber to the sizing unit, where a second layer of adhesive, called the size coat, is applied. The size coat unites with the make coat to anchor the abrasive grains securely. The coated material is then carried by another longer festoon conveyor through the final drying and curing chamber in which the temperature and humidity are closely controlled to insure uniform drying and curing. When the bond is properly dried and cured, the coated abrasive is wound into jumbo rolls and stored for subsequent conversion into marketable forms of coated abrasives. Finished coated abrasives are available as sheets, rolls, belts, discs, bands, cones, and many other specialized forms.

2.2 EMISSIONS[1]

Little information is available on emissions from the manufacturing of abrasive grains and products. However, based on similar processes in other industries, some assumptions can be made about the types of emissions that are likely to result from abrasives manufacturing.

Emissions from the production of synthetic abrasive grains, such as aluminum oxide and silicon carbide, are likely to consist primarily of particulate matter (PM), PM less than 10 micrometers (PM-10) and carbon monoxide (CO) from the furnaces. The PM and PM-10 emissions are likely to consist of filterable, inorganic condensible, and organic condensible PM. The addition of salt and sawdust to the furnace charge for silicon carbide production is likely to result in emissions of chlorides and volatile organic compounds (VOC's). Aluminum oxide processing takes place in an electric arc furnace and involves temperatures up to 2600°C with raw materials of bauxite ore, silica, coke, iron borings, and a variety of minerals that include chromium oxide, cryolite, pyrite, and silane. This processing is likely to emit fluorides, sulfides, and metal constituents of the feed material.

The primary emissions from abrasive grain processing consist of PM and PM-10 from the crushing, screening, and classifying operations. Particulate matter also is emitted from materials handling and transfer operations.

Emissions generated in the production of bonded abrasive products may involve a small amount of dust generated by handling the loose abrasive, but careful control of sizes of abrasives particles limits the amount of fine particulate that can be entrained in the ambient air. However, for products made from finer grit sizes--less than 0.13 mm (200 grit)--PM emissions may be a significant problem. The main emissions from production of grinding wheels are generated during the curing of the bond structure for wheels. Heating ovens or kilns emit various types of VOC's depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Vitrified products produce some emissions as filler materials included to provide voids in the wheel structure are vaporized. Curing resins or rubber that is used in some types of bond systems also produce emissions of VOC's. Another small source of emissions may be vaporization during curing of portions of the chloride- and sulfur-based materials that are included within the bonding structure as grinding aids.

Emissions that may result from the production of coated abrasive products consist primarily of VOC's from the curing of the resin bonds and adhesives used to coat and attach the abrasive grains to the fabric or paper backing. Emissions from dryers and curing ovens also may include products of combustion, such as CO, CO_2, NO_x, and SO_x, in addition to filterable and condensible PM. Emissions that come from conversion of large rolls of coated abrasives into smaller products such as sanding belts consist of PM and PM-10. In addition, some VOC's may be emitted as a result of the volatilization of adhesives used to form joints in those products.

2.3 CONTROL TECHNOLOGY

Little information is available on the types of controls used by the abrasives industry to control emissions. However, it is assumed that conventional devices such as cyclones, scrubbers, fabric filters, and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

REFERENCES FOR SECTION 2

1. Telephone communication from Ted Giese, Abrasive Engineering Society, to R. Marinshaw, Midwest Research Institute, Cary, NC, March 1, 1993.

2. Stuart C. Salmon, Modern Grinding Process Technology, McGraw-Hill, Inc., New York, 1992.

3. Richard P. Hight, "Abrasives," Industrial Minerals and Rocks, Volume 1, Society of Mining Engineers, New York, NY, 1983.

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6. Coated Abrasives-Modern Tool of Industry, 1st edition, Coated Abrasives Manufacturers' Institute, McGraw-Hill Book Company, Inc., New York, 1958.

3. GENERAL DATA REVIEW AND ANALYSIS

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained from a number of sources within the Office of Air Quality Planning and Standards (OAQPS) and from outside organizations. The docket for the development of new source performance standards (NSPS) for calciners and dryers in the mineral industries was reviewed for information on the industry, processes, and emissions. The Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF) and VOC/PM Speciation Data Base Management System (SPECIATE) data bases were searched by SCC for identification of the potential pollutants emitted and emission factors for those pollutants. A general search of the Air CHIEF CD-ROM also was conducted to supplement the information from these two data bases.

Information on the industry , including number of plants, plant location, and annual production capacities, was obtained from the Minerals Yearbook and Census of Manufactures. The Aerometric Information Retrieval System (AIRS) data base also was searched for data on the number of plants, plant location, and estimated annual emissions of criteria pollutants.

A number of sources of information were investigated specifically for emission test reports and data. A search of the Test Methods Storage and Retrieval (TSAR) data base was conducted to identify test reports for sources within the sand and gravel processing industry. Copies of these test reports were obtained from the files of the Emission Measurement Branch (EMB). The EPA library was searched for additional test reports. A list of plants that have been tested within the past 5 years was compiled from the AIRS data base. Using this information and information obtained on plant location from the Minerals Yearbook and Census of Manufactures, State and Regional offices were contacted about the availability of test reports. However, the information obtained from these offices was limited. Publications lists from the Office of Research and Development (ORD) and Control Technology Center (CTC) were also searched for reports on emissions from the sand and gravel processing industry. In addition, representative trade associations were contacted for assistance in obtaining information about the industry and emissions.

To reduce the amount of literature collected to a final group of references from which emission factors could be developed, the following general criteria were used:

1. Emission data must be from a primary reference:

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

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

2. The referenced study must contain test results based on more than one test run.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions. A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 EMISSION DATA QUALITY RATING SYSTEM

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3 EMISSION FACTOR QUALITY RATING SYSTEM

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

A--Excellent: Developed only from A-rated test data from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B--Above average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. The source category is specific enough so that variability within the source category population may be minimized.

C--Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D--Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E--Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

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

REFERENCES FOR SECTION 3

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections (Draft), Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 6, 1992.

4. AP-42 SECTION DEVELOPMENT

4.1 DEVELOPMENT OF SECTION NARRATIVE

The draft AP-42 section is a new section addressing abrasives manufacturing. The new section is based on information gathered from the references cited, and includes a description of the industry, process diagrams, and emission factors for specific process emission points.

4.2 POLLUTANT EMISSION FACTOR DEVELOPMENT

Two test reports were documented and reviewed in the process of developing the section on abrasive manufacturing. These reports are described in the following paragraphs. The emission factors developed from these references are presented in Table 4-1.

4.2.1 Review of Specific Data Sets

4.2.1.1 Reference 1. This report documents measurements of filterable PM from a rotary dryer used to remove water from copper and boiler slag for use as sand blasting grit. The purpose of the emission test was to demonstrate compliance with State regulations. The test was conducted in March 1992. Process rates were provided on the basis of raw material feed. The dryer emissions are controlled with a fabric filter.

Particulate matter emissions were measured using EPA Method 5 and two test runs were conducted. Carbon dioxide concentrations were measured with Fyrite analyzers, but were not presented in the report. Emission factors were developed only for filterable PM.

The emission data for filterable PM are rated C. The test methodology appears to be sound and no problems were reported. However, because only two runs were conducted, and the report lacked complete documentation of the test, a higher rating is not warranted.

4.2.1.2 Reference 2. This report documents measurements of filterable PM, metals, and CO_2 from a rotary kiln used to remove water from copper and boiler slag for use as sand blasting grit. The purpose of the emission test was to demonstrate compliance with State regulations. The

test was conducted in November 1988. Process rates were provided on the bases of raw material feed. The dryer emissions are controlled with a venturi scrubber.

Particulate matter emissions were measured using EPA Method 5. Only one run was conducted, therefore the emission factor developed from the data is unrated and was not incorporated in the draft AP-42 section. Orsat analysis was used to measure carbon dioxide concentrations in the exhaust. Metal emissions were measured using EPA Method 12 and two test runs were conducted. Emission factors were developed for 10 metals and CO_2.

The emission data for metals and CO_2 are rated C. The test methodologies appear to be sound and no problems were reported. However, because the process rates are given as ranges rather than as specific figures, only two test runs were conducted, and the report lacked complete documentation of the test, a higher rating is not warranted.

4.2.2 Review of XATEF and SPECIATE Data Base Emission Factors

No relevant information was found in these data bases.

4.2.3 Results of Data Analysis

Emission factors were developed from Reference 1 for filterable PM emissions from rotary dryers controlled by a fabric filter. Because the PM data from this reference are rated C, the emission factor for filterable PM emissions from rotary dryers is rated E.

Emission factors were developed from Reference 2 for CO_2 and 10 metals. Because the CO_2 and metals emission data from this reference are rated C, the emission factors for CO_2 and metals from rotary dryers are rated E.

The emission factors developed for abrasive manufacturing are presented in Table 4-2.

TABLE 4-1. SUMMARY OF TEST DATA FOR ABRASIVE MANUFACTURING ROTARY DRYERS--DRYING COPPER AND BOILER SLAG FOR SAND BLASTING GRIT

Type of control	Pollutant	No. of test runs	Data rating	Emission factor		Ref. No.
				Range kg/Mg (lb/ton)	Average kg/Mg (lb/ton)	
Fabric filter	Filterable PM	2	C	0.0070 - 0.0075 (0.014 - 0.015)	0.0073 (0.0145)	1
Wet scrubber	Filterable PM	1	C	NA	0.09 (0.18)	2
Wet scrubber	Antimony	2	C	4.0E-05 - 4.05E-05 (8.0E-05 - 8.1E-05)	4.03E-05 (8.05E-05)	2
Wet scrubber	Arsenic	2	C	0.00012 - 0.00012 (0.00024 - 0.00024)	0.00012 (0.00024)	2
Wet scrubber	Beryllium	2	C	4.1E-06 - 4.1E-06 (8.2E-06 - 8.2E-06)	4.1E-06 (8.2E-06)	2
Wet scrubber	Lead	2	C	0.0019 - 0.0025 (0.0038 - 0.0049)	0.0022 (0.0044)	2
Wet scrubber	Cadmium	2	C	0.00041 - 0.00055 (0.00081 - 0.0011)	0.00048 (0.00096)	2
Wet scrubber	Chromium	2	C	0.00019 - 0.00026 (0.00037 - 0.00052)	0.00023 (0.00045)	2
Wet scrubber	Manganese	2	C	2.4E-05 - 3.7E-05 (4.7E-05 -7.4E-05)	3.05E-05 (6.1E-05)	2
Wet scrubber	Mercury	2	C	8.5E-07 - 8.5E-07 (1.7E-06 - 1.7E-06)	8.5E-07 (1.7E-06)	2
Wet scrubber	Thallium	2	C	4.0E-05 - 4.05E-05 (8.0E-05 - 8.1E-05)	4.03E-05 (8.05E-05)	2
Wet scrubber	Nickel	2	C	0.0012 - 0.0014 (0.0023 - 0.0028)	0.0013 (0.0026)	2
Wet scrubber	CO_2	3	C	20 - 23 (39 - 46)	22 (43)	2

TABLE 4-2. SUMMARY OF EMISSION FACTORS DEVELOPED FOR ABRASIVE MANUFACTURING

Process	Type of control	Pollutant	No. of tests	Average emission factor, kg/Mg (lb/ton)	Emission factor rating	Ref. Nos.
Rotary dryer: sand blasting grit	Fabric filter	Filterable PM	1	0.0073 (0.0145)	E	1
Rotary dryer: sand blasting grit	Wet scrubber	Antimony	1	4.03E-05 (8.05E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Arsenic	1	0.00012 (0.00024)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Beryllium	1	4.1E-06 (8.2E-06)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Lead	1	0.0022 (0.0044)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Cadmium	1	0.00048 (0.00096)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Chromium	1	0.00023 (0.00045)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Manganese	1	3.05E-05 (6.1E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Mercury	1	8.5E-07 (1.7E-06)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Thallium	1	4.03E-05 (8.05E-05)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	Nickel	1	0.0013 (0.0026)	E	2
Rotary dryer: sand blasting grit	Wet scrubber	CO_2	1	22 (43)	E	2

REFERENCES FOR SECTION 4

1. Source Sampling Report: Measurement of Particulates Rotary Dryer, MDC Corporation, Philadelphia, PA, Applied Geotechnical and Environmental Service Corp., Valley Forge, PA, March 18, 1992.

2. Source Sampling Report for Measurement of Particulate and Heavy Metal Emissions, MDC Corporation, Philadelphia, PA, Gilbert/Commonwealth, Inc., Reading, PA, November 1988.

5. DRAFT AP-42 SECTION 8.31

8.31 ABRASIVES MANUFACTURING

8.31.1 General[1]

The abrasives industry is composed of approximately 400 companies engaged in several separate industries: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. The abrasive grain industry manufactures abrasive grains for use by the other abrasive industries to manufacture abrasive products. The bonded abrasives industry is very diversified and includes the production of grinding stones and wheels, cutoff saws for masonry and metals, and other products. Coated abrasive products manufacturers include those facilities that produce large rolls of abrasive-coated fabric or paper, known as jumbo rolls, and those facilities that manufacture belts and other products from jumbo rolls for end use.

The Standard Industrial Classification (SIC) code for abrasives manufacturing is 3291, which is the code for abrasive products. This SIC code encompasses abrasive grain production, coated and bonded abrasive products manufacturing, and several related industries. There is currently no Source Classification Code (SCC) for the industry. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

8.31.2 Process Description[1-6]

The process description is broken into three distinct segments discussed in the following sections: production of the abrasive grains, production of bonded abrasive products, and production of coated abrasive products.

Abrasive Grain Manufacturing

The most commonly used abrasive materials are aluminum oxides and silicon carbide. These synthetic materials account for as much as 80 to 90 percent of the total quantity of abrasive grains produced domestically. Other materials used for abrasive grains are cubic boron nitride (CBN), synthetic diamonds, and several naturally occurring minerals such as garnet and emery. Cubic boron

nitride is used for machining the hardest steels to precise forms and finishes. The largest application of synthetic diamonds has been in wheels for grinding carbides and ceramics. Natural diamonds are used primarily in diamond tipped drill bits and saw blades for cutting or shaping rock, concrete, grinding wheels, glass, quartz, gems, and high-speed tool steels. Other naturally occurring abrasive materials (including garnet, emery, silica sand, and quartz) are used in finishing wood, leather, rubber, plastics, glass, and softer metals.

The following paragraphs describe the production of aluminum oxide, silicon carbide, CBN, and synthetic diamond.

1. Silicon carbide. Silicon carbide (SiC) is manufactured in a resistance arc furnace charged with a mixture of approximately 60 percent silica sand and 40 percent finely ground petroleum coke. A small amount of sawdust is added to the mix to increase its porosity so that the carbon monoxide gas formed during the process can escape freely. Common salt is added to the mix to promote the carbon-silicon reaction and to remove impurities in the sand and coke. During the heating period, the furnace core reaches approximately 2200°C (4000°F), at which point a large portion of the load crystallizes. At the end of the run, the furnace contains a core of loosely knit silicon carbide crystals surrounded by unreacted or partially reacted raw materials. The silicon carbide crystals are removed to begin processing into abrasive grains.

2. Aluminum oxide. Fused aluminum oxide (Al_2O_3) is produced in pot-type electric-arc furnaces with capacities of several tons. Before processing, bauxite, the crude raw material, is calcined at about 950°C (1740°F) to remove both free and combined water. The bauxite is then mixed with ground coke (about 3 percent) and iron borings (about 2 percent). An electric current is applied and the intense heat, on the order of 2000°C (3700°F), melts the bauxite and reduces the impurities which settle to the bottom of the furnace. As the fusion process continues, more bauxite mixture is added until the furnace is full. The furnace is then emptied and the outer impure layer is stripped off. The core of aluminum oxide is then removed to be processed into abrasive grains.

3. Cubic boron nitride. Cubic boron nitride is synthesized in crystal form from hexagonal boron nitride, which is composed of atoms of boron and nitrogen. The hexagonal boron nitride is combined with a catalyst such as metallic lithium at temperatures in the range of 1650°C (3000°F) and pressures of up to 6,895,000 kilopascals (kPa) (1,000,000 pounds per square inch [psi]).

4. Synthetic diamond. Synthetic diamond is manufactured by subjecting graphite in the presence of a metal catalyst to pressures in the range of 5,571,000 to 13,100,000 kPa (808,000 to 1,900,000 psi) at temperatures in the range of 1400° to 2500°C (2500° to 4500°F).

Abrasive Grain Processing

Abrasive grains for both bonded and coated abrasive products are made by graded crushing and close sizing of either natural or synthetic abrasives. Raw abrasive materials first are crushed by primary crushers and are then reduced to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]), by jaw crushers. Final crushing is usually accomplished with roll crushers which break up the small pieces into a usable range of sizes. The crushed abrasive grains are then separated into specific grade sizes by passing them over a series of screens. Grains are washed in classifiers to remove slimes, dried, passed through magnetic separators to remove iron-bearing material, and then the grains are again closely sized on screens. This careful sizing is necessary to prevent contamination of grades by coarser grains. Sizes finer than 0.10 millimeter (mm) (250 grit) are separated by hydraulic flotation and sedimentation or by air classification. Figure 8.31-1 presents a process flow diagram for abrasive grain processing.

Bonded Abrasive Products Manufacturing

The grains in bonded abrasive products are held together by one of six types of bonds: vitrified or ceramic (which accounts for more than 50 percent of all grinding wheels); resinoid (synthetic resin); rubber; shellac; silicate of soda; or oxychloride of magnesium. Figure 8.31-2 presents a process flow diagram for the manufacturing of vitrified bonded abrasive products.

Measured amounts of prepared abrasive grains are moistened and mixed with porosity media and bond material. Porosity media are used for creating voids in the finished wheels and consist of filler materials, such as paradichlorobenzene (moth ball crystals) or walnut shells, that are vaporized during firing. Feldspar and clays generally are used as bond materials in vitrified wheels. The mix is moistened with water or another temporary binder to make the wheel stick together after it is pressed. The mix is then packed and uniformly distributed into a steel grinding wheel mold, and compressed in a hydraulic press under pressures varying from 1,030 to 69,000 kPa (150 to 10,000 psi). If there is a pore inducing media in the mix, such as paradichlorobenzene, it is removed

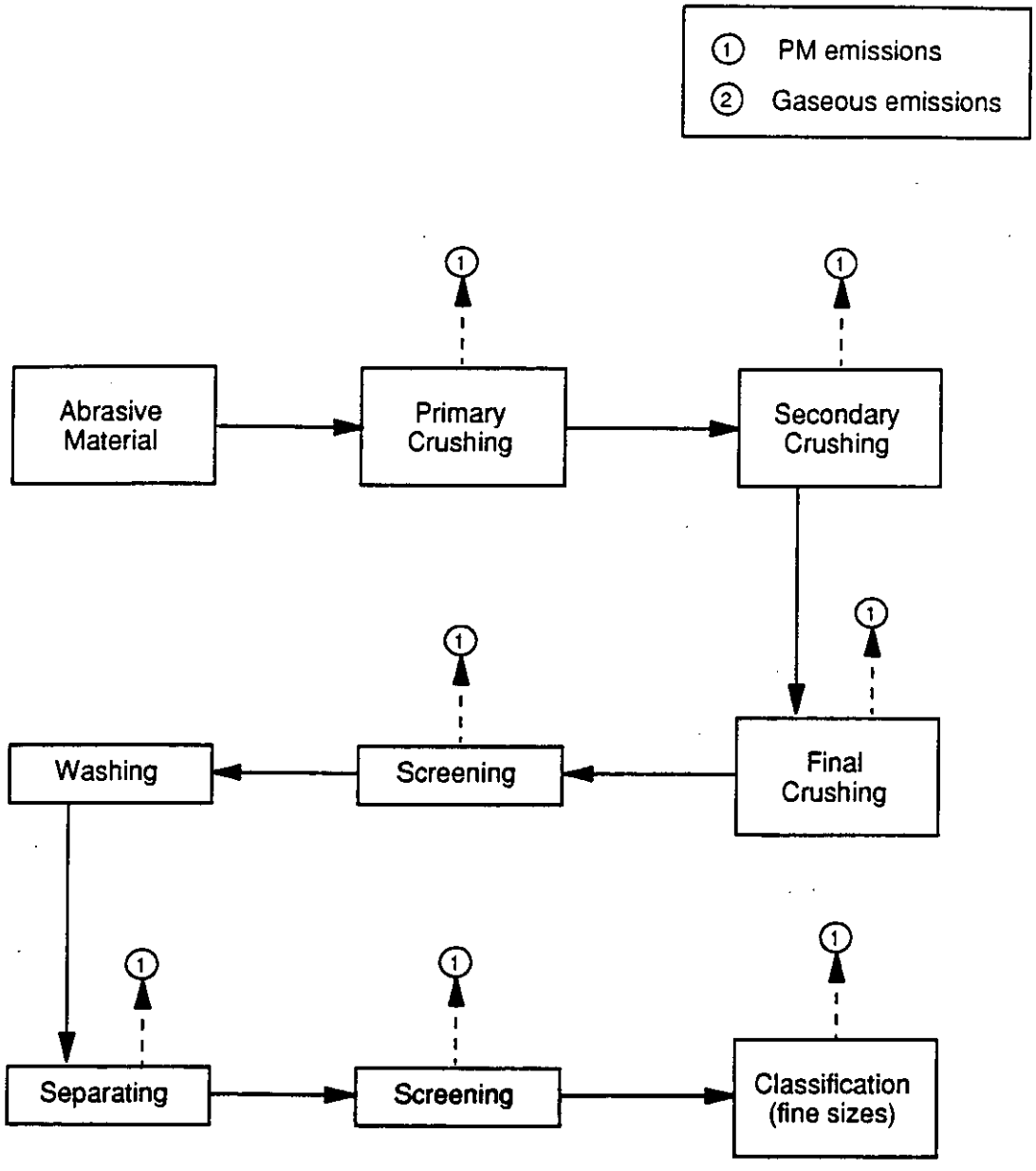

Figure 8.31-1. Process flow diagram for abrasive grain processing.

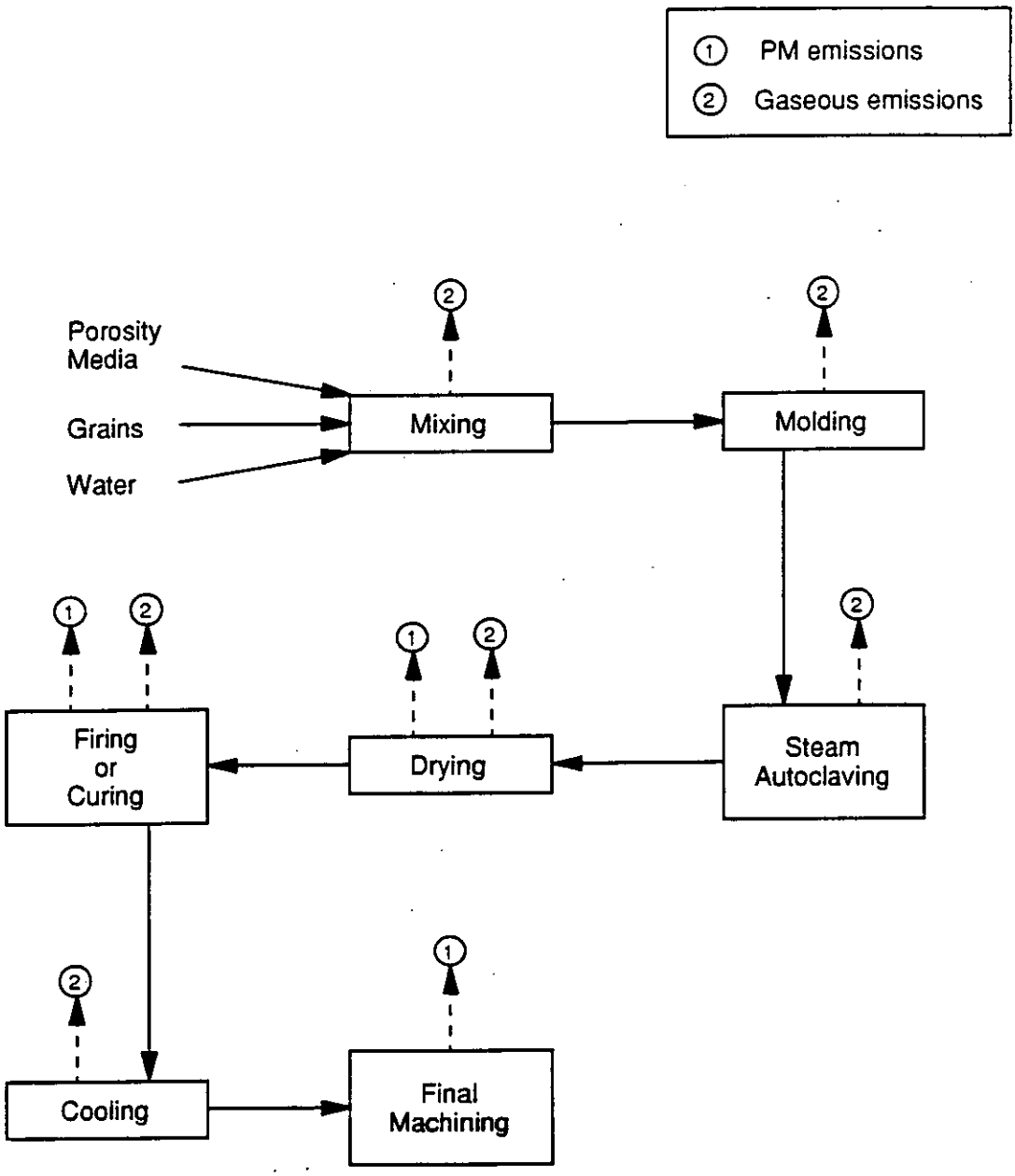

Figure 8.31-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.

in a steam autoclave. Prior to firing, smaller wheels are dried in continuous dryers; larger wheels are dried in humidity-controlled, intermittent dry houses.

Most vitrified wheels are fired in continuous tunnel kilns in which the molded wheels ride through the kiln on a moving belt. However, large wheels are often fired in bell or periodic kilns. In the firing process, the wheels are brought slowly to temperatures approaching 1400°C (2500°F) for as long as several days, depending on the size of the grinding wheels and the charge. This slow temperature ramp fuses the clay bond mixture so that each grain is surrounded by a hard glass-like bond that has high strength and rigidity. The wheels are then removed from the kiln and slowly cooled.

After cooling, the wheels are checked for distortion, shape, and size. The wheels are then machined to final size, balanced, and overspeed tested to ensure operational safety. Occasionally wax and oil, rosin, or sulfur are applied to improve the cutting effectiveness of the wheel.

Resin-bonded wheels are produced similarly to vitrified wheels, except that the bond material is a resin. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C (300° to 400°F) for a period of from 12 hours to 4 or 5 days, depending on the size of the wheel. During the curing period, the mold first softens and then hardens as the oven reaches curing temperature. After cooling, the mold retains its cured hardness. The remainder of the production process is similar to that for vitrified wheels.

Rubber-bonded wheels are produced by selecting the abrasive grain, sieving it, and kneading the grain into a natural or synthetic rubber. Sulfur is added as a vulcanizing agent and then the mix is rolled between steel calendar rolls to form a sheet of the required thickness. The grinding wheels are cut out of the rolled sheet to a specified diameter and hole size. Scraps are kneaded, rolled, and cut out again. Then the wheels are vulcanized in molds under pressure in ovens at approximately 150° to 175°C (300° to 350°F). The finishing and inspection processes are similar to those for other types of wheels.

Shellac-bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a steam-heated mixer,

which thoroughly coats the grain with the bond material (shellac). Wheels 3 mm (0.125 in) thick or less are molded to exact size in heated steel molds. Thicker wheels are hot-pressed in steel molds. After pressing, the wheels are set in quartz sand and baked for a few hours at approximately 150°C (300°F). The finishing and inspection processes are similar to those for other types of wheels.

In addition to grinding wheels, bonded abrasives are formed into blocks, bricks, and sticks for sharpening and polishing stones such as oil stones, scythe stones, razor and cylinder hones. Curved abrasive blocks and abrasive segments are manufactured for grinding or polishing curved surfaces. Abrasive segments can also be combined into large wheels such as pulpstones. Rubber pencil and ink erasers contain abrasive grains; similar soft rubber wheels, sticks and other forms are made for finishing soft metals.

Coated Abrasive Products Manufacturing

Coated abrasives consist of sized abrasive grains held by a film of adhesive to a flexible backing. The backing may be film, cloth, paper, vulcanized fiber, or a combination of these materials. Various types of resins, glues, and varnishes are used as adhesives or bonds. The glue is typically animal hide glue. The resins and varnishes are generally liquid phenolics or ureas, but depending on the end use of the abrasive, they may be modified to yield shorter or longer drying times, greater strength, more flexibility, or other required properties. Figure 8.31-3 presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, typically 1.3 m (52 in.) wide and 46 m (150 ft) long, passing through a printing press which imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Then the backing receives the first application of adhesive bond, the "make" coat, in a carefully regulated film, varying in concentration and quantity according to the particle size of the abrasive to be bonded. Next, the selected abrasive grains are applied either by a mechanical or an electrostatic method. Virtually all of the abrasive grain used for coated abrasive products is either silicon carbide or aluminum oxide, augmented by small quantities of natural garnet or emery for woodworking, and minute amounts of diamond or CBN.

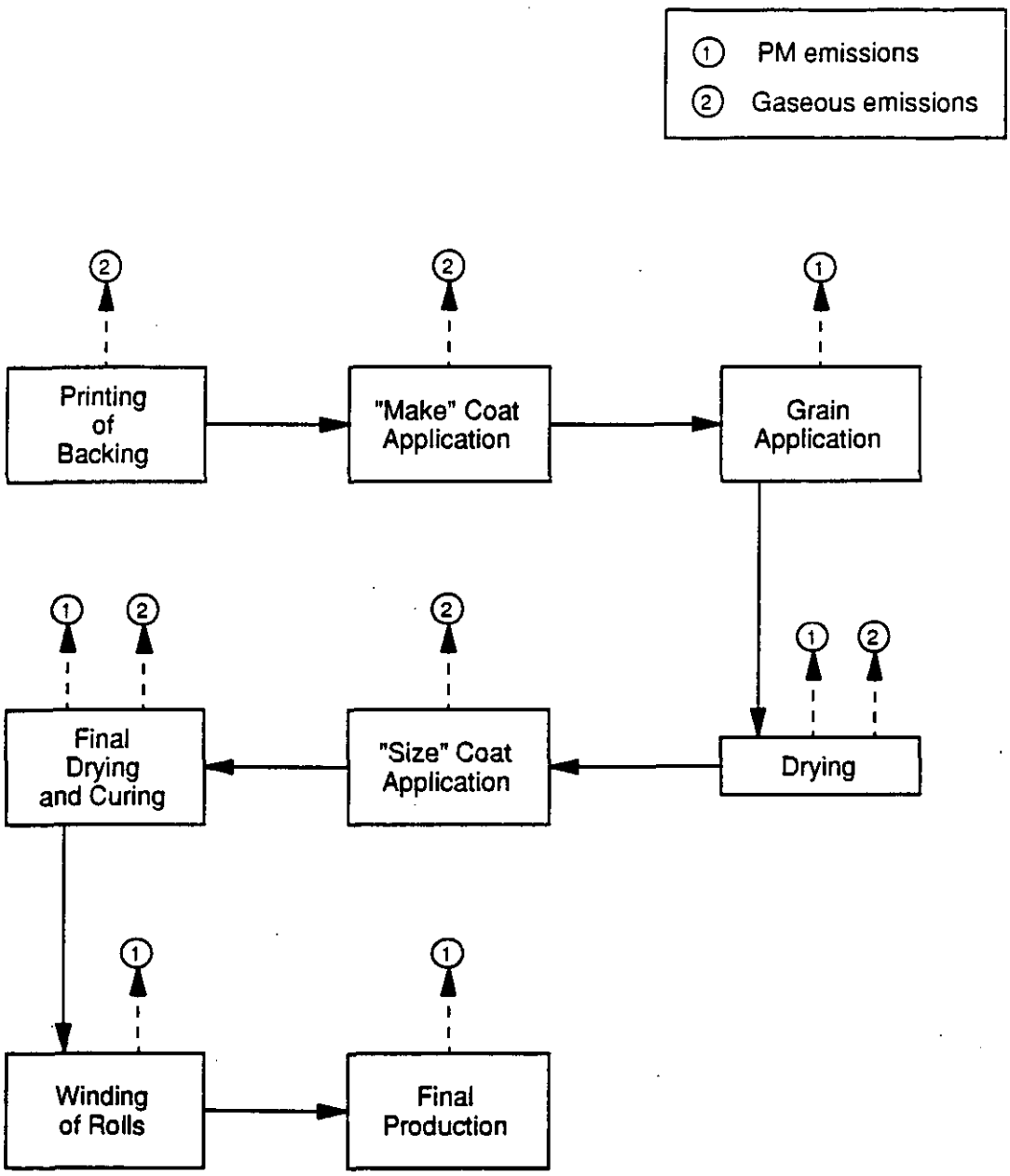

Figure 8.31-3. Process flow diagram for the manufacturing of coated abrasive products.

In mechanical application, the abrasive grains are poured in a controlled stream onto the adhesive-impregnated backing, or the impregnated backing is passed through a tray of abrasive thereby picking up the grains. In the electrostatic method, the adhesive-impregnated backing is passed adhesive-coated side down over a tray of abrasive grains, while at the same time passing an electric current through the abrasive. The electrostatic charge induced by the current causes the grains to imbed upright in the wet bond on the backing. In effect the sharp cutting edges of the grain are bonded perpendicular to the backing. It also causes the individual grains to be spaced more evenly due to individual grain repulsion. The amount of abrasive grains deposited on the backing can be controlled extremely accurately by adjusting the abrasive stream and manipulating the speed of the backing sheet through the abrasive.

After the abrasive is applied, the product is carried by a festoon conveyor system through a drying chamber to the sizing unit, where a second layer of adhesive, called the size coat, is applied. The size coat unites with the make coat to anchor the abrasive grains securely. The coated material is then carried by another longer festoon conveyor through the final drying and curing chamber in which the temperature and humidity are closely controlled to insure uniform drying and curing. When the bond is properly dried and cured, the coated abrasive is wound into jumbo rolls and stored for subsequent conversion into marketable forms of coated abrasives. Finished coated abrasives are available as sheets, rolls, belts, discs, bands, cones, and many other specialized forms.

8.31.3 Emissions and Controls[1]

Little information is available on emissions from the manufacturing of abrasive grains and products. However, based on similar processes in other industries, some assumptions can be made about the types of emissions that are likely to result from abrasives manufacturing.

Emissions from the production of synthetic abrasive grains, such as aluminum oxide and silicon carbide, are likely to consist primarily of particulate matter (PM), PM less than 10 micrometers (PM-10) and carbon monoxide (CO) from the furnaces. The PM and PM-10 emissions are likely to consist of filterable, inorganic condensible, and organic condensible PM. The addition of salt and sawdust to the furnace charge for silicon carbide production is likely to result in emissions of chlorides and volatile organic compounds (VOC's). Aluminum oxide processing takes place in an electric arc furnace and involves temperatures up to 2600°C with raw materials of bauxite ore, silica,

coke, iron borings, and a variety of minerals that include chromium oxide, cryolite, pyrite, and silane. This processing is likely to emit fluorides, sulfides, and metal constituents of the feed material.

The primary emissions from abrasive grain processing consist of PM and PM-10 from the crushing, screening, classifying, and drying operations. Particulate matter also is emitted from materials handling and transfer operations. Tables 8.31-1 and 8.31-2 present emission factors for CO_2 emissions from grain drying operations in metric and English units, respectively, and Tables 8.31-3 and 8.31-4 present emission factors for filterable PM emissions from grain drying in metric and English units. Table 8.31-5 presents emission factors developed from the results of a metals analysis conducted on a rotary dryer controlled by a wet scrubber.

Emissions generated in the production of bonded abrasive products may involve a small amount of dust generated by handling the loose abrasive, but careful control of sizes of abrasives particles limits the amount of fine particulate that can be entrained in the ambient air. However, for products made from finer grit sizes--less than 0.13 mm (200 grit)--PM emissions may be a significant problem. The main emissions from production of grinding wheels are generated during the curing of the bond structure for wheels. Heating ovens or kilns emit various types of VOC's depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Vitrified products produce some emissions as filler materials included to provide voids in the wheel structure are vaporized. Curing resins or rubber that is used in some types of bond systems also produce emissions of VOC's. Another small source of emissions may be vaporization during curing of portions of the chloride- and sulfur-based materials that are included within the bonding structure as grinding aids.

Emissions that may result from the production of coated abrasive products consist primarily of VOC's from the curing of the resin bonds and adhesives used to coat and attach the abrasive grains to the fabric or paper backing. Emissions from dryers and curing ovens also may include products of combustion, such as CO, CO_2, NO_x, and SO_x, in addition to filterable and condensible PM. Emissions that come from conversion of large rolls of coated abrasives into smaller products such as sanding belts consist of PM and PM-10. In addition, some VOC's may be emitted as a result of the volatilization of adhesives used to form joints in those products.

Little information is available on the types of controls used by the abrasives industry to control emissions. However, it is assumed that conventional devices such as cyclones, scrubbers, fabric filters, and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

TABLE 8.31-1. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	22[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-2. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	43[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-3. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.0073[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-4. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.015[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-5. (METRIC AND ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

Ratings (A-E) Follow Each Emission Factor

Source (SCC)	Metal	Emission factor		Rating	Ref.
		kg/Mg	lb/ton		
Rotary dryer: sand blasting grit, with wet scrubber	Antimony	4.0E-05	8.1E-05	E	8
	Arsenic	0.00012	0.00024	E	8
	Beryllium	4.1E-06	8.2E-06	E	8
	Lead	0.0022	0.0044	E	8
	Cadmium	0.00048	0.00096	E	8
	Chromium	0.00023	0.00045	E	8
	Manganese	3.1E-05	6.1E-05	E	8
	Mercury	8.5E-07	1.7E-06	E	8
	Thallium	4.0E-05	8.1E-05	E	8
	Nickel	0.0013	0.0026	E	8

[a]Emission factors in kg/Mg (lb/ton) of grit fed into dryer.

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5. DRAFT AP-42 SECTION 8.31

8.31 ABRASIVES MANUFACTURING

8.31.1 General[1]

The abrasives industry is composed of approximately 400 companies engaged in several separate industries: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. The abrasive grain industry manufactures abrasive grains for use by the other abrasive industries to manufacture abrasive products. The bonded abrasives industry is very diversified and includes the production of grinding stones and wheels, cutoff saws for masonry and metals, and other products. Coated abrasive products manufacturers include those facilities that produce large rolls of abrasive-coated fabric or paper, known as jumbo rolls, and those facilities that manufacture belts and other products from jumbo rolls for end use.

The Standard Industrial Classification (SIC) code for abrasives manufacturing is 3291, which is the code for abrasive products. This SIC code encompasses abrasive grain production, coated and bonded abrasive products manufacturing, and several related industries. There is currently no Source Classification Code (SCC) for the industry. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

8.31.2 Process Description[1-6]

The process description is broken into three distinct segments discussed in the following sections: production of the abrasive grains, production of bonded abrasive products, and production of coated abrasive products.

Abrasive Grain Manufacturing

The most commonly used abrasive materials are aluminum oxides and silicon carbide. These synthetic materials account for as much as 80 to 90 percent of the total quantity of abrasive grains produced domestically. Other materials used for abrasive grains are cubic boron nitride (CBN), synthetic diamonds, and several naturally occurring minerals such as garnet and emery. Cubic boron

nitride is used for machining the hardest steels to precise forms and finishes. The largest application of synthetic diamonds has been in wheels for grinding carbides and ceramics. Natural diamonds are used primarily in diamond tipped drill bits and saw blades for cutting or shaping rock, concrete, grinding wheels, glass, quartz, gems, and high-speed tool steels. Other naturally occurring abrasive materials (including garnet, emery, silica sand, and quartz) are used in finishing wood, leather, rubber, plastics, glass, and softer metals.

The following paragraphs describe the production of aluminum oxide, silicon carbide, CBN, and synthetic diamond.

1. Silicon carbide. Silicon carbide (SiC) is manufactured in a resistance arc furnace charged with a mixture of approximately 60 percent silica sand and 40 percent finely ground petroleum coke. A small amount of sawdust is added to the mix to increase its porosity so that the carbon monoxide gas formed during the process can escape freely. Common salt is added to the mix to promote the carbon-silicon reaction and to remove impurities in the sand and coke. During the heating period, the furnace core reaches approximately 2200°C (4000°F), at which point a large portion of the load crystallizes. At the end of the run, the furnace contains a core of loosely knit silicon carbide crystals surrounded by unreacted or partially reacted raw materials. The silicon carbide crystals are removed to begin processing into abrasive grains.

2. Aluminum oxide. Fused aluminum oxide (Al_2O_3) is produced in pot-type electric-arc furnaces with capacities of several tons. Before processing, bauxite, the crude raw material, is calcined at about 950°C (1740°F) to remove both free and combined water. The bauxite is then mixed with ground coke (about 3 percent) and iron borings (about 2 percent). An electric current is applied and the intense heat, on the order of 2000°C (3700°F), melts the bauxite and reduces the impurities which settle to the bottom of the furnace. As the fusion process continues, more bauxite mixture is added until the furnace is full. The furnace is then emptied and the outer impure layer is stripped off. The core of aluminum oxide is then removed to be processed into abrasive grains.

3. Cubic boron nitride. Cubic boron nitride is synthesized in crystal form from hexagonal boron nitride, which is composed of atoms of boron and nitrogen. The hexagonal boron nitride is combined with a catalyst such as metallic lithium at temperatures in the range of 1650°C (3000°F) and pressures of up to 6,895,000 kilopascals (kPa) (1,000,000 pounds per square inch [psi]).

4. Synthetic diamond. Synthetic diamond is manufactured by subjecting graphite in the presence of a metal catalyst to pressures in the range of 5,571,000 to 13,100,000 kPa (808,000 to 1,900,000 psi) at temperatures in the range of 1400° to 2500°C (2500° to 4500°F).

Abrasive Grain Processing

Abrasive grains for both bonded and coated abrasive products are made by graded crushing and close sizing of either natural or synthetic abrasives. Raw abrasive materials first are crushed by primary crushers and are then reduced to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]), by jaw crushers. Final crushing is usually accomplished with roll crushers which break up the small pieces into a usable range of sizes. The crushed abrasive grains are then separated into specific grade sizes by passing them over a series of screens. Grains are washed in classifiers to remove slimes, dried, passed through magnetic separators to remove iron-bearing material, and then the grains are again closely sized on screens. This careful sizing is necessary to prevent contamination of grades by coarser grains. Sizes finer than 0.10 millimeter (mm) (250 grit) are separated by hydraulic flotation and sedimentation or by air classification. Figure 8.31-1 presents a process flow diagram for abrasive grain processing.

Bonded Abrasive Products Manufacturing

The grains in bonded abrasive products are held together by one of six types of bonds: vitrified or ceramic (which accounts for more than 50 percent of all grinding wheels); resinoid (synthetic resin); rubber; shellac; silicate of soda; or oxychloride of magnesium. Figure 8.31-2 presents a process flow diagram for the manufacturing of vitrified bonded abrasive products.

Measured amounts of prepared abrasive grains are moistened and mixed with porosity media and bond material. Porosity media are used for creating voids in the finished wheels and consist of filler materials, such as paradichlorobenzene (moth ball crystals) or walnut shells, that are vaporized during firing. Feldspar and clays generally are used as bond materials in vitrified wheels. The mix is moistened with water or another temporary binder to make the wheel stick together after it is pressed. The mix is then packed and uniformly distributed into a steel grinding wheel mold, and compressed in a hydraulic press under pressures varying from 1,030 to 69,000 kPa (150 to 10,000 psi). If there is a pore inducing media in the mix, such as paradichlorobenzene, it is removed

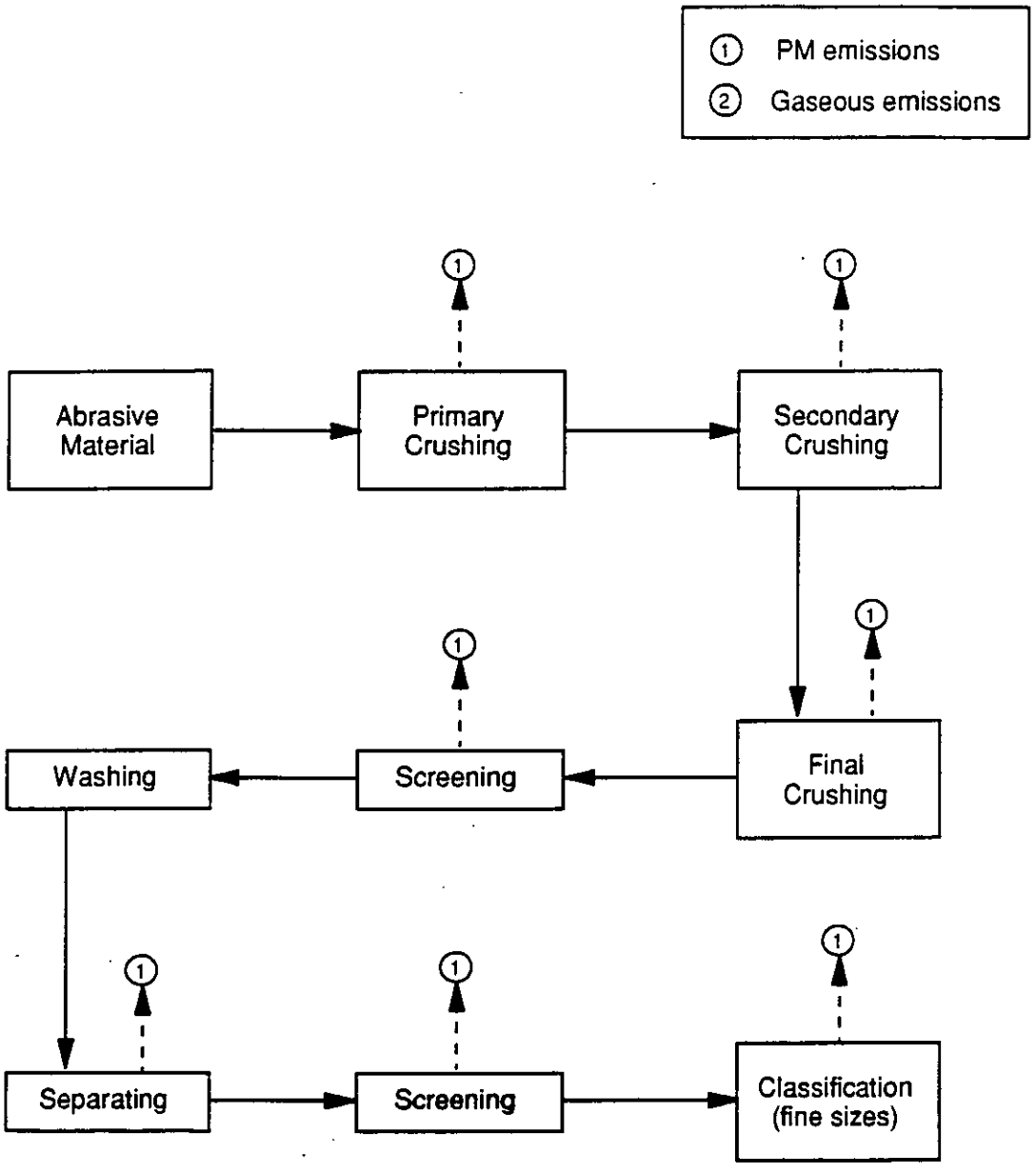

Figure 8.31-1. Process flow diagram for abrasive grain processing.

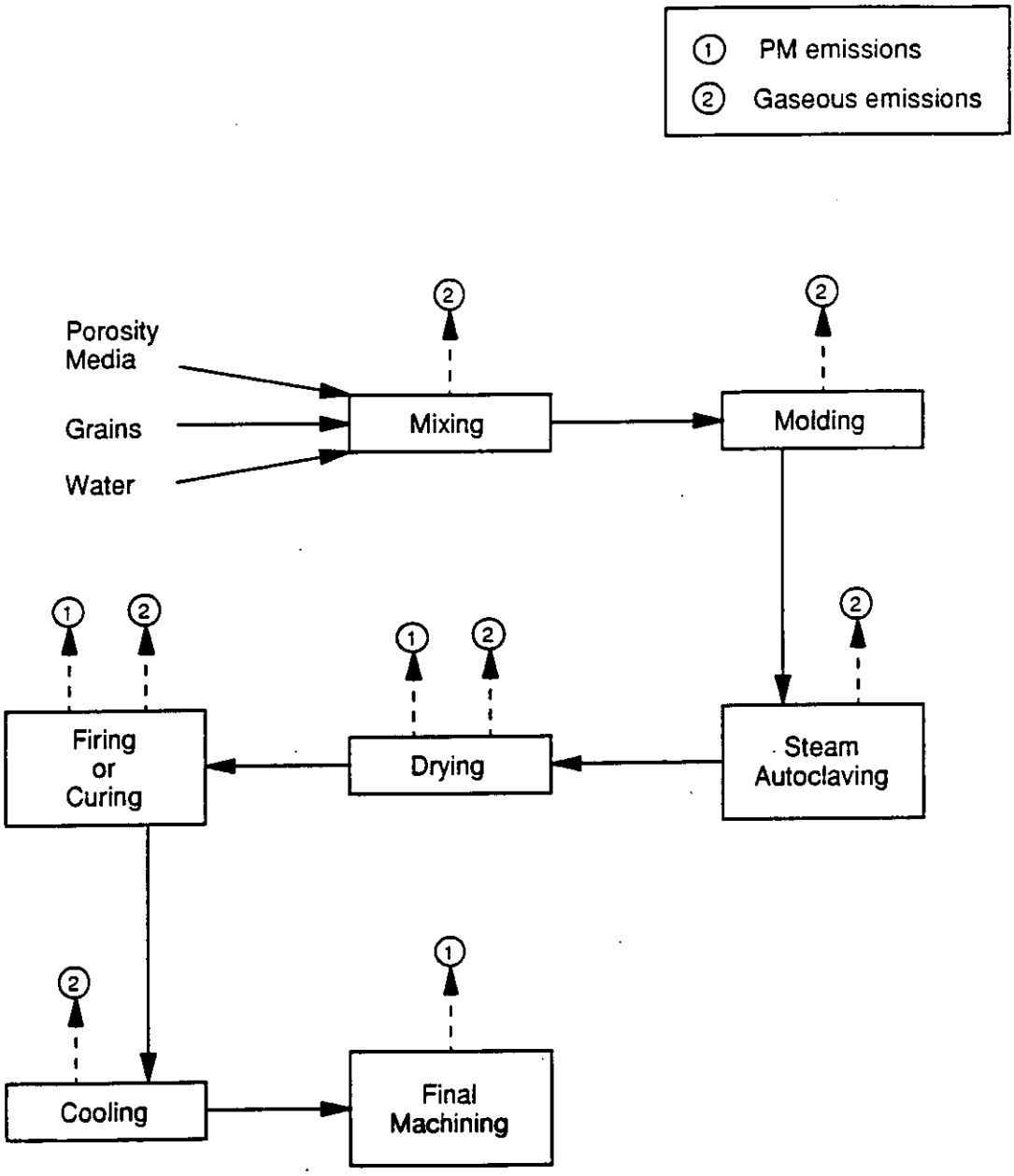

Figure 8.31-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.

in a steam autoclave. Prior to firing, smaller wheels are dried in continuous dryers; larger wheels are dried in humidity-controlled, intermittent dry houses.

Most vitrified wheels are fired in continuous tunnel kilns in which the molded wheels ride through the kiln on a moving belt. However, large wheels are often fired in bell or periodic kilns. In the firing process, the wheels are brought slowly to temperatures approaching 1400°C (2500°F) for as long as several days, depending on the size of the grinding wheels and the charge. This slow temperature ramp fuses the clay bond mixture so that each grain is surrounded by a hard glass-like bond that has high strength and rigidity. The wheels are then removed from the kiln and slowly cooled.

After cooling, the wheels are checked for distortion, shape, and size. The wheels are then machined to final size, balanced, and overspeed tested to ensure operational safety. Occasionally wax and oil, rosin, or sulfur are applied to improve the cutting effectiveness of the wheel.

Resin-bonded wheels are produced similarly to vitrified wheels, except that the bond material is a resin. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C (300° to 400°F) for a period of from 12 hours to 4 or 5 days, depending on the size of the wheel. During the curing period, the mold first softens and then hardens as the oven reaches curing temperature. After cooling, the mold retains its cured hardness. The remainder of the production process is similar to that for vitrified wheels.

Rubber-bonded wheels are produced by selecting the abrasive grain, sieving it, and kneading the grain into a natural or synthetic rubber. Sulfur is added as a vulcanizing agent and then the mix is rolled between steel calendar rolls to form a sheet of the required thickness. The grinding wheels are cut out of the rolled sheet to a specified diameter and hole size. Scraps are kneaded, rolled, and cut out again. Then the wheels are vulcanized in molds under pressure in ovens at approximately 150° to 175°C (300° to 350°F). The finishing and inspection processes are similar to those for other types of wheels.

Shellac-bonded wheels represent a small percentage of the bonded abrasives market. The production of these wheels begins by mixing abrasive grain with shellac in a steam-heated mixer,

which thoroughly coats the grain with the bond material (shellac). Wheels 3 mm (0.125 in) thick or less are molded to exact size in heated steel molds. Thicker wheels are hot-pressed in steel molds. After pressing, the wheels are set in quartz sand and baked for a few hours at approximately 150°C (300°F). The finishing and inspection processes are similar to those for other types of wheels.

In addition to grinding wheels, bonded abrasives are formed into blocks, bricks, and sticks for sharpening and polishing stones such as oil stones, scythe stones, razor and cylinder hones. Curved abrasive blocks and abrasive segments are manufactured for grinding or polishing curved surfaces. Abrasive segments can also be combined into large wheels such as pulpstones. Rubber pencil and ink erasers contain abrasive grains; similar soft rubber wheels, sticks and other forms are made for finishing soft metals.

Coated Abrasive Products Manufacturing

Coated abrasives consist of sized abrasive grains held by a film of adhesive to a flexible backing. The backing may be film, cloth, paper, vulcanized fiber, or a combination of these materials. Various types of resins, glues, and varnishes are used as adhesives or bonds. The glue is typically animal hide glue. The resins and varnishes are generally liquid phenolics or ureas, but depending on the end use of the abrasive, they may be modified to yield shorter or longer drying times, greater strength, more flexibility, or other required properties. Figure 8.31-3 presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, typically 1.3 m (52 in.) wide and 46 m (150 ft) long, passing through a printing press which imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Then the backing receives the first application of adhesive bond, the "make" coat, in a carefully regulated film, varying in concentration and quantity according to the particle size of the abrasive to be bonded. Next, the selected abrasive grains are applied either by a mechanical or an electrostatic method. Virtually all of the abrasive grain used for coated abrasive products is either silicon carbide or aluminum oxide, augmented by small quantities of natural garnet or emery for woodworking, and minute amounts of diamond or CBN.

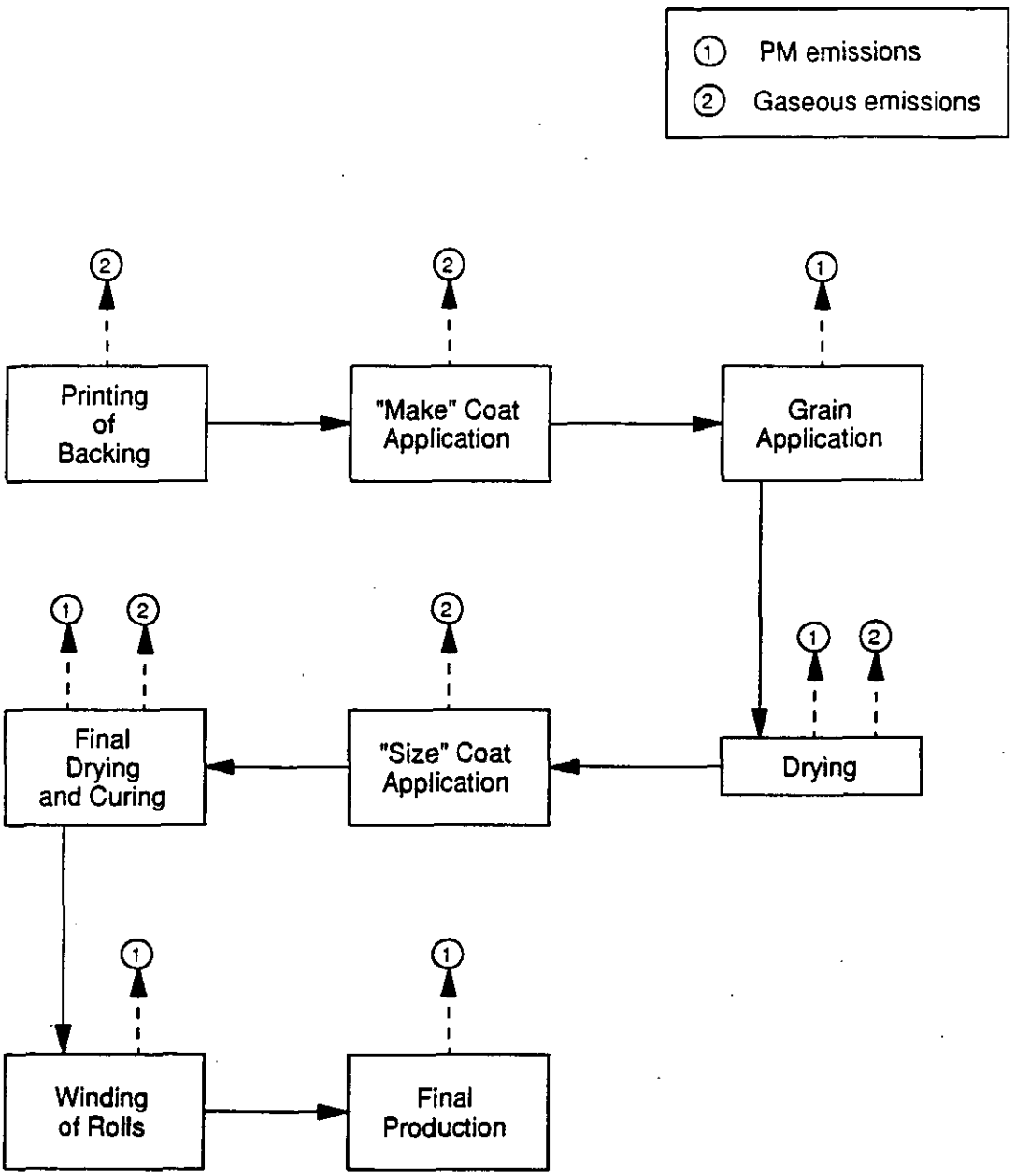

Figure 8.31-3. Process flow diagram for the manufacturing of coated abrasive products.

In mechanical application, the abrasive grains are poured in a controlled stream onto the adhesive-impregnated backing, or the impregnated backing is passed through a tray of abrasive thereby picking up the grains. In the electrostatic method, the adhesive-impregnated backing is passed adhesive-coated side down over a tray of abrasive grains, while at the same time passing an electric current through the abrasive. The electrostatic charge induced by the current causes the grains to imbed upright in the wet bond on the backing. In effect the sharp cutting edges of the grain are bonded perpendicular to the backing. It also causes the individual grains to be spaced more evenly due to individual grain repulsion. The amount of abrasive grains deposited on the backing can be controlled extremely accurately by adjusting the abrasive stream and manipulating the speed of the backing sheet through the abrasive.

After the abrasive is applied, the product is carried by a festoon conveyor system through a drying chamber to the sizing unit, where a second layer of adhesive, called the size coat, is applied. The size coat unites with the make coat to anchor the abrasive grains securely. The coated material is then carried by another longer festoon conveyor through the final drying and curing chamber in which the temperature and humidity are closely controlled to insure uniform drying and curing. When the bond is properly dried and cured, the coated abrasive is wound into jumbo rolls and stored for subsequent conversion into marketable forms of coated abrasives. Finished coated abrasives are available as sheets, rolls, belts, discs, bands, cones, and many other specialized forms.

8.31.3 Emissions and Controls[1]

Little information is available on emissions from the manufacturing of abrasive grains and products. However, based on similar processes in other industries, some assumptions can be made about the types of emissions that are likely to result from abrasives manufacturing.

Emissions from the production of synthetic abrasive grains, such as aluminum oxide and silicon carbide, are likely to consist primarily of particulate matter (PM), PM less than 10 micrometers (PM-10) and carbon monoxide (CO) from the furnaces. The PM and PM-10 emissions are likely to consist of filterable, inorganic condensible, and organic condensible PM. The addition of salt and sawdust to the furnace charge for silicon carbide production is likely to result in emissions of chlorides and volatile organic compounds (VOC's). Aluminum oxide processing takes place in an electric arc furnace and involves temperatures up to 2600°C with raw materials of bauxite ore, silica,

coke, iron borings, and a variety of minerals that include chromium oxide, cryolite, pyrite, and silane. This processing is likely to emit fluorides, sulfides, and metal constituents of the feed material.

The primary emissions from abrasive grain processing consist of PM and PM-10 from the crushing, screening, classifying, and drying operations. Particulate matter also is emitted from materials handling and transfer operations. Tables 8.31-1 and 8.31-2 present emission factors for CO_2 emissions from grain drying operations in metric and English units, respectively, and Tables 8.31-3 and 8.31-4 present emission factors for filterable PM emissions from grain drying in metric and English units. Table 8.31-5 presents emission factors developed from the results of a metals analysis conducted on a rotary dryer controlled by a wet scrubber.

Emissions generated in the production of bonded abrasive products may involve a small amount of dust generated by handling the loose abrasive, but careful control of sizes of abrasives particles limits the amount of fine particulate that can be entrained in the ambient air. However, for products made from finer grit sizes--less than 0.13 mm (200 grit)--PM emissions may be a significant problem. The main emissions from production of grinding wheels are generated during the curing of the bond structure for wheels. Heating ovens or kilns emit various types of VOC's depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Vitrified products produce some emissions as filler materials included to provide voids in the wheel structure are vaporized. Curing resins or rubber that is used in some types of bond systems also produce emissions of VOC's. Another small source of emissions may be vaporization during curing of portions of the chloride- and sulfur-based materials that are included within the bonding structure as grinding aids.

Emissions that may result from the production of coated abrasive products consist primarily of VOC's from the curing of the resin bonds and adhesives used to coat and attach the abrasive grains to the fabric or paper backing. Emissions from dryers and curing ovens also may include products of combustion, such as CO, CO_2, NO_x, and SO_x, in addition to filterable and condensible PM. Emissions that come from conversion of large rolls of coated abrasives into smaller products such as sanding belts consist of PM and PM-10. In addition, some VOC's may be emitted as a result of the volatilization of adhesives used to form joints in those products.

Little information is available on the types of controls used by the abrasives industry to control emissions. However, it is assumed that conventional devices such as cyclones, scrubbers, fabric filters, and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

TABLE 8.31-1. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	22[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-2. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	CO	CO_2	
Rotary dryer, sand blasting grit, with wet scrubber	ND	43[a]	E

ND = No data available.
[a]Reference 8.

TABLE 8.31-3. (METRIC UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.0073[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-4. (ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

All Emission Factors in lb/ton of Feed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Process (SCC)	Filterable[b]			Condensible PM[c]	
	PM		PM-10	Inorganic	Organic
Rotary dryer, sand blasting grit, with fabric filter	0.015[d]	E	ND	ND	ND

ND = No data available.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. PM-10 values are based on particle size distribution data.
[c]Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d]Reference 7.

TABLE 8.31-5. (METRIC AND ENGLISH UNITS)
EMISSION FACTORS FOR ABRASIVE MANUFACTURING[a]

Ratings (A-E) Follow Each Emission Factor

Source (SCC)	Metal	Emission factor		Rating	Ref.
		kg/Mg	lb/ton		
Rotary dryer: sand blasting grit, with wet scrubber	Antimony	4.0E-05	8.1E-05	E	8
	Arsenic	0.00012	0.00024	E	8
	Beryllium	4.1E-06	8.2E-06	E	8
	Lead	0.0022	0.0044	E	8
	Cadmium	0.00048	0.00096	E	8
	Chromium	0.00023	0.00045	E	8
	Manganese	3.1E-05	6.1E-05	E	8
	Mercury	8.5E-07	1.7E-06	E	8
	Thallium	4.0E-05	8.1E-05	E	8
	Nickel	0.0013	0.0026	E	8

[a]Emission factors in kg/Mg (lb/ton) of grit fed into dryer.

REFERENCES FOR SECTION 8.31

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COATED ABRASIVES
MANUFACTURERS' INSTITUTE

THOMAS ASSOCIATES, INC., *Managing Director*

February 15, 1994

To The
SAFETY AND INDUSTRIAL HEALTH COMMITTEE

SUBJECT: Air Pollutant Emission Factors

On September 14, 1993 CAMI distributed an updated draft document from EPA entitled "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources".

Members were asked to provide comments to EPA on Chapter 8, which addresses the mineral products area by October 22, 1993.

We have just been notified by EPA that it has received no comments from members. EPA remains interested in your input and has extended the deadline until March 10.

If you need another copy of the document, please contact us.

Sincerely,

SUSAN M. YOUNG

SMY:tr
cami
Enc.
cc Ron Myers,
Environmental Protection Agency
Dave Zimmerhakl, 3M

1300 Sumner Avenue, Cleveland, Ohio 44115-2851 • (216) 241-7333 • FAX (216) 241-0105

MIDWEST RESEARCH INSTITUTE
Suite 350
401 Harrison Oaks Boulevard
Cary, North Carolina 27513-2412
Telephone (919) 677-0249
FAX (919) 677-0065

March 9, 1993

Mr. Allen Wherry
Manager
Grinding Wheel Institute
30200 Detroit Road
Cleveland, Ohio 44145

Dear Mr. Wherry:

Thank you for the information you provided in a telephone conversation with me on March 8, 1993. Enclosed are two copies of a contact report summarizing the information discussed.

The information that you provided will be used in preparing a new section on bonded abrasive products for the publication Compilation of Air Pollutant Emission Factors, otherwise known as AP-42. To ensure the accuracy of the information, please review the enclosed report and mark any changes you believe are necessary to make the information accurate, complete, and nonconfidential. Return to me one copy that you have signed and dated, and retain one copy for your records. A final version of the report, incorporating any changes you request, will be placed in the background file for the AP-42 section. If we have not received a response from you by March 24, 1993, the report will be considered final and nonconfidential and will be placed in the project files that will be made available to the public.

Thank you for your review of this report. If you have any questions, please call me at (919) 677-0249, extension 5359.

Sincerely,

Richard Marinshaw
Environmental Engineer

Enclosures

CONTACT REPORT--MRI Project No. 3612

From: Richard Marinshaw, Environmental Engineering Department

Date of Contact: March 8, 1993

Contacted by: Telephone

Company/Agency: Grinding Wheel Institute
30200 Detroit Road
Cleveland, Ohio 44145

Telephone Number: (216) 899-0010

Person(s) Contacted/Title(s)

Allen Wherry, Manager

CONTACT SUMMARY:

Mr. Wherry was contacted in order to follow up on the letter from Midwest Research Institute to the Grinding Wheel Institute, dated March 4, 1993, requesting industry statistics and information on the processes and emissions that characterize the bonded abrasive industry.

Mr. Wherry stated that it would be difficult to provide most of the requested information. The Grinding Wheel Institute has been involved in extensive research, the major thrusts of which have been the standardization of the industry and the safe use of bonded abrasive products. However, Mr. Wherry was not aware of any information that had been compiled on pollutants and emission sources for the bonded abrasive industry. Some industry statistics have been compiled, but that information is available only to member companies and cannot be disseminated to other organizations. Mr. Wherry said that The Grinding Wheel was the best general reference on the industry and that he could send a copy to us. He suggested that we contact if we had any specific questions on the bonded abrasive industry that are not addressed by that publication, and he would try to answer them. He also expressed an interest in being included in the external review of the draft AP-42 section on bonded abrasive products.

CONFIRMATION LETTER SENT 3/9/93

RESPONSE RECEIVED 4/9/91

NO CHANGES NEEDED

WRITTEN ☑

NONE ☐

CONTACT REPORT--MRI Project No. 3612

From:	Richard Marinshaw, Environmental Engineering Department
Date of Contact:	March 8, 1993
Contacted by:	Telephone
Company/Agency:	Grinding Wheel Institute 30200 Detroit Road Cleveland, Ohio 44145
Telephone Number:	(216) 899-0010

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Allen P. Wherry
4-7-93

Rec'd 3/23/93

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Organized for the Development of Efficient and Safe Grinding Practices
WHERRY ASSOCIATES, *Managers*

March 19, 1993

Mr. Richard J. Marinshaw
Environmental Engineer
MIDWEST RESEARCH INSTITUTE
401 Harrison Oaks Blvd., Suite 350
Cary, NC 27513-2412

SUBJECT: Your Letter March 4, 1993 Re "Compilation of Air Pollutant Emission Factors Volume I: Stationary Point and Area Sources"

Dear Mr. Marinshaw:

It was nice talking with you on March 8, 1993. I am sorry that we don't have the information which you requested.

I hope that the book "The Grinding Wheel," which we have sent to you, answers some of your questions and will be a valued addition to your library.

Very truly yours,

Allen P. Wherry

ALLEN P. WHERRY

APW:bas
gwi

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FAX (919) 677-0065

March 4, 1993

Allen Wherry
Manager, Grinding Wheel Institute
30200 Detroit Road
Cleveland, OH 44145

Dear Mr. Wherry:

As discussed with you on March 1, 1993, the U.S. Environmental Protection Agency (EPA) currently is updating and revising the publication Compilation of Air Pollutant Emission Factors Volume I: Stationary Point and Area Sources, otherwise known as AP-42. The AP-42 is the primary document used by industry and Regional, State, and local air pollution control agencies throughout the U.S. to estimate emissions of various air pollutants. The revised edition of AP-42 will include several new sections, one of which will be on the abrasive products industry.

The purpose of this letter is to request your assistance in obtaining information on the abrasive products industry. In particular, we are interested in obtaining a process description and flow diagram; information on the types of raw materials and emission controls used, types of emission sources, and types of pollutants emitted; and any emission data. We also are interested in industry statistics, such as the number of plants nationwide, plant locations, and annual production rates.

We currently have very little information on the abrasive products industry. Therefore, your assistance will help ensure that the document that is produced is accurate and representative of current practices in industry. Due to time constraints, we would appreciate a response by March 24, 1993.

If you have any questions about this matter, please contact me at (919) 677-0249, extension 5359, or Mr Ron Myers of EPA's Emission Inventory Branch at (919) 541-5407. I look forward to hearing from you soon.

Sincerely,

Richard J. Marinshaw
Environmental Engineer

cc: Ron Myers, EIB (MD-14)