

**Emission Factor Documentation for AP-42
Section 11.31**

Abrasives Manufacturing

Final Report

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

**EPA Contract 68-D2-0159
Work Assignment No. I-01**

MRI Project No. 4601-01

May 18, 1994

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Section 11.30**

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Final Report

**For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Inventory Branch
Research Triangle Park, NC 27711**

**Attn: Mr. Ron Myers (MD-14)
Emission Factor and Methodology**

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PREFACE

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

Approved for:

MIDWEST RESEARCH INSTITUTE

Roy Neulicht
Program Manager
Environmental Engineering
Department

Jeff Shular
Director, Environmental Engineering
Department

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EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 11.30
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 area-wide 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 11.30, 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 11.30, Abrasives Manufacturing.

2. INDUSTRY DESCRIPTION¹

The abrasives industry is composed of approximately 400 companies engaged in the following separate types of manufacturing: abrasive grain manufacturing, bonded abrasive product manufacturing, and coated abrasive product manufacturing. Abrasive grain manufacturers produce materials for use by the other abrasives manufacturers to make abrasive products. Bonded abrasives manufacturing 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. The six-digit Source Classification Codes (SCC's) for the industry are 3-05-035 for abrasive grain processing, 3-05-036 for bonded abrasives manufacturing, and 3-05-037 for coated abrasives manufacturing. Annual production data for abrasive grains, bonded abrasives, and coated abrasives are not available.

2.1 PROCESS DESCRIPTION¹⁻⁷

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. The use of garnet as an abrasive grain is decreasing. 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 that 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 by jaw crushers to manageable size, approximately 19 millimeters (mm) (0.75 inches [in]). 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. If necessary, the grains are washed in classifiers to remove slimes, dried, and passed through magnetic separators to remove iron-bearing material, before 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 account 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. 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. A thermosetting synthetic resin, in liquid or powder form, is mixed with the abrasive grain and a plasticizer (catalyst) to allow

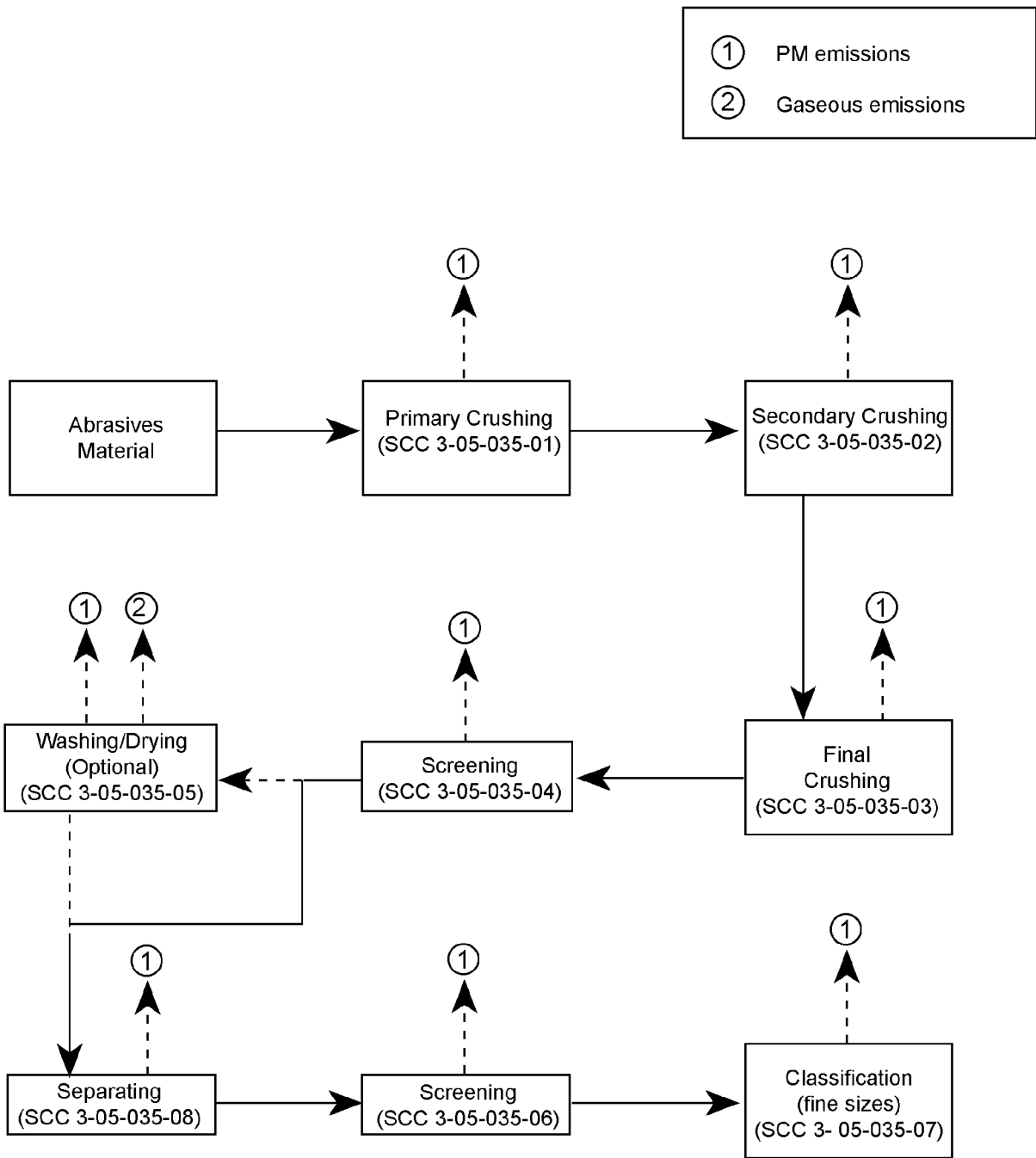


Figure 2-1. Process flow diagram for abrasive grain processing.
(Source Classification Codes in parentheses)

the mixture to be molded. The mixture is then hydraulically pressed to size and cured at 150° to 200°C

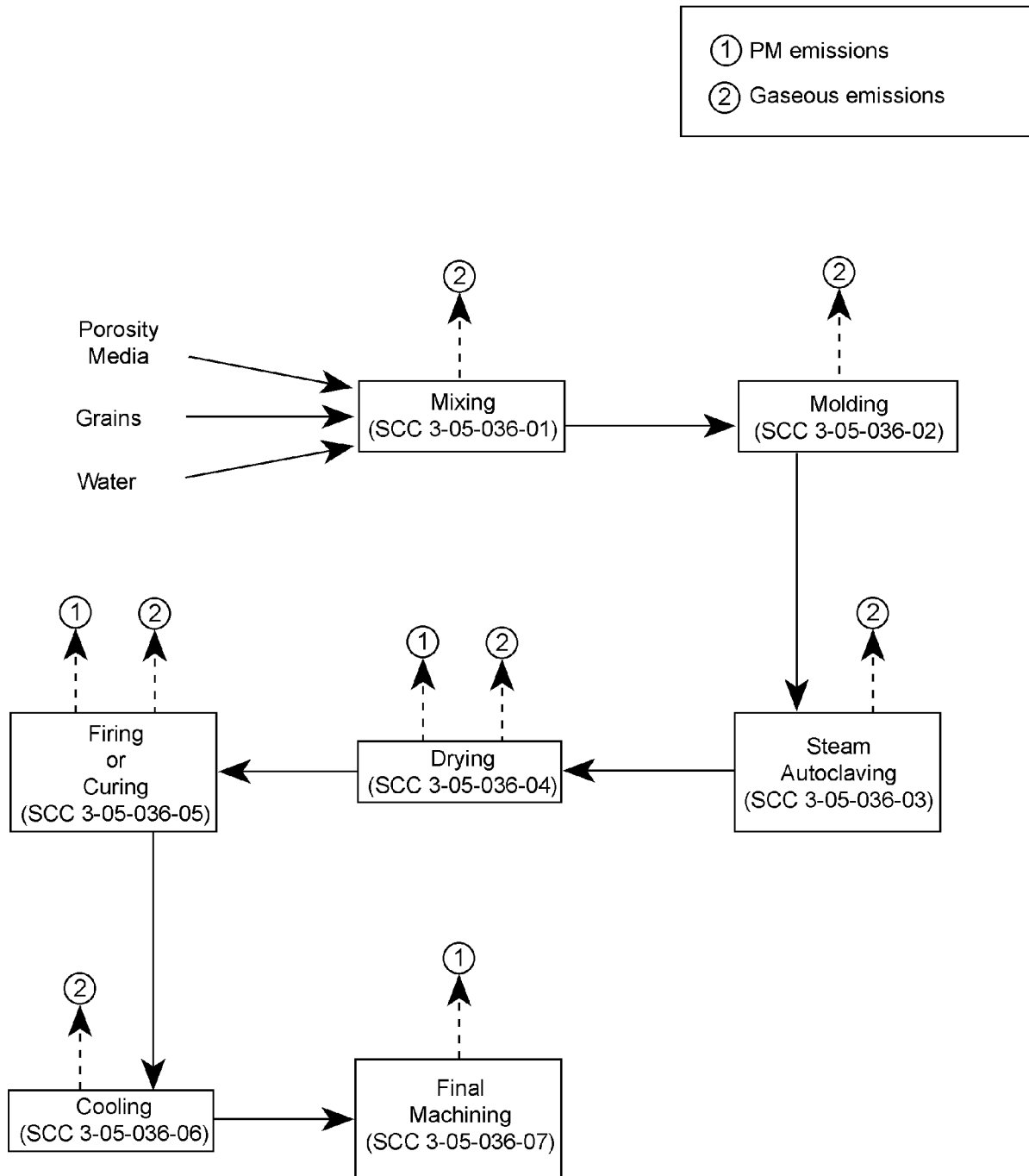


Figure 2-2. Process flow diagram for the manufacturing of vitrified bonded abrasive products.
(Source Classification Codes in parentheses)

(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

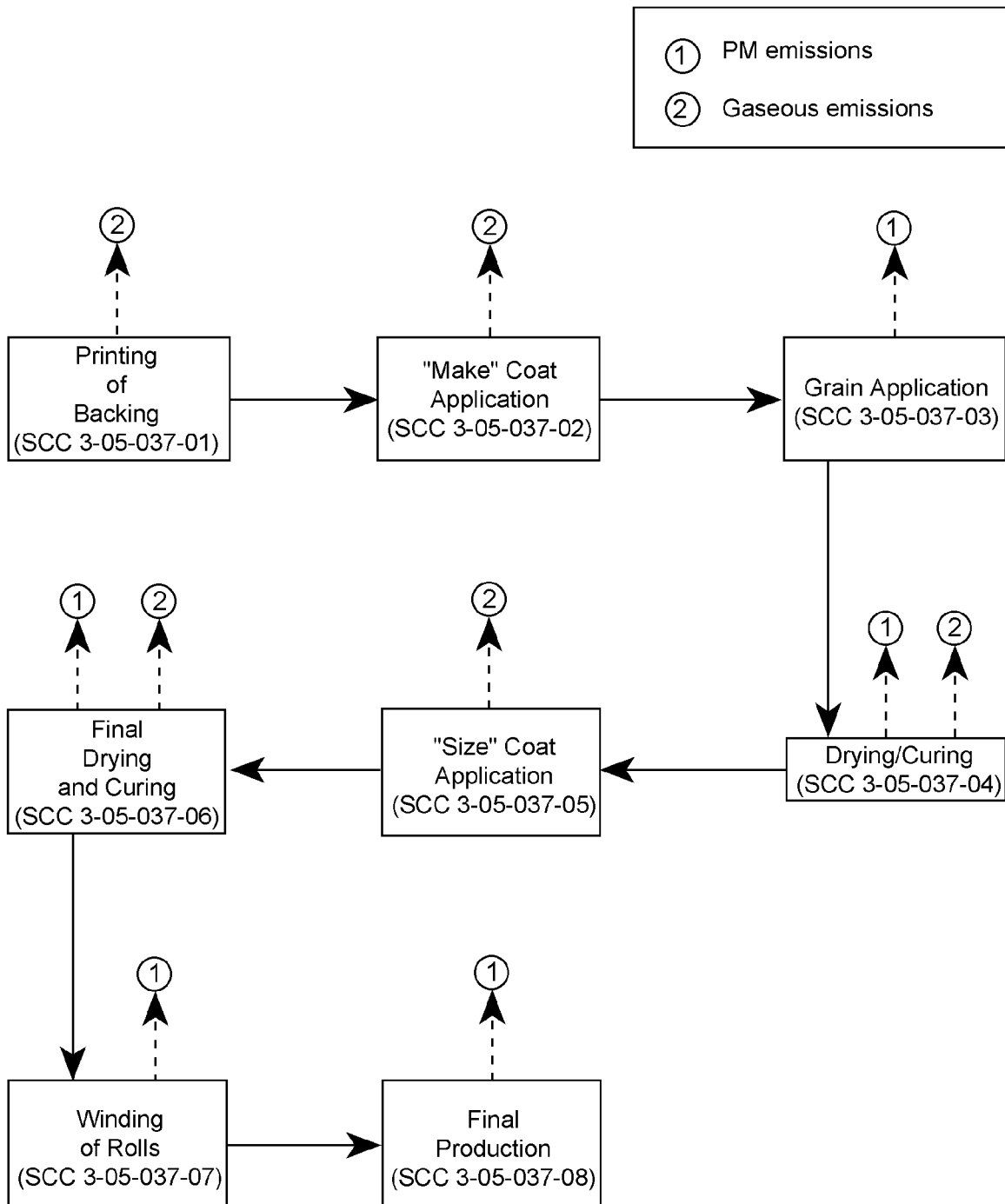


Figure 2-3. Process flow diagram for the manufacturing of coated abrasive products.
(Source Classification Codes in parentheses)

presents a process flow diagram for the manufacturing of coated abrasive products.

The production of coated abrasive products begins with a length of backing, which is passed through a printing press that imprints the brand name, manufacturer, abrasive, grade number, and other identifications on the back. Jumbo rolls typically are 13 m (52 in.) wide by 1,372 m (1,500 yards [yd]) to 2,744 m (3,000 yd) in length. The shorter lengths are used for fiber-backed products and the longer lengths are used for film-backed abrasives. 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 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 or sand size, 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^{1,7}

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 condensable, and organic condensable 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). 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. In addition, nitrogen oxides (NO_x) are emitted from the Solgel method of producing aluminum oxide.

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 abrasive 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 depending upon the composition of the bond system. Emissions from dryers and kilns also include products of combustion, such as CO, carbon dioxide (CO₂), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensable PM. Vitriified 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. 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 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, CO₂, NO_x, and SO_x, in addition to filterable and condensable 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 may be emitted as a result of the volatilization of adhesives used to form joints in those products.

2.3 CONTROL TECHNOLOGY

Fabric filters preceded by cyclones are used at some facilities to control PM emissions from abrasive grain production. This configuration of control devices can attain controlled emission concentrations of 37 micrograms per dry standard cubic meter (0.02 grains per dry standard cubic foot) and control efficiencies in excess of 99.9 percent. Little other information is available on the types of controls used by the abrasives industry to control PM emissions. However, it is assumed that other conventional devices such as scrubbers and electrostatic precipitators can be used to control PM emissions from abrasives grain and products manufacturing.

Scrubbers are used at some facilities to control NO_x emissions from aluminum oxide production. In addition, thermal oxidizers are often used in the coated abrasives industry to control emissions of VOC.

REFERENCES FOR SECTION 2

1. Telephone communication between Ted Giese, Abrasive Engineering Society, and R. Marinshaw, Midwest Research Institute, Cary, NC, March 1, 1993.
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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. Written communication between Robert Renz, 3M Environmental Engineering and Pollution Control, and R. Myers, U. S. Environmental Protection Agency, March 8, 1994.

3. GENERAL DATA REVIEW AND ANALYSIS

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained primarily from industry representatives and publications. Trade associations contacted included the Grinding Wheel Institute/Abrasive Grain Association, The Abrasive Engineering Society, and the Coated Abrasives Manufacturers' Institute. However, several other information sources were investigated, including the project files within the Office of Air Quality Planning and Standards (OAQPS), the docket for the development of new source performance standards (NSPS) for calciners and dryers in the mineral industries, the Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF), the VOC/PM Speciation Data Base Management System (SPECIATE), and the Air CHIEF CD-ROM.

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 abrasives manufacturing industry. State and Regional offices also were contacted about the availability of test reports. However, the information obtained from these offices was limited.

To select the 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*, EPA-454/B-93-050, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1993.

4. AP-42 SECTION DEVELOPMENT

4.1 DEVELOPMENT OF SECTION NARRATIVE

The AP-42 section described in this report 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 CO₂ 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 CO₂.

The emission data for metals and CO₂ 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 CO₂ and 10 metals. Because the CO₂ and metals emission data from this reference are rated C, the emission factors for CO₂ 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 ^a		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	NR	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

NR = not rated.

^aEmission factors in units of kg/Mg (lb/ton) of raw material feed.

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) ^a	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

^aEmission factors in units of kg/Mg (lb/ton) of raw material feed.

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. PROPOSED AP-42 SECTION 11.30

A proposed new AP-42 Section 11.30, Abrasives Manufacturing, is presented in the following pages as it would appear in the document.