

EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 8.27
Feldspar Processing

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 8.27, Feldspar Processing.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the feldspar processing 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 feldspar processing. Section 3 is a review of emission data collection and laboratory 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 8.27, Feldspar Processing.

2. INDUSTRY DESCRIPTION

Feldspar consists essentially of aluminum silicates combined with varying percentages of potassium, sodium, and calcium, and it is the most abundant mineral of the igneous rocks. The two types of feldspar are soda feldspar (7 percent or higher Na₂O) and potash feldspar (8 percent or higher K₂O). Feldspar-silica mixtures can occur naturally, such as in sand deposits, or can be obtained from flotation of mined and crushed rock. The Standard Industrial Classification (SIC) code for feldspar processing is 1459, which is designated for clay, ceramic, and refractory minerals, not elsewhere classified. The Source Classification Code (SCC) for feldspar processing is 3-05-034.

2.1 CHARACTERIZATION OF THE INDUSTRY^{1,2}

There are currently 14 feldspar processing facilities operating in the United States. In 1989, the national production rate was 655,000 Megagrams (Mg) (720,000 tons), valued at \$28 million. Table 2-1

TABLE 2-1. FELDSPAR PRODUCED IN THE UNITED STATES^a

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures		Total	
	Quantity (1000 tons)	Value (\$1000)	Quantity (1000 tons)	Value (\$1000)	Quantity ^b (1000 tons)	Value (\$1000)	Quantity (1000 tons)	Value (\$1000)
1985	14	W	487	16,781	197	W	700	22,800
1986	13	W	522	19,855	200	W	735	26,100
1987	10	W	492	17,800	219	W	720	26,100
1988	14	W	498	18,657	204	W	715	26,400
1989	12	W	468	16,915	241	W	720	28,000

W = Withheld to avoid disclosing company proprietary data; included in "Total."

^aReference 2. Includes potash feldspar (8 percent K₂O or higher).

^bFeldspar content.

^cData may not add to totals shown because of independent rounding.

presents the annual quantity and value of feldspar produced in the United States from 1985 to 1989.

Feldspar and feldspar-silica sand are mined in seven States, led by North Carolina and followed in descending order by Connecticut, California (estimated), Georgia, Oklahoma, Idaho, and South Dakota. North Carolina produced 67 percent of the domestic total production for 1989. Twelve companies operate 14 beneficiating plants and 1 grinding plant, 3 of which produce potash feldspar, the remainder of which produce soda, mixed feldspar, or feldspathic sand mixtures. North Carolina has six plants, California has three plants, and Connecticut, Georgia, Idaho, Oklahoma, and South Dakota each have one plant. Table 2-2 shows the producers of feldspar and feldspathic materials in 1989.

TABLE 2-2. PRODUCERS OF FELDSPAR AND FELDSPATHIC MATERIALS IN 1989²

Company	Plant location	Product
APAC Arkansas, Inc.	Muskogee, OK	Feldspar-silica mixture
Calspar Div. of Steelhead Resources Inc.	Santa Fe Springs, CA	Soda feldspar
CISCO	Corona, CA	Feldspar-silica mixture
Cyprus Foote Mineral Co.	Kings Mountain, NC	Feldspar-silica mixture
The Feldspar Corp.	Middletown, CT	Soda feldspar
The Feldspar Corp.	Monticello, GA	Potash feldspar
The Feldspar Corp.	Spruce Pine, NC	Soda feldspar
The Feldspar Corp.	Montpelier, VA	Aplite
Indusmin, Inc.	Spruce Pine, NC	Soda feldspar
KMG Minerals, Inc.	Kings Mountain, NC	Potash feldspar
Lithium Corp. of America	Bessemer City, NC	Feldspar-silica mixture
Pacer Corp.	Custer, SD	Potash feldspar
Spartan Minerals Corp.	Pacolet, SC	Feldspar-silica mixture
Unimin Corp.	Emmett, ID	Feldspar-silica mixture
Unimin Corp.	Spruce Pine, NC	Soda feldspar
U.S. Silica Co.	Oceanside, CA	Feldspar-silica mixture

Approximately 54 percent of feldspar sold or used in the United States is used for glassmaking, including container glass and glass fiber, and 45 percent is used in pottery and porcelain enamels. The raw materials most often substituted for feldspar in a number of end uses are aplite and nepheline syenite. Aplite, which contains lime-soda feldspar (plagioclase), is mined in Virginia and is used primarily for glassmaking. Nepheline syenite is a coarse crystalline rock resembling granite but consisting essentially of feldspathoid minerals (sodium-potassium feldspars and nepheline) with little or no free quartz. All of the nepheline syenite used in the United States is imported from Ontario, Canada. Talc, pyrophyllite, electric-furnace slag, and Cornwall stone may also be substituted for feldspar in the glass and ceramic industries.

2.2 PROCESS DESCRIPTION^{1,2}

Conventional open-pit mining methods including removal of overburden, drilling and blasting, loading, and transport by trucks are used to mine ores containing feldspar. A froth flotation process is used for most feldspar ore beneficiation. Figure 2-1 shows a process flow diagram of the flotation process. The ore is crushed by primary and secondary crushers and ground by jaw crushers, cone crushers, and rod mills until it is reduced to less than 841 μm (20 mesh). Then the ore passes to a three-stage, acid-circuit flotation process.

An amine collector that floats off and removes mica is used in the first flotation step. Also, sulfuric acid, pine oil, and fuel oil are added. After the feed is dewatered in a classifier or cyclone to remove reagents, sulfuric acid is added to lower the pH. Petroleum sulfonate (mahogany soap) is used to remove iron-bearing minerals. To finish the flotation process, the discharge from the second flotation step is dewatered again, and a cationic amine is used for collection as the feldspar is floated away from quartz in an environment of hydrofluoric acid (pH of 2.5 to 3.0).

If feldspathic sand is the raw material, no size reduction may be required. Also, if little or no mica is present, the first flotation step may be bypassed. Sometimes the final flotation stage is omitted, leaving a feldspar-silica mixture (often referred to as sandspar), which is usually used in glassmaking.

From the completed flotation process, the feldspar float concentrate is dewatered to 5 to 9 percent moisture. A rotary dryer is then used to reduce the moisture content to 1 percent or less. Rotary dryers are the most common dryer type used, although fluid bed dryers are also used. Typical rotary feldspar dryers are fired with No. 2 oil or natural gas, operate at about 230°C (450°F), and have a retention time of 10 to 15 minutes. Magnetic separation is used as a backup process to remove any iron minerals present. Following the drying process, dry grinding is sometimes performed to reduce the feldspar to less than 74 μm (200 mesh) for use in ceramics, paints, and tiles. Drying and grinding are often performed simultaneously by passing the dewatered cake through a rotating gas-fired cylinder lined with ceramic blocks and charged with ceramic grinding balls. Material processed in this manner must then be screened for size or air classified to ensure proper particle size.

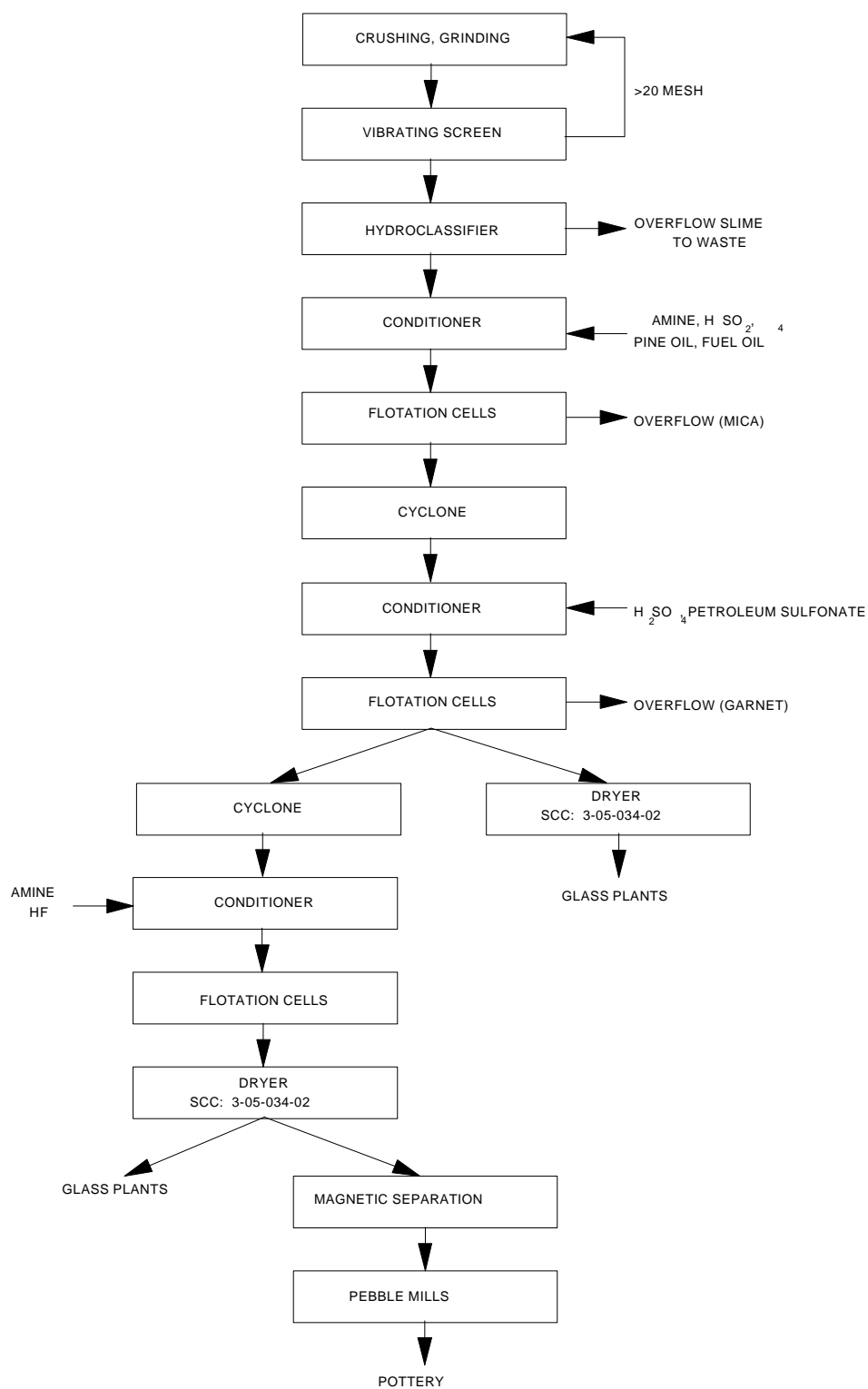


Figure 2-1. Feldspar flotation process.¹

2.3 EMISSIONS¹⁻³

The primary pollutant of concern that is emitted from feldspar processing is particulate matter (PM). Particulate matter is emitted by several feldspar processing operations, including crushing, grinding, screening, drying, and materials handling and transfer operations.

2.4 CONTROL TECHNOLOGY

Emissions from dryers typically are controlled by the combination of a cyclone or a multiclone and a scrubber system. Particulate matter emissions from crushing and grinding generally are controlled by fabric filters.

REFERENCES FOR CHAPTER 2

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-85-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.
2. Feldspar, Nepheline Syenite, and Aplite: U.S. Minerals Yearbook 1989, pp. 389-396.
3. Air Pollution Control Techniques for Non-Metallic Minerals Industry, EPA-450/3-82-014, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

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 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 Source Classification Code (SCC) for identification of the potential pollutants emitted and emission factors for those pollutants. A general search of the Air CHIEF CD-ROM was also 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 Calciners and Dryers in Mineral Industries.

A number of sources of information were investigated specifically for emission test reports and data. A search of the Test Method Storage and Retrieval (TSAR) data base was conducted to identify test reports for sources within the feldspar 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. Using this information and information obtained on plant location from the Minerals Yearbook and Calciners and Dryers in Mineral Industries, 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 feldspar processing industry.

Because of the limited amount of information available on emissions from feldspar processing, the following criteria were used in assessing the usefulness of the data:

1. Emissions data should be from a primary reference. However, secondary references were used if the document included emission data by run, rather than data averaged for the entire test. In such cases, the data were downrated to account for the fact that a secondary reference was used.
2. The referenced report should contain more than one test run. When only one valid test run was conducted, the data were downrated to account for this fact.
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 the Emission Inventory Branch (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 are given a lower rating.

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

3.3 EMISSION FACTOR QUALITY RATING SYSTEM

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

A--Excellent: Developed only from A-rated test data taken 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 industries. 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 upon the individual reviewer. Details of the rating of each candidate emission factor are provided in Chapter 4 of this report.

REFERENCES FOR CHAPTER 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

This draft AP-42 section is a new section addressing feldspar processing. The draft section is based on information gathered from the references cited and includes a description of the industry, a process flow diagram, and emission factors for drying in the feldspar processing industry.

4.2 POLLUTANT EMISSION FACTOR DEVELOPMENT

A total of six test reports were documented and reviewed in the process of developing the section on feldspar processing. All six tests took place at facilities in Spruce Pine, North Carolina. The tests reported in References 1 through 4 were used to determine compliance with the North Carolina Emission Control Standard, 15 NCAC 2D .0509, "Particulates from Mica and Feldspar Processing Plants." The test reported in Reference 5 was performed to determine PM emissions. The test reported in Reference 6 was performed to establish NSPS for the nonmetallic minerals industry. Reference 4 was not used in calculating emission factors because of problems with equipment failures and high sampling velocities that resulted in data of inadequate quality for AP-42 emission factors. Reference 5 was not used because process data were insufficient to calculate emission factors. Reference 6 was not used because no production rates or process information was provided.

4.2.1 Review of Specific Data Sets

4.2.1.1 Reference 1. This test measured PM emissions from the scrubber stack that served the drying process. After the flotation process, a rotary dryer, fueled with 50 gallons per hour of No. 2 fuel oil, was used to reduce the moisture content of the feldspar. Exhaust gases from the dryer passed through a multiclone, a scrubber (type and pressure drop not specified), and a fan and out the stack to the atmosphere. Method 5 was used to measure filterable PM emissions at 20 sampling points throughout the stack. Sample point locations and velocity measurements were made by EPA Methods 1 and 2, and flue gas composition was determined by Fyrite on Run 1 and by integrated bag samples on Runs 2 and 3 with an Orsat analyzer. The Fyrite measurement of the CO₂ concentration was less than half of the Orsat measurements. Fyrite is not considered a valid method for CO₂ measurements, as data from this report show.

A rating of B was assigned to the test data for filterable PM. The methodology appeared to be sound and no problems were reported, but the report lacked adequate detail to warrant a higher rating. A rating of B was assigned to Runs 2 and 3 of the carbon dioxide (CO₂) test data. The test methodology is sound but lacks adequate detail for documentation. Data from Run 1 were not used to develop emission factors because it was conducted using unsound test methodology.

4.2.1.2 Reference 2. This test measured PM emissions from the drying process. Crushed feldspar that had been separated from the ore by froth flotation was dewatered and routed to a direct-fired rotary dryer. The dust-laden exhaust gases from the dryer were then cleaned in a scrubber (type and pressure drop not specified) and routed through a demister to an induced draft (ID) fan, from which they exited the stack. Method 5 was used to test filterable PM emission rates. Sampling port locations and number of test ports to be used were determined according to Method 1. Instead of using Method 3 to determine flue gas composition, a dry molecular weight value of 29.0 was used for flue gas composition because of the large

quantities of air relative to combustion products. No other data regarding flue gas composition were provided.

A rating of B was assigned to this test data. Although a sound methodology was used, the report lacks adequate detail for documentation.

4.2.1.3 Reference 3. This test measured PM emissions from a feldspar dryer and a quartz dryer. Only the emissions data for the feldspar dryer were used to calculate emission factors for the feldspar processing industry, however. For each dryer, ductwork carried the dust-laden gases from the outlets to a cyclone, then through a scrubber (type and pressure drop not specified) to an ID fan. Sampling was performed at the outlet from the fan. A back-up system was attached to this system by ductwork between the cyclone and the scrubber but was isolated from the primary system by blind flanges in the ductwork.

Method 5 was used to test filterable PM emission rates. Sampling port locations and number of test ports to be used were determined according to Method 1. The composition of the flue gas was determined by the following method: CO₂ measurements were taken periodically during the run with a Fyrite instrument. Percent O₂ was determined from a nomograph (not included in the data sheets). Carbon monoxide was assumed to be zero, and the percent N₂ was determined by subtracting the percentages of CO₂ and O₂ from 100 percent.

A rating of B was assigned to the test data for filterable PM emissions. Although a sound methodology was used, the report lacks adequate detail for documentation. Carbon dioxide emission data were not used to develop emission factors because Fyrite is not valid for measuring CO₂ concentrations.

4.2.2 Review of XATEF and SPECIATE Data Base Emission Factors

The XATEF and SPECIATE data bases do not contain emission factors for feldspar processing.

4.2.3 Results of Data Analysis

Emission factors were developed for filterable PM and for CO₂ emissions from feldspar dryers. For filterable PM, emission factors were developed for emissions controlled by scrubbers and by scrubbers in combination with cyclones/multiclones (mechanical collectors). The emission factors for cyclones and multiclones were combined because the emission factor for the multiclone and scrubber combination is higher than the cyclone and scrubber factor. Presenting these factors separately would be misleading because a multiclone should be more efficient than a cyclone. Also, no details on the control systems were supplied in the test reports. For CO₂, the emission factors were developed for dryers with multiclones and scrubbers. Scrubbers may achieve incidental control of CO₂ emissions, and multiclones do not control CO₂ emissions.

Because the emission factors for filterable PM and CO₂ emissions controlled by scrubbers are based on only one test, the emission factors are rated D. The emission factors for filterable PM emissions controlled by a combination of mechanical collectors and scrubbers are based on two tests. Because of the relatively small number of domestic feldspar plants (12), tests from 2 facilities may be representative of the industry. However, because the emission factors from the two tests differ by an order of magnitude, this average emission factor is rated D.

Table 4-1 summarizes the emission data and emission factors developed from References 1, 2, and 3. Table 4-2 summarizes the emission factors to be included in the draft AP-42 section for feldspar processing.

To estimate emission factors for products of combustion, refer to AP-42 Chapter 1, External Combustion Sources.

TABLE 4-1. SUMMARY OF TEST DATA FOR FELDSPAR DRYERS

Type of control ^a	Pollutant	No. of test runs	Data rating	Emission factor ^b		Ref. No.
				Range kg/Mg (lb/ton)	Average kg/Mg (lb/ton)	
Scrubber and demister	Filterable PM	3	B	0.54-0.64 (1.1-1.3)	0.60 (1.2)	2
Multiclone and scrubber	Filterable PM	3	B	0.063-0.093 (0.13-0.19)	0.075 (0.15)	1
Cyclone and scrubber	Filterable PM	3	B	0.0048-0.0073 (0.0095-0.015)	0.0061 (0.012)	3
Multiclone and scrubber ^{c,d}	CO ₂	2	B	47-55 (93-110)	51 (102)	1

^aControl devices are listed in the order of their location in the flue gas stream.

^bEmission factor in units of pollutant weight per weight of feldspar dried.

^cScrubbers may achieve incidental control of CO₂ emissions. Multiclones do not control CO₂ emissions.

^dFuel usage is the preferred method for estimating CO₂ emissions.

TABLE 4-2. SUMMARY OF EMISSION FACTORS FOR FELDSPAR PROCESSING

Process	Type of control ^a	Pollutant	No. of tests	Average emission factor, kg/Mg (lb/ton) ^b	Emission factor rating	Ref. No.
Dryer	Scrubber and demister	Filterable PM	1	0.60 (1.2)	D	2
	Scrubber and mechanical collector	Filterable PM	2	0.041 (0.081)	D	1,3
	Multiclone and scrubber ^{c,d}	CO ₂	1	51 (102)	D	1

^aControl devices are listed in the order of their location in the flue gas stream.

^bEmission factor in units of pollutant weight per weight of feldspar dried.

^cScrubbers may achieve incidental control of CO₂ emissions. Multiclones do not control CO₂ emissions.

^dFuel usage is the preferred method for estimating CO₂ emissions.

REFERENCES FOR SECTION 4

1. Source Sampling Report for The Feldspar Corporation: Spruce Pine, NC, Environmental Testing Inc., Charlotte, NC, May 1979.
2. Particulate Emission Test Report for a Scrubber Stack at International Minerals Corporation: Spruce Pine, NC, North Carolina Department of Natural Resources & Community Development, Division of Environmental Management, September 1981.
3. Particulate Emission Test Report for 2 Scrubber Stacks at Lawson United Feldspar & Mineral Company: Spruce Pine, NC, North Carolina Department of Natural Resources & Community Development, Division of Environmental Management, October 1978.
4. Particulate Emission Test Report for a Scrubber Stack at The Feldspar Corporation: Spruce Pine, NC, North Carolina Department of Natural Resources & Community Development, Division of Environmental Management, July 1978.
5. Source Sampling Report for Indusmin Incorporated: Spruce Pine, NC, Pace Laboratories, Inc., Charlotte, NC, January 1990.
6. Air Pollution Emission Test, International Minerals and Chemical Company: Spruce Pine, NC, EMB Report 76-NMM-1, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1976.

5. AP-42 SECTION 8.27

8.27 FELDSPAR PROCESSING

8.27.1 General¹

Feldspar consists essentially of aluminum silicates combined with varying percentages of potassium, sodium, and calcium, and it is the most abundant mineral of the igneous rocks. The two types of feldspar are soda feldspar (7 percent or higher Na_2O) and potash feldspar (8 percent or higher K_2O). Feldspar-silica mixtures can occur naturally, such as in sand deposits, or can be obtained from flotation of mined and crushed rock.

8.27.2 Process Description^{1,2}

Conventional open-pit mining methods including removal of overburden, drilling and blasting, loading, and transport by trucks are used to mine ores containing feldspar. A froth flotation process is used for most feldspar ore beneficiation. Figure 8.27-1 shows a process flow diagram of the flotation process. The ore is crushed by primary and secondary crushers and ground by jaw crushers, cone crushers, and rod mills until it is reduced to less than $841\ \mu\text{m}$ (20 mesh). Then the ore passes to a three-stage, acid-circuit flotation process.

An amine collector that floats off and removes mica is used in the first flotation step. Also, sulfuric acid, pine oil, and fuel oil are added. After the feed is dewatered in a classifier or cyclone to remove reagents, sulfuric acid is added to lower the pH. Petroleum sulfonate (mahogany soap) is used to remove iron-bearing minerals. To finish the flotation process, the discharge from the second flotation step is dewatered again, and a cationic amine is used for collection as the feldspar is floated away from quartz in an environment of hydrofluoric acid (pH of 2.5 to 3.0).

If feldspathic sand is the raw material, no size reduction may be required. Also, if little or no mica is present, the first flotation step may be bypassed. Sometimes the final flotation stage is omitted, leaving a feldspar-silica mixture (often referred to as sandspar), which is usually used in glassmaking.

From the completed flotation process, the feldspar float concentrate is dewatered to 5 to 9 percent moisture. A rotary dryer is then used to reduce the moisture content to 1 percent or less. Rotary dryers are the most common dryer type used, although fluid bed dryers are also used. Typical rotary feldspar dryers are fired with No. 2 oil or natural gas, operate at about 230°C (450°F), and have a retention time of 10 to 15 minutes. Magnetic separation is used as a backup process to remove any iron minerals present. Following the drying process, dry grinding is sometimes performed to reduce the feldspar to less than $74\ \mu\text{m}$ (200 mesh) for use in ceramics, paints, and tiles. Drying and grinding are often performed simultaneously by passing the dewatered cake through a rotating gas-fired cylinder lined with ceramic blocks and charged with ceramic grinding balls. Material processed in this manner must then be screened for size or air classified to ensure proper particle size.

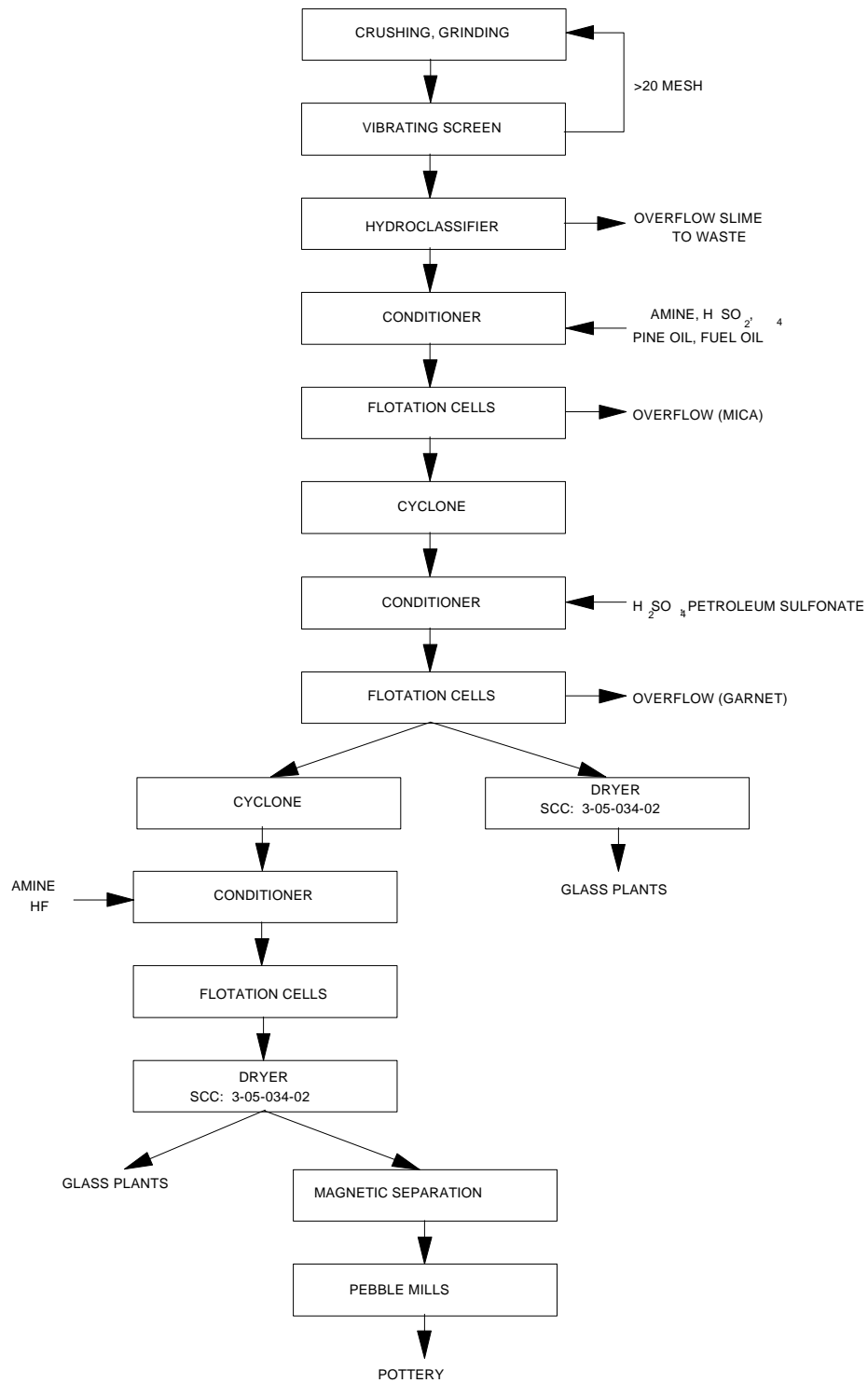


Figure 8.27-1. Feldspar flotation process.¹

8.27.2 Emissions and Controls

The primary pollutant of concern that is emitted from feldspar processing is particulate matter (PM). Particulate matter is emitted by several feldspar processing operations, including crushing, grinding, screening, drying, and materials handling and transfer operations.

Emissions from dryers typically are controlled by a combination of a cyclone or a multiclone and a scrubber system. Particulate matter emissions from crushing and grinding generally are controlled by fabric filters.

Table 8.27-1 presents controlled emission factors for filterable PM from the drying process. Table 8.27-2 presents emission factors for CO₂ from the drying process. The controls used in feldspar processing achieve only incidental control of CO₂.

TABLE 8.27-1 (METRIC UNITS). EMISSION FACTORS FOR FILTERABLE PARTICULATE MATTER

All Emission Factors in kg/Mg Feldspar Dried
Ratings (A-E) Follow Each Factor

Process (SCC)	Emission factor	
Dryer with scrubber and demister ^a (3-05-034-02)	0.60	D
Dryer with mechanical collector and scrubber ^{b,c} (3-05-034-02)	0.041	D

TABLE 8.27-1 (ENGLISH UNITS). EMISSION FACTORS FOR FILTERABLE PARTICULATE MATTER

All Emission Factors in lb/Ton Feldspar Dried
Ratings (A-E) Follow Each Factor

Process (SCC)	Emission factor	
Dryer with scrubber ^a (3-05-034-02)	1.2	D
Dryer with mechanical collector and scrubber ^{b,c} (3-05-034-02)	0.081	D

^a Reference 4.

^b Reference 3.

^c Reference 5.

TABLE 8.27-2 (METRIC UNITS).
EMISSION FACTOR FOR CARBON DIOXIDE³

Emission Factor in kg/Mg Feldspar Dried
Rating (A-E) Follows the Factor

Process (SCC)	Emission factor	
Dryer with multiclone and scrubber ^a (3-05-034-02)	51	D

TABLE 8.27-2 (ENGLISH UNITS). EMISSION FACTOR
FOR CARBON DIOXIDE³

Emission Factor in lb/Ton Feldspar Dried
Rating (A-E) Follows the Factor

Process (SCC)	Emission factor	
Dryer with multiclone and scrubber ^a (3-05-034-02)	102	D

^aScrubbers may achieve incidental control of CO₂ emissions. Multiclones do not control CO₂ emissions.

REFERENCES FOR SECTION 8.27

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-85-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.
2. US Minerals Yearbook 1989: Feldspar, Nepheline syenite, and Aplite: US Minerals Yearbook 1989, pp. 389-396.
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4. Particulate Emission Test Report for a Scrubber Stack at International Minerals Corporation: Spruce Pine, NC, North Carolina Department of Natural Resources & Community Development, Division of Environmental Management, September 1981.
5. Particulate Emission Test Report for Two Scrubber Stacks at Lawson United Feldspar & Mineral Company: Spruce Pine, NC, North Carolina Department of Natural Resources & Community Development, Division of Environmental Management, October 1978.