AP42 Section: 11.28

Title: Comments to Vermiculite section

1995

CONTACT REPORT--MRI Project No. 4602-01

From: Richard Marinshaw, Environmental Engineering Department

Date of Contact: October 11 and , 1994

Contacted by: Telephone

Company/Agency: W.R. Grace & Company
62 Whittemore Avenue
Cambridge, MA 02140-1692

Telephone Number: (617) 876-1400

CALLED AGAIN
11/ NLM

11/8 SAID HE WOULD GET BACK TO ME IN A COUPLE OF DAYS

11/23 Phoned Burrill
NLM

<u>Person(s) Contacted/Title(s)</u>

Jay Burrill, Environmental Coordinator

CONTACT SUMMARY:

Mr. Burrill was contacted for supplemental information on the emission test reports provided by W. R. Grace & Company (W.R. Grace) in their August 26, 1994 response to the external review of the draft AP-42 section on vermiculite processing.

Regarding the emission test at W. R. Grace's Enoree, South Carolina, plant, Mr. Burrill stated the following:

- During the emission test at Enoree, the vermiculite ore dryers were natural gas-fired.

Regarding the emission test at the Dallas, Texas, facility, Mr. Burrill stated the following:

- The three exfoliation furnaces tested were fired with natural gas.
- The process rates provided by W. R. Grace were typical production rates for the furnaces.
- The reason that the process rates for the G-1 and G-2 furnaces were identical is that the furnaces are of identical design.
- The condensible PM data provided in the report most likely represent the organic fraction only, not total condensible PM.

Mr. Burrill also remarked that process rates for exfoliation furnaces typically are measured in terms of production rather than feed rate.

FAX TRANSMISSION

TO: Ron Myers, EFIG

FROM: Rick Marinshaw, MRI

DATE: January 24, 1995

RECEIVING FAX NUMBER: 541-0684

SENDING FAX NUMBER: 919-677-0065

THIS FAX CONSISTS OF 17 PAGES (INCLUDING THIS PAGE)

Here is the revised draft AP-42 section and background memorandum for vermiculite processing. The major changes to the memo and AP-42 section are as follows:

- The industry description was expanded and a table showing the chemical analysis of vermiculite was added (memo only):
- The process description (memo and section) was expanded to provide more details on the process, based on the new information received;
- The two process flow diagrams that appeared in the previous draft were replaced with a single diagram (memo and section) that more accurately depicts the process and includes the Source Classification Codes (SCC's) (six-digit codes only);
- Nine additional emission data sets from three new test reports are presented (memo only);
- The Results of Data Analysis (memo only) was completely rewritten to address the new data; and
- Six new emission factors were added (memo and section).

Please let me know of any changes or comments. I think we should hold off on assigning new SCC's until after we receive the next round of comments.

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

JAN 27 1995

Mr. Jeff Danneker
Product Manager
W.R. Grace and Company
62 Whittemore Avenue
Cambridge, Massachusetts 02140

Dear Mr. Danneker:

The Emission Factor and Inventory Group 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 the next update of AP-42.

Enclosed is a copy of the revised draft Section 11.28, Vermiculite Processing, and the corresponding background memorandum for the section. Following the previous industry review of the draft AP-42 section, we received copies of several emission test reports for vermiculite processing facilities. Consequently, we have made significant changes to the draft AP-42 section. We would appreciate your organization reviewing the enclosed revised draft AP-42 section and background memorandum and sending us your comments. In addition, please feel free to distribute copies of these documents to other interested persons. We would appreciate a response to this request by March 8, 1995.

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 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 would also appreciate specific comments on the process description and process flow diagram presented in the enclosed draft AP-42 section.

We look forward to receiving your comments. If you have questions or need additional time to respond, I can be reached by telephone at (919) 541-5407 or by fax at (919) 541-0684.

Sincerely,

Ron Myers

Ronald E. Myers
Emission Factor and Inventory Group
Emissions, Monitoring, and
Analysis Division

2 Enclosures

OAQPS/EFIG/EMAD:RMyers, rm 455B, 4201 Bldg., 541-5407, MD-14
(MRI/RMarinshaw/LKaufman/677-0249/01/25/95)

IDENTICAL LETTER SENT TO THE FOLLOWING ADDRESSEES:

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DRAFT AP-42 SECTION 11.28

11.28 VERMICULITE PROCESSING

11.28.1 Process Description[1-9]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. The chemical formula for vermiculite is $(Mg,Ca,K,Fe^{+2})_3(Si,Al,Fe^{+3})_4O_{10}(OH)_2\bullet 4H_2O$. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due to the interlaminar generation of steam. The six-digit source classification code (SCC) for vermiculite processing is 3-05-033.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluid bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Crude Ore Processing

Figure 11.28-1 is a process flow diagram for vermiculite processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluidized bed or rotary dryer. Drying reduces the moisture content of the vermiculite concentrate from approximately 15 to 20 percent to approximately 2 to 6 percent. At least one facility uses a hammermill to crush the material exiting the dryer. However, at most facilities, the dryer products are transported by bucket elevators to vibrating screens, where the material is classified. The dryer exhaust generally is ducted to a cyclone for recovering the finer grades of vermiculite concentrate. The classified concentrate then is stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although fluidized bed dryers also are used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

Exfoliation

After being transported to the exfoliation plant, the vermiculite concentrate is stored. The ore concentrate then is conveyed by bucket elevator or other means and is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air conveyed to a classifier system, which collects the vermiculite product and removes excessive fines. The

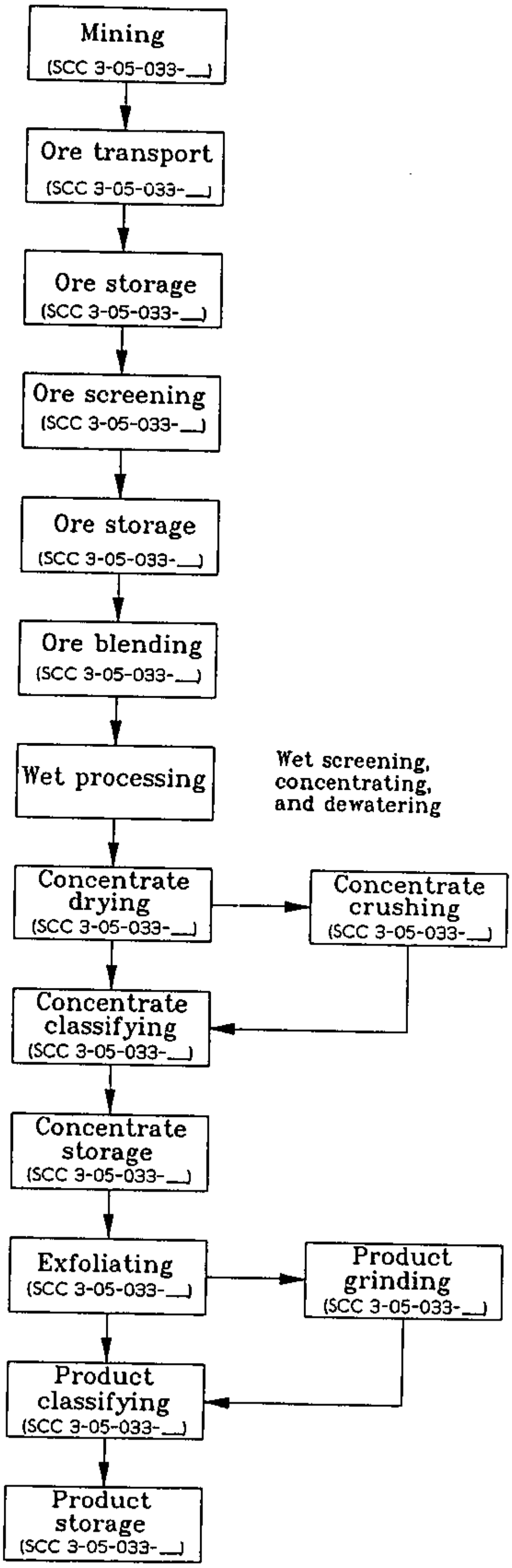

Figure 11.28-1. Process flow diagram for vermiculite processing.
(Source Classification Code in parenthesis)

furnace exhaust generally is ducted through a product recovery cyclone, followed by an emission control device. At some facilities, the exfoliated material is ground in a pulverizer prior to being classified. Finally, the material is packaged and stored for shipment.

11.28.2 Emissions and Controls[1,4-11]

The primary pollutant of concern in vermiculite processing are particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. Emissions from dryers and exfoliating furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM and PM-10.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. Cyclones and fabric filters also are used to control emissions from screening, milling, and materials handling and transfer operations.

Table 11.28-1 (metric and English units) summarizes the emission factors for vermiculite processing.

Draft Table 11.28-1 (Metric And English Units).
EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

EMISSION FACTOR RATING: D

Process	Filterable PM[b]		Condensible organic PM[c]		Total PM[d]		CO_2	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Ore dryer, with wet collector (SCC 3-05-033-__)	0.29[e]	0.57[e]	ND	ND	ND	ND	50[f]	100[f]
Concentrate screening, with cyclone (SCC 3-05-033-__)	0.30[g]	0.61[g]	NA	NA	0.30[g]	0.61[g]	NA	NA
Concentrate conveyor transfer, with cyclone (SCC 3-05-033-__)	0.013[g]	0.025[g]	NA	NA	0.013[g]	0.025[g]	NA	NA
Exfoliating furnace, with fabric filter (SCC 3-05-033-__)	0.32[h]	0.63[h]	0.18[j]	0.37[j]	0.50[k]	1.0[k]	ND	ND
Product grinding, with fabric filter (SCC 3-05-033-__)	0.18[m]	0.37[m]	NA	NA	0.18[m]	0.37[m]	NA	NA

[a] Factors represent uncontrolled emissions unless noted.. Emission factors for drying in units of kg/Mg and lb/ton of material feed; emission factors for other processes in units of kg/Mg and lb/ton of product. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.

[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.

[d] Total PM equals the sum of the filterable PM, condensible organic PM, and condensible inorganic PM.

[e] Reference 8. EMISSION FACTOR RATING: E.

[f] References 8,11. Factor represents uncontrolled emissions of CO_2.

[g] Reference 11. For dried ore concentrate.

[h] Reference 10.

[j] Reference 10. Emissions may be largely due to volatilization of oil used in ore beneficiation.

[k] Sum of factors for filterable PM and condensible organic PM; does not include condensible inorganic PM.

[m] Reference 9.

DRAFT

REFERENCES FOR SECTION 11.28

1. *Calciners and Dryers in Mineral Industries--Background Information For Proposed Standards.* U. S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/3-025a. October 1985.

2. Strand, P. R. and O. F. Stewart. *Vermiculite. Industrial Rocks And Minerals, Volume I.* Society of Mining Engineers. New York. 1983.

3. *Vermiculite, Its Properties And Uses,* The Vermiculite Association, Incorporated, Chicago, IL.

4. Written communication from Jeffrey A. Danneker, W. R. Grace and Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

5. W. J. Neuffer, *Trip Report For The September 30, 1980, Visit To W. R. Grace And Company, Enoree, South Carolina, ESD Project No. 81/08,* U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

6. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit--Virginia Vermiculite Limited, Trevilians, Virginia,* June 8, 1983.

7. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit: W. R. Grace & Company, Irondale, Alabama,* June 29, 1983.

8. *Rotary Dryer Particulate Emissions Testing, Performed For Virginia Vermiculite Limited, Boswell's Tavern, Virginia.* RTP Environmental Association. Research Triangle Park, NC. November 1979.

9. *Particulate Emission Compliance Test On Grinder Baghouse On August 8, 1989 At W. R. Grace & Company Kearney Exfoliating Plant, Enoree, South Carolina 29335.* Environmental Engineering Division, PSI. Greenville, SC. August 24, 1989.

10. *Particulate Emissions Sampling, W. R. Grace Co., Dallas, TX, April 2-4, 1990.* Turner Engineering. Dallas, TX. April 10, 1990.

11. *Particulate Emissions Test Report For W. R. Grace, August 1991.* RTP Environmental Associates, Inc. Greer, SC. August 1991.

Enclosure 2

MRI

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Date: April 6, 1993
(Revised: January 24, 1995)

Subject: Background Information for Proposed AP-42
Section 11.28, Vermiculite Processing
Review and Update of Mineral Products Industry and
Metallurgical Sections of Chapters 11 and 12 of AP-42
EPA Contract 68-D2-0159, Work Assignment II-01
MRI Project 4602-01

From: Richard Marinshaw

To: Ron Myers
EPA/EMAD/EFIG (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

I. INTRODUCTION

This memorandum presents the background information that was used to develop the proposed AP-42 Section 11.28 on vermiculite processing. A description of the industry is presented first. A process description followed by a discussion of emissions and controls is then presented. Following these sections, a description of the references that were used to develop the draft section and the results of the data analysis are presented. Finally, the reference list is provided. The draft AP-42 section is provided as the attachment.

II. DESCRIPTION OF THE INDUSTRY[1-5]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. The chemical formula for vermiculite is:

$$(Mg,Ca,K,Fe^{+2})_3\ (Si,Al,Fe^{+3})_4O_{10}(OH)_2 \cdot 4H_2O.$$

When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due to the interlaminar generation of steam. The Standard Industrial Classification (SIC) code for vermiculite mining is 1499, miscellaneous nonmetallic minerals, except fuels. For vermiculite processing, the SIC Code is 3295, minerals and earths, ground or otherwise treated. The six-digit Source Classification Code (SCC) for vermiculite processing is 3-05-033.

The world's largest deposit of vermiculite, which is located near Libby, Montana, is no longer in operation. Other major vermiculite deposits are located near Enoree, South Carolina, and in the Republic of South Africa. Vermiculite is also mined and beneficiated at a mine in Louisa County, Virginia. Deposits of economic significance contain 25 to 95 percent vermiculite.

Estimated world production of crude vermiculite in 1991 was 523,000 megagrams (Mg) (576,000 tons), more than 80 percent of which came from five mines. The United States and Republic of South Africa account for most of the world production. Estimated U.S. production of crude vermiculite sold or used by producers in 1991 was 168,000 Mg (185,000 tons), of which approximately 136,000 Mg (150,000 tons) were exfoliated.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluidized bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Vermiculite is commercially exfoliated by heating the presized crude vermiculite in a furnace chamber. The bulk volume of commercial grades increases 8- to 12-fold, but individual vermiculite particles may expand as much as 30-fold compared to the raw ore. The bulk density of exfoliated vermiculite ranges from 64 to 160 kilograms per cubic meter (kg/m^3) (4 to 10 pounds per cubic foot [lb/ft^3]). The chemical constituents of a typical sample of vermiculite are summarized in Table 1.

Exfoliated vermiculite was produced at 35 plants in 27 States in 1989. The principal producing States were, in order of decreasing exfoliated vermiculite output, Ohio, California, South Carolina, Florida, New Jersey, Illinois, Texas, and Arkansas. The main uses of exfoliated vermiculite in 1990 were fertilizer carriers (22 percent), concrete aggregate (19 percent), horticultural uses (13 percent), premixes (12 percent), block insulation (12 percent), loose fill insulation (9 percent), soil conditioners (5 percent), and plaster aggregates (1 percent).

III. PROCESS DESCRIPTION[1,3-8,11-13]

A. Crude Ore Processing

Figure 1 is a process flow diagram for vermiculite processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to other stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed

TABLE 1. CHEMICAL CONSTITUENTS OF VERMICULITE[a]

Compound	Weight percent
SiO_2	38 to 46
Al_2O_3	10 to 16
MgO	16 to 35
CaO	1 to 5
K_2O	1 to 6
Fe_2O_3	6 to 13
TiO_2	1 to 3
H_2O	8 to 16
Other[b]	0.2 to 1.2

[a] References 4-5.
[b] May include MnO, Cr_2O_3, Na_2O, and other compounds.

bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluidized bed or rotary dryer. Drying reduces the moisture content of the vermiculite concentrate from approximately 15 to 20 percent to approximately 2 to 6 percent. At least one facility uses a hammermill to crush the material exiting the dryer. However, at most facilities, the dryer products are transported by bucket elevators to vibrating screens, where the material is classified. The dryer exhaust generally is ducted to a cyclone for recovering the finer grades of vermiculite concentrate. The classified concentrate then is stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although fluidized bed dryers also are used. Drying temperatures range from 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

B. Exfoliation

After being transported to the exfoliation plant, the vermiculite concentrate is stored. The concentrate then is conveyed by bucket elevator or other means and dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds

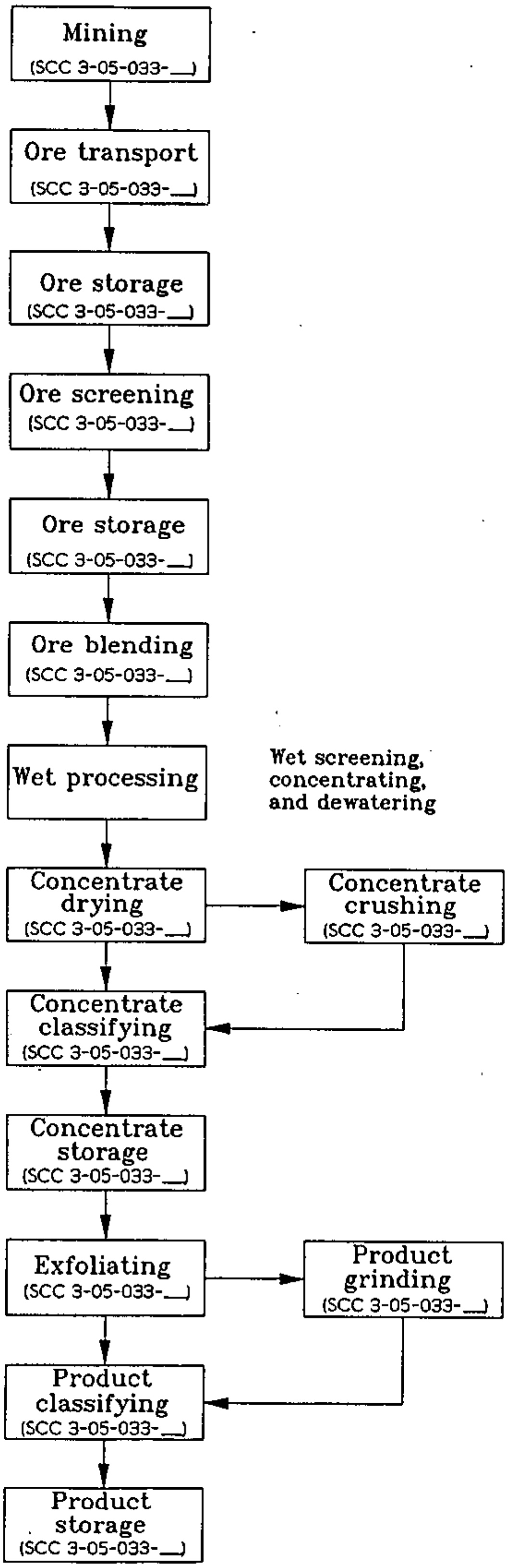

Figure 1. Flow diagram for vermiculite processing.

in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air-conveyed to a classifier system, which collects the vermiculite product and removes excessive fines. The furnace exhaust generally is ducted through a product recovery cyclone, followed by an emission control device. At some facilities, the exfoliated material is ground in a pulverizer prior to being classified. Finally, the material is packaged and stored for shipment.

IV. EMISSIONS AND CONTROLS[1,6-9,11-13]

The primary pollutants of concern in vermiculite processing are particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. In addition, vermiculite ore may contain asbestos. However, other than vermiculite mined from the Libby, Montana, deposit, which is no longer in operation, the amount of asbestos found in vermiculite deposits is considered to be negligible. Emissions from rotary dryers and expansion furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM and PM-10.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. Cyclones and fabric filters also are used to control emissions from screening, milling, and materials handling and transfer operations.

V. DESCRIPTION OF REFERENCES

This section describes the primary references that contained data on emissions from vermiculite processing that were used to develop the draft AP-42 section. Reference 1 is not described because it is a secondary reference, and the vermiculite processing emission data in Reference 1 are taken from Reference 6, which is the primary reference for the data. References 2 to 8 and 10 also are not described because they do not contain emission data. However, References 5 and 14 contain the process operating rates for the emission tests documented in Reference 12 and 13.

A. Reference 9

This report documents measurements of filterable PM and CO_2 from an oil-fired rotary dryer. The purpose of the emission test was to demonstrate compliance with State regulations. The test was conducted in 1979. Process rates were provided on the basis of raw material feed. The dryer emissions are controlled with a low-energy spray tower with a design pressure drop of 1.2 kilopascals (5-in. water column).

Particulate matter emissions were measured during three Method 5 test runs. The method used to measure CO_2 concentrations in the exhaust was not specified in the report. Emission factors were developed for filterable PM and CO_2.

The emission data for filterable PM are rated B. The test methodology was sound, and no problems were reported, but the report lacked adequate documentation for a higher rating. The CO_2 data are rated C because the test method was not specified.

B. Reference 11

This report documents measurements of filterable PM emissions from an exfoliated vermiculite grinder. Emissions from the grinder were controlled with a fabric filter. The test was conducted in August 1989 to demonstrate compliance with State regulations.

Filterable PM emissions were measured using Method 5, and three test runs were conducted. Emission factors were developed for emissions of filterable PM from the grinder. The emission data are rated A. The test methodology was sound, no problems were reported, and the results were adequately documented.

C. Reference 12

This report documents measurements of filterable PM emissions from three gas-fired exfoliation furnaces. In addition, condensible organic PM emissions from two of the three exfoliation furnaces were quantified. Emissions from each furnace were ducted to separate fabric filters. Typical process rates for the furnaces tested were provided in Reference 5 on the basis of exfoliated vermiculite production. The tests were conducted in April 1990 to demonstrate compliance with State regulations.

Emissions of condensible organic PM were quantified in order to evaluate how well two of the three furnaces combusted the residual oil that was used in the process of beneficiating the vermiculite ore. There was no evidence that the third furnace, which was a newer piece of equipment, was emitting uncombusted oil, and the stack for that furnace was not tested for condensible PM.

Filterable PM emissions were measured using Method 5. The report states that condensible organic PM emissions were quantified by means of a methylene chloride extraction of the Method 5 impinger contents, but no other details are provided on the analytical procedures. Three test runs were conducted.

Emission factors were developed for emissions of filterable PM from all three furnaces and condensible organic PM from two of the three furnaces. The emission data are rated B. The test methodology was sound, and no problems were reported. However, the report lacked adequate documentation for a higher rating.

D. Reference 13

This report documents measurements of filterable PM emissions from a rotary dryer, a screening operation, and a concentrate conveyor transfer operation. Emissions from the dryer were ducted to a wet scrubber and cyclones were used to control emissions from the screening and conveyor transfer operations. Process rates for the dryer were provided on the basis of production. However, using the moisture contents of the dryer feed and product, feed rates were determined. The tests were conducted in August 1991 to demonstrate compliance with State regulations.

Filterable PM emissions were measured using Method 5, and three test runs were conducted. Emission factors were developed for emissions of filterable PM from all four sources. The emission data are rated B. The test methodology was sound, and no problems were reported. However, the report lacked adequate documentation for a higher rating.

VI. RESULTS OF DATA ANALYSIS

Table 2 summarizes the emission data from the four test reports reviewed. These data were used to develop the candidate emission factors, which are listed in Table 3, for AP-42 Section 11.28. The following paragraphs describe how the data in Table 2 were used to develop the emission factors presented in the draft AP-42 section. The ratings assigned to each emission factor are based on the guidance provided in Reference 15.

For vermiculite ore dryers, filterable PM data were available from two B-rated emission tests. The data from Reference 9 for a spray tower-controlled dryer averaged 0.095 kilograms per megagram (kg/Mg) (0.19 pounds per ton [lb/ton]), and the data from Reference 13 for a dryer controlled with a wet scrubber averaged 0.48 kg/Mg (0.95 lb/ton). The test reports do not include adequate information on the dryers and control devices to help explain the difference between the two emission rates. Therefore, the data for both tests were averaged to yield an average emission factor of 0.29 kg/Mg (0.57 lb/ton) of ore feed for filterable PM emissions from vermiculite ore

TABLE 2. SUMMARY OF TEST DATA FOR VERMICULITE PROCESSING.

Source	APCD	Pollutant	No. of runs	Data rating	Emission factor						Ref. No.
					kg/Mg			lb/ton			
					Min.	Max.	Ave.	Min.	Max.	Ave.	
Rotary dryer	ST	filterable PM	3	B	0.078	0.11	0.095	0.16	0.22	0.19	9
Rotary dryer	ST	CO2	3	C	45	62	50	91	130	100	9
Product grinder	FF	filterable PM	3	A	0.17	0.19	0.18	0.35	0.37	0.36	11
Exfoliation furnace	FF	filterable PM	3	B	0.31	0.55	0.45	0.63	1.1	0.89	12
Exfoliation furnace	FF	cond. org. PM	3	B	0.10	0.17	0.12	0.19	0.35	0.25	12
Exfoliation furnace	FF	filterable PM	3	B	0.10	0.83	0.38	0.20	1.7	0.75	12
Exfoliation furnace	FF	cond. org. PM	3	B	0.15	0.36	0.24	0.30	0.72	0.48	12
Exfoliation furnace	FF	filterable PM	3	B	0.11	0.14	0.12	0.21	0.28	0.24	12
Rotary dryer	WS	filterable PM	3	B	0.45	0.64	0.55	0.90	1.3	1.1	13
Screening operation	C	filterable PM	3	B	0.26	0.36	0.30	0.52	0.72	0.61	13
Concentrate transfer	C	filterable PM	3	B	0.0085	0.018	0.013	0.017	0.035	0.025	13

APCD = air pollution control device; ST = spray tower; WS = wet scrubber; FF = fabric filter; C = cyclone.

TABLE 3. SUMMARY OF EMISSION FACTORS FOR VERMICULITE PROCESSING.

Source	Control	Pollutant	No. of tests	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rating	References
Ore drying	Wet collector	Filterable PM	2	0.29	0.57	D	9,13
Ore drying	None	CO_2	1	50	100	E	9
Concentrate screening	Cyclone	Filterable PM	1	0.30	0.61	D	13
Concentrate conveyor transfer	Cyclone	Filterable PM	1	0.013	0.025	D	13
Exfoliating	Fabric filter	Filterable PM	3	0.32	0.63	D	12
Exfoliating	Fabric filter	Cond. org. PM	2	0.18	0.37	D	12
Product grinding	Fabric filter	Filterable PM	1	0.18	0.37	D	11

drying controlled with a generic wet collector. This emission factor is rated D because it is based on B-rated data from tests on a relatively small number of sources, and it is likely that the facilities do not represent a random sample of the industry.

For CO_2 emissions from vermiculite dryers, C-rated data from a single emission test were available. Although the dryer exhaust was equipped with a spray tower, the emission factor is considered to represent uncontrolled emissions because spray towers are assumed to have negligible effects on CO_2 emissions. Because it is based entirely on C-rated data, this emission factor (50 kg/mg [100 lb/ton] of ore feed) is rated E.

For dried vermiculite concentrate screening, data were available from one B-rated emission test (Reference 13) on screening operations controlled with a cyclone. The results of the test averaged 0.30 kg/Mg (0.61 lb/ton) for filterable PM emissions from dried vermiculite concentrate screening controlled with a cyclone. This emission factor is rated D because it is based on B-rated data from one test.

For dried vermiculite concentrate conveyor transfer, data were available from one B-rated emission test of filterable PM emissions controlled with a cyclone. The emission factor based on these data (0.013 kg/Mg [0.025 lb/ton]) is assigned a rating of D.

For vermiculite exfoliating, B-rated data were available from Reference 12 for fabric filter-controlled filterable PM emissions from three furnaces and for condensible organic PM emissions from two furnaces. The results of these tests averaged 0.45 kg/Mg (0.89 lb/ton), 0.38 kg/Mg (0.75 lb/ton), and 0.12 kg/Mg (0.24 lb/ton) of exfoliated vermiculite produced for filterable PM, and 0.12 kg/Mg (0.25 lb/ton) and 0.24 kg/Mg (0.48 lb/ton) of exfoliated vermiculite produced for condensible organic PM. These groups of data were combined to yield average emission factors of 0.32 kg/Mg (0.63 lb/ton) for filterable PM, and 0.18 kg/Mg (0.37 lb/ton) for condensible organic PM. These emission factors also are rated D.

For exfoliated vermiculite grinding, A-rated data were available from one emission test (Reference 11). The emission factor developed from this data, 0.18 kg/Mg (0.37 lb/ton) of ground material produced, is also rated D.

REFERENCES

1. *Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards*. U. S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/3-025a. October 1985.

2. Potter, M. J. *Vermiculite in 1991, Mineral Industry Surveys Annual Report*, Bureau of Mines. U.S. Department of the Interior. Washington, DC. August 5, 1992.

3. Strand, P. R., and O. F. Stewart. *Vermiculite. Industrial Rocks and Minerals*, Volume I. Society of Mining Engineers. New York. 1983.

4. *Vermiculite, Its Properties And Uses*, The Vermiculite Association, Incorporated, Chicago, Illinois.

5. Written communication from Jeffrey A. Danneker, W. R. Grace and Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

6. W. J. Neuffer, *Trip Report for the September 30, 1980, Visit to W. R. Grace and Company, Enoree, South Carolina, ESD Project No. 81/08*, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

7. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit--Virginia Vermiculite Limited, Trevilians, Virginia*, June 8, 1983.

8. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit: W. R. Grace & Company, Irondale, Alabama*, June 29, 1983.

9. *Rotary Dryer Particulate Emissions Testing, Performed for Virginia Vermiculite Limited, Boswell's Tavern, Virginia.* RTP Environmental Association. Research Triangle Park, NC. November 1979.

10. *Collection, Analysis and Characterization of Vermiculite Samples for Fiber Content and Asbestos Contamination.* Midwest Research Institute. Prepared for the Office of Pesticides and Toxic Substances. U. S. Environmental Protection Agency. Washington, DC. September 27, 1982.

11. *Particulate Emission Compliance Test on Grinder Baghouse on August 8, 1989 at W. R. Grace & Company Kearney Exfoliating Plant, Enoree, South Carolina 29335*, Environmental Engineering Division, PSI, Greenville, SC, August 24, 1989.

12. *Particulate Emissions Sampling, W. R. Grace Co., Dallas, TX, April 2-4, 1990*, Turner Engineering, Dallas, TX, April 10, 1990.

13. *Particulate Emissions Test Report For W. R. Grace, August 1991*, RTP Environmental Associates, Inc., Greer, SC, August 1991.

14 Fax transmittal from Jay Burrill, W. R. Grace and Company, Cambridge, MA, to Richard Marinshaw, Midwest Research Institute, Cary, NC, January 13, 1995.

15. *Technical Procedures For Developing AP-42 Emission Factors And Preparing AP-42 Sections*, EPA-454/B-93-050, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1993.

This is preliminary material, in draft form, for purposes of review. This material must not be quoted, cited, or in any other way considered or used as final work.

DRAFT AP-42 SECTION 11.28

11.28 VERMICULITE PROCESSING

11.28.1 Process Description[1-9]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. The chemical formula for vermiculite is $(Mg,Ca,K,Fe^{+2})_3(Si,Al,Fe^{+3})_4O_{10}(OH)_2 \bullet 4H_2O$. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due to the interlaminar generation of steam. The six-digit source classification code (SCC) for vermiculite processing is 3-05-033.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluid bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Crude Ore Processing

Figure 11.28-1 is a process flow diagram for vermiculite processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluidized bed or rotary dryer. Drying reduces the moisture content of the vermiculite concentrate from approximately 15 to 20 percent to approximately 2 to 6 percent. At least one facility uses a hammermill to crush the material exiting the dryer. However, at most facilities, the dryer products are transported by bucket elevators to vibrating screens, where the material is classified. The dryer exhaust generally is ducted to a cyclone for recovering the finer grades of vermiculite concentrate. The classified concentrate then is stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although fluidized bed dryers also are used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

Exfoliation

After being transported to the exfoliation plant, the vermiculite concentrate is stored. The ore concentrate then is conveyed by bucket elevator or other means and is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air conveyed to a classifier system, which collects the vermiculite product and removes excessive fines. The

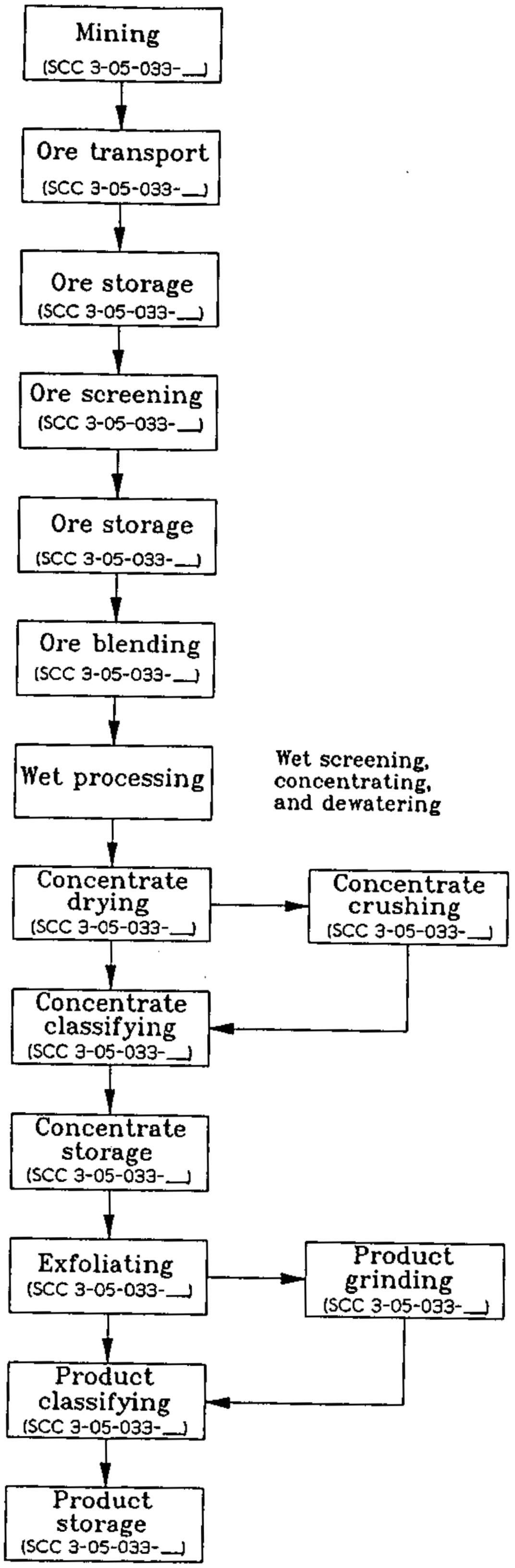

Figure 11.28-1. Process flow diagram for vermiculite processing.
(Source Classification Code in parenthesis)

furnace exhaust generally is ducted through a product recovery cyclone, followed by an emission control device. At some facilities, the exfoliated material is ground in a pulverizer prior to being classified. Finally, the material is packaged and stored for shipment.

11.28.2 Emissions and Controls[1,4-11]

The primary pollutant of concern in vermiculite processing are particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. Emissions from dryers and exfoliating furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM and PM-10.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. Cyclones and fabric filters also are used to control emissions from screening, milling, and materials handling and transfer operations.

Table 11.28-1 (metric and English units) summarizes the emission factors for vermiculite processing.

DRAFT

Draft Table 11.28-1 (Metric And English Units). EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

EMISSION FACTOR RATING: D

	Filterable PM[b]		Condensible organic PM[c]		Total PM[d]		CO_2	
Process	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Ore dryer, with wet collector (SCC 3-05-033-__)	0.29[e]	0.57[e]	ND	ND	ND	ND	50[f]	100[f]
Concentrate screening, with cyclone (SCC 3-05-033-__)	0.30[g]	0.61[g]	NA	NA	0.30[g]	0.61[g]	NA	NA
Concentrate conveyor transfer, with cyclone (SCC 3-05-033-__)	0.013[g]	0.025[g]	NA	NA	0.013[g]	0.025[g]	NA	NA
Exfoliating furnace, with fabric filter (SCC 3-05-033-__)	0.32[h]	0.63[h]	0.18[j]	0.37[j]	0.50[k]	1.0[k]	ND	ND
Product grinding, with fabric filter (SCC 3-05-033-__)	0.18[m]	0.37[m]	NA	NA	0.18[m]	0.37[m]	NA	NA

[a] Factors represent uncontrolled emissions unless noted. Emission factors for drying in units of kg/Mg and lb/ton of material feed; emission factors for other processes in units of kg/Mg and lb/ton of product. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.

[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.

[d] Total PM equals the sum of the filterable PM, condensible organic PM, and condensible inorganic PM.

[e] Reference 8. EMISSION FACTOR RATING: E.

[f] References 8,11. Factor represents uncontrolled emissions of CO_2.

[g] Reference 11. For dried ore concentrate.

[h] Reference 10.

[j] Reference 10. Emissions may be largely due to volatilization of oil used in ore beneficiation.

[k] Sum of factors for filterable PM and condensible organic PM; does not include condensible inorganic PM.

[m] Reference 9.

REFERENCES FOR SECTION 11.28

1. *Calciners and Dryers in Mineral Industries--Background Information For Proposed Standards.* U. S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/3-025a. October 1985.

2. Strand, P. R. and O. F. Stewart. *Vermiculite. Industrial Rocks And Minerals, Volume I.* Society of Mining Engineers. New York. 1983.

3. *Vermiculite, Its Properties And Uses*, The Vermiculite Association, Incorporated, Chicago, IL.

4. Written communication from Jeffrey A. Danneker, W. R. Grace and Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

5. W. J. Neuffer, *Trip Report For The September 30, 1980, Visit To W. R. Grace And Company, Enoree, South Carolina, ESD Project No. 81/08*, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

6. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit--Virginia Vermiculite Limited, Trevilians, Virginia*, June 8, 1983.

7. Memorandum from A. J. Nelson, Midwest Research, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, *Site Visit: W. R. Grace & Company, Irondale, Alabama*, June 29, 1983.

8. *Rotary Dryer Particulate Emissions Testing, Performed For Virginia Vermiculite Limited, Boswell's Tavern, Virginia.* RTP Environmental Association. Research Triangle Park, NC. November 1979.

9. *Particulate Emission Compliance Test On Grinder Baghouse On August 8, 1989 At W. R. Grace & Company Kearney Exfoliating Plant, Enoree, South Carolina 29335.* Environmental Engineering Division, PSI. Greenville, SC. August 24, 1989.

10. *Particulate Emissions Sampling, W. R. Grace Co., Dallas, TX, April 2-4, 1990.* Turner Engineering. Dallas, TX. April 10, 1990.

11. *Particulate Emissions Test Report For W. R. Grace, August 1991.* RTP Environmental Associates, Inc. Greer, SC. August 1991.

VIRGINIA VERMICULITE
P.O. Box 70 Louisa, Virginia 23093 (703) 967-2266 Fax (703) 967-2803

February 22, 1995

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

Dear Mr. Myers:

We have reviewed your letter of January 27, 1995 concerning AP-42 Emission Factors for vermiculite processing. We have a few minor comments:

(1) On page 11.28-3 in the next to last paragraph appears: "Fabric filters also used at some facilities." This sentence follows one that asserts that "Wet scrubbers are the most commonly used device to control dryer emissions." Together these sentences suggest fabric filters are used to control dryer emissions, but is that true? It is my understanding that only wet scrubbers are used after dryers. Fabric filters may be used elsewhere.

(2) On page 2 of the MRI document, the numbers say 35,000 tons of the 185,000 tons of crude vermiculite sold is not expanded. This represents 19%. Both the MRI and 11.28-1 documents conclude that uses of unexpanded vermiculite "are minor." Unexpanded products are very significant and 19% of output is <u>not</u> minor. You may want to delete the two references to "are minor".

(3) Finally in footnote 8 on p. 11.28-5 the company is RTP Environmental Associates.

We appreciate the opportunity to review and comment on your AP-42 documentation.

Sincerely yours,

11.28 Comments

Robert L. Sansom
President, Louisa Properties
General Parnter
Vermiculite Vermiculite, Ltd.

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Mr. Ronald E. Myers
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Research Triangle Park, NC 27711

14

South Carolina
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Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201

Promoting Health, Protecting the Environment

March 8, 1995

Ronald E. Myers
Emission Factor and Inventory Group
Emissions, Monitoring, and Analysis Division
Office of Air Quality planning and Standards
US EPA
Research Triangle Park, NC 27711

Dear Mr. Myers:

Your letter of January 27, 1995 requested review and comments on the revised draft Section 11.28, Vermiculite Processing and the corresponding background memorandum for the section.

Copies of your letter and the draft section were sent to staff within the Bureau of Air Quality who have responsibility for these emissions and comments were requested. After discussion with the concerned individuals we agree that the section is acceptable for publication.

The Bureau provided source test reports used in developing the emission factors. We appreciate having had the opportunity to contribute to the development of the document as well as the opportunity to comment on the draft section. We look forward to the release of the Fifth edition of AP-42.

Sincerely,

Bob Betterton

Bob Betterton, Manager
Emission Inventory Section
Program Development & Support Division
Bureau of Air Quality

Department of
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Lawton Chiles
Governor

Twin Towers Office Building
2600 Blair Stone Road
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Virginia B. Wetherell
Secretary

March 7, 1995

Mr. Ronald E. Myers
Emission Factor and Inventory Group
Emissions, Monitoring, & Analysis Division
United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Dear Mr. Myers:

RE: Request for Comments - January 27 Revised Draft of Section 11.28, Vermiculite Processing, Volume I, AP-42 Emission Factors

The Department has reviewed the referenced document. The draft was also provided to Duval County's Local Program, since the only vermiculite processing facility was located in Duval County. This facility is no longer active. Based on the reviews, we have no comments to offer.

Thank you for the opportunity to provide comments. If you have any questions or need further information, please contact Mr. Bruce Mitchell at (904)488-1344 or at the letterhead address.

Sincerely,

Howard L Rhodes

Howard L. Rhodes, Director
Division of Air Resources
Management

HLR/bm/m

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Research Triangle Park, North Carolina 27711

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Governor

Virginia B. Wetherell
Secretary

FAX TRANSMITTAL SHEET

TO: Ronald E. Myers, Emission Factor and Inventory Group, RTP, N.C.

DATE: 3-8-95 PHONE: 919-541-0684

TOTAL NUMBER OF PAGES, INCLUDING COVER PAGE: 2

FROM: Bruce Mitchell FDEP/DARM/BAR/Title V
DIVISION OF AIR RESOURCES MANAGEMENT

COMMENTS:

PHONE: 904-488-1344 FAX NUMBER: 904/922-6979

If there are any problems with this fax transmittal, please call the above phone number.

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Department of
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Virginia B. Wetherell
Secretary

March 7, 1995

Mr. Ronald E. Myers
Emission Factor and Inventory Group
Emissions, Monitoring, & Analysis Division
United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Dear Mr. Myers:

RE: Request for Comments - January 27 Revised Draft of Section 11.28, Vermiculite Processing, Volume I, AP-42 Emission Factors

The Department has reviewed the referenced document. The draft was also provided to Duval County's Local Program, since the only vermiculite processing facility was located in Duval County. This facility is no longer active. Based on the reviews, we have no comments to offer.

Thank you for the opportunity to provide comments. If you have any questions or need further information, please contact Mr. Bruce Mitchell at (904)488-1344 or at the letterhead address.

Sincerely,

Howard L Rhodes

Howard L. Rhodes, Director
Division of Air Resources
Management

HLR/bm/m

"Protect, Conserve and Manage Florida's Environment and Natural Resources"

MRI Copy

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

JUL 26 1994

Mr. William S. Becker
Executive
State & Territory Air Pollution Program Administrators
444 North Capital Street, NW, Room 307
Washington, DC 20001-1514

Dear Mr. Becker:

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 11 of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 11.28, Vermiculite Processing, and the corresponding background memorandum for the section. We would appreciate it if your agency would review the enclosed draft AP-42 section and background memorandum and would send us your comments. We would appreciate a response to this request by September 2, 1994.

As you can see from the draft AP-42 section, the only emission data we have been able to locate on vermiculite processing are taken from a single emission test report. If you are aware of additional emission data that we could use to develop emission factors for vermiculite processing and exfoliating, we would appreciate your assistance in obtaining copies of the data. Please note that 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. We also would appreciate specific comments on the general process description presented in the enclosed draft AP-42 section, information on variations in vermiculite processing and exfoliating operations, and identification of specific air pollution emission points associated with vermiculite processing and exfoliating. General information on the vermiculite industry, including the location of exfoliation plants also would be helpful.

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

Sincerely,

Ronald E Myers

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/677-0249/07/26/94)

IDENTICAL LETTER SENT TO THE FOLLOWING ADDRESSEES

Mr. William S. Becker
Executive
State & Territory Air Pollution Program Administrators
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MRI

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Date: April 6, 1993
(Revised: February 16, 1994)

Subject: Background Information for Proposed AP-42
Section 11.28, Vermiculite Processing
Review and Update Remaining Sections of Chapter 8
(Mineral Products Industry) of AP-42
EPA Contract 68-D2-0159, Work Assignment 012
MRI Project 3612

From: Richard Marinshaw

To: Ron Myers
EPA/EIB/EFMS (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

I. INTRODUCTION

This memorandum presents the background information that was used to develop the proposed AP-42 Section 11.28 on vermiculite processing. A description of the industry is presented first. A process description followed by a discussion of emissions and controls is then presented. Following these sections, a description of the references that were used to develop the draft section and the results of the data analysis are presented. Finally, the reference list is provided. The draft AP-42 section is provided as the attachment.

II. DESCRIPTION OF THE INDUSTRY[1-3]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due the interlaminar generation of steam. The Standard Industrial Classification (SIC) code for vermiculite mining is 1499, miscellaneous nonmetallic minerals, except fuels. For vermiculite processing, the SIC Code is 3295, minerals and earths, ground or otherwise treated. The six-digit Source Classification Code (SCC) for vermiculite processing is 3-05-033.

The world's largest deposit of vermiculite, which is located near Libby, Montana, is no longer in operation. Other major vermiculite deposits are located near Enoree, South Carolina, and in the Republic of South Africa. Vermiculite is also mined and beneficiated at a mine in Louisa County, Virginia. Deposits of economic significance contain 25 to 95 percent vermiculite.

Estimated world production of crude vermiculite in 1991 was 523,000 megagrams (Mg) (576,000 tons), more than 80 percent of which came from five mines. The United States and Republic of South Africa account for most of the world production. Estimated U.S. production of crude vermiculite sold or used by producers in 1991 was 168,000 Mg (185,000 tons), of which approximately 136,000 Mg (150,000 tons) were exfoliated.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluidized bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Vermiculite is commercially exfoliated by heating the presized crude vermiculite in a furnace chamber. The bulk volume of commercial grades increases 8- to 12-fold, but individual vermiculite particles may expand as much as 30-fold compared to the raw ore.

Exfoliated vermiculite was produced at 35 plants in 27 States in 1989. The principal producing States were, in order of decreasing exfoliated vermiculite output, Ohio, California, South Carolina, Florida, New Jersey, Illinois, Texas, and Arkansas. The main uses of exfoliated vermiculite in 1990 were fertilizer carriers (22 percent), concrete aggregate (19 percent), horticultural uses (13 percent), premixes (12 percent), block insulation (12 percent), loose fill insulation (9 percent), soil conditioners (5 percent), and plaster aggregates (1 percent).

III. PROCESS DESCRIPTION[1,3]

A. Crude Ore Processing

Figure 1 is a flow diagram of vermiculite ore processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to other stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluid bed

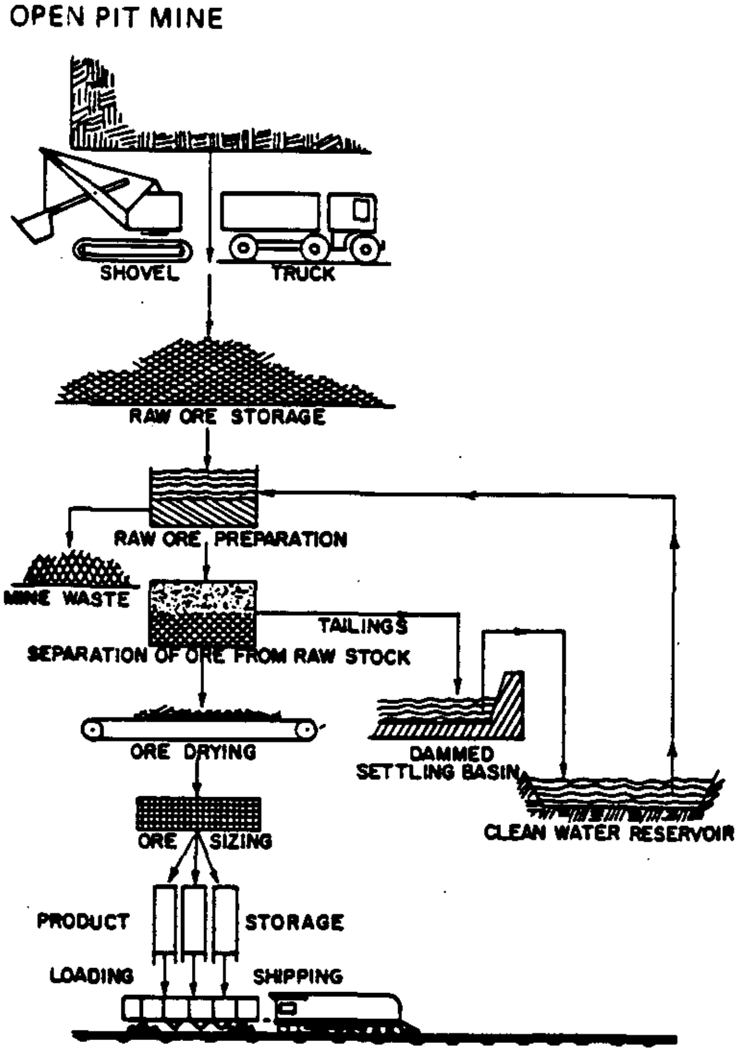

Figure 1. Flow diagram for vermiculite ore processing.[3]

or rotary dryer. The dryer products are separated by standard screens and are stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although one fluid bed dryer is used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

B. Exfoliation

Figure 2 depicts a typical vermiculite expanding process. Sized crude vermiculite is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air-conveyed to a classifier system, which collects the vermiculite product and removes excessive fines.

IV. EMISSIONS AND CONTROLS[1,3-5]

The primary pollutants of concern in vermiculite processing are particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. In addition, vermiculite ore may contain asbestos. However, other than vermiculite mined from the Libby, Montana, deposit, which is no longer in operation, the amount of asbestos found in vermiculite deposits is considered to be negligible. Emissions from rotary dryers and expansion furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. No information is available on the type of emission controls used on screening, milling, and materials handling and transfer operations.

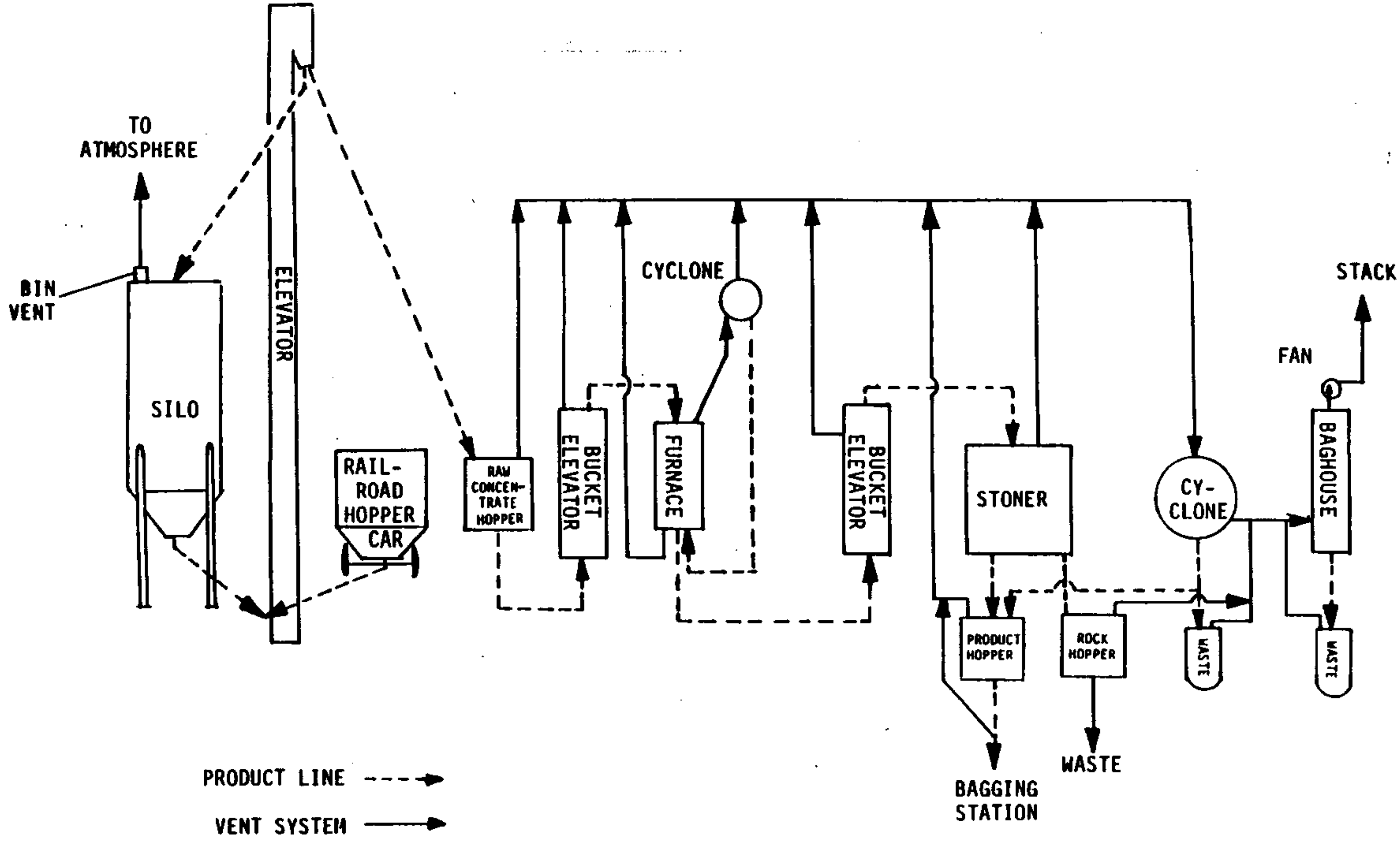

Figure 2. Process flow diagram for vermiculite exfoliation.[1]

V. DESCRIPTION OF REFERENCES

This section describes the primary references that contained data on emissions from vermiculite processing that were used to develop the draft AP-42 section. Reference 1 is not described because it is a secondary reference, and the vermiculite processing emission data in Reference 1 are taken from Reference 4, which is the primary reference for the data. References 2, 3, and 5 also are not described below because they do not contain emission data.

A. Reference 4

This report documents measurements of filterable PM and CO_2 from an oil-fired rotary dryer. The purpose of the emission test was to demonstrate compliance with State regulations. The test was conducted in 1979. Process rates were provided on the basis of raw material feed. The dryer emissions are controlled with a low-energy spray tower with a design pressure drop of 1.2 kilopascals (5-in. water column).

Particulate matter emissions were measured during three Method 5 test runs. The method used to measure CO_2 concentrations in the exhaust was not specified in the report. Emission factors were developed for filterable PM and CO_2.

The emission data for filterable PM are rated B. The test methodology was sound, and no problems were reported, but the report lacked adequate documentation for a higher rating. The CO_2 data are rated C because the test method was not specified.

VI. RESULTS OF DATA ANALYSIS

Emission factors were developed from Reference 4 for filterable PM and CO_2 emissions from rotary vermiculite dryers. The PM emission data from this reference are rated B because the documentation was not adequate to justify a higher rating. The emission factor for controlled filterable PM emissions from rotary dryers is rated D because it is based on a single reference.

The CO_2 emission data are rated C, because the test method is not specified. The emission factor for CO_2 emissions from rotary vermiculite dryers is rated E.

The emission factors developed for vermiculite processing are presented in Table 1.

TABLE 1. SUMMARY OF EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

Process	Control	Pollutant	No. of runs	Emission factor				Data rating	Emission factor rating
				Range		Average			
				kg/Mg	lb/ton	kg/Mg	lb/ton		
Rotary dryer	Spray tower	Filterable PM	3	0.078-0.11	0.16-0.22	0.095	0.19	B	D
		CO_2	3	45-62	91-125	50	100	C	E

[a] Reference 4; emission factor activity level based on material feed.

REFERENCES

1. *Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards.* U. S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/3-025a. October 1985.

2. Potter, M. J. *Vermiculite in 1991, Mineral Industry Surveys Annual Report*, Bureau of Mines. U.S. Department of the Interior. Washington, DC. August 5, 1992.

3. Strand, P. R., and O. F. Stewart. *Vermiculite. Industrial Rocks and Minerals, Volume I.* Society of Mining Engineers. New York. 1983.

4. *Rotary Dryer Particulate Emissions Testing, Performed for Virginia Vermiculite Limited, Boswell's Tavern, Virginia.* RTP Environmental Association. Research Triangle Park, NC. November 1979.

5. *Collection, Analysis and Characterization of Vermiculite Samples for Fiber Content and Asbestos Contamination.* Midwest Research Institute. Prepared for the Office of Pesticides and Toxic Substances. U. S. Environmental Protection Agency. Washington, DC. September 27, 1982.

Attachment

DRAFT AP-42 SECTION 11.28

11.28 VERMICULITE PROCESSING

11.28.1 Process Description[1-4]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due the interlaminar generation of steam. The six-digit source classification code (SCC) for vermiculite processing is 3-05-033.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluid bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Crude Ore Processing

Figure 11.28-1 is a flow diagram of vermiculite ore processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluid bed or rotary dryer. The dryer products are separated by standard screens and are stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although one fluid bed dryer is used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

Exfoliation

Figure 11.28-2 depicts a typical vermiculite expanding process. Sized crude vermiculite is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air conveyed to a classifier system, which collects the vermiculite product and removes excessive fines.

11.28.2 Emissions and Controls[1,3-4]

The primary pollutant of concern in vermiculite processing are particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. Emissions from rotary dryers and expansion furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM.

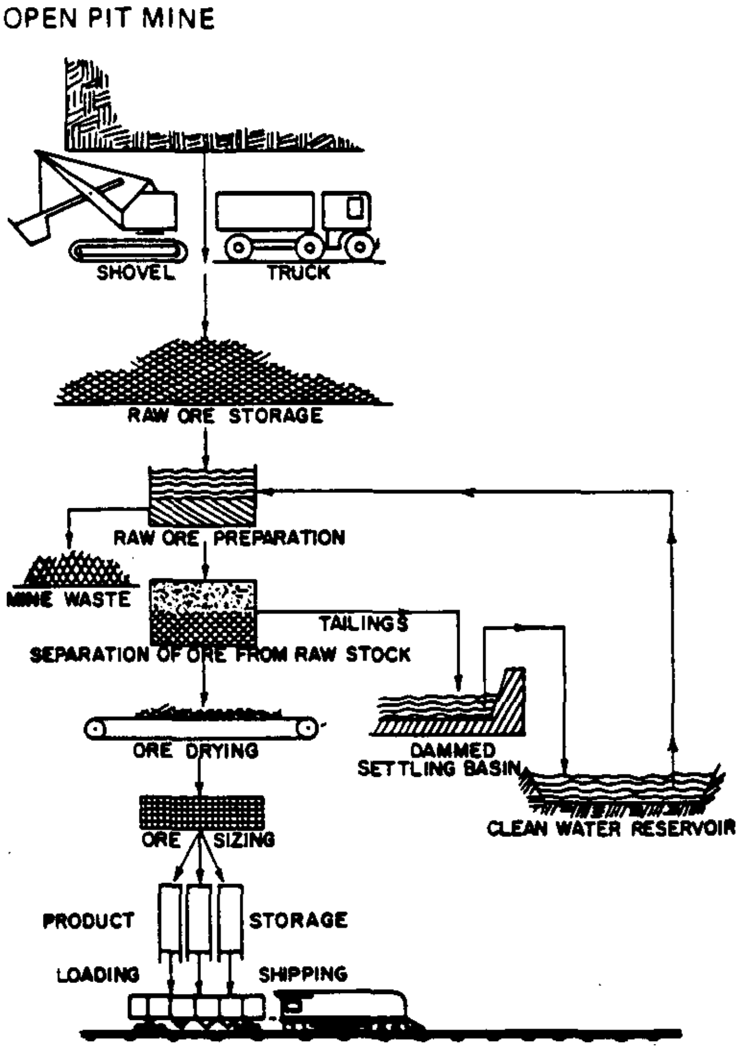

Figure 11.28-1. Process flow diagram for vermiculite ore processing.[3]

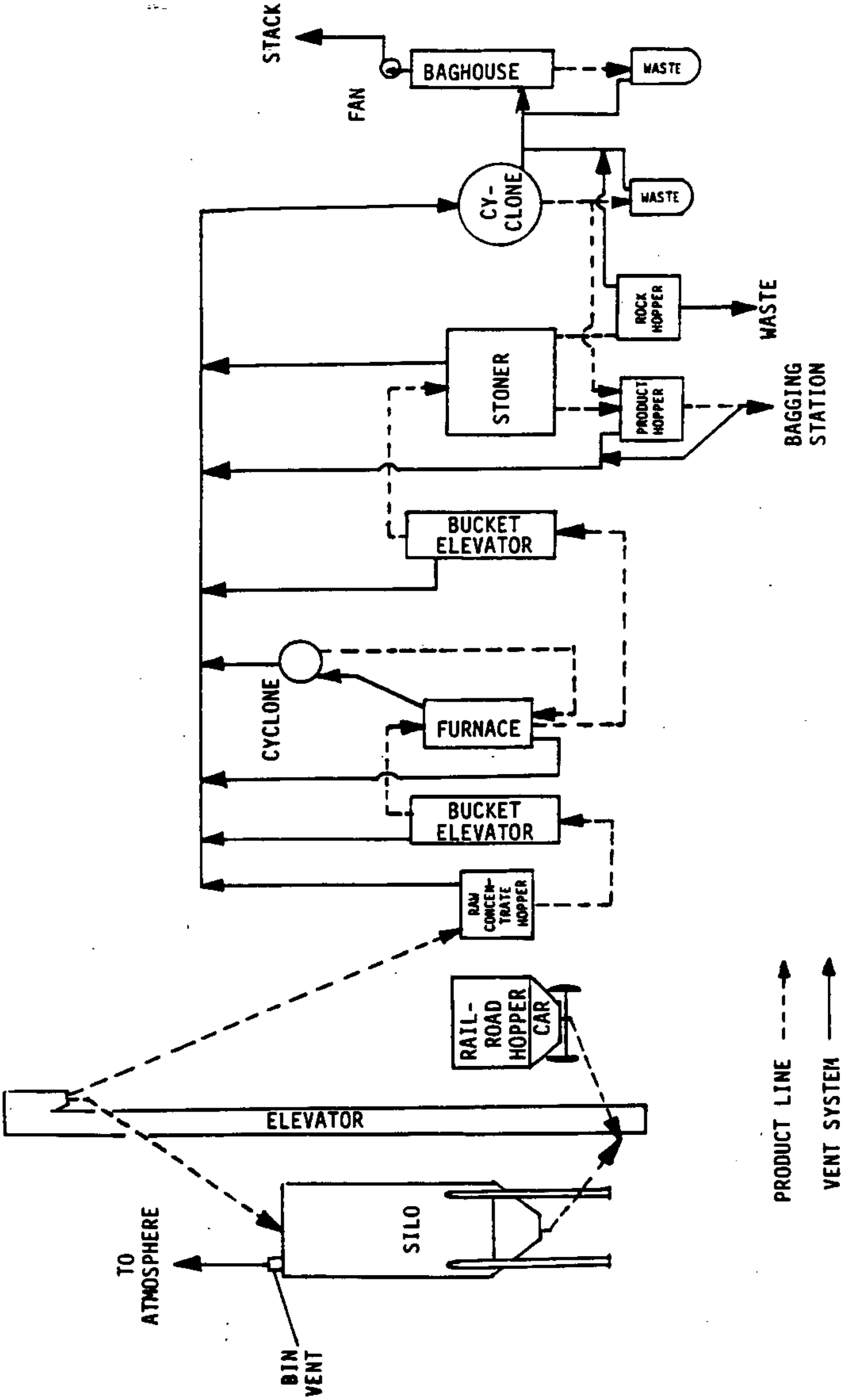

Figure 11.28-2. Process flow diagram for vermiculite exfoliation.[1]

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. No information is available on the type of emission controls used on screening, milling, and materials handling and transfer operations.

Table 11.28-1 summarizes the emission factors for vermiculite processing.

REFERENCES FOR SECTION 11.28

1. *Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards.* U. S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/3-025a. October 1985.

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EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

Source	Filterable[b]			Condensible PM[c]		CO_2	EMISSION FACTOR RATING
	PM	EMISSION FACTOR RATING	PM-10	Inorganic	Organic		
Rotary dryer with spray tower[d] (SCC 3-05-033-__)	0.095	D	ND	ND	ND	50	E

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data available. All emission factors in the kg/Mg of material feed.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.
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	PM	EMISSION FACTOR RATING	PM-10	Inorganic	Organic		
Rotary dryer with spray tower[d] (SCC 3-05-033-__)	0.19	D	ND	ND	ND	100	E

[a] Factors represent uncontrolled emissions unless otherwise noted. ND = no data available. All emission factors in the lb/ton of material feed.
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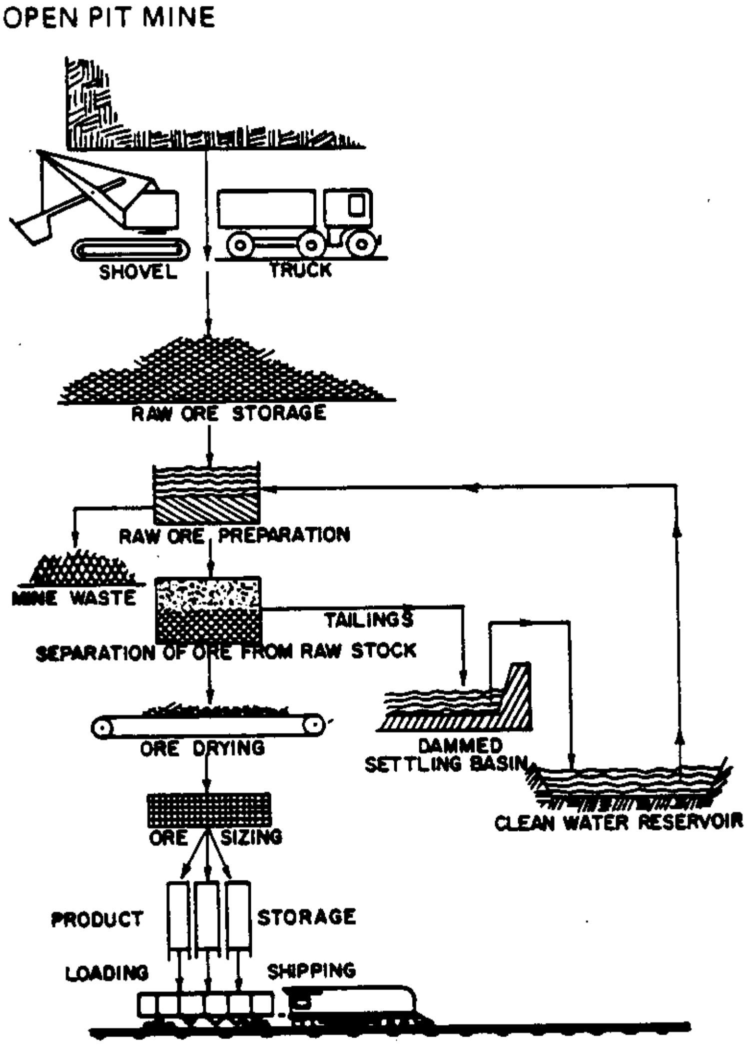

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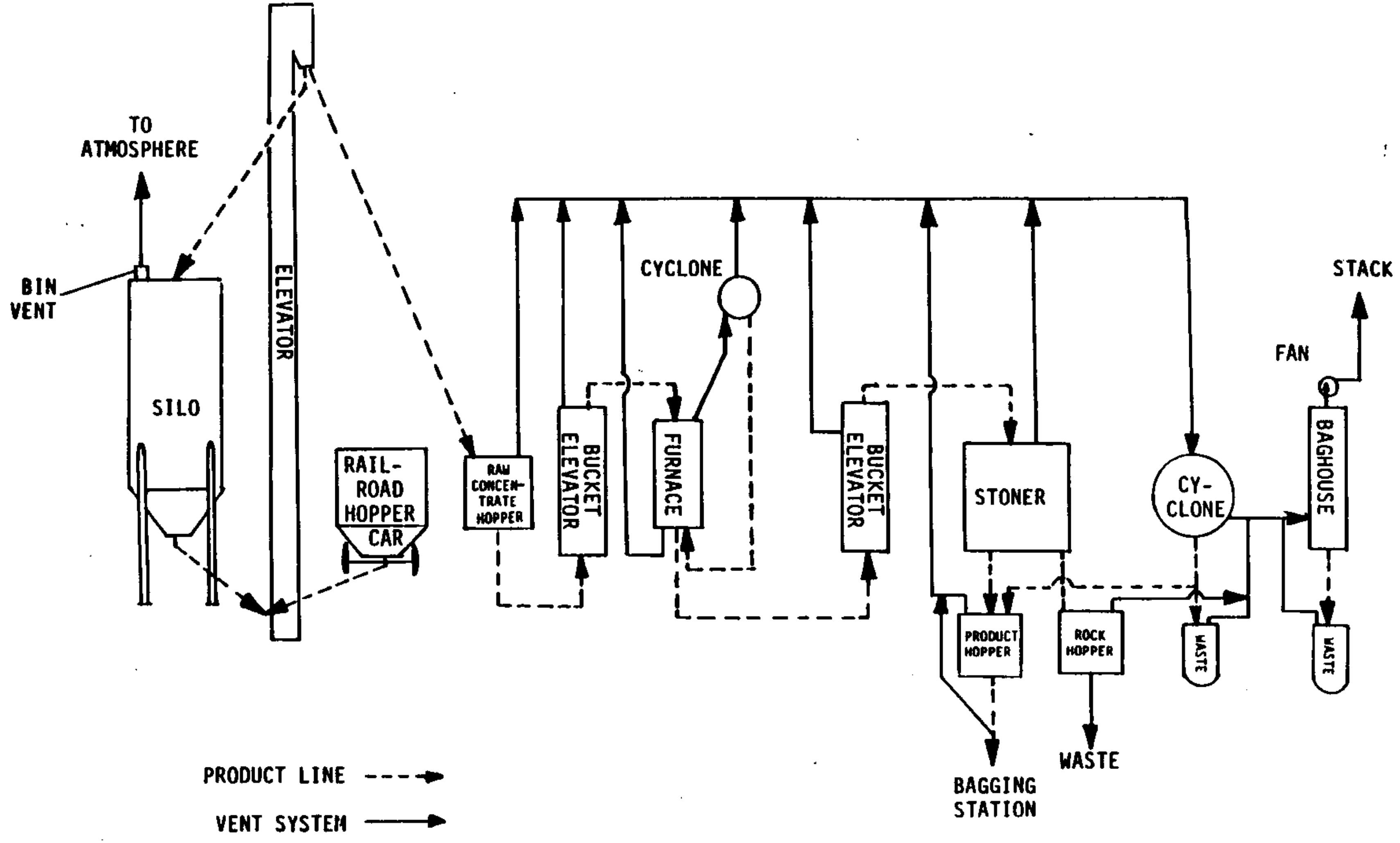

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[d] Reference 4.

VIRGINIA VERMICULITE, LTD.

1901 N. Moore Street, Suite 1200 Arlington, Virginia 22209-1706
TELE: 703/276-8900
FAX: 703/276-9541

TELECOPIER COVER PAGE

TO: Ronald Myers
EPA
TELECOPY #: 919 5410684

FROM: Bob Sanson
TELECOPY #: 703/276-9541

Original will be sent by regular mail.

NUMBER OF PAGES TRANSMITTED (INCLUDING COVER PAGE): 6
PLEASE PHONE IMMEDIATELY IF TRANSMISSION IS INCOMPLETE. THANK YOU.

OPERATOR: Donna Wilson **PHONE:** 703/276-8900

VIRGINIA VERMICULITE
P.O. Box 70 Louisa, Virginia 23093 (703) 967-2266

May 4, 1993

Mr. Ronald E. Myers
Emissions Factors and Methodologies Section
Emission Inventory Branch
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Myers:

I received your proposed draft yesterday. It asks for our comments by tomorrow. This is unreasonable and surely not acceptable.

Your document is full of errors. You try to homogenize an industry that is not homogenous. You cite our stack test, but fail to report no asbestos was found in the particulates taken from the stack (see attachment).

We had previously communicated to your agency (see attached cover sheets) regarding work by MRI on vermiculite. We strongly object to your use of emission data on South Carolina and Libby, Montana as applicable to our vermiculite. Libby is shut down. Of what relevance is its data? I recommend AP42 continue to exclude vermiculite. I can't see how three plants, two in South Carolina and one in Virginia, all different in the ore used, justify the effort (obviously flawed) to arrive at a uniform emission factor.

Moreover your definitions of asbestos and emission factors for the Enoree plant need to be examined and corrected in accordance with the June 2, 1992 CFR 1910 and 1926. If you have the need for technical information, please contact John Stamberg 703/276-8900.

Sincerely,

Robert L. Sansom
President, Louisa Properties
General Partner
Virginia Vermiculite, Ltd.

Enclosures

Energy Ventures Analysis
1901 N. Moore St.
Arlington VA 22209

COMMONWEALTH of VIRGINIA
State Air Pollution Control Board
ROOM 1106, NINTH STREET OFFICE BUILDING
RICHMOND, VIRGINIA 23219
TELEPHONE: (804) 786-2378

W. R. MEYER
EXECUTIVE DIRECTOR

July 7, 1980

Mr. Robert L. Sansom
Virginia Vermiculite, Ltd.
Energy and Environmental Analysis, Inc.
General Partner
1111 N. 19th Street, Suite 600
Arlington, Virginia 22049

Dear Mr. Sansom:

Review of the particulate and asbestos emissions test performed by RTP Environmental Associates on October 27, 1979 indicates that your facility is in compliance with the particulate emissions requirements of the Virginia State Air Pollution Control Board. Tests done by Walter C. McCrone Associates, Inc. also indicate that no asbestiform minerals were present in those ore samples taken at the plant.

Thank you for your patience in waiting for our official report on these tests.

Sincerely,

William M. Jewell, Jr.
Director, Division of Compliance

WMJ/RCJ/jld

cc: Director, Region IV

"An Equal Opportunity Employer"

Virginia Vermiculite

P.O. Box 70 Louisa, Virginia 23093 (703) 967-2266

September 11, 1987

Mr. Alfred E. Vervaert
United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Dear Mr. Vervaert:

I am enclosing herewith our response to your questions put to Virginia Vermiculite under Section 112 of the Clean Air Act. We have stamped selected pages "Confidential" and ask that they be so treated by EPA and its contractors.

We are prepared to answer any questions you may have regarding our response and apologize for any inconvenience our response's delay, due to a mis-routing of your June 16, 1987 letter, may have caused EPA.

Sincerely yours,

Robert L. Sansom
President, Louisa Properties
General Partner
Virginia Vermiculite, Ltd.

Enclosure

MIDWEST RESEARCH INSTITUTE
4505 Creedmoor Road
Raleigh, N.C 27612
Telephone (919) 781-5750

FINAL

Date: June 8, 1983
(Finalized July 11, 1983)

Subject: Site Visit--Virginia Vermiculite Limited, Trevilians, Virginia
Calciners and Dryers in Mineral Industries
EPA Contract No. 68-02-3817; ESED Project No. 81/08
MRI Project No. 7702-L

From: Amy J. Nelson AJN

To: William J. Neuffer
ESED/ISB/SSAS (MD-13)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711
(919) 541-5595

I. Purpose

The purpose of this site visit was to observe the operation of a rotary vermiculite dryer and the associated air pollution control equipment at Virginia Vermiculite, Ltd.

II. Place and Date

Virginia Vermiculite, Limited
Trevilians, Virginia
(703) 967-2266
May 11, 1983

III. Attendees

Virginia Vermiculite, Limited

Robert Sansom, President, Louisa Properties
General Partner of Virginia Vermiculite
1111 North 19th St., Suite 505
Arlington, Va. 22209
(703) 276-8900 (Energy Ventures Analysis)

John Sansom, Plant Manager, Trevilians, Va.

U.S. Environmental Protection Agency

Gil Wood, EPA/ISB

Midwest Research Institute

William H. Maxwell, MRI/Raleigh
Amy J. Nelson, MRI/Raleigh

Principal Laboratories 425 Volker Boulevard, Kansas City, Missouri 64110

federal register

Monday
June 8, 1992

Part II

Department of Labor

Occupational Safety and Health Administration

29 CFR Parts 1910 and 1926

Occupational Exposure to Asbestos, Tremolite, Anthophyllite and Actinolite; Final Rule

MRI Copy

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

14 APR 1993

Mr. August Sisco
Acting Executive Secretary
Vermiculite Association
600 South Federal Street, Suite 400
Chicago, Illinois 60605

Dear Mr. Sisco:

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 8 of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.28, Vermiculite Processing, and the corresponding background memorandum for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and memorandum and would send us your comments. It would also be helpful if you could distribute copies of the enclosed section and memorandum 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 May 5, 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

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

Enclosure

MRI

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

Date: April 6, 1993

Subject: Background Information for Proposed AP-42 Section 8.29, Diatomite Processing
Review and Update Remaining Sections of Chapter 8 (Mineral Products Industry) of AP-42
EPA Contract 68-D2-0159, Work Assignment 012
MRI Project 3612

From: Richard Marinshaw

To: Ron Myers
EPA/EIB/EFMS (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. INTRODUCTION

This memorandum presents the background information that was used to develop the proposed AP-42 Section 8.29 on diatomite processing. A description of the industry is presented first. A process description followed by a discussion of emissions and controls are then presented. Finally, the reference list is provided. The draft AP-42 section is provided as the attachment.

II. INDUSTRY DESCRIPTION[1-3]

Diatomite is a chalky, sedimentary rock consisting mainly of an accumulation of skeletons formed by diatoms, which are single-celled microscopic aquatic plants. The skeletons are essentially amorphous hydrated or opaline silica but occasionally include some alumina. The Standard Industrial Classification (SIC) code for diatomite mining is 1499 (miscellaneous nonmetallic minerals, except fuels), and the SIC code for diatomite processing is 3295 (minerals and earths, ground or otherwise treated). The six-digit Source Classification Code (SCC) for diatomite processing is 3-05-026.

The unique physical properties of diatomite derive from the size, shape, and structure of individual diatom skeletons and the packing characteristics of a mass of the particles. Diatoms range in diameter from about 10 micrometers (μm) (4×10^{-4} inch [in.]) to over 500 μm (0.02 in.) and generally have a spiny structure with intricately pitted surfaces. Contact between particles is chiefly at the outer points of the irregular surfaces. Ground diatomite is a microscopically porous material with an apparent density of 80 to 255 kilograms per cubic meter (kg/m^3) (5 to 16 pounds per cubic foot [lb/ft^3]), giving this material exceptional filtering and thermal characteristics.

Diatomite products are separated into various grades based on different performance characteristics determined by empirical tests. Processed diatomite powders are classified into three general types based on production methods. These types are (1) natural, which is produced by simple milling, drying, and air classification, (2) calcined, or pink, which results from further heat treatment of the natural, and (3) flux-calcined, or white, which is from a similar heat treatment of the natural with the addition of a fusible alkali salt. These process designations do not translate directly into the market classifications. The major processed diatomite products are powders and aggregates of various sizes and grades. Diatomite products are used primarily as filter aids and filters.

Because calcined diatomite has a number of unique physical properties, it has diversified uses. The widest domestic use for diatomite (72 percent in 1991) is as a filter aid for separating suspended solids from fluids. The greatest growth potential for diatomite use is in this area of application because of increased emphasis on water purification and the removal of objectionable impurities in manufactured products and reusable process fluids. Diatomite is processed into filter aids for all types of food and nonfood processing applications. The more commonly known applications are in the filtration of dry cleaning solvents; pharmaceuticals; beer, whisky, and wine; raw sugar liquors; antibiotics; industrial, municipal, and swimming pool waters; fruit and vegetable juices; lube, rolling mill, and cutting oils; jet fuels; organic and inorganic chemicals; and varnishes and lacquers.

The second largest use of diatomite is as a filler or extender for paint, paper, asphalt products, and plastic. Fillers accounted for 14 percent of diatomite production in 1991. Other uses of diatomite include abrasives, absorbents, catalysts, fertilizer coatings, insulation, and lightweight aggregates, which collectively consumed 14 percent of U.S. production in 1991.

All domestic diatomite production comes from California, Nevada, Oregon, and Washington, with California accounting for more than half of the total national production. Total domestic production of diatomite in 1991 was 610,000 megagrams (Mg) (671,000 tons).

III. PROCESS DESCRIPTION[1,3]

Most diatomite deposits are found at or near the surface and can be mined by open pit methods or quarrying. Diatomite mining in the United States is all open pit, normally using some combination of bulldozers, scraper-carriers, power shovels, and trucks to remove overburden and the crude material. In most cases, fragmentation by drilling and blasting is not necessary. The crude diatomite is loaded on trucks and transported to the mill or to stockpiles. Figure 1 shows two alternative flow diagrams for diatomite processing.

The processing of uncalcined or natural-grade diatomite consists of crushing and drying. Crude diatomite commonly contains as much as 40 percent moisture, and in many cases contains over 60 percent. Primary crushing to aggregate size (normally done by a hammermill) is followed by simultaneous milling-drying, with suspended particles of diatomites being carried in a stream of hot gases. Flash and rotary dryers are used to dry the material to approximately 15 percent moisture. Typical flash dryer operating temperatures range from 70° to 430°C (150° to 800°F). The suspended particles exiting the dryer pass through a series of fans, cyclones, and separators to a baghouse. These sequential operations separate the powder into various sizes, remove waste impurities, and expel the absorbed water. These natural milled diatomite products are then bagged or handled in bulk without additional processing and are used principally for fillers and uses other than filter aids.

For filtration uses, natural grade diatomite is calcined by heat treatment in gas- or fuel oil-fired rotary calciners, with or without a fluxing agent. Typical calciner operating temperatures range from 650° to 1200°C (1200° to 2200°F). For straight-calcined grades, the powder is heated to the point of incipient fusion in large rotary calciners, and thus, in the strict technical sense, the process is one of sintering rather than calcining. The material exiting the kiln then is further milled and classified. Straight calcining is used for adjusting the particle size distribution for filter aid applications in which medium flow rates are required; it results in a product with a pink cast. The color, which is caused by the oxidation of iron in the raw material, becomes more intense with increasing iron oxide content.

Further adjustment of particle size is brought about by the addition of a flux, usually soda ash, before the calcining step. The addition of fluxing agent sinters the diatomite particles and increases the particle size, thereby allowing increased flow rate during liquid filtration. The resulting products are called "flux-calcined." Flux-calcining produces a white product that is believed to be formed by the conversion of the iron to complex sodium-aluminum-iron silicates rather than conversion to the oxide. Further milling and classifying follow calcining.

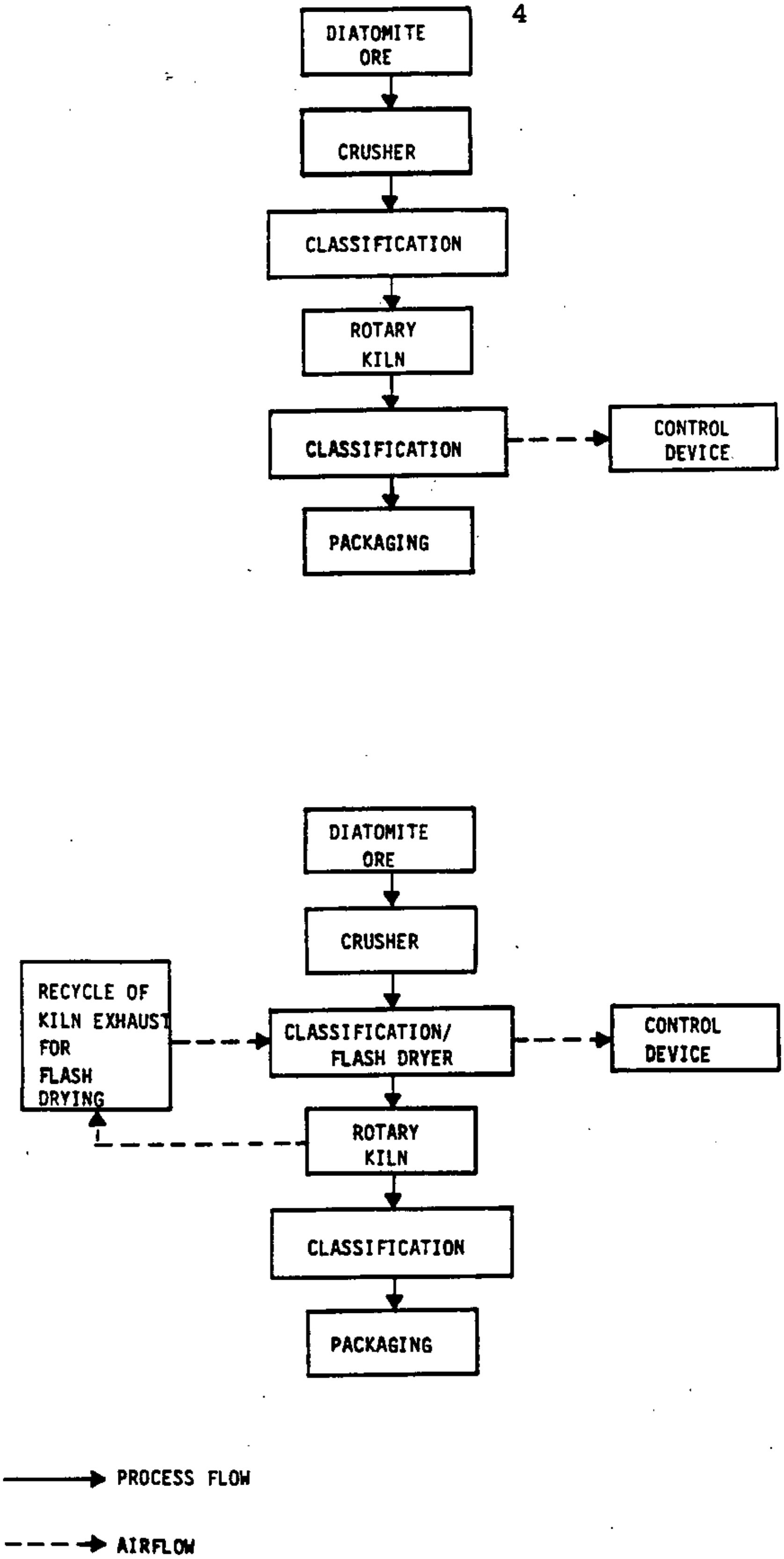

Figure 1. Alternate process flow diagrams for diatomite processing.[1]

IV. EMISSIONS AND CONTROLS[1,3]

Although no data on emissions from diatomite processing were available for the preparation of this memorandum, assumptions concerning diatomite emissions can be made based on the raw material and types of processes used in the industry. The primary pollutant of concern in diatomite processing is particulate matter (PM) and PM less than 10 µm (PM-10). Particulate matter is emitted from crushing, drying, calcining, classifying, and materials handling and transfer operations. Emissions from dryers and calciners include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Table 1 summarizes the results of a trace element analysis for one type of finished diatomite. These elements may constitute a portion of the PM emitted by the sources listed above.

Wet scrubbers and fabric filters are the most commonly used devices to control emissions from diatomite dryers and calciners. No information is available on the type of emission controls used on crushing, classifying, and materials handling and transfer operations.

REFERENCES

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

2. L. L. Davis, Diatomite in 1991, Mineral Industry Surveys, Annual Report, Bureau of Mines, U.S. Department of the Interior, Washington, DC, April 7, 1992.

3. F. L. Kadey, "Diatomite", Industrial Rocks and Minerals, Volume I, Society of Mining Engineers, New York, 1983.

TABLE 1. TRACE ELEMENT CONTENT OF FINISHED DIATOMITE[3]

Element[a]	ppm[b]	Element	ppm
Antimony*	2	Mercury*	0.3
Arsenic*	5	Molybdenum	5
Barium	30	Neodymium	20
Beryllium*	1	Nickel*	120
Bismuth	<0.5	Niobium	5
Boron	100	Osmium	<0.5
Bromine	20	Palladium	<1
Cadmium*	2	Platinum	<2
Cerium	10	Praseodymium	2
Cesium	5	Rhenium	<0.5
Chlorine	400	Rhodium	<0.5
Chromium*	100	Rubidium	10
Cobalt*	5	Ruthenium	<1
Copper	40	Samarium	2
Dysprosium	<1	Scandium	20
Erbium	<0.5	Selenium*	10
Europium	1	Silver	<0.5
Fluorine	50	Strontium	20
Gadolinium	<1	Tantalum	20
Gallium	5	Tellurium	<2
Germanium	<10	Terbium	<0.2
Gold	<0.5	Thallium	<0.5
Hafnium	<0.5	Thorium	5
Holmium	<0.2	Thulium	0.2
Indium	<0.5	Tin	<1
Iodine	1	Tungsten	<0.5
Iridium	<0.5	Uranium	5
Lanthanum	10	Vanadium	200
Lead*	2	Ytterbium	<0.5
Lithium	1	Yttrium	100
Lutetium	<0.2	Zinc	<10
Manganese•	60	Zirconium	20

[a] Hazardous air pollutants are indicated by an asterisk (*).

[b] < indicates below detection limit.

Attachment

DRAFT AP-42 SECTION 8.29

8.29 DIATOMITE PROCESSING

8.29.1 Process Description[1,2]

Diatomite is a chalky, sedimentary rock consisting mainly of an accumulation of skeletons formed by diatoms, which are single-celled microscopic aquatic plants. The skeletons are essentially amorphous hydrated or opaline silica but occasionally include some alumina. The Standard Industrial classification (SIC) code for diatomite mining is 1499 (miscellaneous nonmetallic minerals, except fuels), and the SIC code for diatomite processing is 3295 (minerals and earths, ground or otherwise treated). The six-digit Source Classification Code (SCC) for diatomite processing is 3-05-026.

Most diatomite deposits are found at or near the surface and can be mined by open pit methods or quarrying. Diatomite mining in the United States is all open pit, normally using some combination of bulldozers, scraper-carriers, power shovels, and trucks to remove overburden and the crude material. In most cases, fragmentation by drilling and blasting is not necessary. The crude diatomite is loaded on trucks and transported to the mill or to stockpiles. Figure 8.29-1 shows two alternative flow diagrams for diatomite processing.

The processing of uncalcined or natural-grade diatomite consists of crushing and drying. Crude diatomite commonly contains as much as 40 percent moisture, and in many cases contains over 60 percent. Primary crushing to aggregate size (normally done by a hammermill) is followed by simultaneous milling-drying, in which suspended particles of diatomite are carried in a stream of hot gases. Flash and rotary dryers are used to dry the material to approximately 15 percent moisture. Typical flash dryer operating temperatures range from 70° to 430°C (150° to 800°F). The suspended particles exiting the dryer pass through a series of fans, cyclones, and separators to a baghouse. These sequential operations separate the powder into various sizes, remove waste impurities, and expel the absorbed water. These natural milled diatomite products are then bagged or handled in bulk without additional processing and are used principally for fillers and uses other than filter aids.

For filtration uses, natural grade diatomite is calcined by heat treatment in gas- or fuel oil-fired rotary calciners, with or without a fluxing agent. Typical calciner operating temperatures range from 650° to 1200°C (1200° to 2200°F). For straight-calcined grades, the powder is heated to the point of incipient fusion in large rotary calciners, and thus, in the strict technical sense, the process is one of sintering rather than calcining. The material exiting the kiln then is further milled and classified. Straight calcining is used for adjusting the particle size distribution for filter aid applications in which medium flow rates are required; it results in a product with a pink cast. The color, which is caused by the oxidation of iron in the raw material, becomes more intense with increasing iron oxide content.

Further adjustment of particle size is brought about by the addition of a flux, usually soda ash, before the calcining step. The addition of fluxing agent sinters the diatomite particles and increases the particle size, thereby allowing increased flow rate during liquid filtration. The resulting products are called "flux-calcined." Flux-calcining produces a white product that is believed to be

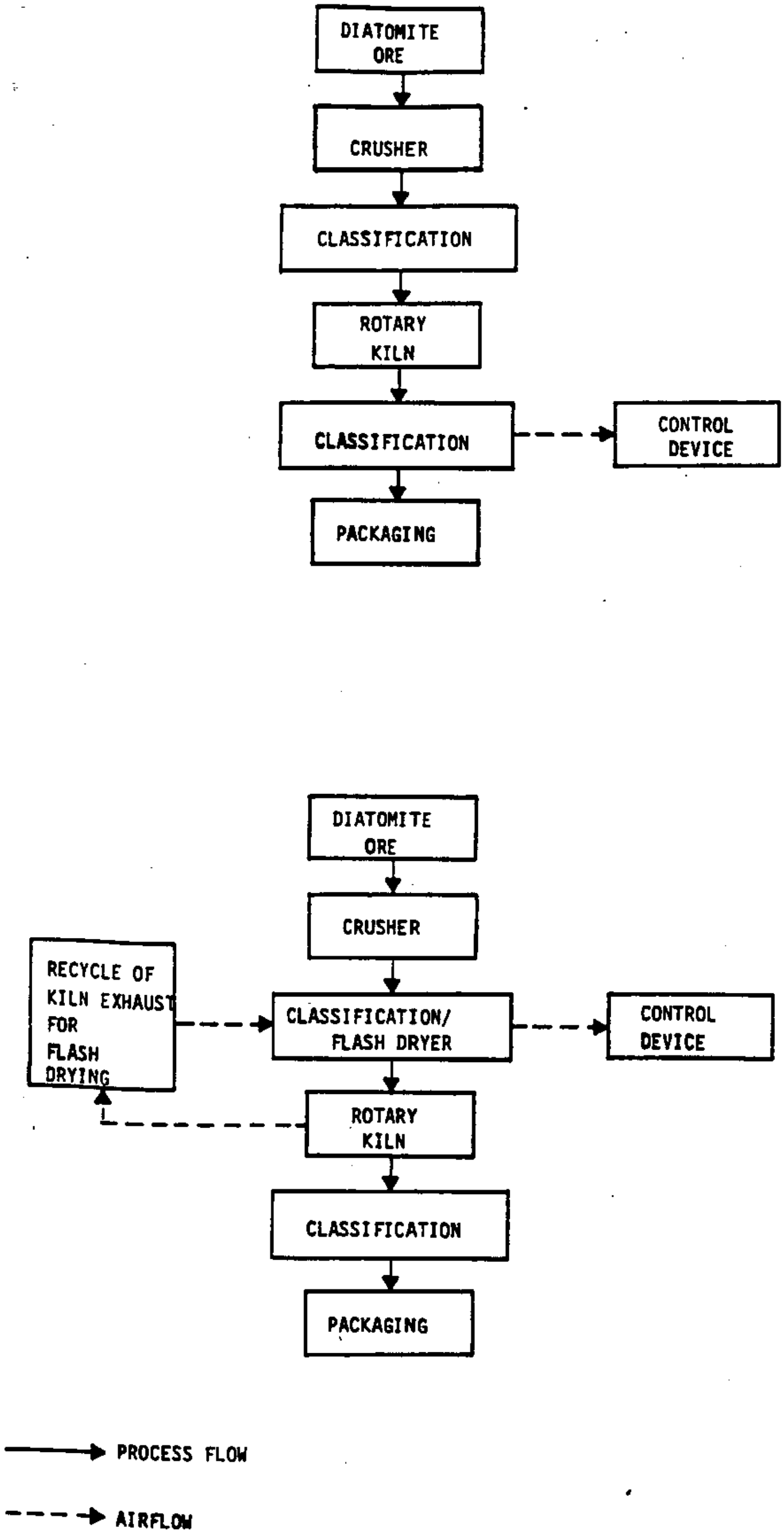

Figure 8.29-1. Alternate process flow diagrams for diatomite processing.[1]

formed by the conversion of the iron to complex sodium-aluminum-iron silicates rather than conversion to the oxide. Further milling and classifying follow calcining.

8.29.2 Emissions and Controls[1,2]

The primary pollutant of concern in diatomite processing is particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from crushing, drying, calcining, classifying, and materials handling and transfer operations. Emissions from dryers and calciners include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM. Table 8.29-1 summarizes the results of a trace element analysis for one type of finished diatomite. These elements may constitute a portion of the PM emitted by the sources listed above.

Wet scrubbers and fabric filters are the most commonly used devices to control emissions from diatomite dryers and calciners. No information is available on the type of emission controls used on crushing, classifying, and materials handling and transfer operations.

Due to a lack of availability, no emission factors for diatomite processing are presented.

TABLE 8.29-1. TRACE ELEMENT CONTENT OF FINISHED DIATOMITE[2]

Element[a]	ppm[b]	Element	ppm
Antimony*	2	Mercury*	0.3
Arsenic*	5	Molybdenum	5
Barium	30	Neodymium	20
Beryllium*	1	Nickel*	120
Bismuth	<0.5	Niobium	5
Boron	100	Osmium	<0.5
Bromine	20	Palladium	<1
Cadmium*	2	Platinum	<2
Cerium	10	Praseodymium	2
Cesium	5	Rhenium	<0.5
Chlorine	400	Rhodium	<0.5
Chromium*	100	Rubidium	10
Cobalt*	5	Ruthenium	<1
Copper	40	Samarium	2
Dysprosium	<1	Scandium	20
Erbium	<0.5	Selenium*	10
Europium	1	Silver	<0.5
Fluorine	50	Strontium	20
Gadolinium	<1	Tantalum	20
Gallium	5	Tellurium	<2
Germanium	<10	Terbium	<0.2
Gold	<0.5	Thallium	<0.5
Hafnium	<0.5	Thorium	5
Holmium	<0.2	Thulium	0.2
Indium	<0.5	Tin	<1
Iodine	1	Tungsten	<0.5
Iridium	<0.5	Uranium	5
Lanthanum	10	Vanadium	200
Lead*	2	Ytterbium	<0.5
Lithium	<1	Yttrium	100
Lutetium	<0.2	Zinc	<10
Manganese*	60	Zirconium	20

[a] Listed hazardous air pollutants indicated by an asterisk (*).

[b] < indicates below detection limit.

REFERENCES FOR SECTION 8.29

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

2. F. L. Kadey, "Diatomite", Industrial Rocks and Minerals, Volume I, Society of Mining Engineers, New York, 1983.

MRI Copy

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

15 APR 1993

Mr. Michael Potter
The Branch of Industrial Minerals
U. S. Bureau of Mines
8910 Seventh Street, NW, MS 5209
Washington, D.C. 20241-9384

Dear Mr. Potter:

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 8 of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.28, Vermiculite Processing, and the corresponding background memorandum for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and memorandum and would send us your comments. Unfortunately, we are on a very tight schedule, and it is important that we have all comments by May 5, 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

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

Enclosure

MRI

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Telephone (919) 677-0249
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Date: April 6, 1993

Subject: Background Information for Proposed AP-42 Section 8.28,
Vermiculite Processing
Review and Update Remaining Sections of Chapter 8
(Mineral Products Industry) of AP-42
EPA Contract 68-D2-0159, Work Assignment 012
MRI Project 3612

From: Richard Marinshaw

To: Ron Myers
EPA/EIB/EFMS (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

I. INTRODUCTION

This memorandum presents the background information that was used to develop the proposed AP-42 Section 8.28 on vermiculite processing. A description of the industry is presented first. A process description followed by a discussion of emissions and controls is then presented. Following these sections, a description of the references that were used to develop the draft section and the results of the data analysis are presented. Finally, the reference list is provided. The draft AP-42 section is provided as the attachment.

II. DESCRIPTION OF THE INDUSTRY[1-3]

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due the interlaminar generation of steam. The Standard Industrial Classification (SIC) code for vermiculite mining is 1499, miscellaneous nonmetallic minerals, except fuels, and for vermiculite processing, the SIC Code is 3295, minerals and earths, ground or otherwise treated. The six-digit Source Classification Code (SCC) for vermiculite processing is 3-05-033.

The world's latest deposit of vermiculite, which is located near Libby, Montana, was recently shut down. Other major vermiculite deposits are located near Enoree, South Carolina, and in the Republic of South Africa. Vermiculite is also mined and beneficiated at a mine in Louisa County, Virginia. Deposits of economic significance contain 25 to 95 percent vermiculite.

Estimated world production of crude vermiculite in 1991 was 523,000 megagrams (Mg) (576,000 tons), more than 80 percent of which came from five mines. The United States and Republic of South Africa account for most of the world production. Estimated U.S. production of crude vermiculite sold or used by producers in 1991 was 168,000 Mg (185,000 tons), of which approximately 136,000 Mg (150,000 tons) were exfoliated.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluidized bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Exfoliated vermiculite was produced at 35 plants in 27 States in 1989. The principal producing States were, in order of decreasing exfoliated vermiculite output, Ohio, California, South Carolina, Florida, New Jersey, Illinois, Texas, and Arkansas. The main uses of exfoliated vermiculite in 1990 were fertilizer carriers (22 percent), concrete aggregate (19 percent), horticultural uses (13 percent), premixes (12 percent), block insulation (12 percent), loose fill insulation (9 percent), soil conditioners (5 percent), and plaster aggregates (1 percent).

Vermiculite is commercially exfoliated by heating the presized crude vermiculite in a furnace chamber. The bulk volume of commercial grades increases 8- to 12-fold, but individual vermiculite particles may expand as much as 30-fold compared to the raw ore.

III. PROCESS DESCRIPTION[1,3]

A. Crude Ore Processing

Figure 1 is a flow diagram of vermiculite ore processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to other stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluid bed

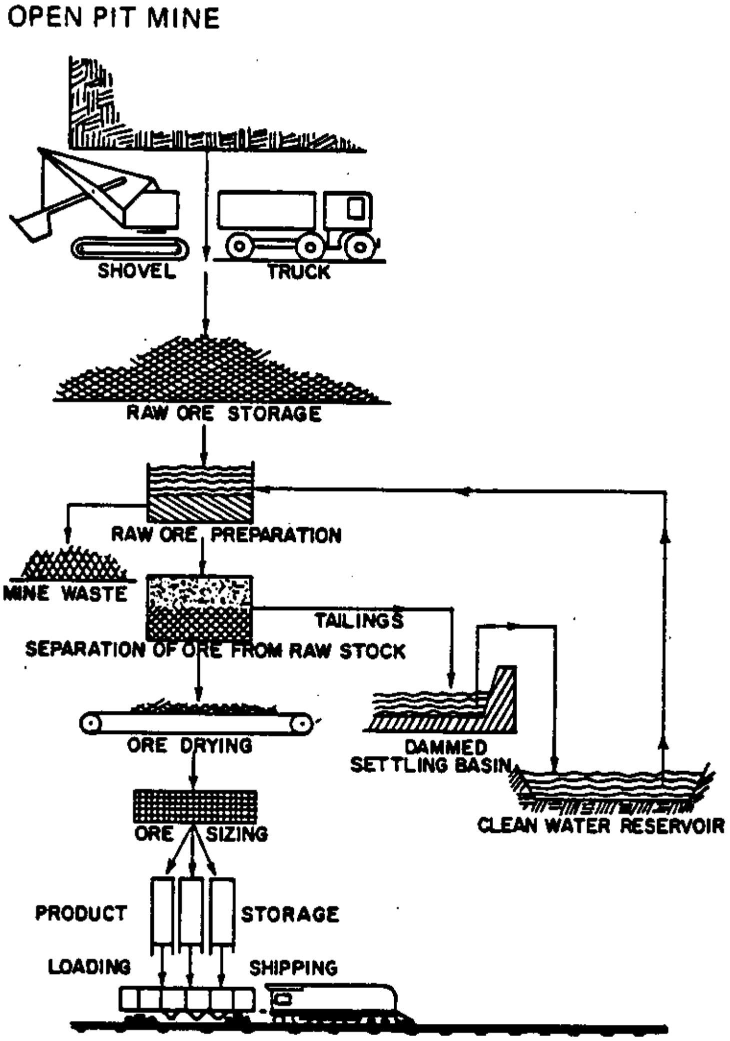

Figure 1. Flow diagram for vermiculite ore processing.[3]

or rotary dryer. The dryer products are separated by standard screens and are stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although one fluid bed dryer is used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

B. Exfoliation

Figure 2 depicts a typical vermiculite expanding process. Sized crude vermiculite is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air-conveyed to a classifier system, which collects the vermiculite product and removes excessive fines.

IV. EMISSIONS AND CONTROLS[1,3-5]

The primary pollutant of concern in vermiculite processing is particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. In addition, vermiculite ore contains asbestos, which can constitute a significant portion of the PM emissions. Much of the asbestos is removed when the ore is beneficiated. As a result, screen and mill dust contains a much higher asbestos content than the raw or processed vermiculite. Thus, fugitive dust emissions also are likely to contain a significant asbestos content. Emissions from rotary dryers and expansion furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. No information is available on the type of emission controls used on screening, milling, and materials handling and transfer operations.

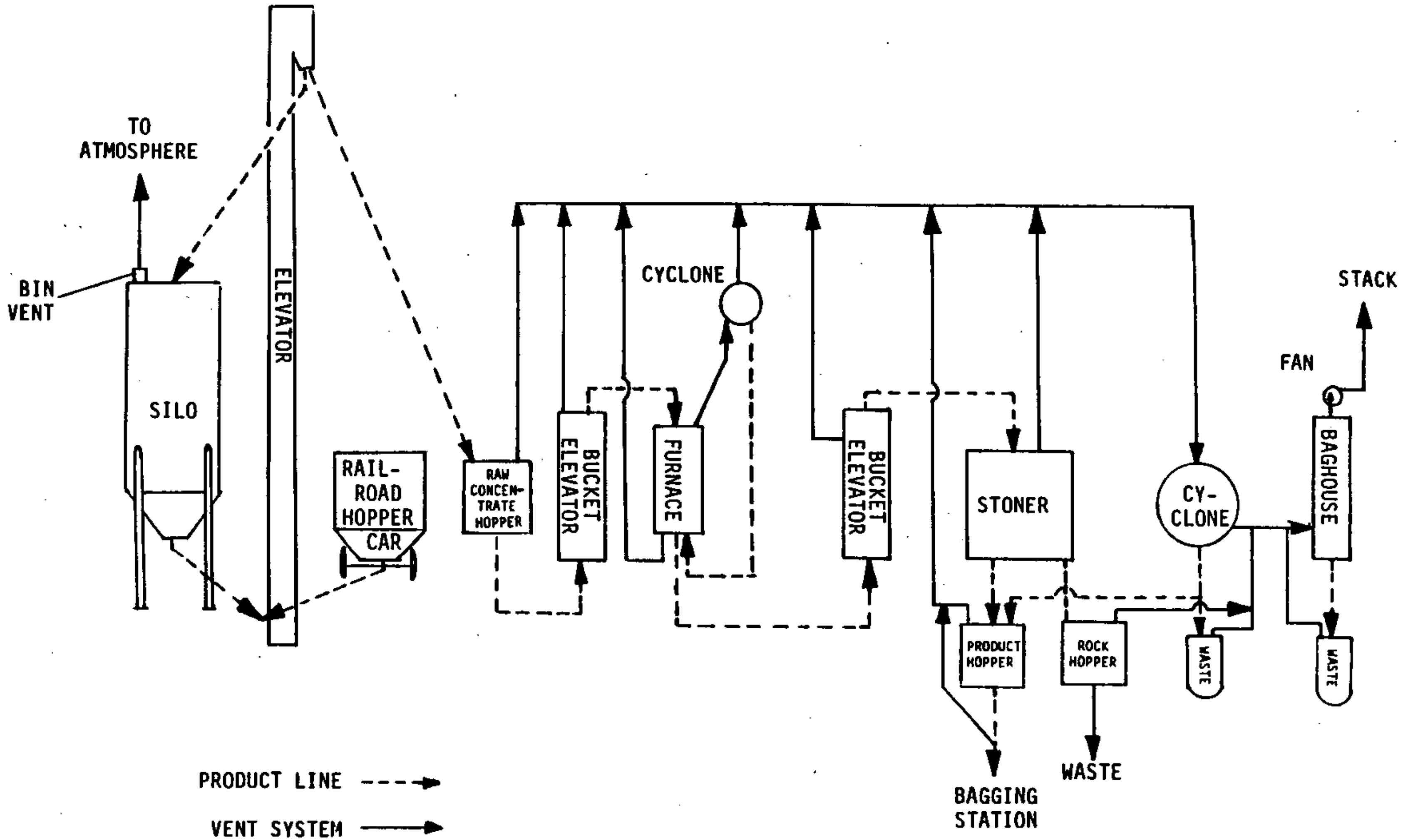

Figure 2. Process flow diagram for vermiculite exfoliation.[1]

V. DESCRIPTION OF REFERENCES

This section describes the primary references that contained data on emissions from vermiculite processing that were used to develop the draft AP-42 section. Reference 1 is not described because it is a secondary reference, and the vermiculite processing emission data in Reference 1 are taken from Reference 4, which is the primary reference for the data. References 2 and 3 also are not described below because they do not contain emission data.

A. Reference 4

This report documents measurements of filterable PM and CO_2 from an oil-fired rotary dryer. The purpose of the emission test was to demonstrate compliance with State regulations. The test was conducted in 1979. Process rates were provided on the basis of raw material feed. The dryer emissions are controlled with a low-energy spray tower with a design pressure drop of 1.2 kilopascals (5-in. water column).

Particulate matter emissions were measured during three Method 5 test runs. The method used to measure CO_2 concentrations in the exhaust was not specified in the report. Emission factors were developed for filterable PM and CO_2.

The emission data for filterable PM are rated B. The test methodology was sound, and no problems were reported, but the report lacked adequate documentation for a higher rating. The CO_2 data are rated C because the test method was not specified.

B. Reference 5

This report presents the results of a study to determine the fiber and asbestos content of raw and processed vermiculite. The study was sponsored by EPA, and the purpose was to provide information to be used in assessing the risk to the population exposed to asbestiform minerals from vermiculite at each of the various stages of its commercial distribution. The study was conducted in 1980 and 1981.

Nonexfoliated and exfoliated vermiculite samples were taken from the various stages of processing from three major domestic vermiculite mines and beneficiating plants in Montana and South Carolina. The samples were analyzed for fiber content using optical microscopy, X-ray diffraction, and transmission electron microscopy. The average asbestiform fiber contents of the samples are summarized in Table 1. The results indicate that more asbestiform fibers are associated with the finer size grades of vermiculite--the dust samples had highest asbestiform fiber content. This conclusion implies that the beneficiation process reduces asbestiform fiber content of the vermiculite significantly. The results also indicate that the asbestiform

TABLE 1. ASBESTIFORM FIBER CONTENT OF VERMICULITE[5]

Deposit location	Sample type	Approx. max. dimension, mm	Average asbestiform fiber content[a]			
			Amphibole		Chrysotile	
			Fibers x 10^6/g	ppm	Fibers x 10^6/g	ppm
Libby, MT[b]	Grade 1	5-10	31.6	78	0.9	0.0035
	Grade 2	3-5	23.4	48.5	0	0
	Grade 3	1-3	41.2	190	< 2.1	0.008
	Grade 4	0.5-1	22.6	160	< 0.4	c
	Grade 5	0.2-0.5	122	1,320	< 1.5	c
	Head feed	d	88.7	650	1.3	< 0.1
	mill dust	< 0.2	440	20,000	c	c
	screen dust	< 0.2	1,100	22,000	< 1.6	c
	extractor	d	55	420	0.7	0.0034
Enoree, SC	Grade 3	1-3	2.3	1.4	< 0.5	0.0005
	Grade 4	0.5-1	2.5	11	< 0.3	c
	Grade 5	0.2-0.5	8	39	1.3	< 1
	Head feed	d	4.5	7.8	0.3	< 1
	Grade 3, exfoliated	d	11.7	c	c	c
	Ungraded	d	0.83	8.5	< 0.3	0.0027

[a] Based on multiple analyses by two laboratories on nonexfoliated and exfoliated samples.
[b] Mine no longer in operation.
[c] No data available.
[d] Not applicable.

fiber content of Montana vermiculite deposits is considerably higher than that of the South Carolina deposits.

Because the report does not contain emission data, the report could not be used to develop asbestos emission factors. However, the data can be used in combination with PM emission rates to provide order of magnitude estimates of asbestos emissions from vermiculite ore processing.

VI. RESULTS OF DATA ANALYSIS

Emission factors were developed from Reference 1 for filterable PM and CO_2 emissions from rotary vermiculite dryers. The PM emission data from this reference are rated B because the documentation was not adequate to justify a higher rating. The emission factor for controlled filterable PM emissions from rotary dryers is rated D because it is based on a single reference.

The CO_2 emission data are rated C, because the test method is not specified. The emission factor for CO_2 emissions from rotary vermiculite dryers is rated E.

The emission factors developed for vermiculite processing are presented in Table 2.

TABLE 2. SUMMARY OF EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

Process	Control	Pollutant	No. of runs	Emission factor				Data rating	Emission factor rating
				Range		Average			
				kg/Mg	lb/ton	kg/Mg	lb/ton		
Rotary dryer	Spray tower	Filterable PM	3	0.078-0.11	0.16-0.22	0.095	0.19	B	D
		CO_2	3	45-62	91-125	50	100	C	E

[a] Reference 4; emission factor activity level based on material feed.

REFERENCES

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

2. M. J. Potter, Vermiculite in 1991, Mineral Industry Surveys Annual Report, Bureau of Mines, U.S. Department of the Interior, Washington, DC, August 5, 1992.

3. P. R. Strand and O. F. Stewart, "Vermiculite", Industrial Rocks and Minerals, Volume I, Society of Mining Engineers, New York, 1983.

4. Rotary Dryer Particulate Emissions Testing, Performed for Virginia Vermiculite Limited, Boswell's Tavern, Virginia, RTP Environmental Association, Research Triangle Park, NC, November 1979.

5. Collection, Analysis and Characterization of Vermiculite Samples for Fiber Content and Asbestos Contamination, Midwest Research Institute, prepared for the Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Washington, DC, September 27, 1982.

Attachment

DRAFT AP-42 SECTION 8.28

8.28 VERMICULITE PROCESSING

8.28.1 Process Description

Vermiculite is the geological name given to a group of hydrated laminar minerals that are aluminum-iron-magnesium silicates and that resemble mica in appearance. When subjected to heat, vermiculite has the unusual property of exfoliating, or expanding, due the interlaminar generation of steam. The Standard Industrial Classification (SIC) code for vermiculite mining is 1499, miscellaneous nonmetallic minerals, except fuels, and the SIC code for vermiculite processing is 3295, minerals and earths, ground or otherwise treated. The six-digit source classification code (SCC) for vermiculite processing is 3-05-033.

Vermiculite ore is mined using open-pit methods. Beneficiation includes screening, flotation, drying in rotary or fluid bed dryers, and expansion by exposure to high heat. All mined vermiculite is dried and sized at the mine site prior to exfoliation. Uses of unexpanded vermiculite are minor and include muds for oil-well drilling and fillers in fire-resistant wallboard.

Crude Ore Processing

Figure 8.28-1 is a flow diagram of vermiculite ore processing. Crude ore from open-pit mines is brought to the mill by truck and loaded onto outdoor stockpiles. Primary processing consists of screening the raw material to remove the waste rock greater than 1.6 centimeters (cm) (5/8 inch [in.]) and returning the raw ore to stockpiles. Blending is accomplished as material is removed from stockpiles and conveyed to the mill feed bin. The blended ore is fed to the mill, where it is separated into fractions by wet screening and concentrated by gravity. All concentrates are collected, dewatered, and dried in a fluid bed or rotary dryer. The dryer products are separated by standard screens and are stored in bins or silos for later shipment or exfoliation.

The rotary dryer is the most common dryer type used in the industry, although one fluid bed dryer is used. Drying temperatures are 120° to 480°C (250° to 900°F), and fuel oil is the most commonly used fuel. Natural gas and propane also are used to fuel dryers.

Exfoliation

Figure 8.28-2 depicts a typical vermiculite expanding process. Sized crude vermiculite is dropped continuously through a gas- or oil-fired vertical furnace. Exfoliation occurs after a residence time of less than 8 seconds in the furnace, and immediate removal of the expanded material from the furnace prevents damage to the structure of the vermiculite particle. Flame temperatures of more than 540°C (1000°F) are used for exfoliation. Proper exfoliation requires a high rate of heat transfer and rapid generation of steam within the vermiculite particles. The expanded product falls through the furnace and is air conveyed to a classifier system, which collects the vermiculite product and removes excessive fines.

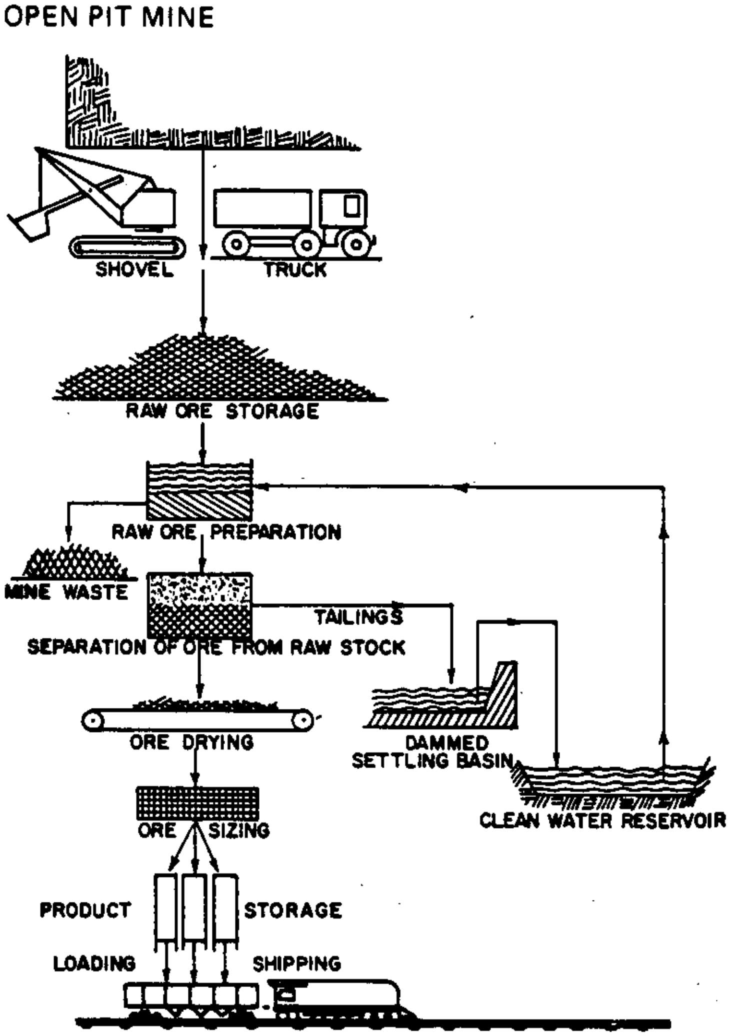

Figure 8.28-1. Process flow diagram for vermiculite ore processing[3]

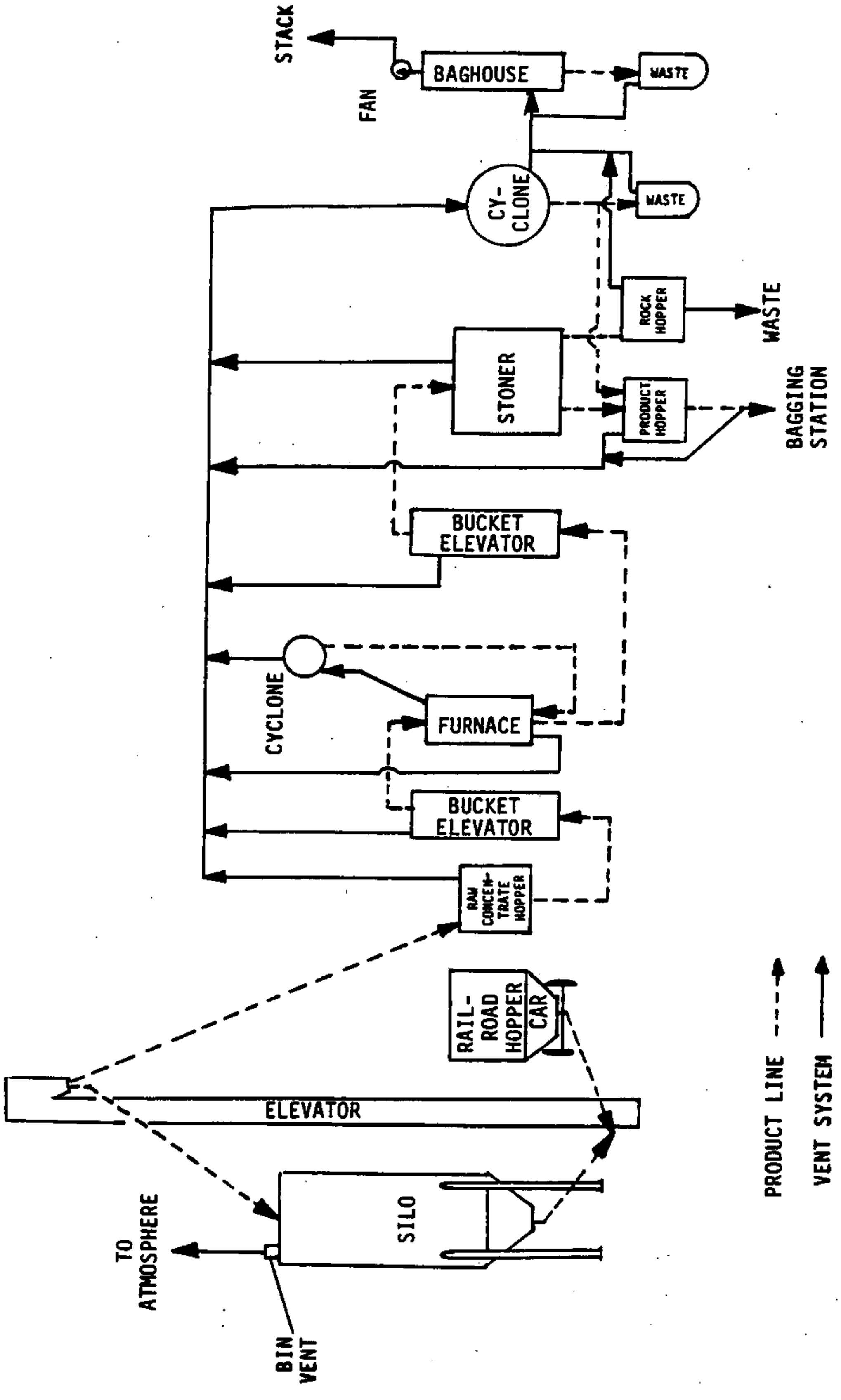

Figure 8.28-2. Process flow diagram for vermiculite exfoliation.[1]

8.28.2 Emissions and Controls[1,3-5]

The primary pollutant of concern in vermiculite processing is particulate matter (PM) and PM less than 10 micrometers (PM-10). Particulate matter is emitted from screening, drying, exfoliating, and materials handling and transfer operations. In addition, vermiculite ore contains asbestos, which can constitute a significant portion of the PM emissions. Table 8.28-1 presents average asbestiform fiber content of vermiculite samples taken from three vermiculite processing plants at two locations. As the table indicates, the asbestiform fiber content of the screen and mill dust is much higher than the content of the processed vermiculite, indicating that much of the asbestos is removed through beneficiation. For the same reason, fugitive dust emissions are likely to be relatively high in asbestos content. Emissions from rotary dryers and expansion furnaces include products of combustion, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x), in addition to filterable and condensible PM.

Wet scrubbers are the most commonly used device to control dryer emissions. Fabric filters also are used at some facilities. The majority of expansion furnaces are ducted to fabric filters for emission control. However, wet scrubbers also are used to control the furnace emissions. No information is available on the type of emission controls used on screening, milling, and materials handling and transfer operations.

Table 8.28-2 summarizes the emission factors for vermiculite processing.

REFERENCES FOR SECTION 8.28

1. Calciners and Dryers in Mineral Industries--Background Information for Proposed Standards, EPA-450/3-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

2. M. J. Potter, Vermiculite in 1991, Mineral Industry Surveys Annual Report, Bureau of Mines, U.S. Department of the Interior, Washington, DC, August 5, 1992.

3. P. R. Strand and O. F. Stewart, "Vermiculite", Industrial Rocks and Minerals, Volume I, Society of Mining Engineers, New York, 1983.

4. Rotary Dryer Particulate Emissions Testing, Performed for Virginia Vermiculite Limited, Boswell's Tavern, Virginia, RTP Environmental Association, Research Triangle Park, NC, November 1979.

5. Collection, Analysis and Characterization of Vermiculite Samples for Fiber Content and Asbestos Contamination, Midwest Research Institute, prepared for the Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Washington, DC, September 27, 1982.

TABLE 8.28-1. ASBESTIFORM FIBER CONTENT OF VERMICULITE[5]

Deposit location	Sample type	Approx. max. dimension, mm	Average asbestiform fiber content[a]			
			amphibole		chrysotile	
			fibers x 10^6/g	ppm	fibers x 10^6/g	ppm
Libby, MT[b]	Grade 1	5-10	31.6	78	0.9	0.0035
	Grade 2	3-5	23.4	48.5	0	0
	Grade 3	1-3	41.2	190	< 2.1	0.008
	Grade 4	0.5-1	22.6	160	< 0.4	c
	Grade 5	0.2-0.5	122	1,320	< 1.5	c
	Head feed	d	88.7	650	1.3	< 0.1
	mill dust	< 0.2	440	20,000	c	c
	screen dust	< 0.2	1,100	22,000	< 1.6	c
	extractor	d	55	420	0.7	0.0034
Enoree, SC	Grade 3	1-3	2.3	1.4	< 0.5	0.0005
	Grade 4	0.5-1	2.5	11	< 0.3	c
	Grade 5	0.2-0.5	8	39	1.3	< 1
	Head feed	d	4.5	7.8	0.3	< 1
	Grade 3, exfoliated	d	11.7	c	c	c
	Ungraded	d	0.83	8.5	< 0.3	0.0027

[a] Based on multiple analyses by two laboratories on nonexfoliated and exfoliated samples.
[b] Mine no longer in operation.
[c] No data available.
[d] Not applicable.

TABLE 8.28-2 (METRIC UNITS)
EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

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

Source (SSC)	Filterable[b]				Condensible PM[c]				CO^2	
	PM		PM-10		Inorganic		Organic			
Rotary dryer with spray tower[d] (3-05-033-__)	0.095	D	e		e		e		50	E

[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.
[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d] Reference 4.
[e] No data available.

TABLE 8.28-2 (ENGLISH UNITS)
EMISSION FACTORS FOR VERMICULITE PROCESSING[a]

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

Source (SSC)	Filterable[b]				Condensible PM[c]				CO^2	
	PM		PM-10		Inorganic		Organic			
Rotary dryer with spray tower[d] (3-05-033-__)	0.19	D	e		e		e		100	E

[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.
[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d] Reference 4.
[e] No data available.

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Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DRAFT

APR 12 1993

Mr. Michael Potter
The Branch of Industrial Minerals
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Washington, D.C. 20241-9384

Dear Mr. Potter:

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 8 of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.28, Vermiculite Processing, and the corresponding background memorandum for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and memorandum and would send us your comments. Unfortunately, we are on a very tight schedule, and it is important that we have all comments by May 5, 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

Enclosure

OAQPS/TSD/EIB:RMyers, rm 455B, 4201 Bldg., 541-5407, MD-14
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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DRAFT

APR 12 1993

Mr. August Sisco
Acting Executive Secretary
Vermiculite Association
600 South Federal Street, Suite 400
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Dear Mr. Sisco:

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.

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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.

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February 17, 1992

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Dear Mr. Myers:

The VA president, Ned GUmble, asked me to send you a copy of our membership directory. You'll find it enclosed.

Sincerely,

Darla Boudjenah
Executive Secretary

TO ADVANCE AND DIFFUSE THE KNOWLEDGE AND USE OF VERMICULITE

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Bob de Boer

The Vermiculite Association (VA) is the international organization representing mining companies, manufacturers, suppliers of equipment or materials and consultants to the vermiculite industry. The VA was founded in 1948. It's mission is to advance and diffuse the knowledge and use of vermiculite. Six major suppliers of crude ore are currently members of the VA, along with many key expanders.

How Can You Benefit From Membership in the VA?

The Vermiculite Association is involved in a wide range of activities from which its members can benefit. We offer:

- The opportunity to join with other expanders, miners and industry suppliers at our Annual Meeting. The Annual Meeting is the perfect forum for the exchange of information and offers you the additional benefit of rubbing elbows with your peers.
- Participation in the development and distribution of promotional and technical bulletins and brochures on various applications of vermiculite. Members have an opportunity to participate in the development process and to use these materials in their own sales efforts.
- Monitoring services of key governmental and allied industry organizations such as OSHA and ASTM. The Technical Committee keeps tabs on such important items as ASTM C-16.

What Is Included In The Membership Fee?

- You will receive a quarterly newsletter and bulletins on matters of timely importance to the Vermiculite Industry.
- Certificate of membership
- Membership Directory
- To keep current on novel uses of vermiculite; periodic distribution of worldwide abstracts.

Membership Classifications

Membership in the Vermiculite Association is open to mining companies, manufacturers and exfoliators, suppliers of equipment or materials and consultants to the industry.

The types of membership available in the VA are:

REGULAR MEMBER

A person firm, organization or corporation actively engaged in the manufacture or exfoliation of vermiculite.

Annual Dues: $750

MINING MEMBER

A person, firm, organization or corporation actively engaged in the mining of vermiculite for commercial sales, or actively engaged as a sales agent or broker for such a mining operation. Companies engaged in mining vermiculite for their own exclusive internal use shall not be considered mining members.

Annual Dues: $1,500

ASSOCIATE MEMBER

A person, firm, organization or corporation acitvely engaged in supplying equipment or materials, other than crude ore, used by Regular Members, or those actively engaged in the technical or scientific advancement of vermiculite and its uses, or those who use vermiculite for commercial purposes and who individually or jointly can not be a member in any other category.

Annual Dues: $300

Want More Information?

Call us at 312/922-6222 if you have further membership questions or if you desire more information.

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ROTARY DRYER
PARTICULATE EMISSIONS TESTING

PERFORMED FOR:

VIRGINIA VERMICULITE LIMITED
BOSWELL'S TAVERN, VIRGINIA

INTRODUCTION

The Virginia Vermiculite mining operation in Boswell's Tavern, Virginia, employs a rotary dryer to burn and evaporate the flotation medium used to separate vermiculite from undesirable mica and silicate deposits. The exhaust gases from the rotary dryer are drawn by an induced fan through a low efficiency cyclone in series with a cylindrical water spray tower with a wire mesh demister; combustion waste gases are then vented to the atmosphere.

RTP Environmental Associates performed particulate and asbestos emissions testing at the waste gas stack of this rotary dryer. The testing objectives were to determine the total process particulate emissions on a lbs/hr basis and qualitative asbestos measurements of the particles emitted from the rotary dryer. Three samples for asbestos determination were collected from three locations: (1) raw ore feed into plant, (2) vermiculite feed into dryer, and (3) rotary dryer exhaust. These three samples will be analyzed by Walter C. McCrone Associates, Inc. All particulate emissions procedures compiled with the August 18, 1977 Federal Reference Method 5 and the April 21, 1977 Commonwealth of Virginia testing requirements.

Test procedures at Virginia Vermiculite were observed by representatives of the Virginia State Air Pollution Control Board. These representatives were Ward Butler, Air Pollution Control Office; Nick Buckholtz, Division of Compliance; and Renaldo Jenkins, Engineering Division.

TESTING METHODOLOGY

All sampling and analytical procedures are those recommended by the United States Environmental Protection Agency and the Commonwealth of Virginia. Complete details of the equipment and procedures used are described in Appendix C.

Method 1 was used to determine the number and location of the sampling points. The dryer exhaust stack was divided into 12 equal areas. Three ports were cut into the stack (see Figure 1 and 2) so that the center of each area could be tested. Every point was sampled for five minutes, giving a total testing time of 60 minutes for each test run on the stack.

Velocity measurements were made in accordance with Method 2. Molecular weights for the stack gases were determined by Method 3 procedures. Particulate emissions were determined using Method 5 analytical and sampling procedures.

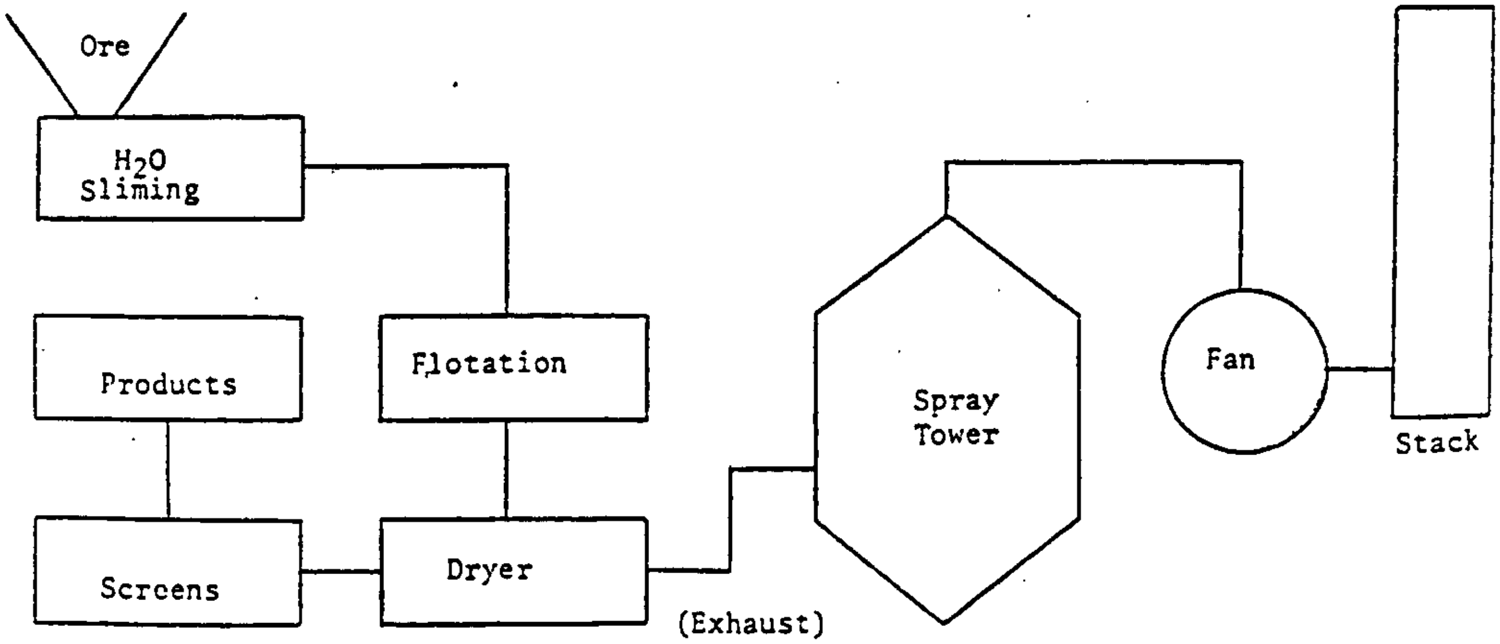
The two process feed samples (asbestos determination) were collected via intermittent grab samples, while the dryer exhaust asbestos sample was collected using the EPA Method 5 sampling train with a 0.5 μm Millipore filter. These samples were sent to Walter C McCrone Associates, Inc. for sample analysis. The results of these analyses will be sent as a separate enclosure with this report.

All sampling equipment used was manufactured by Nutech Corporation or RTP Environmental Associates.

PROCESS DESCRIPTION

The Virginia Vermiculite mining operation removes clay, mica, and silicate deposits from vermiculite laden ore at a site in Boswell's Tavern, Virginia. Clay deposits are removed by a water sliming procedure; the mica and silicates are separated from the vermiculite by flotation in a mixture of #2 fuel oil and other chemicals. The vermiculite is then dried in the rotary dryer and divided into two commerical grades.

Particulate emissions from the rotary dryer are controlled by a low energy water spray tower. The pressure drop across the tower is less than five inches of water. A wire demister prevents excess entrained water from being emitted from the tower. The following block diagram illustrates the process operation.



The rotary dryer normally operates at a process feed rate of eight tons per hour. The maximum operating capacity is rated at 10 tons per hour, but numerous difficulties arise as this feed rate is maintained. The dryer utilizes #2 fuel oil as a fuel; this fuel is rated at 138,000 BTU per gallon with a 0.3 percent sulfur content. The normal operating fuel useage is 60 gallons per hour with a maximum useage of 75 gallons per hour.

TABLE 3

SUMMARY OF TEST RESULTS

TEST*	1	2	3
Date	10/27/79	10/27/79	10/27/79
Stack Temperature (°F)	131	133	130
Percent Isokinetic (%)	103.5	92.0	101.3
Stack Flowrate (SDCFM)**	10,764	11,202	10,123
Gas Sampled (SDCF)**	46.8	43.3	43.1
Filter Catch (mg)	49.3	47.1	46.5
Particulate Emissions (lbs/hr)	1.50	1.61	1.44

*TEST 1: Particulate Emissions Test (11:20-12:34)
TEST 2: Particulate Emissions Test (13:12-14:21)
TEST 3: Particulate Emissions Test (14:48-15:54)

**68°F, 29.92 in. Hg

SUMMARY OF RESULTS

The Reference Method 5 procedures given in the August 18, 1977 Federal Register has been adopted as the particulate compliance testing method in the State of Virginia. Confirmation of the approved methodology was made through Mr. Thomas Creasy of the Virginia State Air Resources Board.

The rotary dryer process rate varied throughout the testing regime. A summary of the process rates occurring during the compliance testing is shown below.

TABLE 1

PROCESS FEED RATES

Time	Process Rate
11:30	6.62
12:00	8.27
12:30	9.45
1:00	8.27
1:30	6.62
2:00	7.35
2:30	8.27
3:00	11.03
3:30	8.27
4:00	9.45

Virginia State particulate emission compliance regulations state that particulate emissions must not exceed a specified limit "E" calculated from the equation $E = 4.10P^{0.67}$ where E = emission rate in lbs/hr and P

= process weight rate in tons/hr (this equation is valid up to a process weight rate of 30 tons/hr). The average process feed rate during each particulate test and its representative particulate emission limit are given in Table 2.

TABLE 2

PARTICULATE EMISSION LIMITS

Test Number	Process Rate (Ton/hr)	Emission Limit (lb/hr)
1	8.11	16.7
2	7.41	15.7
3	9.19	18.1

Table 3 gives the individual test summaries for the particulate compliance tests performed on the dryer exhaust stack.

Visible emissions determinations were attempted by Ward Butler of the State Air Pollution Control Board and Robert Y. Purcell of RTP Environmental Associates. Both personnel agreed that the existing meteorological conditions prevented an accurate estimate.