

[Note: with the publication of the Fifth Edition of AP-42, the Chapter and Section number for Sodium Carbonate changed to 8.12.]

**BACKGROUND REPORT**

**AP-42 SECTION 5.16**

**SODIUM CARBONATE PRODUCTION**

**Prepared for**

**U.S. Environmental Protection Agency  
OAQPS/TSD/EIB  
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**AP-42 Background Report**

**TECHNICAL SUPPORT DIVISION**

**U.S. ENVIRONMENTAL PROTECTION AGENCY**  
Office of Air Quality Planning and Standards  
Research Triangle Park, NC 27711

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## **1.0 INTRODUCTION**

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

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

1. Estimates of area-wide emissions;
2. Emission estimates for a specific facility; and
3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information from process information obtained from industry comment and 39 test reports to support revision of emission factors for sodium carbonate production.

Including the introduction (Chapter 1) this report contains four chapters. Chapter 2 gives a description of the sodium carbonate manufacturing industry. It includes a characterization of the industry, an overview of the different process types, a description of emissions, a description of the technology used to control emissions resulting from sodium carbonate production, and a review of references.

Chapter 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Chapter 4 includes the review of specific data sets and details criteria and noncriteria pollutant emission factor development. It also includes the results of a data gap analysis. Particle size determination and particle size data analysis methodology are described when applicable. Appendix A presents AP-42 Section 5.16.

## 2.0 INDUSTRY DESCRIPTION

### 2.1 GENERAL

Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ), commonly referred to as soda ash, is one of the largest-volume mineral products in the U.S., with 1991 production of over 9 million Mg (10.2 million tons). The 1991 reported distribution of soda ash by end use was glass, 49 percent; chemicals, 24 percent; soap and detergents, 13 percent; flue gas desulfurization, 3 percent; pulp and paper, 2 percent; water treatment, 1 percent; and other uses, including, consumer use, 2 percent. Soda ash for glass container manufacturing is decreasing due to increased use of cullet by the glass industry, and this trend continues as glass manufacturers are mandated to utilize cullet collected by recycling centers. Chemical caustic soda made from Wyoming soda ash competes directly with electrolytic caustic soda for a large market, and the outcome of this competition is highly dependent upon the market for chlorine, which is coproduced with caustic soda in the chlor-alkali process.

Producers of soda ash in the U.S., with their locations and approximate capacities, appear in Table 2.1.1. Roughly 90 percent of this capacity is based upon trona, an ore containing sodium carbonate, sodium bicarbonate ( $\text{NaHCO}_3$ ), and water. The world's largest deposit of trona is in the Green River Basin of Wyoming, with about 47 billion megagrams (52 billion tons) of identified soda ash resources. Searles and Owens lakes in California contain an estimated 815 million megagrams (900 million tons) of soda ash resources. With the exception of one facility that recovers small quantities of  $\text{Na}_2\text{CO}_3$  as a byproduct of cresylic acid production, no processes for synthetic soda ash are presently used in the U.S. A few processes that are not presently utilized in this country but are worthy of note because of their worldwide significance are the Solvay process, which involves saturation of brine with ammonia ( $\text{NH}_3$ ) and carbon dioxide ( $\text{CO}_2$ ) gas, and the Japanese ammonium chloride ( $\text{NH}_4\text{Cl}$ ) coproduction process. Both are synthetic processes resulting in ammonia emissions. Alternative natural processes include the calcination of sodium bicarbonate, or nahcolite, a naturally-occurring ore found in vast quantities in Colorado.

**TABLE 2.1-1  
U.S. SODA ASH PRODUCERS**

| SOURCE                              | LOCATION        | CAPACITY |          |
|-------------------------------------|-----------------|----------|----------|
|                                     |                 | Mg/yr    | (ton/yr) |
| FMC Corporation                     | Green River, WY | 2600     | 2900     |
| General Chemical Corporation        | Green River, WY | 2200     | 2500     |
| Rhône Poulenc of Wyoming            | Green River, WY | 2100     | 2300     |
| Solvay, Inc.                        | Green River, WY | 1000     | 1150     |
| TG (Texasgulf) Soda Ash, Inc.       | Granger, WY     | 1200     | 1300     |
| North American Chemical Corporation | Argus, CA       | 1200     | 1300     |

## 2.2 PROCESS DESCRIPTION

The two processes presently used to produce natural soda ash differ only in the recovery and primary treatment of the raw material used. The raw material for Wyoming soda ash is mined trona ore, while California soda ash is derived from sodium carbonate-rich brine extracted from Searles Lake.

There are four distinct methods used to mine the Wyoming trona ore: 1) solution mining, 2) room-and-pillar, 3) longwall, and 4) shortwall. In solution mining, dilute sodium hydroxide (NaOH), commonly called caustic soda, is injected into the trona to dissolve it. This solution is treated with carbon dioxide gas in carbonation towers to convert the sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) in solution to sodium bicarbonate ( $\text{NaHCO}_3$ ), which precipitates and is filtered out. The crystals are again dissolved in water, precipitated with carbon dioxide, and filtered. The product is calcined to produce dense soda ash. Brine extracted from below Searles Lake in California is treated similarly.

For the room-and-pillar, longwall, and shortwall methods, the conventional blasting agent is prilled ammonium nitrate and fuel oil, or ANFO. Beneficiation is accomplished with either of two methods called the sesquicarbonate and the monohydrate processes. In the sesquicarbonate process (shown schematically in Figure 2.2-1),



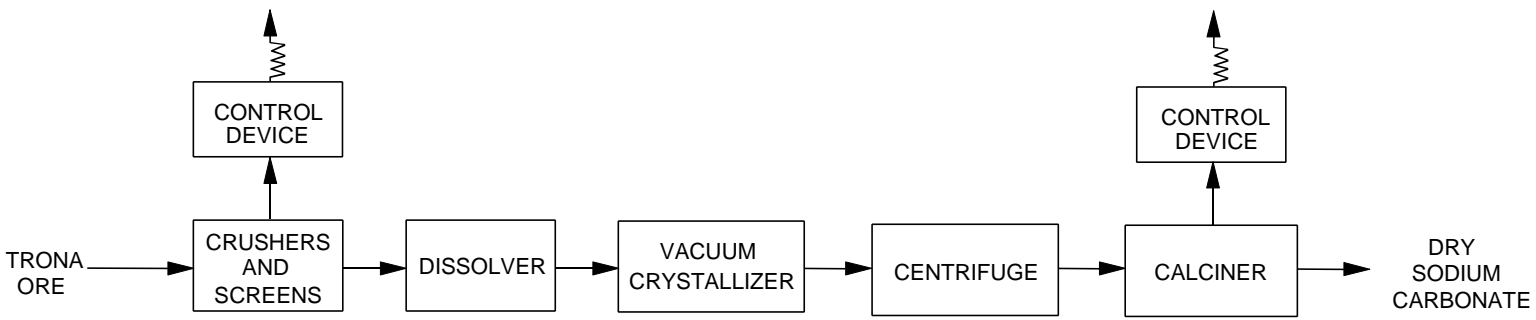
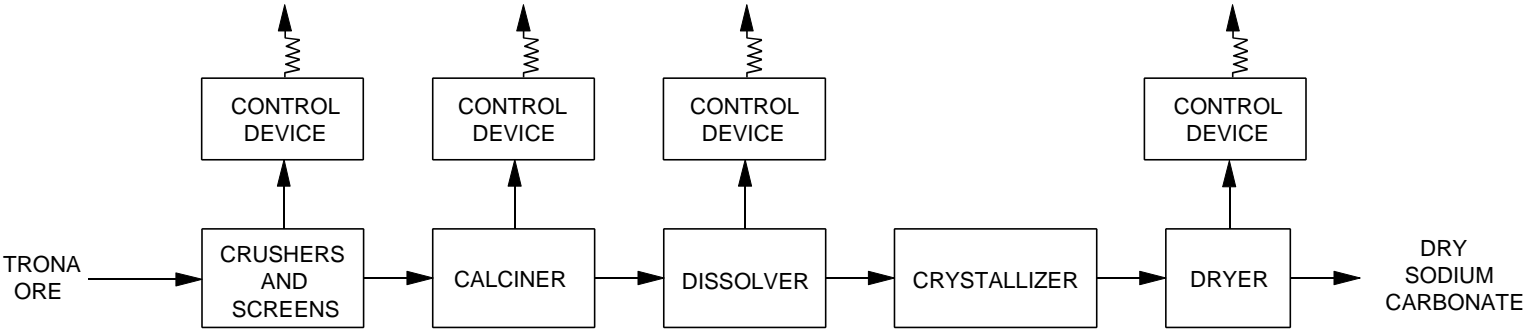


Figure 2.2-1 Flow diagram for sesquicarbonate sodium carbonate processing

trona ore is first dissolved in water and then treated as brine. The liquid is filtered to remove insoluble impurities before the sodium sesquicarbonate ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ) is precipitated by using vacuum

crystallizers. The result is centrifuged to remove remaining water, and can be sold as a finished product or further calcined to yield soda ash of light to intermediate density. In the monohydrate process, shown schematically in Figure 2.2-2, the crushed trona is calcined in a rotary kiln, yielding dense soda ash and carbon dioxide and water as by-products.

Figure 2.2-2 Flow diagram for monohydrate sodium carbonate processing



The calcined material is combined with water to allow settling out or filtering of impurities such as shale, and is then concentrated by triple-effect evaporators and/or mechanical vapor recompression crystallizers to precipitate sodium carbonate monohydrate ( $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ). Impurities such as sodium chloride ( $\text{NaCl}$ ) and sodium sulfate ( $\text{Na}_2\text{SO}_4$ ) remain in solution. The crystals and liquor are centrifuged, and the recovered crystals are calcined again to remove remaining water. The product must then be cooled, screened, and possibly bagged before shipping.

### **2.3 EMISSIONS AND CONTROLS**

The principal air emissions from sodium carbonate production are particulate in nature; annual particulate emissions from the four Wyoming sodium carbonate production facilities for which 1991 inventory/inspection reports were available ranged from 79.9 to 729.5 megagrams (88.1 to 804.3 tons), exclusive of boilers and miscellaneous processes not directly related to soda ash production. Of these totals, emissions from the ore calciners comprised between 47 percent and 81 percent; soda ash coolers and dryers comprised between 5 percent and 42 percent; mining and ore crushing, screening, and transporting operations comprised between 3 percent and 11 percent; and product handling and shipping operations comprised between 4 percent and 21 percent. Emission factors are presented for both filterable particulate matter and total particulate matter. Particulate emissions from soda ash manufacturing facilities in Wyoming are regulated in terms of total filterable and condensable particulate matter, with no regard to particle size; thus, available test data do not afford a particle size distribution. Emission factors are also presented for carbon dioxide from direct-fired process units such as ore calciners and soda ash dryers. Other by-products of combustion, such as nitrogen oxides, carbon monoxide, and sulfur dioxide, are emitted from these sources, but insufficient data are available to allow the development of emission factors for these pollutants. Emissions from combustion sources such as boilers, from evaporation of hydrocarbon fuels used to fire these combustion sources, and from sources not directly related to the soda ash manufacturing process (such as lime kilns used in conjunction with solution

mining) are covered in other chapters of AP-42.

Particulate emissions from calciners and dryers are typically controlled by venturi scrubbers, electrostatic precipitators, and/or cyclones. Baghouse filters are not well suited for application to these sources due to the exceptionally high moisture content of exhaust gases from them. Particulate emissions from the ore and product handling operations are typically controlled by either venturi scrubbers or baghouse filters. These control devices are an integral part of the manufacturing process, capturing raw materials and product for economic reasons. For this reason, and because little data exist on uncontrolled processes, controlled emission factors for this industry are presented.

The previous AP-42 section 5.16 contained emission factors for predryers, calciners, bleachers, and dryers only. These emission factors were based upon a small number of test runs conducted on both controlled and uncontrolled process equipment in the late 1970's. As discussed in the review of specific data sets in section 4.1, the questionable testing methodologies and insufficient documentation found in the reports summarizing the results of these tests make them unsuitable for use in the development of emission factors for this update. The particle size distribution given in the previous section was based upon the same sources, and was also eliminated for this update. Emission factors for the Solvay process of synthetic sodium carbonate production were also eliminated due to the phase-out of this industry in the U.S.

The controlled particulate matter emission factors developed from the large body of recent source test data collected for the purpose of updating the section are, as could be expected given the approximate efficiencies of the control equipment used in this industry for raw material and product recovery, two to three orders of magnitude lower than those uncontrolled factors given in the corresponding previous section. Application of nominal control efficiencies to these controlled factors yields uncontrolled emission factors comparable to those in the previous section. The emission factors for trona ore mining and transferring, and product screening and storage, are not highly rated but are a new addition to the section.

## **2.4 REVIEW OF REFERENCES FOR CHAPTER 2**

Pacific Environmental Services (PES) contacted the following sources to obtain the most up-to-date industry characterization and descriptions of processes, emissions, and controls for this industry:

- 1) U.S. Department of the Interior, Bureau of Mines, Washington, DC;

- 2) Wyoming Department of Environmental Quality, Air Quality Division, Lander, Wyoming;
- 3) U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division, Emission Measurement Branch;
- 4) San Bernardino Air Pollution Control District, Victorville, California;
- 5) FMC-Wyoming Corporation, Green River, Wyoming;
- 6) Rhône-Poulenc of Wyoming, Green River, Wyoming;
- 7) J.T. Baker, Inc., Phillipsburg, New Jersey; and
- 8) Merichem Company, Houston, Texas.

Responses were received from all of the government agencies except No. [4], and from three of the companies. Conversations between PES personnel and the EMB engineer responsible for testing performed on sodium carbonate manufacturing processes in the late 1970's revealed that the process data, raw field data, and other documentation necessary to the evaluation of several emission test reports were no longer available. No response to a request for confidential process information was received from Rhône-Poulenc. PES has incorporated the information received from these sources into the AP-42 section revision by developing new emission factors and by describing the industry and its processes as they currently exist. A brief discussion of each reference used to revise this section is given below.

Reference #1: "Soda Ash," *Mineral Commodity Summaries 1992*

Reference #2: "Soda Ash," *Minerals Yearbook 1989*

These publications from the U.S. Bureau of Mines were obtained from Mr. Dennis Kostick of that agency. Reference #2, authored by Mr. Kostick, was invaluable for its description of all those industrial processes specific to the sodium carbonate production industry. The corresponding section in Reference #1 was used in conjunction with the more detailed 1989 document to accurately characterize the industry as it exists in 1992, including total soda ash production and soda ash usage by category. Because the primary focus of these two documents is commercial rather than environmental, they are lacking in their coverage of emissions and control techniques associated with sodium carbonate production.

Reference #3: 1990 Directory of Chemical Producers

This document was used in conjunction with References #1 and 2 to determine the sodium carbonate capacity of the six major U.S. producers, as well as to discover whether any U.S. firms still engage in the manufacture of synthetic sodium carbonate. The two firms listed as being producers of synthetic soda ash (sources [7] and [8] from above) were both contacted by PES, and neither is presently active in this market.

References #4-7: 1991/92 Annual Inspection Reports

These documents, obtained from their author at the Wyoming Department of Environmental Quality, were used in estimating total annual particulate emissions from four of the five Wyoming soda ash manufacturers (a report on the Solvay facility, known as Tenneco until 1992, was not available). In addition, these reports contained valuable information on process components and control devices which supplemented the documentation in the source test reports used to revise the emission factors.



## 2.5 REFERENCES FOR CHAPTER 2

1. D.S. Kostick, "Soda Ash," Mineral Commodity Summaries 1992, pp. 162-163, U.S Department of the Interior, Bureau of Mines, 1992.
2. D.S. Kostick, "Soda Ash," Minerals Yearbook 1989, Volume I: Metals and Minerals, pp. 951-968, U.S Department of the Interior, Bureau of Mines, 1990.
3. SRI International, 1990 Directory of Chemical Producers: United States.
4. L. Gribovicz, Wyoming Department of Environmental Quality, Air Quality Division, "FY 91 Annual Inspection Report: FMC-Wyoming Corporation, Westvaco Soda Ash Refinery," 11 June 1991.
5. L. Gribovicz, Wyoming Department of Environmental Quality, Air Quality Division, "FY 92 Annual Inspection Report: General Chemical Partners, Green River Works," 16 September 1991.
6. L. Gribovicz, Wyoming Department of Environmental Quality, Air Quality Division, "FY 92 Annual Inspection Report: Rhône-Poulenc Chemical Company, Big Island Mine and Refinery," 17 December 1991.
7. L. Gribovicz, Wyoming Department of Environmental Quality, Air Quality Division, "FY 91 Annual Inspection Report: Texasgulf Chemical Company, Granger Trona Mine & Soda Ash Refinery," 15 July 1991.
8. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming," Western Environmental Services and Testing, Inc., Casper, WY, February 1988.
9. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming," Western Environmental Services and Testing, Inc., Casper, WY, November 1989.
10. "Rhône-Poulenc Wyoming Co. Particulate Emission Compliance Program," TRC Environmental Measurements Division, Englewood, CO, 21 May 1990.
11. "Rhône-Poulenc Wyoming Co. Particulate Emission Compliance Program," TRC Environmental Measurements Division, Englewood, CO, 6 July 1990.
12. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, October 1990.
13. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, February 1991.
14. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, January 1991.

15. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, October 1990.
16. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, 6 June 1988.
17. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, 24 May 1988.
18. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, 28 August 1985.
19. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming," FMC-Wyoming Corporation, Green River, WY, December 1990.
20. "Emission Measurement Test Report of GR3A Crusher," The Emission Measurement People, Inc., Cañon City, CO, 16 October 1990.
21. "Stack Emissions Survey: TG Soda Ash, Inc., Granger, Wyoming," Western Environmental Services and Testing, Inc., Casper, WY, August 1989.
22. "Compliance Test Reports," Tenneco Minerals, Green River, WY, 30 November 1983.
23. "Compliance Test Reports," Tenneco Minerals, Green River, WY, 8 November 1983.
24. "Particulate Stack Sampling Reports," Texasgulf, Inc., Granger, WY, October 1977-September 1978.
25. "Fluid Bed Dryer Emissions Certification Report," Texasgulf Chemicals Co., Granger, WY, 18 February 1985.
26. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming," Western Environmental Services and Testing, Inc., Casper, WY, May 1987.

### **3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES**

#### **3.1 LITERATURE SEARCH AND SCREENING**

The first step of this investigation involved a search of available literature relating to criteria and noncriteria pollutant emissions associated with sodium carbonate production. This search included the reference AP-42 background files maintained by the Emission Factor and Methodologies Section.

To reduce the amount of literature collected to a final group of references pertinent to this report, the following general criteria were used:

1. Emissions data must be from a primary reference, i.e. the document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document.
2. The referenced study must contain test results based on more than one test run.
3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

If no primary data was found and the previous update utilized secondary data, this secondary data was still used and the Emission Factor Rating lowered, if needed. A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria. The final set of reference materials is given in Chapter 4.0.

#### **3.2 EMISSION DATA QUALITY RATING SYSTEM**

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

1. Test series averages reported in units that cannot be converted to the selected reporting units;
2. Test series representing incompatible test methods (i.e., comparison of the EPA Method 5 front-half with the EPA Method 5 front- and back-half);
3. Test series of controlled emissions for which the control device is not specified;

4. Test series in which the source process is not clearly identified and described; and
5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Data sets that were not excluded were assigned a quality rating. The rating system used was that specified by the OAQPS for the preparation of AP-42 sections. The data were rated as follows:

**A**

Multiple tests performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in either the inhalable particulate (IP) protocol documents or the EPA reference test methods, although these documents and methods were certainly used as a guide for the methodology actually used.

**B**

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

**C**

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

**D**

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

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

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.
2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data are documented in the report. Many variations can occur unnoticed and without warning during testing. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and were given a lower rating.
4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by the EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

### 3.3 EMISSION FACTOR QUALITY RATING SYSTEM

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

#### **A (Excellent)**

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

#### **B (Above average)**

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

#### **C (Average)**

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

#### **D (Below average)**

The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a

random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

**E (Poor)**

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

The use of these criteria is somewhat subjective and depends to an extent on the individual reviewer.

**3.4 REFERENCES FOR CHAPTER 3**

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections. U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711, April, 1992. [Note: this document is currently being revised at the time of this printing.]
2. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Sources, Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1986.

## 4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT

### 4.1 REVIEW OF SPECIFIC DATA SETS

This section provides a discussion of specific references utilized in revising the emission factors presented in the updated AP-42 Section 5.16 on sodium carbonate production. With the exception of References 32-34, which due to poor documentation and sampling methodology are not used in updating emission factors, all quantitative emissions data collected for the AP-42 update were found exclusively in terms of English units (such as pounds per hour); therefore, these source test summaries are given in English units only. Table 4.5-1 gives factors to be used in converting these data to metric units if desired, and Sections 4.2 and 4.3 tabulate the results of each source test in both English and metric units.

#### **Calciners**

Reference #8a: General Chemical, GR3-D-1 monohydrate-process coal-fired rotary calciner, February 1988

(test incorrectly indicates source #GR3-E-1)

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1975, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #8b: General Chemical, GR3-E-2 monohydrate-process coal-fired rotary calciner, February 1988

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic

condensable particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1975, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #9a: General Chemical, GR3-D-1 monohydrate-process coal-fired rotary calciner, November 1989

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensable particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensable particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1975, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #9b: General Chemical, GR3-E-2 monohydrate-process coal-fired rotary calciner, November 1989

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensable particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensable particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1975, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #10a: Rhone-Poulenc Wyoming, 4SC-10 monohydrate-process coal-fired rotary calciner, May 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensable



particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1972. At the time of this test, it was controlled with a series of cyclones and a wet scrubber, but it was retrofitted with a Ducon venturi scrubber in 1991.

Reference #10c: Rhone-Poulenc Wyoming, 5ES-10 monohydrate-process coal-fired rotary calciner, May 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1977, and is controlled with a Research-Cottrell electrostatic precipitator.

Reference #11: Rhone-Poulenc Wyoming, 4SC-10 monohydrate-process coal-fired rotary calciner, June 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This calciner was installed in 1972. At the time of this test, it was controlled with a series of cyclones and a wet scrubber, but was retrofitted with a Ducon venturi scrubber in 1991.

Reference #12: FMC-Wyoming Corporation, Mono-5 monohydrate-process gas-fired rotary calciner, October 1990

This test was performed in accordance with EPA Reference Methods 1-5 with the exception of too small a sample volume for all three runs. The test also lacks some documentation of calibration procedures and testing equipment, but consistent results allow the emission factor for filterable particulate matter to be rated "B." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "C." Method 7E was run concurrently for NO<sub>x</sub> emissions, and all necessary documentation of equipment and methodology allows these results to be rated "A."

This calciner was installed in 1972, and is controlled with a Ducon Type VVO vertical venturi oriclone scrubber.

References #13 and 14: FMC-Wyoming Corporation, Mono-2 monohydrate-process gas-fired rotary calciner, January and February 1991

These tests were performed in accordance with EPA Reference Methods 1-5, contain all necessary documentation for validation, and have consistent results. The emission factors for filterable particulate matter from these tests are thus rated "A." Because organic condensible particulate matter is not quantified in these tests, emission factors for filterable plus inorganic condensible particulate matter are presented in lieu of the preferred factors for total particulate emissions. These emission factors are rated "B." The throughput rates for these tests are proprietary.

This calciner was installed in 1975, and is controlled with a Research-Cottrell electrostatic precipitator.

Reference #15: FMC-Wyoming Corporation, Mono-2 monohydrate-process gas-fired rotary calciner, October 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

Method 7E was run concurrently for NO<sub>x</sub> emissions, and all necessary documentation of equipment and methodology allows these results to be rated "A."

This calciner was installed in 1975, and is controlled with a Research-Cottrell electrostatic precipitator.

References #16a, 16b, and 17: FMC-Wyoming Corporation, RA-22, RA-23, and RA-24 gas-fired sesquicarbonate-process rotary calciners, May and June 1988

These tests were performed in accordance with EPA Reference Methods 1-5, contain all necessary documentation for validation, and have consistent results. The emission factors for filterable particulate matter from these tests are thus rated "A." Because organic condensible particulate matter is not quantified in these tests, emission factors for filterable plus inorganic condensible particulate matter are presented in lieu of the preferred factors for total particulate emissions. These emission factors are rated "B." Calciner RA-22 was installed in 1958, and was retrofitted with twin Peabody wet scrubbers in 1981; calciner RA-23 was installed in 1964, and was retrofitted with twin FMC Model 50K dual-throat venturi scrubbers in 1979; and calciner RA-24 was installed in 1966 and is controlled with twin Ducon multivane Type L Model II wet scrubbers.

Reference #18: FMC-Wyoming Corporation, RA-26 sesquicarbonate-process fluid-bed calciner, June 1985

This test was performed in accordance with EPA Reference Methods 1-5, contains all documentation necessary for validation, and has consistent results. Thus, this test is rated "A." Only emissions of filterable particulate matter are quantified in this test.

This calciner was installed in 1984 and is controlled with an FMC Model 120K venturi scrubber.

Reference #26: General Chemical, GR3-D-1 monohydrate-process coal-fired rotary calciner, May 1987

This test was performed in accordance with EPA Reference Methods 1-5, and contains all necessary documentation for validation, but its results are inconsistent with other tests on the same source. The emission factor for filterable particulate matter from this test is thus rated "B." Because organic condensible particulate matter is not quantified in this test, an emission factor

for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "C."

The test review attached to the test report contains an explanation for the fact that filterable plus inorganic particulate emissions, as indicated by this test, are 127 percent the permitted allowable rate (and considerably higher than indicated by References #8a and #9a). Evidently, the ore crusher feeding this calciner is badly in need of maintenance, and is feeding too large a pebble size to the calciner. This necessitates higher temperature and exhaust volume, thus lowering retention time in the precipitators.

This calciner was installed in 1975, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #27: Allied Chemical, GR2-C-4 monohydrate-process gas-fired rotary calciner, February 1986

(plant now owned by General Chemical)

Only a brief test review performed by Mike Crawford of the Wyoming AQD is available; the test passed this review, but without raw data and narrative no verification of accuracy can be made. Thus, this reference is rated "C." Only emissions of filterable particulate matter are quantified in this reference.

This calciner was installed in 1973, and is controlled with a Buell cyclone precleaner and a Research-Cottrell electrostatic precipitator.

Reference #29: FMC-Wyoming Corporation, Mono-2 monohydrate-process gas-fired rotary calciner, March 1991

This test was performed in accordance with EPA Reference Methods 1-5 with the exceptions of too small a sample volume for all three runs and too high a sampling temperature at several times during testing. This test also lacks some documentation of calibration procedures and testing equipment. These deviations from accepted methodology are not deemed to have a significant effect on the results, and consistent results allow the emission factor for filterable particulate matter to be rated "B." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "C." The throughput rates for these test runs are proprietary.

This calciner was installed in 1975, and is controlled with a Research-Cottrell electrostatic precipitator.

Reference #30: Texasgulf Soda Ash, Nos. 1 and 2 monohydrate-process coal-fired rotary calciners, September and October 1978

These tests were ostensibly performed in accordance with EPA Reference Methods 1-5, but their results are highly inconsistent, they lack documentation of quality assurance, calibrations, and sampling methodology, and are thus rated "D."

Each of these calciners was installed in 1976, and is controlled with a Buell Model 6B#80CG37 cyclone precleaner and a Buell Model Ba1.1X42L434-2.3P electrostatic precipitator.

Reference #32b: Texasgulf, Inc., ore calciner, May 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-6 and an unreferenced hydrocarbon emissions measurement method, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. No description of the calciner itself is given, including the emissions point number associated with its control equipment. This source is controlled with a cyclone precleaner and an electrostatic precipitator in series, but no manufacturer's data is included. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks (for particulate emissions testing); sampling temperatures, measurement frequency and duration, traceability protocol of the calibration gases, analyzer specifications, and system calibration tests, bias tests, span drift tests, zero drift tests, and response time tests (for hydrocarbon emissions testing); sampling duration, sample volume, performance of leak checks, analysis of reagent blanks, or system purge (for sulfur dioxide testing); or transcription of data to calculation sheets. Emissions testing was performed at both inlet to and the outlet from the control devices, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and no indication is given that the inlet and outlet tests were performed concurrently, precluding the use of this data in determining control efficiency. Due to the breakdown of a conveyor gearbox, only

two test runs for each pollutant were performed at the inlet to the control equipment, and the sample volumes collected for the two filterable particulate test runs (19.23 and 18.81 dry standard cubic feet, or dscf) were significantly less than that required by EPA Reference Method 5 (30 dscf). Also, no calculations are shown in the report.

No tests were performed on the ore calciner for carbon monoxide, nitrogen oxides, or any pollutants other than filterable particulate matter, hydrocarbons, and sulfur dioxide. No measurement of carbon dioxide concentration in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 465575.65 and 45042.41 pounds per hour at the inlet to the control equipment, and 33.49, 24.01, and 6.53 pounds per hour at the outlet from the control equipment. It is not clear what portion of the total particulate emissions these values represent, due to confusion in the labeling of the results table: Table 2-3, in English units, is titled "*Total Particulate - Filter Catch and Front Half Acetone Wash,*" while Table 2-4, in Metric units, is titled "*Insoluble Particulate - Filter Catch and Front Half Acetone Wash,*" and both contain the same values. Results of the testing for sulfur dioxide indicate emission rates of 1.58 pounds per hour at the inlet to the control equipment (only one test run was performed at this location) and 0.91, 0.85, and 0.85 pounds per hour at the outlet from the control equipment. These values are derived from concentration measurements that are at the lower limit of detection of the analytical method, and are thus suspect. Results of the testing for hydrocarbon emissions indicate concentrations of 30 and 22 parts per million by volume (ppmv) as methane at the inlet to the control equipment, and 28 and 32 ppmv as methane at the outlet from the control equipment serving the ore calciner (only two test runs were performed at this location). No stack gas volumetric flow rate information is provided in the test report for the hydrocarbon test runs, precluding the use of these concentration measurements in calculating mass hydrocarbon emission rates. Particle size analyses were performed at the inlet to the control equipment using both an Anderson cascade impactor and the Bahco procedure, but no indication of the number of sampling points utilized for the Anderson analysis is given, and the results of the two methods differ appreciably: the Anderson analysis indicates that those particles less than ten microns in diameter comprise only 9 percent of the filterable particulate emissions by weight, while the Bahco analysis indicates 97.5 percent.

Reference #33b: FMC, Mono-5 monohydrate-process gas-fired rotary ore calciner, May 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and an unreferenced hydrocarbon emissions measurement method, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. This calciner was installed in 1972, and is controlled with a Ducon type VVO vertical venturi Oriclone scrubber. The report includes a statement of confidentiality indicating that stack gas volumetric flow rate information, as well as temperature and moisture measurements, at the inlet to the control equipment are proprietary and as such are not included. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, sample volume collected, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks (for particulate emissions testing); sampling temperatures, measurement frequency and duration, traceability protocol of the calibration gases, analyzer specifications, and system calibration tests, bias tests, span drift tests, zero drift tests, and response time tests (for hydrocarbon emissions testing); or transcription of data to calculation sheets. Emissions testing was performed at both inlet to and the outlet from the control devices, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and the inlet and outlet tests were not performed concurrently, precluding the use of this data in determining control efficiency. Also, no calculations are shown in the report.

No tests were performed on the ore calciner for carbon monoxide, nitrogen oxides, sulfur dioxide, or any pollutants other than filterable particulate matter and hydrocarbons. No measurement of carbon dioxide concentration in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 39517.36, 48624.06, and 44010.36 pounds per hour at the inlet to the control equipment, and 37.93, 46.21, and 43.98 pounds per hour at the outlet from the control equipment. Results of the testing for hydrocarbon emissions indicate concentrations of 917 and 2587 parts per million by volume (ppmv) as methane at the inlet to the control equipment, and 154 and 261 ppmv as methane at the outlet from the control equipment serving the ore calciner (only two test runs were performed at each of these locations). The lack of volumetric flow rate information at the inlet precludes the calculation of mass hydrocarbon emission rates using these concentration measurements, but mass hydrocarbon emission rates at the outlet from the control equipment can be calculated as follows:



$$\begin{aligned} & [(154 + 261) (10^{-6}) / 2] [(47308 + 44343 \text{ ft}^3/\text{min}) (60 \text{ min/hr}) / 2] [16.0 \text{ lb/lb mole}] \\ & \times [.00278 \text{ lb mole/ft}^3] = 25.4 \text{ pounds per hour total hydrocarbons as methane.} \end{aligned}$$

Particle size analyses were performed at both test locations using an Anderson cascade impactor and at the inlet to the control equipment using the Bahco procedure. No indication is given as to the number of sampling points utilized for the Anderson procedure, and only one test run was performed at each location. The results of the Bahco particle size analysis performed on the filter catch at the inlet to the control equipment are suspect, due to the 111.1 percent isokinetic sampling ratio of the third test run. Due to inertial properties of large particles, sampling at a rate greater than isokinetic tends to underestimate the proportion of total mass particulate emissions represented by these particles. Results of the Anderson particle size analysis performed at the outlet from the control equipment serving the Mono-5 ore calciner indicate that approximately 70 percent of the mass filterable particulate emissions are in the form of particles of less than ten microns in diameter. Results of the Anderson particle size analysis performed at the inlet to the control equipment indicate that those particles less than ten microns in diameter comprise approximately 10 percent of the mass filterable particulate emissions, while the Bahco analysis indicates 86 percent.

Reference #33c: FMC, NS-3 monohydrate-process gas-fired rotary ore calciner, May 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and an unreferenced hydrocarbon emissions measurement method, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. This calciner was installed in 1975, and is controlled with a cyclone and a Research-Cottrell electrostatic precipitator in series. The report includes a statement of confidentiality indicating that stack gas volumetric flow rate information, as well as temperature and moisture measurements, at the inlet to the control equipment are proprietary and as such are not included. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, sample volume collected, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks (for particulate emissions testing); sampling temperatures, measurement frequency and duration, traceability protocol of the calibration gases, analyzer specifications, and system calibration tests, bias tests, span drift tests, zero drift tests,

and response time tests (for hydrocarbon emissions testing); or transcription of data to calculation sheets. Emissions testing was performed at both inlet to and the outlet from the control devices, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and the inlet and outlet tests were not performed concurrently, precluding the use of this data in determining control efficiency. Also, no calculations are shown in the report.

No tests were performed on the ore calciner for carbon monoxide, nitrogen oxides, sulfur dioxide, or any pollutants other than filterable particulate matter and hydrocarbons. No measurement of carbon dioxide concentration in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 93577.33, 83311.77, and 57897.52 pounds per hour at the inlet to the control equipment, and 68.25, 89.49, and 53.63 pounds per hour at the outlet from the control equipment. Results of the testing for hydrocarbon emissions indicate concentrations of 47, 178, and 222 parts per million by volume (ppmv) as methane at the inlet to the control equipment, and 361 and 314 ppmv as methane at the outlet from the control equipment serving the NS-3 ore calciner (only two test runs were performed at this location). The lack of volumetric flow rate information at the inlet precludes the calculation of mass hydrocarbon emission rates using these concentration measurements, but mass hydrocarbon emission rates at the outlet from the control equipment can be calculated as follows:

$$\begin{aligned} & [(361 + 314) (10^{-6}) / 2] [(85421 + 84751 \text{ ft}^3/\text{min}) (60 \text{ min}/\text{hr}) / 2] [16.0 \text{ lb}/\text{lb mole}] \\ & \times [.00278 \text{ lb mole}/\text{ft}^3] = 76.8 \text{ pounds per hour total hydrocarbons as methane.} \end{aligned}$$

Particle size analyses were performed at both test locations using an Anderson cascade impactor and at the inlet to the control equipment using the Bahco procedure. No indication is given as to the number of sampling points utilized for the Anderson procedure, and only one test run was performed at the outlet from the control equipment, but three test runs were performed at the inlet to the control equipment. No isokinetic ratios are presented for any of the Anderson particle size analyses, and the isokinetic ratio for the first particulate test run (which is the basis for part of the Bahco particle size analysis) is 78.1 percent. Due to inertial properties of large particles, sampling at a rate lower than isokinetic tends to overestimate the proportion of total mass particulate emissions represented by these particles. Results of the Anderson particle size analysis performed at the outlet from the control equipment serving the NS-3 ore calciner indicate that 87 percent of the mass filterable particulate emissions are in the form of particles of

less than ten microns in diameter. Results of the three Anderson particle size analyses performed at the inlet to the control equipment indicate that those particles less than ten microns in diameter comprise 3, 4.5, and 9 percent of the mass filterable particulate emissions, while the Bahco analysis indicates 87 percent.

### **Ore Mining/Transporting/Crushing/Screening**

#### Reference #19: FMC-Wyoming, Mono-II dual ore reclaim system, December 1990

This test was performed in accordance with EPA Reference Methods 1-5, and contains all necessary documentation for validation. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate.

Because of a questionable reported value for the ore feed rate for the third test run, due to a stockpile reclaim feeder being plugged, this run has been excluded from emission factor calculations. The two remaining test runs are consistent enough to allow their results to be used with a reasonable level of confidence in emission factor development. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "B."

This ore crusher was installed in 1990 and is controlled with a Ducon type VVO venturi scrubber.

The carbon dioxide concentration of the stack gas was assumed to be zero.

#### Reference #20: General Chemical, GR3-A ore crusher, September 1990

This test was performed in accordance with EPA Reference Methods 1-5 and contains all necessary documentation for validation. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being

vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The ratio of filterable to inorganic condensible particulate matter varies somewhat between the three runs in this test, indicating the possibility of breakthrough of particulate matter which should have collected on the filter. As a result, the emission factor for filterable particulate matter from this test is rated "C." The emission factor for filterable plus inorganic condensible particulate matter is rated "B." The emission factors presented agree with those calculated by Dan Olson of Wyoming AQD and presented in the review accompanying the original test report (the report contains minor mathematical errors).

This crusher was modified in 1990, and at that time was retrofitted with a Buell-Norfelt Model 40-CE-320 baghouse.

Carbon dioxide concentrations of 1, 2, and 1 percent for the three test runs are reported to have been measured. Given that no combustion is associated with this process, and the low accuracy of the measurement method used, no emission factor for carbon dioxide from ore crushing operations has been developed.

Reference #21: Texasgulf Soda Ash, mine headframe collector, June 1989

This test was performed in accordance with EPA Reference Methods 1-5, contains all documentation necessary for validation, has consistent results, and is thus rated "A." Only emissions of filterable particulate matter are quantified in this test. The emission factors reported agree with those calculated by Chad Schlichtemeier of Wyoming AQD in the accompanying test evaluation (the original test report contains minor mathematical errors).

The mine headframe baghouse filter tested collects dust generated during the unloading of ore transported to the surface by the mine skips. It was installed in 1976, and is controlled by a Mikropul Model 241-K-8-TRH baghouse.

The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero.

Reference #22a: Tenneco Minerals, BF-1 ore crusher, November 1983

This test was performed in accordance with EPA Reference Methods 1-5, but is lacking sufficient documentation for validation. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The ratio of filterable to inorganic condensible particulate matter varies somewhat between the three runs in this test, indicating the possibility of breakthrough of particulate matter which should have collected on the filter. As a result, the emission factor for filterable particulate matter from this test is rated "C." The emission factor for filterable plus inorganic condensible particulate matter is rated "B."

This ore crusher is controlled with a baghouse filter.

The carbon dioxide concentration of the stack gas was assumed to be zero.

Reference #22b: Tenneco Minerals, BF-8 trona transfer baghouse, November 1983

This test was performed in accordance with EPA Reference Methods 1-5, but is lacking sufficient documentation for validation. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "B."

This source is a baghouse filter which itself is an integral part of the process, and is otherwise uncontrolled.

The carbon dioxide concentration of the stack gas was assumed to be zero.

Reference #24a: Texasgulf Soda Ash, ore crusher, October 1977/April 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but its results are highly inconsistent and it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D."

This ore crusher was installed in 1976, and is controlled with a Buffalo Forge Model P-1-320 baghouse.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #28: Texasgulf Soda Ash, ore crusher (point #3), November 1987

This test was performed in accordance with EPA Reference Methods 1-5, but validation of the process data is difficult and the results are somewhat inconsistent. This test is thus rated "B." The back half of the particulate matter sampling train was employed, but no condensible particulate matter was collected, so an emission factor for filterable plus inorganic condensible particulate equal to that for filterable particulate is presented.

This crusher was installed in 1976, and is controlled with a Buffalo Forge Model P-1-320 baghouse.

The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero.

**Product Handling and Shipping**

Reference #23a: Tenneco Minerals, product screening, August 1983

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but its results are somewhat inconsistent and it lacks documentation of quality assurance, calibrations, and sampling methodology, and is thus rated "D." The fact that condensible particulate matter was collected for only one of the three test runs, and in a significant quantity, indicates the possibility of breakthrough of particulate matter which should have collected on the filter.

This source is controlled with a baghouse filter.

The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero.

Reference #23b: Tenneco Minerals, product silo top (loading) vent, October 1982

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but it contains the results of only two test runs and it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D."

This source is controlled with a baghouse filter.

The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero.

Reference #23c: Tenneco Minerals, product silo bottom (reclaim) vent, October 1982

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but its results are highly inconsistent, it lacks documentation of quality assurance, calibrations, and sampling methodology, and is thus rated "D." It can not be determined from the test report

whether the inorganic condensible particulate collected in two of the three test runs can be attributed to the temperature of the front half of the Method 5 sampling train or to breakthrough of particulate which should have collected on the filter.

This source is controlled with a baghouse filter.

The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero.

Reference #24b: Texasgulf Soda Ash, product sizing system, August 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D."

This system was installed in 1976, and is controlled with a Buffalo Forge Model P-1-440 baghouse.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #24c: Texasgulf Soda Ash, product handling, August 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore



calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D." This source was installed in 1976, and is controlled with a Buffalo Forge Model P-1-380 baghouse.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #24d: Texasgulf Soda Ash, product silo vent (point #12), March 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D." This source was installed in 1976, and is controlled with a Buffalo Forge Model P-1-380 baghouse.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #24e: Texasgulf Soda Ash, product sizing system, August 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology. In performing the particulate matter emissions test in accordance with Method 5, wherein the sampling probe and filter are heated to approximately 120°C, some of the particulate matter is measured as condensed particulate, despite a process temperature approximating ambient. This can be attributed to a portion of the emissions being vaporized in the front half of the sampling train and recondensing in the impinger train. As with processes such as ore

calcining which incorporate relatively high temperatures, the particulate matter collected on the filter and in the probe wash is reported as filterable particulate and that collected in the ice water-cooled impingers is reported as inorganic condensible particulate. The emission factors for filterable and filterable plus inorganic condensible particulate matter are both rated "D." This source was installed in 1976, and is controlled with a Buffalo Forge Model P-1-440 baghouse.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

### **Soda Ash Coolers and Dryers**

#### Reference #10b: Rhone-Poulenc Wyoming, 4SC-12a gas-fired rotary soda ash drying kiln, May 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This dryer was installed in 1972 and at the time of this test was controlled with the original cyclone and wet scrubber. It was retrofitted with a Ducon venturi scrubber in 1991.

#### Reference #10d: Rhone-Poulenc Wyoming, 5ES-12 gas-fired rotary soda ash drying kiln, coolers, and classifier, May 1990

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. Three separate processes are vented through the same Research-Cottrell electrostatic precipitator, however, and the contribution of each process to the particulate matter concentration measured is not determinable from the test report. The results of this test can not be used for emission factor development, and are thus rated "D." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions.

Effluent from the kiln, which was installed in 1980, is vented through a cyclone before entering the common ESP stack, and the product coolers and product classifier are vented first to a baghouse before entering the common ESP stack.

Reference #24f: Texasgulf Soda Ash, #1 steam tube soda ash dryer, September 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology, and is thus rated "D." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions.

This dryer was installed in 1976, and is controlled with a Ducon Oriclone Size 59/126 type VVO venturi scrubber.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #24g: Texasgulf Soda Ash, #1 steam tube soda ash dryer, March 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology, and is thus rated "D." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions.

This dryer was installed in 1976, and is controlled with a Ducon Oriclone Size 59/126 type VVO venturi scrubber.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #24h: Texasgulf Soda Ash, #2 steam tube soda ash dryer, September 1978

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and has consistent results, but it lacks documentation of quality assurance, calibrations, and sampling methodology, and is thus rated "D." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions.

This dryer was installed in 1976, and is controlled with a Ducon Oriclone Size 59/126 type VVO venturi scrubber.

No measurements of nor assumptions concerning the carbon dioxide concentration of the stack gas were reported.

Reference #25: Texasgulf Soda Ash, fluid bed soda ash dryer/cooler, January/February 1985

This test was performed in accordance with EPA Reference Methods 1-5, contains all necessary documentation for validation, and has consistent results. The emission factor for filterable particulate matter from this test is thus rated "A." Because organic condensible particulate matter is not quantified in this test, an emission factor for filterable plus inorganic condensible particulate matter is presented in lieu of the preferred factor for total particulate emissions. This emission factor is rated "B."

This source was installed in 1984, and can be operated as either a cooler or dryer. It is controlled with a Sly Manufacturing Model #5 venturi scrubber. The operating mode has no significant effect on the particulate matter emission rate nor the efficiency of the scrubber.

The concentration of carbon dioxide in the stack gas was assumed to be zero.

Reference #32a: Texasgulf, Inc., soda ash dryer, May 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. No description of the dryer itself is given, including the emissions point number associated with its control equipment. This source is controlled with a scrubber, but no manufacturer's data is included. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks, or transcription of data to calculation sheets. Also, no calculations are shown in the report, and the sample volume at the inlet was significantly less than that required by EPA reference methods for all three runs. Particulate emissions testing was performed at both inlet to and the outlet from the control devices during this test, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any

emission factors, and no indication is given that the inlet and outlet tests were performed concurrently, precluding the use of this data in determining control efficiency.

The particulate emission rates indicated from the testing performed at the inlet to the control equipment are more suspect due to the ratios of isokineticity for the three test runs: 146.5, 149.1, and 120.9 percent. These unacceptably high values are explained in the test report as being the result of excessive moisture content in the stack gas. The results of the particle sizing analysis performed at this location with an Anderson cascade impactor can be assumed to have been affected to an even greater degree than the total particulate mass emission results. This is due to the tendency of larger particles, because of their inertia, to not be collected by the sampling probe in a representative concentration. Similarly, but to a lesser degree, the results of the particulate sampling at the outlet from the control equipment are also misleading, due to isokinetic ratios for the three runs of 111.0, 94.2, and 115.8 percent.

No tests were performed on the soda ash dryer for carbon monoxide, nitrogen oxides, hydrocarbons, sulfur dioxide, or any pollutants other than filterable particulate matter. No measurement of the concentration of carbon dioxide in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 4665.61, 3930.81, and 3606.65 pounds per hour at the inlet to the control equipment, and 4.43, 5.95, and 3.66 pounds per hour at the outlet from the control equipment serving the soda ash dryer.

Reference #33a: FMC, NS-6 monohydrate-process fluid-bed soda ash dryer, May 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5 and with an unreferenced hydrocarbon emissions measurement method, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. This dryer was installed in 1975, and is controlled with a cyclone and an FMC dual throat Model 50K venturi scrubber. The report includes a statement of confidentiality indicating that stack gas volumetric flow rate information, as well as temperature and moisture measurements, at the inlet to the control equipment are proprietary and as such are not included. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, sample volumes, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks (for particulate emissions testing); sampling temperatures, measurement frequency and duration, traceability protocol of the calibration gases, analyzer specifications, and system calibration tests, bias tests, span drift tests, zero drift tests, and response time tests (for

hydrocarbon emissions testing); or transcription of data to calculation sheets. Also, no calculations are shown in the report. Particulate emissions testing was performed at both inlet to and the outlet from the control devices during this test, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and no indication is given that the inlet and outlet tests were performed concurrently, precluding the use of this data in determining control efficiency.

The particulate emission rates indicated from the testing performed at the inlet to the control equipment are more suspect due to the ratios of isokineticity for the three test runs: 72.6, 68.8, and 76.2 percent. These unacceptably low values are not explained in the test report, but are most likely the result of excessive moisture content in the stack gas. The results of the particle sizing analysis performed at this location with an Anderson cascade impactor can be assumed to have been affected to an even greater degree than the total particulate mass emission results. This is due to the tendency of larger particles, because of their inertia, to be collected by the sampling probe in a greater-than-representative concentration during sub-isokinetic sampling. No particle size analysis was performed at the outlet from the control equipment.

No tests were performed on the soda ash dryer for carbon monoxide, nitrogen oxides, sulfur dioxide, or any pollutants other than hydrocarbons and filterable particulate matter. No measurement of the concentration of carbon dioxide in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 26082.05, 11853.49, and 11501.76 pounds per hour at the inlet to the control equipment, and 18.33, 6.13, and 2.43 pounds per hour at the outlet from the control equipment. Results of the testing for hydrocarbon emissions at the inlet to the control equipment indicate concentrations of 25 and 88 parts per million by volume (ppmv) as methane at the inlet to the control equipment, and 103 and 72 ppmv as methane at the outlet from the control equipment. Only two test runs were performed at each of these locations. The lack of volumetric flow rate information at the inlet precludes the calculation of mass hydrocarbon emission rates using these concentration measurements, but mass hydrocarbon emission rates at the outlet from the control equipment can be calculated as follows:

|   |
|---|
| $[(103 + 72) (10^{-6}) / 2] [(43330 + 41987 \text{ ft}^3/\text{min}) (60 \text{ min}/\text{hr}) / 2] [16.0 \text{ lb}/\text{lb mole}]$ $\times [.00278 \text{ lb mole}/\text{ft}^3] = 10. \text{ pounds per hour total hydrocarbons as methane.}$ |
|---|

## **Direct-Carbonation Process Equipment**

### Reference #34a: Kerr-McGee, direct-carbonation process soda ash bleacher/dryer, July 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. This bleacher/dryer is controlled with two cyclones in parallel and an electrostatic precipitator, but neither the installation date of the equipment or any manufacturer's information for the control devices are presented in the report. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, sample volumes, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks, or transcription of data to calculation sheets. Also, no calculations are shown in the report. Particulate emissions testing was performed at both inlets to and the outlet from the control devices during this test, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and the test runs at the inlet and outlet were not performed concurrently, precluding the use of this data in determining control efficiency.

The particulate emission rates indicated from the testing performed at both the inlets to and outlet from the control equipment are suspect, because no ratios of isokineticity are presented. This is especially true for the particle size analyses performed at these locations using an Anderson cascade impactor, due to the magnified effects of non-isokinetic sampling on large particles because of their inertia. In addition, only one traverse point at each location was analyzed for particle size distribution.

No tests were performed on the soda ash bleacher/dryer for carbon monoxide, nitrogen oxides, sulfur dioxide, or any pollutants other than filterable particulate matter. No measurement of the concentration of carbon dioxide in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 19400, 15400, and 16900 pounds per hour at the inlet to the #1 cyclone, 14600 and 6070 pounds per hour at the inlet to the #2 cyclone (only two runs were performed at this location), and 6.1, 3.5, and 2.5 pounds per hour at the outlet from the electrostatic precipitator. Results from the two Anderson particle size analyses performed at each of the inlets to the control equipment indicate that less than 3 percent of the mass filterable particulate emissions are in the form of particles less than ten microns in diameter. Extrapolation of the results from the single Anderson particle size analysis performed

at the outlet from the control equipment indicates that nearly 100 percent of the mass filterable particulate emissions are in the form of particles less than ten microns in diameter.

Reference #34b: Kerr-McGee, direct-carbonation process sodium bicarbonate slurry predryer, July 1979

This test was ostensibly performed in accordance with EPA Reference Methods 1-5, but is lacking much of the documentation necessary for validation, and cannot be given an emission factor rating. This predryer is controlled with two cyclones in parallel and an electrostatic precipitator, but neither the installation date of the equipment or any manufacturer's information for the control devices are presented in the report. No production data is available to allow the emission rates given to be used in calculating emission factors. No raw field data is present in the test report, precluding the evaluation of sampling temperatures or duration, sample volumes, desiccation of filters, performance of leak checks, analysis of filter and reagent blanks, or transcription of data to calculation sheets. Also, no calculations are shown in the report. Particulate emissions testing was performed at both inlets to and the outlet from the control devices during this test, which in theory would allow calculation of both uncontrolled emission factors and control efficiency. However, the lack of process data precludes the calculation of any emission factors, and the test runs at the inlet and outlet were not performed concurrently, precluding the use of this data in determining control efficiency.

The particulate emission rates indicated from the testing performed at both the inlets to and outlet from the control equipment are suspect, because no ratios of isokineticity are presented. This is especially true for the particle size analyses performed at these locations using an Anderson cascade impactor, due to the magnified effects of non-isokinetic sampling on large particles because of their inertia. In addition, only one traverse point at each location was analyzed for particle size distribution.

No tests were performed on the predryer for carbon monoxide, nitrogen oxides, sulfur dioxide, or any pollutants other than filterable particulate matter. No measurement of the concentration of carbon dioxide in the stack gas was reported or apparent. Results of the testing for filterable particulate indicate emission rates of 1100, 80.9, and 37.5 pounds per hour at the inlet to the #1 cyclone, 36.4, 67.9, 199.2, and 209.9 pounds per hour at the inlet to the #2 cyclone, and 8.8, 3.4, and 3.3 pounds per hour at the outlet from the electrostatic precipitator. Results from the three Anderson particle size analyses performed at each of the inlets to the control equipment are highly inconsistent, indicating that between 0.1 and 20 percent of the mass



filterable particulate emissions are in the form of particles less than ten microns in diameter. Results from the two Anderson particle size analyses performed at the outlet from the control equipment are also inconsistent, indicating that between 25 and 80 percent of the mass filterable particulate emissions are in the form of particles less than ten microns in diameter.

## **4.2 CRITERIA POLLUTANT EMISSIONS DATA**

### Volatile Organic Compounds.

Volatile organic compounds are emitted from process heating units such as trona ore calcining kilns and soda ash dryers, but very little data are available for these processes. Also, the data that are available are derived from testing performed using questionable methodologies, are somewhat inconsistent, and are felt to be insufficient for development of emission factors for presentation in the AP-42 section on sodium carbonate production. These data are presented in Table 4.2-1 as background information. A more detailed discussion of the references obtained for VOC emissions is provided in Section 4.1.

**TABLE 4.2-1  
TOTAL VOLATILE ORGANIC COMPOUNDS (As Methane)**

| Control Equipment           | Run #          | Emission Concentration |
|-----------------------------|----------------|------------------------|
| <b>32b. Ore calciner</b>    |                |                        |
| Inlet to control equipment  | 1              | 30 ppmv                |
|                             | 2              | 22 ppmv                |
|                             | <b>Average</b> | 26 ppmv                |
| Cyclone/ESP outlet          | 1              | 28 ppmv                |
|                             | 2              | 32 ppmv                |
|                             | <b>Average</b> | 30 ppmv                |
| <b>33a. Fluid-bed dryer</b> |                |                        |
| Inlet to control equipment  | 1              | 25 ppmv                |
|                             | 2              | 88 ppmv                |
|                             | <b>Average</b> | 57 ppmv                |
| Cyclone/scrubber outlet     | 1              | 103 ppmv               |
|                             | 2              | 72 ppmv                |
|                             | <b>Average</b> | 88 ppmv                |
| <b>33b. Ore calciner</b>    |                |                        |
| Inlet to control equipment  | 1              | 917 ppmv               |
|                             | 2              | 2587 ppmv              |
|                             | <b>Average</b> | 1752 ppmv              |
| Scrubber outlet             | 1              | 154 ppmv               |
|                             | 2              | 261 ppmv               |
|                             | <b>Average</b> | 208 ppmv               |
| <b>33c. Ore calciner</b>    |                |                        |
| Inlet to control equipment  | 1              | 47 ppmv                |
|                             | 2              | 178 ppmv               |
|                             | 3              | 222 ppmv               |
|                             | <b>Average</b> | 149 ppmv               |
| Cyclone/ESP outlet          | 1              | 361 ppmv               |
|                             | 2              | 314 ppmv               |
|                             | <b>Average</b> | 338 ppmv               |

Lead.

No data on emissions of lead were found for the sodium carbonate manufacturing process.

Sulfur dioxide.

Sulfur dioxide is emitted from direct-fired process heating units such as trona ore calcining kilns and soda ash dryers, but very little data are available for these processes. Also, the data that are available are derived from testing performed using questionable methodologies, are somewhat inconsistent, and are felt to be insufficient for development of emission factors for presentation in the AP-42 section on sodium carbonate production. These data are presented in Table 4.2-2 as background information. A more detailed discussion of the references obtained for SO<sub>2</sub> emissions is provided in Section 4.1.

**TABLE 4.2-2 (METRIC UNITS)  
SULFUR DIOXIDE  
(Units in kg/hr)**

| Control Equipment          | Test Method | Run #          | Emission Rate |
|----------------------------|-------------|----------------|---------------|
| <b>32b. Ore Calciner</b>   |             |                |               |
| Inlet to control equipment | 6           | 1              | 0.717         |
|                            |             | <b>Average</b> | 0.717         |
| Cyclone/ESP outlet         | 6           | 1              | 0.41          |
|                            |             | 2              | 0.39          |
|                            |             | 3              | 0.39          |
|                            |             | <b>Average</b> | 0.39          |

**TABLE 4.2-2 (ENGLISH UNITS)**  
**SULFUR DIOXIDE**  
 (Units in lb/hr)

| Control Equipment          | Test Method | Run #          | Emission Rate |
|----------------------------|-------------|----------------|---------------|
| <b>32b. Ore Calciner</b>   |             |                |               |
| Inlet to control equipment | 6           | 1              | 1.58          |
|                            |             | <b>Average</b> | 1.58          |
| Cyclone/ESP outlet         | 6           | 1              | 0.91          |
|                            |             | 2              | 0.85          |
|                            |             | 3              | 0.85          |
|                            |             | <b>Average</b> | 0.87          |

Nitrogen oxides.

Nitrogen oxides are emitted from direct-fired process heating units such as trona ore calcining kilns and soda ash dryers, but very little data are available for these processes. The data that are available, while derived from testing using apparently sound methodologies, are highly inconsistent and are felt to be insufficient for development of emission factors for presentation in the AP-42 section on sodium carbonate production. These data are presented in Table 4.2-3 as background information. A more detailed discussion of the references obtained for NO<sub>x</sub> emissions is provided in Section 4.1.

**TABLE 4.2-3 (METRIC UNITS)  
NITROGEN OXIDES**

| Control Equipment       | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|-------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>12. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/Scrubber        | A           | 7E          | 1              | 81                           | 0.063                      | 0.0008                       |
|                         |             |             | 2              | 81                           | 0.063                      | 0.0008                       |
|                         |             |             | 3              | 81                           | 0.065                      | 0.0008                       |
|                         |             |             | <b>Average</b> | 81                           | 0.064                      | 0.0008                       |
| <b>15. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP             | A           | 7E          | 1              | 232                          | 13.2                       | 0.057                        |
|                         |             |             | 2              | 232                          | 13.4                       | 0.057                        |
|                         |             |             | 3              | 232                          | 12.1                       | 0.052                        |
|                         |             |             | <b>Average</b> | 232                          | 12.9                       | 0.056                        |

<sup>a</sup> Units in Mg/hr.

<sup>b</sup> Units in kg/hr.

<sup>c</sup> Units in kg/Mg.

**TABLE 4.2-3 (ENGLISH UNITS)  
NITROGEN OXIDES**

| Control Equipment   | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>12. Calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/Scrubber    | A           | 7E          | 1              | 89                           | 0.139                      | 0.0016                       |
|                     |             |             | 2              | 89                           | 0.140                      | 0.0016                       |
|                     |             |             | 3              | 89                           | 0.144                      | 0.0016                       |
|                     |             |             | <b>Average</b> | 89                           | 0.141                      | 0.0016                       |
| <b>15. Calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP         | A           | 7E          | 1              | 256                          | 29.1                       | 0.114                        |
|                     |             |             | 2              | 256                          | 29.5                       | 0.115                        |
|                     |             |             | 3              | 256                          | 26.6                       | 0.104                        |
|                     |             |             | <b>Average</b> | 256                          | 28.4                       | 0.111                        |

<sup>a</sup> Units in ton/hr.

<sup>b</sup> Units in lb/hr.

<sup>c</sup> Units in lb/ton.

Carbon monoxide.

Carbon monoxide is emitted from direct-fired process heating units such as trona ore calcining kilns and soda ash dryers, but no quantitative emissions data are available for these processes.

Particulate Matter.

The principal air emissions from sodium carbonate production are particulate in nature; annual total particulate emissions from the four Wyoming sodium carbonate production facilities for which 1991 inventory/inspection reports were available ranged from 79.9 to 729.5 megagrams (88.1 to 804.3 tons), exclusive of boilers and miscellaneous processes not directly related to soda ash production. Of these totals, emissions from the ore calciners comprised between 47 percent and 81 percent; soda ash coolers and dryers comprised between 5 percent and 42 percent; mining and ore crushing, screening, and transporting operations comprised between 3 percent and 11 percent; and product handling and shipping operations comprised between 4 percent and 21 percent.

Emissions of particulate matter can be divided into three categories: filterable, organic condensible, and inorganic condensible. Filterable particulate matter is that which collects on the filter and in the sampling probe assembly of a particulate sampling train. When emissions testing is performed in accordance with Method 5, the filter and probe are maintained at approximately 120°C (248°F); materials that condense at a temperature lower than this will pass through the filter. Many emissions tests also quantify emissions of condensible particulate matter, typically that which condenses at or above 20°C (68°F). This condensible particulate matter is collected by passing the effluent gas through ice water-cooled impingers such that the gas exiting the last impinger is at a temperature less than 20°C. The preferred method for quantification of emissions of condensible particulate matter is EPA Reference Method 202. This method entails extraction of the organic portion of the condensible, or back-half, catch with methylene chloride, evaporation of the extract at room temperature, desiccation, and weighing. The inorganic portion of the back-half catch is evaporated at 105°C (221°F), desiccated, and weighed.

Because of the regulations imposed upon the sodium carbonate manufacturing facilities by state air pollution control agencies, and the short time Method 202 has existed, the data reviewed for this update do not follow the organic condensible particulate matter recovery procedures

outlined above. Nearly all of the quantitative emissions references (numbers 8-34) report both filterable and condensible particulate matter emissions. The procedure used to quantify the condensible particulate matter emissions in these tests is equivalent to the inorganic condensible fraction measurement procedure in Method 202. The condensible particulate emissions reported in these tests are used herein in the development of emission factors for filterable plus inorganic condensible particulate matter. These tests are described in Section 4.1, and the resulting data are summarized in Tables 4.2-4 and 4.2-5.

The previous AP-42 Section 5.16 contained particulate emission factors for predryers, calciners, bleachers, and dryers only. These emission factors were based upon a small number of test runs conducted in the late 1970's; the reports containing the results of these source tests are References 32-34 in this chapter, and are described in Section 4.1. The particle size distribution analyses in these references, upon which the particle size distribution in the previous AP-42 section is based, were thoroughly evaluated for this update; the methodologies used during these tests were felt to be questionable, and the documentation insufficient. As a result, no particle size distribution is included in the updated AP-42 section. Emission factors for the Solvay process of synthetic sodium carbonate production were also eliminated due to the phase-out of this industry in the U.S.

The controlled emission factors developed from the large body of recent source test data collected for the purpose of updating the section are, as could be expected given the approximate efficiencies of the control equipment used in this industry for raw material and product recovery, two to three orders of magnitude lower than the uncontrolled emission factors presented in the previous version of this section. Uncontrolled particulate matter emission factors presented in the revised section are based upon a number of emission tests on controlled processes, to which nominal control efficiencies have been applied. For instance, applying a nominal efficiency of 99.9% to the emission factor of 0.091 kg/Mg given for filterable particulate matter from monohydrate process rotary ore calciners results in an uncontrolled emission factor of 91 kg/Mg [ $0.091 \times (1 - 0.999) = 91$ ]. Control equipment has no effect on the condensible fraction of the particulate emissions, and adding the condensible fraction to the much larger filterable fraction has negligible effect [ $91 + (1.16 - 0.91) = 91$ ]. These uncontrolled factors are comparable to those in the previous version of AP-42 Section 5.16. The emission factors for trona ore mining and transferring, and product screening and storage, are not highly rated but are a new addition to the section.

The filterable particulate matter emission factor given for monohydrate-process calciners is calculated as the arithmetic average of the corresponding emission factors from five separate calciners for which "A"-rated source tests are available. Each of these facility-specific emission factors is calculated as the arithmetic average of all "A"-rated source tests on that particular calciner, which totaled ten tests. Thus, these ten source tests are the basis for the "A"-rated emission factor. Similarly, the emission factor for filterable plus inorganic condensible particulate matter is derived from ten "B"-rated tests on five calciners.

The filterable particulate matter emission factor given for rotary sesquicarbonate-process calciners is derived from three "A"-rated tests on separate calciners, and is rated "B." The emission factor for filterable plus inorganic condensible particulate matter is derived from three "B"-rated tests on separate calciners.

The filterable particulate matter emission factor given for fluid-bed sesquicarbonate-process calciners is derived from one "A"-rated source test, and is rated "C." No source tests quantifying condensible particulate emissions from sesquicarbonate-process fluid-bed calciners are available.

The filterable particulate matter emission factor given for trona ore crushers is derived from two "B"-rated tests, and is rated "D." The emission factor given for filterable plus inorganic condensible particulate matter from trona ore crushers is derived from four "B"-rated source tests on separate crushers and is rated "C."

The filterable particulate matter emission factor given for trona ore mining is based upon one "A"-rated source test and is rated "C." No source tests quantifying condensible particulate emissions from trona ore mining are available. The particulate matter emission factors given for trona ore transfer are derived from one "B"-rated source test and are rated "E."

The particulate matter emission factors given for product screening, or classification, are derived from three "D"-rated source tests on separate operations and are rated "E."

The particulate matter emission factors given for product storage silo loading and unloading are calculated as the arithmetic averages of one "D"-rated source test on a single silo vent and two "D"-rated source tests, summed together, on the top and bottom vents of one silo. These factors are rated "E."

The filterable particulate matter emission factors given for both rotary and fluid-bed product dryers are each based upon one "A"-rated source test, and are rated "C." The emission



factors for filterable plus inorganic condensible particulate matter from both of these types of soda ash dryers are based upon one "B"-rated source test, and are rated "D."

All of the quantitative particulate matter source test data reviewed for this update of the AP-42 section on sodium carbonate production, whether directly utilized in emission factor development or not, are summarized in the following tables. The data that appear in these tables are taken directly from the source test reports. The more detailed review of specific data sets in Section 4.1 of this document should be consulted for further information.

**TABLE 4.2-4 (METRIC UNITS)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 109                          | 7.796                      | 0.0716                       |
|                          |             |             | 2              | 109                          | 8.485                      | 0.0780                       |
|                          |             |             | 3              | 109                          | 8.490                      | 0.0780                       |
|                          |             |             | <b>Average</b> | 109                          | 8.257                      | 0.0759                       |
| <b>8b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 118                          | 6.159                      | 0.0522                       |
|                          |             |             | 2              | 118                          | 6.803                      | 0.0577                       |
|                          |             |             | 3              | 118                          | 7.850                      | 0.0666                       |
|                          |             |             | <b>Average</b> | 118                          | 6.939                      | 0.0588                       |
| <b>9a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 109                          | 7.900                      | 0.0726                       |
|                          |             |             | 2              | 109                          | 8.231                      | 0.0756                       |
|                          |             |             | 3              | 109                          | 8.721                      | 0.0801                       |
|                          |             |             | <b>Average</b> | 109                          | 8.284                      | 0.0761                       |
| <b>9b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 118                          | 6.834                      | 0.0580                       |
|                          |             |             | 2              | 118                          | 9.574                      | 0.0812                       |
|                          |             |             | 3              | 118                          | 8.816                      | 0.0748                       |
|                          |             |             | <b>Average</b> | 118                          | 8.408                      | 0.0713                       |
| <b>10a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/Scrubber         | A           | 5           | 1              | 116                          | 21.87                      | 0.188                        |
|                          |             |             | 2              | 116                          | 25.52                      | 0.220                        |
|                          |             |             | 3              | 116                          | 23.11                      | 0.199                        |
|                          |             |             | <b>Average</b> | 116                          | 23.50                      | 0.202                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>10b. Product Dryer</b>                     |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | A           | 5           | 1              | 77                           | 20.20                      | 0.262                        |
|   |             |             | 2              | 81                           | 20.49                      | 0.254                        |
|   |             |             | 3              | 85                           | 20.55                      | 0.241                        |
|   |             |             | <b>Average</b> | 81                           | 20.42                      | 0.253                        |
| <b>10c. Ore calciner</b>                      |             |             |                |                              |                            |                              |
| Cyclone/ESP                                   | A           | 5           | 1              | 126                          | 10.11                      | 0.0802                       |
|   |             |             | 2              | 125                          | 7.823                      | 0.0625                       |
|   |             |             | 3              | 129                          | 10.29                      | 0.0799                       |
|   |             |             | <b>Average</b> | 128                          | 9.41                       | 0.0742                       |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |                              |                            |                              |
| Cyclone/<br>Baghouse/<br>ESP                  | D           | 5           | 1              | 44                           | 1.67                       | 0.38                         |
|   |             |             | 2              | 45                           | 1.26                       | 0.28                         |
|   |             |             | 3              | 50                           | 1.91                       | 0.38                         |
|   |             |             | <b>Average</b> | 47                           | 1.61                       | 0.35                         |
| <b>11. Calciner</b>                           |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | A           | 5           | 1              | 116                          | 16.19                      | 0.139                        |
|   |             |             | 2              | 116                          | 14.63                      | 0.126                        |
|   |             |             | 3              | 116                          | 13.95                      | 0.120                        |
|   |             |             | <b>Average</b> | 116                          | 14.92                      | 0.129                        |
| <b>12. Calciner</b>                           |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | B           | 5           | 1              | 81                           | 14.29                      | 0.18                         |
|   |             |             | 2              | 81                           | 15.12                      | 0.19                         |
|   |             |             | 3              | 81                           | 11.24                      | 0.14                         |
|   |             |             | <b>Average</b> | 81                           | 13.55                      | 0.17                         |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 13.1                       |                              |
|                                      |             |             | 2              |                              | 14.4                       |                              |
|                                      |             |             | 3              |                              | 11.1                       |                              |
|                                      |             |             | 4              |                              | 12.9                       |                              |
|                                      |             |             | <b>Average</b> | 237                          | 12.9                       | 0.0544                       |
| <b>14. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 14.7                       |                              |
|                                      |             |             | 2              |                              | 21.9                       |                              |
|                                      |             |             | 3              |                              | 24.5                       |                              |
|                                      |             |             | <b>Average</b> | 243                          | 20.3                       | 0.0837                       |
| <b>15. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 24.15                      |                              |
|                                      |             |             | 2              |                              | 19.51                      |                              |
|                                      |             |             | 3              |                              | 17.49                      |                              |
|                                      |             |             | <b>Average</b> | 232                          | 20.39                      | 0.0878                       |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | A           | 5           | 1              | 24.3                         | 10.15                      | 0.418                        |
|                                      |             |             | 2              | 25.0                         | 8.122                      | 0.324                        |
|                                      |             |             | 3              | 23.1                         | 8.435                      | 0.365                        |
|                                      |             |             | <b>Average</b> | 24.2                         | 8.904                      | 0.369                        |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | A           | 5           | 1              | 26.7                         | 14.16                      | 0.531                        |
|                                      |             |             | 2              | 28.0                         | 12.77                      | 0.456                        |
|                                      |             |             | 3              | 28.4                         | 13.06                      | 0.460                        |
|                                      |             |             | <b>Average</b> | 27.7                         | 16.30                      | 0.482                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>           |             |             |                |                              |                            |                              |
| Scrubbers                                     | A           | 5           | 1              | 47.3                         | 11.58                      | 0.245                        |
|   |             |             | 2              | 49.2                         | 12.90                      | 0.262                        |
|   |             |             | 3              | 47.3                         | 9.156                      | 0.194                        |
|   |             |             | <b>Average</b> | 47.9                         | 11.21                      | 0.234                        |
| <b>18. Sesquicarbonate fluid-bed calciner</b> |             |             |                |                              |                            |                              |
| Scrubbers                                     | A           | 5           | 1              |                              | 1.507                      |                              |
|   |             |             | 2              |                              | 1.728                      |                              |
|   |             |             | 3              |                              | 1.964                      |                              |
|   |             |             | <b>Average</b> | 81.3                         | 1.733                      | 0.0213                       |
| <b>19. Ore crusher</b>                        |             |             |                |                              |                            |                              |
| Scrubber                                      | B           | 5           | 1              | 392                          | 0.24                       | 0.00061                      |
|   |             |             | 2              | 392                          | 0.27                       | 0.00068                      |
|   |             |             | <b>Average</b> | 392                          | 0.25                       | 0.00065                      |
| <b>20. Ore crusher</b>                        |             |             |                |                              |                            |                              |
| Cyclone/Baghouse                              | C           | 5           | 1              | 264.1                        | 0.2350                     | 0.000890                     |
|   |             |             | 2              | 216.3                        | 0.1864                     | 0.000862                     |
|   |             |             | 3              | 258.5                        | 0.6517                     | 0.00252                      |
|   |             |             | <b>Average</b> | 246.3                        | 0.3577                     | 0.00145                      |
| <b>21. Mine headframe collector</b>           |             |             |                |                              |                            |                              |
| Baghouse                                      | A           | 5           | 1              |                              | 0.437                      |                              |
|   |             |             | 2              |                              | 0.353                      |                              |
|   |             |             | 3              |                              | 0.439                      |                              |
|   |             |             | <b>Average</b> | 252                          | 0.410                      | 0.00163                      |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>22a. Ore crusher</b>              |             |             |                |                              |                            |                              |
| Baghouse                             | C           | 5           | 1              | 508                          | 0.503                      | 0.000991                     |
|                                      |             |             | 2              | 508                          | 0.1                        | 0.00035                      |
|                                      |             |             | 3              | 508                          | 0.25                       | 0.00050                      |
|                                      |             |             | <b>Average</b> | 508                          | 0.31                       | 0.00062                      |
| <b>22b. Trona transfer collector</b> |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 209                          | 0.01                       | 0.00007                      |
|                                      |             |             | 2              | 209                          | 0.01                       | 0.00004                      |
|                                      |             |             | 3              | 209                          | 0.03                       | 0.0001                       |
|                                      |             |             | <b>Average</b> | 209                          | 0.02                       | 0.00008                      |
| <b>23a. Product screening</b>        |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 79.5                         | 0.24                       | 0.0030                       |
|                                      |             |             | 2              | 94.7                         | 0.32                       | 0.0034                       |
|                                      |             |             | 3              | 106.6                        | 0.12                       | 0.0011                       |
|                                      |             |             | <b>Average</b> | 93.6                         | 0.23                       | 0.0025                       |
| <b>23b. Product silo loading</b>     |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 110.01                       | 0.086                      | 0.00078                      |
|                                      |             |             | 2              | 108.4                        | 0.10                       | 0.00096                      |
|                                      |             |             | <b>Average</b> | 109.3                        | 0.095                      | 0.00087                      |
| <b>23c. Product silo reclaim</b>     |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 369.8                        | 0.26                       | 0.00070                      |
|                                      |             |             | 2              | 369.8                        | 0.12                       | 0.00032                      |
|                                      |             |             | 3              | 369.8                        | 0.02                       | 0.00005                      |
|                                      |             |             | <b>Average</b> | 369.8                        | 0.13                       | 0.00036                      |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|-------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24a. Ore crusher</b>       |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 92.5                         | 2.598                      | 0.0281                       |
|                               |             |             | 2              | 92.5                         | 2.331                      | 0.0252                       |
|                               |             |             | 3              | 179                          | 7.364                      | 0.0412                       |
|                               |             |             | <b>Average</b> | 121                          | 4.098                      | 0.0315                       |
| <b>24b. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 46.49                        | 0.270                      | 0.0058                       |
|                               |             |             | 2              | 46.49                        | 0.180                      | 0.0038                       |
|                               |             |             | 3              | 46.49                        | 0.136                      | 0.0029                       |
|                               |             |             | <b>Average</b> | 46.49                        | 0.195                      | 0.0042                       |
| <b>24c. Product handling</b>  |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 100.9                        | 0.356                      | 0.0035                       |
|                               |             |             | 2              | 81.5                         | 0.220                      | 0.0027                       |
|                               |             |             | 3              | 81.5                         | 0.190                      | 0.0023                       |
|                               |             |             | <b>Average</b> | 87.9                         | 0.255                      | 0.0029                       |
| <b>24d. Product silo</b>      |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 56                           | 0.17                       | 0.0030                       |
|                               |             |             | 2              | 56                           | 0.17                       | 0.0030                       |
|                               |             |             | 3              | 56                           | 0.16                       | 0.0028                       |
|                               |             |             | <b>Average</b> | 56                           | 0.16                       | 0.0029                       |
| <b>24e. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 38.5                         | 0.793                      | 0.0206                       |
|                               |             |             | 2              | 38.5                         | 0.878                      | 0.0228                       |
|                               |             |             | 3              | 35.8                         | 0.858                      | 0.0239                       |
|                               |             |             | <b>Average</b> | 37.6                         | 0.843                      | 0.0224                       |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                  | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24f. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 54.6                         | 0.342                      | 0.0063                       |
|                                    |             |             | 2              | 54.6                         | 0.469                      | 0.0086                       |
|                                    |             |             | 3              | 54.6                         | 0.129                      | 0.0024                       |
|                                    |             |             | <b>Average</b> | 54.6                         | 0.313                      | 0.0057                       |
| <b>24g. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 37                           | 0.1697                     | 0.0046                       |
|                                    |             |             | 2              | 47                           | 0.2272                     | 0.0048                       |
|                                    |             |             | 3              | 47                           | 0.0936                     | 0.0020                       |
|                                    |             |             | <b>Average</b> | 44                           | 0.1635                     | 0.0038                       |
| <b>24h. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 52                           | 0.617                      | 0.012                        |
|                                    |             |             | 2              | 47                           | 0.352                      | 0.0075                       |
|                                    |             |             | 3              | 47                           | 0.546                      | 0.012                        |
|                                    |             |             | <b>Average</b> | 49                           | 0.505                      | 0.010                        |
| <b>25. Product fluid-bed dryer</b> |             |             |                |                              |                            |                              |
| Scrubber                           | A           | 5           | 1              | 15.1                         | 0.28                       | 0.019                        |
|                                    |             |             | 2              | 13.6                         | 0.19                       | 0.014                        |
|                                    |             |             | 3              | 12.0                         | 0.14                       | 0.012                        |
|                                    |             |             | <b>Average</b> | 13.5                         | 0.20                       | 0.015                        |
| <b>26. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | B           | 5           | 1              | 122                          | 17.72                      | 0.145                        |
|                                    |             |             | 2              | 122                          | 14.25                      | 0.153                        |
|                                    |             |             | 3              | 122                          | 24.07                      | 0.197                        |
|                                    |             |             | <b>Average</b> | 122                          | 18.68                      | 0.178                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.



**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>27. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | C           | N/A         | 1              |                              | 2.356                      |                              |
|                          |             |             | 2              |                              | 2.027                      |                              |
|                          |             |             | 3              |                              | 1.877                      |                              |
|                          |             |             | <b>Average</b> | 35.8                         | 2.087                      | 0.0582                       |
| <b>28. Ore crusher</b>   |             |             |                |                              |                            |                              |
| Baghouse                 | B           | 5           | 1              |                              | 0.485                      |                              |
|                          |             |             | 2              |                              | 0.34                       |                              |
|                          |             |             | 3              |                              | 0.21                       |                              |
|                          |             |             | <b>Average</b> | 237                          | 0.343                      | 0.0014                       |
| <b>29. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              |                              | 10.5                       |                              |
|                          |             |             | 2              |                              | 11.4                       |                              |
|                          |             |             | 3              |                              | 12.2                       |                              |
|                          |             |             | <b>Average</b> | 238                          | 11.4                       | 0.478                        |
| <b>30a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 100.3                        | 1.34                       | 0.0134                       |
|                          |             |             | 2              | 93.9                         | 2.07                       | 0.0220                       |
|                          |             |             | 3              | 93.9                         | 0.576                      | 0.00614                      |
|                          |             |             | <b>Average</b> | 96.0                         | 1.33                       | 0.0138                       |
| <b>30b. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 85.2                         | 5.950                      | 0.0699                       |
|                          |             |             | 2              | 85.2                         | 1.14                       | 0.0134                       |
|                          |             |             | 3              | 86.3                         | 0.785                      | 0.00909                      |
|                          |             |             | <b>Average</b> | 85.6                         | 2.63                       | 0.0307                       |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment          | Test Method | Run #          | Emission Rate <sup>a</sup> |
|----------------------------|-------------|----------------|----------------------------|
| <b>32a. Product dryer</b>  |             |                |                            |
| Inlet to control equipment | 5           | 1              | 2115.92                    |
|                            |             | 2              | 1782.68                    |
|                            |             | 3              | 1635.67                    |
|                            |             | <b>Average</b> | 1844.76                    |
| Scrubber                   | 5           | 1              | 2.01                       |
|                            |             | 2              | 2.70                       |
|                            |             | 3              | 1.66                       |
|                            |             | <b>Average</b> | 2.12                       |
| <b>32b. Ore calciner</b>   |             |                |                            |
| Inlet to control equipment | 5           | 1              | 211145.42                  |
|                            |             | 2              | 20427.40                   |
|                            |             | <b>Average</b> | 115786.41                  |
| Cyclone/ESP                | 5           | 1              | 15.19                      |
|                            |             | 2              | 10.89                      |
|                            |             | 3              | 2.96                       |
|                            |             | <b>Average</b> | 9.68                       |

<sup>a</sup>Units in kg/hr.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment          | Test Method | Run #          | Emission Rate <sup>a</sup> |
|----------------------------|-------------|----------------|----------------------------|
| <b>33a. Product dryer</b>  |             |                |                            |
| Inlet to control equipment | 5           | 1              | 11828.59                   |
|                            |             | 2              | 5375.73                    |
|                            |             | 3              | 5216.22                    |
|                            |             | <b>Average</b> | 7473.51                    |
| Cyclone/Scrubber           | 5           | 1              | 8.31                       |
|                            |             | 2              | 2.78                       |
|                            |             | 3              | 1.10                       |
|                            |             | <b>Average</b> | 4.07                       |
| Inlet to control equipment | 5           | 1              | 17921.71                   |
|                            |             | 2              | 22051.73                   |
|                            |             | 3              | 19959.35                   |
|                            |             | <b>Average</b> | 19978.95                   |
| Scrubber                   | 5           | 1              | 17.20                      |
|                            |             | 2              | 20.96                      |
|                            |             | 3              | 19.95                      |
|                            |             | <b>Average</b> | 19.37                      |

<sup>a</sup>Units in kg/hr.

**TABLE 4.2-4 (METRIC UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Method | Run #          | Emission Rate <sup>a</sup> |
|---|-------------|----------------|----------------------------|
| <b>33c. Ore calciner</b>                      |             |                |                            |
| Inlet to control equipment                    | 5           | 1              | 42438.70                   |
|   |             | 2              | 37783.12                   |
|   |             | 3              | 26257.38                   |
|   |             | <b>Average</b> | 35493.06                   |
| Cyclone/ESP                                   | 5           | 1              | 30.95                      |
|   |             | 2              | 40.95                      |
|   |             | 3              | 24.32                      |
|   |             | <b>Average</b> | 31.95                      |
| <b>34a. Direct carbonation bleacher/dryer</b> |             |                |                            |
| Inlet #1 to control equipment                 | 5           | 1              | 8800                       |
|   |             | 2              | 6980                       |
|   |             | 3              | 7660                       |
|   |             | <b>Average</b> | 7800                       |
| Inlet #2 to control equipment                 | 5           | 1              | 6620                       |
|   |             | 2              | 2750                       |
|   |             | <b>Average</b> | 4670                       |
| Cyclones/ESP                                  | 5           | 1              | 2.8                        |
|   |             | 2              | 1.6                        |
|   |             | 3              | 1.1                        |
|   |             | <b>Average</b> | 1.8                        |

<sup>a</sup>Units in kg/hr.

**TABLE 4.2-4 (METRIC UNITS) (concluded)  
 FILTERABLE PARTICULATE MATTER**

| Control Equipment                              | Test Method | Run #          | Emission Rate <sup>a</sup> |
|--|-------------|----------------|----------------------------|
| <b>33b. Direct carbonation slurry predryer</b> |             |                |                            |
| Inlet #1 to control equipment                  | 5           | 1              | 500                        |
|  |             | 2              | 36.7                       |
|  |             | 3              | 17.0                       |
|  |             | <b>Average</b> | 18.0                       |
| Inlet #2 to control equipment                  | 5           | 1              | 16.5                       |
|  |             | 2              | 30.8                       |
|  |             | 3              | 90.3                       |
|  |             | 4              | 95.2                       |
|  |             | <b>Average</b> | 61.8                       |
| Cyclones/ESP                                   | 5           | 1              | 4.0                        |
|  |             | 2              | 1.5                        |
|  |             | 3              | 1.5                        |
|  |             | <b>Average</b> | 2.3                        |

<sup>a</sup>Units in kg/hr.

**TABLE 4.2-4 (ENGLISH UNITS)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 120                          | 17.19                      | 0.143                        |
|                          |             |             | 2              | 120                          | 18.71                      | 0.156                        |
|                          |             |             | 3              | 120                          | 18.72                      | 0.156                        |
|                          |             |             | <b>Average</b> | 120                          | 18.21                      | 0.152                        |
| <b>8b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 130                          | 13.58                      | 0.104                        |
|                          |             |             | 2              | 130                          | 15.00                      | 0.115                        |
|                          |             |             | 3              | 130                          | 17.31                      | 0.133                        |
|                          |             |             | <b>Average</b> | 130                          | 15.30                      | 0.118                        |
| <b>9a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 120                          | 17.42                      | 0.145                        |
|                          |             |             | 2              | 120                          | 18.15                      | 0.151                        |
|                          |             |             | 3              | 120                          | 19.23                      | 0.160                        |
|                          |             |             | <b>Average</b> | 120                          | 18.27                      | 0.152                        |
| <b>9b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | A           | 5           | 1              | 130                          | 15.07                      | 0.116                        |
|                          |             |             | 2              | 130                          | 21.11                      | 0.162                        |
|                          |             |             | 3              | 130                          | 19.44                      | 0.150                        |
|                          |             |             | <b>Average</b> | 130                          | 18.54                      | 0.155                        |
| <b>10a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/Scrubber         | A           | 5           | 1              | 128                          | 48.22                      | 0.377                        |
|                          |             |             | 2              | 128                          | 56.27                      | 0.440                        |
|                          |             |             | 3              | 128                          | 50.96                      | 0.398                        |
|                          |             |             | <b>Average</b> | 128                          | 51.82                      | 0.405                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>10b. Product Dryer</b>                     |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | A           | 5           | 1              | 85                           | 44.55                      | 0.524                        |
|   |             |             | 2              | 89                           | 45.18                      | 0.508                        |
|   |             |             | 3              | 94                           | 45.32                      | 0.482                        |
|   |             |             | <b>Average</b> | 89                           | 45.02                      | 0.505                        |
| <b>10c. Ore calciner</b>                      |             |             |                |                              |                            |                              |
| Cyclone/ESP                                   | A           | 5           | 1              | 139                          | 22.29                      | 0.160                        |
|   |             |             | 2              | 138                          | 17.25                      | 0.125                        |
|   |             |             | 3              | 142                          | 22.68                      | 0.160                        |
|   |             |             | <b>Average</b> | 140                          | 20.72                      | 0.148                        |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |                              |                            |                              |
| Cyclone/<br>Baghouse/<br>ESP                  | D           | 5           | 1              | 49                           | 3.68                       | 0.75                         |
|   |             |             | 2              | 50                           | 2.78                       | 0.56                         |
|   |             |             | 3              | 55                           | 4.22                       | 0.77                         |
|   |             |             | <b>Average</b> | 51                           | 3.56                       | 0.69                         |
| <b>11. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | A           | 5           | 1              | 128                          | 35.69                      | 0.279                        |
|   |             |             | 2              | 128                          | 32.26                      | 0.252                        |
|   |             |             | 3              | 128                          | 30.77                      | 0.240                        |
|   |             |             | <b>Average</b> | 128                          | 32.91                      | 0.257                        |
| <b>12. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | B           | 5           | 1              | 89                           | 31.51                      | 0.35                         |
|   |             |             | 2              | 89                           | 33.33                      | 0.37                         |
|   |             |             | 3              | 89                           | 24.78                      | 0.28                         |
|   |             |             | <b>Average</b> | 89                           | 29.87                      | 0.34                         |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 28.8                       |                              |
|                                      |             |             | 2              |                              | 31.8                       |                              |
|                                      |             |             | 3              |                              | 24.5                       |                              |
|                                      |             |             | 4              |                              | 28.4                       |                              |
|                                      |             |             | <b>Average</b> | 261                          | 28.4                       | 0.109                        |
| <b>14. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 32.4                       |                              |
|                                      |             |             | 2              |                              | 48.2                       |                              |
|                                      |             |             | 3              |                              | 54.0                       |                              |
|                                      |             |             | <b>Average</b> | 268                          | 44.9                       | 0.167                        |
| <b>15. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | A           | 5           | 1              |                              | 53.24                      |                              |
|                                      |             |             | 2              |                              | 43.03                      |                              |
|                                      |             |             | 3              |                              | 38.57                      |                              |
|                                      |             |             | <b>Average</b> | 256                          | 44.95                      | 0.176                        |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | A           | 5           | 1              | 26.8                         | 22.39                      | 0.835                        |
|                                      |             |             | 2              | 27.6                         | 17.91                      | 0.649                        |
|                                      |             |             | 3              | 25.5                         | 18.60                      | 0.729                        |
|                                      |             |             | <b>Average</b> | 26.6                         | 19.63                      | 0.738                        |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | A           | 5           | 1              | 29.4                         | 31.23                      | 1.06                         |
|                                      |             |             | 2              | 30.9                         | 28.15                      | 0.911                        |
|                                      |             |             | 3              | 31.3                         | 28.80                      | 0.920                        |
|                                      |             |             | <b>Average</b> | 30.5                         | 29.39                      | 0.964                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.



**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>           |             |             |                |                              |                            |                              |
| Scrubbers                                     | A           | 5           | 1              | 52.1                         | 25.53                      | 0.490                        |
|   |             |             | 2              | 54.2                         | 28.44                      | 0.525                        |
|   |             |             | 3              | 52.1                         | 20.19                      | 0.388                        |
|   |             |             | <b>Average</b> | 52.8                         | 24.72                      | 0.467                        |
| <b>18. Sesquicarbonate fluid-bed calciner</b> |             |             |                |                              |                            |                              |
| Scrubbers                                     | A           | 5           | 1              |                              | 3.323                      |                              |
|   |             |             | 2              |                              | 3.811                      |                              |
|   |             |             | 3              |                              | 4.331                      |                              |
|   |             |             | <b>Average</b> | 89.6                         | 3.822                      | 0.0426                       |
| <b>19. Ore crusher</b>                        |             |             |                |                              |                            |                              |
| Scrubber                                      | B           | 5           | 1              | 432                          | 0.53                       | 0.0012                       |
|   |             |             | 2              | 432                          | 0.59                       | 0.0014                       |
|   |             |             | <b>Average</b> | 432                          | 0.56                       | 0.0013                       |
| <b>20. Ore crusher</b>                        |             |             |                |                              |                            |                              |
| Cyclone/Baghouse                              | C           | 5           | 1              | 291.2                        | 0.5181                     | 0.000178                     |
|   |             |             | 2              | 238.5                        | 0.4111                     | 0.000172                     |
|   |             |             | 3              | 285.0                        | 1.437                      | 0.00504                      |
|   |             |             | <b>Average</b> | 271.6                        | 0.7887                     | 0.00285                      |
| <b>21. Mine headframe collector</b>           |             |             |                |                              |                            |                              |
| Baghouse                                      | A           | 5           | 1              |                              | 0.964                      |                              |
|   |             |             | 2              |                              | 0.778                      |                              |
|   |             |             | 3              |                              | 0.969                      |                              |
|   |             |             | <b>Average</b> | 278                          | 0.904                      | 0.00325                      |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>22a. Ore crusher</b>              |             |             |                |                              |                            |                              |
| Baghouse                             | C           | 5           | 1              | 560                          | 1.11                       | 0.00198                      |
|                                      |             |             | 2              | 560                          | 0.39                       | 0.00070                      |
|                                      |             |             | 3              | 560                          | 0.56                       | 0.0010                       |
|                                      |             |             | <b>Average</b> | 560                          | 0.69                       | 0.0012                       |
| <b>22b. Trona transfer collector</b> |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 230                          | 0.03                       | 0.0001                       |
|                                      |             |             | 2              | 230                          | 0.02                       | 0.0001                       |
|                                      |             |             | 3              | 230                          | 0.06                       | 0.0003                       |
|                                      |             |             | <b>Average</b> | 230                          | 0.04                       | 0.0002                       |
| <b>23a. Product screening</b>        |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 87.6                         | 0.52                       | 0.0059                       |
|                                      |             |             | 2              | 104.4                        | 0.71                       | 0.0068                       |
|                                      |             |             | 3              | 117.5                        | 0.27                       | 0.0023                       |
|                                      |             |             | <b>Average</b> | 103.2                        | 0.50                       | 0.0050                       |
| <b>23b. Product silo loading</b>     |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 121.4                        | 0.19                       | 0.0016                       |
|                                      |             |             | 2              | 119.4                        | 0.23                       | 0.0019                       |
|                                      |             |             | <b>Average</b> | 120.4                        | 0.21                       | 0.0017                       |
| <b>23c. Product silo reclaim</b>     |             |             |                |                              |                            |                              |
| Baghouse                             | D           | 5           | 1              | 407.7                        | 0.57                       | 0.0014                       |
|                                      |             |             | 2              | 407.7                        | 0.26                       | 0.00064                      |
|                                      |             |             | 3              | 407.7                        | 0.04                       | 0.0001                       |
|                                      |             |             | <b>Average</b> | 407.7                        | 0.29                       | 0.00071                      |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|-------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24a. Ore crusher</b>       |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 102                          | 5.728                      | 0.0562                       |
|                               |             |             | 2              | 102                          | 5.141                      | 0.0504                       |
|                               |             |             | 3              | 197                          | 16.237                     | 0.0824                       |
|                               |             |             | <b>Average</b> | 134                          | 8.441                      | 0.0630                       |
| <b>24b. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 51.25                        | 0.596                      | 0.0116                       |
|                               |             |             | 2              | 51.25                        | 0.396                      | 0.0077                       |
|                               |             |             | 3              | 51.25                        | 0.300                      | 0.0059                       |
|                               |             |             | <b>Average</b> | 51.25                        | 0.431                      | 0.0084                       |
| <b>24c. Product handling</b>  |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 111.2                        | 0.784                      | 0.0071                       |
|                               |             |             | 2              | 89.8                         | 0.485                      | 0.0054                       |
|                               |             |             | 3              | 89.8                         | 0.418                      | 0.0047                       |
|                               |             |             | <b>Average</b> | 96.9                         | 0.562                      | 0.0057                       |
| <b>24d. Product silo</b>      |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 62                           | 0.370                      | 0.0060                       |
|                               |             |             | 2              | 62                           | 0.370                      | 0.0060                       |
|                               |             |             | 3              | 62                           | 0.346                      | 0.0056                       |
|                               |             |             | <b>Average</b> | 62                           | 0.362                      | 0.0058                       |
| <b>24e. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 42.5                         | 1.749                      | 0.0411                       |
|                               |             |             | 2              | 42.5                         | 1.936                      | 0.0456                       |
|                               |             |             | 3              | 39.5                         | 1.891                      | 0.0479                       |
|                               |             |             | <b>Average</b> | 41.5                         | 1.859                      | 0.0449                       |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                  | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24f. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 60.2                         | 0.754                      | 0.0125                       |
|                                    |             |             | 2              | 60.2                         | 1.034                      | 0.0172                       |
|                                    |             |             | 3              | 60.2                         | 0.284                      | 0.0047                       |
|                                    |             |             | <b>Average</b> | 60.2                         | 0.691                      | 0.0115                       |
| <b>24g. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 41                           | 0.3741                     | 0.0091                       |
|                                    |             |             | 2              | 52                           | 0.5009                     | 0.0096                       |
|                                    |             |             | 3              | 52                           | 0.2063                     | 0.0040                       |
|                                    |             |             | <b>Average</b> | 48                           | 0.3661                     | 0.0076                       |
| <b>24h. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 57                           | 1.361                      | 0.024                        |
|                                    |             |             | 2              | 52                           | 0.777                      | 0.015                        |
|                                    |             |             | 3              | 52                           | 1.203                      | 0.023                        |
|                                    |             |             | <b>Average</b> | 54                           | 1.114                      | 0.021                        |
| <b>25. Product fluid-bed dryer</b> |             |             |                |                              |                            |                              |
| Scrubber                           | A           | 5           | 1              | 16.6                         | 0.62                       | 0.037                        |
|                                    |             |             | 2              | 15.0                         | 0.42                       | 0.028                        |
|                                    |             |             | 3              | 13.2                         | 0.31                       | 0.023                        |
|                                    |             |             | <b>Average</b> | 14.9                         | 0.45                       | 0.030                        |
| <b>26. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | B           | 5           | 1              | 135                          | 39.07                      | 0.289                        |
|                                    |             |             | 2              | 135                          | 31.43                      | 0.233                        |
|                                    |             |             | 3              | 135                          | 39.90                      | 0.296                        |
|                                    |             |             | <b>Average</b> | 135                          | 36.80                      | 0.273                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>27. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | C           | N/A         | 1              |                              | 5.195                      |                              |
|                          |             |             | 2              |                              | 4.470                      |                              |
|                          |             |             | 3              |                              | 4.139                      |                              |
|                          |             |             | <b>Average</b> | 39.5                         | 4.601                      | 0.116                        |
| <b>28. Ore crusher</b>   |             |             |                |                              |                            |                              |
| Baghouse                 | B           | 5           | 1              |                              | 1.07                       |                              |
|                          |             |             | 2              |                              | 0.74                       |                              |
|                          |             |             | 3              |                              | 0.46                       |                              |
|                          |             |             | <b>Average</b> | 261                          | 0.76                       | 0.0029                       |
| <b>29. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              |                              | 23.2                       |                              |
|                          |             |             | 2              |                              | 25.2                       |                              |
|                          |             |             | 3              |                              | 26.8                       |                              |
|                          |             |             | <b>Average</b> | 262                          | 25.1                       | 0.0957                       |
| <b>30a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 110.6                        | 2.96                       | 0.0267                       |
|                          |             |             | 2              | 103.5                        | 4.56                       | 0.0440                       |
|                          |             |             | 3              | 103.5                        | 1.27                       | 0.0123                       |
|                          |             |             | <b>Average</b> | 105.9                        | 2.93                       | 0.0277                       |
| <b>30b. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 93.9                         | 13.12                      | 0.140                        |
|                          |             |             | 2              | 93.9                         | 2.52                       | 0.0268                       |
|                          |             |             | 3              | 95.2                         | 1.73                       | 0.0182                       |
|                          |             |             | <b>Average</b> | 94.3                         | 5.79                       | 0.061                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment          | Test Method | Run #          | Emission Rate <sup>a</sup> |
|----------------------------|-------------|----------------|----------------------------|
| <b>32a. Product dryer</b>  |             |                |                            |
| Inlet to control equipment | 5           | 1              | 4665.61                    |
|                            |             | 2              | 3930.81                    |
|                            |             | 3              | 3606.65                    |
|                            |             | <b>Average</b> | 4067.69                    |
| Scrubber                   | 5           | 1              | 4.43                       |
|                            |             | 2              | 5.95                       |
|                            |             | 3              | 3.66                       |
|                            |             | <b>Average</b> | 4.68                       |
| <b>32b. Ore calciner</b>   |             |                |                            |
| Inlet to control equipment | 5           | 1              | 465575.65                  |
|                            |             | 2              | 45042.41                   |
|                            |             | <b>Average</b> | 255309.03                  |
| Cyclone/ESP                | 5           | 1              | 33.49                      |
|                            |             | 2              | 24.01                      |
|                            |             | 3              | 6.53                       |
|                            |             | <b>Average</b> | 21.34                      |

<sup>a</sup>Units in lb/hr.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                   | Test Method | Run #          | Emission Rate <sup>a</sup> |
|-------------------------------------|-------------|----------------|----------------------------|
| <b>33a. Fluid-bed product dryer</b> |             |                |                            |
| Inlet to control equipment          | 5           | 1              | 26082.05                   |
|                                     |             | 2              | 11853.49                   |
|                                     |             | 3              | 11501.76                   |
|                                     |             | <b>Average</b> | 16479.10                   |
| Cyclone/scrubber                    | 5           | 1              | 18.33                      |
|                                     |             | 2              | 6.13                       |
|                                     |             | 3              | 2.43                       |
|                                     |             | <b>Average</b> | 8.96                       |
| Inlet to control equipment          | 5           | 1              | 39517.36                   |
|                                     |             | 2              | 48624.06                   |
|                                     |             | 3              | 44010.36                   |
|                                     |             | <b>Average</b> | 44050.59                   |
| Scrubber                            | 5           | 1              | 37.93                      |
|                                     |             | 2              | 46.21                      |
|                                     |             | 3              | 43.98                      |
|                                     |             | <b>Average</b> | 42.71                      |

<sup>a</sup>Units in lb/hr.

**TABLE 4.2-4 (ENGLISH UNITS) (continued)  
FILTERABLE PARTICULATE MATTER**

| Control Equipment                             | Test Method | Run #          | Emission Rate <sup>a</sup> |
|---|-------------|----------------|----------------------------|
| <b>33c. Ore calciner</b>                      |             |                |                            |
| Inlet to control equipment                    | 5           | 1              | 93577.33                   |
|   |             | 2              | 83311.77                   |
|   |             | 3              | 57899.52                   |
|   |             | <b>Average</b> | 78262.07                   |
| Cyclone/ESP                                   | 5           | 1              | 68.25                      |
|   |             | 2              | 89.49                      |
|   |             | 3              | 53.63                      |
|   |             | <b>Average</b> | 70.46                      |
| <b>34a. Direct carbonation bleacher/dryer</b> |             |                |                            |
| Inlet #1 to control equipment                 | 5           | 1              | 19400                      |
|   |             | 2              | 15400                      |
|   |             | 3              | 16900                      |
|   |             | <b>Average</b> | 17200                      |
| Inlet #2 to control equipment                 | 5           | 1              | 14600                      |
|   |             | 2              | 6070                       |
|   |             | <b>Average</b> | 10300                      |
| Cyclones/ESP                                  | 5           | 1              | 6.1                        |
|   |             | 2              | 3.5                        |
|   |             | 3              | 2.5                        |
|   |             | <b>Average</b> | 4.0                        |

<sup>a</sup>Units in lb/hr.



**TABLE 4.2-4 (ENGLISH UNITS) (concluded)  
 FILTERABLE PARTICULATE MATTER**

| Control Equipment                              | Test Method | Run #          | Emission Rate <sup>a</sup> |
|--|-------------|----------------|----------------------------|
| <b>34b. Direct carbonation slurry predryer</b> |             |                |                            |
| Inlet #1 to control equipment                  | 5           | 1              | 1100                       |
|  |             | 2              | 80.9                       |
|  |             | 3              | 37.5                       |
|  |             | <b>Average</b> | 410                        |
| Inlet #2 to control equipment                  | 5           | 1              | 36.4                       |
|  |             | 2              | 67.9                       |
|  |             | 3              | 199.2                      |
|  |             | 4              | 209.9                      |
|  |             | <b>Average</b> | 128                        |
| Cyclones/ESP                                   | 5           | 1              | 8.8                        |
|  |             | 2              | 3.4                        |
|  |             | 3              | 3.3                        |
|  |             | <b>Average</b> | 5.2                        |

<sup>a</sup>Units in lb/hr.

**TABLE 4.2-5 (METRIC UNITS)  
FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 109                          | 13.3                       | 0.122                        |
|                          |             |             | 2              | 109                          | 17.0                       | 0.156                        |
|                          |             |             | 3              | 109                          | 16.7                       | 0.153                        |
|                          |             |             | <b>Average</b> | 109                          | 15.6                       | 0.144                        |
| <b>8b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 118                          | 13.8                       | 0.117                        |
|                          |             |             | 2              | 118                          | 13.6                       | 0.115                        |
|                          |             |             | 3              | 118                          | 15.6                       | 0.132                        |
|                          |             |             | <b>Average</b> | 118                          | 14.3                       | 0.122                        |
| <b>9a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 109                          | 12.6                       | 0.116                        |
|                          |             |             | 2              | 109                          | 13.2                       | 0.122                        |
|                          |             |             | 3              | 109                          | 14.2                       | 0.131                        |
|                          |             |             | <b>Average</b> | 109                          | 13.4                       | 0.123                        |
| <b>9b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 118                          | 10.2                       | 0.086                        |
|                          |             |             | 2              | 118                          | 13.9                       | 0.118                        |
|                          |             |             | 3              | 118                          | 12.8                       | 0.109                        |
|                          |             |             | <b>Average</b> | 118                          | 12.3                       | 0.104                        |
| <b>10a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/Scrubber         | B           | 5           | 1              | 116                          | 22.3                       | 0.192                        |
|                          |             |             | 2              | 116                          | 26.1                       | 0.225                        |
|                          |             |             | 3              | 116                          | 24.1                       | 0.208                        |
|                          |             |             | <b>Average</b> | 116                          | 24.2                       | 0.208                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>10b. Product dryer</b>                     |             |             |                |                              |                            |                              |
| Cyclone/Scrubber                              | B           | 5           | 1              | 77                           | 20.6                       | 0.27                         |
|   |             |             | 2              | 81                           | 20.6                       | 0.25                         |
|   |             |             | 3              | 85                           | 20.6                       | 0.24                         |
|   |             |             | <b>Average</b> | 81                           | 20.6                       | 0.25                         |
| <b>10c. Ore calciner</b>                      |             |             |                |                              |                            |                              |
| Cyclone/ESP                                   | B           | 5           | 1              | 126                          | 10.3                       | 0.082                        |
|   |             |             | 2              | 125                          | 8.4                        | 0.067                        |
|   |             |             | 3              | 129                          | 10.5                       | 0.082                        |
|   |             |             | <b>Average</b> | 128                          | 9.8                        | 0.077                        |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |                              |                            |                              |
| Cyclone/Baghouse/ESP                          | D           | 5           | 1              | 44                           | 1.71                       | 0.039                        |
|   |             |             | 2              | 45                           | 1.31                       | 0.029                        |
|   |             |             | 3              | 50                           | 2.27                       | 0.046                        |
|   |             |             | <b>Average</b> | 47                           | 1.77                       | 0.038                        |
| <b>11. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/Scrubber                              | B           | 5           | 1              | 116                          | 16.4                       | 0.142                        |
|   |             |             | 2              | 116                          | 14.9                       | 0.128                        |
|   |             |             | 3              | 116                          | 16.8                       | 0.145                        |
|   |             |             | <b>Average</b> | 116                          | 16.0                       | 0.138                        |
| <b>12. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/Scrubber                              | C           | 5           | 1              | 81                           | 15.1                       | 0.19                         |
|   |             |             | 2              | 81                           | 15.6                       | 0.19                         |
|   |             |             | 3              | 81                           | 11.7                       | 0.14                         |
|   |             |             | <b>Average</b> | 81                           | 14.2                       | 0.18                         |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 15.1                       |                              |
|                                      |             |             | 2              |                              | 16.6                       |                              |
|                                      |             |             | 3              |                              | 13.0                       |                              |
|                                      |             |             | 4              |                              | 15.0                       |                              |
|                                      |             |             | <b>Average</b> | 237                          | 14.9                       | 0.063                        |
| <b>14. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 17.5                       |                              |
|                                      |             |             | 2              |                              | 24.8                       |                              |
|                                      |             |             | 3              |                              | 26.6                       |                              |
|                                      |             |             | <b>Average</b> | 243                          | 22.9                       | 0.094                        |
| <b>15. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 26.9                       |                              |
|                                      |             |             | 2              |                              | 23.0                       |                              |
|                                      |             |             | 3              |                              | 21.1                       |                              |
|                                      |             |             | <b>Average</b> | 232                          | 23.7                       | 0.102                        |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 24.3                         | 10.18                      | 0.419                        |
|                                      |             |             | 2              | 25.0                         | 8.44                       | 0.337                        |
|                                      |             |             | 3              | 23.1                         | 8.61                       | 0.372                        |
|                                      |             |             | <b>Average</b> | 24.2                         | 9.07                       | 0.376                        |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 26.7                         | 14.19                      | 0.503                        |
|                                      |             |             | 2              | 28.0                         | 12.79                      | 0.456                        |
|                                      |             |             | 3              | 28.4                         | 13.07                      | 0.460                        |
|                                      |             |             | <b>Average</b> | 27.7                         | 13.37                      | 0.483                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>  |             |             |                |                              |                            |                              |
| Scrubbers                            | B           | 5           | 1              | 47.3                         | 11.6                       | 0.245                        |
|                                      |             |             | 2              | 49.2                         | 12.9                       | 0.263                        |
|                                      |             |             | 3              | 47.3                         | 9.2                        | 0.195                        |
|                                      |             |             | <b>Average</b> | 47.9                         | 11.3                       | 0.235                        |
| <b>19. Ore crusher</b>               |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 392                          | 0.28                       | 0.00071                      |
|                                      |             |             | 2              | 392                          | 0.33                       | 0.00084                      |
|                                      |             |             | <b>Average</b> | 392                          | 0.30                       | 0.00077                      |
| <b>20. Ore crusher</b>               |             |             |                |                              |                            |                              |
| Cyclone/Baghouse                     | B           | 5           | 1              | 264.1                        | 1.414                      | 0.00535                      |
|                                      |             |             | 2              | 216.3                        | 0.572                      | 0.00264                      |
|                                      |             |             | 3              | 258.5                        | 1.066                      | 0.00412                      |
|                                      |             |             | <b>Average</b> | 246.3                        | 1.017                      | 0.00404                      |
| <b>22a. Ore crusher</b>              |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 508                          | 0.60                       | 0.0012                       |
|                                      |             |             | 2              | 508                          | 0.32                       | 0.0006                       |
|                                      |             |             | 3              | 508                          | 0.25                       | 0.0005                       |
|                                      |             |             | <b>Average</b> | 508                          | 0.39                       | 0.00077                      |
| <b>22b. Trona transfer collector</b> |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 209                          | 0.02                       | 0.0001                       |
|                                      |             |             | 2              | 209                          | 0.01                       | 0.00004                      |
|                                      |             |             | 3              | 209                          | 0.05                       | 0.0002                       |
|                                      |             |             | <b>Average</b> | 209                          | 0.03                       | 0.0001                       |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|----------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>23a. Product screening</b>    |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 79.5                         | 0.24                       | 0.0030                       |
|                                  |             |             | 2              | 94.7                         | 0.32                       | 0.0034                       |
|                                  |             |             | 3              | 106.6                        | 0.20                       | 0.0019                       |
|                                  |             |             | <b>Average</b> | 93.6                         | 0.25                       | 0.0029                       |
| <b>23b. Product silo loading</b> |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 110.01                       | 0.091                      | 0.0008                       |
|                                  |             |             | 2              | 108.4                        | 0.11                       | 0.0010                       |
|                                  |             |             | <b>Average</b> | 109.3                        | 0.10                       | 0.0009                       |
| <b>23c. Product silo reclaim</b> |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 369.8                        | 0.517                      | 0.0014                       |
|                                  |             |             | 2              | 369.8                        | 0.12                       | 0.00032                      |
|                                  |             |             | 3              | 369.8                        | 0.03                       | 0.00009                      |
|                                  |             |             | <b>Average</b> | 369.8                        | 0.22                       | 0.00060                      |
| <b>24a. Ore crusher</b>          |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 92.5                         | 2.63                       | 0.0284                       |
|                                  |             |             | 2              | 92.5                         | 2.39                       | 0.0258                       |
|                                  |             |             | 3              | 179                          | 7.45                       | 0.0417                       |
|                                  |             |             | <b>Average</b> | 121                          | 4.15                       | 0.0320                       |
| <b>24b. Product screening</b>    |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 46.49                        | 0.359                      | 0.00769                      |
|                                  |             |             | 2              | 46.49                        | 0.239                      | 0.00509                      |
|                                  |             |             | 3              | 46.49                        | 0.194                      | 0.00418                      |
|                                  |             |             | <b>Average</b> | 46.49                        | 0.263                      | 0.00565                      |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|-------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24c. Product handling</b>  |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 100.9                        | 0.522                      | 0.00517                      |
|                               |             |             | 2              | 81.5                         | 0.356                      | 0.00437                      |
|                               |             |             | 3              | 81.5                         | 0.302                      | 0.00371                      |
|                               |             |             | <b>Average</b> | 87.9                         | 0.393                      | 0.00447                      |
| <b>24d. Product silo</b>      |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 56                           | 0.192                      | 0.0034                       |
|                               |             |             | 2              | 56                           | 0.208                      | 0.0037                       |
|                               |             |             | 3              | 56                           | 0.210                      | 0.0037                       |
|                               |             |             | <b>Average</b> | 56                           | 0.203                      | 0.0036                       |
| <b>24e. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 38.5                         | 1.09                       | 0.0282                       |
|                               |             |             | 2              | 38.5                         | 1.34                       | 0.0348                       |
|                               |             |             | 3              | 35.8                         | 1.02                       | 0.0286                       |
|                               |             |             | <b>Average</b> | 37.6                         | 1.15                       | 0.0306                       |
| <b>24f. Product dryer</b>     |             |             |                |                              |                            |                              |
| Scrubber                      | D           | 5           | 1              | 54.6                         | 0.635                      | 0.0117                       |
|                               |             |             | 2              | 54.6                         | 0.875                      | 0.0161                       |
|                               |             |             | 3              | 54.6                         | 0.322                      | 0.0059                       |
|                               |             |             | <b>Average</b> | 54.6                         | 0.691                      | 0.0112                       |
| <b>24g. Product dryer</b>     |             |             |                |                              |                            |                              |
| Scrubber                      | D           | 5           | 1              | 37                           | 0.205                      | 0.0055                       |
|                               |             |             | 2              | 47                           | 0.256                      | 0.0054                       |
|                               |             |             | 3              | 47                           | 0.221                      | 0.0047                       |
|                               |             |             | <b>Average</b> | 44                           | 0.228                      | 0.0052                       |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (METRIC UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                  | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24h. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 52                           | 1.01                       | 0.020                        |
|                                    |             |             | 2              | 47                           | 0.902                      | 0.019                        |
|                                    |             |             | 3              | 47                           | 0.948                      | 0.020                        |
|                                    |             |             | <b>Average</b> | 49                           | 0.961                      | 0.020                        |
| <b>25. Product fluid-bed dryer</b> |             |             |                |                              |                            |                              |
| Scrubber                           | B           | 5           | 1              | 15.1                         | 0.35                       | 0.023                        |
|                                    |             |             | 2              | 13.6                         | 0.25                       | 0.019                        |
|                                    |             |             | 3              | 12.0                         | 0.20                       | 0.016                        |
|                                    |             |             | <b>Average</b> | 13.5                         | 0.27                       | 0.020                        |
| <b>26. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | C           | 5           | 1              | 122                          | 22.84                      | 0.187                        |
|                                    |             |             | 2              | 122                          | 18.75                      | 0.153                        |
|                                    |             |             | 3              | 122                          | 24.07                      | 0.197                        |
|                                    |             |             | <b>Average</b> | 122                          | 21.89                      | 0.179                        |
| <b>28. Ore crusher</b>             |             |             |                |                              |                            |                              |
| Baghouse                           | B           | 5           | 1              |                              | 0.49                       |                              |
|                                    |             |             | 2              |                              | 0.34                       |                              |
|                                    |             |             | 3              |                              | 0.21                       |                              |
|                                    |             |             | <b>Average</b> | 237                          | 0.34                       | 0.0014                       |
| <b>29. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | C           | 5           | 1              |                              | 12.2                       |                              |
|                                    |             |             | 2              |                              | 13.0                       |                              |
|                                    |             |             | 3              |                              | 14.1                       |                              |
|                                    |             |             | <b>Average</b> | 238                          | 13.1                       | 0.055                        |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.



**TABLE 4.2-5 (METRIC UNITS) (concluded)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>30a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 100.3                        | 1.36                       | 0.0136                       |
|                          |             |             | 2              | 93.9                         | 2.46                       | 0.0262                       |
|                          |             |             | 3              | 93.9                         | 0.907                      | 0.00966                      |
|                          |             |             | <b>Average</b> | 96.0                         | 1.58                       | 0.0165                       |
| <b>30b. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 85.2                         | 6.22                       | 0.0731                       |
|                          |             |             | 2              | 85.2                         | 1.78                       | 0.0209                       |
|                          |             |             | 3              | 86.3                         | 0.95                       | 0.0110                       |
|                          |             |             | <b>Average</b> | 85.6                         | 2.99                       | 0.0350                       |

<sup>a</sup>Units in Mg/hr.

<sup>b</sup>Units in kg/hr.

<sup>c</sup>Units in kg/Mg.

**TABLE 4.2-5 (ENGLISH UNITS)  
FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 120                          | 29.25                      | 0.244                        |
|                          |             |             | 2              | 120                          | 37.43                      | 0.312                        |
|                          |             |             | 3              | 120                          | 36.72                      | 0.306                        |
|                          |             |             | <b>Average</b> | 120                          | 34.47                      | 0.287                        |
| <b>8b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 130                          | 30.49                      | 0.234                        |
|                          |             |             | 2              | 130                          | 29.96                      | 0.230                        |
|                          |             |             | 3              | 130                          | 34.39                      | 0.265                        |
|                          |             |             | <b>Average</b> | 130                          | 31.61                      | 0.243                        |
| <b>9a. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 120                          | 27.85                      | 0.232                        |
|                          |             |             | 2              | 120                          | 29.18                      | 0.243                        |
|                          |             |             | 3              | 120                          | 31.38                      | 0.262                        |
|                          |             |             | <b>Average</b> | 120                          | 29.47                      | 0.246                        |
| <b>9b. Ore calciner</b>  |             |             |                |                              |                            |                              |
| Cyclone/ESP              | B           | 5           | 1              | 130                          | 22.40                      | 0.172                        |
|                          |             |             | 2              | 130                          | 30.61                      | 0.235                        |
|                          |             |             | 3              | 130                          | 28.28                      | 0.218                        |
|                          |             |             | <b>Average</b> | 130                          | 27.10                      | 0.208                        |
| <b>10a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber     | B           | 5           | 1              | 128                          | 49.24                      | 0.385                        |
|                          |             |             | 2              | 128                          | 57.58                      | 0.450                        |
|                          |             |             | 3              | 128                          | 53.16                      | 0.415                        |
|                          |             |             | <b>Average</b> | 128                          | 53.33                      | 0.417                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|---|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>10b. Product dryer</b>                     |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | B           | 5           | 1              | 85                           | 45.33                      | 0.53                         |
|   |             |             | 2              | 89                           | 45.33                      | 0.51                         |
|   |             |             | 3              | 94                           | 45.40                      | 0.48                         |
|   |             |             | <b>Average</b> | 89                           | 45.35                      | 0.51                         |
| <b>10c. Ore calciner</b>                      |             |             |                |                              |                            |                              |
| ESP   | B           | 5           | 1              | 139                          | 22.79                      | 0.164                        |
|   |             |             | 2              | 138                          | 18.58                      | 0.135                        |
|   |             |             | 3              | 142                          | 23.21                      | 0.164                        |
|   |             |             | <b>Average</b> | 141                          | 21.53                      | 0.154                        |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |                              |                            |                              |
| Cyclone/<br>Baghouse/<br>ESP                  | D           | 5           | 1              | 49                           | 3.78                       | 0.077                        |
|   |             |             | 2              | 50                           | 2.89                       | 0.058                        |
|   |             |             | 3              | 55                           | 5.01                       | 0.091                        |
|   |             |             | <b>Average</b> | 51                           | 3.89                       | 0.075                        |
| <b>11. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | B           | 5           | 1              | 128                          | 36.25                      | 0.283                        |
|   |             |             | 2              | 128                          | 32.85                      | 0.257                        |
|   |             |             | 3              | 128                          | 37.02                      | 0.289                        |
|   |             |             | <b>Average</b> | 128                          | 35.37                      | 0.276                        |
| <b>12. Ore calciner</b>                       |             |             |                |                              |                            |                              |
| Cyclone/<br>Scrubber                          | C           | 5           | 1              | 89                           | 33.40                      | 0.38                         |
|   |             |             | 2              | 89                           | 34.49                      | 0.38                         |
|   |             |             | 3              | 89                           | 25.72                      | 0.29                         |
|   |             |             | <b>Average</b> | 89                           | 31.20                      | 0.35                         |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 33.4                       |                              |
|                                      |             |             | 2              |                              | 36.7                       |                              |
|                                      |             |             | 3              |                              | 28.7                       |                              |
|                                      |             |             | 4              |                              | 33.1                       |                              |
|                                      |             |             | <b>Average</b> | 261                          | 32.9                       | 0.126                        |
| <b>14. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 38.5                       |                              |
|                                      |             |             | 2              |                              | 54.7                       |                              |
|                                      |             |             | 3              |                              | 58.6                       |                              |
|                                      |             |             | <b>Average</b> | 268                          | 50.6                       | 0.189                        |
| <b>15. Ore calciner</b>              |             |             |                |                              |                            |                              |
| Cyclone/ESP                          | B           | 5           | 1              |                              | 59.34                      |                              |
|                                      |             |             | 2              |                              | 50.67                      |                              |
|                                      |             |             | 3              |                              | 46.46                      |                              |
|                                      |             |             | <b>Average</b> | 256                          | 52.16                      | 0.204                        |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 26.8                         | 22.44                      | 0.837                        |
|                                      |             |             | 2              | 27.6                         | 18.62                      | 0.675                        |
|                                      |             |             | 3              | 25.5                         | 18.98                      | 0.744                        |
|                                      |             |             | <b>Average</b> | 26.6                         | 20.01                      | 0.752                        |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 29.4                         | 31.29                      | 1.06                         |
|                                      |             |             | 2              | 30.9                         | 28.20                      | 0.913                        |
|                                      |             |             | 3              | 31.3                         | 28.81                      | 0.920                        |
|                                      |             |             | <b>Average</b> | 30.5                         | 29.49                      | 0.966                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>  |             |             |                |                              |                            |                              |
| Scrubbers                            | B           | 5           | 1              | 52.1                         | 25.58                      | 0.491                        |
|                                      |             |             | 2              | 54.2                         | 28.50                      | 0.526                        |
|                                      |             |             | 3              | 52.1                         | 20.35                      | 0.391                        |
|                                      |             |             | <b>Average</b> | 52.8                         | 24.81                      | 0.469                        |
| <b>19. Ore crusher</b>               |             |             |                |                              |                            |                              |
| Scrubber                             | B           | 5           | 1              | 432                          | 0.61                       | 0.0014                       |
|                                      |             |             | 2              | 432                          | 0.72                       | 0.0017                       |
|                                      |             |             | <b>Average</b> | 432                          | 0.66                       | 0.0015                       |
| <b>20. Ore crusher</b>               |             |             |                |                              |                            |                              |
| Cyclone/<br>Baghouse                 | B           | 5           | 1              | 291.2                        | 3.117                      | 0.0107                       |
|                                      |             |             | 2              | 238.5                        | 1.261                      | 0.00529                      |
|                                      |             |             | 3              | 285.0                        | 2.350                      | 0.0082                       |
|                                      |             |             | <b>Average</b> | 271.6                        | 2.243                      | 0.00808                      |
| <b>22a. Ore crusher</b>              |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 560                          | 1.33                       | 0.0024                       |
|                                      |             |             | 2              | 560                          | 0.71                       | 0.0013                       |
|                                      |             |             | 3              | 560                          | 0.56                       | 0.0010                       |
|                                      |             |             | <b>Average</b> | 560                          | 0.87                       | 0.0015                       |
| <b>22b. Trona transfer collector</b> |             |             |                |                              |                            |                              |
| Baghouse                             | B           | 5           | 1              | 230                          | 0.05                       | 0.0002                       |
|                                      |             |             | 2              | 230                          | 0.02                       | 0.00009                      |
|                                      |             |             | 3              | 230                          | 0.10                       | 0.0004                       |
|                                      |             |             | <b>Average</b> | 230                          | 0.06                       | 0.0002                       |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Source Test #                    | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|----------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>23a. Product screening</b>    |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 87.6                         | 0.52                       | 0.0059                       |
|                                  |             |             | 2              | 104.4                        | 0.71                       | 0.0068                       |
|                                  |             |             | 3              | 117.5                        | 0.44                       | 0.0037                       |
|                                  |             |             | <b>Average</b> | 103.2                        | 0.57                       | 0.0055                       |
| <b>23b. Product silo loading</b> |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 121.4                        | 0.20                       | 0.0016                       |
|                                  |             |             | 2              | 119.5                        | 0.25                       | 0.0021                       |
|                                  |             |             | <b>Average</b> | 120.4                        | 0.23                       | 0.0019                       |
| <b>23c. Product silo reclaim</b> |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 407.7                        | 1.14                       | 0.0028                       |
|                                  |             |             | 2              | 407.7                        | 0.26                       | 0.00064                      |
|                                  |             |             | 3              | 407.7                        | 0.07                       | 0.0002                       |
|                                  |             |             | <b>Average</b> | 407.7                        | 0.49                       | 0.0012                       |
| <b>24a. Ore crusher</b>          |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 102                          | 5.80                       | 0.0569                       |
|                                  |             |             | 2              | 102                          | 5.27                       | 0.0517                       |
|                                  |             |             | 3              | 197                          | 16.42                      | 0.0834                       |
|                                  |             |             | <b>Average</b> | 134                          | 9.16                       | 0.0640                       |
| <b>24b. Product screening</b>    |             |             |                |                              |                            |                              |
| Baghouse                         | D           | 5           | 1              | 51.25                        | 0.788                      | 0.0154                       |
|                                  |             |             | 2              | 51.25                        | 0.522                      | 0.0102                       |
|                                  |             |             | 3              | 51.25                        | 0.428                      | 0.0084                       |
|                                  |             |             | <b>Average</b> | 51.25                        | 0.579                      | 0.0113                       |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment             | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|-------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24c. Product handling</b>  |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 111.2                        | 1.15                       | 0.0103                       |
|                               |             |             | 2              | 89.8                         | 0.784                      | 0.0087                       |
|                               |             |             | 3              | 89.8                         | 0.666                      | 0.0074                       |
|                               |             |             | <b>Average</b> | 96.9                         | 0.867                      | 0.0088                       |
| <b>24d. Product silo</b>      |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 62                           | 0.423                      | 0.0068                       |
|                               |             |             | 2              | 62                           | 0.458                      | 0.0074                       |
|                               |             |             | 3              | 62                           | 0.462                      | 0.0075                       |
|                               |             |             | <b>Average</b> | 62                           | 0.448                      | 0.0072                       |
| <b>24e. Product screening</b> |             |             |                |                              |                            |                              |
| Baghouse                      | D           | 5           | 1              | 42.5                         | 2.40                       | 0.0565                       |
|                               |             |             | 2              | 42.5                         | 2.96                       | 0.0696                       |
|                               |             |             | 3              | 39.5                         | 2.26                       | 0.0572                       |
|                               |             |             | <b>Average</b> | 41.5                         | 2.54                       | 0.0611                       |
| <b>24f. Product dryer</b>     |             |             |                |                              |                            |                              |
| Scrubber                      | D           | 5           | 1              | 60.2                         | 1.40                       | 0.0233                       |
|                               |             |             | 2              | 60.2                         | 1.93                       | 0.0321                       |
|                               |             |             | 3              | 60.2                         | 0.71                       | 0.0118                       |
|                               |             |             | <b>Average</b> | 60.2                         | 1.35                       | 0.0224                       |
| <b>24g. Product dryer</b>     |             |             |                |                              |                            |                              |
| Scrubber                      | D           | 5           | 1              | 41                           | 0.453                      | 0.011                        |
|                               |             |             | 2              | 52                           | 0.564                      | 0.011                        |
|                               |             |             | 3              | 52                           | 0.488                      | 0.0094                       |
|                               |             |             | <b>Average</b> | 48                           | 0.500                      | 0.010                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

**TABLE 4.2-5 (ENGLISH UNITS) (continued)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment                  | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|------------------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>24h. Product dryer</b>          |             |             |                |                              |                            |                              |
| Scrubber                           | D           | 5           | 1              | 57                           | 2.23                       | 0.039                        |
|                                    |             |             | 2              | 52                           | 1.99                       | 0.038                        |
|                                    |             |             | 3              | 52                           | 2.09                       | 0.040                        |
|                                    |             |             | <b>Average</b> | 54                           | 2.12                       | 0.039                        |
| <b>25. Product fluid-bed dryer</b> |             |             |                |                              |                            |                              |
| Scrubber                           | B           | 5           | 1              | 16.6                         | 0.77                       | 0.046                        |
|                                    |             |             | 2              | 15.0                         | 0.56                       | 0.037                        |
|                                    |             |             | 3              | 13.2                         | 0.43                       | 0.033                        |
|                                    |             |             | <b>Average</b> | 14.9                         | 0.59                       | 0.039                        |
| <b>26. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | C           | 5           | 1              | 135                          | 50.36                      | 0.373                        |
|                                    |             |             | 2              | 135                          | 41.34                      | 0.306                        |
|                                    |             |             | 3              | 135                          | 53.08                      | 0.393                        |
|                                    |             |             | <b>Average</b> | 135                          | 48.26                      | 0.357                        |
| <b>28. Ore crusher</b>             |             |             |                |                              |                            |                              |
| Baghouse                           | B           | 5           | 1              |                              | 1.07                       |                              |
|                                    |             |             | 2              |                              | 0.74                       |                              |
|                                    |             |             | 3              |                              | 0.46                       |                              |
|                                    |             |             | <b>Average</b> | 261                          | 0.76                       | 0.0029                       |
| <b>29. Ore calciner</b>            |             |             |                |                              |                            |                              |
| Cyclone/ESP                        | C           | 5           | 1              |                              | 26.9                       |                              |
|                                    |             |             | 2              |                              | 28.7                       |                              |
|                                    |             |             | 3              |                              | 31.0                       |                              |
|                                    |             |             | <b>Average</b> | 262                          | 28.9                       | 0.110                        |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.



**TABLE 4.2-5 (ENGLISH UNITS) (concluded)**  
**FILTERABLE PLUS INORGANIC CONDENSIBLE PARTICULATE MATTER**

| Control Equipment        | Test Rating | Test Method | Run #          | Production Rate <sup>a</sup> | Emission Rate <sup>b</sup> | Emission Factor <sup>c</sup> |
|--------------------------|-------------|-------------|----------------|------------------------------|----------------------------|------------------------------|
| <b>30a. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 110.6                        | 3.00                       | 0.0271                       |
|                          |             |             | 2              | 103.5                        | 5.43                       | 0.0525                       |
|                          |             |             | 3              | 103.5                        | 2.00                       | 0.0193                       |
|                          |             |             | <b>Average</b> | 105.9                        | 3.48                       | 0.0330                       |
| <b>30b. Ore calciner</b> |             |             |                |                              |                            |                              |
| Cyclone/ESP              | D           | 5           | 1              | 93.9                         | 13.72                      | 0.1461                       |
|                          |             |             | 2              | 93.9                         | 3.93                       | 0.0418                       |
|                          |             |             | 3              | 95.2                         | 2.10                       | 0.0221                       |
|                          |             |             | <b>Average</b> | 94.3                         | 6.58                       | 0.0700                       |

<sup>a</sup>Units in tons/hr.

<sup>b</sup>Units in lb/hr.

<sup>c</sup>Units in lb/ton.

### 4.3 NONCRITERIA POLLUTANT EMISSION DATA

#### Hazardous Air Pollutants.

Hazardous Air Pollutants (HAPs) are defined in the 1990 Clean Air Act Amendments. No data on emissions of any of these pollutants were found for the sodium carbonate manufacturing process.

#### Global Warming Gases.

Pollutants such as methane, carbon dioxide, and nitrous oxide have been found to contribute to overall global warming. The combustion of fossil fuels is one of the main anthropogenic sources of CO<sub>2</sub> emissions. As a result, significant quantities of this pollutant are emitted from direct-fired rotary ore calcining kilns and soda ash dryers. For source testing purposes, the concentration of carbon dioxide in the stack gas being tested is measured in order to approximate the molecular weight of the stack gas. In the emissions tests utilized in developing emission factors for sodium carbonate production, as with most emissions tests, this measurement is performed in such a way that its level of accuracy is less than that of the primary pollutants of interest. It is for this reason that the emission factors for CO<sub>2</sub> presented in the AP-42 section are rated no higher than "C." Carbon dioxide emission factors from one of the references (#30) have been assigned a rating of "D" due to a lack of documentation, and that from another (#20) has been assigned a rating of "D" due to questionable values at ambient temperature.

The preferred method of quantifying emissions of carbon dioxide from combustion processes is through fuel analyses. All of the carbon in the fuel, minus that contained in unburned hydrocarbons and carbon monoxide in the effluent gases, can be assumed to be in the form of carbon dioxide.

The emission rate of a gas such as carbon dioxide can readily be calculated, given the volumetric flow rate of the stack gas at standard conditions and the concentration of carbon dioxide in the stack gas, using ideal gas laws. The carbon dioxide emissions data used in creating emission factors for AP-42 Section 5.16 is summarized in both Metric and English units in Tables 4.3-1.

**TABLE 4.3-1 (METRIC UNITS)  
GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment        | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 12.0                                       | 1285                              | 109                       | 170                          |
|                          |             |             | 2              | 11.2                                       | 1283                              | 109                       | 160                          |
|                          |             |             | 3              | 12.0                                       | 1242                              | 109                       | 160                          |
|                          |             |             | <b>Average</b> | 11.7                                       | 1270                              | 109                       | 160                          |
| <b>8b. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 10.3                                       | 1297                              | 118                       | 130                          |
|                          |             |             | 2              | 10.7                                       | 1347                              | 118                       | 140                          |
|                          |             |             | 3              | 10.1                                       | 1306                              | 118                       | 130                          |
|                          |             |             | <b>Average</b> | 10.4                                       | 1316                              | 118                       | 140                          |
| <b>9a. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 13.6                                       | 1173                              | 109                       | 170                          |
|                          |             |             | 2              | 14.0                                       | 1201                              | 109                       | 180                          |
|                          |             |             | 3              | 12.8                                       | 1299                              | 109                       | 170                          |
|                          |             |             | <b>Average</b> | 13.5                                       | 1191                              | 109                       | 170                          |
| <b>9b. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 13.0                                       | 1277                              | 118                       | 170                          |
|                          |             |             | 2              | 13.2                                       | 1341                              | 118                       | 180                          |
|                          |             |             | 3              | 11.0                                       | 1339                              | 118                       | 150                          |
|                          |             |             | <b>Average</b> | 12.4                                       | 1320                              | 118                       | 160                          |
| <b>10a. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/Scrubber         | C           | ORSAT       | 1              | 8.0  | 1441                              | 116                       | 120                          |
|                          |             |             | 2              | 7.4  | 1247                              | 116                       | 94                           |
|                          |             |             | 3              | 7.4  | 1128                              | 116                       | 85                           |
|                          |             |             | <b>Average</b> | 7.6  | 1272                              | 116                       | 98                           |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic meters per minute.

<sup>c</sup>Units in Mg/hr.

<sup>d</sup>Units in kg/Mg.

**TABLE 4.3-1 (METRIC UNITS) (continued)**  
**GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                             | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|---|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>10b. Product dryer</b>                     |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 6.2  | 729.8                             | 77                        | 69                           |
|   |             |             | 2              | 6.0  | 713.7                             | 81                        | 62                           |
|   |             |             | 3              | 6.0  | 706.1                             | 85                        | 59                           |
|   |             |             | <b>Average</b> | 6.1  | 716.5                             | 81                        | 63                           |
| <b>10c. Ore calciner</b>                      |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 9.8  | 1947                              | 126                       | 180                          |
|   |             |             | 2              | 9.2  | 1926                              | 125                       | 170                          |
|   |             |             | 3              | 9.4  | 1965                              | 129                       | 170                          |
|   |             |             | <b>Average</b> | 9.5  | 1946                              | 128                       | 170                          |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Baghouse/<br>ESP                  | C           | ORSAT       | 1              | 8.4  | 642.8                             | 44                        | 140                          |
|   |             |             | 2              | 8.6  | 838.8                             | 45                        | 190                          |
|   |             |             | 3              | 8.6  | 899.6                             | 50                        | 180                          |
|   |             |             | <b>Average</b> | 8.5  | 793.7                             | 47                        | 170                          |
| <b>11. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 7.8  | 1441                              | 116                       | 110                          |
|   |             |             | 2              | 8.0  | 1404                              | 116                       | 110                          |
|   |             |             | 3              | 7.8  | 1385                              | 116                       | 110                          |
|   |             |             | <b>Average</b> | 7.9  | 1410                              | 116                       | 110                          |
| <b>12. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 14.0                                       | 1815                              | 81                        | 370                          |
|   |             |             | 2              | 12.9                                       | 1750                              | 81                        | 330                          |
|   |             |             | 3              | 15.25                                      | 1743                              | 81                        | 390                          |
|   |             |             | <b>Average</b> | 14.05                                      | 1769                              | 81                        | 360                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic meters per minute.

<sup>c</sup>Units in Mg/hr.

<sup>d</sup>Units in kg/Mg.

**TABLE 4.3-1 (METRIC UNITS) (continued)  
GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                    | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 16.6                                       | 3055                              |                           |                              |
|                                      |             |             | 2              | 17.3                                       | 3150                              |                           |                              |
|                                      |             |             | 3              | 15.2                                       | 3112                              |                           |                              |
|                                      |             |             | 4              | 16.8                                       | 3151                              |                           |                              |
|                                      |             |             | <b>Average</b> | 16.5                                       | 3141                              | 237                       | 250                          |
| <b>14. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 16.0                                       | 3077                              |                           |                              |
|                                      |             |             | 2              | 16.2                                       | 3138                              |                           |                              |
|                                      |             |             | 3              | 16.2                                       | 3017                              |                           |                              |
|                                      |             |             | <b>Average</b> | 16.1                                       | 3077                              | 243                       | 240                          |
| <b>15. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 13.2                                       | 3529                              |                           |                              |
|                                      |             |             | 2              | 14.1                                       | 3413                              |                           |                              |
|                                      |             |             | 3              | 14.0                                       | 3558                              |                           |                              |
|                                      |             |             | <b>Average</b> | 13.8                                       | 3500                              | 232                       | 240                          |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                             | C           | ORSAT       | 1              | 1.1  | 1413                              | 24.3                      | 75                           |
|                                      |             |             | 2              | 1.4  | 1251                              | 25.0                      | 82                           |
|                                      |             |             | 3              | 1.3  | 1252                              | 23.1                      | 83                           |
|                                      |             |             | <b>Average</b> | 1.3  | 1305                              | 24.2                      | 80                           |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                             | C           | ORSAT       | 1              | 3.6  | 1905                              | 26.7                      | 300                          |
|                                      |             |             | 2              | 3.5  | 1917                              | 28.0                      | 280                          |
|                                      |             |             | 3              | 4.6  | 1887                              | 28.4                      | 360                          |
|                                      |             |             | <b>Average</b> | 3.9  | 1903                              | 27.7                      | 320                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic meters per minute.

<sup>c</sup>Units in Mg/hr.

<sup>d</sup>Units in kg/Mg.

**TABLE 4.3-1 (METRIC UNITS) (continued)**  
**GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                             | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|---|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>           |             |             |                |  |                                   |                           |                              |
| Scrubbers                                     | C           | ORSAT       | 1              | 2.2  | 1228                              | 47.3                      | 67                           |
|   |             |             | 2              | 2.4  | 1180                              | 49.2                      | 68                           |
|   |             |             | 3              | 2.1  | 1153                              | 47.3                      | 60                           |
|   |             |             | <b>Average</b> | 2.2  | 1187                              | 47.9                      | 65                           |
| <b>18. Sesquicarbonate fluid-bed calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                                      | C           | ORSAT       | 1              | 3.9  | 1616                              |                           |                              |
|   |             |             | 2              | 3.83                                       | 1689                              |                           |                              |
|   |             |             | 3              | 3.6  | 1663                              |                           |                              |
|   |             |             | <b>Average</b> | 3.77                                       | 1656                              | 81.3                      | 90                           |
| <b>20. Ore crusher</b>                        |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Baghouse                          | D           | ORSAT       | 1              | 1  |                                   | 264.1                     | 2                            |
|   |             |             | 2              | 2  |                                   | 216.3                     | 4                            |
|   |             |             | 3              | 1  |                                   | 258.5                     | 2                            |
|   |             |             | <b>Average</b> | 1  |                                   | 246.3                     | 4                            |
| <b>26. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 10.4                                       | 1498                              | 122                       | 150                          |
|   |             |             | 2              | 10.6                                       | 1488                              | 122                       | 150                          |
|   |             |             | 3              | 11.2                                       | 1457                              | 122                       | 160                          |
|   |             |             | <b>Average</b> | 10.7                                       | 1481                              | 122                       | 150                          |
| <b>29. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 16.6                                       | 2943                              |                           |                              |
|   |             |             | 2              | 17.3                                       | 3206                              |                           |                              |
|   |             |             | 3              | 15.2                                       | 3102                              |                           |                              |
|   |             |             | <b>Average</b> | 16.4                                       | 3084                              | 238                       | 250                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic meters per minute.

<sup>c</sup>Units in Mg/hr.

<sup>d</sup>Units in kg/Mg.

**TABLE 4.3-1 (METRIC UNITS) (concluded)**  
**GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment        | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>30a. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | D           | ORSAT       | 1              | 10.1                                       | 3675                              | 100.3                     | 160                          |
|                          |             |             | 2              | 5.5  | 3768                              | 93.9                      | 160                          |
|                          |             |             | 3              | 5.0  | 3544                              | 93.9                      | 110                          |
|                          |             |             | <b>Average</b> | 6.9  | 3662                              | 96.0                      | 140                          |
| <b>30b. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | D           | ORSAT       | 1              | 4.5  | 2999                              | 85.2                      | 510                          |
|                          |             |             | 2              | 4.5  | 2871                              | 85.2                      | 290                          |
|                          |             |             | 3              | 3.0  | 2972                              | 86.3                      | 240                          |
|                          |             |             | <b>Average</b> | 4.0  | 2947                              | 85.6                      | 350                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic meters per minute.

<sup>c</sup>Units in Mg/hr.

<sup>d</sup>Units in kg/Mg.

**TABLE 4.3-1 (ENGLISH UNITS)  
GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment        | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>8a. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 12.0                                       | 45380                             | 120                       | 330                          |
|                          |             |             | 2              | 11.2                                       | 45300                             | 120                       | 310                          |
|                          |             |             | 3              | 12.0                                       | 43852                             | 120                       | 320                          |
|                          |             |             | <b>Average</b> | 11.7                                       | 45511                             | 120                       | 320                          |
| <b>8b. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 10.3                                       | 45787                             | 130                       | 270                          |
|                          |             |             | 2              | 10.7                                       | 47558                             | 130                       | 290                          |
|                          |             |             | 3              | 10.1                                       | 46120                             | 130                       | 260                          |
|                          |             |             | <b>Average</b> | 10.4                                       | 46488                             | 130                       | 270                          |
| <b>9a. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 13.6                                       | 41414                             | 120                       | 350                          |
|                          |             |             | 2              | 14.0                                       | 42423                             | 120                       | 360                          |
|                          |             |             | 3              | 12.8                                       | 42340                             | 120                       | 330                          |
|                          |             |             | <b>Average</b> | 13.5                                       | 42059                             | 120                       | 350                          |
| <b>9b. Ore calciner</b>  |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | C           | ORSAT       | 1              | 13.0                                       | 45093                             | 130                       | 330                          |
|                          |             |             | 2              | 13.2                                       | 47472                             | 130                       | 350                          |
|                          |             |             | 3              | 11.0                                       | 47299                             | 130                       | 290                          |
|                          |             |             | <b>Average</b> | 12.4                                       | 46621                             | 130                       | 330                          |
| <b>10a. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/Scrubber         | C           | ORSAT       | 1              | 8.0  | 50886                             | 128                       | 230                          |
|                          |             |             | 2              | 7.4  | 44048                             | 128                       | 190                          |
|                          |             |             | 3              | 7.4  | 39849                             | 128                       | 170                          |
|                          |             |             | <b>Average</b> | 7.6  | 44928                             | 128                       | 200                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic feet per minute.

<sup>c</sup>Units in tons/hr.

<sup>d</sup>Units in lb/ton.



**TABLE 4.3-1 (ENGLISH UNITS) (continued)**  
**GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                             | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|---|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>10b. Product dryer</b>                     |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 6.2  | 25772                             | 85                        | 140                          |
|   |             |             | 2              | 6.0  | 25203                             | 89                        | 120                          |
|   |             |             | 3              | 6.0  | 24934                             | 94                        | 120                          |
|   |             |             | <b>Average</b> | 6.1  | 25303                             | 89                        | 130                          |
| <b>10c. Ore calciner</b>                      |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 9.8  | 68742                             | 139                       | 360                          |
|   |             |             | 2              | 9.2  | 68009                             | 138                       | 330                          |
|   |             |             | 3              | 9.4  | 69398                             | 142                       | 340                          |
|   |             |             | <b>Average</b> | 9.5  | 68716                             | 140                       | 340                          |
| <b>10d. Product dryer, cooler, classifier</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Baghouse/<br>ESP                  | C           | ORSAT       | 1              | 8.4  | 22699                             | 49                        | 290                          |
|   |             |             | 2              | 8.6  | 29620                             | 50                        | 370                          |
|   |             |             | 3              | 8.6  | 31767                             | 55                        | 370                          |
|   |             |             | <b>Average</b> | 8.5  | 28027                             | 51                        | 350                          |
| <b>11. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 7.8  | 50886                             | 128                       | 230                          |
|   |             |             | 2              | 8.0  | 49569                             | 128                       | 230                          |
|   |             |             | 3              | 7.8  | 48899                             | 128                       | 220                          |
|   |             |             | <b>Average</b> | 7.9  | 49785                             | 128                       | 230                          |
| <b>12. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Scrubber                          | C           | ORSAT       | 1              | 14.0                                       | 64077                             | 89                        | 740                          |
|   |             |             | 2              | 12.9                                       | 61783                             | 89                        | 660                          |
|   |             |             | 3              | 15.25                                      | 61544                             | 89                        | 780                          |
|   |             |             | <b>Average</b> | 14.05                                      | 62468                             | 89                        | 720                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic feet per minute.

<sup>c</sup>Units in tons/hr.

<sup>d</sup>Units in lb/ton.

**TABLE 4.3-1 (ENGLISH UNITS) (continued)  
GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                    | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>13. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 16.6                                       | 107880                            |                           |                              |
|                                      |             |             | 2              | 17.3                                       | 111242                            |                           |                              |
|                                      |             |             | 3              | 15.2                                       | 109906                            |                           |                              |
|                                      |             |             | 4              | 16.8                                       | 111286                            |                           |                              |
|                                      |             |             | <b>Average</b> | 16.5                                       | 110079                            | 261                       | 510                          |
| <b>14. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 16.0                                       | 108656                            |                           |                              |
|                                      |             |             | 2              | 16.2                                       | 110828                            |                           |                              |
|                                      |             |             | 3              | 16.2                                       | 106526                            |                           |                              |
|                                      |             |             | <b>Average</b> | 16.5                                       | 108670                            | 268                       | 480                          |
| <b>15. Ore calciner</b>              |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                          | C           | ORSAT       | 1              | 13.2                                       | 124612                            |                           |                              |
|                                      |             |             | 2              | 14.1                                       | 120522                            |                           |                              |
|                                      |             |             | 3              | 14.0                                       | 125631                            |                           |                              |
|                                      |             |             | <b>Average</b> | 13.8                                       | 123588                            | 256                       | 490                          |
| <b>16a. Sesquicarbonate calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                             | C           | ORSAT       | 1              | 1.1  | 49891                             | 26.8                      | 150                          |
|                                      |             |             | 2              | 1.4  | 44173                             | 27.6                      | 160                          |
|                                      |             |             | 3              | 1.3  | 44219                             | 25.5                      | 170                          |
|                                      |             |             | <b>Average</b> | 1.3  | 46094                             | 26.6                      | 160                          |
| <b>16b. Sesquicarbonate calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                             | C           | ORSAT       | 1              | 3.6  | 67286                             | 29.4                      | 600                          |
|                                      |             |             | 2              | 3.5  | 67709                             | 30.9                      | 560                          |
|                                      |             |             | 3              | 4.6  | 66650                             | 31.3                      | 720                          |
|                                      |             |             | <b>Average</b> | 3.9  | 67215                             | 30.5                      | 630                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic feet per minute.

<sup>c</sup>Units in tons/hr.

<sup>d</sup>Units in lb/ton.

**TABLE 4.3-1 (ENGLISH UNITS) (continued)**  
**GLOBAL WARMING GASES: CARBON DIOXIDE**

| Control Equipment                             | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|---|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>17. Sesquicarbonate calciner</b>           |             |             |                |  |                                   |                           |                              |
| Scrubbers                                     | C           | ORSAT       | 1              | 2.2  | 43360                             | 52.1                      | 130                          |
|   |             |             | 2              | 2.4  | 41679                             | 54.2                      | 140                          |
|   |             |             | 3              | 2.1  | 40705                             | 52.1                      | 120                          |
|   |             |             | <b>Average</b> | 2.2  | 41915                             | 52.8                      | 130                          |
| <b>18. Sesquicarbonate fluid-bed calciner</b> |             |             |                |  |                                   |                           |                              |
| Scrubber                                      | C           | ORSAT       | 1              | 3.9  | 57063                             |                           |                              |
|   |             |             | 2              | 3.83                                       | 59638                             |                           |                              |
|   |             |             | 3              | 3.6  | 58719                             |                           |                              |
|   |             |             | <b>Average</b> | 3.77                                       | 58473                             | 89.6                      | 180                          |
| <b>20. Ore crusher</b>                        |             |             |                |  |                                   |                           |                              |
| Cyclone/<br>Baghouse                          | D           | ORSAT       | 1              | 1  | 15394                             | 291.2                     | 3                            |
|   |             |             | 2              | 2  | 16339                             | 238.5                     | 8                            |
|   |             |             | 3              | 1  | 16178                             | 285.0                     | 4                            |
|   |             |             | <b>Average</b> | 1  | 15970                             | 271.6                     | 7                            |
| <b>26. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 10.4                                       | 52889                             | 135                       | 300                          |
|   |             |             | 2              | 10.6                                       | 52549                             | 135                       | 300                          |
|   |             |             | 3              | 11.2                                       | 51440                             | 135                       | 310                          |
|   |             |             | <b>Average</b> | 10.7                                       | 52293                             | 135                       | 310                          |
| <b>29. Ore calciner</b>                       |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP                                   | C           | ORSAT       | 1              | 16.6                                       | 103943                            |                           |                              |
|   |             |             | 2              | 17.3                                       | 113227                            |                           |                              |
|   |             |             | 3              | 15.2                                       | 109541                            |                           |                              |
|   |             |             | <b>Average</b> | 16.4                                       | 108904                            | 262                       | 500                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic feet per minute.

<sup>c</sup>Units in tons/hr.

<sup>d</sup>Units in lb/ton.

**TABLE 4.3-1 (ENGLISH UNITS) (concluded)**

## GLOBAL WARMING GASES: CARBON DIOXIDE

| Control Equipment        | Test Rating | Test Method | Run #          | CO <sub>2</sub> Concentration <sup>a</sup> | Volumetric flow rate <sup>b</sup> | Process Rate <sup>c</sup> | Emission Factor <sup>d</sup> |
|--------------------------|-------------|-------------|----------------|--|-----------------------------------|---------------------------|------------------------------|
| <b>30a. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | D           | ORSAT       | 1              | 10.1                                       | 129773                            | 110.6                     | 320                          |
|                          |             |             | 2              | 5.5  | 133064                            | 103.5                     | 320                          |
|                          |             |             | 3              | 5.0  | 125147                            | 103.5                     | 220                          |
|                          |             |             | <b>Average</b> | 6.9  | 129328                            | 105.9                     | 290                          |
| <b>30b. Ore calciner</b> |             |             |                |  |                                   |                           |                              |
| Cyclone/ESP              | D           | ORSAT       | 1              | 4.5  | 105893                            | 93.9                      | 1000                         |
|                          |             |             | 2              | 4.5  | 101375                            | 93.9                      | 570                          |
|                          |             |             | 3              | 3.0  | 104962                            | 95.2                      | 480                          |
|                          |             |             | <b>Average</b> | 4.0  | 104077                            | 94.3                      | 690                          |

<sup>a</sup>Concentration in percent.

<sup>b</sup>Units in dry standard cubic feet per minute.

<sup>c</sup>Units in tons/hr.

<sup>d</sup>Units in lb/ton.

#### Stratospheric Ozone-Depleting Gases.

Chlorofluorocarbons, halons, carbon tetrachloride, methyl chloroform and hydro fluorocarbons have been found to contribute to depletion of the stratospheric ozone layer. No data on emissions of these pollutants were found for the sodium carbonate manufacturing process.

#### **4.4 DATA GAP ANALYSIS**

No quantitative emissions data suitable for the development of emission factors were obtained for the direct carbonation process, which is presently used at one plant in California. The possibility of additional facilities utilizing this method of obtaining soda ash from sodium carbonate-rich brine would greatly increase the value of such data.

As discussed in section 4.2, characteristics of the industry and of regulations imposed upon it by the state of Wyoming are such that compliance test reports on sodium carbonate manufacturing facilities generally do not include particle size distribution data, nor do they test efficiencies of particulate control devices. Therefore, the only information of this nature that PES was able to obtain was that in References 32-34. As discussed in section 4.1, the questionable testing methodologies and insufficient documentation found in these source test reports makes the information found therein unsuitable for use in the development of emission factors or particle size distributions or the estimation of typical control efficiencies.

Similarly, emissions of sulfur dioxide, oxides of nitrogen, carbon monoxide, and other products of combustion occur from direct-fired rotary calcining kilns and product dryers, but the only quantitative emissions information found for these pollutants was that contained in References 32-34. References 12 and 15 also contain NO<sub>x</sub> emissions data, but the inconsistency of these data make the development of emission factors infeasible.

Sufficient high-quality source test data on calciners and dryers, which are responsible for a large percentage of total particulate emissions from each of the Wyoming sodium carbonate manufacturing facilities, exists to allow development of "A" and "B" rated emission factors. However, as could be expected given their contribution to total facility emissions, the quality and quantity of source test data for ore processing before calcining (mining, transfer, etc.) and for product handling is significantly less than that for calciners and dryers. These source categories should be tested more frequently to accurately assess their contribution to facility emission inventories.

#### 4.5 REFERENCES FOR CHAPTER 4

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**TABLE 4.5-1.  
LIST OF CONVERSION FACTORS**

| <b>Multiply:</b> | <b>by:</b>              | <b>To obtain:</b> |
|------------------|-------------------------|-------------------|
| mg/dscm          | 4.37 x 10 <sup>-4</sup> | gr/dscf           |
| m <sup>2</sup>   | 10.764                  | ft <sup>2</sup>   |
| acm/min          | 35.31                   | acfm              |
| m/s              | 3.281                   | ft/s              |
| kg/hr            | 2.205                   | lb/hr             |
| kPa              | 1.45 x 10 <sup>-1</sup> | psia              |
| kg/Mg            | 2.0                     | lb/ton            |
| Mg               | 1.1023                  | ton               |

**Temperature conversion equations:**

Fahrenheit to Celsius:

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

Celsius to Fahrenheit:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

**APPENDIX A.**

**AP-42 SECTION 5.16**

[Not presented here. See instead current AP-42 Section 8.12.]