[Note: with the publication of the Fifth Edition of AP-42, the Chapter and Section number for Sulfuric Acid was changed to 8.10.]

BACKGROUND REPORT

AP-42 SECTION 5.17

SULFURIC ACID

Prepared for

U.S. Environmental Protection Agency
OAQPS/TSD/EIB
Research Triangle Park, NC 27711

December 3, 1992

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919/941-0333

1-96

AP-42 Background Report

TECHNICAL SUPPORT DIVISION

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

This report has been reviewed by the Technical Support Division of the Office of Air Quality Planning and Standards, EPA. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-15), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 programs and industry.

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

1. Estimates of area-wide emissions;
2. 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 test reports to support revision of emission factors for sulfuric acid.

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

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 details criteria and noncriteria pollutant emission factor development. It includes the review of specific data sets and the results of data analysis. Particle size determination and particle size data analysis methodology are described when applicable. Appendix A presents AP-42 Section 5.17.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL[1,2]

Sulfuric acid (H_2SO_4) is a basic raw material used in a wide range of industrial processes and manufacturing operations. Almost 70 percent of sulfuric acid is used in the production of phosphate fertilizers. Other uses include copper leaching, inorganic pigment production, petroleum refining, paper production, and industrial organic chemical production.

Sulfuric acid plants are scattered throughout the nation near every industrial complex due to its widespread use and relatively low production versus shipping costs. The combustion of elemental sulfur is the predominant source of SO_2 used to manufacture H_2SO_4. The combustion of hydrogen sulfide from waste gases, the thermal decomposition of spent sulfuric acid or other sulfur containing materials, and the roasting of pyrites are also used as sources of SO_2. In recent years, primarily for environmental reasons, many non-ferrous metal producers have built sulfuric acid plants to recover the large amounts of SO_2 generated in the smelting process.

Sulfuric acid may be manufactured commercially by either the lead chamber process or the contact process. Because of economics, all of the sulfuric acid produced in the U.S. is now produced by the contact process. U.S. facilities produce approximately 42 million megagrams (46.2 million tons) of H_2SO_4 annually. Growth in demand has been about 1 percent per year from 1981 to 1991 and is projected to continue to increase at about 0.5 percent per year.

2.2 PROCESS DESCRIPTION[3-5]

Since the contact process is the only process currently used, it will be the only one discussed in this section.

Contact plants are classified according to the raw materials charged to them: elemental sulfur burning, spent sulfuric acid and hydrogen sulfide burning, and metal sulfide ores and smelter gas burning. The contributions from these plants to the total acid production are 81, 8 and 11 percent respectively.

The contact process incorporates three basic operations, each of which corresponds to a distinct chemical reaction.

First, the sulfur in the feedstock is oxidized (burned) to sulfur dioxide:

$$S + O_2 \rightarrow SO_2 \qquad (1)$$

The resulting sulfur dioxide is fed to a process unit called a converter where it is catalytically oxidized to sulfur trioxide:

$$2\,SO_2 + O_2 \rightarrow 2SO_3 \qquad (2)$$

Finally, the sulfur trioxide is absorbed in a strong sulfuric acid (98 percent) solution:

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad (3)$$

Elemental Sulfur Burning Plants

A schematic diagram of a dual absorption contact process sulfuric acid plant that burns elemental sulfur is shown in Figure 2.2-1.

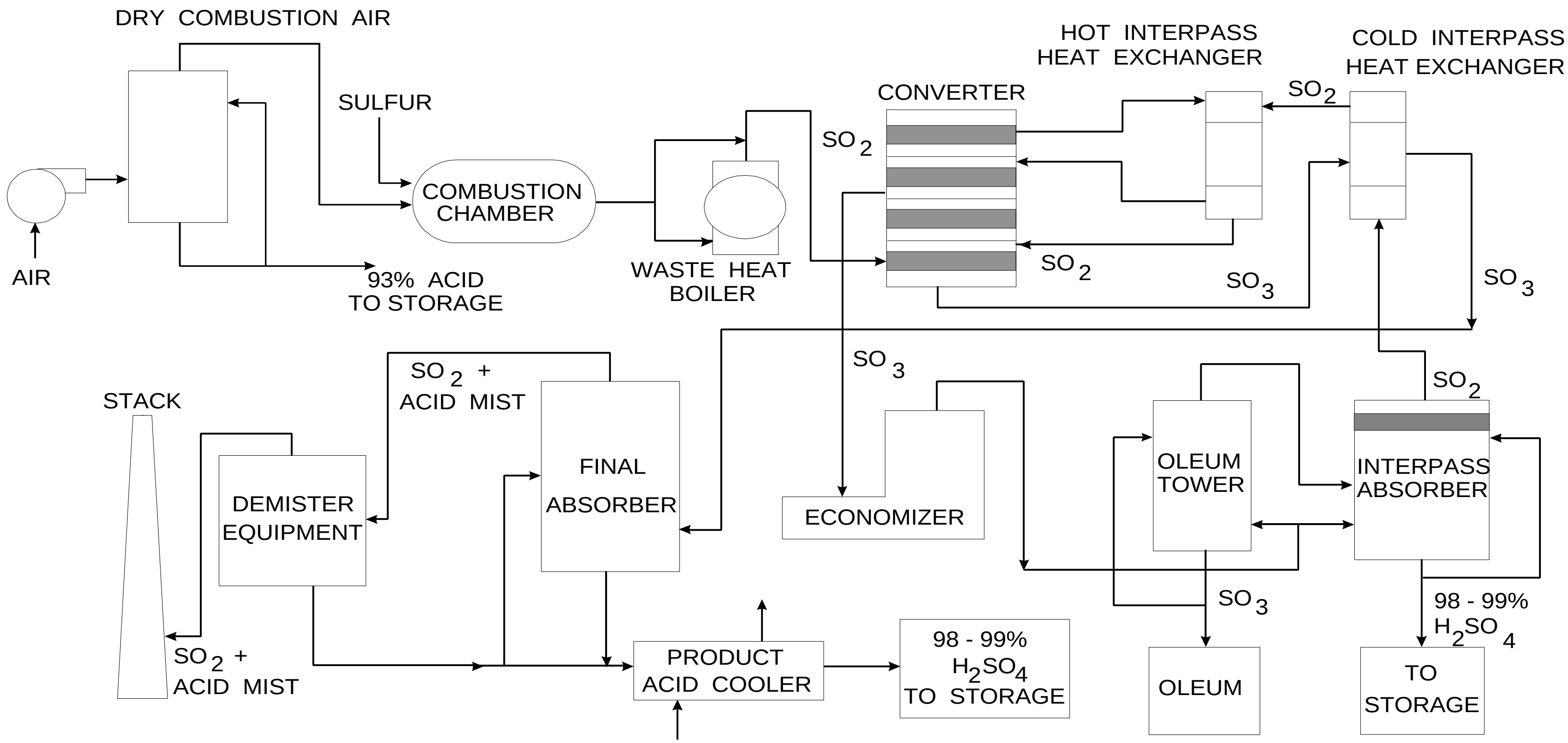

Figure 2.2-1 Basic flow diagram of contact process sulfuric acid plant burning elemental sulfur

In the Frasch process, elemental sulfur is melted, filtered to remove ash, and sprayed under pressure into a combustion chamber. The sulfur is burned in clean air that has been dried by scrubbing with 93 to 99 percent sulfuric acid. The gases from the combustion chamber cool by passing through a waste heat boiler and then enter the catalyst (vanadium pentoxide) converter. Usually, 95 to 98 percent of the sulfur dioxide from the combustion chamber is converted to sulfur trioxide, with an accompanying large evolution of heat. After being cooled, again by generating steam, the converter exit gas enters an absorption tower. The absorption tower is a packed column where acid is sprayed in the top and the sulfur trioxide enters from the bottom. The sulfur trioxide is absorbed in the 98 to 99 percent sulfuric acid. The sulfur trioxide combines with the water in the acid and forms more sulfuric acid.

If oleum (a solution of uncombined SO_3 dissolved in H_2SO_4) is produced, SO_3 from the converter is first passed to an oleum tower that is fed with 98 percent acid from the absorption system. The gases from the oleum tower are then pumped to the absorption column where the residual sulfur trioxide is removed.

In the dual absorption process shown in Figure 2.2-1, the SO_3 gas formed in the primary converter stages is sent to an interpass absorber where most of the SO_3 is removed to form H_2SO_4. The remaining unconverted sulfur dioxide is forwarded to the final stages in the converter to remove much of the remaining SO_2 by oxidation to SO_3, from whence it is sent to the final absorber for removal of the remaining sulfur trioxide. The single absorption process uses only one absorber as the name implies.

Spent Acid and Hydrogen Sulfide Burning Plants

A schematic diagram of a contact process sulfuric acid plant that burns spent acid is shown in Figure 2.2-2.

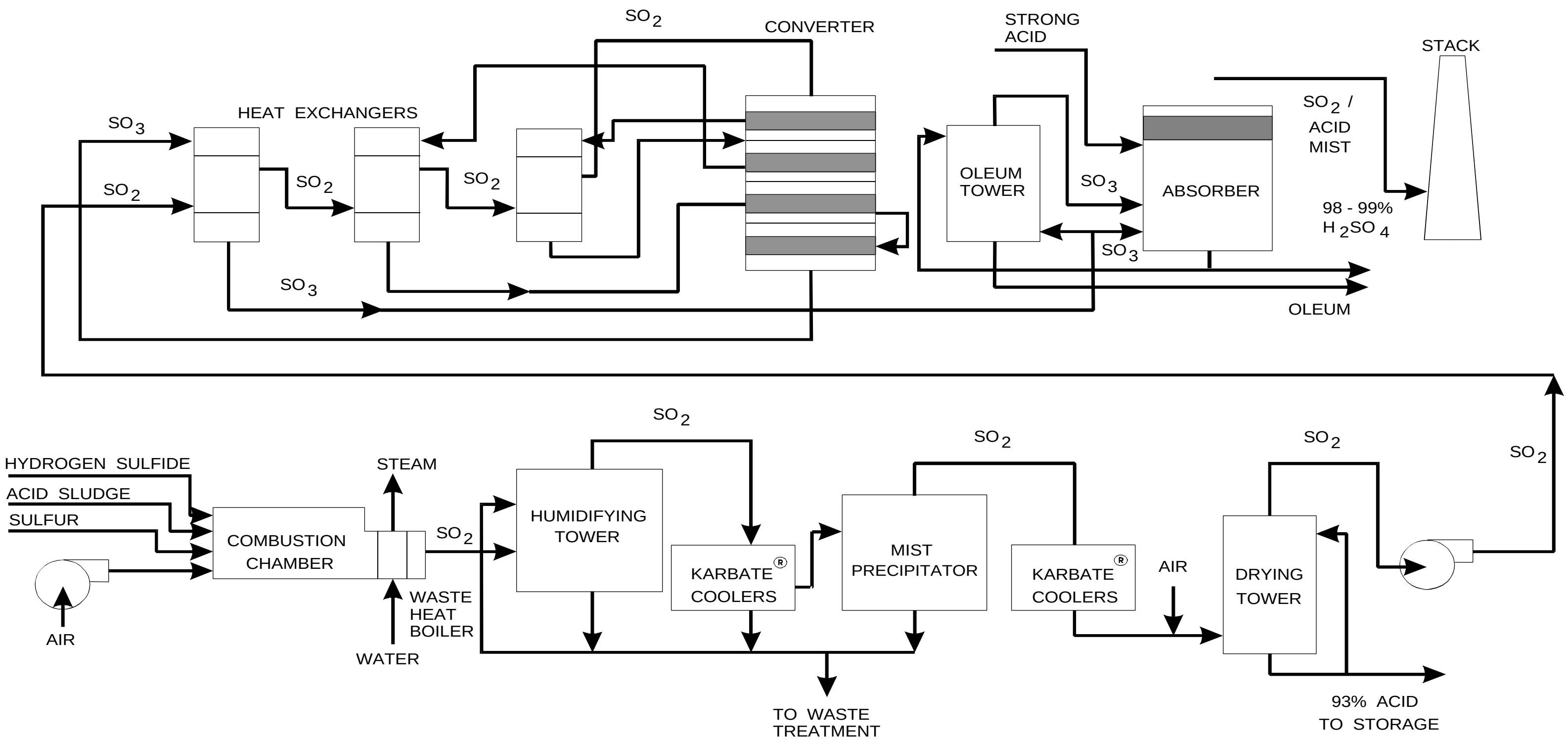

Figure 2.2-2 Basic flow diagram of contact process sulfuric acid plant burning spent acid

Two types of plants are used to process this type of sulfuric acid. In one, the sulfur dioxide and other combustion products from the combustion of spent acid and/or hydrogen sulfide with undried atmospheric air are passed through gas cleaning and mist removal equipment. The gas stream next passes through a drying tower. A blower draws the gas from the drying tower and discharges the sulfur dioxide gas to the sulfur trioxide converter, then to the oleum tower and/or absorber, as discussed in the previous flow diagram.

In a "wet gas plant," the wet gases from the combustion chamber are charged directly to the converter with no intermediate treatment. The gas from the converter flows to the absorber, through which 93 to 98 percent sulfuric acid circulates.

Sulfide Ores and Smelter Gas Plants

The configuration of this type of plant is essentially the same as that of a spent acid plant (Figure 2.2-2), with the primary exception that a roaster is used in place of the combustion furnace.

The feed used in these plants is smelter gas, available from such equipment as copper converters, reverberatory furnaces, roasters and flash smelters. The sulfur dioxide in the gas is contaminated with dust, acid mist and gaseous impurities. To remove the impurities, the gases must be cooled and passed through purification equipment consisting of cyclone dust collectors, electrostatic dust and mist precipitators, and scrubbing and gas cooling towers. After the gases are cleaned and the excess water vapor is removed, they are scrubbed with 98 percent acid in a drying tower. Beginning with the drying tower stage, these plants are nearly identical to the elemental sulfur plants shown in Figure 2.2-1.

2.3 EMISSIONS AND CONTROLS[3,4,6,7]

Sulfur Dioxide

Nearly all sulfur dioxide emissions from sulfuric acid plants are found in the exit stack gases. Extensive testing has shown that the mass of these SO_2 emissions is an inverse function of the sulfur conversion efficiency (SO_2 oxidized to SO_3). This conversion is always incomplete, and is affected by the number of stages in the catalytic converter, the amount of catalyst used, temperature and pressure, and the concentrations of the reactants (sulfur dioxide and oxygen). For example, if the inlet SO_2 concentration to the converter were 9 percent by volume (a representative value), and the conversion temperature was 430°C (806°F), the conversion efficiency would be 98 percent. At this conversion, the uncontrolled emission factor for SO_2 would be 13 kg/Mg (26 pounds per ton) of 100 percent sulfuric acid produced. (For purposes of comparison, note that the Environmental Protection Agency's (EPA) new source performance standard (NSPS) for new and modified plants is 2 kg/Mg (4 pounds per ton) of 100 percent acid produced, maximum 2 hour average). As Figure 2.3-1

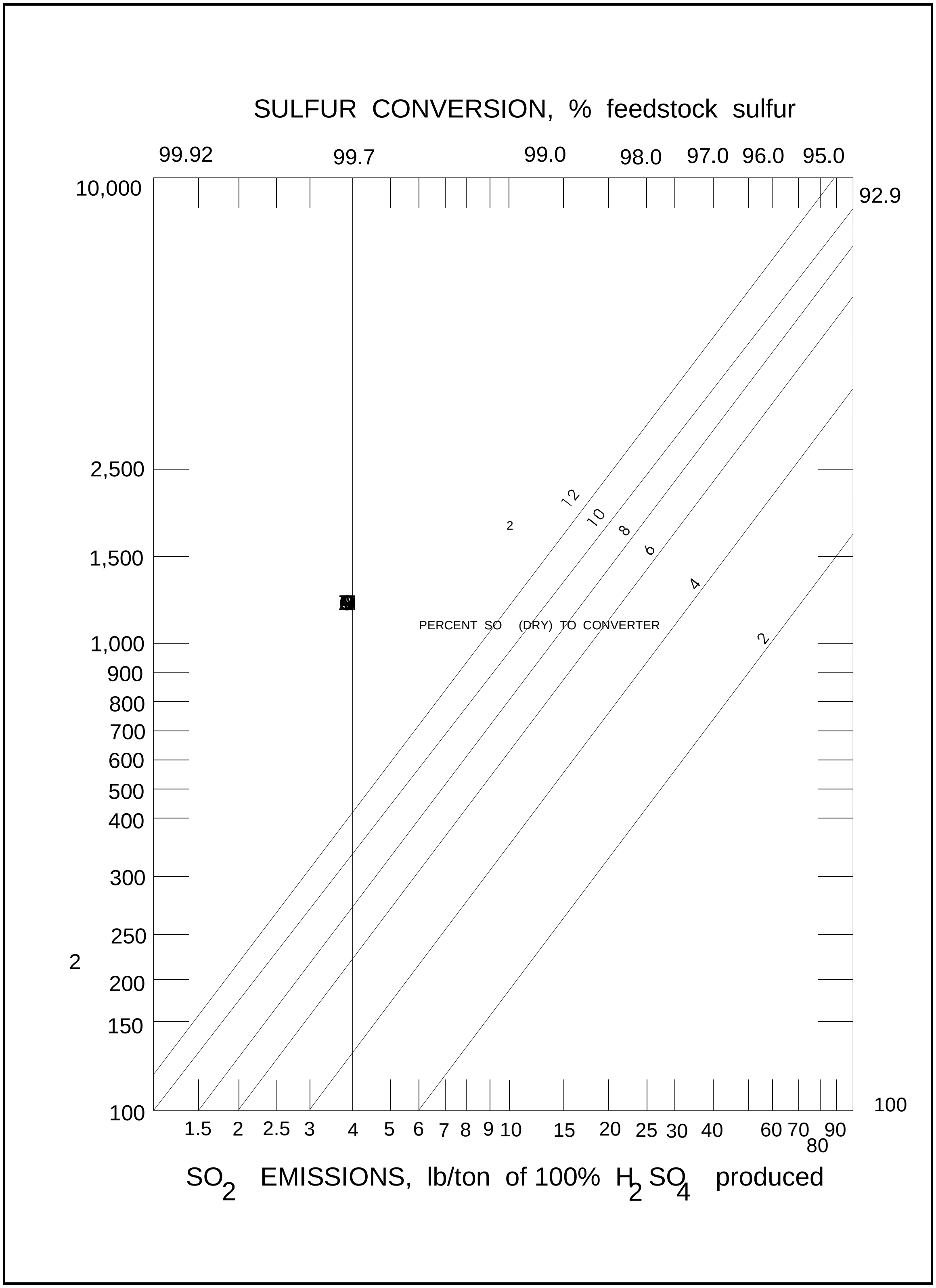

Figure 2.3-1 Sulfuric acid plant feedstock conversion versus volumetric and mass SO2 emissions at various inlet SO2 concentrations by volume.

indicates, achieving this standard requires a conversion efficiency of 99.7 percent in an uncontrolled plant or the equivalent SO_2 collection mechanism in a controlled facility.

In addition to exit gases, small quantities of sulfur oxides are emitted from storage tank vents and tank car and tank truck vents during loading operations, from sulfuric acid concentrators, and through leaks in process equipment. Very limited data are available on the quantity of emissions from these sources (See Chapter 4.2).

Dual absorption, as discussed in the Process Description section, has generally been accepted as the Best Available Control Technology (BACT) for meeting SO_2 emission limits. There are no by-products or waste scrubbing materials created, only additional sulfuric acid. Conversion efficiencies of 99.7 percent and higher are achievable, whereas most single absorption plants have SO_2 conversion efficiencies ranging from 95 to 98 percent. Furthermore, dual absorption permits higher converter inlet sulfur dioxide concentrations than are used in single absorption plants because the final conversion stages effectively remove any residual sulfur dioxide from the interpass absorber.

Acid Mist

Nearly all the acid mist emitted from sulfuric acid manufacturing can be traced to the absorber exit gases. Acid mist is created when sulfur trioxide combines with water vapor at a temperature below the dew point of sulfur trioxide. Once formed within the process system, this mist is so stable that only a small quantity can be removed in the absorber.

In general, the quantity and particle size distribution of acid mist are dependent on the type of sulfur feedstock used, the strength of acid produced, and the conditions in the absorber. Because it contains virtually no water vapor, bright elemental sulfur produces little acid mist when burned. However, the hydrocarbon impurities in other feedstocks (i.e. dark sulfur, spent acid and hydrogen sulfide) oxidize to water vapor during combustion. The water vapor, in turn, combines with sulfur trioxide as the gas cools in the system.

The strength of acid produced, whether oleum or 99 percent sulfuric acid, also affects mist emissions. Oleum plants produce greater quantities of finer more stable mist. For example, an unpublished report found that uncontrolled mist emissions from oleum plants burning spent acid range from 0.5 to 5.0 kg/Mg (1.0 to 10.0 pounds per ton), while those from 98 percent acid plants burning elemental sulfur range from 0.2 to 2.0 kg/Mg (0.4 to 4.0 pounds per ton).[4] Furthermore, 85 to 95 weight percent of the mist particles from oleum plants are less than two microns in diameter, compared with only 30 weight percent that are less than two microns in diameter from 98 percent acid plants.

The operating temperature of the absorption column directly affects sulfur trioxide absorption and, accordingly, the quality of acid mist formed after exit gases leave the stack. The optimum absorber operating temperature depends on the strength of the acid produced, throughput rates, inlet sulfur trioxide concentrations, and other variables peculiar to each individual plant. Finally, it should be emphasized that the percentage conversion of sulfur trioxide has no direct effect on acid mist emissions.

2.4 REVIEW OF SPECIFIC DATA SETS

Pacific Environmental Services (PES) contacted the following sources to obtain the most up-to-date information on process descriptions and emissions for this industry:

1) Zinc Corporation of America, Bartlesville, OK, and Monarch, PA.
2) Alabama Department of Environmental Management, Montgomery, AL.
3) Allied-Signal, Hopewell, VA.
4) Chemical Manufacturers' Association, Washington, DC.
5) Church and Dwight, Princeton, NJ.
6) Florida Department of Environmental Regulation, Tallahassee, FL.
7) Georgia Department of Natural Resources, Atlanta, GA.
8) J.R. Simplot Co., Pocatello, ID.
9) Kansas Department of Health and Environment, Topeka, KS.
10) Magna Copper Co., Tucson, AZ.
11) Michigan Department of Natural Resources, Lansing, MI.
12) Missouri Department of Natural Resources, Jefferson City, MO.
13) North Carolina Division of Environmental Management, Raleigh, NC.
14) Pennsylvania Department of Environmental Resources, Harrisburg, PA.
15) Rhone Poulênc, Shelton, CT.
16) Texas Gulf, Inc., Aurora, NC.

Responses were received from three of the contacts. No responses were received from the remaining sources. Both locations for Source (1) provided general process descriptions that were incorporated into the update. Source (6) provided a large amount of source test data results that are discussed in Chapter 4.3.

Reference 1: *Chemical Marketing Reporter*

Reference 1 was obtained through a literature search and used to update statistical information about the industry such as production volumes and regional statistics.

Reference 2: *Control of Sulfuric Acid Emissions*

Reference 3: *Atmospheric Emissions from Sulfuric Acid Manufacturing Processes*

Reference 4: *Unpublished report on control of sulfuric acid emissions*

Reference 6: *Standards of Performance for New Stationary Sources*

These references were used in the previous AP-42 Section 5.17 update. The information presented based on these references was left unchanged.

Reference 5: *Review of New Source Performance Standards for Sulfuric Acid Plants*

Reference 5 was obtained through a literature search and reviewed to confirm the process descriptions and control techniques discussed in this update.

Reference 7: *Air Pollution Engineering Manual (AP-40)*

Reference 7 was obtained from the author of the sulfuric acid chapter, Tom Muller with DuPont Chamber Works, and was used to update the process diagrams and descriptions.

2.5 REFERENCES FOR CHAPTER 2

1. Chemical Marketing Reporter, Schnell Publishing Company, Inc., New York, NY, Volume 240, Number 8, September 16, 1991.

2. Final Guideline Document: Control of Sulfuric Acid Mist Emissions from Existing Sulfuric Acid Production Units, EPA 450/2-77-019, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1977.

3. Atmospheric Emissions from Sulfuric Acid Manufacturing Processes, 999-AP-13, U.S. Department of Health, Education and Welfare, Washington, DC, 1966.

4. Unpublished report on control of air pollution from sulfuric acid plants, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1971.

5. Review of New Source Performance Standards for Sulfuric Acid Plants, EPA 450/3-85-012, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1985.

6. Standards of Performance for New Stationary Sources, 36 FR 24875, December 23, 1971.

7. Air Pollution Engineering Manual (AP-40), Air and Water Management Association, Sulfuric Acid Chapter, to be published in June 1992.

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 sulfuric acid production. This search included, but was not limited to, the following references:

1) AP-42 background files maintained by the Emission Factor and Methodologies Section.
2) Files maintained by the Emission Standards Division.
3) Background Information Documents for NSPS and NESHAPS.
4) Handbook of Emission Factors, Parts I and II, Ministry of Health and Environmental Protection, The Netherlands, 1980/1983.
5) The EPA databases, including but not limited to the *VOC/Particulate Matter* (PM) *Speciation Database Management System* (SPECIATE) and the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF), and the Emission Measurement Technical Information Center's *Test Methods Storage and Retrieval System* (TSAR).

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. AP-42, Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, October, 1986.

4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT

4.1 REVIEW OF SPECIFIC DATA SETS

Reference 1

Reference 1 is a source test at Facility No. 1 on June 21, 1989. The test has been rated "B" due to the lack of a control device description. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 2

Reference 2 is a source test at Facility No. 1 on November 18, 1987. The test has been rated "B" due to the lack of a control device description. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 3

Reference 3 is a source test at Facility No. 2 on December 15, 1989. The test has been rated "B" due to the lack of a control device description. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 4

Reference 4 is a source test at Facility No. 1 on November 20, 1991. The test has been rated "B" due to the lack of a control device description. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 5

Reference 5 is a source test at Facility No. 3 on January 27, 1983. The test has been rated "C" due to the lack of a control device efficiency or any pre or post test calibration information. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 6

Reference 6 is a source test at Facility No. 3 on January 26, 1983. The test has been rated "C" due to the lack of a control device efficiency or any pretest calibration information. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 7

Reference 7 is a source test at Facility No. 4 on October 22 and 23, 1991. The test has been rated "C" due to the lack of a control device efficiency, missing equipment setup descriptions, and a process description. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 8

Reference 8 is a source test at Facility no. 5 on March 13, 1991. The test has been rated "B" due to the lack of control device efficiencies and ambiguity in the equipment setup. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 9

Reference 9 is a source test at Facility No. 4 on June 6, 1991. The test has been rated "C" due to the lack of a control device description or equipment setup descriptions. No information was available on these tests to further define the "elemental sulfur" feedstock. All other pertinent test data is available.

Reference 10

Reference 10 is a source test at Facility No. 4 on February 21, 1992. The test has been rated "D" due to lack of a control device description, minimum Methods 1-4 documentation, no equipment descriptions and no calibration documentation. No information was available on these tests to further define the "elemental sulfur" feedstock.

Reference 11

Reference 11 is a comprehensive emission study done in 1966 on the sulfuric acid production industry. Although it contains detailed discussions of testing results and techniques, no primary source test data is available to confirm the results. The data is also over 25 years old and may not be representative of the industry today. Note too that the emissions data is not consistent, i.e., sulfuric acid mist emissions do not always increase with increasing oleum percentage as was discussed in Chapter 2.3 (e.g., tests 10 and 11). The study has therefore been rated "C" versus "A" in the previous update. The emission factors presented in the AP-42 document and based on this data have been downgraded to "E."

As discussed in section 4.2, the sulfuric acid mist emission factors are shown as ranges to reflect the varying emissions from plants that produce oleum. The emission factor ranges for uncontrolled emissions are listed below for each category:

Recovered Sulfur

Minimum (0 Percent Oleum):

0.174 kg/Mg (0.35 lbs/ton) from Source Test # 8

Maximum (43 Percent Oleum):

0.40 kg/Mg (0.80 lbs/ton) from Source Test # 7B

Bright Virgin Sulfur

Minimum (0 Percent Oleum):

0.85 kg/Mg (1.7 lbs/ton) from Source Test # 9

Maximum (0 Percent Oleum):

0.85 kg/Mg (1.7 lbs/ton) from Source Test # 9

(Only one data point was available)

Dark Virgin Sulfur

Minimum (0 Percent Oleum):

0.162 kg/Mg (0.32 lbs/ton) from Source Test # 11

Maximum (100 Percent Oleum):

3.14 kg/Mg (6.28 lbs/ton) from Source Test # 12

Pyrite

Minimum (25 Percent Oleum):

0.600 kg/Mg (1.20 lbs/ton) from Source Test # 13

Maximum (0 Percent Oleum):

3.68 kg/Mg (7.4 lbs/ton) from Source Test # 14

Note: Pyrite was eliminated from this update of Section 5.17 due to data inconsistency (i.e., the emission factors should be higher with higher oleum percentages).

Spent Acid

Minimum (0 Percent Oleum):

1.11 kg/Mg (2.22 lbs/ton) from Source Test # 18

Maximum (77 Percent Oleum):

1.20 kg/Mg (2.40 lbs/ton) from Source Test # 16

The maximums and minimums for controlled emissions are shown below:

Dark Virgin Sulfur

Minimum (0 Percent Oleum):

0.26 kg/Mg (0.52 lbs/ton) from Source Test # 2A

Maximum (13 Percent Oleum):

1.80 kg/Mg (3.6 lbs/ton) from Source Test # 2B

Spent Acid

Minimum (0 Percent Oleum):

0.014 kg/Mg (0.028 lbs/ton) from Source Test # 3C

Maximum (56 Percent Oleum):

0.20 kg/Mg (0.40 lbs/ton) from Source Test # 4

The emission factors quoted in this update are, in some cases, different than those included in the previous update. Other than those changes noted above, the differences are the result of minor changes that were necessary to correct mistakes made in transmitting the data from Reference 11.

Reference 12

The State of Florida, Department of Environmental Regulation, provided PES with a summary listing of the results of 242 separate compliance source tests from 11 different sulfuric acid plants. The data was not used to update the emission factors for Section 5.17, however, since none of the background information (e.g., testing procedures, calibration information, process descriptions, etc.) was available to verify the test results.

Pacific Environmental Services has included this reference in the background report for information purposes only. Note that the average controlled sulfuric acid mist emission factor calculated from the 242 tests is 0.043 kg/Mg (0.086 lb/ton) which agrees well with the 0.064 kg/Mg (0.128 lb/ton) factor calculated from the nine "A" and "B" rated source tests (See Chapter 4.3). This implies that the Florida data is reliable, although no background information is available for confirmation.

Reference 13

Reference 13 is a collection of three consecutive source tests at Mississippi Chemical Corporation in Pascagoula, Mississippi. The tests have been rated "B" due to the lack of calibration documentation. These tests were used to substantiate the sulfuric acid NSPS.

References 14 and 15

References 14 and 15 are a collection of 20 source tests at two separate Kennecott Copper Corporation sulfuric acid plants in Salt Lake City, Utah. The tests have been rated "A". These tests were used to substantiate the sulfuric acid NSPS.

Reference 16

Reference 16 is a collection of 8 source tests at American Smelting and Refining Company in Hayden, Arizona. The tests have been rated "B" due to the lack of documentation of pre and post-test calibration. These tests were used to substantiate the sulfuric acid NSPS.

4.2 CRITERIA POLLUTANT EMISSIONS DATA

Volatile Organic Compounds.

No data on emissions of these pollutants were found for sulfuric acid production.

Lead.

No data on emissions of these pollutants were found for sulfuric acid production.

Sulfur dioxide.

As discussed in Chapter 2.3, sulfur dioxide emissions are an inverse function of sulfur conversion efficiency (SO_2 oxidized to SO_3). Consequently, source tests will yield a variety of results depending on the specific operating conditions at the test site.

Table 4.2-1 is a compilation of sulfur dioxide source tests from several acid production plants, source tests used to substantiate the sulfuric acid NSPS, as well as the results from tests found in Reference 11. The data is included in this background report for information purposes only. Each publication referred to in Chapter 2.4 contained a copy of Figure 2.2-3 and recommended it be used to estimate SO_2 emissions from sulfuric acid production, as did the previous AP-42 Section 5.17. Although the text in the references indicated that the Figure was developed through "extensive testing," PES was unable to locate this test data. Attempts to verify the Figure using the test data in Table 4.2-1 were also unsuccessful due to the lack of several key parameters (e.g., percent SO_2 (dry) to the converter) used to plot the data. Consequently, the emission factors based on Figure 2.2-3 have been lowered from "A" to "E". Note that the emission factors calculated from these source tests do fall within the range of values on Figure 2.2-3.

TABLE 4.2-1 (METRIC UNITS)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.						
Unknown	B	Method 8	1	41.6	100	2.41
			2	41.6	107	2.56
			3	41.5	96.1	2.31
			Average	41.6	101	2.43
2.						
Unknown	B	Method 8	1	40.6	81.6	2.01
			2	42.1	58.5	1.39
			3	38.2	51.7	1.35
			Average	40.3	63.9	1.59
3.						
Unknown	B	Method 8	1	48.3	605.7	12.53
			2	48.3	572.7	11.87
			3	63.3	1041.9	16.46
			4	62.7	1039.2	16.58
			5	63.3	1078.7	17.04
			Average	57.1	867.6	15.18
4.						
Unknown	B	Method 8	1	43.7	25.24	0.578
			2	43.7	22.78	0.522
			3	41.3	21.10	0.512
			Average	42.9	23.04	0.538
5.						
Absorber	C	Method 8	1	4.2	49.61	11.90
			2	4.2	54.87	13.16
			3	4.2	56.42	13.53
			Average	4.2	53.65	12.86

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (METRIC UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6.						
Absorber	B	Method 8	1	2.81	35.72	12.71
			2	2.81	38.01	13.52
			3	2.81	39.94	14.21
			Average	2.81	37.89	13.48
7.						
Unknown	C	Method 8	1	121.0	231.1	1.91
			2	120.5	224.8	1.87
			3	122.9	243.4	1.98
			Average	121.5	233.1	1.92
8.						
Absorber	B	Method 8	1	11.3	143.1	12.63
			2	11.3	171.7	15.15
			3	11.3	137.2	12.11
			Average	11.3	150.7	13.29
9.						
Unknown	C	Method 8	1	136.1	259.9	1.91
			2	136.1	257.1	1.89
			3	138.1	245.2	1.78
			Average	136.8	254.1	1.86
10.						
Unknown	D	Method 8	1	64.9	91.9	1.42
			2	64.9	97.7	1.51
			3	64.8	100.5	1.55
			Average	64.9	96.7	1.49

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (METRIC UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
13a.						
Absorber	B	Method 8	1	1365	128.7	2.27
			2	1365	131.5	2.31
			3	1365	118.8	2.08
			Average	1365	126.6	2.22
13b.						
Absorber	B	Method 8	1	1367	129.3	2.27
			2	1367	137.9	2.42
			3	1367	121.6	2.13
			Average	1367	129.7	2.27
13c.						
Absorber	B	Method 8	1	1369	154.7	2.71
			2	1369	158.3	2.78
			3	1369	142.9	2.50
			Average	1369	152	2.67
14.						
Absorber	A	Method 8	1	1161.2	865.5	0.75
			2	1161.2	2262	1.95
			3	1161.2	4917	4.23
			4	1161.2	6559	5.65
			5	1161.2	13555	11.67
			6	1161.2	7069	6.09
			7	1161.2	11956	10.3
			8	1161.2	5914	5.09
			9	1161.2	8729	7.52
			10	1161.2	6768	5.83
			Average	1161.2	6863	5.91

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (METRIC UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
15.						
Absorber	A	Method 8	1	1161.2	3802	3.27
			2	1161.2	1951	1.68
			3	1161.2	5023	4.33
			4	1161.2	14718	12.7
			5	1161.2	9288	8.00
			6	1161.2	7934	6.83
			7	1161.2	19245	16.6
			8	1161.2	8138	7.01
			9	1161.2	10288	8.86
			10	1161.2	10742	9.25
			Average	1161.2	9113	7.85
16.						
Absorber	B	Method 8	1	794	19697	24.8
			2	794	42779	53.9
			3	794	30251	38.1
			4	794	19156	24.1
			5	794	35182	44.3
			6	794	26807	33.8
			7	794	24181	30.5
			8	794	25729	32.4
			Average	794	27973	35.2

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (METRIC UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.[d]						
Unknown	C		1	667	10433	15.7
			2	872	9435	10.8
			Average	769	9934	12.9
2a.[d]						
Unknown	C		1	590	17237	29.3
			2	136	1633	12
			Average	363	9435	26
2b.[d]						
Unknown	C		1	590	17237	29.3
			2	136	1724	12.7
			Average	363	9480	26.2
3c.[d]						
Unknown	C		1	109	1996	18.4
			2	199	3629	18.3
			Average	154	2812	18.3
4.[d]						
Unknown	C		1	383	7258	19
			2	121	1361	11.3
			Average	252	4309	17.1
5a.[d]						
Unknown	C		1	118	2449	20.8
			2	272	6350	23.4
			Average	195	4400	22.6

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.2-1 (METRIC UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6a.[d]						
Unknown	C		1	91	1542	17
			2	240	2540	10.6
			Average	166	2041	12.3
6b.[d]						
Unknown	C		1	91	1542	17
			2	272	4627	17
			Average	181	3084	17
7a.[d]						
Unknown	C		Average	295	10251	34.8
7b.[d]						
Unknown	C		**Average**	295	1043	3.5
7c.[d]						
Unknown	C		**Average**	73	1633	11.1
8.[d]						
Unknown	C		1	104	1633	15.7
			2	389	6169	15.9
			Average	247	3901	15.8
9.[d]						
Unknown	C		1	191	3357	17.6
			2	247	4536	18.4
			Average	219	3946	18.1
10.[d]						
Unknown	C		**Average**	454	13971	30.8
11.[d]						
Unknown	C		**Average**	281	4899	17.4

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.2-1 (METRIC UNITS) (*concluded*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
12.[d]						
Unknown	C		**Average**	240	6804	28.3
13.[d]						
Unknown	C		**Average**	259	4899	19
16.[d]						
Unknown	C		**Average**	590	25129	42.6
17.[d]						
Unknown	C		**Average**	274	4536	16.6
18.[d]						
Unknown	C		**Average**	816	24494	30

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.2-1 (ENGLISH UNITS)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.						
Unknown	B	Method 8	1	45.9	221	4.815
			2	45.9	235	5.120
			3	45.8	212	4.629
			Average	45.9	223	4.855
2.						
Unknown	B	Method 8	1	44.8	180	4.018
			2	46.4	129	2.780
			3	42.1	114	2.708
			Average	44.4	141	3.173
3.						
Unknown	B	Method 8	1	53.3	1335.5	25.06
			2	53.2	1262.7	23.73
			3	69.8	2297.4	32.91
			4	69.1	2291.4	33.16
			5	69.8	2378.5	34.08
			Average	63.0	1913.1	30.35
4.						
Unknown	B	Method 8	1	48.2	55.65	1.155
			2	48.2	50.23	1.043
			3	45.5	46.52	1.023
			Average	47.3	50.8	1.075
5.						
Unknown	C	Method 8	1	4.6	109.4	23.79
			2	4.6	121.0	26.31
			3	4.6	124.4	27.05
			Average	4.6	118.3	25.72

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.

TABLE 4.2-1 (ENGLISH UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6.						
Unknown	B	Method 8	1	3.1	78.77	25.41
			2	3.1	83.82	27.04
			3	3.1	88.07	28.41
			Average	3.1	83.55	26.95
7.						
Unknown	C	Method 8	1	133.4	509.6	3.82
			2	132.9	495.7	3.73
			3	135.5	536.6	3.96
			Average	133.9	514.0	3.84
8.						
Unknown	B	Method 8	1	12.5	315.6	25.25
			2	12.5	378.6	30.29
			3	12.5	302.6	24.21
			Average	12.5	332.3	26.58
9.						
Unknown	C	Method 8	1	150	573	3.82
			2	150	567	3.78
			3	152.3	540.7	3.55
			Average	150.8	560.2	3.72
10.						
Unknown	D	Method 8	1	76.6	202.6	2.83
			2	71.6	215.5	3.01
			3	71.5	221.7	3.10
			Average	71.6	213.3	2.98

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.

TABLE 4.2-1 (ENGLISH UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
13a.						
Absorber	B	Method 8	1	1505	284	4.53
			2	1505	290	4.62
			3	1505	262	4.17
			Average	1505	279	4.44
13b.						
Absorber	B	Method 8	1	1507	285	4.54
			2	1507	304	4.84
			3	1507	268	4.27
			Average	1507	286	4.55
13c.						
Absorber	B	Method 8	1	1509	341	5.42
			2	1509	349	5.56
			3	1509	315	5.01
			Average	1509	335	5.33
14.						
Absorber	A	Method 8	1	1280	1908	1.49
			2	1280	4988	3.90
			3	1280	10839	8.47
			4	1280	14459	11.30
			5	1280	29883	23.4
			6	1280	15584	12.2
			7	1280	26358	20.6
			8	1280	13037	10.2
			9	1280	19244	15.0
			10	1280	14921	11.7
			Average	1280	15122	11.8

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (ENGLISH UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
15.						
Absorber	A	Method 8	1	1280	8381	6.55
			2	1280	4302	3.36
			3	1280	11073	8.65
			4	1280	32446	25.3
			5	1280	20477	16.0
			6	1280	17490	13.7
			7	1280	42428	33.1
			8	1280	17940	14.0
			9	1280	22682	17.7
			10	1280	23681	18.5
			Average	1280	20090	15.7
16.						
Absorber	B	Method 8	1	875	43424	49.6
			2	875	94310	108
			3	875	66692	76.2
			4	875	42230	48.3
			5	875	77562	88.6
			6	875	59098	67.5
			7	875	53310	60.9
			8	875	56723	64.8
			Average	875	61669	70.5

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.2-1 (ENGLISH UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.[d]						
Unknown	C		1	735	23000	31.3
			2	961	20800	21.6
			Average	848	21900	25.8
2a.[d]						
Unknown	C		1	650	38000	58.5
			2	150	3600	24
			Average	400	20800	52
2b.[d]						
Unknown	C		1	650	38000	58.5
			2	150	3800	25.3
			Average	400	20900	52.3
3c.[d]						
Unknown	C		1	120	4400	36.7
			2	219	8000	36.5
			Average	170	6200	36.5
4.[d]						
Unknown	C		1	422	16000	37.9
			2	133	3000	22.6
			Average	278	9500	34.2
5a.[d]						
Unknown	C		1	130	5400	41.5
			2	300	14000	46.7
			Average	215	9700	45.1

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

TABLE 4.2-1 (ENGLISH UNITS) (*continued*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6a.[d]						
Unknown	C		1	100	3400	34
			2	265	5600	21.1
			Average	183	4500	24.6
6b.[d]						
Unknown	C		1	100	3400	34
			2	300	10200	34
			Average	200	6800	34
7a.[d]						
Unknown	C		Average	325	22600	69.5
7b.[d]						
Unknown	C		**Average**	325	2300	7.08
7c.[d]						
Unknown	C		**Average**	162	3600	22.2
8.[d]						
Unknown	C		1	115	3600	31.3
			2	429	13600	31.7
			Average	272	8600	21.6
9.[d]						
Unknown	C		1	210	7400	35.2
			2	272	10000	36.8
			Average	241	8700	36.1
10.[d]						
Unknown	C		**Average**	500	30800	61.6
11.[d]						
Unknown	C		**Average**	310	10800	34.8

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

TABLE 4.2-1 (ENGLISH UNITS) (*concluded*)
SULFUR DIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
12.[d]						
Unknown	C		**Average**	256	10500	56.6
13.[d]						
Unknown	C		**Average**	285	10800	37.9
16.[d]						
Unknown	C		**Average**	650	55400	85.2
17.[d]						
Unknown	C		**Average**	302	10000	33.1
18.[d]						
Unknown	C		**Average**	900	54000	60

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

Nitrogen oxides.

No data on emissions of these pollutants were found for sulfuric acid production.

Carbon monoxide.

No data on emissions of these pollutants were found for sulfuric acid production.

Total Suspended Particulate & PM_{10}.

PM_{10} is a subset of total suspended particulate (TSP) and consists of particles having a diameter of less than ten microns (µm). There is no single method which is universally accepted for the determination of particle size. A number of different techniques can be used which measure the size of particles according to their basic physical properties. Since there is no "standard" method for particle size analysis, a certain degree of subjective evaluation was used to determine if a test series was performed using a sound methodology for particle sizing.

For pollution studies, the most common types of particle sizing instruments are cyclones, rotoclones, and cascade impactors. Traditionally, cyclones and rotoclones have been used as a preseparator ahead of a cascade impactor to remove the larger particles. These devices are of the standard reverse-flow design whereby the flue gas enters the cyclone through a tangential inlet and forms a vortex flow pattern. Particles move outward toward the cyclone wall with a velocity that is determined by the geometry and flow rate in the cyclone and by their size. A series of cyclones with progressively decreasing cut-points can be used to obtain particle size distributions.

Cascade impactors used for the determination of particle size in process streams consist of a series of plates or stages containing either small holes or slits with the size of the openings decreasing from one plate to the next. In each stage of an impactor, the gas stream passes through the orifice or slit to form a jet directed toward an impaction plate. For each stage, there is a characteristic particle diameter that has a 50 percent probability of impaction. This characteristic diameter is called the cut-point (D50) of the stage. Typically, commercial instruments have six to eight impaction stages with a backup filter to collect those particles which are either too small to be collected by the last stage or which are re-entrained off the various impaction surfaces by the moving gas stream.

No data on emissions of these pollutants were found for sulfuric acid production.

4.3 NONCRITERIA POLLUTANT EMISSIONS DATA

Hazardous Air Pollutants.

Hazardous Air Pollutants (HAPs) are defined in the 1990 Clean Air Act Amendments. No data on emissions of these pollutants were found for sulfuric acid production.

Global Warming Gases.

Pollutants such as methane, carbon dioxide, and N_2O have been found to contribute to overall global warming. No data was found for methane or N_2O.

Carbon dioxide (CO_2) emissions from 13 source tests are given in Table 4.3-1. Although the emissions were not specifically stated in the source tests, PES calculated CO_2 emissions from the data used to calculate stack gas molecular weight, and hence, the pollutant mass emission rates for each source test. This data was unavailable for the source tests found in References 11, 12 and 13. Using only the nine "A" and "B" rated tests, the arithmetic average emission factor for carbon dioxide is 4.05 kg/Mg (8.10 lb/ton). The calculation is as follows:

$$[(0.054 + 0.034 + 0 + 0.052 + 0 + 0.513 + 2.23 + 11.1 + 22.5)/9] = 4.05 \text{ kg/Mg}$$

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.						
None	B	Method 8	1	41.6	2.36	0.052
			2	41.6	2.54	0.055
			3	41.5	2.54	0.055
			Average	41.6	2.45	0.054
2.						
None	B	Method 8	1	40.6	1.52	0.034
			2	42.1	1.47	0.032
			3	38.2	1.62	0.039
			Average	40.3	1.54	0.034
3.						
None	B	Method 8	1	48.3	0	0
			2	48.3	0	0
			3	63.3	0	0
			4	62.7	0	0
			5	63.3	0	0
			Average	57.1	0	0
4.						
None	B	Method 8	1	43.7	2.18	0.045
			2	43.7	2.75	0.057
			3	41.3	2.37	0.052
			Average	42.9	2.43	0.052
5.						
None	C	Method 8	1	4.2	0	0
			2	4.2	0	0
			3	4.2	0	0
			Average	4.2	0	0

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6.						
None	B	Method 8	1	2.81	0	0
			2	2.81	0	0
			3	2.81	0	0
			Average	2.81	0	0
7.						
None	C	Method 8	1	121.0	0	0
			2	120.5	0	0
			3	122.9	0	0
			Average	121.5	0	0
8.						
None	B	Method 8	1	11.3	6.36	0.509
			2	11.3	6.49	0.519
			3	11.3	6.37	0.510
			Average	11.3	6.40	0.513
9.						
None	C	Method 8	1	136.1	0	0
			2	136.1	0	0
			3	138.1	0	0
			Average	136.8	0	0
10.						
None	D	Method 8	1	64.9	0.546	0.007
			2	64.9	0.547	0.007
			3	64.8	0.412	0.005
			Average	64.9	0.502	0.007

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
14.						
Absorber	A	Method 8	1	1161.1	2514	2.16
			2	1161.1	2133	1.84
			3	1161.1	2393	2.06
			4	1161.1	2319	2.00
			5	1161.1	2847	2.45
			6	1161.1	2759	2.38
			7	1161.1	2725	2.35
			8	1161.1	2729	2.35
			9	1161.1	2835	2.44
			10	1161.1	2667	2.30
			Average	1161.1	2592	2.23
15.						
Absorber	A	Method 8	1	1161.1	12593	10.8
			2	1161.1	12078	10.4
			3	1161.1	10800	9.3
			4	1161.1	11839	10.2
			5	1161.1	14103	12.1
			6	1161.1	12855	11.1
			7	1161.1	13810	11.9
			8	1161.1	13508	11.6
			9	1161.1	13906	12.0
			10	1161.1	13737	11.8
			Average	1161.1	12923	11.1

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
16.						
Absorber	B	Method 8	1	793.8	14705	18.5
			2	793.8	19078	24.0
			3	793.8	16892	21.3
			4	793.8	18812	23.7
			5	793.8	19363	24.4
			6	793.8	17788	22.4
			7	793.8	17999	22.7
			8	793.8	18327	23.1
			Average	793.8	17870	22.5

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.						
None	B	Method 8	1	45.9	2.60	0.057
			2	45.9	2.80	0.061
			3	45.8	2.80	0.061
			Average	45.9	2.70	0.059
2.						
None	B	Method 8	1	44.8	1.68	0.038
			2	46.4	1.62	0.035
			3	42.1	1.79	0.043
			Average	44.4	1.70	0.038
3.						
None	B	Method 8	1	53.3	0	0
			2	53.2	0	0
			3	69.8	0	0
			4	69.1	0	0
			5	69.8	0	0
			Average	63.0	0	0
4.						
None	B	Method 8	1	48.2	2.40	0.050
			2	48.2	3.03	0.063
			3	45.5	2.61	0.057
			Average	47.3	2.68	0.057
5.						
None	C	Method 8	1	4.6	0	0
			2	4.6	0	0
			3	4.6	0	0
			Average	4.6	0	0

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6.						
None	B	Method 8	1	3.1	0	0
			2	3.1	0	0
			3	3.1	0	0
			Average	3.1	0	0
7.						
None	C	Method 8	1	133.4	0	0
			2	132.9	0	0
			3	135.5	0	0
			Average	133.9	0	0
8.						
None	B	Method 8	1	12.5	7.01	0.561
			2	12.5	7.15	0.572
			3	12.5	7.02	0.562
			Average	12.5	7.06	0.565
9.						
None	C	Method 8	1	150	0	0
			2	150	0	0
			3	152.3	0	0
			Average	150.8	0	0
10.						
None	D	Method 8	1	76.6	0.602	0.008
			2	71.6	0.603	0.008
			3	71.5	0.454	0.006
			Average	71.6	0.553	0.008

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
14.						
Absorber	A	Method 8	1	1280	5541.5	4.33
			2	1280	4702	3.67
			3	1280	5276	4.12
			4	1280	5113	4.00
			5	1280	6276	4.90
			6	1280	6083	4.75
			7	1280	6007	4.69
			8	1280	6016	4.70
			9	1280	6250	4.88
			10	1280	5880	4.59
			Average	1280	5714	4.46
15.						
Absorber	A	Method 8	1	1280	27763	21.7
			2	1280	26627	20.8
			3	1280	23809	18.6
			4	1280	26101	20.4
			5	1280	31092	24.2
			6	1280	28341	22.1
			7	1280	30446	23.8
			8	1280	29779	23.3
			9	1280	30657	23.9
			10	1280	30285	23.7
			Average	1280	28490	22.3

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

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

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
16.						
Absorber	B	Method 8	1	875	32419	37.1
			2	875	42058	48.0
			3	875	37239	42.6
			4	875	41473	47.4
			5	875	42686	48.7
			6	875	39216	44.8
			7	875	39680	45.3
			8	875	40404	46.2
			Average	875	39397	45.0

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

The emission factor utilizing these tests is rated "C." This is the first time a CO_2 emission factor has been presented in AP-42 Section 5.17.

Ozone Depletion Gases.

Chlorofluorocarbons have been found to contribute to ozone depletion. No data on emissions of these pollutants were found for sulfuric acid production.

Sulfuric Acid Mist.

Sulfuric acid mist emissions data are shown in Table 4.3-2. The first thirteen source tests are from seven different sulfuric acid manufacturing facilities. The remaining tests are from Reference 11. The previous update utilized only Reference 11.

The emission factors in Section 5.17 are presented in two ways. First, the two "A" rated and the seven "B" rated tests were averaged to give a "C" rated, controlled emission factor of 0.064 kg/Mg (0.128 lb/ton). The calculation is as follows:

$$[(0.0689 + 0.0537 + 0.0219 + 0.0746 + 0.061 + 0.051 + 0.028 + 0.006 + 0.209)/9]=0.064 \text{ kg/Mg}$$

This is a new entry in Section 5.17.

The remaining emissions data is from Reference 11 and includes tests from facilities that produce varying percentages of oleum. The information is important since emissions have been found to be higher from plants that produce greater volumes of oleum (See Chapter 2.3). As in the previous section update, the emission factors presented are shown as ranges to reflect the varying emissions from these plants. Note that the controlled emissions table now presents only emission factors based on test results and avoids the use of manufacturer's estimates. See Chapter 4.1 for a more detailed discussion of the data from Reference 11 as well as the other source tests.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	41.6	2.70	0.0643
			2	41.6	3.20	0.0763
			3	41.5	2.74	0.0661
			Average	41.6	2.87	0.0689
2. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	40.6	2.83	0.0698
			2	42.1	1.73	0.0412
			3	38.2	1.92	0.0504
			Average	40.3	2.16	0.0537
3. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	48.3	3.00	0.0619
			2	48.3	0.12	0.0026
			3	63.3	1.03	0.0164
			4	62.7	1.12	0.0178
			5	63.3	0.99	0.0157
			Average	57.1	1.25	0.0219
4. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	43.7	2.59	0.0594
			2	43.7	2.11	0.0483
			3	41.3	4.88	0.1185
			Average	42.9	3.20	0.0746
5. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	C	Method 8	1	4.2	0.067	0.016
			2	4.2	0.094	0.023
			3	4.2	0.100	0.024
			Average	4.2	0.088	0.021

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	B	Method 8	1	2.81	0.107	0.038
			2	2.81	0.194	0.069
			3	2.81	0.215	0.077
			Average	2.81	0.171	0.061
7. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	C	Method 8	1	121.0	2.239	0.019
			2	120.5	2.833	0.024
			3	122.9	2.704	0.022
			Average	121.5	2.592	0.022
8. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	B	Method 8	1	11.3	0.095	0.009
			2	11.3	0.912	0.081
			3	11.3	0.739	0.065
			Average	11.3	0.580	0.051
9. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	C	Method 8	1	136.1	2.925	0.022
			2	136.1	0.680	0.005
			3	138.1	0.689	0.005
			Average	136.8	1.433	0.011
10. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	D	Method 8	1	64.9	0.553	0.009
			2	64.9	0.649	0.010
			3	64.8	0.649	0.010
			Average	64.9	0.617	0.010

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
14.						
Unknown	A	Method 8	1	1161.2	8.20	0.007
			2	1161.2	13.9	0.012
			3	1161.2	31.2	0.027
			4	1161.2	15.1	0.013
			5	1161.2	97.6	0.084
			6	1161.2	54.0	0.047
			7	1161.2	62.2	0.054
			8	1161.2	13.4	0.012
			9	1161.2	18.5	0.016
			10	1161.2	13.1	0.011
			Average	1161.2	32.7	0.028
15.						
Unknown	A	Method 8	1	1161.2	822	0.007
			2	1161.2	7.89	0.007
			3	1161.2	10.6	0.009
			4	1161.2	7.73	0.007
			5	1161.2	4.60	0.004
			6	1161.2	8.39	0.007
			7	1161.2	9.01	0.008
			8	1161.2	4.41	0.004
			9	1161.2	4.54	0.004
			10	1161.2	4.48	0.004
			Average	1161.2	6.98	0.006

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
16.						
Unknown	B	Method 8	1	794	196	0.247
			2	794	119	0.150
			3	794	165	0.208
			4	794	215	0.271
			5	794	142	0.179
			6	794	242	0.305
			7	794	166	0.210
			8	794	79.8	0.100
			Average	794	166	0.209

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	667	154	0.23
1.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	872	544	0.624
2a.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	590	1070	1.81
2a.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	137	36	0.26
2b.[d] Oleum %: 25; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	590	1642	2.78
2b.[d] Oleum %: 13; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	136	245	1.80
3c.[d] Oleum %: 0; Raw Material: Spent Acid						
None	C		**Average**	199	2.7	0.014
4.[d] Oleum %: 51; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	383	109	0.285
4.[d] Oleum %: 56; Raw Material: Spent Acid						
Demister	C		**Average**	121	2.7	0.022
5.[d] Oleum %: 0; Raw Material: Recovered Sulfur						
None	C		**Average**	118	100	0.847
5a.[d] Oleum %: 0; Raw Material: Spent Acid						
Demister	C		**Average**	272	27.2	0.10
6a.[d] Oleum %: 0; Raw Material: Recovered Sulfur						
None	C		**Average**	90.7	36.3	0.40

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6a.[d] Oleum %: 0 Raw Material: Spent Acid						
Demister	C		**Average**	240	4.54	0.019
6b.[d] Oleum %: 0; Raw Material: Recovered Sulfur						
None	C		**Average**	90.7	18.1	0.20
6b.[d] Oleum %: 0; Raw Material: Spent Acid						
Demister	C		**Average**	272	54.4	0.20
7.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	90.7	36.3	0.40
7a.[d] Oleum %: 43; Raw Material: Recovered Sulfur						
None	C		**Average**	295	54.4	0.185
7b.[d] Oleum %: 43; Raw Material: Recovered Sulfur						
None	C		**Average**	295	118	0.40
7c.[d] Oleum %: 35; Raw Material: Recovered Sulfur						
None	C		**Average**	147	36.3	0.247
8.[d] Oleum %: 0; Raw Material: Recovered Sulfur						
None	C		**Average**	104	18.1	0.174
9.[d] Oleum %: 0; Raw Material: Bright Virgin Sulfur						
None	C		**Average**	191	163	0.85
10.[d] Oleum %: 40; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	454	263	0.579
11.[d] Oleum %:100; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	281	45.4	0.162
12.[d] Oleum %: 33; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	240	753	3.14

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.3-2 (METRIC UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Concluded)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
13.[d] Oleum %: 25: Raw Material: Pyrite						
None	C		**Average**	259	154	0.60
14.[d] Oleum %: 0; Raw Material: Pyrite						
None	C		**Average**	454	1669	3.68
16.[d] Oleum %: 77; Raw Material: Spent Acid						
None	C		**Average**	274	308	1.13
17.[d] Oleum %: 71.5; Raw Material: Spent Acid						
None	C		**Average**	274	308	1.13
18.[d] Oleum %: 0; Raw Material: Spent Acid						
None	C		**Average**	816	907	1.11

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.
[d]Reference 11.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	45.9	5.9	0.1285
			2	45.9	7.0	0.1525
			3	45.8	6.05	0.1321
			Average	45.9	6.32	0.1377
2. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	44.8	6.25	0.1395
			2	46.4	3.82	0.0823
			3	42.1	4.24	0.1007
			Average	44.4	4.77	0.1074
3. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	53.3	6.6	0.1238
			2	53.2	0.27	0.0051
			3	69.8	2.28	0.0327
			4	69.1	2.46	0.0356
			5	69.8	2.19	0.0314
			Average	63.0	2.76	0.0438
4. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	B	Method 8	1	48.17	5.72	0.1187
			2	48.17	4.65	0.0965
			3	45.46	10.77	0.2369
			Average	47.26	7.05	0.1491
5. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	C	Method 8	1	4.6	0.1472	0.032
			2	4.6	0.207	0.045
			3	4.6	0.221	0.048
			Average	4.6	0.193	0.042

[a]Units in tons/day
[b]Units in lbs/day.
[c]Units in lbs/ton.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	B	Method 8	1	3.1	0.236	0.076
			2	3.1	0.428	0.138
			3	3.1	0.474	0.153
			Average	3.1	0.378	0.122
7. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	C	Method 8	1	133.4	4.936	0.037
			2	132.9	6.246	0.047
			3	135.5	5.962	0.044
			Average	133.9	5.715	0.043
8. Oleum %: 0; Raw Material: Elemental Sulfur						
Demister	B	Method 8	1	12.5	0.21	0.017
			2	12.5	2.01	0.161
			3	12.5	1.63	0.130
			Average	12.5	1.28	0.102
9. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	C	Method 8	1	150	6.45	0.043
			2	150	1.5	0.010
			3	152.3	1.52	0.010
			Average	150.8	3.16	0.021
10. Oleum %: 0; Raw Material: Elemental Sulfur						
Unknown	D	Method 8	1	71.6	1.22	0.017
			2	71.6	1.43	0.020
			3	71.5	1.43	0.020
			Average	71.6	1.36	0.019

[a]Units in tons/day
[b]Units in lbs/day.
[c]Units in lbs/ton.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
14.						
Unknown	A	Method 8	1	1280	18.1	0.014
			2	1280	30.7	0.024
			3	1280	68.9	0.054
			4	1280	33.4	0.026
			5	1280	215	0.168
			6	1280	119	0.093
			7	1280	137	0.107
			8	1280	29.5	0.023
			9	1280	40.8	0.032
			10	1280	28.8	0.022
			Average	1280	72.1	0.056
15.						
Unknown	A	Method 8	1	1280	18.1	0.014
			2	1280	17.4	0.014
			3	1280	23.3	0.018
			4	1280	17.0	0.013
			5	1280	10.1	0.008
			6	1280	18.5	0.014
			7	1280	19.9	0.016
			8	1280	9.72	0.008
			9	1280	10.0	0.008
			10	1280	9.88	0.008
			Average	1280	15.4	0.012

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
16.						
Unknown	B	Method 8	1	875	432	0.494
			2	875	263	0.301
			3	875	365	0.417
			4	875	474	0.541
			5	875	313	0.358
			6	875	533	0.609
			7	875	367	0.419
			8	875	176	0.201
			Average	875	365	0.418

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-2 (ENGLISH)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
1.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	735	340	0.46
1.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	961	1200	1.25
2a.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	650	2360	3.63
2a.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	150	80	0.53
2b.[d] Oleum %: 25; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	650	3620	5.57
2b.[d] Oleum %: 13; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	150	540	3.60
3c.[d] Oleum %: 0; Raw Material: Spent Acid						
None	C		**Average**	219	6	0.027
4.[d] Oleum %: 51; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	422	240	0.57
4.[d] Oleum %: 56; Raw Material: Spent Acid						
Demister	C		**Average**	133	6	0.045
5.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	130	220	1.69
5a.[d] Oleum %: 0; Raw Material: Spent Acid						
Demister	C		**Average**	300	60	0.20
6a.[d] Oleum %: 0; Raw Material: Recovered Sulfur						
None	C		**Average**	100	80	0.80

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
6a.[d] Oleum %: 0 Raw Material: Spent Acid						
Demister	C		**Average**	265	10	0.038
6b.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	100	40	0.40
6b.[d] Oleum %: 0; Raw Material: Spent Acid						
Demister	C		**Average**	300	120	0.40
7.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
Demister	C		**Average**	100	80	0.80
7a.[d] Oleum %: 43; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	325	120	0.37
7b.[d] Oleum %: 43; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	325	260	0.80
7c.[d] Oleum %: 35; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	162	80	0.49
8.[d] Oleum %: 0; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	115	40	0.35
9.[d] Oleum %: 0; Raw Material: Bright Virgin Sulfur						
None	C		**Average**	210	360	1.71
10.[d] Oleum %: 40; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	500	580	1.16
11.[d] Oleum %:100; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	310	100	0.32
12.[d] Oleum %: 33; Raw Material: Dark Virgin Sulfur						
None	C		**Average**	265	1660	6.26

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

TABLE 4.3-2 (ENGLISH UNITS)
SULFURIC ACID MIST SOURCE TESTS
(Concluded)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
13.[d] Oleum %: 25: Raw Material: Pyrite						
None	C		**Average**	285	340	1.19
14.[d] Oleum %: 0; Raw Material: Pyrite						
None	C		**Average**	500	3680	7.36
16.[d] Oleum %: 77; Raw Material: Spent Acid						
None	C		**Average**	650	1560	2.40
17.[d] Oleum %: 71.5; Raw Material: Spent Acid						
None	C		**Average**	302	680	2.25
18.[d] Oleum %: 0; Raw Material: Spent Acid						
None	C		**Average**	900	2000	2.22

[a]Units in ton/day.
[b]Units in lb/day.
[c]Units in lb/ton.
[d]Reference 11.

Sulfur Trioxide

Sulfur trioxide (SO_3) emissions were reported for two source tests that PES obtained. The results of these tests are presented in Table 4.3-3. Utilizing the "B" and "C" rated data, the arithmetic average emission factor of is 0.0031 kg/Mg (0.0062 lb/ton). The emission factor utilizing these tests is rated "D."

This data is included for information purposes only and was not included in the AP-42 update since only two tests documented any SO_3 emissions. The source tests found in Reference 11 contained no data on SO_3 emissions. Two source tests do not provide an adequate or representative sampling of the industry.

TABLE 4.3-3 (METRIC UNITS)
SULFUR TRIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
5.						
Demister	C	Method 8	1	4.2	0.025	0.006
			2	4.2	0.011	0.0026
			3	4.2	0.021	0.0050
			Average	4.2	0.019	0.0045
6.						
Demister	B	Method 8	1	2.81	0.0020	0.0007
			2	2.81	0.0022	0.0008
			3	2.81	0.0098	0.0035
			Average	2.81	0.0048	0.0017

[a]Units in Mg/day.
[b]Units in kg/day.
[c]Units in kg/Mg.

TABLE 4.3-3 (ENGLISH UNITS)
SULFUR TRIOXIDE SOURCE TESTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
5.						
Demister	C	Method 8	1	4.6	0.055	0.012
			2	4.6	0.024	0.0052
			3	4.6	0.046	0.0099
			Average	4.6	0.041	0.0090
6.						
Demister	B	Method 8	1	3.1	0.004	0.0014
			2	3.1	0.005	0.0015
			3	3.1	0.022	0.0070
			Average	3.1	0.010	0.0033

[a]Units in tons/day.
[b]Units in lbs/day.
[c]Units in lbs/ton.

4.4 DATA GAP ANALYSIS

The previous AP-42 section contained emission factors for both controlled and uncontrolled emissions in plants that utilized a variety of feedstocks. The source of the uncontrolled emissions data was Reference 11.

The data from Reference 11 has been retained in the update of Section 5.17 because of the lack of any new detailed studies of the industry. Although limited, an additional entry has been added to the controlled acid mist emission factor table that presents the results from six tests PES was able to obtain in addition to tests at three facilities used to substantiate the sulfuric acid NSPS. Note that the emission factor calculated from the new data falls within the range found in the old data. Despite the good agreement, PES recommends that a comprehensive study be undertaken to either obtain the full range of source testing data available from industry for each type feed and production scheme or an independent source test program be initiated to better define current emissions from the industry. The Florida data in conjunction with the tests PES obtained could be used to provide "B" or "C" rated emission factors for this industry if the missing background information could be obtained.

4.5 REFERENCES FOR CHAPTER 4

1. Source Emissions Compliance Test Report, Sulfuric Acid Stack. Roy F. Weston, Inc., West Chester, Pennsylvania. October 1989.

2. Source Emissions Compliance Test Report, Sulfuric Acid Stack. Roy F. Weston, Inc., West Chester, Pennsylvania. February 1988.

3. Compliance Test Report on Sulfur Emissions at a Sulfuric Acid Plant. Cubix Corporation, Austin, Texas. December 1989.

4. Source Emissions Compliance Test Report, Sulfuric Acid Stack. Roy F. Weston, Inc., West Chester, Pennsylvania. December 1991.

5. Stationary Source Sampling Report Sulfuric Acid Plant. Entropy Environmentalists, Inc., Research Triangle Park, North Carolina. January 27, 1983.

6. Stationary Source Sampling Report Sulfuric Acid Plant. Entropy Environmentalists, Inc., Research Triangle Park, North Carolina. January 26, 1983.

7. Source Performance Test. Sulfuric Acid Plant Number 5. October 1991.

8. Source Emissions Test: Sulfuric Acid Plant. Ramcon Environmental Corporation, Memphis, Tennessee. March 1991.

9. Source Performance Test. Sulfuric Acid Plant No. 6. June 1991.

10. Source Performance Test. Sulfuric Acid Plant No. 3. March 1990.

11. Atmospheric Emissions from Sulfuric Acid Manufacturing Processes, 999-AP-13, U.S. Department of Health, Education and Welfare, Washington, DC, 1966.

12. Various sulfuric acid plant compliance tests from the State of Florida, Department of Environmental Regulation.

13. Mississippi Chemical Corporation, Air Pollution Emission Tests, Sulfuric Acid Stack. Environmental Science and Engineering, Inc., Gainesville, Florida. September 1973.

14. Kennecott Copper Corporation, Air Pollution Emission Tests, Sulfuric Acid Stack - Plant 6. Engineering Science, Inc., Washington, DC. August 1972.

15. Kennecott Copper Corporation, Air Pollution Emission Tests, Sulfuric Acid Stack - Plant 7. Engineering Science, Inc., Washington, DC. August 1972.

16. American Smelting Corporation, Air Pollution Emission Tests, Sulfuric Acid Stack. Engineering Science, Inc., Washington, DC. June 1972.

TABLE 4.5-1

LIST OF CONVERSION FACTORS

Multiply:	by:	To obtain:
mg/dscm	4.37×10^{-4}	gr/dscf
m^2	10.764	ft^2
acm/min	35.31	acfm
m/s	3.281	ft/s
kg/hr	2.205	lb/hr
Kpa	1.45×10^{-1}	psia
kg/Mg	2.0	lb/ton
Mg	1.1023	ton

Temperature conversion equations:

Fahrenheit to Celsius:

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

Celsius to Fahrenheit:

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

APPENDIX A.

AP-42 SECTION 5.17

[Not presented here. See instead current AP-42 Section 8.10.]