[Note: with the publication of the Fifth Edition of AP-42, the Chapter and Section number for Phosphate Fertilizers was changed to 8.5.]

BACKGROUND REPORT

AP-42 SECTION 6.10

PHOSPHATE FERTILIZERS

Prepared for

U.S. Environmental Protection Agency
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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 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 9 test reports to support revision of emission factors for sections 6.10.1, "Normal superphosphates," 6.10.2 "Triple Superphosphates," and 6.10.3, "Ammonium Phosphates."

Including the introduction (Chapter 1), this report contains four chapters. Chapter 2 gives descriptions of the normal superphosphates, triple superphosphates, and ammonium phosphates industries. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from the production of normal superphosphates, triple superphosphates and ammonium phosphates productions, 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, details criteria and noncriteria pollutant emission factor development, and contains the results of a data gap analysis. Appendix A presents AP-42 Sections 6.10.1, 6.10.2, and 6.10.3.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL

The phosphate fertilizer industry is divided into three segments: phosphoric acid and superphosphoric acid, normal and triple superphosphate, and granular ammonium phosphate. Only normal superphosphate, triple superphosphate, and ammonium phosphate are discussed in this background report.

Normal Superphosphates

Normal superphosphate refers to fertilizer material containing 15 to 21 percent phosphorous as phosphorous pentoxide (P_2O_5). As defined by the Census Bureau, normal superphosphate contains not more than 22 percent of available P_2O_5. There are currently about eight fertilizer facilities producing normal superphosphates in the U.S. with an estimated total production of about 273,000 megagrams (300,000 tons) per year.

Triple Superphosphates

Triple superphosphate, also known as double, treble, or concentrated superphosphate, is a fertilizer material with a phosphorus content of over 40 percent, measured as phosphorus pentoxide (P_2O_5). Triple superphosphate is produced in only six fertilizer facilities in the U.S. In 1989, there were an estimated 3.2 million megagrams (3.5 million tons) of triple superphosphate produced. Production rates from the various facilities range from 23 to 92 megagrams (25 to 100 tons) per hour.

Ammonium Phosphates

Ammonium phosphate ($NH_4H_2PO_4$) is produced by reacting phosphoric acid (H_3PO_4) with anhydrous ammonia (NH_3). Ammoniated superphosphates are produced by adding normal superphosphate or triple superphosphate to the mixture. The production of liquid ammonium phosphate and ammoniated superphosphates in fertilizer mixing plants is considered a separate process. Both solid and liquid ammonium phosphate fertilizers are produced in the U.S. and the most common ammonium phosphate fertilizer grades are monoammonium phosphate (MAP) and diammonium phosphate (DAP). This discussion covers only the granulation of phosphoric acid with anhydrous ammonia to produce granular fertilizer. Total ammonium phosphate production in the U.S. in 1992 was estimated to be 7.7 million megagrams (8.5 million tons).

2.2 PROCESS DESCRIPTION

Normal Superphosphates

Normal superphosphates are prepared by reacting ground phosphate rock with 65 to 75 percent sulfuric acid. An important factor in the production of normal superphosphates is the amount of iron and aluminum in the phosphate rock. Aluminum (as Al_2O_3) and iron (as Fe_2O_3) above five percent imparts an extreme stickiness to the superphosphate and makes it difficult to handle.

The two general types of sulfuric acid used in superphosphate manufacture are virgin and spent acid. Virgin acid is produced from elemental sulfur, pyrites, and industrial gases and is relatively pure. Spent acid is a recycled waste product from various industries that use large quantities of sulfuric acid. Problems encountered with using spent acid include unusual color, unfamiliar odor, and toxicity.

A generalized flow diagram of normal superphosphate production is shown in Figure 2.2-1. Ground phosphate rock and acid are mixed in a reaction vessel, held in an enclosed area for about 30 minutes until the reaction is partially completed, and then transferred, using an enclosed conveyer known as the den, to a storage pile for curing (the completion of the reaction). Following curing, the product is most often used as a high-phosphate additive in the production of granular fertilizers. It can also be granulated for sale as granulated superphosphate or granular mixed fertilizer. To produce granulated normal superphosphate, cured superphosphate is fed through a clod breaker and sent to a rotary drum granulator where steam, water, and acid may be added to aid in granulation. Material is processed through a rotary drum granulator, a rotary dryer, a rotary cooler, and is then screened to specification. Finally, it is stored in bagged or bulk form prior to being sold.

Triple Superphosphates

Two processes have been used to produce triple superphosphate: run-of-the-pile (ROP-TSP) and granular (GTSP). At this time, no facilities in the U.S. are currently producing ROP-TSP, but a process description is given.

The ROP-TSP material is essentially a pulverized mass of variable particle size produced in a manner similar to normal superphosphate. Wet-process phosphoric acid (50 to 55 percent P_2O_5) is reacted with ground phosphate rock in a cone mixer. The resultant slurry begins to solidify on a slow moving conveyer en route to the curing area. At the point of discharge from the den, the material passes through a rotary mechanical cutter that breaks up the solid mass. Coarse ROP-TSP product is sent to a storage pile and cured for three to five weeks. The product is then mined from the storage pile to be crushed, screened, and shipped in bulk.

Granular triple superphosphate yields larger, more uniform particles with improved storage and handling properties. Most of this material is made with the Dorr-Oliver slurry granulation process, illustrated in Figure 2.2-2.

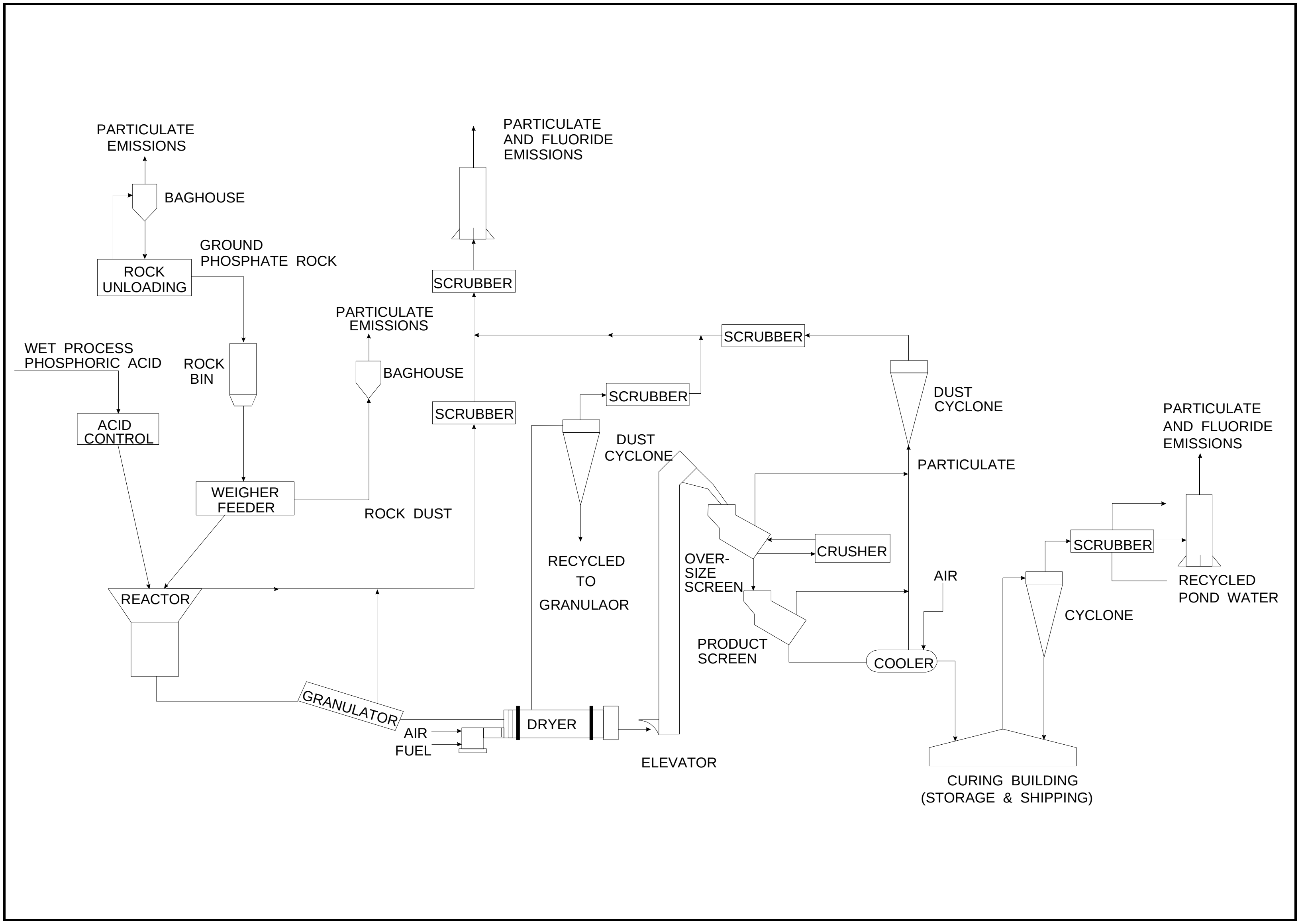

Figure 2.2-2 Dorr-Oliver process for granular triple superphosphate production[1]

In this process, ground phosphate rock or limestone is reacted with phosphoric acid in one or two reactors in series. The phosphoric acid used in this process is appreciably lower in concentration (40 percent P_2O_5) than that used to manufacture ROP-TSP product. The lower strength acid maintains the slurry in a fluid state during a mixing period of one to two hours. A small sidestream of slurry is continuously removed and distributed onto dried, recycled fines, where it coats the granule surfaces and builds up its size.

Pugmills and rotating drum granulators have been used in the granulation process. Only one pugmill is currently operating in the U.S. A pugmill is composed of a U-shaped trough carrying twin counter-rotating shafts, upon which are mounted strong blades or paddles. The blades agitate, shear, and knead the liquefied mix and transport the material along the trough. The basic rotary drum granulator consists of an open-ended, slightly inclined rotary cylinder, with retaining rings at each end and a scraper or cutter mounted inside the drum shell. A rolling bed of dry material is maintained in the unit while the slurry is introduced through distributor pipes set lengthwise in the drum under the bed. Slurry-wetted granules are then discharged onto a rotary dryer, where excess water is evaporated and the chemical reaction is accelerated to completion by the dryer heat. Dried granules are then sized on vibrating screens. Oversize particles are crushed and recirculated to the screen, and undersize particles are recycled to the granulator. Product-size granules are cooled in a countercurrent rotary drum, then sent to a storage pile for curing. After a curing period of three to five days, granules are removed from storage, screened, bagged and shipped.

Ammonium phosphates

Two basic mixer designs are used by ammoniation-granulation plants: the pugmill ammoniator and the rotary drum ammoniator. Approximately 95 percent of ammoniation-granulation plants in the United States use a rotary drum mixer developed and patented by the Tennessee Valley Authority (TVA). The basic rotary drum ammoniator-granulator consists of a slightly inclined open-end rotary cylinder with retaining rings at each end, and a scrapper or cutter mounted inside the drum shell. A rolling bed of recycled solids is maintained in the unit.

Ammonia-rich offgases pass through a wet scrubber before exhausting to the atmosphere. Primary scrubbers use raw materials mixed with acids (such as scrubbing liquor), and secondary scrubbers use gypsum pond water.

In the TVA process, phosphoric acid is mixed in an acid surge tank with 93 percent sulfuric acid (H_2SO_4), which is used for product analysis control, and with recycled acid from wet scrubbers. (A schematic diagram of the ammonium phosphate process flow diagram is shown in Figure 2.2-3.)

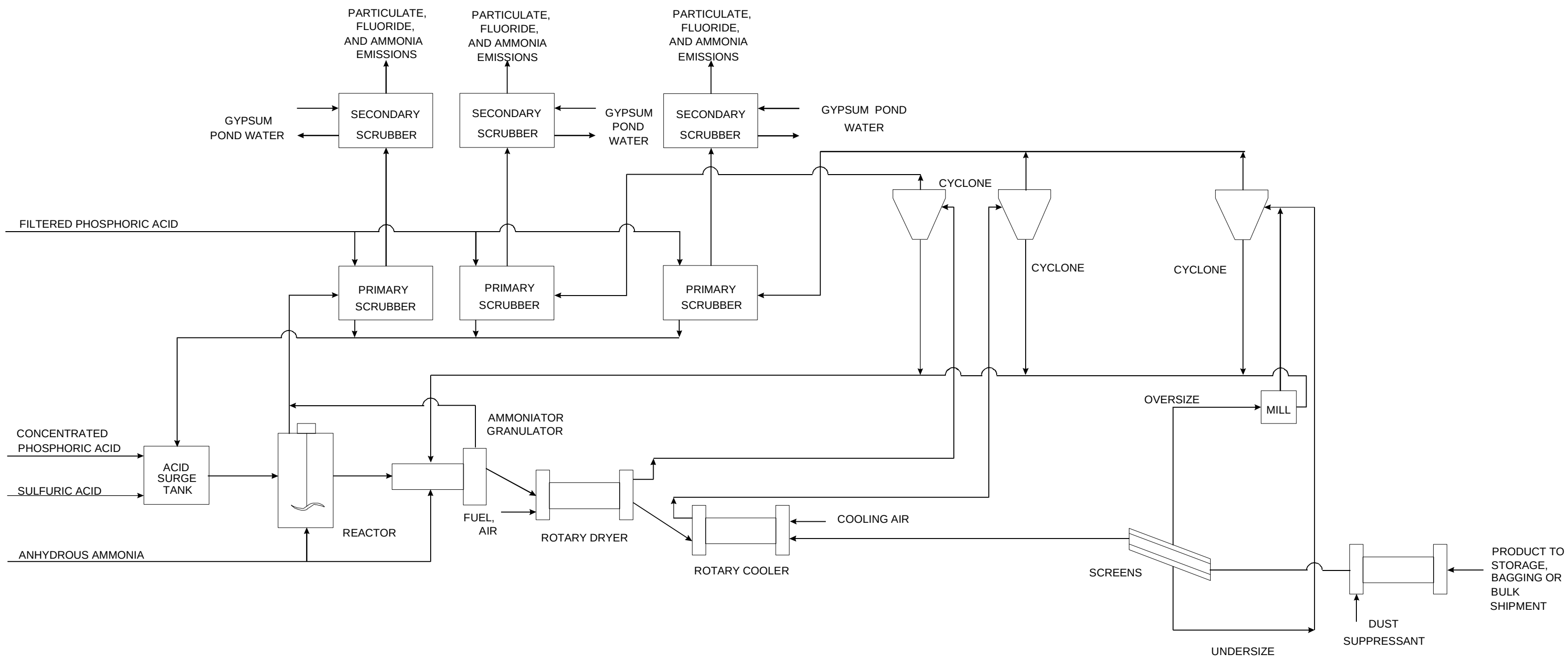

Figure 2.2-3 Ammonium phosphate process flow diagram

Mixed acids are then partially neutralized with liquid or gaseous anhydrous ammonia in a brick-lined acid reactor. All of the phosphoric acid and approximately 70 percent of the ammonia are introduced into this vessel. A slurry of ammonium phosphate and 22 percent water are produced and sent through steam-traced lines to the ammoniator-granulator. Slurry from the reactor is distributed on the bed, the remaining ammonia (approximately 30 percent) is sparged underneath. Granulation, by agglomeration and by coating particulate with slurry, takes place in the rotating drum and is completed in the dryer. Ammonia-rich offgases pass through a wet scrubber before exhausting to the atmosphere. Primary scrubbers use raw materials mixed with acid (such as scrubbing liquor), and secondary scrubbers use pond water.

Moist ammonium phosphate granules are transferred to a rotary concurrent dryer and then to a cooler. Before being exhausted to the atmosphere, these offgases pass through cyclones and wet scrubbers. Cooled granules pass to a double-deck screen, in which oversize and undersize particles are separated from product particles. The product ranges in granule size from 1 to 4 millimeters (mm). The oversized granules are crushed, mixed with the undersized, and recycled back to the ammoniator-granulator.

2.3 EMISSIONS AND CONTROLS

Normal Superphosphates

Sources of emissions at a normal superphosphate plant include rock unloading and feeding, mixing operations (in the reactor), storage (in the curing building), and fertilizer handling operations. Rock unloading, handling and feeding generate particulate emissions of phosphate rock dust. The mixer, den and curing building emit gases in the form of silicon tetrafluoride (SiF_4), hydrogen fluoride (HF) and particulates composed of fluoride and phosphate material. Hydrogen fluoride is identified as one of hazardous air pollutants defined in the 1990 Clean Air Act Amendments. Fertilizer handling operations release fertilizer dust.

At a typical normal superphosphate plant, emissions from the rock unloading, handling and feeding operations are controlled by a baghouse. Baghouse cloth filters have reported efficiencies of over 99 percent under ideal conditions. Collected dust is recycled. Emissions from the mixer and den are controlled by a wet scrubber. The curing building and fertilizer handling operations normally are not controlled.

Silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF) emissions, and particulate from the mixer, den and curing building are controlled by scrubbing the offgases with recycled water. Gaseous silicon tetrafluoride in the presence of moisture reacts to form gelatinous silica, which has a tendency to plug scrubber packings. The use of conventional packed-countercurrent scrubbers and other contacting devices with small gas passages for emissions control is therefore limited. Controls that can be used are cyclones and venturi, impingement, jet ejector and spray-crossflow packed scrubbers. Spray towers are also used as precontactors for fluorine removal at relatively high concentration levels of greater than 4.67 g/m^3 (3000 ppm).

Air pollution control techniques vary with particular plant designs. The effectiveness of abatement systems in removing fluoride and particulate also varies from plant to plant, depending on a number of factors. The effectiveness of fluorine abatement is determined by the inlet fluorine concentration, outlet or saturated gas temperature, composition and temperature of the scrubbing liquid, scrubber type and transfer units, and the effectiveness of entrainment separation. Control efficiency is enhanced by increasing the number of scrubbing stages in series and by using a fresh water scrub in the final stage. Reported efficiencies for fluoride control range from less than 90 percent to over 99 percent, depending on inlet fluoride concentrations and the system employed. An efficiency of 98 percent for particulate control is achievable.

Triple Superphosphates

Sources of particulate emissions include the reactor, granulator, dryer, screens, cooler, mills, and transfer conveyors. Additional emissions of particulate result from the unloading, grinding, storage, and transfer of ground phosphate rock. One facility uses limestone, which is received in granulated form and does not require additional milling.

Emissions of fluorine compounds and dust particles occur during the production of GTSP triple superphosphate. Silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF) are released by the acidulation reaction and they evolve from the reactors, den, granulator, and dryer. Hydrogen fluoride is identified as one of hazardous air pollutants defined in the 1990 Clean Air Act Amendments. Evolution of fluoride is essentially finished in the dryer and there is little fluoride evolved from the storage pile in the curing building.

At a typical plant, baghouses are used to control the fine rock particles generated by the rock grinding and handling activities. Emissions from the reactor, den and granulator are controlled by scrubbing the effluent gas with recycled gypsum pond water in cyclonic scrubbers. Emissions from the dryer, cooler, screens, mills, product transfer systems, and storage building are sent to a cyclone separator for removal of a portion of the dust before going to wet scrubbers to remove fluorides.

Particulate emissions from ground rock unloading, storage and transfer systems are controlled by baghouse collectors. These baghouse cloth filters have reported efficiencies of over 99 percent. Collected solids are recycled to the process. Emissions of silicon tetrafluoride, hydrogen fluoride, and particulate from the production area and curing building are controlled by scrubbing the offgases with recycled water. Exhausts from the dryer, cooler, screens, mills, and curing building are sent first to a cyclone separator and then to a wet scrubber. Tailgas wet scrubbers perform final cleanup of the plant offgases.

Gaseous silicon tetrafluoride in the presence of moisture reacts to form gelatinous silica, which has a tendency to plug scrubber packings. Therefore, the use of conventional packed countercurrent scrubbers and other contacting devices with small gas passages for emissions control is not feasible. Scrubber types that can be used are 1) spray tower, 2) cyclone, 3) venturi, 4) impingement, 5) jet ejector, and 6) spray-crossflow packed.

The effectiveness of abatement systems for the removal of fluoride and particulate varies from plant to plant, depending on a number of factors. The effectiveness of fluorine abatement is determined by: 1) inlet fluorine concentration, 2) outlet or saturated gas temperature, 3) composition and temperature of the scrubbing liquid, 4) scrubber type and transfer units, and 5) effectiveness of entrainment separation. Control efficiency is enhanced by increasing the number of scrubbing stages in series and by using a fresh water scrub in the final stage. Reported efficiencies for fluoride control range from less than 90 percent to over 99 percent, depending on inlet fluoride concentrations and the system employed. An efficiency of 98 percent for particulate control is achievable.

Ammonium Phosphates

Sources of air emissions from the production of ammonium phosphate fertilizers include the reactor, the ammoniator-granulator, the dryer and cooler, product sizing and material transfer, and the gypsum pond. The reactor and ammoniator-granulator produce emissions of gaseous ammonia, gaseous fluorides such as hydrogen fluoride (HF) and silicon tetrafluoride (SiF_4), and particulate ammonium phosphates. These two exhaust streams are generally combined and passed through primary and secondary scrubbers. Hydrogen fluoride is identified as one of the hazardous air pollutants defined in the 1990 Clean Air Act Amendments.

Exhaust gases from the dryer and cooler also contain ammonia, fluorides and particulates, and these streams are commonly combined and passed through cyclones and primary and secondary scrubbers. Particulate emissions and low levels of ammonia and fluorides from product sizing and material transfer operations are controlled the same way.

Exhaust streams from the reactor and ammoniator-granulator pass through a primary scrubber, in which phosphoric acid is used to recover ammonia and particulate. Exhaust gases from the dryer, cooler and screen first go to cyclones for particulate recovery, and then to primary scrubbers. Materials collected in the cyclone and primary scrubbers are returned to the process. The exhaust is sent to secondary scrubbers, where recycled gypsum pond water is used as a scrubbing liquid to control fluoride emissions. The scrubber effluent is returned to the gypsum pond.

Primary scrubbing equipment commonly includes venturi and cyclonic spray towers. Impingement scrubbers and spray-crossflow packed bed scrubbers are used as secondary controls. Primary scrubbers generally use phosphoric acid of 20 to 30 percent as scrubbing liquor, principally to recover ammonia. Secondary scrubbers generally use gypsum and pond water for fluoride control.

Throughout the industry, however, there are many combinations and variations. Some plants use reactor-feed concentration phosphoric acid (40 percent P_2O_5) in both primary and secondary scrubbers, and some use phosphoric acid near the dilute end of the 20 to 30 percent P_2O_5 range in only a single scrubber. Existing plants are equipped with ammonia recovery scrubbers on the reactor, ammoniator-granulator and dryer, and particulate controls on the dryer and cooler. Additional scrubbers for fluoride removal exist, but they are not typical. Only 15 to 20 percent of installations contacted in an EPA survey were equipped with spray-crossflow packed bed scrubbers or their equivalent for fluoride removal.

Emission control efficiencies for ammonium phosphate plant control equipment are reported as 94 to 99 percent for ammonium, 75 to 99.8 percent for particulates, and 74 to 94 percent for fluorides.

2.4 REVIEW OF REFERENCES

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

1) Cargill Fertilizer Inc., Tampa, FL.
2) CF Industries, Inc., Plant City, FL.
3) Farmland Industries, Inc. Bartow, FL.
4) Florida Department of Environmental Regulation, Bureau of Air Quality Management, Tallahassee, FL.
5) IMC Fertilizer, Mulberry, FL.
6) J.R. Simplot Co., Pocatello, ID.
7) North Carolina Department of Environment, Raleigh, NC.
8) Occidental Chemical Corp., White Springs, FL.
9) Royster Company, Mulberry, FL.
10) Seminole Fertilizer, Bartow, FL.
11) Texasgulf, Inc., Aurora, NC.

Of the eleven sources contacted, no responses were received for normal and triple superphosphates. Responses were received from two state agencies (Sources #4 and #7) and three fertilizer plants (Sources #3, #5 and #9) for ammonium phosphates. No responses were received from the remaining sources. A source test report received from Farmland Industries

(Source #3) contained only a stack sample summary sheet. It did not provide any description of the testing procedure, and the sampling done using Methods 2, 3 and 4 is incomplete. There was no documentation on sample preparation, nozzle calibration or phosphate feed or production rates. Therefore, this report could not be used to revise the emission factors in the previous AP-42 document (October 1980). Florida Department of Environmental Regulation (Source #4) sent computer printouts of summaries of source tests performed at fertilizer plants located in Florida. The printouts only summarized the type of pollutant, the actual emissions, the maximum processing rate and the permit allowable emissions, but there was no information on how the emission tests were performed. Therefore, the printouts could not be used to revise or add to the existing emission factors. A source test report received from Royster Company (Source #9) could not be used to revise the existing emission factors since the test methods used were no longer approved. IMC Fertilizer (Source #5) sent four separate source test reports; one of the reports was done in 1973 and the remaining three were done in 1991. The 1973 report did not provide production or feed rates, calibration data and boiler tests data. Therefore, it could not be used in the emission factor calculation. The North Carolina Department of Environmental Resources (Source #7) provided six source test reports for Texasgulf, Inc. located in Aurora. All of these six source test reports and three reports from IMC will be discussed in further detail in Chapter 4.

<u>Reference #1: Source Assessment: Phosphate Fertilizer Industry</u>

This document was obtained from AP-42 Background File for Sections 6.10.1, 6.10.2, and 6.10.3 and was used in the process description and emissions and controls sections.

<u>Reference #2: AP-40 Revisions - Normal and Triple Superphosphates</u>

These reports, obtained from Mr. Horace Mann of the Tennessee Valley Authority (TVA), were used to rewrite the process descriptions and emissions and controls sections for normal and triple superphosphates.

<u>Reference #3: North American Fertilizer Capacity Data</u>

This report, obtained from the Tennessee Valley Authority (TVA), contained information on the name of phosphate fertilizer companies, plant status, locations and estimated productions from 1987 through 1997. The report was used in estimating the superphosphates and phosphates fertilizer production for 1992.

Reference #4: Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 1: Proposed Standards

This report was obtained from AP-42 Background File for Sections 6.10.1 and 6.10.2 and provided process descriptions and emissions and controls information.

Reference #5: Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 2: Test Data Summary

This report provided the basis for the emission factors calculated in the previous revision (October 1980). It was also reviewed for process descriptions, emissions and controls, but was not used directly in modifying the AP-42 superphosphates fertilizer sections. This document also contained fluoride emission test summaries for normal superphosphates, triple superphosphates, and ammonium phosphates. The tests were undertaken to evaluate the best fluoride control equipment available. Due to lack of documentation, the test results were not used to revise the emission factors for normal superphosphates, triple superphosphates, or ammonium phosphates.

Reference #6: Final Guideline Document: Control of Fluoride Emissions from Existing Phosphate Fertilizer Plants

This report was obtained from AP-42 Background File for Sections 6.10.1 and 6.10.2 and was reviewed for the process descriptions and emissions and controls information.

2.5 REFERENCES FOR CHAPTER 2

1. J.M. Nyers, et al., Source Assessment: Phosphate Fertilizer Industry, EPA-600/2-79-019c, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.

2. H.C. Mann, Phosphate Fertilizers, National Fertilizer & Environmental Research Center, Tennessee Valley Authority, Muscle Shoals, Alabama, February 1992.

3. North American Fertilizer Capacity Data (including supplement), Tennessee Valley Authority, Muscle Shoals, AL,. December 1991.

4. Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 1: Proposed Standards, EPA-450/2-74-019a, U.S. Environmental Protection Agency, Research Triangle park, NC, October 1974.

5. Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 2: Test Data Summary, EPA-450/2-74-019b, U.S. Environmental Protection Agency, Research Triangle park, NC, October 1974.

6. Final Guideline Document: Control of Fluoride Emissions from Existing Phosphate Fertilizer Plants, EPA-450/2-77-005, U.S. Environmental Protection Agency, Research Triangle park, NC, March 1977.

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 normal superphosphates, triple superphosphates, and ammonium phosphates. This search included the following references:

AP-42 background files maintained by the Emission Factor and Methodologies Section. PES was able to use the information in these files to ascertain that the emission factors were correctly taken from the cited references. No new information was found.

Information in the *Air Facility Subsystems* (AFS) of the EPA *Aerometric Information Retrieval System* (AIRS), *Clearinghouse for Inventories and Emission Factors* (CHIEF) and *National Air Toxics Information Clearinghouse* (NATICH), *VOC/Particulate Matter* (PM) *Speciation Database Management System* (SPECIATE), the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF). No unique information was found from these sources.

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 a 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).

The emission factors in the previous revision (October 1980) utilized data that were obtained from primary reference material such as source tests. However, only summaries of source tests were provided in the appendix of the primary reference document. PES was unable to obtain full reports of these source tests. Therefore, the emission factor ratings were downgraded from "A" to "E."

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.

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 (e.g., 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 to which such alternative procedures could influence the test results.
3. Sampling and process data. Adequate sampling and process data are documented in the report. 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

The emission factors for normal superphosphates, triple superphosphates, and ammonium phosphates in the previous (October 1980) AP-42 document were taken from Reference 1. They were derived from source test data provided by Florida Department of Environmental Regulation in Winter Haven. Appendix B in Reference 1 summarized emission factors calculated from these source data. However it did not provide any information on how the tests were performed and how the existing emission factors were calculated from these data. PES was unable to obtain the source test reports to evaluate the accuracy of the test data. Therefore, the emission factors for normal superphosphates, triple superphosphates, and ammonium phosphates remained unchanged. However, as described in Section 3.1, the ratings were downgraded from A to E.

Three reports from IMC Fertilizer (References 13, 14 and 15) and six reports from the North Carolina Department of Environmental Resources (References 7 through 12) were used to revise the total plant particulate and fluoride emission factors in the previous ammonium phosphates section (October 1980). A sulfur dioxide (SO_2) emission factor for the total plant will also be included. The rest of the emission factors in the existing AP-42 document remained unchanged.

The source test data received (References 7 through 15) report all air emissions as "total plant" emissions. Therefore, total plant emission factors from these data were used to revise the total plant emission factors in the previous revision (October 1980).

Most of the emission tests used to develop the new total plant emission factors for ammonium phosphates were performed in 1990 and 1991; only two were done in 1987 and 1989. Since the test reports were received from two different plants, the emission factors for the individual plants were averaged separately. The average total emission factors were then combined to generate the final emission factors used to revise the existing factors.

One of the source tests from IMC (Reference 14) reported that SO_2 and nitrogen oxide (NO_x) were emitted during diammonium phosphate manufacturing. The sulfur dioxide emission factor was added to the revised section of AP-42. However, the NO_x emission factor could not be used since the report did not have any raw field data or the calculations used to generate this emission factor.

The emission factors calculated in this document were reported in units of kilograms per megagram and pounds per ton of P_2O_5 input, P_2O_5 output, and product. All P_2O_5 except losses due to emissions was assumed to reach the product. Therefore, input and output emission factors are equivalent. All of the emission factors developed for this report are expressed in units of kilograms per megagram and pounds per ton of P_2O_5.

The nine test reports used to generate total plant particulate and fluoride emission factors for ammonium phosphates are discussed separately below.

Reference #7: Compliance Source Test Report: Texasgulf Inc., Granular Triple Super Phosphate Plant, Aurora, NC, May 1987.

Two compliance tests were conducted at the granular triple superphosphate plant producing monoammonium phosphate. The first test was performed using EPA Method 5 to determine particulate emissions. The second test was done using EPA Method 13B to determine fluoride emissions. Both emissions were measured at the outlet of the fume scrubber stack. This report was given an "A" rating. Particulate emissions for three runs were 21.16, 16.82, and 17.43 pounds per hour and the production rates were 1574, 1556, and 1587 tons per day. Since the monoammonium phosphate contained 48 percent phosphate and assuming the plant operated 24 hours per day, the average particulate emission factor is thus

$$[(21.16/31.48) + (16.82/31.12) + (17.43/31.74)]/3 = 0.59 \text{ pounds per ton.}$$

Fluoride emissions for three runs were 2.46, 2.41, and 3.57 pounds per day and phosphate feed rates were 1349, 1300, and 1422 tons per day. The average fluoride emission factor is thus

$$[(0.10/26.98) + (0.10/26.00) + (0.15/28.44)]/3 = 0.004 \text{ pounds per ton.}$$

Reference #8: Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant No.2, Aurora, NC, August 1989.

The test was conducted using EPA Method 13B to determine fluoride emissions. The sample analyses were performed using an Orion 901 Specific Ion Electrode Analyzer. The report was rated "A." Fluoride emission rates for three runs were 8.36, 6.48, and 8.72 pounds per day and P_2O_5 feed rates were 836.79, 836.54, and 850.85 tons per day. The average fluoride emission factor is thus

$$[(8.36/836.79) + (6.48/836.54) + (8.72/850.85)]/3 = 0.009 \text{ pounds per ton.}$$

Reference #9: Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant #2, Aurora, NC, December 1991.

The test was conducted using EPA Reference Method 5 to determine particulate emissions. Particulate emission rates for three runs were 20.65, 16.50, and 19.53 pounds per hour and P_2O_5 production rates were 757, 872, and 863 tons per day. The report did not include any description of control devices or calibration data for the pitot tube or nozzle. Therefore, the report was given a "B" rating. Assuming the plant operated 24 hours per day, the average particulate emission factor is thus

[(20.65/31.54) + (16.50/36.33) + (19.53/35.96)]/3 = 0.55 pounds per ton.

Reference #10: Compliance Test Report: Texasgulf, Inc., Diammonium Phosphate #1, Aurora, NC, September 1990.

Two sampling analyses were conducted to determine particulate emissions using EPA Method 5 and fluoride emissions using EPA Method 13B. The report contained all necessary information and was thus rated "A." Particulate emissions rates for three runs were 45.72, 39.92, and 38.45 pounds per hour and P_2O_5 feed rates were 395, 395, and 393 tons per day. Fluoride emissions rates were 1.74, 4.15, and 3.59 pounds per hour and P_2O_5 feed rates were 293, 321 and 350 tons per day. Assuming the plant operated 24 hours per day, the average particulate emission factor is thus

[(45.72/16.46) + (39.92/16.46) + (38.45/16.38)]/3 = 2.52 pounds per ton,

and the average fluoride emission factor is

[(1.74/12.21) + (4.15/13.38) + (3.59/14.58)]/3 = 0.23 pounds per ton.

Reference #11: Compliance Source Test Report: Texasgulf Inc., Ammonium Phosphate Plant #2, Aurora, NC, November 1990.

The test was conducted using EPA Method 13B to determine total fluoride emissions. The sample analysis was performed using an Orion 901 Specific Ion Electrode Analyzer. The instrument had the ability to compute a calibration slope from the calibration samples and display the output directly as parts per million total fluoride. The report provided all necessary documentation and was rated "A." The total fluoride emissions for three runs were 1.14, 0.83, and 0.94 pounds per hour and P_2O_5 feed rates were 889, 938, and 926 tons per day. Assuming the plant operated 24 hours per day, the average fluoride emission factor is thus

$$[(1.14/37.04) + (0.83/39.08) + (0.94/38.58)]/3 = 0.025 \text{ pounds per ton.}$$

Reference #12: Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant #2, Aurora, NC, November 1991.

The test was conducted to determine total fluoride emissions using EPA Reference Method 13B. The sample analysis was performed using an Orion 901 Specific Ion Electrode Analyzer. The instrument had the ability to compute a calibration slope from the calibration samples and display the output directly as parts per million total fluoride. The report provided all necessary documentation and was rated "A." The total fluoride emissions for three runs were 0.61, 0.88, and 1.14 pounds per hour and P_2O_5 feed rates were 798, 856, and 914 tons per day. Assuming the plant operated 24 hours per day, the average fluoride emission factor is thus

$$[(0.61/33.25) + (0.88/35.67) + (1.14/38.08)]/3 = 0.024 \text{ pounds per ton.}$$

Reference #13: Compliance Source Test Report: IMC Fertilizer, Inc., #1 DAP plant, Western Polk County, FL, October 1991.

The test was performed using EPA Reference Method 5 to measure particulate emissions, and Method 5 was modified to determine fluoride emissions. The front half catch consisting of the probe wash and filtered particulate were combined with the impinger water and analyzed for fluoride content. The recoverable fluoride in the particulate was then used to calculate fluoride emissions by relating it back to the standard volume of the gas sampled. This report contained all necessary documentation and was thus rated "A." The phosphate (P_2O_5) feed rate for three runs was 40.54 tons per hour. Particulate emissions for three runs were 290.5, 302.4, and 272.7 pounds per day and fluoride emissions were 26.7, 27.8, and 27.9 pounds per day. Assuming the plant operated 24 hours per day, the average particulate emission factor is thus

$$[(12.10/40.54) + (12.60/40.54) + (11.36/40.54)]/3 = 0.30 \text{ pounds per ton,}$$

and the average fluoride emission factor is

$$[(1.11/40.54) + (1.16/40.54) +(1.16/40.54)]/3 = 0.028 \text{ pounds per ton.}$$

Reference #14: Compliance Source Test Report: IMC Fertilizer, Inc., #2 DAP Plant, Western Polk County, FL, June 1991.

The test was conducted to determine particulate and fluoride emissions using EPA Reference Method 5. The test was modified to determine fluoride emissions. The front-half catch consisting of the probe rinse and filtered particulate was combined with the impinger water and analyzed for fluoride content. The recoverable fluoride in the particulate was then used to calculate fluoride emissions by relating it back to the standard volume of gas sampled. The test was also conducted to determine NO_X and SO_2 emissions. Although there were NO_x emissions reported during the test, no test data and calculations were available to evaluate the validity of the test. Therefore, no NO_x emission factor has been included in the revision section. This report was rated "A." The P_2O_5 feed rate for the test was 62.55 tons per hour. The total particulate emissions rates were 136.7, 112.9, and 103.0 pounds per day and the total fluoride emission rates were 28.7, 23.6, and 25.4 pounds per day. The total SO_2 emission rates were 149, 104, and 108 pounds per day. Assuming the plant operated 24 hours per day, the total particulate emission factor is thus:

$$[(5.70/62.55) + (4.70/62.55) + (4.29/62.55)]/3 = 0.078 \text{ pounds per ton;}$$

the average fluoride emission factor is

$$[(1.20/62.55) + (0.98/62.55) + (1.06/62.55)]/3 = 0.017 \text{ pounds per ton;}$$

and the average sulfur dioxide emission factor is

$$[(6.21/62.55) + (4.33/62.55) + (4.50/62.55)]/3 = 0.080 \text{ pounds per ton.}$$

Reference #15: Compliance Source Test Report: IMC Fertilizer, Inc., Western Polk County, FL, April 1991.

The test was conducted on the MAP plant scrubber to determine the total fluoride and particulate emissions. The test was performed in accordance with EPA Reference Method 5 to determine particulate and fluoride emissions. The test was modified to determine fluoride emissions. The front-half catch consisting of the probe rinse and filtered particulate was combined with the impinger water and analyzed for fluoride content. The recoverable fluoride in the particulate was then used to calculate fluoride emissions by relating it back to the standard volume of gas sampled. The report was given an "A" rating. The plant was producing 1,200 tons per day of monoammonium phosphate. Assuming monoammonium phosphate contains 48 percent phosphate, the total amount of phosphate produced was 576 tons per day. The total particulate emission rates for three runs were 16.6, 17.0, and 15.4 pounds per day and fluoride emission rates were 3.6, 4.3, and 2.9 pounds per day. The average total particulate emission factor is

$$[(16.6/576) + (17.0/576) + (15.4/576)]/3 = 0.028 \text{ pounds per ton;}$$

and the average total fluoride emission factor is

$$[(3.6/576) + (4.3/576) + (2.9/576)]/3 = 0.006 \text{ pounds per ton.}$$

Reference #16: AIRS Emission Factor Listing for Criteria Air Pollutants

This document did not contain sufficient information to revise the emission factors in the existing section.

4.2 CRITERIA POLLUTANT EMISSIONS DATA

No data on emissions of volatile organic compounds, lead, or carbon monoxide were found nor expected for the superphosphates and ammonium phosphates fertilizer processes.

Sulfur Dioxide.

No SO_2 emission factor was reported in the previous revision (October 1980) of ammonium sulfate. However, one of the source tests received from IMC (Reference 14) reported sulfur dioxide (SO_2) emissions. Reference 1 discussed that SO_2 might be emitted during ammonium phosphate manufacturing. The emissions can result from dissolved SO_2 in phosphoric acid and released during a reaction with ammonia. Sulfur dioxide in phosphoric acid is formed from reactions of the phosphate rock with sulfuric acid. SO_2 could also be emitted from the acid surge tank (for the TVA process). The SO_2 emission factor calculated from Reference 14 was given an "E" rating since the report did not indicate the type of method used to measure the emissions and one test did not represent a random sample of the industry. A summary of SO_2 emission factors is presented in Table 4.2-1.

TABLE 4.2-1 (METRIC UNITS)
SULFUR DIOXIDE

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 14. Exhaust stack						
Scrubber	A	unknown	1	56.74	2.82	0.050
			2	56.74	1.96	0.034
			3	56.74	2.04	0.036
			Average	56.74	2.27	0.040

[a] Units in Mg/hr.
[b] Units in kg/hr.
[c] Units in kg/Mg of P_2O_5.

TABLE 4.2-1 (ENGLISH UNITS)
SULFUR DIOXIDE

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 14. Exhaust stack						
Scrubber	A	unknown	1	62.55	6.21	0.099
			2	62.55	4.33	0.069
			3	62.55	4.50	0.071
			Average	62.55	5.01	0.080

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

Nitrogen oxides.

Reference 14 also reported nitrogen oxides (NO_x) emissions during ammonium phosphate production. Since the report did not provide a description of how the test was performed or any raw field data, no NO_x emission factor could be included the revised section. However, Reference 14 did contain sufficient information and raw data to warrant inclusion of the SO_2 emission factor as discussed above.

Particulate Matter.

Particulates are emitted from rock unloading, rock handling and feeding, the den and curing building, and from fertilizer handling. As mentioned in Section 4.1, the particulate and fluoride emission factors in the previous revision (October 1980) were derived from source test data provided by the Florida Department of Environmental Regulation. Due to a lack of documentation, the emission factors were not changed but the rating were downgraded from "A" to "E." PM_{10} emission factors for normal and triple superphosphates were taken from the AIRS Listing of Criteria Air Pollutants which is also rated "E."

As discussed in Section 2.3, particulate matter from ammonium phosphate processing is emitted in ammoniator-granulator, dryer, cooler, product sizing and material transfer. Particulate emission species may also include ammonium fluoride and ammonium fluosilicates. Particulate emission factor for the total plant in the previous section (October 1980) of AP-42 document was revised with the new emission factor generated from three source tests from Texasgulf (References 7, 9 and 10) and three from IMC (References 13, 14 and 15). The total plant particulate emission factor in the revised section was calculated by taking the average of the average total plant particulate emission factors from Texasgulf and IMC. The average particulate emission factor from Texasgulf was

$$[0.59 + 0.55 + 2.52]/3 = 1.22 \text{ pounds per ton.}$$

The average particulate emission factor from IMC was

$$[0.30 +0.078 +0.029]/3 = 0.14 \text{ pounds per ton.}$$

The average total plant particulate emission factor is thus

$$[1.22 + 0.14]/2 = 0.68 \text{ pounds per ton.}$$

The new particulate emission factor for the total plant was derived from five "A" rated reports and one "B" rated report. The "B" rating was given due to lack of some calibration data and the average emission factor is very close to the one from the "A"-rated report. Therefore, the particulate emission factor for the total plant is given an "A" rating.

TABLE 4.2-2 (METRIC UNITS)
FILTERABLE PARTICULATE MATTER

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 7. Exhaust stack						
Scrubber	A	5	1	28.56	9.60	0.34
			2	28.23	7.63	0.27
			3	28.79	7.91	0.28
			Average	28.53	8.38	0.30
Reference 9. Exhaust stack						
Scrubber	B	5	1	28.61	9.37	0.33
			2	32.96	7.48	0.23
			3	32.62	8.86	0.27
			Average	31.40	8.57	0.27
Reference 10. Exhaust stack						
Scrubber	A	5	1	14.93	20.74	1.39
			2	14.93	18.11	1.21
			3	14.86	17.44	1.17
			Average	14.91	18.76	1.26
Reference 13. Exhaust stack						
Scrubber	A	5	1	36.78	5.49	0.15
			2	36.78	5.71	0.16
			3	36.78	5.15	0.14
			Average	36.78	5.45	0.15

[a] Units in Mg/hr.
[b] Units in kg/hr.
[c] Units in kg/Mg of P_2O_5

TABLE 4.2-2 (METRIC UNITS)
FILTERABLE PARTICULATE MATTER (continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 14. Exhaust stack						
Scrubber	A	5	1	56.74	2.59	0.046
			2	56.74	2.13	0.038
			3	56.74	1.95	0.034
			Average	56.74	2.22	0.039
Reference 15. Exhaust stack						
Scrubber	A	5	1	21.77	0.31	0.015
			2	21.77	0.32	0.015
			3	21.77	0.29	0.013
			Average	21.77	0.31	0.014

[a] Units in Mg/hr.
[b] Units in kg/hr.
[c] Units in kg/Mg of P_2O_5.

TABLE 4.2-2 (ENGLISH UNITS)
FILTERABLE PARTICULATE MATTER

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 7. Exhaust stack						
Scrubber	A	5	1	31.48	21.16	0.67
			2	31.12	16.82	0.54
			3	31.74	17.43	0.55
			Average	31.45	18.47	0.59
Reference 9. Exhaust stack						
Scrubber	B	5	1	31.54	20.65	0.65
			2	36.33	16.50	0.45
			3	35.96	19.53	0.54
			Average	34.61	18.89	0.55
Reference 10. Exhaust stack						
Scrubber	A	5	1	16.46	45.72	2.78
			2	16.46	39.92	2.42
			3	16.38	38.45	2.35
			Average	16.43	41.36	2.52
Reference 13. Exhaust stack						
Scrubber	A	5	1	40.54	12.10	0.30
			2	40.54	12.60	0.31
			3	40.54	11.36	0.28
			Average	40.54	12.02	0.30

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

TABLE 4.2-2 (ENGLISH UNITS)
FILTERABLE PARTICULATE MATTER (continued)

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 14. Exhaust stack						
Scrubber	A	5	1	62.55	5.70	0.091
			2	62.55	4.70	0.075
			3	62.55	4.29	0.069
			Average	62.55	4.90	0.078
Reference 15. Exhaust stack						
Scrubber	A	5	1	24.00	0.69	0.029
			2	24.0	0.71	0.030
			3	24.00	0.64	0.027
			Average	24.00	0.68	0.029

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

4.3 NONCRITERIA POLLUTION EMISSION DATA

No data on emissions of global warming gases or ozone depletion gases were found nor expected for the superphosphates and phosphates fertilizer processes.

Hazardous Air Pollutants.

Hazardous air pollutants (HAPs) are defined in Title III of the 1990 Clean Air Act Amendments. Gaseous fluoride is emitted in the form of hydrogen fluoride, a HAP, during normal superphosphates, triple superphosphates, and ammonium phosphates processing. Ammonia, also a HAP, is emitted from ammonium phosphates processing and is volatilized from the reactor and ammoniator-granulator due to incomplete chemical reactions and excess free ammonia. Ammonia is also emitted from the dryer and cooler as a result of dissociation of fertilizer product. The ammonia emission factor in the previous section (October 1980) was derived from source test data provided by the Florida Department of Regulation. Since complete test reports were not available to verify the validity of the tests, the total plant ammonia emission factor remained unchanged. However, its rating was downgraded from "A" to "E."

In normal and triple superphosphate processing, gaseous and particulate fluoride is emitted. Gaseous fluoride is emitted in the form of hydrogen fluoride, a HAP, and silicon tetrafluoride from the mixer, den, and curing building. Fluoride emission factors in the previous sections were derived from source test data provided by the Florida Department of Regulation. Since complete test reports were not available to determine the validity of the tests, the fluoride emission factors were not changed. However, the ratings were downgraded from A to E.

In ammonium phosphates processing, fluoride vapor that evolves as hydrogen fluoride originates from the fluoride content of phosphoric acid. The total plant fluoride emission factor in the October 1980 revision (0.08 lb/ton of P_2O_5) was revised with the new factor derived from new source tests received from Texasgulf (References 7, 8, 10, 11 and 12) and IMC (References 13, 14 and 15). These reports provided only fluoride emissions, which consist of hydrogen fluoride, silicon tetrafluoride, and other impurities. Since only hydrogen fluoride is identified as a HAP, it was assumed that fluoride emissions contain only hydrogen fluoride. Table 4.3-1 presents a summary of the emission factors calculated from these source tests. The average fluoride emission factor for the total plant from Texasgulf was

$$[0.004 + 0.009 + 0.233 + 0.025 + 0.024]/5 = 0.059 \text{ pounds per ton;}$$

and the average fluoride emission factor for the total plant from IMC was

$$[0.028 + 0.017 + 0.006]/3 = 0.017 \text{ pounds per ton.}$$

The final average of the fluoride emission factor for the total plant is thus

$$[0.059 + 0.017]/2 = 0.038 \text{ pounds per ton.}$$

The fluoride emission factor for the total plant in the revised section was developed from A-rated source test reports. No specific bias in the data is evident and the facilities tested were representative of the industry. Therefore, an "A" rating was assigned.

TABLE 4.3-1 (METRIC UNITS)
HAZARDOUS AIR POLLUTANTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 7.	Exhaust stack					
Scrubber	A	13B	1	24.48	0.045	0.002
			2	23.59	0.045	0.002
			3	25.80	0.068	0.003
			Average	24.62	0.054	0.002
Reference 8.	Exhaust stack					
	A	13B	1	31.63	0.16	0.005
			2	31.62	0.12	0.004
			3	32.16	0.16	0.005
			Average	31.81	0.15	0.005
Reference 10.	Exhaust stack					
	A	13B	1	11.08	0.79	0.072
			2	12.14	1.88	0.155
			3	13.20	1.63	0.123
			Average	12.14	1.43	0.117
Reference 11.	Exhaust stack					
	A	13B	1	33.60	0.52	0.016
			2	35.45	0.38	0.011
			3	35.00	0.43	0.012
			Average	34.68	0.44	0.013

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

TABLE 4.3-1 (METRIC UNITS) (*concluded*)
HAZARDOUS AIR POLLUTANTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 12. Exhaust stack						
	A	13B	1	30.16	0.28	0.009
			2	32.36	0.40	0.012
			3	34.55	0.52	0.015
			Average	32.36	0.40	0.012
Reference 13. Exhaust stack						
	A	13B	1	36.78	0.50	0.014
			2	36.78	0.53	0.015
			3	36.78	0.53	0.015
			Average	36.78	0.52	0.015
Reference 14. Exhaust stack						
	A	13B	1	56.74	0.54	0.010
			2	56.74	2.16	0.008
			3	56.74	2.34	0.008
			Average	56.74	2.38	0.009
Reference 15. Exhaust stack						
	A	13B	1	26.45	0.07	0.003
			2	26.45	0.08	0.003
			3	26.45	0.05	0.002
			Average	26.45	0.07	0.003

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

TABLE 4.3-1 (ENGLISH UNITS)
HAZARDOUS AIR POLLUTANTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 7.	Exhaust stack					
	A	13B	1	26.98	0.10	0.004
			2	26.00	0.10	0.004
			3	28.44	0.15	0.005
			Average	27.14	0.12	0.004
Reference 8.	Exhaust stack					
	A	13B	1	34.87	0.35	0.010
			2	34.86	0.27	0.008
			3	35.45	0.36	0.010
			Average	35.06	0.33	0.009
Reference 10.	Exhaust stack					
	A	13B	1	12.21	1.74	0.143
			2	13.38	4.15	0.310
			3	14.55	3.59	0.247
			Average	13.38	3.16	0.233
Reference 11.	Exhaust stack					
	A	13B	1	37.04	1.14	0.031
			2	39.08	0.83	0.021
			3	38.58	0.94	0.024
			Average	38.23	0.97	0.025

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton of P_2O_5.

TABLE 4.3-2 (ENGLISH UNITS) (*concluded*)
HAZARDOUS AIR POLLUTANTS

Control Equipment	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Reference 12.	Exhaust stack					
	A	13B	1	33.25	0.61	0.018
			2	35.67	0.88	0.025
			3	38.08	1.14	0.030
			Average	35.67	0.88	0.024
Reference 13.	Exhaust stack					
	A	13B	1	40.54	1.11	0.027
			2	40.54	1.16	0.029
			3	40.54	1.16	0.029
			Average	40.54	1.14	0.028
Reference 14.	Exhaust stack					
	A	13B	1	62.55	1.20	0.019
			2	62.55	0.98	0.016
			3	62.55	1.06	0.017
			Average	62.55	1.08	0.017
Reference 15.	Exhaust stack					
	A	13B	1	24.00	0.15	0.006
			2	24.00	0.18	0.007
			3	24.00	0.12	0.005
			Average	24.00	0.15	0.006

[a] Units in ton/hr.
[b] Units in lb/hr.
[c] Units in lb/ton P_2O_5.

4.4 DATA GAP ANALYSIS

The emission factors presented for normal and triple superphosphates are unchanged from the previous revision but have been downgraded from "A" to "E" quality due to a lack of documented source tests. Current source tests of operating normal and triple superphosphate processing facilities are required to either verify the current emission factors or to generate new ones.

Only one source test report received (Reference 14) provided SO_2 and NO_x emissions from ammonium phosphate production, because these emissions are rarely measured at fertilizer plants. In order to confirm these emission factors, more source tests are suggested.

4.5 REFERENCES FOR CHAPTER 4

1. J.M. Nyers, et al., Source Assessment: Phosphate Fertilizer Industry, EPA-600/2-79-019c, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.

2. H.C. Mann, Normal Superphosphate, National Fertilizer & Environmental Research Center, Tennessee Valley Authority, Muscle Shoals, AL, February 1992.

3. North American Fertilizer Capacity Data (including supplement), Tennessee Valley Authority, Muscle Shoals, AL, December 1991.

4. Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 1: Proposed Standards, EPA-450/2-74-019a, U.S. Environmental Protection Agency, Research Triangle park, NC, October 1974.

5. Background Information for Standards of Performance: Phosphate Fertilizer Industry: Volume 2: Test Data Summary, EPA-450/2-74-019b, U.S. Environmental Protection Agency, Research Triangle park, NC, October 1974.

6. Final Guideline Document: Control of Fluoride Emissions from Existing Phosphate Fertilizer Plants, EPA-450/2-77-005, U.S. Environmental Protection Agency, Research Triangle park, NC, March 1977.

7. Compliance Source Test Report: Texasgulf Inc., Granular Triple Super Phosphate Plant, Aurora, NC, May 1987.

8. Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant No.2, Aurora, NC, August 1989.

9. Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant #2, Aurora, NC, December 1991.

10. Compliance Test Report: Texasgulf, Inc., Diammonium Phosphate #1, Aurora, NC, September 1990.

11. Compliance Source Test Report: Texasgulf Inc., Ammonium Phosphate Plant #2, Aurora, NC, November 1990.

12. Compliance Source Test Report: Texasgulf Inc., Diammonium Phosphate Plant #2, Aurora, NC, November 1991.

13. Compliance Source Test Report: IMC Fertilizer, Inc., #1 DAP plant, Western Polk County, FL, October 1991.

14. Compliance Source Test Report: IMC Fertilizer, Inc., #2 DAP Plant, Western Polk County, FL, June 1991.

15. Compliance Source Test Report: IMC Fertilizer, Inc., Western Polk County, FL, April 1991.

16. AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA Number 450/4-90-003. March 1990.

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:

$$°C = \frac{(°F - 32)}{1.8}$$

Celsius to Fahrenheit:

$$°F = 1.8(°C) + 32$$

APPENDIX A.

AP-42 SECTION 6.10.1

[Not presented here. See instead current AP-42 Section 8.5.]