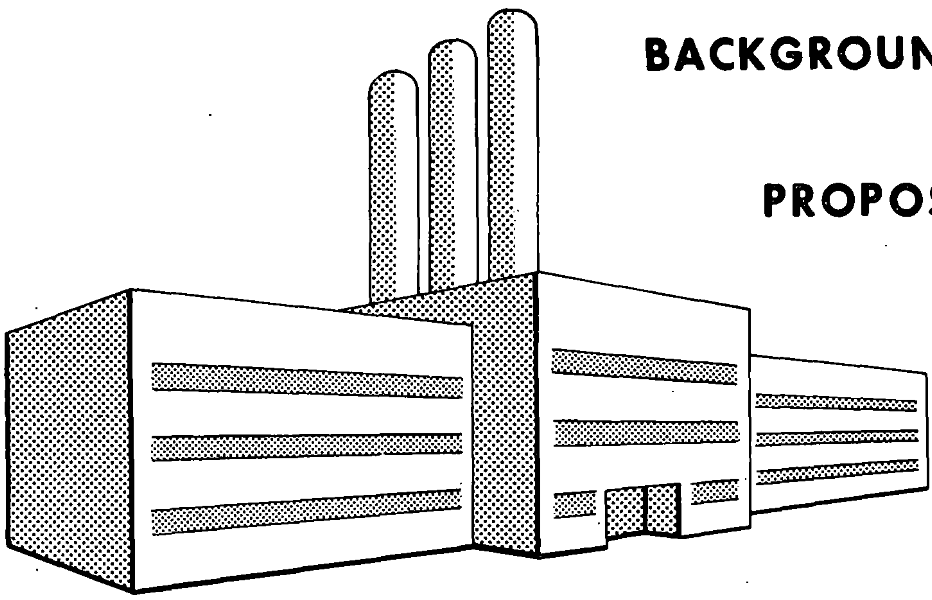

BACKGROUND INFORMATION FOR PROPOSED NEW-SOURCE PERFORMANCE STANDARDS:

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Steam Generators
Incinerators
Portland Cement Plants
Nitric Acid Plants
Sulfuric Acid Plants

U. S. ENVIRONMENTAL PROTECTION AGENCY

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ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Research Triangle Park, North Carolina
August 1971

Office of Air Programs Technical Report No. APTD-0711

CONTENTS

INTRODUCTION

This document provides background information on the derivation of the proposed new-source performance standards and their economic impact on the construction and operation of new steam generators, municipal incinerators, sulfuric and nitric acid manufacturing facilities, and portland cement plants. The proposed standards, published in the Federal Register under Title 42 CFR Part 466, are being distributed concurrently with this document. The information presented herein was prepared for the purpose of facilitating review and comment prior to promulgation of the standards.

The performance standards were developed after consultation with plant owners and operators, appropriate advisory committees, equipment designers, independent experts, and Federal departments and agencies. Review meetings were held with the Federal Agency Liaison Committee and the National Air Pollution Control Techniques Advisory Committee. The proposed standards reflect consideration of comments provided by these committees and by other individuals having knowledge regarding the control of pollution from the specific source categories.

The National Air Pollution Control Techniques Advisory Committee is made up of 16 persons who are knowledgeable concerning air quality, air pollution sources, and technology for the control of air pollutants. The membership includes state and local control officials, industrial representatives, university professors, and engineering consultants.

Members are appointed by the EPA Administrator pursuant to Section 117 (d), (e), and (f) of the Clean Air Amendments of 1970, Public Law 91-604. In addition, persons with specific expertise in the respective source categories participated in the meeting of the Advisory Committee.

The Federal Agency Liaison Committee includes persons knowledgeable concerning air pollution control practices as they affect Federal facilities and the nation's commerce. The committee is made up of representatives of 19 Federal agencies.

The promulgation of standards of performance for new stationary sources under Section 111 of the Clean Air Act does not prevent state or local jurisdictions from adopting more stringent emission limitations for these same sources. In heavily polluted areas, more restrictive standards, including a complete ban on construction, may be necessary in order to achieve National Ambient Air Quality Standards. Section 116 of the Act provides specific authorization to states and other political subdivisions to enact such standards and limitations.

TECHNICAL REPORT NO. 1 - STEAM GENERATORS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new fossil-fuel-fired steam-generating units with a capacity greater than 250 million Btu per hour heat input. The proposed standards include emission limitations for particulates (including visible emissions), sulfur dioxide, and nitrogen oxides. The particulate limits are based on the EPA sampling procedure, which employs a dry filter as well as wet impingement collectors.

The proposed standards would limit emissions to the atmosphere as follows:

Particulate Matter

1. No more than 0.2 pound of particulates per million Btu heat input, or 0.36 gram per million calories.
2. Visible emissions shall not be darker in shade than that designated as No. 1 on the Ringelmann Scale or 20 percent equivalent opacity, except for 2 minutes in any one hour when emissions may be as great as No. 2 on the Ringelmann Scale or 40 percent equivalent opacity.

Sulfur Dioxide

1. No more than 0.8 pound of sulfur dioxide per million Btu heat input, or 1.4 grams per million calories, when liquid fossil fuel is fired.

2. No more than 1.2 pounds of sulfur dioxide per million Btu heat input, or 2.1 grams per million calories, when solid fossil fuel is fired.

Nitrogen Oxides

1. No more than 0.20 pound of nitrogen oxides (measured as NO_2) per million Btu heat input, or 0.36 gram per million calories, when gaseous fossil fuel is fired.

2. No more than 0.30 pound of nitrogen oxides (measured as NO_2) per million Btu heat input, or 0.54 gram per million calories, when liquid fossil fuel is fired.

3. No more than 0.70 pound of nitrogen oxides (measured as NO_2) per million Btu heat input, or 1.26 grams per million calories, when solid fossil fuel is fired.

The proposed particulate standard is equivalent to a stack concentration level of 0.12 to 0.13 grain per standard cubic foot corrected to 15 percent excess air. To burn most fuel oils (less than 0.10 percent ash), no particulate controls would be required. Coal-fired steam generators would, however, require high-efficiency particulate collectors. The visible emissions standard is compatible with the mass emission limit; if particulates are at or below 0.20 pound per million Btu, visible emissions normally will be less than 20 percent opacity.

The proposed SO_2 limits can be achieved by the use of low-sulfur fuels, stack-gas cleaning systems, or combinations of the two. No stack-gas cleaning would be required for high-grade coal of 0.7 percent sulfur or less, or for fuel oil of 0.8 percent sulfur or less. The corresponding stack-gas concentration for coal is 620 ppm and for oil, 440 ppm, both referenced to 15 percent excess air.

The proposed nitrogen oxides standards correspond to 165 ppm for burning natural gas, 227 ppm for fuel oil, and 525 ppm for high-grade coal, all referenced to 15 percent excess air.

EMISSIONS FROM STEAM GENERATORS

Particulate collectors are common to coal-fired boilers and are sometimes used with oil-fired units. Coal-fired steam generators tend to use mechanical collectors and electrostatic precipitators of varying efficiencies. If coal-fired operations were completely uncontrolled, particulate emissions would range from 6 to 10 pounds per million Btu. At most existing installations, emissions range from 1 to 4 pounds per million Btu. Particulates from oil-fired steam generators are seldom controlled except for mechanical collectors, which are used chiefly during periods of soot blowing. Particulate emissions from uncontrolled oil-fired steam generators normally range from 0.04 to 0.06 pound per million Btu, with most of the particulates traceable to inorganic ash in the oil. Unless the ash content of the oil is excessive (greater than 0.4 percent by weight), or unless there is poor combustion, particulate emissions are well below the limits of the standard.

Most state and local regulations limit particulate emissions from coal-fired steam generators to a level between 0.10 and 0.80 pound per million

Btu heat input. A few jurisdictions have more stringent restrictions for oil-fired equipment. One local agency has established limits for all three pollutants (particulates, SO_2, and NO_x) from new steam generators at such a low level that solid and liquid fuel utilization is precluded. In most instances, particulate limits that are more restrictive than the performance standard of 0.20 pound per million Btu heat input are based on American Society of Mechanical Engineers (ASME) testing procedures that are different from the specified EPA test method.

Although no definite correlation between these methods has been established, it appears that the proposed new-source standard is consistent with a level of about 0.07 pound per million Btu if the ASME test procedure is used as the reference test method. Despite the numerical difference, both standards require about the same degree of control.

With existing fuel sulfur levels, uncontrolled SO_2 emissions range from 1 to 7 pounds per million Btu. Few existing steam generators have stack-gas desulfurization except for the demonstration installations on which these standards are based. Several state and local regulations limit SO_2 emissions from combustion sources by restricting sulfur in fuels. Stack-gas desulfurization usually can be utilized at the option of the operator. Fuel sulfur limits of 0.50 to 1.0 percent (0.5 to 1.4 pounds per million Btu) have been established in a number of areas of the country.

Most of the steam generators in the United States were not designed specifically to reduce nitrogen oxides emissions. Nitrogen oxides emissions tend to vary with boiler design, and range from 0.3 to 2.0

pounds per million Btu. Only a few states and local jurisdictions restrict NO_x emissions. Limits range from 0.15 to 0.60 pound per million Btu heat input for gaseous fuels, and from 0.13 to 0.60 pound per million Btu for liquid fuels. These regulations have only recently been promulgated, and there has been little experience with their enforcement. The performance standards for gaseous and liquid fuels are slightly higher than the minimum levels for local agencies. Regulations for oxides of nitrogen produced by solid-fuel combustion have not as yet been adopted by states or local jurisdictions.

In developing performance standards for steam generators, consideration was given to the availability and cost of fuels and control techniques and to effects on the economics of producing electric power. The major considerations were:

The necessity of making use of all the principal fossil fuels - coal, oil, and natural gas. The cleanest fuels are in limited supply. It is estimated that the use of coal will increase at a much greater rate over the next 30 years than will that of residual oil and natural gas.

The desirability of setting standards that would allow the use of combination control systems to collect both particulates and sulfur dioxide. It does not appear that the particulate/SO_2 systems under study are capable of collecting nitrogen oxides.

The desirability of setting sulfur dioxide standards that would allow the use of low-sulfur fuels as well as fuel cleaning, stack-gas cleaning, and equipment modifications.

The fact that most low-sulfur fuel oil or crude oil will have to be imported from Alaska or from foreign countries. Substantial quantities of desulfurized fuel oil will be available from Caribbean facilities, several of which will go on-stream in 1971 and 1972.

The fact that naturally occurring low-sulfur coal is restricted for the most part to the Rocky Mountain area, so that shipping costs to eastern and midwestern power stations can be appreciable. Coal-cleaning techniques can be used to remove substantial portions of sulfur and ash from some coals, but the processes are highly dependent on the make-up of the coal.

The fact that stack-gas desulfurization processes have only recently been developed to the point at which they can be applied to steam generators. The first new steam generators to be affected by the standards will be put into operation in 1975 and 1976. In many cases owners and operators can delay decisions on air pollution control equipment for a year or longer after the steam generator has been designed. At that time there should be a greater number of options for sulfur dioxide control schemes from which to choose.

JUSTIFICATION OF PROPOSED STANDARDS

The proposed performance standards are based on inspections and tests of prototype and full-scale control systems, on consultations with state and local officials and operators and designers of steam generators and control systems, on EPA surveys of available combustion fuels, and on review of the literature. Essentially all of the technology applicable to the subject was developed in the United States.

The adequately demonstrated techniques include the use of electrostatic precipitators for particulate removal, low-sulfur fuels and flue-gas cleaning for sulfur dioxide removal, and combustion modifications for nitrogen oxides abatement. For the most part, these systems have been developed independently for each pollutant. The best systems for sulfur dioxide and particulate removal have not necessarily been operated on the same coal-fired steam generators. Many of the nitrogen oxides control techniques have been developed on units fired with low-sulfur fuel oil and natural gas, which had no requirements for sulfur dioxide or particulate control.

Particulate Matter

The particulate limits are based primarily on EPA tests of existing electrostatic precipitators that were reported to have high collection efficiencies. Seven precipitator-equipped steam generators were tested during coal burning using the EPA test method. Two of the installations were shown to meet the particulate limit, and two more barely exceeded the limit at 0.21 pound per million Btu. At the most effective precipitators only a trace of the emissions was visible.

Tests of the one scrubber showed particulate emissions of 0.32 pound per million Btu. The marble-bed scrubber, however, was designed principally for SO_2 removal rather than high-efficiency particulate control. Information obtained from various pilot-scale test programs indicates that advanced scrubber designs can achieve the particulate standard of performance. Full-scale scrubbers are now being installed at large steam generators. They have been designed to meet particulate levels that are consistent with the standard.

To date no full-scale fabric filters have been demonstrated on coal-fired steam generators, although two such units are scheduled to be installed at a New Mexico power station. Experience with industrial operations would indicate that baghouses could be employed to meet the particulate limit of the standards.

The results cited are based on the EPA sampling method, which utilizes a dry filter and wet impingement collectors. Most of the data available in the literature are based on the American Society of Mechanical Engineers (ASME) test method, which generally reflects lower particulate loadings than the EPA method. Reported values with the ASME method range below 0.05 pound per million Btu for high-efficiency electrostatic precipitators.

Visible emissions were recorded at the seven coal-fired installations where particulates were measured. At the two plants that met the proposed standard, as well as at the two steam generators that barely exceeded the standard, visible emissions were less than 20 percent opacity. No black smoke was observed at any of the tested installations.

Sulfur Dioxide

The standards for sulfur dioxide are based on limited demonstrations of stack-gas desulfurization processes and on the availability of low-sulfur fuels. At this time only the lime-slurry scrubbing system is considered adequately demonstrated on large steam generators. Three other processes have been shown capable of continuous operation at smaller installations.

A lime-slurry scrubbing system, demonstrated for 6 months on two coal-fired units of 125 and 140 mW capacity, approached the SO_2 emission limit of 1.2 pounds per million Btu. This operation represents 73 percent removal of SO_2 from fuel gases in instances where the bituminous coal contains 3.0 percent sulfur by weight. One of the units was selected for the EPA test program, resulting in a verification of the SO_2 removal performance reported by the control system manufacturer and facility operator. These lime-slurry systems have been operated at greater SO_2 removal efficiency, but only for limited periods, so that sustained operation at this level is not considered to have been adequately demonstrated.[1] A prototype unit, however, employing a dual-bed design, has achieved emission levels as low as 1.0 pound per million Btu heat input for an extended period of time.[2] This system is also applicable to steam generators burning fuel oil. The demonstrated removal efficiency (76 percent), applied to a typical fuel oil of 2.5 percent sulfur content, results in an emission level of 0.7 pound per million Btu heat input, which is below the standard of performance. Lime-scrubbing systems are essentially throwaway processes that produce significant quantities of solid waste. For a 3.0-percent-sulfur coal, the additional wastes are roughly equal to the ash generated from burning coal.

Some other processes have been utilized on pilot or prototype installations to the point that there is reasonable assurance of successful operation, but they are not deemed adequately demonstrated for the purposes of these standards. In Sweden, another lime-slurry system, utilizing a different scrubber design, has been demonstrated on a 70,~~000~~ $\times 10^6$-Btu-per-hour oil-fired unit at emission values of 0.25 pound per million Btu heat input (95 percent SO_2 removal) without interruption of steam generator operation over the past 3 years.[3] An integrated catalytic-oxidation system has been operated at an emission level of 0.5 pound per million Btu heat input during a program that accumulated some 7000 hours of operation on coal-generated flue gases with a volumetric flow rate equivalent to a 120 $\times 10^6$-Btu-per-hour steam-electric unit.[4] Sodium sulfite/bisulfite scrubbing has been continuously operated at sulfur dioxide removal efficiencies in excess of 90 percent on a sulfuric acid plant with a tail-gas volume flow rate equivalent to a 220 $\times 10^6$-Btu-per-hour steam-electric unit.[5] This system has been installed at a 630,000,000-Btu-per-hour oil-fired power plant in Japan, which is scheduled for operation in late 1971. To date, magnesium oxide-slurry scrubbing has been demonstrated only on pilot-scale tests. A full-scale magnesium oxide scrubbing system is being installed to serve a 1.5×10^9-Btu-per-hour steam-electric generator and is scheduled for operation in October 1971.

Coal and fuel oil of low sulfur content and natural gas can be used to satisfy the standards at many new steam generators. It is not expected, however, that there will be enough low-sulfur fuel to supply all new steam generators as well as existing sources requiring SO_2 control under state implementation plans. In addition, transportation costs in many areas may make these fuels more expensive than stack-gas desulfurization.

Principal sources of low-sulfur crude oil are Africa, Indonesia, Canada, and Alaska. Because South American crudes are generally high in sulfur, several desulfurization plants have recently been put into operation in Central America to satisfy fuel specifications of the eastern United States. To ensure reasonable supplies of 0.8-percent-sulfur oil to meet the new-source performance standard, some increases in desulfurization capacity will be required, as well as growth of low-sulfur imports and extensive use of blending.

Most of the naturally occurring United States coal of 0.7 percent sulfur or less is located in the Rocky Mountain area. Shipping costs have thus far precluded widespread use in the midwest and on the east coast. In the eastern United States, some coals could be upgraded to meet the standard. In other areas that are remote from low-sulfur-coal production sites, however, stack-gas cleaning probably will be the least expensive method for many operators to meet the standard.

Nitrogen Oxides

Nitrogen oxides standards of performance for liquid and gaseous fuels were based on tests on units having modifications to the combustion process. Combustion modifications of primary importance include flue-gas recirculation, off-stoichiometric combustion techniques, low excess combustion air, and reduced combustion air preheat. Flexibility in application of these methods will be required for compliance with the standards of performance. Flue-gas recirculation and off-stoichiometric combustion individually have the potential of meeting the standards for liquid and gaseous fuels.

Published test data from six tangentially fired units of 3.2×10^9 to 3.3×10^9 Btu per hour (320 to 330 mW) capacity utilizing flue-gas recirculation, and from seven units of capacities ranging from 1.25×10^9 to 7.5×10^9 Btu per hour (125 to 750 mW) with off-stoichiometric combustion techniques, indicate routine operations at or below the required emission level of 0.2 pound per million Btu for gaseous fuels.[6,7] An EPA test on one of the six tangentially fired units utilizing flue-gas recirculation verified the published data for these units burning natural gas and fuel oil. Off-stoichiometric combustion is generally utilized to limit emissions of nitrogen oxides from steam generators burning liquid fuels. Emissions from eight oil-fired units ranging in capacity from 1.32×10^9 to 4.8×10^9 Btu per hour (132 to 480 mW) were reported in various publications at levels below the standard of performance for liquid fuels.[6,7] Combined methods show promise of much lower emission levels, although these techniques have not been adequately demonstrated.

The NO_x standard for solid fuels is based on results from tangentially fired units burning coal. Four tangentially fired units burning bituminous coal, which were tested by EPA, had emissions of nitrogen oxides that were well below the required level of 0.7 pound per million Btu. Published data from numerous sources, and other test results from steam-generator manufacturers, indicate comparable results for tangential firing, and considerably higher levels for wall-fired units.[7,8] Combustion modifications have not as yet been applied to solid-fuel units to any extent. The fact that tangential firing alone reduces NO_x emissions in units burning coal, however, indicates that combustion modifications that have been incorporated in units burning natural gas and fuel oil will produce similar reductions with solid fuels. In addition, experience gained from gas- and oil-fired units shows that there is little difference in NO_x production between tangentially fired and wall-fired steam generators when combustion modifications are employed. Emission levels are anticipated to be considerably lower than the standard after combined modifications have been instituted. Fuel-constituent nitrogen appears to be of secondary importance in the emission of NO_x when combustion modifications are utilized.

ECONOMIC IMPACT OF PROPOSED STANDARDS

Approximately 35 steam-electric generation units and 40 industrial steam generators are presently being installed in the United States annually. Some 96 percent of the total capacity of new units greater than 250 million Btu heat per hour input will be utilized by the electrical utility industry. Since construction of steam generators requires from 3 to 5 years, a substantial portion of the economic impact will be delayed.

The economics involved with controlling particulate, SO_2, and NO_x emissions will vary, depending on the (1) availability of low-sulfur fuels in the geographical location, (2) fuel, and (3) control techniques selected. The capital investment required to control these three pollutants will seldom exceed 25 percent of the total installed cost of a steam-electric generation unit. Since units burning gaseous fuels need only control NO_x, the capital investment will amount to only 5 percent of the installed cost. The corresponding increases in operating costs for electrical production will range from 15 to 40 percent for solid- and liquid-fuel units, and only 4 percent for gaseous fuels. More stringent requirements to meet ambient air quality standards as specified by state implementation plans (Section 110 of the Clean Air Act) will force control costs much higher in some areas.

Particulate Matter

The present trend involves the installation of high-efficiency electrostatic precipitators of near the same size as those necessary to meet the standard of performance. Hence, there is a marginal additional cost resulting from the particulate standard. The total costs, however, reflect an allotment for an increase of 6 percent in the total capital investment and 4 percent in operating costs. These costs exceed those for precipitators alone and are high enough to include installation of scrubber systems and baghouses.

The standard of performance is sensitive to cost/benefit analysis. The standard is based on high-efficiency electrostatic precipitators, scrubbers, and baghouse collectors. The use of less efficient precipitators and scrubbers would require that the standard be relaxed by a factor of 2 with a savings of up to 3 percent of the total plant initial investment.

Sulfur Dioxide

Control costs for SO_2 are by far the highest of the three pollutants, with increases of about 10 percent in capital investment and 7 to 30 percent in operating costs. Sulfur dioxide control is not normally practiced by the steam-generation industry and will result in a direct additional cost in most areas. The reimbursements for salable by-products, such as elemental sulfur and sulfuric acid, were not included as credits in the cost estimates because of the market variabilities involved. In addition, the cost for disposal of spent reagents incurred by some processes was not considered in any depth.

The standards of performance are insensitive to cost/benefit analysis when stack-gas cleaning is employed in that it is the only control system available. Since the availability of low-sulfur fuel varies with the location of the plant, it is not possible to analyze the cost of this control strategy. The decision to use low-sulfur fuels instead of flue-gas cleaning may force the opening of new mines to meet demand.

Nitrogen Oxides

Nitrogen oxides combustion-modification economics are similar to those for electrostatic precipitators, with capital investment increases approaching 7 percent as a maximum, and elevation in operating costs reaching 4 percent. The capital investment should decline to 0 percent, however, as combustion-modification becomes common practice and not a special modification. A few coal-fired steam generator designs inherently produce high levels of NO_x, and it is unlikely that some of these can be modified to meet the standards. Three of the four major steam-generator manufacturers would have to modify their coal-fired designs in order to realize the NO_x limits of the standard. The fourth manufacturer's design can meet the standards with no increase in cost, however. This manufacturer presently accounts for 40 percent of the coal-fired steam-generator market. All four firms sell boilers that can meet the limits proposed for gas and oil burning.

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TECHNICAL REPORT NO. 2 - INCINERATORS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed that will limit particulate emissions from new municipal incinerators with a capacity greater than 50 tons per day (24-hour). The particulate limits are based on the EPA sampling procedure, which employs a dry filter as well as wet impingement collectors.

The standards of performance would apply only to those incinerators used to burn predominantly municipal solid wastes, e.g., household and commercial paper, cardboard, garbage, and yard wastes. The standards will not apply to incinerators used exclusively to burn sewage sludge, pathological wastes, sawdust, or other specialized trade wastes.

The proposed standard would limit particulate emissions to the atmosphere as follows:

> No more than 0.10 grain of particulates per standard cubic foot (scf) of dry flue gases, corrected to 12 percent carbon dioxide (CO_2).

For burning of typical solid wastes in the United States, the limit of 0.10 grain per scf, corrected to 12 percent CO_2, corresponds to the production of 1.9 pounds of particulates per ton of solid wastes charged to the incinerator, and about 0.17 pound of particulates per 1000 pounds of flue gas, corrected to 50 percent excess air.

EMISSIONS FROM INCINERATORS

An uncontrolled incinerator will emit considerably more particulates than the standard allows. Available data indicate that, on the average, uncontrolled furnace gases contain about 1 grain of particulates per scf dry gas at 12 percent CO_2.[1,2] For average domestic solid waste, this corresponds to about 19 pounds of particulates per ton of wastes burned. In most cases, these data were obtained using sampling methods different from the EPA method that is to be used to determine compliance. Gases from existing furnaces, therefore, may contain somewhat more than 1 grain of particulate matter per scf. The range of 15 to 30 pounds of particulates per ton of waste charged probably covers most existing incinerators of conventional design. The average particulate collection efficiency required to meet the standard is about 90 to 95 percent, based on the above uncontrolled emission rate.

State and local regulations are, in some cases, more stringent than the proposed standard. Typical standards range from 0.03 to 0.3 grain per scf, corrected to 12 percent CO_2. Several state and local standards are based on particulate test methods that differ from the EPA technique. Although no definite correlation between these methods has been established, it appears that the proposed standard is not inconsistent with the most stringent state standards in existence, which are based on the test procedure of the American Society of Mechanical Engineers. Despite the numerical difference, both standards will require approximately the same degree of particulate control.

Some state and local standards are corrected to a reference base of 50 percent excess air rather than 12 percent CO_2. Others are given in terms of mass emissions per unit weight of solid waste charged to the incinerator. All of these units can be interrelated if suitable gas and solid waste analyses are available.

JUSTIFICATION OF PROPOSED STANDARDS

The proposed performance standards are based on a study of incinerators in the United States and Europe. Information was obtained by inspections and stack tests of operating plants and by consultation with designers, plant operators, and state and local control officials. The Systems Study of Air Pollution from Municipal Incineration,[1] performed under contract by Arthur D. Little, Inc., provided a comprehensive review of American operations and incinerator technology. The study showed that almost all existing municipal incinerators release excessive amounts of particulates and that, until recently, none were equipped with high-efficiency particulate collectors.

Investigations by EPA engineers show that electrostatic precipitators, fabric filters, and high-energy scrubbers are being utilized to control particulates from municipal incinerators. Tests using the EPA method show that particulate emissions from precipitators are within the limits of the proposed standard. European tests and pilot studies in this country also indicate that fabric filters will provide sufficient particulate control to meet the standard. On one recent installation of a venturi scrubber, the designer guaranteed particulate emission levels consistent with the proposed standard.

Of the approximately 250 municipal incinerators in the United States, only 6 are equipped with high-efficiency particulate collectors. Five plants have electrostatic precipitators, and one is controlled with a high-energy venturi scrubber. Two of the domestic precipitators were tested by EPA and EPA contractors. Particulate emissions ranged from 0.07 to 0.09 grain per scf dry gas, corrected to 12 percent CO_2. These values were the average of three 2-hour sampling runs at each plant. One of the values was confirmed in an independent test in which the EPA sampling method was used. At one of the plants, previous tests with a similar sampling method indicated much higher values. Even though the discrepancy has not been explained, the EPA results are considered valid.

Several incinerators in Europe and Japan are equipped with electrostatic precipitators designed to achieve an efficiency of better than 99.0 percent in removing particulates. Two European plants, one in Germany (with an efficiency of 99 percent) and one in Sweden (with an efficiency of 98 percent), were tested by EPA personnel. Emissions averaged, respectively, 0.05 and 0.07 grain per scf of dry gas at 12 percent CO_2. The German plant was tested by European methods both before and during the EPA tests. Results of all tests - by both European and EPA methods - are in approximate agreement.

The U.S. plants tested are of both refractory and water-wall design, and capacities range from 300 to 400 tons of municipal refuse per day. The European incinerators were of water-wall design, with capacities ranging from 220 to 400 tons of municipal refuse per day.

The few existing data on municipal incinerators equipped with baghouses indicate that these devices also could be used to meet the standard. One small Swiss unit (36 tons per day) with a fabric filter was tested with European sampling procedures; measured values averaged 0.04 grain per scf, corrected to 12 percent CO_2.[3] Lower emissions of particulates are reported for a small pilot installation operated by the City of Pasadena (California) in 1960.[4] The first large municipal incinerators (greater than 50 tons per day) equipped with baghouses will be put into service in late 1971 in the United States and Switzerland.

Test data are not yet available for the one high-energy scrubber in use. The venturi scrubber is operated with a 12-inch (water column) pressure drop, and it serves a 240-ton-per-day incinerator. The designer has guaranteed an emission level consistent with the performance standard.

ECONOMIC IMPACT OF PROPOSED STANDARDS

Over the next few years it is estimated that 20 to 25 new municipal incinerator furnaces will be constructed annually in the United States. The actual rate of construction may vary considerably from this estimate depending on the availability of alternative solid waste disposal methods.

In order to meet the limits of the performance standards, new incinerators of conventional design will have to be equipped with high-efficiency particulate collectors. In addition the incinerators themselves may cost more than many existing units because of the need to provide optimum combustion of particulates. Very few existing furnaces are expected to be modified to the degree that they will have to comply with the new source standard.

Information on the cost of incinerators and control equipment is derived primarily from the cited Arthur D. Little study.[1] Reported costs are based on extensive review of manufacturers' quotations, estimated by Little to have an accuracy of plus or minus 20 percent. Both total installed costs and annual operating costs are presented. Installed costs include the incinerator, excavation, foundations, dump pits, buildings, and access roads. Annual operating costs include amortization, interest, utilities, maintenance, and wages.

The standard of performance is sensitive to cost/benefit analysis based on the use of electrostatic precipitators, scrubbers, or baghouse collectors. If the standard were relaxed by a factor of 2, capital and operating costs of necessary precipitators or scrubbers would be reduced 30 percent. Baghouse costs and collection efficiencies are the same regardless of the standard. The use of a mechanical collector would require that the standard be relaxed by a factor of 4. This would halve capital costs and save as much as $.50 per capita. The benefit of increased particulate control warrants the additional expenditure.

Installed costs for a 100-ton-per-day refractory furnace are about $1,000,000 for the incinerator, including about $150,000 for high-efficiency control equipment. Installed costs of control equipment are therefore about 15 percent of the entire plant costs. For plants with a capacity of 300 tons per day, costs decrease to 13 percent of the incinerator cost.

For a 100-ton-per-day water-wall furnace, incinerator costs are about ~~$1,500,000~~ $$1.15 \times 10^6$ installed, including about $105,000 for the cost of high-efficiency control equipment. Control equipment costs are therefore about 9 percent of installed costs for the 100-ton-per-day plant. This decreases to about 5 percent for a 300-ton-per-day plant.

The cost of operating the control equipment at the refractory furnace plant ranges from $29,000 (100 tons per day) to $65,000 (300 tons per day) per year. For the water-wall plant, these costs are $13,000 (100 tons per day) and $23,000 (300 tons per day) per year.

Refuse generation rates as determined by the Office of Solid Wastes Management, and equipment costs determined by Arthur D. Little, Inc., were used to calculate per capita control costs. Per capita cost varies with incinerator design and capacity and with the pollution control equipment employed. For the examples developed above, per capita cost is less than about 1 dollar per year, decreasing as furnace capacity increases.

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TECHNICAL REPORT NO. 3 - PORTLAND CEMENT PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for all new wet- and dry-process portland cement production facilities. The proposed standards would limit particulate releases. The limits are based on the EPA particulate sampling procedure, which includes a dry filter as well as wet impingment collectors.

The emission limitations are summarized as follows:

Particulate Matter from Kilns

1. No more than 0.30 pound of particulates per ton of solids fed to the kiln, or 0.15 kilogram of particulates per metric ton of solids fed to the kiln. The feed rate to the kiln is to be expressed on a dry basis.

2. Visible emissions shall not be darker in shade than that designated as No. 1/2 on the Ringelmann Scale or 10 percent equivalent opacity.

Particulate Matter from Clinker Coolers

1. No more than 0.10 pound of particulates per ton of solids fed

to the kiln, or 0.05 kilogram of particulates per metric ton of solids fed to the kiln. The feed rate to the kiln is to be expressed on a dry basis.

2. Visible emissions shall not be released to the atmosphere.

Particulate Matter from Other Equipment

Visible emissions shall not be released to the atmosphere from any other areas of the plant, including the raw-material and finished-product grinding-mill systems; raw material, clinker, and finished product storage facilities; conveyors; transfer points; bagging operations; and bulk loading and unloading facilities. For the purposes of this standard, visible emissions are considered to be any emission of greater than 5 percent opacity, or No. 1/4 Ringelmann. This limit is only slightly above the level detectable with the human eye.

The proposed visible emission standards are compatible with the mass emission limits for the kiln and clinker cooler; observations have shown that if mass emissions are at or below the respective limits, visible emissions will be at or below 10 percent opacity from the kiln and no emissions will be visible from the clinker cooler. Observations of the other process equipment - mills, conveyors, etc. - have shown that no visible emissions occur if common dust collection equipment is installed and properly maintained.

EMISSIONS FROM PORTLAND CEMENT PLANTS

Poorly controlled kilns can release as much as 45 pounds of particulates to the atmosphere per ton of raw material processed, and poorly controlled clinker coolers can release as much as 30 pounds of particulates per ton of raw material.[1,2,3] Such installations are likely to be equipped only with centrifugal dust collectors. The proposed standards would require owners and operators of new facilities to reduce the level of particulate emissions to 99.3 percent below that of a very poorly controlled kiln and 99.7 percent below that of a very poorly controlled clinker cooler.

At many modern cement plants either electrostatic precipitators or baghouses are used to collect dust from the kiln. The kiln is the most difficult item in a cement plant to control properly and thus is the most likely to be controlled inadequately. Baghouses, electrostatic precipitators, and centrifugal collectors are used for control of the other process equipment. Baghouses are the most commonly employed control devices for mills, conveyors, transfer points, storage silos, etc. Many of the dust collectors serve to recover product from exhaust gas streams and to increase product yields. Their function as air pollution control devices may, therefore, be secondary.

Many state and local regulations, unlike the proposed standards, allow particulate emissions to vary with the rate of input of raw materials. For a typical kiln-feed rate of 100 tons per hour, existing state and local limits range from 0.32 to 0.90 pound per ton for kilns and from 0.19 to 0.64 pound per ton for clinker coolers, all of which are higher than the proposed standards. A few agencies have adopted stack-gas concentration limits comparable to the proposed standards. Because some agencies use particulate sampling methods other than the EPA method, the limits are not directly comparable.

JUSTIFICATION FOR PROPOSED STANDARDS

The proposed performance standards are based on inspections and stack tests of existing facilities; consultation with plant operators and designers, control equipment manufacturers, and state and local control officials; and review of the literature. A principal literature source was a government publication, resulting from a cooperative study conducted with representatives of companies manufacturing portland cement, entitled Atmospheric Emissions from the Manufacture of Portland Cement.[1]

Preliminary investigations revealed the locations of the 12 reportedly best-controlled plants in the United States. No information obtained indicated that foreign plants were using better technology than the United States. Consequently, no foreign plants were inspected. Twelve United States plants were visited and information was obtained on the process and control equipment; judgment was also made as to the feasibility of conducting stack tests. Five locations were unsatisfactory because control equipment was inadequate or the physical layout of the equipment made it impossible to conduct tests (e.g., a pressure baghouse that does not have a stack). Stack tests were conducted at seven locations and covered four kilns, three clinker coolers, and four raw-material and finished-product mills.

Particulate Matter from Kilns and Clinker Coolers

Four kilns, as stated, were tested by EPA; corroborative test data were obtained from a local air pollution control agency on one of the EPA tested kilns. Results of only three tests were available at the time the standards were proposed. Neither of the two wet-process kilns controlled with electrostatic precipitators was able to meet the proposed standards. A test of a dry-process kiln controlled with a baghouse, however, showed particulate emissions of 0.20 pound per ton of feed, which is below the proposed standard. Inspections were made of three additional kilns controlled with baghouses. No visible emissions were produced from the latter three kilns, although one wet-process kiln showed a moisture-condensation plume during cold weather. These kilns were not tested because of the physical layout of the equipment.

Three clinker coolers were tested by EPA. The cooler with an electrostatic precipitator and one of the two units with baghouses were shown to meet the proposed standard. No visible emissions were observed from two additional clinker coolers with baghouses, although they were not tested due to the physical layout of the equipment.

Investigations confirmed that fabric-filter collectors can be applied to both kilns and clinker coolers in conventional wet- and dry-process portland cement production facilities to reduce particulate emissions to the limits of the proposed standards. It is possible that electrostatic precipitators also can be used to meet the proposed standard for kilns, but such precipitators would have to be more efficient and probably larger than units presently installed in existing plants, since tests of the two kilns with electrostatic precipitators showed that neither was able to meet the proposed standards. No other particulate abatement schemes have been demonstrated to be capable of achieving the standards, although investigations of high-energy scrubbing are under way.

Particulate Matter from Other Equipment

No emission standards other than visible emission limits have been proposed for other equipment in cement plants, such as raw-material mill systems, finished-product mill systems, raw-material and finished-product storage facilities, conveyors, bagging operations equipment, and bulk loading and unloading facilities. The normal industrial practice is to control dust from these sources by the use of baghouses, although precipitators sometimes are used on finish mills. These devices prevent loss of material from the process and reduce air pollution. In most instances, the economics of material recovery are sufficient to justify the abatement devices without regard to air pollution control regulations. Inspections by EPA engineers show that no visible emissions occur from these devices when they are properly maintained. Where visible emissions are encountered, they are likely to be the result of bag failure.[4]

ECONOMIC IMPACT OF PROPOSED STANDARDS

It is estimated that three new Portland cement kilns and associated equipment will be constructed in the U. S. each year and that three existing systems will be modified to the extent that they will come under the proposed standards.[5]

Many state and local agencies presently have regulations for cement plants that require the same types of dust-control equipment mandated by the proposed standards. These standards will not result, then, in an appreciable increase in the cost of a new cement plant. The only significant increase in cost would be to a company that would otherwise have constructed a poorly controlled plant in an area not covered by adequate state or local regulations. In any case, the installed investment and operating costs of baghouse collectors and electrostatic precipitators cannot be attributed entirely to air pollution control because many of the devices are used for product recovery and are economically justifiable on that basis. Thus, investment costs cannot be computed for air pollution control alone.

The standard of performance for the kiln is sensitive to cost/benefit analysis. The standard is based on a baghouse collector; electrostatic precipitators are alternative control devices. The use of electrostatic precipitators of efficiencies consistent with existing installations would require that the standard be relaxed by a factor of 3 with a saving of only about 1 percent of total plant investment. More efficient precipitators could be installed, but the cost would be about 1.1 times that of baghouses. The trend in the cement industry is toward the use of baghouse collectors, and this trend should be encouraged.

For a new wet-process plant with a capacity of 2.5 million barrels per year (90 tons of feed per hour to the kiln), the total investment for all installed air pollution control equipment will represent approximately 12 percent of the investment for the total facility. The cost of control equipment for the clinker cooler will be approximately 10 percent of the cost of all air pollution equipment. An electrostatic precipitator or baghouse for the kiln represents approximately 60 percent of the cost of all air pollution equipment. The remaining 30 percent of the costs will cover dust control for the finished-product mill grinding system, conveyors, transfer points, storage silos, etc. Annual operating costs for the control equipment will be approximately 7 percent of the total plant operating costs if a baghouse is used for the kiln, and 5 percent if an electrostatic precipitator is used.[5,6]

For a new plant of 2.5 million barrels per year, using the dry process, the total installed investment cost of all air pollution control equipment will be slightly higher than 13 percent of the total facility investment because additional control equipment will be required for the raw material mill grinding system.[6] The operating costs for dry-process control will be approximately the same as those for the wet process.

The impact of the proposed standards on control-equipment manufacturers will be small. Because the major manufacturers of control equipment offer a complete line (electrostatic precipitators, baghouses, and scrubbers), the possible reduction in sales of electrostatic precipitators will have little economic impact on manufacturers because the sale of baghouses will increase.

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TECHNICAL REPORT NO. 4 - NITRIC ACID PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new facilities producing so-called "weak nitric acid" (defined as 50 to 70 percent strength). The standards will not apply to the various processes used to produce strong acid by extraction or evaporation of weak acid, or by the direct strong-acid process.

The standards of performance are being proposed for total oxides of nitrogen and for attendant visible emissions, which are a function of nitrogen dioxide concentration.

The standards would limit emissions to the atmosphere as follows:

1. No more than 3.0 pounds of nitrogen oxides (NO_x) per ton of acid produced or 1.5 kilograms NO_x per metric ton, averaged over a 2-hour period. Acid produced is expressed in tons of equivalent 100-percent-strength nitric acid.

2. Visible air pollutants shall not be released to the atmosphere.

For a typical weak-nitric acid production facility, the standard of 3.0 pounds per ton of acid is equivalent to an undiluted stack-gas concentration of 209 parts per million (ppm) by volume. This assumes an exhaust volume of 122,000 standard cubic feet (scf) per ton of acid produced.

EMISSIONS FROM NITRIC ACID PLANTS

Without control equipment, nitric acid production facilities will release about 43 pounds of NO_x per ton of acid produced at a concentration of about 3000 ppm NO_x (by volume) in the exit gas stream. Approximately 50 percent of this emission will be in the form of nitrogen dioxide (NO_2), an opaque reddish-brown gas; the remainder will be colorless nitric oxide (NO). The standards would require owners and operators of new facilities to reduce NO_x emissions to a level 93 percent below the emissions produced by an uncontrolled facility.

Of the existing 194 weak-nitric acid production facilities operated by government and commercial operators in the United States in 1971,[1] only 10 were specifically designed to include NO_x abatement, which is accomplished by means of decomposition of NO_x to elemental nitrogen and oxygen. An additional 52 plants, however, were designed to use catalytic combustion devices for decolorization and, subsequently, heat recovery. The so-called "decolorizers" convert visible NO_2 to colorless NO with the concurrent generation of appreciable heat. Energy recovered from the exhaust gases is used primarily to power the air-compressor turbine in the acid process.

There are no state or local NO_x emission regulations in the United States that apply specifically to nitric acid production. Ventura County, California, has enacted a limitation of 250 ppm NO_x that governs nitric acid plants as well as steam generators and other sources.[2]

Visible-emission regulations with equivalent opacity provisions also restrict nitric acid manufacturing operations in many areas. Nevertheless, operators can meet these requirements through the use of decolorizer devices, which have little effect on total NO_x emissions.

JUSTIFICATION OF PROPOSED STANDARDS

The proposed performance standards are based on inspections and stack tests of existing facilities; consultations with operators, designers, and state and local control officials; and review of the literature.

In 1962, a cooperative project was initiated by the Manufacturing Chemists' Association and the U.S. Public Health Service to study emissions from selected chemical manufacturing processes. A goal of that program was to publish relevant information in a form helpful to control agencies and to the chemical industry. The results of the study were subsequently published as Atmospheric Emissions from Nitric Acid Manufacturing Processes.[3]

Investigations of current nitric acid control technology by EPA engineers showed that catalytic decomposition systems can be applied to conventional nitric acid production facilities to reduce NO_x emissions to levels within the limits of the proposed standard. Although alternate techniques are under development, no other NO_x abatement schemes have been demonstrated capable of achieving the standard.

The catalytic systems are installed downstream of the absorption tower at conventional acid-production facilities utilizing the ammonia-oxidation process. Natural gas or hydrogen-rich fuel is burned in the gas stream to raise the temperature and to remove excess oxygen prior to catalysis. Nitrogen oxides are destroyed in a stepwise process. Initially, NO_2 is converted to NO; then the NO is decomposed to nitrogen and oxygen. The reactions are exothermic, and reaction products leave the system at temperatures as high as 1500°F. Operators recover heat from the tail gases.

A survey of the ten plants in the United States that are equipped with these systems indicated that five were consistently achieving low NO_x emission levels. Testing and inspection confirmed that three of the plants could be operated well within the performance standard. The other two were found to exceed the standard during EPA tests; their emissions were 4.8 and 8.4 pounds of NO_x per ton of acid produced. Both were found to be operating with partially deactivated catalyst. Company tests using accepted test procedures indicated that one of the facilities had been achieving an average of 2.0 pounds NO_x per ton of acid a few months prior to the test. At each installation, testing was conducted for about 6 hours on each of 3 consecutive days.

Two of the three facilities found to meet the standard burned hydrogen-rich purge gas from an adjacent ammonium nitrate plant. The third plant burned natural gas. During the EPA tests, NO_x emissions from each of the three facilities were consistently lower than the maximum levels of the performance standards. Measurements were conducted with continuous-NO_x-monitoring devices, and values were confirmed by the phenoldisulfonic acid method specified in the regulation.

The nitric acid production facilities on which the tests were conducted were of the conventional ammonia-oxidation type of design. They ranged in size from 55 to 350 tons per day (24-hour).

All five of the facilities with catalytic abatement devices were found to operate with no visible emissions, which indicated that even the two systems with partially spent catalyst were serving as effective decolorizers. Although no separate NO_2 analyses were performed, it appears that most of the NO_2 was converted to colorless NO. Thus, any facility meeting the mass NO_x limit will produce no visible emissions from the stack.

ECONOMIC IMPACT OF PROPOSED STANDARDS

Based on projections made by nitric acid plant builders and operators, it is estimated that construction of new plants will average five facilities per year.

In considering costs for NO_x control, the assumption was made that any new nitric acid facility would be equipped with a catalytic decomposition system for heat recovery and possible NO_x abatement even if NO_x limits were not imposed. In the absence of any regulation on NO_x emissions, this unit would be operated as a decolorizer and would produce the heat recovery needed to drive a process-air compressor. Abatement of NO_x requires that all oxygen be burned from the tail-gas stream; this is not a requirement for heat recovery. Consequently, the fuel used for decolorization and partial abatement is less that that necessary for meeting the proposed standards. Furthermore, typical catalysts will become inactive for NO_x abatement purposes long before they lose their ability to decolorize.

The standard of performance represents full control and is insensitive to cost/benefit analysis. The alternative is essentially no control. The standard of performance does not represent a significant increase in the capital cost for a new plant, although operating costs will increase as the result of increased fuel use and decreased catalyst life.

Estimates of both capital investment and operating costs for catalytic decomposition systems vary widely because of differences in design philosophy and choices of heat and power recovery among different construction firms. Also, reported catalyst life varies from several months to several years. Cost estimates for a modern plant with a capacity of 300 tons per day show that full control adds 1 percent to the cost of the most typical product, ammonium nitrate, and represents 4 to 8 percent of the total capital investment for the facility.

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TECHNICAL REPORT NO. 5 - SULFURIC ACID PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new contact-process sulfuric acid and oleum facilities that burn elemental sulfur, alkylation acid, hydrogen sulfide, organic sulfides, mercaptans, or acid sludge. They do not apply to metallurgical plants that use acid plants as SO_2 control systems, or to chamber process plants or acid concentrators.

The proposed standards establish limitations on sulfur dioxide and acid mist emissions, and attendant visible emissions.

The emission limitations being proposed are summarized as follows:

Sulfur Dioxide

No more than 4.0 pounds of sulfur dioxide (SO_2) per ton of acid (100 percent H_2SO_4) produced or 2.0 kilograms SO_2 per metric ton.

Acid Mist

1. No more than 0.15 pound of acid mist (measured as H_2SO_4) per ton of acid (100 percent H_2SO_4) produced or 0.075 kilogram acid mist per metric ton.

2. No visible air pollutants shall be released to the atmosphere.

The standard allows about 0.3 percent of the feedstock sulfur to be released to the atmosphere as SO_2. For a typical plant, the sulfur dioxide standard is equivalent to an exit-gas concentration of 280 ppm. Where rich SO_2 streams (greater than 8.0 percent) are processed, the equivalent concentration will be greater than 280 ppm. Conversely, where weak SO_2 streams are handled, permissible concentrations will be lower and more restrictive. The range 180 to 350 ppm will cover emissions from most contact acid plants.

The acid mist standard of 0.15 pound per ton of acid is equivalent to a concentration of 0.8 mg of sulfuric acid per standard cubic foot of effluent for a typical sulfur-burning system. Volumetric equivalent concentrations in milligrams per standard cubic foot (mg/scf) will vary from plant to plant because they are dependent on the inlet sulfur dioxide concentration.

EMISSIONS FROM SULFURIC ACID PLANTS

Almost all existing domestic contact-process sulfuric acid plants are of the single-absorption design and have no sulfur dioxide emission controls. Emissions from these plants range from 1500 to 6000 ppm SO_2 by volume, or 21.5 to 85 pounds of SO_2 per ton of acid produced. Several state and local agencies limit SO_2 emissions to 500 ppm from new sulfuric acid plants, but few such facilities have been put into operation.

Many sulfuric acid plants utilize some type of acid mist control device, but a significant number have no controls whatever. Uncontrolled acid mist emissions vary between 2 and 50 milligrams per standard cubic foot (mg/scf), or 0.4 to 9 pounds of H_2SO_4 per ton of acid produced.

The lower figure represents emissions from a plant burning high-purity sulfur. State and local regulatory agencies have only recently made limits on acid mist emissions more stringent; some agencies, for example, have adopted limits of 1 and 2 mg/scf, respectively, for new and existing plants.

JUSTIFICATION OF PROPOSED STANDARDS

The proposed performance standard for SO_2 is based on inspections and stack tests of existing facilities; consultations with operators, designers, and state and local control officials; and review of the literature. Appreciable information concerning existing single-absorption plants was derived from a cooperative study initiated in 1962 by the Manufacturing Chemists' Association, Inc., and one of EPA's predecessor organizations, the National Air Pollution Control Administration. Results of the study were published in a Public Health Service document, Atmospheric Emissions from Sulfuric Acid Manufacturing Processes.[1]

Much reliance necessarily had to be placed on the two demonstrated SO_2 removal processes and on the single domestic application of each process to full-scale acid production facilities. Tests of the two plants for both acid mist and SO_2 emissions were conducted in 1971 by EPA personnel, using test methods presented in the regulations.

Sulfur Dioxide

The two plants tested and evaluated by EPA engineers were: (1) a plant of typical dual-absorption design and (2) a conventional single-absorption spent-acid-burning plant that uses a sodium sulfite-bisulfite scrubbing process to recover SO_2 from tail gas. The dual-absorption plant keeps

SO_2 emissions low by converting more of the feedstock sulfur to sulfuric acid. Other processes in use can control SO_2 to the levels set by the proposed standards; however, they are considered suitable for special situations only since they produce either a weak acid or a by-product that has limited marketability.

Over 20 dual-absorption plants that have been operating successfully in Europe for several years use both elemental sulfur and roaster gas as feed. The literature reveals that three of these plants produce maximum emissions ranging from 1.2 to 3.1 pounds of SO_2 per ton of acid produced, or 91 to 260 ppm SO_2 by volume.

The first U. S. dual-absorption plant was put into operation in 1970 and has been in continuous operation since then. Stack tests conducted by both EPA and company personnel show that SO_2 emissions normally do not exceed the limits of the performance standards. During EPA tests, the facility was being operated at only 52 percent of rated production and SO_2 emissions were correspondingly lower than normal, ranging from 1.5 to 1.9 pounds per ton of acid produced. These values were corroborated by company tests. Testing by the operator showed full-load SO_2 emissions to be consistently less than 4.0 pounds of SO_2 per ton of acid, with emissions below 3.0 pounds per ton much of the time.

It has been demonstrated that sulfur dioxide can be removed from tail gases of single-stage acid plants by means of a sodium sulfite-bisulfite scrubbing process. In this system, SO_2 is thermally recovered from the scrubbing solution and fed back to the acid-manufacturing process. The only full-scale sulfite-bisulfite system was installed on an existing spent-acid plant in 1970. Since January of 1971, it has been in continuous operation. Tests of this plant by EPA personnel have shown emissions of 2.6 to 2.9 pounds of SO_2 per ton of acid produced. The tests represent some 18 hours of testing over a 3-day period. Similar tests conducted by company personnel indicate that the plant is capable of sustained operation at this level of SO_2 collection.

Sulfite-bisulfite scrubbing processes produce waste liquor that contains sodium sulfate and sodium thiosulfate. Methods for disposing of these products will have to be considered by plant operators. The process designers are investigating several means of handling these wastes.

Continuous stack monitoring at the plants tested indicates that at full load the plant can be consistently operated so that emissions are kept within the limits of the performance standard. Emissions exceed these values only during abnormal operation, and on these occasions the values are seldom more than 6.5 pounds of SO_2 per ton of acid produced, or about 500 ppm. As operators obtain more experience with these systems, abnormal operating conditions are expected to occur less frequently.

Acid Mist

Review of the literature and investigations by EPA engineers showed that many existing plants have already installed high-efficiency acid-mist eliminators, including both fiber demisters and wire and tube electrostatic precipitators. Fiber demisters are more commonly employed in the industry.

The standard for new sources is based principally on stack tests conducted at the two plants that use sulfur dioxide control systems. EPA tests of the dual-absorption plant and the plant using the sulfite scrubber system show that acid-mist emissions can be held below the standard. The lowest levels, 0.02 pound per ton of acid produced, were recorded at the dual-absorption plant during periods when the plant was operating at about one-half load. At other times, the acid mist emissions from the two plants ranged from 0.04 to 0.15 pound per ton of acid produced.

It must be emphasized that the acid mist standard is based on results obtained with the EPA method published in the regulations. Measurements with other test methods may give greater or lesser values, depending on whether the method measures sulfur trioxide (SO_3) and acid vapor. (The latter two materials are sometimes considered under the collective term "acid mist.") Acid vapor and SO_3 are converted to acid mist on cooling and/or moisture absorption.

Inasmuch as new plants will be required to install either the dual-absorption process or a tail-gas scrubbing system, it would appear that emissions from the plants tested are representative of emissions from new plants. It is uncertain whether the dual absorption or the sulfite scrubbing process inherently reduces acid mist levels below those that would normally be encountered from a single-absorption plant. In any case, the literature indicates that both high-efficiency fiber demisters and electrostatic precipitators can reduce acid mist emissions to 0.10 pound per ton of acid produced.[2] The most severe conditions possibly are encountered at spent-acid plants that process oleum (fuming sulfuric acid). The best-controlled plants of this type produce no visible emissions.

ECONOMIC IMPACT OF PROPOSED STANDARDS

It is estimated that over the next few years two new sulfuric acid plants will be constructed annually in the United States.

Sulfur dioxide control systems represent a significantly greater capital investment than acid mist collectors. Nevertheless, SO_2 control systems provide a dividend to the operator in the form of increased acid yields. Elevated sulfur costs provided part of the incentive for the development of the dual-absorption process. The economics of high-yield processes such as dual absorption and sulfite scrubbing will continue to be dependent on the price of sulfur, with higher prices favoring greater SO_2 control.

The standard of performance for sulfur dioxide is insensitive to cost/benefit analysis because no other control systems are available. The alternative would be a single-stage plant with no SO_2 control.

The costs of control vary with location. Nevertheless, new plants would be expected to use the dual-absorption process, whereas modified existing plants would probably use an SO_2-scrubbing system, such as the sulfite-bisulfite process. A dual-absorption plant with a 700- to 750-ton-per-day capacity may cost 22 percent more than an uncontrolled single-absorption plant; however, the operating costs are essentially the same. Full control adds 3 to 5 percent to the cost of sulfuric acid, not including return on investment.

A new single-absorption plant, of the same capacity, with a sodium sulfite-bisulfite scrubbing process attached may cost 35 percent more than an uncontrolled plant. The SO_2-control cost is about 5.5 percent of the sulfuric acid list price, without return on investment.

Acid mist control equipment is relatively less costly, representing from 1 to 2 percent of the capital investment of a 700- to 750-ton-per-day plant. The additional operating costs, including amortization, represent 0.1 to 0.7 percent of the current sulfuric acid list price, depending on the type of control equipment used. Again, return on investment is not included.

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