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FOREWORD

This decade marks the beginning of an era of assessment of the impact of the tremendous technological advances in agriculture, medicine, communications, transportation, and space exploitation, and the enactment of noteworthy measures towards the preservation of our natural environment. Instead of wanton exploitation, man finally is recognizing that resources available on this plant are finite and that, unless he uses them wisely, he will likely find himself as extinct a species as those he has exterminated.

Specifically, the growing problem of air pollution and its control has taken a new dimension in the United States with the passage of the Clean Air Amendments of the Clean Air Act. At long last, we have quantified and established national goals for the quality of the air we breathe. This volume reports on the technological advances towards purification of our environment and towards achieving national standards on air quality, not only in the metropolitan areas but all over the country during this short period. All of the papers were presented at the National Meetings of the American Institute of Chemical Engineers during 1972. They testify to the significant role of chemical engineers in the purification of our environment and therefore in the service of humanity.

The book has been divided into six major sections: The first two deal with the national emission standards and their impact on industry and with industrial air pollution control programs. Three sections are categorized by emission species (oxides of nitrogen, oxides of sulfur, and particulates). The final section is devoted to miscellaneous topics, including control systems and consideration of pollution control as a process design variable. Some abstracts of papers presented at AIChE meetings and published elsewhere have also been included.

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NATIONAL EMISSION STANDARDS AND THEIR IMPACT ON INDUSTRY

The passage of the Clean Air Act of 1970 and subsequent promulgation of National Emission Standards from various sources by the Environmental Protection Agency has had direct socio-economic impact on a number of segments of industry. This section deals with the effect of National Emission Standards as viewed by representatives from the chemical, automotive, and electrical power industries. It focuses on the complex problems associated with the implementation of these standards and their overall short- and long-range effect on national air quality and the industry. The role of academia in the assessment, design, and research associated with the implementation of such standards is also discussed.

Charanjit Rai

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FEDERAL EMISSION STANDARDS FOR STATIONARY SOURCES

Donald F. Walters
and
Don R. Goodwin

Two approaches to the control of stationary sources of air pollution were considered by the Congress early in 1967. A bill offered by the Administration provided (among other things) for national emission standards to be developed by the Federal government and enforced by state and local control agencies. An alternate approach developed in a Senate draft bill provided for what has been called regional air quality management. This bill called for (1) establishment of Air Quality Control Regions (AQCR), (2) development of ambient air quality standards by states based on Federal air quality criteria, and (3) state implementation plans that provided the necessary controls via emission standards to achieve the ambient air quality standards in a given region.

You know the outcome; the regional air quality approach was adopted in the Air Quality Act of 1967. However, as a result of various discussions and compromises the Air Quality Act directed the Department of Health, Education and Welfare to provide Congress with a study of the need and effect of National Emission Standards.

A report entitled National Emission Standards Study was prepared and sent to Congress in March of 1970 (*1*). In this report three alternate approaches to the control of stationary sources were presented. The recommended approach was essentially one of speeding up the regional air quality by setting National Ambient Air Quality Standards, having states develop implementation plans for their entire territory, establishing national emission standards for major new stationary sources as well as for new and existing sources of extremely hazardous air pollutants.

Congress elected to incorporate the principal features of this recommendation into the Clean Air Amendments of 1970 (*2*). The amendments called for a speed-up of Federal action in the control of air pollution. Automobile emission control levels were mandated for 1975, National Ambient Air Quality Standards to protect health and welfare were authorized. AQCR's covering the whole country were to be designated in 90 days. Strict timetables for state and Federal actions were established for the development and evaluation of State Implementation Plans that would cover the nation with regulations for air pollution control. Also included was authority to promulgate national emission standards for major new sources; and new and existing sources of hazardous pollutants.

Office of Air Quality Planning and Standards, Environmental Protection Agency, Research Triangle Park, North Carolina.

NEW SOURCE PERFORMANCE STANDARDS

Section 111 of the Clean Air Amendments authorizes the establishment of standards of performance for new air pollution sources. The Act states that "The term 'standard performance' means a standard for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated."

Congress felt that "the maximum use of available means of preventing and controlling air pollution is essential to the elimination of new air pollution problems while cleaning up existing sources." Further, they felt that "maximum feasible control of new sources at the time of their construction . . . . . as the most effective and in the long run the least expensive approach" (*3*).

Under this section of the Act, Congress intended that major new industrial plants and facilities built in this country would include the best practicable air pollution control at the time of their design and construction (*3*), (*4*). These standards must (a) realistically represent best demonstrated control practices: (b) adequately consider the cost of such control; (c) be applicable to major modifications as well as new installations; and (d) meet these conditions for all variations of the industrial process being considered anywhere in the country. It is not surprising that developing standards is a complex business.

We have developed a conceptual framework for new source performance standards and are in the process of obtaining the data base and selecting standards for a wide variety of source categories. These guidelines now include:

1. Source test data on existing well-controlled plants are the most desirable basis for setting emission limits for new plants. Most of this data is obtained from EPA source tests on best controlled plants.

2. Interpretation of test results from any single best-controlled plant must consider (a) representativeness of the plant tested (feedstock, operation, size, age, etc.); (b) age and maintenance schedule for the control equipment tested and probable degradation of similar new equipment even with good maintenance procedures; and (c) design uncertainties for the type of control equipment being considered and the safety factor that must be used to ensure meeting the emission standard.

3. For sources where emerging technology is significant, consideration is given to (a) test data from pilot and prototype installations and application of reasonable engineering judgment to these data, (b) vendor guarantees; (c) existing design contracts; (d) foreign technology, and (e) published literature.

4. Cost of control is in reference to the cost of the new industrial installations and the economic impact on the industry, not in reference to air quality improvements or the economic benefits of such improvement.

5. Where possible, standards should be able to be met through the use of more than one control technique or licensed process. (Electrostatic precipitators or fabric filters can meet standards for cement plants.

6. Where possible, standards should encourage, or at least permit, the use of process modifications or new processes in place of add-on air pollution control systems. (Use of low sulfur fuel.)

7. Where possible, standards should allow the use of control systems capable of controlling other pollutants (that is, scrubbers versus electrostatic precipitators on steam electric generators).

8. Where possible, standards should allow the use of control systems that can minimize the impact on other aspects of the environment.

9. Where appropriate, visibility standards are established which are compatible with mass emission standards. A prime purpose of this type of standard is to facilitate surveillance and enforcement.

The timetable in the Clean Air Act requires that EPA first publish a list of source categories for which it intends to establish performance standards. Within 120 days after the list is published in the *Federal Register*, the Agency must propose standards for those categories. Within 90 days following their proposal, EPA must promulgate the standards. As required by the act, time is provided for interested parties to comment on the proposed standards and for the Agency to review and react to the comments prior to promulgation. The standards are effective upon promulgation; however, a source is subject to the standards if construction or modification is begun after the date the applicable standards are proposed.

In carrying out the requirements of Section 111 of the act, EPA proposed on August 17 and promulgated on December 23, 1971, New Source Performance Standards for the first group of designated categories: fossil fuel-fired steam generators of more than 250 million B.t.u./hr. heat input; incinerators processing more than 50 tons/day of municipal waste: Portland cement plants; nitric acid plants; and sulfuric acid plants (*5*), (*6*). These standards are briefly summarized in Table 1.

TABLE 1. SUMMARY OF STANDARDS FOR NEW OR SUBSTANTIALLY MODIFIED SOURCES

1. **Steam Generators** (>250 million B.t.u./hr. heat input)
   (a) Particulate matter
      (1) 0.1 lb./million B.t.u. heat input (0.18 g/million calorie)
      (2) No more than 20% opacity visible emissions, except for two minutes in any hour visible emissions may be as great as 40% opacity.
   (b) Sulfur dioxide
      (1) 0.8 lb./million B.t.u. heat input (1.4/million calorie) when oil is fired.
      (2) 1.2 lb./million B.t.u. heat input (2.2 g/million calorie) when coal is fired.
   (c) Nitrogen oxides (as NO_2)
      (1) 0.20 lb./million B.t.u. heat input (0.36 g/million calorie) when gas is fired.
      (2) 0.30 lb./million B.t.u. heat input (0.54 g/million calorie) when oil is fired.
      (3) 0.70 lb./million B.t.u. heat input (1.26 g/million calorie) when coal is fired.
2. Incinerators (>50 tons/day charging rate)
   Particulate Matter:
   0.08 grains/st. cu. ft. corrected to 12% CO_2 (0.18 g/NM^3)
3. Portland Cement Plants
   Particulate matter
   (1) 0.30 lb. from the kiln per ton of feed to the kiln (0.15 kg/metric ton of feed).
   (2) 0.10 lb. from the clinker cooler/ton of feed to the kiln (0.05 kg/metric ton of feed).
   (3) No more than 10% opacity visible emission from kiln and cooler.
   (4) Less than 10% opacity visible emission from all other sources in the plant.
4. Nitric Acid Plants
   Nitrogen Oxide (as NO_2):
   (1) 3 lb./ton of acid produced (1.5 kg/metric ton).
   (2) Less than 10% opacity visible emission.
5. Sulfuric Acid Plants
   (a) Sulfur Oxide:
      4 lb./ton of acid produced (2 kg/metric ton).
   (b) Acid Mist:
      (1) 0.15 lb./ton of acid produced (0.075 kg/metric ton).
      (2) Less than 10% opacity visible emission.

In addition to setting emission limits for major pollutants for these sources, this initial regulation interpreted and further defined several important provisions of the act for purposes of enforcing Section 111. These included definition of "*new source*," "*modification*," and an interpretation of the term *affected facility* to define the process or equipment within a source category to which a standard applies.

At this writing a second group of standards that cover facilities in the following categories has been proposed for public comment:

Source	Affected facility	Pollutant
Asphalt concrete plants	Dryer; hot aggregate elevator screening equipment; hot aggregate weighing equipment; mineral filler loading transfer and storage	Particulates
Petroleum refineries	Process gas burned in process heaters, boilers and waste gas disposal systems	Sulfur dioxide
	Catalyst regenerators	Particulates Carbon Monoxide
Gasoline, crude oil, and petroleum distillate storage tanks	Storage vessel of more than 65,000-gal. capacity	Hydrocarbons
Iron and steel mills	Basic oxygen furnaces	Particulates
Sewage treatment plants	Sludge incinerators	Particulates
Secondary brass or bronze refining facilities	Reverberatory furnaces	Particulates
Secondary lead smelters and refineries	Blast and reverberatory furnaces	Particulates

Development of standards is well advanced for facilities in the following primary smelting industries.

Source	Affected facility	Pollutant
Copper smelters	Roasters, reverberatory furnaces, converters, or metallurgically equivalent	Particulates Sulfur dioxide
Lead smelters	Sintering machines, roasters or metallurgically equivalent	Particulates Sulfur dioxide
Zinc smelters	Sintering machines, roasters or metallurgically equivalent	Particulates Sulfur dioxide

Other industrial categories that are candidates for proposed New Source Performance Standards along about late spring 1974.

Source	Affected facility	Pollutant
Aluminum reduction plants	Pot lines	Fluorides
Ferro-alloy plants	Furnaces	Particulates
Coal cleaning plants	Air tables, thermal dryers	Particulates
Iron and steel mills	Electric furnaces	Particulates Carbon monoxide
Phosphate fertilizer plants	Wet process phosphoric acid Diammonium phosphate Superphosphoric acid Triple superphosphate	Fluorides
Gas turbines		Particulates Nitrogen oxides Sulfur oxides

As noted above, Performance Standards apply to new or modified sources. There is an important exception in Section 111 (d) whereby states are required to control existing source categories when the pollutant for which performance standards are set is a noncriteria pollutant (that is, there is no National Ambient Air Quality Standard for that pollutant) or has not been designated a hazardous pollutant. Examples of noncriteria pollutants for which performance standards for new sources have been, or will be, established are acid mist from sulfuric acid plants, total reduced sulfur from Kraft pulp processes and fluorides from phosphate fertilizer processes and aluminum reduction plants. This provision of the act is obviously an important option that will be considered in developing a national strategy for the control of a given pollutant.

NATIONAL EMISSION STANDARDS FOR HAZARDOUS POLLUTANTS.

Section 112 of the Clean Air Amendments provides for the control of hazardous pollutants through the establishment of national emission standards that apply to both new and existing sources.

The act defines a hazardous pollutant as "an air pollutant to which no ambient air quality standard is applicable and which in the judgment of the Administrator may cause, or contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness."

The Administrator of EPA was directed to publish a list of hazardous pollutants 90 days after passage of the Act (and from time to time revise such a list). On March 31, 1971, in the *Federal Register*, asbestos, beryllium, and mercury were listed as hazardous pollutants.

The Act directs EPA to propose emission standards within 180 days after the designation of any hazardous pollutant. Standards are to be established at those levels which provide "an ample margin of safety to protect the public health . . .". Public hearings on the question of whether or not a designated pollutant is hazardous must be scheduled within 30 days after proposal of standards.

Not later than 180 days after proposal of standards and after public hearing, EPA is directed to promulgate standards

unless the Administrator determines upon the basis of the hearing that the pollutant is not hazardous.

On December 7, 1971, National Emission Standards for Hazardous Air Pollutants were proposed (7). The standards, revised to accomodate comments received since proposal, were promulgated on April 6, 1973, and are briefly summarized in Table 2. These standards are best discussed by pollutant category.

TABLE 2. SUMMARY OF HAZARDOUS POLLUTANT STANDARDS

Pollutant	Affected Facility	Limitation
Mercury	Mercury ore processing facilities Mercury cell chlor-alkali plants	Not more than 2300 g/day for the entire facility
Beryllium	Extraction plants, foundries ceramic manufacturing plants beryllium waste disposal incinerators propellant plants, machine shops processing alloys with > 5% Be.	Not more than 10 gm/day (Option of meeting ambient level of 0.01 ugm/m^3 if three years of ambient data available).
	Rocket testing facilities	Limited to 75 ugm-min/m^3
Asbestos	Asbestos mills, manufacturing operations	No visible emissions or use control equipment meeting specific performance characteristics
	Spraying of asbestos fireproofing and insulation that contains more than 1% asbestos on buildings, structures, pipes and conduits.	Banned
	Spraying of asbestos fireproofing and insulation that contains more than 1% asbestos on equipment and machinery.	No visible emissions
	Use of asbestos mill tailings on roadways	Banned except on asbestos ore deposits
	Demolition operations	Good control practics are required

ASBESTOS

The standards are designed to minimize asbestos emissions to the atmosphere. The lack of a suitable asbestos sampling and analytical technique and knowledge of a safe asbestos exposure level made it necessary to express the standards in terms of visible emissions, equipment specifications, and prohibitions on the use of asbestos.

The sources covered by the asbestos standard are milling, manufacturing, spraying roadway surfacing, and demolition. Examples of prohibitions are the spraying of asbestos–containing fireproofing, thermal insulation, or acoustical insulating materials containing more than 1% asbestos on any portion of a building or structure. The surfacing or resurfacing of nonmine roads with asbestos tailings is also prohibited.

For manufacturing operations a properly maintained and operated fabric filter or equivalent will meet requirements of the regulation.

BERYLLIUM

The total allowable emission for beryllium sources is no more than 10 g/day. Total emissions to the atmosphere from any source shall not exceed amounts that will cause ambient air levels to exceed 0.01 micrograms/m^3 averaged over a 30-day period.

Major known sources of beryllium are extraction plants, machine shops processing beryllium or beryllium alloys containing more than 5% beryllium, foundries processing beryllium alloys, beryllium oxide ceramic plants, rocket propellants (both manufacturing and testing), and beryllium waste disposal operations. There are only four extraction plants in the country. There are, however, many foundries and machine shops that will be affected by this standard. A beryllium alloy is defined in the regulation as any metal to which beryllium is deliberately added in the amount of 0.1% by weight or more. Total emission means emission from all the points within a given facility, including disposal of beryllium contaminated waste. The standard specifies source test methods and analytical procedures.

A separate beryllium standard is proposed for rocket motor test sites. Emissions from this source are not to cause the atmospheric concentrations of beryllium to exceed microgram min./cu. m. within 10 to 60 min., accumulated during any two consecutive weeks. If combustion products are collected in a closed tank, emissions are not to exceed 2 g/hr. and 10 g/day.

MERCURY

Emissions to the atmosphere from mercury ore processing and mercury cell chlor-alkali plants are not to exceed 5 lb./24-hr. period (2300 g./24 hr.). Again, testing methods and procedures are specified.

In the case of chlor-alkali plants, the 5 lb./day limitation applies to all sources in a given plant including cell room ventilation air.

Beryllium and asbestos air pollutants are inhalation problems associated with specific diseases. In contrast, mercury emissions must be viewed from the standpoint of man's total body burden. Thus in considering airborne mercury, consideration must be given to the contribution of food and water to the total body burden. Based on certain dietary assumptions, it has been calculated that the air intake should be limited to 20 ug./day. This can be accomplished if the average daily concentration of mercury in the air is no more than 1 ug./m^3. The 2300 g./day emission standard is based on achieving an ambient level of 1 ug./m^3 or less.

Additional potential sources of mercury emissions are under investigation including burning of fuels in power plants and primary nonferrous smelters.

Following publication of proposed standards, hearings were held in New York City and Los Angeles, California. The Ad-

ministrator is currently reviewing information presented at the hearings to determine if there is a basis for changing the designation of asbestos, beryllium, or mercury as hazardous pollutants.

Newly constructed or modified sources of hazardous pollutants are subject to these standards immediately upon promulgation. Such sources must make application to the Environmental Protection Agency for approval of construction or modification.

Existing sources must report to EPA within 90 days of the effective date of the regulations on the nature of their process and emissions and must be in compliance with standards within 90 days unless granted a waiver. The Administrator of EPA is authorized to grant a waiver for up to two years provided he finds that additional time is needed to install controls and that adequate steps will be taken during the waiver period to assure that "the health of persons will be protected from imminent endangerment."

The President may initially exempt any source from compliance for a period of two years if he finds that the necessary control technology is not available and the operation of such a source is required for reasons of national security. An exemption may be extended for one or more additional periods not to exceed two years each. The President is required to report exemptions to Congress.

In the case of both New Source Performance Standards and National Emission Standards for Hazardous Pollutants the Administrator of EPA can delegate enforcement authority to states if he finds that State procedures are suitable. It is expected the states will be the principal enforcers of these standards and EPA guidelines setting forth qualifying criteria for this responsibility are forthcoming. Whether or not this delegation is made, EPA retains the authority to enforce any emission standard when the Administrator considers such action appropriate.

STANDARD DEVELOPMENT AND REVIEW

New Source Performance Standards and Hazardous Emission Standards are developed by the Office of Air Quality Planning and Standards which reports to the Assistant Administrator for Air and Water Programs in EPA. A wide variety of groups are asked to participate in the development and review of proposed NSPS. Within EPA, active participation is invited from enforcement, research, water pollution, solid waste, economic analysis, and Office of General Counsel. Many extramural groups also provide guidance and assistance during the standards development process. These include:

1. *Industrial.* Trade association, equipment vendors, individual companies and other private groups that will be affected by the standards advise EPA and provide data as appropriate. Examples of associations which have participated in the standards development process are the American Mining Congress, the Edison Electric Institute, the American Iron and Steel Institute, and the American Petroleum Institute.

2. *Committees.* As called for in the Clean Air Act, standards are reviewed in detail by two advisory committees to EPA. The first of these, the National Air Pollution Control Techniques Advisory Committee, has 16 members representing industry, control equipment manufacturers, air pollution control agencies, consultants specializing in air pollution control and environmental groups. To assist this group several individuals with special expertise related to the specific source categories being considered are asked to attend committee meetings as technical consultants.

The second committee with whom the standards are discussed prior to proposal is the Federal Agency Liaison Committee. It is composed of representatives from the Federal agencies and departments, who appraise the standards in light of their programs and responsibilities. The standards and EPA's support documents are also reviewed with State and Territorial Air Pollution Administrators (STAPPA). This group has contributed to the enforcement provision of the standards and has advised EPA on priorities for New Source Performance Standards.

After these reviews, EPA selects standards and publishes them as proposed regulations in the *Federal Register.* At this time, we also publish a summary report which contains the basis for our decisions including source test results and economic analyses. (*8*), (*9*). Usually several hundred written comments on the proposed standards are received from interested industries, citizen groups, control agencies, trade associations, universities, and research institutes after the initial publication in the *Federal Register.* These comments are considered individually by EPA staff and are made known to the advisory committee for their comments before the standards become law.

Discussion of Federal emission standards would not be complete without mention of three additional sections of the Clean Air Act.

Section 114 of the Act, gives the Environmental Protection Agency broad powers in regard to inspections, monitoring, and right of entry. This section can be used to obtain information both for developing and enforcing standards. Powers include the right of entry at reasonable times onto property where an emission source is located, legal authority to require testing by the source using EPA approved methods, and legal authority to require the installation, operation, and maintenance of monitoring equipment.

Section 114 also requires that any records or information obtained during an investigation be made available to the public, unless a satisfactory showing has been made to the Administrator of EPA that the release of the information obtained would divulge a trade secret. Information requested under this section cannot be withheld on the grounds that it is considered to be confidential. If the Administrator rules that such information would reveal a trade secret if divulged, it will be held confidential as provided by section 1905 of title 18 of the United States Code except that it may be disclosed to others . . . . carrying out the Act. In no case, however, can emission data be considered confidential.

Federal enforcement powers provided by Section 113 of the Act allow the Administrator to issue orders requiring com-

pliance or by taking civil action, including seeking temporary or permanent injunctions. An order, however, does not take effect until the person to whom it has been issued has had an opportunity to confer with EPA concerning the alleged violation. Under the Act, penalties are assessed for each day of violation.

Section 307 of the Act provides for judicial review of the actions of the Administrator of EPA in promulgating any national ambient air quality standard, or national emission standard. Petition for such review must be filed within 30 days from the promulgation of such standard. At this writing, petitions for review have been filed by various industries with regard to new source performance standards for cement plants, sulfuric acid plants, and large steam generators.

NATIONAL EMISSION STANDARDS IN CONTEXT

The Clean Air Amendments of 1970 provide EPA with great flexibility in attacking air pollution. To round out the discussion, other important provisions of the act will be briefly noted:

1. New Motor Vehicle Emission Standards.
2. Regulation of fuel additives and fuel composition.
3. National Ambient Air Quality Standards (and associated State Implementation Plans).
4. Aircraft Emission Standards.
5. Citizens are specifically authorized to take civil court action against private or government officials for failing to carry out provisions of the law.

Ideally, a potential pollutant is characterized as to its concentration in the atmosphere, its effects of health and welfare; its sources, their strength and location; and the control techniques available. A decision can then be made as to the need for control and the section or sections of the Clean Air Act that will best achieve the control objectives.

Thus, in a case of a given pollutant that came from relatively few stationary sources and whose effects do not qualify it as hazardous the New Source Performance Standard approach would be compared with exercising the National Ambient Air Quality Standard option. In this case because only a few sources were involved Performance Standards might be the preferred route–recalling that for a noncriteria pollutant both new and existing sources must be controlled.

For another pollutant that entered the environment principally through fuel combustion in automobile engines the control approach would obviously involve EPA's authority to control emissions from new motor vehicles.

In this paper two sections of the Act which effect stationary sources have been discussed in detail to set the stage for discussion of the impact on industry of decisions already made regarding control options in the Clean Air Amendments of 1970. At the same time, you should be aware that National Emission Standards are only a part, albeit an important part, of several possible national air pollution control strategies.

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