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ID/140
(ID/WG.178/16)

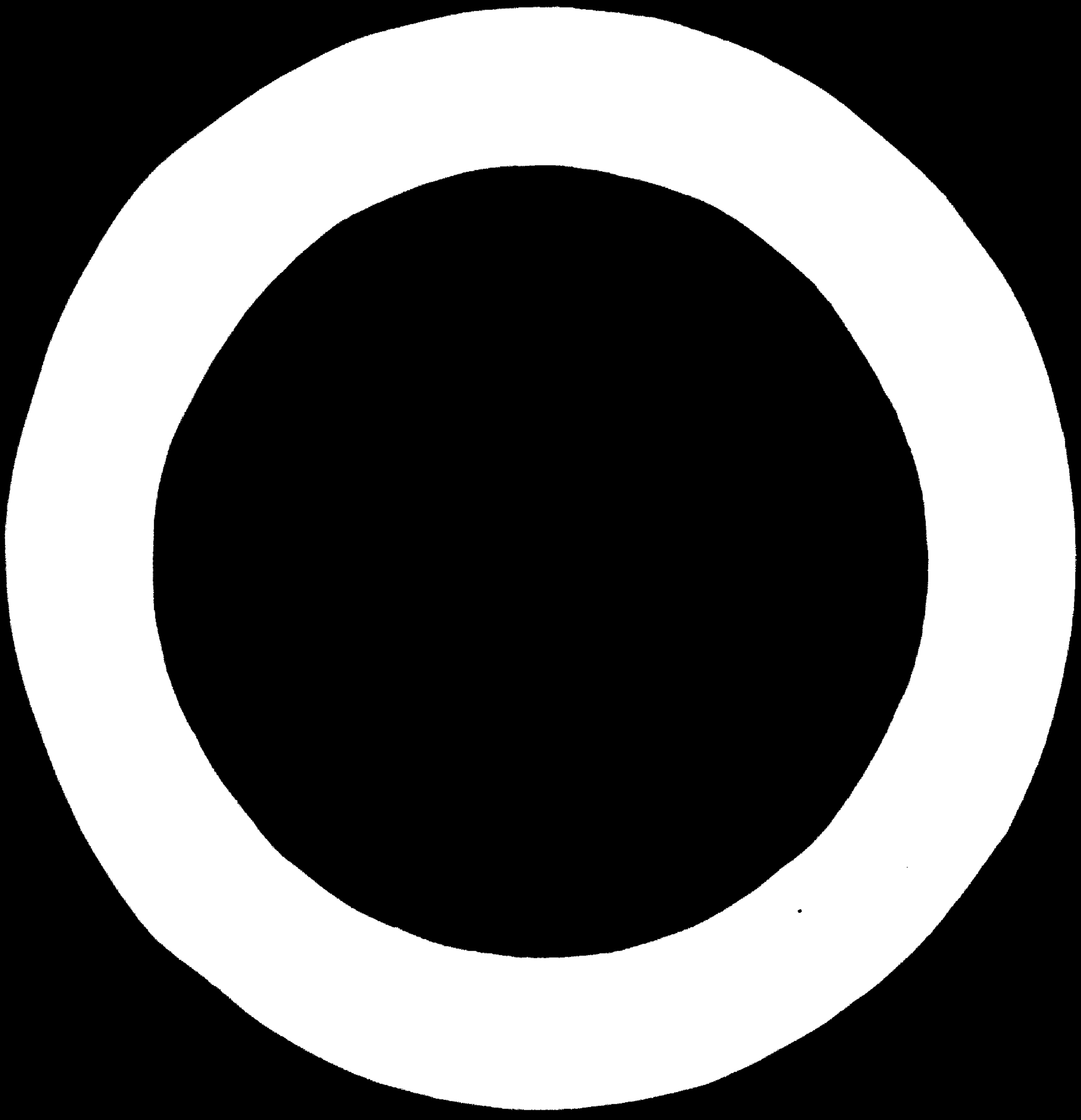
06188

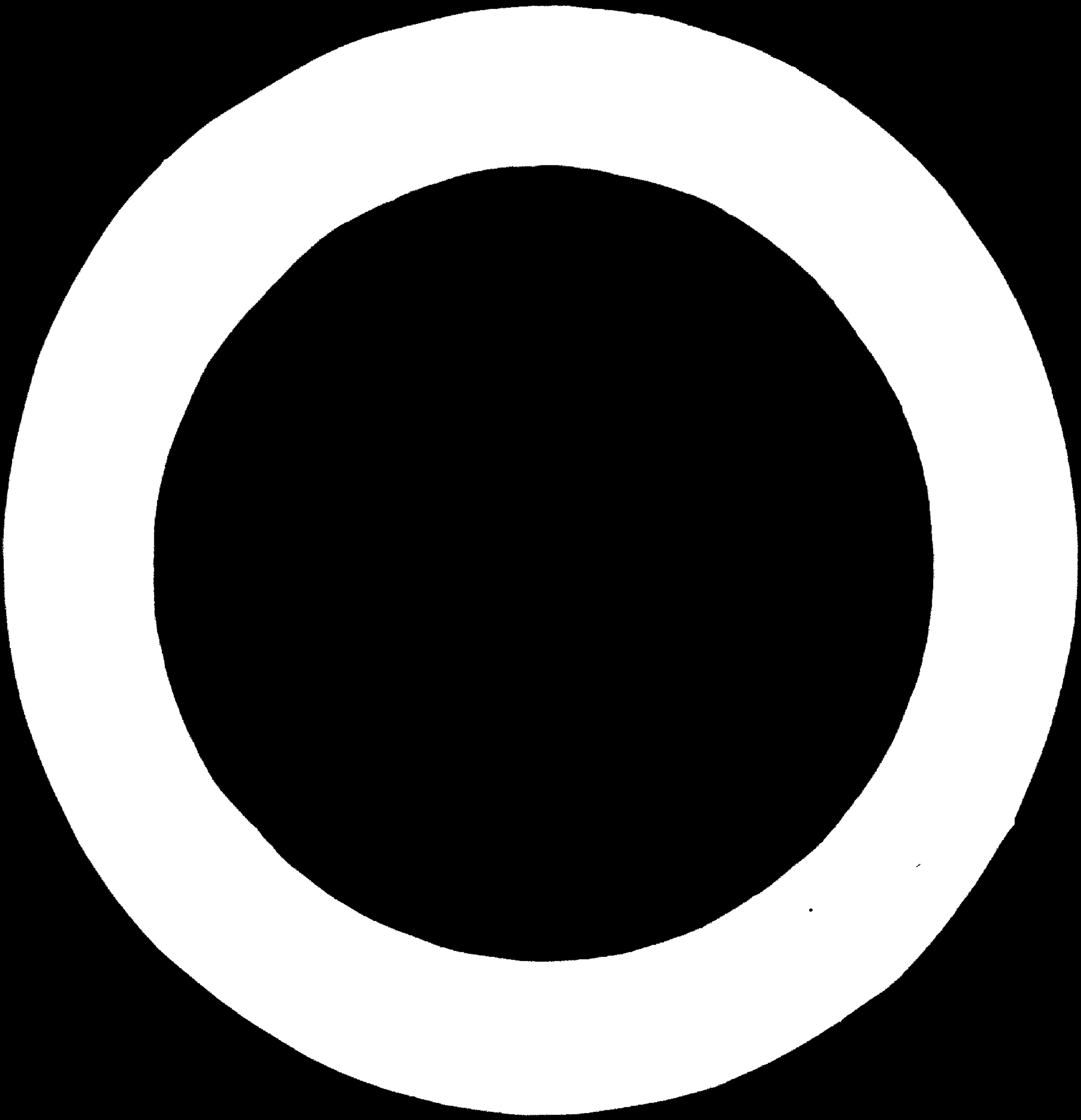
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

MINIMIZING POLLUTION FROM FERTILIZER PLANTS.

Report of an Expert Group Meeting

Helsinki, 26–31 August 1974.





CONTENTS

EXPLANATORY NOTES

The term "billion" is used to signify a thousand million.

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

Reference to "tons" indicates metric tons, unless otherwise stated.

The following abbreviations are used in this document:

BOD	biochemical oxygen demand
COD	chemical oxygen demand
ppm	parts per million

INTRODUCTION

As part of the programme of work of the United Nations Industrial Development Organization (UNIDO) for 1974, an Expert Group Meeting on Minimising Pollution from Fertilizer Plants was held at Helsinki, Finland, from 26 to 31 August 1974 in co-operation with the Government of Finland. The main objectives of the Meeting were to discuss and promote the transfer of technology in identifying pollution problems attendant upon fertilizer and captive-acid production and to recommend ways and means of reducing pollution and its effect upon the environment by proper design and control as well as the location of captive-acid and fertilizer plants.

corp. author

A long-range objective of the Meeting was to contribute to the formulation of suitable international standards and guidelines to minimize effluents (particulate, gaseous and aqueous) from production facilities, to reduce the pollution load on the environment and to determine whether existing standards in developed countries were suitable and could be adapted to developing countries.

Additionally, the Meeting had as a most important objective the discussion and evaluation of the role of UNIDO in international collaboration of the problems affecting the environment and solutions in the fertilizer industry.

Supplemental specific objectives of the Meeting were

To illustrate by case history and environmental evaluation of specific plants, the pollution effects of a fertilizer production complex on its environment

To make a comparative analysis of the costs of installing adequate pollution abatement equipment in new facilities as opposed to making changes in existing plants

To suggest guidelines for site selection for new "grass-root" fertilizer complexes with due regard for environmental considerations

To examine known ways and means to control gaseous, particulate and solid effluents from fertilizer plants not only to meet the lowest cost principle for design but to minimize the pollution satisfactorily; this would include waste/re-use recovery schemes, which could offset additional investment costs

To examine the possibilities of training engineers and chemists from developing countries in the field of control of pollution during design stages

To evaluate the need and possibility of alternative processes and equipment technologies to minimize pollution

To assess the effect of pollutants on workers, habitation, air and water quality

To investigate the possible economic effects of including environmental considerations in existing and planned fertilizer complexes

To examine legal measures which might be relevant to the problem of minimizing pollution from fertilizer plants

The Meeting was attended by 49 participants from 21 countries. There were 14 country participants, 35 representatives of industrial companies and other organizations and 4 UNIDO consultants. The geographical distribution of the participants from developing countries is given below:

Region	Number of countries	Number of participants
Africa	2	3
Asia and the Far East	3	5
Europe	3	4
Latin America	1	1
the Middle East	1	1
	10	14

C. Keleti, who was Officer-in-Charge of the Meeting, read a message to the participants from the Executive Director of UNIDO. Jan-Magnus Jansson, Minister of Trade and Industry of Finland, welcomed the participants in an opening address. Yrjö Pessi (Finland) was unanimously elected Chairman of the Meeting. Wahjudi Wisaksono (Indonesia) and Niilo Lounamaa (Finland) were unanimously elected Vice-Chairmen of the Meeting. Edward C. Bingham (United States of America) was elected Rapporteur for all sessions of the Meeting.

During the 9 sessions of the Meeting, 21 technical papers were presented and discussed. A list of the documents presented to the Meeting is given in annex I.

The report of a visit to a fertiliser complex is given in annex II.

CONCLUSIONS AND RECOMMENDATIONS

Recent developments in pollution control of fertilizer manufacturing

Conclusion

The Expert Working Group effectively provided a transfer of technology among the participants representing developed and developing countries. The case histories presented on recent developments in pollution control indicated that the control techniques enumerated below were worthy of world-wide attention.

Recommendation 1

The fertilizer industry should give serious consideration to the use of biological nitrification-denitrification processes of varied sophistication for the reduction of nitrogenous wastes when economics favour this approach. Consideration should be given to simple lagooning with carbon provided from domestic sewage, particularly in developing countries.

Recommendation 2

As an alternative to disposal of the gypsum by-product on land or in the sea, the producers of wet-process phosphoric acid should increase efforts to dispose of it through economic uses. Possible uses were found in building materials, in fertilizer production, and in the manufacture of sulphuric acid and Portland cement.

Recommendation 3

The producers of wet-process phosphoric acid should be encouraged to reduce fluorine emissions by recovery using scrubbing and conversion to fluorosilicic acid and then to salable salts.

Recommendation 4

In view of the continuing development and improvement in the use of continuous ion-exchange systems for removal and recovery of ionic nitrogenous pollutants in waste water, serious consideration should be given to the use of such systems in pollution control during fertilizer manufacture.

Recommendation 5

From the array of control techniques available, producers of nitric acid should be encouraged to select and use for proper abatement of NO_x in stack gas, the method favoured by consideration of local economics and conditions. Current control techniques included catalytic combustion, extended absorption, adsorption, scrubbing and incineration.

Recommendation 6

Solutions for pollution abatement applied to fertilizer manufacturing should consider a combined approach such as the combining of air-vented emissions from ammonium nitrate and/or urea plants and scrubbing the gases with process condensate which was then recycled for product recovery.

Conclusion

Protection of the environment, the energy crisis and the growing shortages of raw materials have had a significant effect on fertiliser production technology.

Recommendation 7

Future technical improvements to production processes should be aimed at increasing production efficiency and decreasing the accumulation of by-products.

Minimising all types of pollution from nitrogenous and phosphate complex fertiliser plants

Conclusion

On the basis of the technical information exchanged during the Meeting, the Group concluded that serious pollution of all segments of the environment had resulted from the manufacture of fertilisers. Solutions for minimizing this pollution had been found and better ones were being developed. However, there was a definite need for meaningful cost studies on which to base technological choices in both developed and developing countries.

Recommendation 8

Both developed and developing countries should be urged to perform meaningful cost studies on environmental protection during fertilizer manufacture to provide a useful base from which intelligent technological choices might be made.

Pollution abatement equipment: cost/benefit ratios, capital and operating costs

Conclusion

The Group concluded that the available data on pollution control during fertilizer manufacturing were unreliable and insufficient for meaningful calculations of cost/benefit ratios or comparisons of capital and operating costs.

Recommendation 9

Future studies on the economic impact of environmental protection in the world fertilizer industry should use uniform terminology and definitions of terms so that cost data would be relevant and comparable.

International pollution control legislation for the fertilizer industry

Conclusion

Participants from both developed and developing countries concurred that a definite need existed for effective guidelines for international pollution control legislation in the fertilizer industry.

Recommendation 10

All countries should be urged to draft and implement environmental protection legislation appropriate to their needs taking into account economics, available fiscal and technical resources, and social and envrionmental conditions. These statutes should be based on technology that offered the best available solutions.

Recommendation 11

Definitive international limits, particularly for toxic pollutants, should be established on the basis of environmental quality considerations for air and water crossing national boundaries.

Recommendation 12

International effluent guidelines and performance criteria defining the best practicable pollution abatement technology for new fertiliser plants should be established and up-dated regularly. These guidelines should focus heavily on costs and should perhaps be designed on a regional basis to take into account special environmental and climatic conditions which could affect the choice of technology.

Recommendation 13

International assistance should be provided to Governments of developing countries in organising, staffing and training organisations to monitor discharges and enforce environmental pollution limits on a sound technical basis.

Recommendation 14

Agreements should be made for the exchange of pollution control research and development data and personnel.

Recommendation 15

Technological provisions should be made for a model basin, multinational waterway, and special low-cost abatement research and development demonstration projects should be included in any pollution legislative programme.

The role of UNIDO in assisting developing countries in minimising pollution from fertiliser plants

Conclusion

International collaboration was urgently needed in many areas to assist all countries of the world in minimising pollution from fertiliser plants. UNIDO appeared to be the proper agency to effect such collaboration.

Recommendation 16

UNIDO should promptly disseminate information available from international agencies and from developed countries which have already employed effective environmental protection techniques. The dissemination of such technical information should be from reference centres established in various countries under UNIDO aegis. Information dissemination should also be continued through the organization of expert group meetings on a regular basis held alternatively in developed and developing countries.

Recommendation 17

UNIDO should provide broad international guidelines for environmental protection measures needed in industrialised regions. Among these guidelines should be minimum standards of effluent control which must be maintained when plant contractors tendered bids to developing countries.

Recommendation 18

UNIDO should, upon proper request, provide the service of experts, as well as international exchanges of personnel, to provide solutions for pollution abatement. Moreover, UNIDO should develop the capability to provide model studies on effluent disposal and air emissions.

Recommendation 19

UNIDO should assist in establishing and financing training programmes for senior management as well as for operator/technician personnel.

Recommendation 20

UNIDO should conduct a study that would lead to the development of an internationally acceptable code of standard nomenclature and units of measurement that would facilitate the interpretation and comparison of data.

I. RECENT DEVELOPMENTS IN POLLUTION CONTROL: CASE HISTORIES FROM FERTILIZER-PRODUCING COMPANIES

Recent developments in pollution control were given in 15 of 21 papers from both developed and developing countries at the Meeting. The most significant case histories are given below.

Effluent

A most interesting study was presented of the pollution problems facing a large fertiliser, chemical and petrochemical manufacturing complex in Europe. Waste water containing high biochemical oxygen demand (BOD) was generated by these plants and required reduction before discharge into the river Maas. Of several alternative techniques, biodegradation of the waste water was chosen. Since 1964, a Pasveer ditch had been effectively used for the biological process. The remarkable features of this ditch were (a) high capability to accommodate shock waste loads, (b) less sludge production than with conventional activated sludge systems, and (c) the production of sludge that was largrly mineralised when wasted from the ditch.

When discharge limits on nitrogen were lowered by the regulatory agency, the need for better nitrogen removal than that provided by the ditch became apparent. From available technology, a biological nitrification-denitrification process was selected that used the extensive experience on biological processes gained with the Pasveer ditch. The process used by-product methanol from other chemical plants in the complex to provide the carbon required to support the biological processes. The removal of 95 per cent of ammonia- and nitrate-nitrogen, as well as 80 per cent chemical oxygen demand (COD) reduction was anticipated. The physical plant investment was estimated at $30 million.

A significant feature of the treatment plant was a unique method of providing oxygen to the process. A new water-jet aerator was used in which aeration was effected by jets of recirculated water sprayed over the surface of the treatment basin. An oxygen-transfer efficiency of 3 kg O_2 per kWh of electricity was reported.

The key to success of the treatment scheme was the availability of a cheap source of assimilatable carbon. In the United States and other countries where most fertiliser plants were remote from other industries, the supply of suitable, cheap organic material would be an obstacle to the use of the nitrification-denitrification waste treatment system. In developing countries, particularly those in mild climates, the use of domestic sewage to supply the organic requirement would seem applicable. However, since there was evidence that simple lagooning of plant effluent with sewage had been successful in reducing the nitrogen content, it appeared that less sophisticated treatment schemes than the one discussed above might be appropriate for use in some countries.

Gypsum

The disposal of gypsum by-product from the manufacture of phosphoric acid might be difficult because of costs and/or environmental effects. Although economics would be important in a simple substitution of naturally occurring gypsum by the by-product gypsum, a paper indicated other possible uses for it In each case, the impurities in the by-products would determine the economic use. Potential applications, however, could be (a) the construction industry, as a setting controller for cement, in plaster, plasterboards and building blocks, (b) the fertiliser industry for the production of ammonium sulphate in which the co-product calcium carbonate was suitable as feedstock for calcium ammonium nitrate or in cement manufacture, and (c) the production of sulphuric acid and Portland cement.

The applicability of these possibilities was, of course, entirely dependent upon local conditions.

Fluorides

Case studies indicated means of effectively combating the problems of disposal of fluoride in the off-gas from wet-process phosphoric acid production.

It had been shown that fluorides could be economically reduced to satisfactory levels by scrubbing and conversion to fluorosilicic acid and then to salable salts such as aluminium fluoride or alkaline silicofluorides. The aluminium fluoride so obtained was reported to be cheaper than that produced from fluorspar.

Some of the recent developments in pollution control in the fertilizer industry discussed at the Meeting reflected the influence of considerations for environmental protection on fertilizer production technology. A paper on this subject proposed the philosophy that under present conditions, technological improvements resulting in higher production efficiency and less by-products should be selected in preference to investments in plants which merely converted by-products from cheaper processes to less undesirable by-products. In view of the present energy crisis and the growing shortages of raw materials, emphasis must be placed on increasing production efficiency.

Urea dust

The synthesis and prilling of urea resulted in water pollution from process condensate and air pollution from urea dust from the prilling tower. A case history was presented of a unique solution whereby the process condensate was used as scrubbing liquor in a prilling-tower de-dusting system. In a 1,500 tons per day urea plant, it was reported that ammonia in the process condensate was reduced to 200 ppm and urea dust was reudced to less than 30 mg/m^3 in effluent air. Three case histories were presented citing the effective use of the Higgins-type continuous ion-exchange system for removal and recovery of ammonium nitrate from nitrogen-laden process waste waters. A new development described in a European paper was the use of strongly resistant ion-exchange resins that remitted the use of highly concentrated regenerants - 47-60 per cent nitric acid and 17 to 20 per cent NH_3. The distinct advantage of this development was that a far higher concentrated recovered product would be possible than previously. This would improve the economics of the treatment scheme and help overcome some of the objections to the ion-exchange process.

From the developing countries, several case histories were presented on pollution problems from fertiliser manufacture. In at least two countries, it was indicated that problems arose from three basic sources: (a) plants that had ineffective or no control equipment; (b) lack of knowledge or failure to apply operating and maintenance know-how to prevent pollution by established techniques; and (c) lack of effective legislation to enforce reasonable standards.

The case histories cited actions taken by governmental agencies that had effectively resulted in reduced pollution. The actions taken followed a thorough investigation by a competent outside body of the causes as well as the sources of pollution. Such a course of action appeared to be the prerequisite in cases of environmental pollution where the plant management had not taken corrective actions.

A wealth of information regarding new developments in pollution control in fertiliser manufacture flowed from the case histories presented at the Meeting. It was the consensus of the participants that an urgent need exists for the rapid dissemination of such information on a world-wide scale as a means of combating environmental pollution from fertiliser plants.

II. MINIMIZING ALL TYPES OF POLLUTION FROM NITROGENOUS AND PHOSPHATE COMPLEX FERTILIZER PLANTS

Pollution problems in the fertilizer industry tended to arise from limitations to process efficiency, the disposal of unwanted by-products, contaminants in process condensates and/or accidental losses. Significant aspects of the papers presented to the Meeting on these pollution problems are given below.

The Commission of the European Economic Community (EEC) required a complete study of all processes applied in the fertiliser industry in order to prepare recommendations for the improvement of existing plants and/or the limitation of air and water pollution by new plants in member countries. A paper based on this study was presented to the Meeting and was considered a very useful guide for promoting satisfactory operations in fertilizer manufacture. Other papers dealing with separate sections of the industry provided essential confirmation of the EEC survey or in some cases provided additional information.

In a most comprehensive study of the nitrogen situation in the United States, very elaborate cleaning operations were described. The use of this method should effect minimal environmental pollution by the nitrogenous fertiliser industry.

Another contribution of great interest in the field of phosphate fertilisers was made by the participants from Finland. This was effectively illustrated by a visit to a fertilizer plant (see annex II).

The major pollution problem from a modern ammonia plant was the aqueous process condensate. This condensate might be effectively stripped of its ammonia by steam heating and the ammonia recovered as an aqueous solution for use elsewhere.

The only source of pollution from a nitric acid plant should be the tail gas containing oxides of nitrogen, NO_x. This pollutant might be reduced considerably either by extended absorption or by catalytic reduction. A few successful applications of the latter method had been reported from the United States, but experience in Europe had been less satisfactory. Selective reduction by means of ammonia could be used and was likely to receive more consideration in the future. The adsorption of NO_x on molecular sieves was mentioned, but no specific data on operation were reported.

Air pollution by SO_2 from sulphuric-acid contact plants might be reduced by the well-established "double-contact" process or by ammonia scrubbing, especially if the resulting ammonium sulphite could be used in an integrated chemical manufacturing complex. Pollution by sulphuric acid mist was an additional problem. Its solution required the use of efficient mist elimination.

The production of phosphoric acid entailed several environmental problems. During the acid digestion of phosphate rock, approximately 10 per cent of the fluorine in the rock was evolved and must be removed by scrubbing with water. A further 30 per cent or so of the fluorine in the rock was released in the acid concentration unit when present. This emission could be scrubbed with a fluorosilicic acid solution, which was concentrated or converted to the salt and sold whenever possible.

The production of phosphoric acid also resulted in by-product gypsum that was sometimes dumped in estuaries or into the sea. Dumping on land was the alternative in which proper care should be taken that no excessive amounts of phosphates or fluorides drained into bodies of water. The use of by-product gypsum for building materials had found application but often could not be realized for economic reasons.

In the production of ammonium nitrate, nitrogen losses from the neutraliser could be minimized by using a two-stage process with adequate control. The steam condensate from the neutraliser after acidification with nitric acid might be recycled to the absorption tower of the nitric acid plant. This procedure was not free from hazard, and other ways of recycling or treatment of this waste stream were preferable.

The ammonium-nitrate prilling towers should be high enough to allow for moderate air velocities that would prevent entrainment of smaller particles.

The production of urea prills entailed similar problems. The removal of urea dust and ammonia from the exhaust of the prilling tower might be partially successful by means of water scrubbing on the top of the tower, but this was difficult to apply in existing plants. Urea in the condensate from the concentrator could be hydrolyzed to ammonia at 180° C.

The large number of variations in the processes for production of complex NPK fertilizers resulted in a wide variety of pollution problems and solutions. For dry-process streams, cyclones and filter bags were used to reduce dust emissions, but wet-process streams generally required scrubbers of various types.

Ammoniacal - and nitrate-nitrogen - containing waste waters originated in many ways. Papers from Romania, Spain and the United States described continuous ion-exchange processes to provide the ultimate of a closed-loop process water system. The processes yielded ammonium nitrate solutions ranging from 18 per cent to 25 per cent NH_4NO_3 which could be used in liquid fertilizers but created problems if only solid fertilizers were produced.

In Europe, a four-stage process for biological treatment of nitrogenous waste waters had been demonstrated. It involved nitrification of the ammonia followed by denitirfication of the nitrate with the help of waste organic material available from a nearby plant.

Although the environmental protection measures and processes mentioned here mainly apply to situations in the United States and Europe, most of these treatments were also applicable to situations elsewhere. There were exceptions, however, arising from the use of raw materials and/or processes of a different nature or under greatly different climatic conditions. It was felt that increased attention should be given in the following years to promote the capability of combating pollution by developing countries.

III. POLLUTION ABATEMENT EQUIPMENT: COST/BENEFIT RATIOS, CAPITAL AND OPERATING COSTS

The fertilizer industry presently ranks as one of the largest industries in the world, and is exceeded in tonnage output only by steel, petroleum, cement, lumber and basic agricultural food commodities. Estimated annual world-wide production of fertilizer was now about 250 million tons containing about 83 million tons of plant nutrients. The fertilizer industry had experienced an average growth rate of approximately 9 per cent per year during the period 1960-1974. The significant growth resulted from unprecedented world-wide demand for fertilizer and was made possible by highly sophisticated technological breakthroughs in production techniques in recent years.

While major emphasis had been placed on increased production, the fertilizer industry generally had not ignored its responsibilities in the area of pollution abatement. The fertilizer industry in the United States has spent well over 100 million dollars on pollution control since 1968. Although international data were not available, a projection based on expenditures in the United States and factored to include developing countries, indicated total world-wide costs of almost 400 million dollars for air and water pollution abatement during the same period. These sums might appear substantial, but in view of impending enforcement of existing legislation to further control pollution throughout the world, they might be considered only a beginning.

Because of the almost infinite array of variables depending on geographical location and local conditions, it was impossible to accurately determine the actual costs for a world-wide level of pollution abatement. In the developing countries, cost-benefit considerations must be evaluated in a different manner from those in developed countries. Several participants in the Meeting from developing countries stressed the need for greater uniformity in specifications for pollution abatement equipment included in contracts for new fertilizer plants. These participants emphasized that lower costs would be incurred in the long run if adequate equipment for pollution control was incorporated in new plants rather than modifying existing facilities. Only if a minimum degree of uniformity in equipment specification was assumed could any meaningful, though rough, calculation of world-wide capital expenditures for fertilizer manufacture pollution control be made in the years ahead.

The estimates of pollution abatement expenditures for the fertilizer industry in the United States to achieve total compliance with specified limitations by 1983 ranged from $600 million to $1 billion. These estimates were considerably higher than those calculated by the United States Environmental Protection Agency (EPA), but they were reflective of actual costs experienced by the industry to date. Projected on a world-wide basis, total expenditures by all countries for air and water pollution control in the fertilizer industry through 1980 could approach $3 billion to $5 billion. A more definitive estimate of relative cost percentages for air <u>versus</u> water pollution abatement would be meaningless because of the variables discussed above. A more accurate estimate of the effects of costs for environmental regulations on the world fertilizer industry could perhaps be obtained through the efforts of a qualified international engineering firm.

Not only were meaningful cost-benefit ratios difficult to calculate to any acceptable degree of accuracy, they were, moreover, subject to many different interpretations by industry, Governments, environmentalists and the general public. Hence, little purpose was served by quantifying them in numerical terms. One striking example of these difficulties was the inability to place a significant monetary value on the enhancement of the environment resulting from desirable pollution control on the one hand, or on the degradation of the environment resulting from improper pollution control, on the other hand. There was no general agreement among the various groups as to the optimum level of pollution control; one faction might seek the ultimate abatement of pollution, while another sought control only to the extent of minimizing complaints. Therefore, the responsibility for achieving a solution agreeable to all fell upon the Governments, who must provide the necessary motivation through legislation to attain a realistic level of control. Moreover, it is the responsibility of industry to assist the Governments in obtaining adequate and accurate information for use in developing environmental standards. Unfortunately, difficulties might arise in this area because of the proprietary nature of industrial know-how, or, in many cases the absence of necessary information.

Generally, the view was expressed that pollution abatement requirements should be flexible enough to reflect local environmental considerations instead of being rigid national standards. The many ramifications of cost-benefit evaluations were best identified by a detailed analysis of local environmental impact. For example, a plant discharging into a stream already heavily polluted by natural upstream surface run-off from non-point sources should not be required to abate pollution to the same level as a plant discharging into a clear mountain stream. Any requirement to do so would constitute a violation of the economic law of diminishing returns. On the other hand, it was agreed that a plant discharging into a very sensitive body of water must abate pollution extensively to comply with necessary water quality criteria. Future enforcement actions by regulatory agencies would undoubtedly result in expenditures for pollution control that violated the law of diminishing returns. Mutual assessment of the effect of such actions by industry and governmental control agencies could keep such misuse of resources to a minimum.

Fertilizer producers in developed countries had taken a responsible approach to pollution abatement even before stringent regulations were required by national laws. Recent legislation would force fertilizer manufacturers to attain an unprecendented level of pollution abatement consistent with national goals of reducing pollution to the maximum possible extent. If the fertilizer industry was to remain a viable production entity throughout the world, the same approach must be taken by the developing countries, and the world industry must accept the challenge by allocating more funds for research and development to reduce pollution through process modifications and advanced pollution abatement equipment and techniques.

IV. ANTI-POLLUTION LEGISLATION AND REGULATORY CONTROL

Two papers presented at the Meeting directly addressed the need for national environmental control legislation for fertilizer manufacturing. The legislation and resulting quantitative waste discharge limitations of the United States were presented in detail. Other papers from developed countries alluded to features of their existing control statutes.

In general, two philosophies of control were revealed: (a) control based on technology - the best practicable solution developed on a case-by-case analysis and (b) the ideal or universal solution using environmental quality criteria. The consensus of the participants was that both approaches, to one degree or another, were suitable for developed and developing countries alike.

Some developed countries used both of the above-mentioned control philosophies simultaneously, for instance, technology-based control for aqueous effluents and environmental quality criteria based on human health effects for air emissions. The Group recognized that appropriate legislation was needed to assist meaningful industrial planning and that drafting and implementation of any legislation must be undertaken as a co-operative effort between Government and the the industrial community affected.

With regard to the establishment of specific, uniform international environmental control standards, representatives of developing countries expressed apprehension that such standards, whatever the basis, could operate to slow the pace of urgently needed industrial development. Even if development was not to suffer, fear was expressed that the establishment of regulations could divert limited resources of both capital and technical manpower to the various aspects of pollution control as opposed to the development of new industrial capacity. In the case of fertilisers, where serious world-wide shortages already existed, a significant diversion of resources could not be accepted. On the other hand, all representatives of developing countries expressed an eagerness to accept responsibilities for environmental protection in so far as practicable while providing the technical groundwork for improving pollution control in the future, commensurate with industrial growth within such countries.

V. THE ROLE OF UNIDO IN ASSISTING DEVELOPING COUNTRIES IN MINIMIZING POLLUTION FROM FERTILIZER PLANTS

Industrial development in many countries of the world which were endowed with plentiful raw materials and the means to explore and exploit these materials, had given rise to a severe problem of pollution of the environment. Even though pressures applied by regulatory agencies and the public for a reduction of pollutants in waste-water discharges and emissions to the atmosphere had led many industries to employ abatement, water-reuse and reclamation techniques, such ecological treatment had not been practised at all in most developing countries until recently.

The principal reason for this lag in the practice of pollution control in the developing countries had been that attention had first focused on the processing and utilization of materials that were available from indigenous sources. Such emphasis, besides providing employment, had assisted in improving the trade balance of the countries and had contributed to the development of secondary industries. Although the Governments of developing countries were aware of the severe and often irreparable damage caused by industrial pollution, they were reluctant to take measures to abate existing pollution and to prevent damage from newly created industries because of the immense economic and social benefits accruing from such industries. In recent years, however, some of the developing countries realised the importance of pollution control in their industrial activities.

Increasing the yield per hectare was probably the most important means of developing agriculture on sound lines in developing countries where land was limited and the pressure of population was heavy. The application of fertilizers for increasing soil fertility to improve crop yields had been considered as a means of meeting urgent needs for food production.

There had been a surge in the building of fertilizer plants in regions where raw materials were available in substantial quantities or where cost economics had favoured plants based on imported materials.

Such fertilizer plants inherently caused effluent discharges and gaseous emissions of various magnitudes that created gross pollution of the environment unless adequate treatment and control measures were adopted. Factors contributing to pollution from fertilizer plants in developing countries were identified as:

Lack of proper operation and maintenance of the plant equipment and existing pollution control facilities

Unawareness of, or indifference to, the hazards of environmental pollution by the factory management and/or control authorities

Lack of technical guidance on the requirements of the control measures

Absence of control legislation and lack of adequate guidance from Government

Solutions to the above listed limiting factors in most developing countries should become part of national goals and efforts. The actions that needed to be taken included legislation on minimum environmental control measures and the creation of agencies to enforce these regulations, training courses, technical guidance and comprehensive research and development work. Further, the Governments should discourage the construction of new plants that did not provide adequate pollution abatement.

Since developing countries were handicapped by inadequate resources and technological expertise, it was the consensus of the participants that international efforts through UNIDO were needed for effective collaboration and co-ordination between developed and developing countries. Such activities might originate with other international bodies such as the United Nations Environment Programme (UNEP) the World Health Organization (WHO), the World Meteorological Organisation (WMO), the International Clean Air Congress or the International Water Pollution Control Federation.

It was also generally agreed that when a country was unable to find a solution to its pollution problems, the Government should approach UNIDO for the service of experts in achieving the pollution solution. In all environmental protection efforts, care should be taken to preserve the social and economic benefits of industry to the developing countries. UNIDO, acting through governmental and university institutes, should play a strong advisory role in the development of adequate environmental protection for fertilizer manufacture throughout the world.

A significant development at the Meeting was the free interchange of information among participants within a pervading atmosphere of co-operation. The need clearly existed for continuing interchange of personnel as well as information between and among developing and developed countries.

Annex I

LIST OF DOCUMENTS[a/]

ID/WG.175/1/Rev.2	Agenda and Programme of Work
ID/WG.175/2	Studies to eliminate NO_x from medium pressure nitric acid plants using absorption D. Joaquin Olivares, Spain
ID/WG.175/3	Establishment of a pragmatic mathematical approach for predicting particulate matter emissions from fertilizer plants J. A. Rakestraw, United Kingdom of Great Britain and Northern Ireland
ID/WG.175/4	The influence of effluent standards on the economics of alternative waste water treatment designs F. de Lora and A. Kasiá, Spain
ID/WG.175/5	The use of the alonizing process in sulphuric acid plant construction W. A. McGill and M. J. Weinbaum, United States of America
ID/WG.175/6/Rev.1	The purification of gaseous waste streams from nitric acid plants which contain nitrogen oxides W. R. Hatfield, United States of America
ID/WG.175/7	Influence of environmental protection of the fertilizer protection technologies A. D. Almásy, Hungary
ID/WG.175/8	Modern technology for minimizing pollution from fertilizer plants L. Whalley, United Kingdom of Great Britain and Northern Ireland
ID/WG.175/9	Environmental pollution from fertiliser production in India - some case studies J. M. Dave, India
ID/WG.175/10	Solutions for minimum pollution in nitrogen fertiliser plants R. C. Bingham, United States of America
ID/WG.175/11	Measures to minimise aqueous waste pollution from fertilizer plants situated in an integrated chemical complex F. Dijkstra, Netherlands

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[a/] A limited number of copies are available from UNIDO upon request.

ID/WG.175/12	Minimizing pollution from phosphate fertilizer plants including captive acid plants T. Kivelä, Finland
ID/WG.175/13	Pollution from fertilizer plants in Bangladesh A. Huq, Bangladesh
ID/WG.175/14	Pollution abatement in a urea plant T. Jojima and T. Sato, Japan
ID/WG.175/15	Utilization of by-products from the wet phosphoric acid production to prevent environmental pollution E. Steininger, Austria
ID/WG.175/16/Rev.1	List of participants
ID/WG.175/17/Rev.1	List of documents
ID/WG.175/18	Technical solutions and technological advances made in Romania to control environmental pollution effects arisen from fertilizer plants N. Popovici, Romania
ID/WG.175/19	Environmental regulations confronted by fertilizer producers in the United States J. Reynolds, United States of America
ID/WG.175/20	UNIDO's role in assisting developing countries to minimize pollution from fertilizer plants M. C. Geerling, Austria
ID/WG.175/21	Federal legislation and discharge limits (air-water) for fertilizer manufacturing plants in the United States R. R. Swank, Jr., United States of America
ID/WG.175/22	Some environmental problems in developing fertilizer industry with reference to Indonesia M. A. Wirjoasmoro, Indonesia
ID/WG.175/23	The fertilizer industry in Mexico and the pollution problems J. Avila Calinzaga, Mexico
ID/WG.175/24	Direct reduction of fluorapatite in fluid-phase carrier: conceptual applications to pollution control and other implications H. K. E. Iteke, Nigeria

Annex II

DESCRIPTION OF THE PLANT VISIT

A fertilizer complex at Siilinjärvi produces 93 per cent sulphuric acid, phosphoric acid (43-50 per cent P_2O_5), 25 per cent fluorosilicic acid, mono-ammonium phosphate; 65 per cent nitric acid and concentrated complex fertilizers of various NPK formulations.

The sulphuric acid plant has an annual output capacity of 265,000 tons (100 per cent basis). The acid is produced by the roasting of pyrrhotite. The plant operates with the conventional contact process achieving 98 per cent conversion. The sulphuric acid is used in the wet-process production of phosphoric acid and some is sold.

The nitric acid plant has an annual output capacity of 85,000 tons (100 per cent basis). The acid is produced by the conventional ammonia oxidation process using ammonia imported from other locations. The plant uses two oversized absorber towers which reduce NO_x emissions to an average of 400 ppm. Most of the nitric acid produced is used in production of the nitrophosphate complex fertilizers, but some acid is sold.

The phosphoric acid plant has an annual output capacity of 120,000 tons (P_2O_5). The acid is produced by the classical dihydrate wet process using as raw material rock phosphate from Kola, Union of Soviet Socialist Republics; 95 per cent P_2O_5 recovery is reported. Gypsum sludge containing about 40 per cent water is discharged to a huge waste pile. No recovery of the gypsum is accomplished. Fluorides released when the phosphoric acid is concentrated are recovered as a 25 per cent solution of fluorosilicic acid that is shipped to plants in Uusikaupunki where it is processed into alkaline silicofluorides. Most of the phosphoric acid produced is used in the production of mono-ammonium phosphate and the complex fertilizers.

The mono-ammonium phosphate plant has an annual output capacity of 150,000 tons. The product is made by the neutralization of phosphoric acid with ammonia, followed by crystallization and drying. The product is shipped to fertilizer plants in Harjavalta and Kokkola where it is used as an intermediate material. Mono-ammonium phosphate has been exported as well.

The complex fertilizer plant has an annual output capacity of 200,000 tons. Various NPK formulations are produced in a series of four reactors by the nitrophosphate process in which the phosphate rock is dissolved in nitric acid, ammonia is added, phosphoric and sulphuric acids are added, an imported muriate of potash is introduced. The NPK sludge is granulated and dried in two spherodizers. The reactor system is equipped with floating bed scrubbers, while dust is controlled by the use of bag filters.

The plant in Siilinjärvi has an outstanding environmental protection programme. With the exception of NO_x from the nitric acid plant, all emissions to the atmosphere are either collected as dust or are water scrubbed. The plant operates with a closed-water circulation system for cooling, process, scrubbing and run-off waters. Even the rain run-off from gypsum storage pile is collected and re-used. Treatment by double-liming is provided in the event discharge to the lake (receiving waters) becomes necessary because the capacity of storage ponds is exceeded by excess rain or otherwise. Air pollution emission were reported to be 1 kg/hr F, 12 kg/hr N and 10 kg/hr dust. No attempt has been made to monitor the sulphuric acid plant emissions. Water pollution discharges (to the closed re-circulating water system - not to the lake) have averaged 5.0 kg/day P, 32.3 kg/day N and 15.4 kg/day F.

The Siilinjärvi plant comprises an investment of 220 million Finnish marks or $60 million. It employs 500 workers. In 1972, the cost of installation of environmental protection equipment at the fertilizer plant accounted for 19 per cent of the investment in that plant. Over-all, through 1973, the cost of installation of environmental protection equipment at the Siilinjärvi plant has been Fmk 11.33 or about $3 million. These figures do not include the installation of oversized absorbers at the nitric acid plant or equipment for the recovery of fluorosilicic acid in the phosphoric acid plant.

Annex III

TABLES: AQUEOUS EFFLUENT AND AIR EMISSION LIMITATIONS FOR THE UNITED STATES FERTILIZER INDUSTRY [a]

(United States of America Environmental Protection Agency)

1. Category listing
2. Effluent limitations for best practicable control technology currently available
3. Standards of performance for new sources
4. Effluent limitations for best available control technology economically achievable
5. Phosphate effluent limitations
6. Ambient air quality standards
7. New or modified source standards of performance

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[a] Based on a paper submitted to the Expert Group Meeting by Robert R. Swank, United States of America Environmental Protection Agency (ID/WG.175/21).

Table 1. Fertilizer Manufacturing Point Source Category. Effluent Limitation Subcategories

A. Phosphate subcategory
   1. Phosphate rook grinding
   2. Wet process phosphoric acid
   3. Wet process phosphoric acid concentration and clarification
   4. Normal superphosphate
   5. Triple superphosphate (run-of-pile and granular)
   6. Ammonium phosphates (mono- and di-ammonium)
   7. Sulphuric acid (sulphur burning)

B. Ammonia subcategory

C. Urea subcategory

D. Ammonium nitrate subcategory

E. Nitric acid subcategory

F. Ammonium sulphate subcategory[a]
   1. Synthetic process
   2. Steel mill by-product process

G. Mixed and blend fertilizers[a]
(types A, B, C, and D N-P-K plants)

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[a] Subcategory status and effluent limitations in draft form are currently under EPA review (1 September 1974).

Table 2. **Fertiliser Manufacturing Effluent Limitations for "Best Practicable" Control Technology Currently Available (1 July 1971)**

Subcategory	Effluent Limitation Parameters[a] (Kilograms/1000 kilograms of product)			
	Ammonia (as N)	Organic Nitrogen (as N)	Nitrate (as N)	pH (Range)
Ammonia	0.0625	-	-	6.0-9.0
Urea	0.0375 (non-prill) 0.05 (prill)	0.175 (non-prill) 0.5 (prill)	-	6.0-9.0
Ammonium nitrate	0.0375 (solution) 0.1 (non-solution)	-	0.05 (solution) 0.11 (non-solution)	6.0-9.0
Phosphate	No discharge of process waste water pollutants			
Nitric Acid	No discharge of process waste water pollutants			
Ammonium sulphate[b]	No discharge of process waste water pollutants			
Mixed-blend fertilisers[b]	No discharge of process waste water pollutants			

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[a] Values listed are the maxiumu allowed average of daily averages for 30 consecutive operating days, i.e. the 30-day maximum averages. Maximum allowed single day (average) values are equal to twice the 30-day averages except urea organic nitrogen for which the factor is 2½.

[b] These subcategory effluent limitations are draft values only, currently under EPA review (1 September 1974).

Table 3. Fertilizer Manufacturing Effluent Limitations
"Standards of Performance for New Sources"

Subcategory	Effluent Limitation Parameters[a] (Kilograms/1000 Kilograms of Product)			
	Ammonia (as N)	Organic Nitrogen (as N)	Nitrate (as N)	pH (Range)
Ammonia	0.055	-	-	6.0-9.0
Urea	0.0325 (non-prill) 0.0325 (prill)	0.12 (non-prill) 0.35 (prill)	-	6.0-9.0
Ammonium nitrate	0.025 (solution) 0.05 (non-solution)	-	0.0125 (solution) 0.025 (non-solution)	6.0-9.0
Phosphate	No discharge of process waste water pollutants			
Nitric acid	No discharge of process waste water pollutants			
Ammonium sulphate[b]	No discharge of process waste water pollutants			
Mixed-blend fertilizers[b]	No discharge of process waste water pollutants			

[a] Values listed are the maximum allowed average of daily averages for 30 consecutive operating days, i.e., the 30-day maximum averages. Maximum allowed single day (average) values are equal to twice the 30-day averages.

[b] These subcategory effluent limitations are draft values only, currently under EPA review. (1 September 1974).

Table 4. **Fertilizer Manufacturing Effluent Limitations for "Best Available" Control Technology Economically Achievable (1 July 1973)**

Subcategory	Effluent Limitation Parameters[a] (Kilograms/1000 Kilograms of Product)			
	Ammonia (as N)	Organic Nitrogen (as N)	Nitrate (as N)	pH (Range)
Ammonia	0.025	-	-	6.0-9.0
Urea	0.015 (non-prill) 0.015 (prill)	0.025 (non-prill) 0.0375 (prill)	-	6.0-9.0
Ammonium nitrate	0.0075 (any)	-	0.0125 (any)	6.0-9.0
Phosphate	No discharge of process waste water pollutants			
Nitric acid	No discharge of process waste water pollutants			
Ammonium sulphate[b]	No discharge of process waste water pollutants			
Mixed-blend fertilizers[b]	No discharge of process waste water pollutants			

[a] Values listed are the maximum allowed average of daily averages for 30 consecutive operating days, i.e. the 30-day maximum averages. Masimum allowed single day (average) values are equal to twice the 30-day averages.

[b] These subcategory effluent limitations are draft values only, currently under EPA review (1 September 1974).

Table 5. Phosphate Subcategory Effluent Limitations for Allowed Discharges under Monthly Rainfall-Evaporation Excess Conditions

	Effluent limitations (metric units - mg/l)	
Effluent characteristic	**Maximum for any 1 day**	**Average** of daily values for 30 consecutive days shall not exceed
Total phosphorus (as P)	70	35
Fluoride	30	15
TSS a/	50	25
pH	Within the range of 8.0 to 9.5 b/	

a/ Total suspended solids.

b/ pH range specified is to insure that heavy metal discharge, particularly Ra-226, is adequately controlled.

Table 6. National Ambient Air Quality Standards

Pollutant	Primary[a] (ug/m^3)	Secondary[b] (ug/m^3)
PARTICULATE MATTER		
Annual geometric mean	75	60
Maximum 24-hour concentration[c]	260	150
SULPHUR OXIDES		
Annual arithmetic mean	80 (0.03 ppm)	60 (0.02 ppm)
Maximum 24-hour concentration [c]	365 (0.14 ppm)	260 (0.1 ppm)
Maximum 3-hour concentration [c]		1 300 (0.5 ppm)
CARBON MONOXIDE		
Maximum 8-hour concentration [c]	10 000 (9 ppm)	
Maximum 1-hour concentration [c]	40 000 (35 ppm)	same as primary
PHOTOCHEMICAL OXIDANTS		
Maximum 1-hour concentration [c]	160 (0.08 ppm)	same as primary
HYDROCARBONS		
Maximum 3-hour (6-9 am) concentration [c]	160 (0.24 ppm)	same as primary
NITROGEN OXIDES		
Annual arithmetic mean	100 (0.05 ppm)	same as primary

[a] Primary standard: for public health protection.

[b] Secondary standard: for protection of public welfare.

Equivalent measurements in parts per million (ppm) are given for the gaseous pollutants.

[c] Not to be exceeded more than once a year.

Table 7. New or Modified Source Standards of Performance - Fertilizer Production and Processing Plants

Processes and effluent parameters	Emission limits[a]
Nitric Acid	
Total nitrogen oxides	1.5 kg (as NO_2)/ton of product (as 100% acid)
Visible emission	10% opacity
Sulphuric acid	
Sulphur dioxide	2.0 kg (as SO_2)/ton of product (as 100% acid)
Visible emission	10% opacity
Acid mist	0.075 kg/ton of product (as 100% acid)
Wet process phosphoric acid[b]	
Fluorine	10.0 gm total (as F)/ton of P_2O_5 feed
Diammonium phosphate[b]	
Fluorine	30.0 gm total (as F)/ton of P_2O_5 feed
Visible emission	20% opacity
Triple superphosphate[b] (ROP and granular manufacture)	
Fluorine	100 gm total (as F)/ton of P_2O_5 feed
Visible emission	20% opacity
Triple superphosphate[b] (Granular storage)	
Fluorine	0.25 gm total (as F)/hour/ton of P_2O_5 feed

[a] All discharge quantities are maximum averages for the test procedure and time specified (usually for one hour minimum).

[b] Limits given for these operations are draft only, currently under EPA review (1 September 1974).

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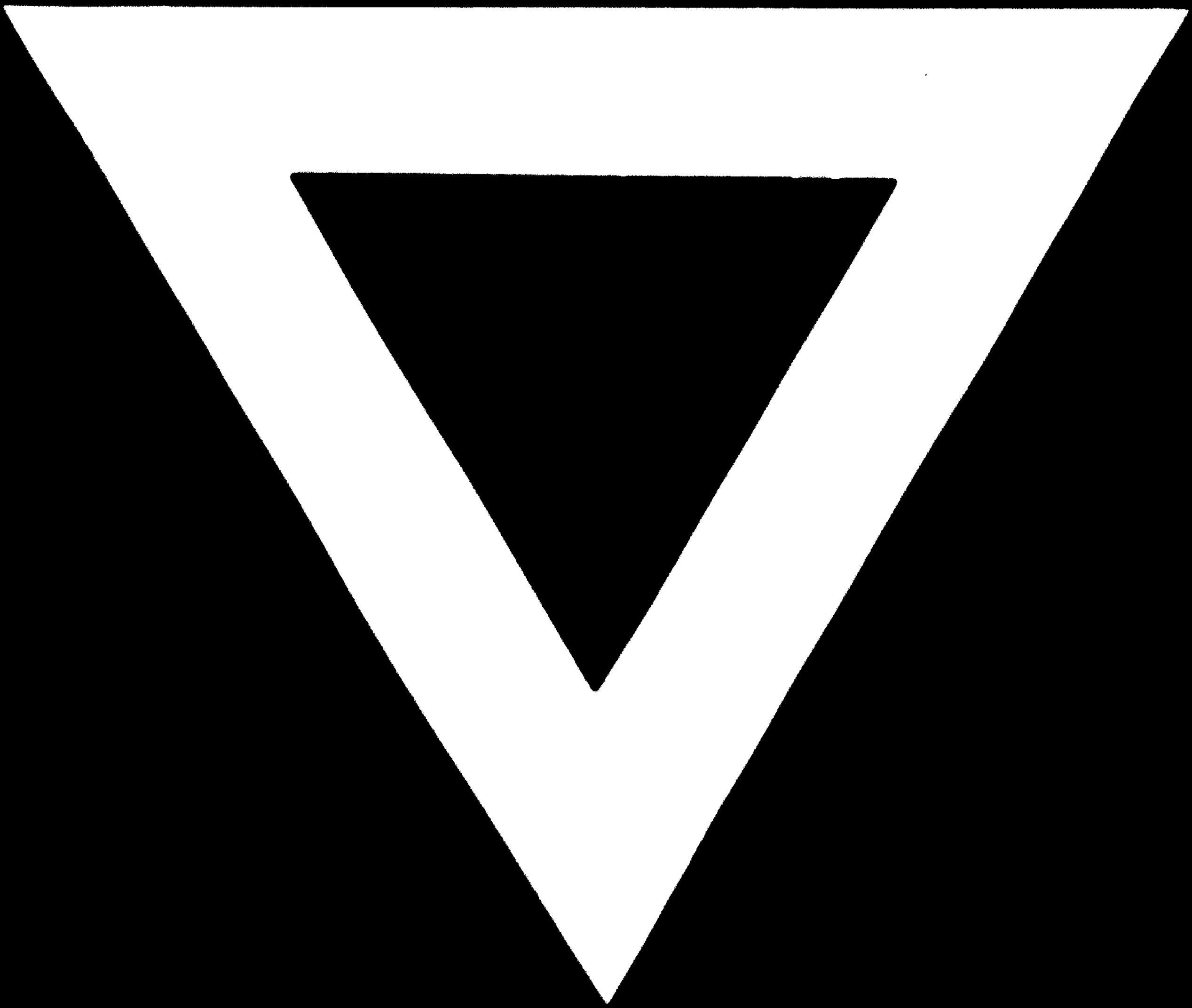

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