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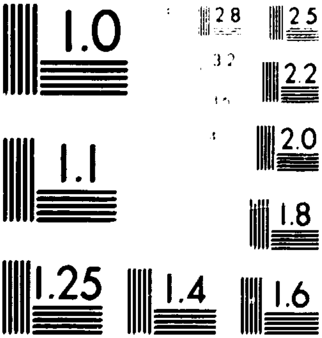

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Distr.
LIMITED

ID/WG.364/38
19 October 1982

ENGLISH

United Nations Industrial Development Organization

Technical Conference on Ammonia Fertilizer Technology for Promotion of Economic Co-operation among Developing Countries

Beijing, People's Republic of China, 13 - 28 March 1982

REPORT *

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ANNEXES

I. INTRODUCTION

1. The promotion of Economic Co-operation among Developing Countries (ECDC) as a New Dimension of International Co-operation for Development is an increasingly important field of activities of the United Nations system for the benefit of the developing countries. The fundamental aim of ECDC is to stimulate and intensify exchange of experience among the developing countries themselves in all areas of their economies.

2. In pursuance of relevant resolutions of the UN General Assembly, and in particular, following the Plan of Action adopted by the Buenos Aires UN Conference on Technical Co-operation among Developing Countries (August/ September 1978) the United Nations Industrial Development Organization (UNIDO) has embarked on an extensive work programme with the aim of assisting the countries in the implementation of relevant resolutions in the field of its competence. In accordance with its established procedures and practices relating to industrialization of developing countries, UNIDO has been urged by the General Assembly to support measures of economic and technical co-operation among these countries, and to provide the necessary Secretariat support services as and when requested, to assist the developing countries in organizing meetings pursuant to the objectives of the ECDC Programme of the UN system.

3. It has been recognized that those developing countries which have already reached a relatively advanced stage of industrialization are in a position to share their experience and to transfer their technological knowledge to the less developed countries. In the fertilizer industry a number of developing countries have extensive experience in this field while others have so far no fertilizer manufacturing facilities at all.

All countries, however, are aware of the fact that fertilizer availability is of strategical importance as far as food security and agricultural development are concerned. It is for this reason that the developing countries make every efforts to become self-reliant in fertilizer supplies wherever conditions warrant successful implementation of development projects relating to fertilizer industries.

4. The World fertilizer market is periodically affected by supply shortages and oversupply as well as by considerable price instability regarding fertilizer raw materials and products. In consequence of this perpetuating situation, Governments of developing countries are increasingly concerned with fertilizer production and trade, and in particular with problems relating to the establishment and efficient operation of fertilizer plants.

5. The Second and Third UNIDO Consultation Meetings on Fertilizer Industry (Innsbruck, Austria, November 1978, and Sao Paulo, Brazil, September 1980) identified a number of areas in which the involvement of UNIDO would help to strengthen co-operation between developing countries in all matters relating to the fertilizer industry. The meeting recommended that UNIDO should play a leading role in the promotion of fertilizer industries in the developing countries and place emphasis on those issues which, while being of common interest to them, are likely to be solved by transfer of experience among the countries themselves.

6. In pursuance of the aforementioned resolutions and recommendations and in the light of UNIDO's mandate concerning the promotion of industrialization,

UNIDO organized a Technical Conference on Ammonia Fertilizer Technology for Promotion of Economic Co-operation among Developing Countries in co-operation with the Government of the People's Republic of China.

II. ORGANIZATION OF THE CONFERENCE

7. The Technical Conference on Ammonia Fertilizer Technology was convened in Beijing, People's Republic of China, from 13 to 28 March 1982.

8. The Conference elected Mr. Huang Hongning, Chief Engineer of **the Planning** Institute, Ministry of Chemical Industry, as Chairman and Mr. S.R. Panfil, Senior Interregional Adviser of UNIDO, as Co-Chairman of the Conference, and adopted the following agenda:

   i) Presentation and discussion of technical papers prepared by the UNIDO consultants, the host country's experts and the participants from developing countries

   ii) Panel discussions in Working Groups;

   iii) Plant visits.

9. The Conference was attended by fifty-eight delegates from thirteen developing countries, seven consultants, and three observers from the industrialized countries.

10. Mr. Qin Zonghda, Minister of the Chemical Industry, received the participants of the Conference and offered his active support.

11. Selected topics of particular interest to the host country and UNIDO were discussed by four Working Groups:

   1. Small size plants;
   2. Medium size plants;
   3. Energy consumption of fertilizer plants;

4. Operation of large scale **plants**, new processes and equipment.

12. At its closing session the Conference adopted the conclusions of the Working Groups and recommended to include them in the final report of the Conference.

13. The Conclusions and Recommendations of the Conference (Ref. Section V of this report) **shall** be reported to the Fourth UNIDO Consultation Meeting on the Fertilizer Industry, with the aim of disseminating the experience emanating from technical issues surveyed by the Conference, and to consider follow-up action within the ECDC programme of the UN system for the benefit of the developing countries' fertilizer industries.

III. RESUMÉ OF THE PLENARY SESSIONS

Opening Session

14. The Conference was inaugurated on Saturday, 13 March 1982, by Mr. Feng Bohua, Vice Minister of the Chemical Industry of the People's Republic of China. The plenary sessions were held at conference facilities of the Great Hall of the People. An opening address of the Executive Director of UNIDO, Mr. Abd-El Rahman Khane, was conveyed to the Conference by Mr. S.R. Panfil, Senior Interregional Adviser who acted as officer-in-charge on behalf of UNIDO. Mr. A.W. Sissingh, Senior Industrial Development Field Adviser of UNIDO stationed at the United Nations Development Programme(UNDP) in Beijing, welcomed the host country's representatives and delegates. The technical part of the Conference was introduced by Mr. Liu Gang, who presented his paper on past and present development of the fertilizer industry in China.

Plenary Sessions

15. The Conference heard and discussed seven lead papers dealing with the selected important subjects of the present status and future development of ammonia technology. The following topics **were covered** by the UNIDO consultants' presentation:

- General aspects of energy consumption and conservation in ammonia plants, taking into account the technical and economic conditions prevailing in developing countries, plant location and sources of raw materials and power supply.
- The main process steps in synthesis gas production and in the synthesis loop (hydrogen recovery, design criteria for CO_2 removal processes, reactor design and catalysts).
- Corrosion problems in ammonia plants.
- Future trends of technological developments of the nitrogen fertilizer industry.

The contents of the lead papers and the ensuing discussions are summarized in Section VI of this report.

16. The host country's delegates presented sixteen papers providing a detailed account of the development of the chemical fertilizer industry in China. They elaborated on processes which were developed in China and are still widely applied in the country in all the locally constructed ammonia plants. The papers dealt also with different raw materials, and plant capacities ranging from 5,000 tons/year to 333,000 tons/year of ammonia, and reported on salient features of research work which presently is being conducted in China with the aim of developing new processes. The Chinese specialists focussed on their experience and achievements relating to catalysts for ammonia plants. The papers contained valuable information

on manufacture, application and operating efficiency of catalysts produced in China.

17. Technical details of the manufacture and use of ammonium bicarbonate, a unique Chinese fertilizer product, were presented by Chinese specialists in manufacturing technology and agricultural application techniques. A movie film on the latter subject received high attention and attracted numerous questions and comments. Many operation problems were exposed and discussed at the plenary sessions.

18. The Conference noted with interest that the number of operating fertilizer plants in China exceeds 2200. Nitrogenous fertilizer products are manufactured in more than 1400 plants, whereas approximately 700 plants produce phosphate fertilizer. Throughout the entire period since 1949 the Government allocated highest priority to the development of fertilizer industries. Capital investment in chemical fertilizer plants accounted for more than 50 per cent of total volume of capital investment in the Chinese chemical industry.

19. The production of chemical fertilizer in China in 1980 exceeded 10 million tons N(nitrogen), 2.3 million tons P_2O_5(phosphate) and 20,000 tons K(potassium). The average annual growth rate of production between 1949 and 1980 was 28.1 per cent.

20. Ca. 55 per cent of the total amount of nitrogeneous fertilizer produced in China originated from ca. 1300 small plants (5,000 to 20,000 tons/year

of ammonia capacity, mostly combined with equivalent capacities of downstream processing units). The majority of these plants produce ammonium bicarbonate aqua-ammonia, using briquetted anthracite-grade coal as raw material. Some plants use low grade (high ash content) coal as raw material, depending on the location of the plant. The process design of all these plants is based on indigenous Chinese technology. Small size plants are spread all over the country. The equipment for many of them was manufactured in small workshops, where in particular low pressure vessels made of carbon steel could easily be manufactured.

21. Currently the Chinese experts are of the opinion that only those combined ammonia/ammonium bicarbonate plants are still economically viable which are larger than 15,000 tons/year in terms of ammonia production. Ammonia plants of capacities larger than 25,000 tons/year should rather be combined with urea plants. The preferred size, however, at present is much larger, i.e. at least 200 tons/day urea combined with ammonia plants of 120 tons/day capacity. The Chinese engineers and scientists have indigenously developed an integrated ammonia/urea manufacturing technology. The new process is presently being tested in a pilot plant.

22. 45 per cent of the total quantity of nitrogenous fertilizer is produced in medium and large scale plants. Medium size plants have production capacities in the range of 200 - 500 tons/day ammonia, combined with matching urea plants of ca. 300 - 800 tons daily capacity. Over the past few years 13 large scale plants have been put in operation. All these plants are of world-standard size, i.e. ammonia plant: 1,000 tons/day combined with a urea plant of 1740 tons/day. Most of the large scale plants use natural gas as feedstock.

23. The basic engineering and process design of medium size plants is of Chinese origin. Elements of conventional (traditionally European) technology have also been incorporated. The entire equipment and machinery for the presently operating plants was and continues to be manufactured locally (e.g. spare parts, replacement equipment and some more new plants). More than 50 medium scale ammonia/urea plants are in operation. Three plants were exported to Albania, Bangladesh and Pakistan. The Chinese equipment manufacturing companies for chemical plants indicated that they are in a position to engineer and construct reactors, vessels, compressors, pumps etc., in accordance with internationally accepted traditional standards(ASME, BS, DIN, JIS material and pressure vessel codes).

24. The aforementioned 13 large scale plants are based on imported technology. All the equipment was manufactured abroad. The plants were put in operation in subsequent years during the second half of the 1970's. Capacity utilization and on-stream factors attained in practice are generally very favourable. Reportedly one plant recorded for the period 1979 to 1981 an average on-stream factor of 90 per cent (365 days/year basis), and during the period 1980/81 370 days of continuous operation were reached. The average on-stream factor of the latter period was 91.5 per cent.

25. Preparations are being made for the construction of four large scale urea plants. Most of the equipment shall be manufactured locally. The Chinese engineering industries indicated that they have the prerequisite experience, know-how and outfit to manufacture also fully up-to-date turbo compressors, steam turbines, large-diameter high-pressure reactors made of carbon steel lined with special grades of stainless steel, and air separation units of various sizes. Some licences and manufacturing know-how have been acquired from European machine and equipment makers.

26. China commenced the manufacture of phosphate fertilizer in 1955. Ca. 90 per cent of the production of fertilizer phosphates originate from small scale rock phosphate processing units, using indigenous technology and equipment. The Chinese chemical research institutes have also developed the production of trace elements and humate fertilizers, and in general, the country can be considered self-sufficient in this field.

27. The Chinese chemical industry produces about 20,000 tons/year of catalysts for the fertilizer industry and is completely self-sufficient in this respect. Technical specifications and performance data presented at the Conference indicate that the catalysts are of internationally comparable quality.

28. The Chinese specialized enterprises for construction and erection of chemical plants have accumulated extensive experience. They are capable of erecting small scale plants in one year, and medium and large scale plants in two and three years, respectively.

29. Comprehensive information was presented at the Conference concerning the use of ammonium bicarbonate fertilizer in China. This nitrogenous fertilizer contains only 17 per cent N. Because of unfavourable storage and transportation properties of the bicarbonate, its economic shipment radius is only 25 km (on the average). For this reason a very large **number** of relatively small fertilizer plants has been established. Some of the storage and transportation problems were overcome by using double layer bags composed of a woven polypropylene outer bag and an impermeable plastic film layer or lining inside.

Caking of the bicarbonate during storage has largely been eliminated by controlling the moisture content of the product before bagging. The permissible highest level of water content is 3.5 per cent. However, anti-caking agents (detergents) have to be applied as a finishing operation. The fertilizer, in its crystalline form, deteriorates and decomposes easily also during application in the fields. The losses of nitrogen are particularly high when the fertilizer material is spread over the surface of the soil. A special application method has been developed suiting best the Chinese climatic conditions. The bicarbonate is injected 5 - 10 cm deep into the soil by means of a hand-operated device designed for this purpose. This operation, if properly carried out, reduces the losses of N to around 2 per cent only during the first 15 days of application. Otherwise, losses might exceed 4 per cent per day.

More details of the individual papers are presented in the summary of Chinese papers in Section VII of this report.

30. In addition to the presentation of papers and panel discussions of the Conference, possibilities of co-operation between China and other developing countries were reviewed. Pertinent brochures distributed at the Conference by the Chinese equipment manufacturing and plant engineering and erecting companies, and the manufacturers of catalysts, publicized their achievements and capabilities. The export potential of Chinese equipment makers and construction contractors represents a sound basis for the formulation and promotion of UNIDO-ECDC programmes and possible bilateral arrangements between the People's Republic of China and the countries represented at the Conference.

World Bank Report

31. Mr. Edilberto L. Segura, representative of the World Bank, informed the Conference on the activities of the World Bank and its keen interest in the development of fertilizer production in the developing countries.

Since 1968 the World Bank Group financed 45 fertilizer projects in 17 countries, providing in total a lending facility of US$2.3 billion. Details on financial and technical assistance methods and means as well as other related activities of the Bank in the fertilizer field were presented.

Country Papers

32. Thirteen papers were presented by delegates of the developing countries represented at the Conference. The papers dealt with the development of the fertilizer industry in the respective countries, reported on difficulties encountered, and highlighted problems which presently are being tackled by them in order to improve plant operations. The delegates of some countries emphasized the need for technical assistance which they would wish to receive from other developing countries. Delegates from the more advanced developing countries elaborated on the potentialities of their fertilizer industries for rendering advisory services to the less advanced developing countries. The Conference provided a forum for exchange of views and experience in bilateral assistance projects and co-operation. The potential of UNIDO and UNIDO's mandate in this field was brought to the attention of the delegates who then have been requested to follow up on their concepts with their government authorities and the UNDP Resident Representatives of the respective countries. A detailed summary of the country papers is given in Section VIII of this report.

33. As the country papers were intended to provide information on the status and problems of their fertilizer industry, no technical discussion was opened on this subject.

IV. REPORTS OF THE WORKING GROUPS

Report of the Working Group on Small-Scale Fertilizer Plants

34. The group discussed technical and economic problems connected with the establishment of small-scale nitrogen fertilizer plants and considered ways and means of sharing the experience of the Chinese chemical fertilizer industry with other developing countries.

The group reached the following conclusions, which reflect the experience and specific project conditions of the Chinese fertilizer industry:

(a) The capacities for the various fertilizer products recommended for establishing small-scale plants in developing countries comprises two ranges of ammonia plant sizes: from 30 to 60 tons/day and from 80 to 100 tons/day;

(b) Down-stream ammonia processing plants should preferably be combined with the above-mentioned sources of ammonia in the following way:

Ammonium bicarbonate: 30 and 60 tons/day in terms of ammonia processing.

Urea: 80 to 100 tons/day of ammonia equivalent to 140/160 tons/day of urea

Ammonium sulphate: Based on commercial sulphuric acid, is not not recommended, but it may be further analyzed for specific circumstances provided sulphuric acid would be available as a by-product from gypsum/cement production or reprocessing of phospho-gypsum.

Ammonium nitrate: In general not recommended but if specific conditions warrant, plants of capacities over 50 tons/day ammonia to be processed into nitric acid, and at least 50 tons/day ammonia for neutralization may be considered justifiable. The total capacity of the ammonia plant thus recommended should not be less than 100 tons/day.

Aqua ammonia: Frequently considered as part of the ammonium bicarbonate production, when the ammonia plant is based on natural gas. Any capacity between 30 to 60 tons/day might be feasible depending on the agricultural market demand in the area around the factory.

(c) Fertilizer products

i) The primarily recommended product is urea for which plant capacities of 140 to 160 tons/day are considered still economically viable. However, larger capacities would yield better economic results;

ii) Ammonium bicarbonate is recommendable for locations where it would be feasible to introduce this type of fertilizer to agriculture along with proper application methods;

iii) Ammonium sulphate is recommendable only under exceptional circumstances;

iv) Ammonium nitrate though commedable as a fertilizer, should not be considered for small-scale plants because of the unfavourably high investment cost of the plant as compared to options i) and ii) above.

(d) Raw materials: Natural gas, coke or anthracite and fuel oil have been found suitable for small-scale plants according to Chinese experience.

(e) Production cost: Under Chinese conditions the production cost per 1 ton of N of ammonia converted into final fertilizer products is approximately the same for small scale and medium size plants.

(f) The Chinese know-how and operating experience: The relevant organizations of the People's Republic of China are prepared to co-operate with UNIDO and the developing countries in engineering, manufacture of equipment and supply/erection of complete small scale plants of the sizes considered and recommended by the Working Group.

Report of the Working Group on Technology for Medium-Size Plants

35. China is capable of supplying nitrogenous fertilizer plants based upon a standard ammonia plant of 200 - 220 tons/day and a urea plant of ca. 340 tons/day. Feedstocks can be anthracite, natural gas, heavy fuel oil or coke oven gas. For all the different feedstocks, Chinese technology can be applied and all the equipment can be fabricated in China. For anthracite

a fixed bed gasification system is used; for natural gas steam primary and air secondary reforming; for heavy oil partial oxidation; and for coke oven gas steam reforming or catalytic partial oxidation, with steam reforming being preferred. The Chinese Export Organization can supply all the plants either on FOB or CIF basis, or construct the plants on a turnkey basis. They can also prepare feasibility reports on projects if desired. The currently expected energy efficiency of newly designed ammonia/urea plants (with electricity being converted at 3,000 kcal/kwh) would under normal conditions amount to:

natural gas based:	9.67 million kcal/ton ammonia
heavy oil:	12.45 million kcal/ton ammonia
anthracite:	14.30 million kcal/ton ammonia

While modifications are under consideration, lower energy consumption can be anticipated, particularly with the natural gas based plant. Catalysts for all the plants would be of Chinese origin. The expected life of catalysts would be two years or more for any catalysts, but with a standard guaranteed lifetime of one year. The lifetime of the synthesis catalyst is expected to be three years. The reformer tubes would also come from China. Ammonia/urea plants of medium size are designed in China to operate 330 days per year. The actual construction period of such plants would be two to years in most developing countries. From signing of the contract to the completion of erection, the period would be 36 - 40 months for most of the medium size plants.

36. In view of the foregoing, the Conference recommended to developing countries to consider the People's Republic of China as a potential contractor for the supply and erection of nitrogen fertilizer plants of this size. The Conference also recommended that UNIDO should make a cost of production

analysis of these medium scale plants for locations in African and Asian sites and present it to the proposed seminar on mini-fertilizer plants scheduled to be held at Lahore, Pakistan, in November 1982.

Report of the Working Group on Energy Conservation

37. The Working Group reviewed the flowsheet of the 1,000 tons/day ammonia plant and discussed in great detail the possibilities of energy conservation in the existing plants in China. Effective savings could be achieved in the following areas:

- combustion air preheating;
- elimination of the residual CO content before methanation;
- synthesis loop and catalyst;
- recovery of hydrogen from the purge gas.

The possibilities, technical solutions, technical and economic advantages and possible gains were discussed and agreed upon. Although the medium size plants offer also considerable energy saving possibilities, owing to shortage of time the Working Group could not pursue detailed discussions on this topic.

38. The Working Group took note of the opinions and expert advice expressed during the discussions and adopted the following recommendations:

(a) In view of the possibility to make substantial savings in energy consumption in the 1,000 tons/day ammonia plants through application of appropriate corrective engineering and investment measures, the Conference recommended that the People's Republic of China, with the help of UNIDO experts, should conduct a detailed study, with the aim of identifying technically and economically feasible engineering concepts. The concepts shall form the basis for detailed engineering projects of plant modifications to be made through supplementary investment. The study shall comprise all the necessary cost estimates and economic calculations in order to enable the Government of the People's Republic of China to apply for financial assistance of the World Bank for the execution of specific investment projects on the subject covering engineering design, procurement of equipment,erection and start-up of the improved sections of the plants. UNIDO should take the necessary steps to obtain the prerequisite clearance from the respective licensors. Official clearance is necessary to permit the UNIDO experts to have access to the know-how and technological documents which are restricted by standard secrecy agreements signed between the licensor and the Chinese Government.

(b) For the medium size plants which offer also large energy saving possibilities the Conference recommended that a similar study be conducted jointly by UNIDO and the People's Republic of China.

Report of the Working Group on Operation of Large Scale Plants, New Processes and Equipment

39. Issues of prime interest to the participants, and technical problems concerning plant engineering design, operation and performance as well as new technological trends relating to the progress of the developing countries' fertilizer industries were discussed and summarized.

40. Design, Engineering and Construction

(a) From the beginning of the engineering phase of a project, the buyer and the principal engineering contractor should closely co-operate. The implementation of a fertilizer project on turn-key basis does not warrant successful operations of the plant unless the buyer of the plant participantes actively in the execution of the contract and the project.

(b) The buyer should be in a position to specify correctly his requirements and basic data (climate, environment, power situation, water etc.) prior to the design and engineering stage.

(c) When the buyer chooses to award a lump sum contract for process design and engineering services the engineering company (principal contractor) tends to offer a low priced basic package, and promises unrealistically low construction costs and extended erection time schedules (long critical path programmes). This type of contract should be avoided.

(d) In some cases the detailed engineering documentation is carried out by local engineering companies, but the responsibility for erection and plant performance rests with the principal contractor and process designer. Local engineering firms should be involved in the contractor's responsibility for proper erection and commissioning of the plant.

(e) Some developing countries locate their new plants in areas which lack the necessary infrastructural facilities (port, rail and road connexions, power plants or power supply grids etc.). Such locations should be avoided unless sufficient funds are available for proper development of off-site and off-plot facilities.

(f) Adequate information regarding the chemical analysis of water from available supply sources, the preferred or applicable water treatment methods, other utilities such as steam and power generation etc., should be provided by the buyer and given to the design, engineering and construction company (principal contractor). This should be done before and during the process design and plant engineering stages so that the contractor would later be in a position to discharge his duties in a professionally correct manner and to fulfil his contractural obligations, in particular his plant performance guarantees.

(g) From the beginning of implementation of the project and contract environmental engineering and pollution control measures deserve proper attention. Sufficient safeguards can thus be included in the project by the principal engineering contractor during the process design and engineering stage and during the initial construction period of the plant.

(h) The buyer's requirements concerning the supply of utilities and pollution control measures should be integrated with the engineering design of the plant.

41. Plant Operation and Management

(a) Training of personnel should be included in the contract and cover a much larger field of specialized professions and larger number of trainees than presently practised by the contractors. Training facilities should be extended to plant operators, mechanical and instrument maintenance engineers, electrical engineers, process engineering specialists, design engineers, equipment and plant inspection specialists, equipment and plant inspection specialists, safety and pollution control inspectors, analystical chemists etc.

(b) The operating and maintenance manual of the plant should be prepared and reviewed by the contractor in close co-operation with the buyer of the plant. It is considered essential to review the manuals jointly during erection of the plant, but in any event before the training of operators begins.

(c) Personnel should be trained in a modern operating plant which is based on similar technology, engineering design and layout, preferably in a neighbouring developing country. The programme should also envisage training of key personnel in overseas plants and at the engineering design facilities of the contractor.

(d) The management of the buyer of the plant should recognize, right from the beginning, the need for establishing a preventive and predictive maintenance system and a safety inspection unit. For this purpose the management should encourage the adoption of modern concepts and techniques, and should develop a system in-built into the plant design in order to facilitate inspection and reliable/safe operation of the plant.

42. New Developments and Technology

(a) Only proven process and demonstrated new technologies (catalysts, process improvements) should be considered suitable for transfer to a developing country.

(b) New technologies which offer savings in energy consumption, such as "SELEXOL" carbon dioxide removal, hydrogen recovery from purge gases ("PRISM" separator or Cryogenic Absorption and Separation etc.) may be considered for improving operations of existing plants.

The buyer should carry out a thorough investigation and evaluation of the technical viability and economic feasibility of introducing new technologies. All related aspects such as quantitative and qualitative energy savings, production increase, technical limitations brought about by existing elements of plant/process design and equipment etc., should be reviewed before decisions on capital investment and contracting are taken.

(c) It is considered advisable to apply the aforementioned new elements and technologies on an experimental basis in one medium size plant of 300 - 400 t/d ammonia plant, and gain experience before trying to use them for improving operation and economic efficiency of large-scale 1000/1350 t/d ammonia plants.

(d) Completely new ammonia technologies need to be thoroughly evaluated before proposing them for application in developing countries (e.g. the LEAD process of Humphreys and Glasgows, similar or other technologies offered by Kellogg, Haldor Topsøe, UHDE and C.F. Brown etc.).

(e) It appears not advisable to consider energy saving programmes for ammonia plants of 1000 t/d capacity which would be expected to reduce the consumption to the otherwise possibly attainable level of 7.0 - 7.5 million kcal/ton. Such ambitious objectives are bound to call for extensive modifications and costs which may not be justifiable.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

43. The conference provided the participants from fertilizer industries of developing countries with up-to-date technical information on available ammonia fertilizer technologies and manufacturing techniques, development trends, problem areas and applicable improvements.

44. The sessions provided a forum for review and evaluation of the present status of development of the industrial production of ammonia and urea in the developing countries represented at the Conference. The production of ammonium bicarbonate fertilizer in China was recognized as a feasible option.

45. The papers presented and ensuing discussions highlighted the growing potential of some of the developing countries to render engineering services, to manufacture equipment, and to construct/erect complete plants in the less advanced developing countries.

46. Extensive exchange of experience took place at the various meetings, covering a wide range of aspects of manufacturing technology and related issues. Experts and consultants from the industrialized countries contributed favourably to the understanding of new technological developments and technical problems.

47. The Conference appreciated sincerely the achievements of the fertilizer industry of the People's Republic of China, and expressed its gratitude for the wealth of information on Chinse indigenous experience made available to the participants and observers.

Recommendations

48. The Conference recommended that UNIDO should consider the following measures with the aim of promoting and enhancing co-operation among the developing countries in the field of ammonia fertilizer technology.

49. In connexion with the preparations for the Fourth Consultation Meeting on the Fertilizer Industry UNIDO should take into account the detailed technical data received and the outcome of this Conference.

In particular, UNIDO should convey to the meeting the Conclusions of the Working Groups on plant capacities, energy conservation, product mix and new processes which were found applicable and advisable for construction and operation of medium and small scale nitrogen fertilizer plants.

50. The Seminar on Mini and Small-scale Fertilizer Plants which will be convened by UNIDO in Lahore, Pakistan in November 1982, in co-operation with the Government and the fertilizer industry of Pakistan, shall be requested to scrutinize the terms of reference and provide directives pertaining to studies to be undertaken on the feasibility of investment in small-scale fertilizer units, and on comparative production costs.

51. As a corollary of basic data received and of the experience of the Chinese fertilizer industry presented to the Conference, the People's Republic of China should be considered as a potential contractor for supply of equipment and construction/erection of nitrogenous fertilizer plants of small and medium size.

52. In view of substantial gains expected to materialize as a result of plant modernization and modification under an energy savings engineering and supplementary investment programme for the existing 1000 t/d ammonia plants, the People's Republic of China in close co-operation with UNIDO experts and consultants should prepare a detailed engineering study on the subject. The study shall identify the necessary plant modifications and establish reliable investment cost estimates. Positive conclusions of the study shall constitute the basis for an application of the Government of the People's Republic of China, to the World Bank, with the aim of receiving financial support to cover the investment cost of the energy savings programme.

53. UNIDO should take the necessary steps to obtain the concurrence of the licensors of ammonia technology to engage external consultants and experts for the implementation of the project.

54. The Conference recommended to undertake a similar study for the medium size ammonia plants which have a large potential for implementation of profitable energy saving measures. The study shall be conducted jointly by the Government's engineering institutions and UNIDO consultants.

VI. SUMMARY OF PAPERS PRESENTED BY UNIDO CONSULTANTS

55. Seven UNIDO consultants presented lead papers of the Conference dealing with essential features and issues of ammonia production.

Energy Conservation

56. The attention of the Conference was focussed on the consumption and conservation of energy in ammonia plants starting with a description of the historical development of the ammonia industry. The paper analysed aspects of energy

requirements and pointed out possibilities of improving the energy balance of ammonia process technologies with a view to energy conservation in both existing and future new plants. The conclusion was arrived at that in spite of many favourable new developments regarding the use of various raw materials, natural gas proved to be and remains the most energy efficient feedstock for ammonia production. The paper explored several ways and means of reaching higher energy efficiency of production processes employed. Improved utilization of hydrogen by more effective separation methods was figures out as one of trend-setting approaches. Others conentrate on perfection of the energy efficiency of the individual process steps and units, again others propore partly new process schemes. The energy consumption indicators claimed by authors of the new flowsheets are in the region of 30 GJ/ton NH_3.

57. By applying the new concepts the energy consumption of not only the large-scale plants (1000 - 1500 tons/day NH_3) but also of medium and small-scale units can considerably be reduced. There is, however, an obviously unfavourably close relationship between the attainable increase of energy recovery and the consequentially increased sophistication of processes and plants.

Synthesis gas purification

58. A paper was presented describing a new low-temperature hydrogen separation technology which has been applied successfully in many commercial-scale plants. It consists of a pretreatment step at which the ammonia present in purge gas is eliminated, followed by a low-temperature section where separation of the gas into a recycle hydrogen stream and a fuel gas stream takes place. The standard process design assures a good yield of recycled hydrogen containing 90 per cent H_2 and less than 1.4 per cent (CH_4+ Ar) at 70 bar pressure. The efficiency of hydrogen recovery depends on the fuel gas pressure dictated by the plant design. It varies between 91 per cent at 4 bar fuel gas pressure and 95 per cent at 1.5 bar.

59. In summary the economical improvements resulting from hydrogen separation become evident either in form of feedstock savings of 4-5 per cent or increase of plant capacity by roughly 5-6 per cent. The paper elaborated on a number of detailed issues, namely molecular sieves, possibility of argon recovery, recuperation of ammonia, general economics and capital costs.

60. The representative of the know-how owner of a specific method of selective permeation of hydrogen through membranes displayed details of its application in practice. Hollow fibres are the essential elements of the gas separation equipment. After pretreatment of the purge gas eliminating the ammonia, it passes through bundles of hollow fibres through which approximately 40 per cent of the hydrogen penetrates, yielding a gas of 92 per cent purity under 70 bar pressure.

The bundles of hollow fibres are arranged in a bank of tube-shaped pressure vessels, similar to heat exchangers.

The first stage of separation is followed by a second stage of identical design. Most of the remaining hydrogen permeates through the walls of the hollow fibres in a series of separators of the second stage, yielding a gas of 82 per cent purity at 28 bar pressure. The residual gas contains about 7 per cent hydrogen and inert components. It is used as fuel for the primary reformer. Total hydrogen recovery reaches ca. 90 per cent. The technical life-time of the hollow fibres is expected to be more than 5 years, whereas the manufacturer guarantees 5 years of troublefree operation.

Other possible applications of the permeation method were described and discussed.

61. Methods of carbon dioxide removal were extensively dealt with because of their importance for both energy conservation and reliability of ammonia plant operation. The major CO_2 removal processes, their characteristics

and performance of plant and equipment were presented and compared. The paper indicated that all the well established processes offer advantageous modifications assuring higher energy efficiency. However, there is a comeback of physical solvents which can be regenerated without using heat. Improved solvents and flowsheets provide the clude to the success of these modifications. The author presented a very interesting table comparing the various processes by classifying them according to their overall energy requirements, which range from as high as 150 MJ/Kg.mol CO_2 to the relatively very low 20-30 MJ/Kg.mol CO_2.

62. The conclusion of the paper gives to understand that the choice of a given process depends always on the conditions and circumstances under which the selection is made. Energy consumption is but one parameter while other factors such as capital and operating costs, corrosion problems, CO_2 recovery may also play a decisive role. They may well overrule in a particular case the potentially straight-forward advantage offered by low energy consumption.

Ensuing discussions concentrated on economies of scale and their impact on the choice of a given CO_2 removal technology. Furthermore, packing meterials and the feasibility of revamping existing units by adapting them to use improved solvents, were topics of major interest and concern to the participants who presented also their critical views on these issues.

The Ammonia synthesis converter

63. The development of ammonia technology led to a remarkable decrease of the operating pressure of the synthesis loop, and to an increase of the daily capacity of single stream plants. Consequently, it was necessary and possible to design ammonia converters of very large size capable of accommodating large volumes of catalysts. New designs and new catalysts are continuously emerging.

They offer a number of advantages, such as minimizing the pressure drop through the converter, optimizing the temperature regime and concentration profile of the reaction as well as solving the inherent engineering and construction problems in connexion with the large-size reactors.

64. The paper reviewed and discussed past and present converter designs, as well as design features of new developments. In this connexion the elaboration dwelt on the activity, size, shape and overall performance of catalysts. Recent developments on spherical catalysts were of particular interest to the participants, as was the discussion on advantages and disadvantages of pre-reduction of catalysts.

65. Corrosion of ammonia plant equipment was recognized as one of the major problems affecting the on-stream factor of large scale ammonia manufacturing units. Corrosion problems are known as a severe drawback faced by operators of plants in particular in the developing countries.

The paper dealing with this topic concluded that the performance of ammonia plants could greatly be improved if the conditions leading to corrosion failures would properly be understood. The behaviour of media causing corrosion need to be investigated and proper construction materials able to withstand corrosion need to be selected or developed.

Case histories were presented displaying the causes and effects of a number of stress-corrosion-cracking failures in reformers, steam turbine condensers and heat exchangers. Various other phenomena of corrosion and failures of equipment and machinery caused by corrosion were discussed. The inherent prime causes were identified and remedial measures were described.

66. Future trends in the production of ammonia and development of the ammonia technology were looked at from a far-sighted point of view. A broad review was presented on possible new avenues to be pursued to further improve in the nearest future the existing variety of ammonia technologies. Prospects of entirely new developments were evaluated. In general, it was indicated that the trend will continue attempting to substantially decrease the operating

temparature of sections of the plants, in particular the synthesis loop, and hence to further considerably reduce the operating pressure of the plants.

New horizons were elaborated upon e.g. the possible use of biological nitrogen fixation methods on a large scale, the use of enzymes and complex chemical compounds offering special effects and features of fertilization.

VII. PAPERS PRESENTED BY THE HOST COUNTRY'S SPECIALISTS

67. The fertilizer specialists of the host country presented 15 papers reporting on the development and application of fertilizer technology in the People's Republic of China. The papers provided an insight in the achievements of the industry and institutions, in particular, relating to indigenous process know-how, performance of locally-made catalysts, manufacture of equipment, construction and erection of plants and operating experience.

68. The Government of China has recognized the importance of the chemical fertilizer industry and has allocated high priority to capital investment in fertilizer plants. While the population of China accounts for 25 per cent of the world's total, it occupies only 7 per cent of the world's total arable land area. For many years about half of all the government's investment in the chemical industry was designated and spent on the establishment of fertilizer plants. The output of the fertilizer industry grew, at an average rate of ca. 28 per cent per year, from 5700 t/y in 1949 to 12.3 million tons per year in terms of nutrients produced in 1980. The number of operating plants exceeds now 2,200.

69. China had no phosphate fertilizer industry in 1945. At present there are small phosphate plants all over the country in more than 1/3 of the districts. These plants produce mainly single superphosphate and calcium magnesium phosphate. Basic slag, dicalcium phosphate and ammonium phosphate, nitrophosphate and NPK compounds represent a minor share. The total number of plants producing phosphatic fertilizer exceeds 700.

70. The production of potash fertilizer is relatively small. It amounts to only ca. 20,000 - 30,000 t/y in terms of K_2O nutrient content.

71. The nitrogen fertilizer industry produces over 10 million tons of N per year in three groups of plants: small, medium and large scale plants. The feedstock is mainly anthracite, briquetted anthracite and coke in particular for the small scale plants. For the medium scale plants natural gas and heavy fuel oil is also being used,while the large scale plants use only natural gas.

72. More than 1,300 small scale plants based on indigenous Chinese technology have been built. The production capacity in terms of ammonia is 5,000 to 20,000 t/y. Most of the small scale plants convert ammonia into ammonium bicarbonate. They account for 55 per cent of the total Chinese nitrogenous fertilizer output.

73. Lump anthracite or coke is readily available from local mines and coke ovens in most districts of China. Fines of coal are also being used. For this purpose a special briquetting technique has been developed. The fines are being mixed with slaked lime, moulded in form of egg-shaped briquettes and carbonated by using carbon dioxide from the lime kilns. The compressed and cured briquettes have high mechanical strength. The ash content and composition of ash (high melting point!) and reactivity of the briquettes is favourable so that gasification in semi-continuously operating gasifiers (gas generators) poses virtually no problem. Most of the available grades of coal suit the requirements of the Chinese fertilizer industry, therefore, the briquetting technique is applied all over the country in almost all small scale ammonia/ammonium bicarbonate plants.

74. The coal or coke feedstock is gasified in fixed bed semi water-gas generators under atmospheric pressure. Air alternating with steam is blown into the reaction bed in mechanically controlled regular cycles. The air feed sustains the reaction temperature and provides the nitrogen component of the water - gas/syngas mixture. The pure synthesis gas of controlled composition is obtained through a sequence of chemical processes and physical operations: desulphurization by lean ammonia solution or caustic soda wash; HT shift conversion, carbon dioxide removal with acqua ammonia; final purification of the gas by couprous acetate solution and/or caustic soda wash. The ammonia synthesis-loop of small scale plants operates at a working pressure of approx. 320 bar.

75. A unique feature of the Chinese technology is the combined CO_2 removal and final fertilizer production. The ammonia produced in the synthesis loop, after separation and liquefaction is evaporated and thus used as a cooling agent. The gaseous ammonia proceeds to the CO_2 removal section. There it is absorbed in water and serves as an absorbent for the CO_2 contained in the syngas. Usually gaseous ammonia is available in excess of the quantity needed to fix the CO_2 in the syngas. The surplus ammonia, in form of aqua ammonia, is used as a final fertilizer product for agricultural purposes (direct application to the soil). During the crude syngas washing operation ammonium bicarbonate precipitates in crystal form. The crystals can easily be separated by centrifuging. This processing method is advantageous because it eliminates the necessity of regenerating the CO_2 absorbent. No further processing of the product ammonia is needed, while final desulphurization takes place simultaneously with the CO_2 washing operation.

76. Ammonium bicarbonate has a relatively low nutrient content (17 per cent N). Its chemical stability during storage under ambient temperature is low as well. Consequently it must be bagged and sealed immediately. A comparative economic study concluded that the optimum capacity of an ammonium bicarbonate

plant of the described type is 15,000 t/y, provided the consumer area circle (average transportation radius) does not exceed 25 km. Under these conditions it can be demonstrated that the savings in capital investment owing simplicity of the technology (per ton of fertilizer N produced) outweigh the bagging cost and decomposition losses during transportation and storage, and the higher transportation cost of the low-unutrient product as compared to urea. For plants of higher capacity urea is the preferred product as all the aforementioned related economic parameters appear to be more favourable.

77. The advantages of ammonium bicarbonate fertilizer incited the Chinese research workers to find ways and means of overcoming technical and application difficulties caused by some of its disadvantageous chemical and physical properties. They developed additives to the CO_2 scrubbing solution which permit to produce larger crystals, to decrease the moisture content, and to reduce caking of the finished, bagged product. Application of hot air drying and pelletizing further improved the quality of the product. Extensive studies revealed that application of the fertilizer for top dressing is not recommendable because of high decomposition losses. Application of ammonium bicarbonate by injection into the soil by 5 - 10 cm below the surface eliminates practically all losses. Field experiments showed that the effectiveness of fertilization was only slightly below that of urea and ammonium sulphate, and it was comparable to that of ammonium chloride and nitrate.

78. In the capacity range of 100 to 300 tons/day of ammonia over 50 plants have been in operation since the sixties. The feedstock equivalent to approximately 25 per cent of this capacity is heavy fuel oil, ca. 50 per cent is based on coke/anthracite, and ca. 25 per cent on natural gas.

79. Medium size ammonia plants based on coke/anthracite follow two alternative flowsheets which differ in the final stage of syngas purification: methanation or copper liquor wash.

The methanation process is combined with the following route of syngas generation and purification:

Atmospheric intermittent semi-water-gas generation, first desulphurization under atmospheric pressure, high temperature (H.T.) shift conversion, second desulphurization under pressure. Two-stage CO_2 removal using aminoacetic acid, followed by L.T. shift conversion and final desulphurization using ZnO. After methanation the purified gas is fed into the synthesis loop.

The copper liquor wash follows a similar gas generation route: fixed bed gasification of coke/anthracite, first desulphurization under atmospheric pressure. HT shift conversion, second desulphurization and CO_2 removal under presusre followed by copper liquor wash.

80. The energy recovery system generates steam of 38 bar pressure which is being used for steam turbine drives, and electric power generation. The overall energy consumption attained was 14.3 GCal per ton ammonia (60 GJ per ton NH_3). Certain improvements are being planned:

- to use a sulphur resistant catalyst for shift conversion;
- to reduce the number od desulphurization and decarbonation stages;
- to apply purge-gas separation for hydrogen recovery.

It is expected to reduce energy consumption by more than 1 Gcal per ton ammonia (4-5 GJ per ton NH_3).

81. For gasification of heavy fuel oil the partial oxidation process is applied. An oxygen/steam mixture is used under pressure of 34 bars. The crude gas is quenched by direct contact with water and RDC extraction using heavy oil which is recycled to the burners. Thereafter the gas passes through the HT and LT shift conversion, ADA (anthraquinon disulphuric acid) desulphurization hot carbonate CO_2 removal and methanation. Good performance of the processing route of heavy oils containing 0.3 to 1.0 wt. per cent S is ensured by using sulphur

resistant LT shift catalysts developed in China.

82. The waste heat boiler of the ammonia synthesis section as part of the comprehensive heat recovery system generates superheated steam (50 bar, 425 deg.C). The energy efficiency of this type of plant can be relatively high: 12.45 Gcal per ton of ammonia, equivalent to 52.5 GJ/ton NH_3 (expected improved specific consumption).

83. A detailed study has been conducted to assess the effect of the gasification pressure (between 22 and 50 bar) on the choice of heat recovery system (waste heat boiler or direct quench). No substantial energy saving could be demonstrated and therefore the well established direct quench working at 34 bar pressure was maintained in operation. The presentation dwelled on operating experience, particularly touching upon the construction of the burner and its operational life time.

84. Several medium size ammonia plants of 200 - 300 tons daily capacity have been constructed in China. These plants use as feedstock natural gas, refinery offgas, or coke oven gas. The flowsheets of the plants are almost identical with those of the large-scale ammonia plants, except for the following details:

- reciprocating compressors are used instead of centrifugal compressors;
- compressors are run on electric power and not on steam;
- the synthesis pressure is 300 bar;
- the steam pressure is 40 bar.

The design value of energy consumption is 9,67 Gcal/ton NH_3 (40.51 GJ/ton NH_3).

85. Since the early seventies China has imported thirteen ammonia plants of 1000 tons daily capacity. One paper elaborated on Chinese experience in operating these highly complex single-stream plants. Initially the on-stream factor was 0.62 and later it was improved reaching presently a three-year average of 0.915. This performance was achieved through application of the following measures:

- efficient training of operators before and after start-up;
- thereafter, a continued learning process is maintained;
- good supervision (inspection) of construction and erection work carried out by the contractor;
- meticulous and reliable maintenance services;
- proper process control;
- application of well prepared safety and emergency rules and codes;
- generally high standards of discipline and strict adherence to operating instructions.

The paper provided valuable information on difficulties encountered in the Benfield system and the cooling water circuit, and remedial measures applied. The longest period of continuous operation achieved was 379 days.

86. The integrated urea process combining the ammonia and urea production into one complex stream was investigated on bench and pilot scale. It was planned to construct a urea plant of 80 tons/day capacity, taking into account the experience of a 10,000 tons/year urea plant erected in 1974. The process developed by the Shanghai Research Institute uses the gas coming from the shift conversion for stripping of the unreacted carbamate in the process stream coming from the urea reactor outlet. The crude synthesis gas is then decarbonated and returned to the ammonia unit. It was demonstrated that the integrated process has several advantages i.e. lower energy consumption and investment costs. A techno-economic evaluation was presented which compares the integrated process to the conventional separate ammonia and urea units.

87. Chinese operating experience indicated that the quality of the recycled cooling water is of prime importance. Corrosion caused by bad quality of the water is a major problem area leading to serious equipment failures, interruptions, and breakdown repairs which can be avoided. Proper treatment

of the cooling water was recognized as the key factor.

At the Cangzhou Chemical Fertilizer Plant a phosphate water treatment agent without zinc as additive was used. Severe corrosion occurred. By using polyphosphates with zinc the corrosive effect of the water was eliminated. Contamination of the water by micro-organisms was controlled by using non-oxyative germicides. Good corrosion resistance of the internal surfaces of coolers made of carbon steel was achieved by applying corrosion resistant paints. Good management techniques contributed a great deal to the success of measures taken to eliminate corrosion.

88. One report pointed out that ammonia converters need periodic inspection because of their operating parameters: high pressure, relatively high temperatures, and high hydrogen content of the gas passing through the converter. The paper presented to the Conference revealed a number of interesting findings resulting from the application of the Chinese system which was especially developed for this purpose.

89. The large number of operating ammonia plants and the increasing amount of ammonia produced induced the necessity of producing in China different types of catalysts. Commercial production began already in 1953. Two types of catalysts were produced at a rate of 50 tons/year. Today 15 types of catalysts in over 40 grades (modifications)are produced in China. The annual output has reached approximately 2000 tons. China is self-sufficient in supply of catalysts for ammonia production. The export potential is developing favourably.

90. The production of catalysts for the primary and secondary reformer was studied since 1959. The commercial product was used for the first time in the early seventies for reformer units of ammonia plants working under atmospheric pressure.

Catalysts for reforming systems working under pressure and for the new large scale ammonia plants have been developed and successfully applied in the operating plants. Comparison of efficiency between Chinese and imported catalysts has documented favourable results. The major parameters such as:

mechanical strength, heat resistance, activity and volatility compare well with the specification of foreign products. Research and development work is being continued in order to further improve the quality of catalysts. Favourable results are expected to materialize soon.

91. Catalysts for shift conversion, methanation and ammonia synthesis have been developed and are being produced in commercial quantities. The HT shift catalysts of various grades are low in sulphur content. The LT shift catalysts were first developed in 1965 and constantly improved since then. The properties of this catalyst are outstanding, in particular its activity, stability, high mechanical strength and low shrinkage qualify it among the most efficient catalysts. The methanation catalyst containing a special new promotor is highly active and has an excellent thermo-stability. These unique parameters have been attained by applying a new manufacturing technology.

92. Locally manufactured ammonia catalysts are generally being used since 1960. Recently the low-temperature activity of the catalyst has been improved. The production of pre-reduced and spherical catalysts is the most recent achievement.

93. The attainment of the present-day high level of fertilizer production is the result of government initiatives through which the manufacture of machines and equipment as well as plant construction capacities have been developed. Investment in chemical fertilizer plants without foreign assistance has thus become possible.

94. High-pressure vessels are the most important components of ammonia plants. Manufacture of this type of equipment started in 1958. Four different techniques have been developed and are being used for fabrication of a large number of pressure vessels for all the existing and new ammonia plants.

95. By using the multilayer shrink-fit design 10 pieces of two and three-layer vessels of internal diameter 900 to 3200 mm for working pressures 150-320 bar were produced and put into operation (Max. wall thickness 162 mm).

96. The second method is being used for the fabrication of mono-layer vessels composed of thick shell plates (rolled and welded longitudinally to form tube shaped segments which are welded together by circumferential weld seams, in a similar way as the segments of the multi-layer vessels).

97. The third method is the welded multi-layer shrink-fit design. More than 6 vessels of this type have been produced to-date. At present it is possible to manufacture vessels of diameters 500 - 3200 mm from plates of individual thickness 6 - 12 mm.

98. The fourth method is used for fabrication of strip-wound segments of reactor and vessel shells. The continuous strip of thin steel sheet is wound around an inner shell. The segments are assembled by welding them together, but the adjacent segments are wound in opposite direction. More than 1500 vessels of this type of up to 1000 mm diameter and wall thickness up to 144 mm have been manufactured.

99. Urea reactors equipped with a special corrosion resistant inner shell (lining) were also fabricated as well as explosion lined vessels.

100. The internal cartridges of ammonia synthesis converters are important elements of the outfit of the ammonia plant. Considerable engineering design and research work has been carried out until conclusions were reached on the recommended type of cartridge for a specific case. The evaluation of experience in the design, manufacture and operation of the cartridges over the past two decades (for the medium and small scale ammonia synthesis converters in use) permitted to single out the preferred types. These are the co-current/two-bed

(parallel) types with inner cooling tubes - for the medium size plants, and the single layer co-current type for the small size converters. Many types, however, had been experimented in the past:

- the co-current triple-tubed heat exchanger type;
- the multi-bed quench type;
- the multi-bed type with interstage heat exchanger;
- the radial flow type;
- the parallel working two-bed co-current triple tubed type.

The efficiency of different types of internal heat exchangers, both spiral and tubular have been compared. The efficiency of spherical catalysts has also been investigated in this connexion. The heat recovery by using waste-heat boilers outside the converters has been discussed.

101. The technological and mechanical know-how accummulated by the fertilizer and engineering industries of China is the basis of their present capacity and potential of constructing and erecting ammonia plants of any size. These industries through their respective institutions have presented an impressive list of references. Their capabilities are steadily developing and are not only available for the construction of more and more fertilizer plants in China but also are being offered to other developing countries.

102. Details of construction and erection related activities were presented at the Conference. Particular attention was drawn to Chinese experience in lifting operations of heavy equipment, assembling of precision mechinery and special site welding techniques.

VIII. SUMMARY OF COUNTRY PAPERS

103. Twelve delegates from ten developing countries attending the Conference presented a general review of the fertilizer industry in their countries. Their country papers provided information on the attained level of development of the fertilizer sector, and permitted and insight into the technical problems encountered.

104. BANGLADESH, being the most densely populated country in the world (2,030 people per square mile) faces persisting food problems. Development of fertilizer industries is of highest priority in the country's industrial and economic development plans. The growth of population still outpaces the steady increase of food production. Intensification of fertilizer use is considered the key factor in the Government's strategy which aims at basic self-sufficiency in food supplies. Fortunately the country is endowed with ample resources of natural gas, and is therefore in a position to produce nitrogenous fertilizer from an indigenous raw material.

105. Starting in 1962 the nitrogen fertilizer industry attained to-date a total of 970,000 tons/year of urea production capacity (including one new large-scale plant). The actual level of output of the operational capacities is only 60 - 80 per cent owing to severe operation and management problems. These are chiefly caused by deficiencies in the design and construction of the relatively old plants, and by lack of experience in plant maintenance and proper operating techniques.

106. Although the internal demand for urea was only around 550,000 tons in 1981, it was necessary to continue importing certain quantities of fertilizer in order to make up for the low utilization of the existing capacities. According to forecasts production is expected to catch up with consumption only around 1986/87 when the total of installed capacities will reach 1.2 to 1.3 million tons/year of urea.

107. The country has a relatively well developed infrastructure for the nitrogen fertilizer industry which is based on the indigenous natural gas discovered in many locations. Because of the physical structure of the country it is particularly suited for establishment of small-scale plants which would serve the nearby local markets and thus considerably reduce

transportation problems. One small-scale ammonia/urea plant of Chinese origin is under construction. MOre plants of similar size may be considered in the future inter alia also for spreading industrialization and creation of job opportunities in remote areas.

108. EGYPT depends to a large extent on fertilizer use to meet agricultural production targets. Both the quantities needed and the importance of use of the fertilizer are further enhanced by the vital government policy of reclaiming agricultural land from the desert. Another issue causing increased fertilizer demand is the necessity of replacement of the fertilizer effect of the silt which was carried and spread by the river Nile but now is retained by the dams.

109. Actual production of nitrogen fertilizer in 1979 was 264,000 tons/year in terms of N(nitrogen). Four factories are in operation, producing CAN(calcium ammonium nitrate),ammonium sulphate and urea. Coke oven gas, water electrolysis and natural gas is being used as feedstock. The establishment of two new units, each of 200,000 tons/year capacity in terms of N, is being planned, both based on natural gas. One plant shall produce DAP (diammonium phosphate), CAP(calcium ammonium phosphate) and AS (ammonium sulphate). The other plant shall be designed to produce AN(ammonium nitrate) and/or urea. The use of ammonia for direct application is also being considered. Revamping of the relatively old manufacturing facilities is envisaged. According to the conclusions of recent studies all future nitrogen fertilizer plants in Egypt shall be based on natural gas. The capacities shall be of moderate size. Under Egyptian climatic and soil conditions AN should be the preferred type of fertilizer.

110. INDIA: The chemical fertilizer industry producing nitrogen fertilizers has a long tradition. It started in forties with a 5 tons/day ammonia plant. In 1981 the installed capacities totalled 4,580,000 tons/year in terms of

N (nitrogen), while projects presently under implementation will add a potential of further 2,107,000 tons/year fertilizer nitrogen (N) manufacturing capacity (mostly in form of urea). Projects under consideration or approved in principle are expected to contribute another 2,500,000 tons/year (N) production capacity.

111. A wide variety of feedstocks and consequently a multiplicity of processes and plant sizes characterize the Indian fertilizer industry of today. 52 per cent of the production is still based on naphtha, 21 per cent on fuel oil, 12 per cent on natural gas, 11 per cent on coal, 2 per cent on electrolysis of water, and 2 per cent on coke/coke oven gas. There are 20 fertilizer manfuacturing companies, operating 35 production units ranging from 6 to 1350 tons/day of ammonia. Finished fertilizer products produced in India comprise: AS, CAN, ASN(ammonium sulphate nitrate), urea and several grades of NP and NPK compounds.

112. India has built up the necessary skilled manpower, research and development facilities, design and engineering as well as equipment manufacturing capabilities which gradually are becoming more and more self-reliant. The respective government organizations and private companies involved are ready to offer their services to other developing countries and are in a position to execute their work in a highly responsible and qualified manner.

113. Problems faced by the Indian fertilizer industry are similar to those encountered in other developing countries of equivalent economic structures and level of industrialization, namely: shortage of funds for investment; bottlenecks in equipment manufacture; limited supply capabiliites of specific construction materials, inadequacy of infrastructure. Training facilities of all grades and for all professions are available, and are being offered to as well as utilized increasingly by other developing countries.

114. JORDAN has no nitrogen fertilizer industry to-date, but it is an important producer of rock phosphates. Part of this raw material is being processed to phosphoric acid, DAP and MAP. There are projects under consideration or implementation which assure continued development of the fertilizer raw materials and producing sector of the Jordanian industry. Ultimately, Jordan will become one of the major suppliers of high analysis fertilizers(NPK) to the world market.

115. The oil shales discovered in the country will also be used for fertilizer production, through shale oil extraction and its fractionation to fuel distillates, which would be suitable for ammonia plants.

116. The existing DAP-MAP plant is composed of two sulphuric acid lines each of 1800 tons/day capacity, one single stream phosphoric acid plant producing 1250 tons/day in terms of P_2O_5, and two units each producing DAP/MAP at a rate of 50 tons/hour. By-product fluor compounds are recovered in form of AlF_3 in a plant of 20,000 tons/yar capacity.

117. MEXICO was historically the first country in Latin America, starting in 1947,to produce ammonia in a small-scale plant (by today's standards) of 50 tons/day capacity. Presently the installed ammonia manufacturing capacity exceeds 3 million tons/year, while the production of fertilizer nutrients corresponds to 1,109,500 tons/year N (nitrogen), 320,940 tons/year P_2O_5 (phosphates), and 36,200 tons/year K_2O (potash). Ca. 300,000 tons/year ammonia is applied directly to the soil and there is also a substantial export of liquid ammonia to the world market.

118. Capacities of the ammonia units now in operation range from 70 to 1350 tons/day. By quantities of fertilizer materials produced, one third is ammonium sulphate, one half is urea, and the remainder is ammonium nitrate, DAP and NPK. Plants presently under construction will increase the existing capacity by 2,125,000 tons/year in terms of N. The majority (82.2 per cent) of ammonia

is being produced at the Minatitlan plant. A pipeline of 1500 km is under construction. It shall transfer ca. 3000 tons/day of ammonia to the central highlands and supply all the important agricultural areas and down-stream processing plants along the pipeline. Transportation and distribution of fertilizer is a persisting major problem area of the Mexican fertilizer industry.

119. For the projects presently under implementation only the licences, basic engineering and critical items of equipment are imported. The country's indigenous technical potential and skills are being utilized to the largest possible extent in order to provide the necessary equipment supplies and services, which otherwise would have to be acquired from abroad.

120. PAKISTAN initiated chemical fertilizer production in the fifties by establishing an ammonium sulphate plant of ca. 50,000 tons/year capacity. The presently installed capacity totals 730,000 tons/year (N) while capacities of ca. 300,000 tons/year (N) are under construction. Unit capacities of ammonia plants range from very small up to 1000 tons/day.

121. Serious difficulties were encountered during construction, commissioning start-up and operation of most of the plants. A detailed account of the nature and causes of deficiencies was presented, and well taken recommendations were addressed to other developing countries in order to help them avoid recurrence of similar situations.

122. ROMANIA has 19 ammonia plants of a capacity amounting to 4.12 million tons/year. Two more plants are under construction which will add ca. 0.6 million tons/year to the existing capacities. The entire ammonia production is based on natural gas. Measures are being taken and planned to reduce the energy consumption of ammonia plants. The Romanian engineering institutions, the

fertilizer industry and equipment manufacturing companies offer their potential to render technical assistance services to other developing countries in particular in such areas as: engineering design, construction/erection, training and exchange of experience.

123. SRI LANKA has recently started an ammonia plant of 540 and 940 tons/day ammonia/urea manufacturing capacity, respectively. The country was heavily depending on imported fertilizer (over 250,000 tons of nitrogen fertilizer in 1980). The feedstock of the new plant is naphtha from the local refinery. The project schedule of the plant suffered serious dalays till end 1981. However, at present the plant is fully operational, having already passed its teething troubles. It attains ca. 90 per cent of its design capacity.

124. THAILAND does not produce fertilizer materials. The uneconomic lignite based small ammonia plant had to be shut down in 1978. Present production of compound/blended fertilizer uses imported components as input material. The consumption of fertilizer in 1981 was high, amounting to 966,000 tons of fertilizer product containing 169,000 tons(N), 144,000 tons(P_2O_5) and 39,000 tons(K_2O). Relatively large quantities were marketed in form of locally mixed and compounded (granulated) fertilizer.

125. The recently discovered commercial quantities of natural gas, combined with a well developed internal market for fertilizer justified preparations for establishing a large scale fertilizer plant. The project is vigorously being pursued, though being very expensive because of the concept of establishing a barge mounted/landed plant, the first of its kind in the world. The estimated investment cost is US$540,000. The plant shall produce 260,000 tons/year (N) in form of ammonia, 100,000 tons/year (N) as urea and 190,000 tons/year (P_2O_5) in form of MAP, DAP and NPK.

126. ZAMBIA has one nitrogen plant in operation since 1970. The original capacity of the plant, i.e. 30,000 tons/year of ammonia was expanded after 1975 to 90,000 tons/year. Ammonia is processed to ammonium nitrate, ammonium

sulphate and NPK. The company produces also a small quantity of methanol (1650 tons/year).

127. In the existing Zambian plant the production of ammonia is based on the Krupp.Totzek coal gasification process, followed by sulphur removal, two-step shift conversion, carbon dioxide removal and methanation. The synthesis loop operates under 350 bar pressure.

128. Zambia is a land-locked country. The fertilizer company faces a number of problems which are common to many developing countries. Lack of skilled labour, inadequacy of infrastructure, transportation and financial issues were identified as the main problem areas. The fertilizer company co-operated with India and is looking forward to establish co-operative links with other developing countries in order to solve its operational, maintenance and manpower training problems.

IV. PLANT VISITS

129. The following plants were visited:

1. Experimental plant, (Beijing Chemical Pilot Plant); (Ammonia/Ammonium Bicarbonate)
2. First Shengli Chemical Fertilizer Plant, Shangdong Province (Shiln Petrochemical Complex), (Ammonia/urea - medium scale plant).
3. Second Shengli Chemical Fertilizer Plant, Shangdong Province (Ammonia/urea - large-scale plant)
4. Shanghai Compressor Manufacturing Plant;
5. Chemical Equipment Manufacturing Factory, Shanghai;
6. Taicang Chemical Fertilizer Plant (Ammonia/Ammonium Bicarbonate).

130. The participants enjoyed the opportunity of being acquainted with details of the Chinese technology, plant design and operating parameters of various units and sections of plants which were completely based on Chinese indigenous inventiveness.

131. The **Experimental Plant** is one of the first fertilizer plants constructed in China, based on indigenous technology. Production started in 1959 with a capacity of 5000 tons/year ammonia and 40,000 tons/year ammonium bicarbonate. Presently its ammonia capacity is 100,000 tons/year whereby part of its output is used in agriculture as liquid ammonia and aqua ammonia. The raw material for ammonia production is coke.

132. The **First Shhengli Chemical Fertilizer Plant** is part of the Shilu Petrochemical Complex. It uses refinery offgases as feedstock for the ammonia plant. Actual ammonia capacity is 50,000 tons/year combined with a medium scale urea plant producing 110,000 tons/year. It went on stream in 1972/73.

133. The **Second Shangli Chemical Fertilizer Plant** represents one of the series of imported large scale ammonia/urea plants of 330,000/480,000 tons/year capacity respectively. It was commissioned in 1976. The feedstock for the ammonia plant is associated gas from the nearby oil fields.

134. The **Shanghai Compressor Manufacturing Plant** was founded in 1937. It produces presently a large variety of reciprocating compressors, screw compressors, large centrifugal compressors and a wide range of ancillary and auxiliary equipment. It has a well established foundry shop and compressor testing facilities.

135. The **Chemical Equipment Manufacturing Factory** in Shanghai produces a wide range of vessels, heat excahngers and reactors (autoclaves) as well as sophisticated special apparatuses for chemical, oil processing and pharmaceutical plants. In particular, it produces high pressure vessels of various diameters, mainly for the small-scale ammonia plants.

136. The <u>Taicang Chemical Fertilizer Plant</u> represents one of the typical Chinse medium-scale plants which produce ammonium bicarbonate as the main product and aqua ammonia as by-product. The raw material for ammonia production is anthracite in form of lime/anthracite egg-shaped briquettes. The lime is produced locally and the carbon dioxide from the lime kilns is used to cure the briquettes. The factory is located in a well developed agricultural area which consumes all the fertilizer material throughout the year because of favourable climatic conditions. The factory was designed, constructed and erected entirely by applying Chinese technology and equipment. It demonstrates the feasibility of producing ammonium bicarbonate under technological conditions and material management without incurring losses of ammonia by decomposition before it reaches the fields.

ANNEX I

LIST OF PARTICIPANTS

Developing Countries

Country	Name and address
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ANNEX II: List of Papers presented by UNIDO consultants, the host country's specialists, and the participants from developing countries

SYMBOL	TITLE	AUTHOR(S), ORGANIZATION COUNTRY
ID/WG.364/1	Reactor Designs and Catalysts for Ammonia Synthesis	Umberto Zardi Ammonia Casale SA, Italy (Switzerland)
ID/WG.364/2	Hydrogen Recovery from Ammonia Purge Gas The Petrocarbon Experience	W.H. Isalski Petrocarbon Developments Limited, United Kingdom
ID/WG.364/3	Criteria for Selecting CO_2 Removal Processes	Frank C. Brown Humphreys and Glasgow Limited United Kingdom
ID/WG.364/4	Hydrogen Recovery from Ammonia Plant Purge Gas via PRISM Separators	J.M. Van Gelder Monsanto Company, USA
ID/WG.364/5	Corrosion Problems in an Ammonia Plant (Case Histories)	C.V. Srinivasan T.R. Sabapathy and V.R.R. Gupta Madras Fertilizers Limited India
ID/WG.364/6	Energy Conservation in Ammonia Plants	G.D. Honti VEGYTERV - Hungarian Chemical Industries Engineering Center Hungary
ID/WG.364/7	Future Trends in Ammonia Technology	Ahmad Shah Nawaz Chemical Consultants (Pakistan) Ltd. Pakistan
ID/WG.364/8	Jordan Phosphate Mines Company	Y.A. Abu-Rish Jordan Phosphate Mines Company Jordan
ID/WG.364/9	Ammonia Industry in India	K.S. Sarma The Fertilizer (Planning and Development) India Limited India
ID/WG.364/10	Fertilizer Production in Zambia Facilities and Problems	I.M. Liayo Nitrogen Chemicals of Zambia Zambia
ID/WG.364/11	200 MT/D Ammonia Plant with Heavy Oil as Feedstock	Li Shaoquing and Zhang Jinzhong Lanzhou Chemical Industry Corporation China

SYMBOL	TITLE	AUTHOR(S), ORGANIZATIONS COUNTRY
ID/WG.364/12	Periodical Insepction and Treatement of Defects of Ammonia Converters	Yao Zu Yun Dalial Chemical Industry Plant China
ID/WG.364/13	Developments in Catalysist for Water-Gas Shift, Methanation and Ammonia Synthesis in China	Chen Wuzheng The Research Institute of Nanjing Chemical Industry Company China
ID/WG.364/14	How China has developed its Ability of Building Nitrogenous Fertilizer Plants	Han Xue-Tong China National Chemical Corporation China
ID/WG.364/15	The Manufacture of High Pressure Vessels for Nitrogenous Fertilizer Plant	Shi Huimin Chemical Machinery Research Institute China
ID/WG.364/16	The Preparation and Gasification of Carbonated Lime Coal Briquettes	Yang Yun Zao The Design Institute of Chemical Industry of Fujian Province China
ID/WG.364/17	Study on the Structure of the Ammonia Converter Cartridge	Huang Wenxiong The Fourth Design Institute of the Ministry of Chemical Industry China
ID/WG.364/18	The Chemical Fertilizer Industry in China	Liu Gang Chemical Fertilizer Department of the Ministry of Chemical Industry China
ID/WG.364/19	The Viability of 200-300 MTPD Natural Gas based Ammonia Plant	Wu Hong-ye and Xue Tian-xiang Chemical Industry Engineering Corporation China
ID/WG.364/20	Treatment of Recirculation Cooling Water in a nitrogenous Fertilizer Plant	Feng Hua-you Cangzhou Chemical Fertilizer Plant China
ID/WG.364/21	Synthetic Ammonia Plant of 200/D with Anthracite as Raw Material	Yu Qingzu The Third Design Institute of the Ministry of Chemical Industry China
ID/WG.364/22	Combined Production of Ammonia and Urea - A study on integrated Urea Process with Shift Gas Shipping	Yu Bing Liang Shanghai Research Institute of Chemical Industry China

SYMBOL	TITLE	AUTHOR(S), ORGANIZATIONS COUNTRY
ID/WG.364/23	Application of Steam Gaseous Hydrocarbons Reforming Catalyst	Feng Xiaoting The Southwest Research Institute of Chemical Industgry China
ID/WG.364/24	The Technic-Economic Evaluation of the 10000 tons/year Ammonia Plant	Chen Yi Ying, Wang Zhiguo and Mai An Hua The Fourth Designing Institute, Ministry of Chemical Industry China
ID/WG.364/25	Raising the Onstream Factor of 1,000 TPD Ammonia Installation	Yin Xuejin Sichuan Chemical Plant China
ID/WG.364/26	Improvements of the Quality of Ammonium Bicarbonate Fertilizer and its Application	Ding Heng-lin and Zhuang Lian-juan Shanghai Research Institute of Chemical Industry China
ID/WG.364/27	The Fertilizer Industry in Mexico	Adolfo Sisto Valasco Fertilizantes Mexicanos SA Mexico
ID/WG.364/28	Fertilizer Production Capacities in Pakistan and Problems faced during Execution of Paksaudi Fertilizer Ammonia Plant	S. Chaudhri Paksaudi Fertilizers Limited Pakistan
ID/WG.364/29	Fertilizer Industry in Pakistan - a Brief Review	Zahur Ahmad Khan PAKARAB Fertilizers Limited Pakistan
ID/WG.364/30	Fertilizer Industry in the Sudan	Ahmed Hamid Ahmed Chemical Industries Department Sudan Industrial Research and Consultancy Institute Sudan
ID/WG.364/31	World Bank Assistance in the Development of Fertilizer Industry in the Developing Countries	Edilberto L. Segura The World Bank Washington, D.C., USA
ID/WG.364/32	A Brief History of the Current Status of Ammonia based Fertilizer Industry in Sri Lanka	A.R. Munasinghe State Fertilizer Manufacturing Corporation Sri Lanka
ID/WG.364/33	Present Situation and Prospects of Ammonia Technology and Fertilizer in Romania Suggestion on Co-operation	Mircea F.R. Russu IPROCHIM Bucharest Romania

SYMBOL	TITLE	AUTHOR(S), ORGANIZATIONS COUNTRY
ID/WG.364/34	Development of Ammonia Fertilizer Industry in Bangladesh - a Prospect for Economic Co-operation among Developing Countries	S.M. Nuruzzaman Bangladesh Chemical Industries Corporation Bangladesh
ID/WG.364/35	Country Paper on Bangladesh Fertilizer Industry	B.K. Mozumdar Urea Fertilizer Factory Limited Bangladesh
ID/WG.364/36	Fertilizer Industry in Thailand	Sunsanee Supapa Ministry of Industry Thailand
ID/WG.364/37	Nitrogen Fertilizer Industry in Egypt with some Details on Helwan Fertilizer Plant	Mohamed I.M. El Nashar

ANNEX III: Time-table of the Conference and Plant Visits

13 March 1982, Saturday

10:00 - 11:00 a.m.	Inauguration of the Conference 1. Election of Chairman; 2. Opening address by Mr. Feng Bohua, Vice-Minister of the Ministry of Chemical Industry; 3. Message to the Conference presented on behalf of Dr. Abd-El Rahman Khane, Executive Director of UNIDO, by Mr. Sylvester R. Panfil, UNIDO Senior Interregional Adviser; 4. Address on behalf of the Resident Representative of UNDP, Beijing, by Mr. A.W. Sissingh, UNIDO Senior Industrial Development Field Adviser, Beijing.
11:00 - 12:00 a.m.	Mr. Liu Gang: Presentation of the introductory paper of the host country: The Chemical Fertilizer Industry of China.
01:30 - 05:30 p.m.	Presentation of lead papers by UNIDO consultants
06:00 p.m.	Reception of the foreign guests: by Mr. Qin Zhongda, Minister of the Ministry of Chemical Industry
06:30 p.m.	Official Dinner given by Mr. Qin Zhongda

14 March 1982, Sunday

09:00 - 12:00 a.m.	Continuation - Presentation of lead papers by UNIDO consultants
01:30 - 05:30 p.m.	Presentation of host country's papers

15 March 1982, Monday

09:00 - 12:00 a.m.	Continuation - Presentation of host country's papers
01:30 - 05:30 p.m.	Continuation - Presentation of host country's papers

16 March 1982, Tuesday

09:00 - 10:40 a.m.	Continuation - Presentation of host country's papers
10:40 - 12:00 p.m.	Paper presented by the Representative of the World Bank; Presentation of country papers.
01:30 - 05:30 p.m.	Continuation - Presentation of country papers

17 March 1982, Wednesday

09:00 - 12:00 a.m.	Working Group Sessions
03:00 - 06:00 p.m.	Drafting of Working Group Reports

18 March 1982, Thursday

09:00 - 12:00	Closing Session
	Rapporteur's report;
	Report of the four chairmen of the Working Groups;
	Adoption of the reports;
	Closing addresses by Mr. Sylwester R. Panfil and Mr. A.W. Sissingh;
	Closing address by the Chairman of the Conference, Mr. Huang Hongning;
	Closing speech delivered by Mr. Feng Bohua, Vice-Minister of the Ministry of Chemical Industry.
19 - 26 March 1982	Plant visits
27 - 28 March 1982	Departure of foreign participants of the Conference and plant visits

ANNEX IV: Messsage to the Conference from Dr. Abd-El Rahman Khane, Executive Director, UNIDO

Your Excellency Mr. Vice-Minister, Representatives of the Ministry of Chemical Industry and the Ministry of Economic Relations with Foreign Countries, distinguished participants, ladies and gentlemen:

It is a great pleasure to extend to you my best greetings on this occasion and welcome all of you on behalf of UNIDO to this Conference.

In line with the New Delhi Declaration and Plan of Action agreed to in 1980 by UNIDO's Third General Conference as well as in pursuance of the recommendations of the Third Consultation Meeting on Fertilizers, UNIDO at the request of the Ministry of Chemical Industry of the People's Republic of China decided to convene this Conference. As you are aware, the former particularly called for strengthening the transfer of technology and know-how between developing and developed countries, and therefore I welcome the active participation of over twenty experts from both developing and developed countries at this Conference.

It has been recognized that those developing countries which have already reached a relatively advanced stage of industrialization are in the position to share their experience and to transfer their technological knowledge to less devleoped countries.

In the fertilizer industry a number of developing countries have extensive experience in the manufacture of ammonia while others have so far no ammonia manufacturing facilities at all. All countries, however, are aware of the fact that the availability of fertilizer is strategical importance as far as food security and agricultural development is concerned; It is for this reason that developing countries make every effort to become self-reliant in fertilizer supplies whereever conditions warrant successful implementation of industrial development projects relating to fertilizers.

In pursuance of the aforementioned objectives and in light of UNIDO's mandate concerning the promotion of industrialization, UNIDO is organizing this technical conference on ammonia fertilizer technology in co-operation with the Government of the People's Republic of China.

The Conference should provide a unique opportunity for exchange of experience among participants on ammonia technology.

In the forefront of our concerns today both in developed and developing countries is conservation of energy in the manufacture of ammonia which will be one of the topics to be discussed at this Conference. In the same context two papers will be presented on hydrogen recovery from ammonia plant purge gas. Another session will cover reactor design and catalysts for ammonia synthesis, and various processes used for the removal of carbon dioxide. Discussions will also cover corrosion problems including case histories of successful solution in ammonia plants.

The Conference will close with a look to the future on new trends - in the ammonia manufacturing technology. In addition, in line with UNIDO's mandate and constant concern, this Conference shall also provide an opportunity to inform our distinguished participants about UNIDO's function and potential in rendering technical assistance services whenever needed by the industry and requested by governments of developing countries.

I am grateful, indeed, to our Chinese counterparts who have come up with a comprehensive programme and have contributed excellently to the preparation of this Conference and wish to record UNIDO's deep gratitude to the Ministry of Chemical Industry for hosting this Conference. I wish your deliberations every success.