

# IFA Technical Conference

**Amman, Jordan  
2-6 October 1994**

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**STATEMENT BY C.R. GIBSON**  
**Chairman of the Technical Committee**

Honorable Minister, Your Excellencies, distinguished guests, fellow participants, ladies and gentlemen,

On behalf of the Technical Committee, I wish to welcome all of you to our 25th biennial Technical Conference. We are deeply honoured and extremely grateful that this Conference is placed under the patronage of His Royal Highness the Crown Prince.

IFA's Technical Conferences date back to 1947 and we are proud that they have been a source of many outstanding technological advances by our industry. The credit must go to the researchers whose enthusiasm and openness have been largely responsible for the rapid pace of innovation. The present Conference will continue this strong tradition. We received some sixty offers of papers and ultimately forty-four were selected for presentation. To accommodate this enthusiastic response, we have organized parallel sessions for papers relevant to specialized segments of the production or manufacturing processes.

The Conference is more than just a social event. Important information is exchanged, contributing to the progress of the industry.

The role played by the host country is vital to the success of the Conference, Jordan is the 18th country which has graciously accepted the challenge to invite IFA's Technical Committee. Amman is the 23rd host city, indicating the strong interest on the part of the participants to widen their knowledge and study developments in as many places as possible. I wish to congratulate the Jordanian members of IFA for their excellent co-operation in ensuring the success of this Conference. Over the next four days, you will be able to witness the results of their meticulous efforts.

May I now call upon Mr. Sameh Madani, Chairman of the Jordanian Fertilizer Industry Co-ordination Committee to deliver his welcome address.

Thank you.

**WELCOME ADDRESS BY S. MADANI  
Chairman of the Jordanian Fertilizer Industry Co-ordination Committee**

Honorable Minister, Your Excellencies, Distinguished Participants,

I am honoured and privileged to welcome you on behalf of the Jordanian IFA members, and the Jordan Fertilizer Industry Co-ordination Committee.

We indeed feel especially delighted by the decision of the IFA Management to hold this Technical Conference in Amman and would like to wish the Conference every success.

Jordan has been a well known phosphate rock producer and exporter for the past 40 years. The discovery of the sedimentary rock deposits goes back to 1908 during the construction of the Hijazi Railway. In 1930 the first mining operations were commenced at Russaifa near Amman on a limited scale by a private company, following this became the establishment of Jordan Phosphate Mines Co in 1953, where noticeable efforts were exerted by JPMC to extend the Company's operations, and increase its export capabilities.

As a result, two modern mines were put into operation at El-Hassa and El-Abyad in 1962 and 1979 respectively, amounting to a total production capacity of about 6 million tons per year.

High grade phosphate rocks produced from these mines enabled JPMC to become one of the world's major exporter of these grades.

Furthermore, during the mid-seventies, the largest single deposit was discovered at Eshydia, located at 55 km South-East the City of Ma'an. The reserves have been estimated at 1200 million tons of phosphate, thus increasing the total exploitable reserves to about 2000 million tons.

The Eshydia Mine is now under development at which the first stage is expected to reach a target production of 3.25 million tons per year which is to be completed by the end of 1995.

The second stage consisting of uprating the capacity to 7 million tons per year is planned for completion in 1998. By the turn of the century, a third stage of expansion will follow to increase the capacity to 9 million tons per year, expansion from which about 40% will be locally converted to fertilizer products. The balance i.e. 5 to 5.5 million tons per year of phosphate rock will continue to be exported.

It is worthwhile mentioning that, the mining activities at Russaifa have now been discontinued for economical and environmental reasons.

The previously mined area is being restored such that it will be available for urban use.

Similar environmental protection initiatives have been carried out by JPMC in other mining locations. At El-Hassa for example, a massive campaign is being organized to plant appropriate varieties of trees, around the city of El-Hassa.

Furthermore, large quantities of rain water can now be collected in one of the mine excavation pits for distribution to farmers in the nearby area, for irrigation purposes.

Honorable Minister, Ladies and Gentlemen,

In addition to being a world leader in phosphate rock production, Jordan is also one of the world's major producers and exporters of potash, which is extracted from the Dead Sea brines. According to the experts, there are some 40 billion tons of valuable salts including 2 billion tons of potassium chloride.

Potash is exploited by Arab Potash Company (APC) a Pan Arab Company in which the Government of Jordan is the main shareholder, in its Ghor-Al-Safi Complex on the Dead Sea which was commissioned in 1983 with an initial design capacity of 1.2 million tons per year.

During the first few years of operation, APC carried out additional modifications to extend the capacity to 1.4 million tons per year. Earlier this year, a further extension was completed raising the annual production capacity of 1.8 million tons.

The second stage of the extension of the potash production is expected to be completed by 1998 raising the annual production to 2.2 million tons.

On the other hand, APC is looking forward to establish a number of new future projects relying on the Dead Sea brines during the period 1994-1998. These projects are expected to create more than one thousand employment opportunities, and will reflect on fortifying the Jordanian economy. In this regard, an agreement was reached on the establishment of a holding company with a capital of 60 million Jordanian dinars to handle such projects.

On the fertilizer production side, the year 1982 witnessed the start of production from the Aqaba fertilizer complex, with nominal capacity of 740,000 TPY of DAP.

In 1985, a 20,000 TPY plant for liquid fertilizer preparation was installed by a private company adjacent to JPMC Fertilizer Complex in Aqaba, from which phosphoric acid and other raw materials have been procured.

Since then, three other liquid and suspension fertilizer units have been constructed by private companies located in Aqaba, Amman and Mafraq.

In 1987, a blending project was constructed by JPMC and other Jordanian partners, located near the Jordan Valley agricultural area. The plant was designed to produce 40,000 TPY of NPK blends, based on DAP, potash and other indigenous ingredients.

In order to meet the growing domestic demand, JPMC presently operates a SSP plant located at El-Abyad Mine with an installed annual capacity of about 30,000 tons per year.

Honorable Minister, Ladies and Gentlemen,

Under the guidance of His Royal Highness the Crown Prince, JPMC and APC are continuing the process of development since the past two decades, within a framework of a long-term strategy, based on increasing production capacities and product diversification. Promotion of joint venture projects between fertilizer materials producers and consumers constitute one of the major milestones in this strategy. JPMC and APC have during the last four years reached agreements with partners from Japan, India and Pakistan to set-up joint venture projects utilizing indigenous fertilizer raw materials.

Three major agreements have been concluded in the past few years in this respect:

- The first was signed by JPMC with Southern Petrochemical Industries Corporation of India and Arab Investment Company of Saudi Arabia, to build a merchant grade phosphoric acid manufacturing plant at Eshydia Mine.

This plant will utilize some 700,000 TPY of Eshydia rock to produce 224,000 TPY of phosphoric acid which is to be entirely exported to the Indian partner.

- The second agreement was signed by APC/JPMC with a consortium of four Japanese companies and organizations, namely Zen-Noh, Mitsubishi Corporation, Mitsubishi Kasei and ASAHI Industry, to set-up a Joint Venture NPK fertilizer production facility in Aqaba. The annual production of this facility amounting to 300,000 tons of different NPK formulations will be exported to Japan.
- The third agreement has been concluded between JPMC and Fauji Fertilizer Company of Pakistan to implement a fertilizer production complex in Pakistan.

The basic philosophy behind this project is to jointly develop the indigenous material resources of each country namely, natural gas (in Pakistan) and rock phosphate (in Jordan) to produce fertilizers materials, destined to meet the growing Pakistani market requirements.

The project comprises facilities for manufacturing 419,000 TPY of ammonia, 551,000 TPY of urea and 445,000 TPY of DAP.

Phosphoric acid required for DAP manufacturing amounting to 210,000 TPY will entirely be supplied by JPMC.

Other similar projects are also under consideration.

Finally, may I wish you all again, great success in the proceedings of this conference, and

Thank you very much for your attention.

## **KEYNOTE ADDRESS BY E. ONER President of IFA**

Honorable Minister, Distinguished Invitees, Fellow Delegates, Ladies and Gentlemen,

It is a privilege and honour for me to address this distinguished audience on the occasion of the 1994 Technical Conference of the International Fertilizer Industry Association. It is most encouraging to see key fertilizer production managers, from more than 40 countries, present in Amman, capital of a most hospitable host country. We are greatly indebted and deeply grateful to His Royal Highness the Crown Prince for placing this year's Technical Conference under his patronage.

IFA's Technical Conference, which is held every two years, provides an opportunity for fertilizer production managers to interact with colleagues and reflect on the state of the technology. The Conference creates a platform where problems are discussed and solutions proposed. Our Technical Conferences have reported many innovations, particularly in phosphate production and granulation processes. Many of these innovations, introduced in the fifties and sixties, were the foundation of modern fertilizer production technology. Indeed, prior to World War II, there were those who thought that the ammonia technology was a mature technology, but subsequent innovations proved how wrong they were. To refresh your memory and in order to assist you in your deliberations during the Conference, let me briefly refer to some of the achievements, to mention just a few.

As regards ammonia production, the first major improvement following the Second World War came in 1950 with the development of the non-catalytic partial oxidation of hydrocarbons under high pressure. The sixties were an exciting time for production engineers, firstly with the development of centrifugal compressors to replace reciprocating compressors. There was also a breakthrough in the steam naphtha reforming process through the use of a new catalyst. Improvements in the ammonia converter permitted an increase in capacity from 300 tons per day to 1350 tons per day. Effective heat recovery was also improved. Then came the seventies and the oil shock of 1973. As a result, major efforts were made to improve energy efficiency, to reach today between 6.7 and 7.2 Gcal/metric ton of ammonia, depending on the process design.

Developments in urea production followed those of the ammonia technology. In the 60's, the total solution recycle process of carbamates permitted a reduction in the consumption of raw materials and utilities. In 1968, a major breakthrough in the urea production process was achieved with the introduction of the CO<sub>2</sub> stripping technique. Eleven years later, another quantum improvement was made in the stripping technique for ammonia production. These stripping techniques ultimately led to the third generation urea production process.

In phosphoric acid production, the adoption of the hemihydrate and dihydrate processes were major breakthroughs. In 1974, the adoption of the pipe reactor technology in the manufacture of DAP/MAP was a major advance.

As regards sulphuric acid production, the notable achievement was the adoption of the cogeneration and heat recovery system.

While singling out some key achievements in the various production sectors, it should be realized that there were major achievements with an impact on the industry as a whole. These include a whole range of catalysts, advanced construction materials, environmental protection technologies, fluidized bed drying and the application of computer and fuzzy logic in production monitoring.

I could continue with the enumeration of innovations in fertilizer production and the list would be very long indeed. Instead, I have mentioned just a few of these achievements to indicate how much the production processes have changed since the establishment of our Association.

Turning to this year's Conference, I am pleased to note that such a large number of presentations will be made. Of the 44 interventions, some may be classified as "hard" or basic technology, others as "soft" or applied technology and the remainder are in between. Developments in basic technology have slowed down considerably in the last decade or two. Indeed, in recent years, the emphasis has shifted to problems in the "soft" technology field. Two major directions are evident: environment and process management.

Today, environmental issues feature prominently in the list of priorities of any industrial organization. Indeed, the population pressure on the space available for human development on our planet, the food requirements and other needs of its inhabitants, and the impact of industrial production on the environment, have led to the conclusion that only sustainable development strategies are viable options if we want to maintain and improve the quality of life.

Environmental awareness began to gather momentum in the early sixties. Over the last three decades, this movement has become universal. Environmental considerations influence the way we produce our goods, how they are packaged and transported, the manner we dispose of the effluents and how manufactured products are finally used. The fertilizer industry is not the only one which has to comply with environmental regulations. Virtually every sector of human activity is now affected.

For a long time, the fertilizer industry remained complacent as regards environmental aspects of fertilizer use were concerned, on the basis that these products were indispensable for food production. By the time it was realized that action was necessary, the environmentalists had taken the lead. However, I am proud to mention that the fertilizer manufacturing industry led in the adoption of environment-protection technology. Moreover, major efforts have been made to improve application practices and it is encouraging to note that environmental concerns are moving from the emotional to the technical field. We have to be pro-active, responsive to genuine concerns but firm as to the need for our products to meet current and future food requirements. In this connection, our Association is committed to the enhancement of the public image of the fertilizer industry.

Process technology management is another important factor in the industrial sector. Research results need to be converted into practical applications benefitting the manufacture of the final product and contributing to its commercialization.

In the area between "hard" and "soft" technology, experts forecast that over the next two decades, seven disciplines will experience the most intensive progress - information technology, biotechnology, micro-electronics, material science, civil aviation, robotics and computer technology. I know from the proceedings of the Conference that some of these areas are already incorporated in your studies. But much more needs to be accomplished. The fertilizer industry cannot afford to be complacent.

Most of the technological developments we know today have been realized in the developed countries. But in many of these countries, fertilizer production is no longer a growth sector and the profitability has fallen strongly. Research and development efforts by fertilizer producers have been reduced and new developments come largely from a small number of specialized companies.

The developing countries are facing an interesting time. It is expected that they will account for 80% of the additional population during the next five decades. How well they will perform economically will largely depend on their ability to organize, invest, absorb new technologies. The quality of life in these countries will depend on how they interact with the environment.

In conclusion, I would like to express my hope that the participants will take the opportunity of the present Conference to interact and to obtain inspiration from the discussions. I wish you well in your deliberations.

Finally, on behalf of the International Fertilizer Industry Association and on my own behalf, I should like to express once more my gratitude to The Crown Prince, who has so kindly consented to place this Conference under his patronage. We are indeed highly honoured. I wish to thank all our Jordanian members for their splendid efforts to make this Conference a success. I wish the participants a most pleasant stay in this beautiful country, in the midst of excellent hosts whose hospitality seems to be without limits.

Thank you.



## **INAUGURATION'S SPEECH BY DR.(MRS.) R. KHALAF Minister of Trade and Industry, Jordan**

Distinguished Participants, Ladies and Gentlemen,

It gives me great pleasure to inaugurate this International Fertilizer Association Technical Conference, which I regard as a significant activity in the continuing efforts to develop the world's fertilizer industry.

I am gratified by the presence of such a distinguished group of experts and scientists from all over the world, representing a broad spectrum of national, regional and international organizations.

Your individual contribution to the technological development and support to this industry is universally recognized.

The topics to be addressed in this Conference will surely have a great impact on the advancement of the fertilizer industry, and the resolution of its technical, environmental and related ecological problems.

Distinguished Participants, Ladies and Gentlemen,

We all know that the present situation of fertilizer business is not as healthy as it might be. Depressed market conditions, uncertainties in the short and medium terms and non-resilient competition have characterized this field of industry for several years.

The prime reasons such as cyclical swings, structural mutations and legislative constraints are certainly well known to you all.

In fact, during the past decade or so, this industry has been seriously affected by tremendous political, economic and social changes which took place in many parts of the world, resulting in a significant decline in fertilizer application, and consequently in their production and trade.

Jordan, as with most other producers and exporters of fertilizer commodities has suffered from these circumstances. The Gulf War and the embargo imposed on Iraq added more difficulties to Jordan's economy, and in particular to its fertilizer industry.

There are reasons to believe however, that this gloomy situation for the fertilizer industry and trade will not last much longer.

The world population growth, especially in developing countries, is expected to result in a tremendous expansion in fertilizer application in order to meet the necessary increase in food requirements. This line of thinking is further strengthened by the fact that the ongoing research and development in the field of genetic engineering and microbiology with respect to food production is not expected to radically change the traditional methods of food production for at least the coming three decades, in spite of the marvellous results achieved so far.

The dramatic growth in world population, which is predicted to reach 8.5 billion by year 2030, or double the present number will have a significant impact of the food supply situation and this will be further aggravated by other immense obstacles confronting agriculture.

Severe drought, soil erosion, transformation into deserts of large areas in Asia, Africa and other parts of the world, in addition to the continuing abuse of available natural resources such as forests, arable land, surface and underground waters, are examples of such obstacles to agricultural programmes.

Whilst, experts on one hand are talking about overfertilization in some parts of the world with resulting surplus food production, other parts of the world are suffering from underfertilization and consequent food shortage.

How can the world overcome such obstacles without a complete review of strategies, policies, and long term plans for development in all respects?

How can one address these gigantic issues without a complete commitment from national, regional and international organizations, governmental and non-governmental?

The role of fertilizer industry and its contribution to such challenges is evident.

Jordan with its large reserves of rock phosphate and potassium salts, is well qualified to play a key-role in securing the world's need for fertilizer materials.

Jordan has during the past decade or more developed its fertilizers industry on a solid foundation, providing a firm basis for future development.

In spite of the difficulties encountered during the time of tension and conflicts in the region, more than 1.4 billion US Dollars have been allocated to fertilizer projects over the past 14 years. This is a significant investment in anyone's language.

At the present time, Jordan is one of the world's major producers and exporters of rock phosphate and potash and is planning to increase its capacities for both raw materials and fertilizer products in order to meet the world's future needs.

With respect to the finished fertilizer products, Jordan has developed a strategy involving joint-venture partners in its projects with the production destined for export to the markets of such partners.

Today, projects with India, Japan and Pakistan are in the course of implementation.

The present political situation in the area will surely open up prospects for regional co-operation in terms of joint development of natural resources. We believe that industrial projects for fertilizer manufacturing, among others, will be given serious consideration in the future.

It is for these reasons that the topics to be addressed by this Conference are of paramount importance to Jordan and certainly to other fertilizer producing countries.

The exchange of "know-how" and knowledge in technical, environmental and sustainable development aspects will surely enrich our experience in these fields.

Finally, I welcome you all again and wish your Conference every success and hope that our guests will have a pleasant and fruit stay in Jordan.

Thank you, Ladies and Gentlemen.



## **PLENARY SESSION: "GENERAL I"**

**Chairman:** C.R. Gibson, Firstmiss Fertilizer Inc., USA  
**Rapporteurs:** J. Jolly, Freeport McMoRan Inc., USA  
M.M. Handley, IMC Fertilizer Group, Inc., USA

**PAPER 1** Current situation and prospects for fertilizer industry in Jordan  
A.D. Ghosheh, JPMC and J. Salem, APC, Jordan

No question and comment.

**PAPER 2** Towards a world CO<sub>2</sub> tax?  
F. Laroui and J.W. Velthuisen, SEO, Foundation for Economic Research,  
Netherlands

**Q - L.K. Rasmussen, Kemira Oy, Finland**

*How many countries have introduced the tax today and what is the level of the tax?*

**Ans:** The answer is, to my knowledge, two countries who have introduced a series of CO<sub>2</sub> tax, the Netherlands and Denmark. In the Netherlands, the tax is approximately 15 cents per litre of crude oil. In the petrol price at the gas filling station, you will notice a 10% increase in the price due to this energy tax. Households in the Netherlands and in Denmark have an energy tax of 2 or 3%.

**Q - K.G. Soh, IFA**

*a. What is the amount of CO<sub>2</sub>, in gigatons, that is produced annually? What % of that amount is fixed/immobilized - by forest/agriculture and the sea? Amount carried forward or unfixed?*

**Ans:** a. I do not know the exact figures for the amount of CO<sub>2</sub> produced per year.

The next part of the question is what % of the CO<sub>2</sub> is fixed. Well, I know the difference between what is produced on earth and what is assimilated again on earth is a about one half a percent per year. However, I do not know the exact amounts of CO<sub>2</sub> fixed by forest and sea.

**Q - b. Is there any study on the net balance of energy in terms of fertilizer usage, i.e. energy used for fertilizer production and the positive or improved CO<sub>2</sub> fixation as a result of fertilizer application?**

**Ans:** b. That is a very interesting question, but I'm sorry I do not know the answer.

**Q - B. Christensen, Kemira Denmark, Denmark**

*CO<sub>2</sub> tax may change a little on the global CO<sub>2</sub> problem. But since energy is an essential part in the human life, further steps must be taken. Don't you believe that added focus for increased use of:*

- nuclear power
- bio fuel
- solar energy

*will be necessary in order not to prolong the CO<sub>2</sub> problem, but to make step changes in CO<sub>2</sub> reduction?*

**Ans:** Well, I totally agree. But nuclear energy is another issue. If you say the words nuclear energy, then all of a sudden all of the environmental economists say that nuclear is even worse than burning fossil fuels. About the other renewable energy resources, we in the Netherlands produce a lot of natural gas. I know that this natural gas is very cheap and as long as these fossil fuels are very cheap, people will keep on using them. Natural gas is cheap in the Netherlands but expensive on the world market. But even at the world market price, natural gas is much cheaper than solar energy or wind energy. There are a lot of studies going on to improve the energy efficiency of solar and wind energy production and their cost effectiveness. However, at this stage, these energy sources are much more expensive than petrol and as long as that is the case, the implementation of renewable energy resources will not be stimulated.

**Comments from Mr. L. Pritchard, Kemira Ince Ltd., United Kingdom**

*As well as controlling CO<sub>2</sub> emissions is there a case for sponsoring/encouraging the use of fertilizers in areas of deforestation caused by farming?*

*Firstly: Fertilizer industries are very energy intensive, and would therefore pay heavily, in case there is a tax on purchased energy. But the idea is to tax burnt fuel, and in your industry much of the energy is not burnt. So that is good.*

*Secondly: (But here my chemical/biological knowledge is too limited). Agricultural (stimulated by cheaper fertilizers) has a much smaller assimilative capacity of CO<sub>2</sub> than rain forests, so this substitution of forests for farming is not in itself a way to seriously reduce net CO<sub>2</sub> production. So my answer would be no. But I would be glad to discuss this further with you.*

**PAPER 3 EFMA Task Force on best available techniques for pollution prevention and control in the fertilizer industry**  
T.K. Jenssen, Norsk Hydro a.s., Norway

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

*The draft directive (IPPC directive I) will require older industries to clean up and comply with pollution reduction measures by 2005. Whilst I believe this is a good direction for the industry and many will already be taking steps to reduce emissions, has the cost impact on the older industries been determined and what effect is it expected to have on their business? What will happen if industries cannot comply?*

**Ans:** This has been a dilemma for the Task Force; what are the emission limits that the Task Force should propose. We've had a couple of rounds with all of the members to get feedback on the emission levels that the Task Force has proposed. We have not done a direct survey of the cost aspects that this will imply. We believe that each company has made its own cost analysis of what these measures will cost the company.

What will happen to the industries not complying; well, what do you think? I think there is only one thing for the industry to do and that is to document the reasons why one cannot comply. If the cost, as we said, are too high, or if the local environment cannot take that pollution, then it is possible to get it approved. So we have to be very open in our efforts with dealing with the authorities and dealing with the local public. So openness is the name of the game in the future.

**Q - N. Louizos, Moretco (Drapetsona Fertilizers), Greece**

- a. Does the author know any similar work on BAT techniques exist in the USA, and do you expect co-operation between Europe and USA in that field?*
- b. Is there any idea for the cost of applying BAT?*

**Ans:** a. I don't know of any such Task Force or any work in this context that has produced the same guidelines as the EFMA is trying to produce. There have been some initiatives through UNIDO and the World Bank to issue some guidelines but these guidelines are brief and more general than what are now being produced by EFMA.

b. There will, of course, be cost aspect. However, we have found that effective environmental management goes hand-in-hand with cost effective production. I'm not willing to accept that there is a cost for environmental matters. I think it is more and more understood that there is an integrated approach in production aspects. So you will optimize your production as well as optimize on your environmental emissions.

**Q - J.A. Benes, Uhde GmbH, Germany**

*When "available" means "reasonably accessible to the operator", why do major fertilizer companies, including Norsk Hydro and BASF, patent environmental techniques - sometimes re-inventing the wheel - and thus make such techniques less accessible?*

**Ans:** I would say that in the EFMA Task Force we have tried to cover a number of technologies without specifying individual available technologies. So whether BASF or Norsk Hydro has special technologies does not concern the Task Force. The BAT Task Force does not promote any specific technology. We are trying to focus on what is achievable throughout the European fertilizer industry. We have taken the give and take approach to get the whole process harmonized. I believe we will stand stronger if we stand together. Therefore, we have to harmonize. That is not to say that further developments are needed. Further technology developments have to take place in certain areas to satisfy the local environmental constraint; some local environments need better technologies.

**PAPER 4** Sulphur granulation with Kaltenbach-Thüring fluid drum granulation (FDG) process  
M. Besson, Kaltenbach-Thüring S.A., France

No question and comment.

**PAPER 5** New products and technologies for the sulphuric acid industry  
A. Vavere, N. Bhambri, J.R. Horne and L.S. Houille, Monsanto Enviro-Chem Systems Inc., USA

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd, Australia**

*What is the life of the Caesium promoted catalysts compared to conventional alkali-vanadium catalyst and how does the cost of the catalyst compare?*

**Ans:** Depends on exposure conditions. Normally 5-7 years, the same as conventional catalyst. Caesium cost is double the conventional cost.

**Q - Does Monsanto take back spent catalyst (vanadium catalyst) for reprocessing and if not, how can it be encouraged to do so?**

**Ans:** We assist customers with spent disposal by identifying vanadium reclaimers in Europe and the U.S.

**Q - Is the PeGASyS approved by the US EPA for measuring source emissions? What is the cost and availability of these limits? Is it possible to measure SO<sub>3</sub> with them?**

**Ans:** PeGASyS has not been evaluated for EPA approval; preference is not to be involved in government testing. We can measure SO<sub>3</sub> in a semi-quant manner. The PeGASyS service fees and availability can be obtained by contacting Monsanto Enviro-Chem.

**Q - G. du Plessis, Indian Ocean Fertilizer (Pty) Ltd., South Africa**

*A number of failures of drying tower (98% H<sub>2</sub>SO<sub>4</sub>) mist eliminators made from SX were reported:*

- *What are the cause of these failures?*
- *What steps are required to minimize the risk of such failures?*

**Ans:** I'm not exactly sure which mist eliminators you're referring to. Are you sure there were SX cages in this particular case?

*Mr. G. du Plessis: At our plant, Indian Ocean Fertilizer had such a failure of an SX eliminator in the drying tower of the H<sub>2</sub>SO<sub>4</sub> plant and I've read some articles indicating similar failures in other plants.*

**Ans:** I'm not familiar with that particular case. Is this a 93 or 98 tower?

*Mr. G. du Plessis: 98 tower.*

**Ans:** I can't imagine why SX would fail in a 98 system. Without knowing more about that particular set-up, I can't answer that question. I don't have an answer for you. I have not heard of this one before and I haven't seen any of the cases where we've had a failure, especially in the 98 acid. Everything that we've seen indicates corrosion rates of less than one tenth of per mil, per year. Is this the case where the cages completely fall apart? I'd be more than happy to take to you about this, get some details and look into it but I can't answer why they failed, if they did.

Would there any possibility that in that particular tower you'd be going to an oleum range? Because we've known of some instances where if you get into supersaturated H<sub>2</sub>SO<sub>4</sub>, it has a deleterious effect on some of the silicon steels. The steel do not perform well in the oleum service. I don't know under what circumstances you'd be generating oleum, but that is one possibility.

**Q - R. Bollat, Chas. S. Lewis & Co., Inc., USA**

*Can you go to oleum range in the tower?*

**Ans:** We are not sure that we understand this question. Would appreciate it if you could elaborate.

**Q - K. Abdul-Fattah, Indo-Jordan Chemicals Co. Ltd**

*1. What is the price difference between Cs catalyst and LP 110 & LP 120?*

*2. How does the Cs catalyst affect the following:*

- a. Less pressure build up*
- b. Reduce start up time*
- c. Increase catalyst screening cycle to more than 2 years.*

*3. Can you give a reference list of plants operating with Cs catalyst?*

**Ans:** 1. In relative terms, the Cs catalyst cost is probably 40-50% higher than the LP catalyst.

2. In the normal operating range, Cs and LP catalysts are very similar. Cs catalyst simply allows you to operate at a lower temperature. Somebody once asked me if we can put a lot less Cs catalyst if we change or replace catalyst? The answer to that is no. The pressure drop isn't going to be affected a whole lot.
3. We have a list. I can hand it out. As soon as we have our booth set up, we'll have literature on Cs catalyst for everybody.

**PAPER 6** The problems of engineering support of chemical production plants under operation  
I.M. Kisil, GIAP, Russia

No question and comment.

**PAPER 7** Integrated environmental protection design and successful implementation at Kemira Siilinjärvi site  
M. Autti, T. Karjalainen and M. Sipilä, Kemira Agro Oy, Finland

**Q - J.W. Velthuisen, SEO, Netherlands**

*Why are you performing so far below allowed levels? The cost must be - have been - enormous. In other words, what is the value of the avoided emissions to your firms?*

**Ans:** As I mentioned, these low emission figures have already been taken into account in the design phase. So it means we should not see any enormous cost due to our activities. The landfill for phosphogypsum is an extra cost for us, but it is insignificant compared to the production cost.

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

- *What is the purification system used to treat drainage and effluent waters to remove phosphorus?*
- *Can you give some details of the continuous HF monitor (gaseous emission monitoring)?*

**Ans:** In our scheme, we collect all the drainage water from the landfill of the gypsum. The collected water is then recirculated to the production. If and when there is a small excess of water because of rainfall, the excess is precipitated chemically.

We have an on-line analyzer and will be happy to provide additional details to the person who put this question.

**Q - A. Davister, Belgium**

*Why not use one of the lakes for disposal such as gypsum?*

**Ans:** All of the lakes are connected together and they form one single waterway system. It is, therefore, not easy to take one lake for this purpose. The point in the beginning was that because of the geography and because of the very solid rock in the soil, geographically this area is very old and very stable. So there are no cracks in the rock in the soil. It was possible to make a very good landfill for phosphogypsum and, because of the slope of the ground, it was very easy to collect all drain water by natural flow from the gypsum pile to pond area. That was the reason why this method was selected. And I must say we are happy that it does not include a single lake.



**PLENARY SESSION: "GENERAL II"**

**Chairman:** N. Hummadi, JPMC, Jordan

**Rapporteurs:** P. Becker, France

I.G. Hirst, Davy Process Technology, United Kingdom

**PAPER 8** Plant maintenance techniques

V.K. Khanna, Gujarat Narmada Valley Fertilizers Company Limited, India

**Q - A. van Brempt, Kemira Agro Benelux, Belgium**

1. You are using the Trevi test for testing safety valves in running plants, even for main boilers. Is the Trevi test recognized for legal inspection and certification by the Authorities?
2. After the implementation of your plant maintenance techniques, you have certainly recorded the progress made on lost time "for mechanical breakdown". Please could you report about the new progress, for example, on your production of:

- calcium ammonium nitrate
- ammonium nitrophosphates

**Ans:** 1. Yes, we are using the Trevi test for testing of safety valves in running plants for the main boilers. The Trevi test is recognized/approved by the Ministry of Industry, Government of India vide their letter N° 20(35)/88-Boilers dated August 24, 1990.

By use of Trevi test, we are avoiding steam losses to the tune of 30 t/h for 8 h. Boiler is not required to isolate, so we can cater full requirement of plants and there is no need for power import and fluctuations can be controlled (in our case, we are having our own power generation plant 25 MW - 2 Nos.)

2. We are implementing plant maintenance techniques in all plants including calcium ammonium nitrate and ammonium nitrophosphate. The improvement in actual production is as follows:

1. Ammonium nitrophosphate (ANP)\*

<u>Actual Production MT:</u>	<u>1990-91</u>	<u>1991-92</u>	<u>1992-1993</u>	<u>1993-94</u>
	21,036	123,654	141,491	132,974

\* Commissioned on 12.9.1990

2. Calcium ammonium nitrate (CAN)\*\*

<u>Actual Production MT:</u>				
	18,587	62,526	93,807	160,547

\*\* Commissioned on 2.8.1990

We do not have complete up-to-date record for the down time due to mechanical but the average down time in ANP plant in the last 2 years is around 330 h, and for the CAN plant, it is around 600 h.

**Notes:**

- (1) Due to change in the Government policy to give subsidy to these products, the priorities in production of ANP and CAN are changed. ANP was under subsidy till October 1993 and since then the CAN is under subsidy.
- (2) There have been serious problems of the stress corrosion cracking in both ANP and CAN plants leading to frequent stoppage of the plants and for last 1 1/2 year we are replacing all carbon steel ductings to stainless steel material. Presently, only 50% work is completed and the balance job will be completed by May 1995. Both ANP and CAN production will improve considerably once this problem is eliminated.

**PAPER 9** Modifying existing DAP/NPK fertilizer plants to comply with new environmental regulations  
 J.A. Benes and H. Franzrahe, Uhde GmbH, Germany

**Q - B. Christensen, Kemira Denmark, Denmark**

*Overall emission figures for modified DAP and NPK plants are not specifically mentioned in terms of kg/tonnes of product. Could you specify these figures for NH<sub>3</sub>, NO<sub>x</sub>, F and dust?*

**Ans:** The following data are preliminary and reflect a two weeks period of measurements supervised by Uhde specialist. In this period, no DAP was produced, but apart from a slightly increased load of fluorides, we expect no drastic changes.

For NP 20:20:0 and NPK 15:15:15, we calculated emissions as follows:

Ammonia (scrubber stack only)	50 grams/MT
Fluorides (scrubber stack only)	5 grams/MT
Dust (scrubber stack plus bag filters from cooler and general dedusting)	50 grams/MT

It must be stated that the bags of the bag filters were new. When they have been washed several times, dust emission may increased by 100 or 200 percent.

DAP will be produced only from the second half of March onward.

**Q - D.W. Leyshon, Jacobs International, Inc., USA**

*I would comment that most USA plants recognize the benefits of the prescrubber (dual mole) or 2 stage fume scrubber as it is variously known and fail to use it only because existing systems are adequate. We would dispute the statement that: "Some European designers have a better hand in designing scrubber systems". My question: Does Uhde offer detail design of scrubber equipment? Jacobs' experience is that USA scrubber vendors don't understand the interrelationship between the scrubbing system and the DAP, MAP or NPK process and further don't get feedback from operating company revamps. Jacobs provides detail scrubber equipment design as well as system design for most types of fertilizer plant scrubbers, including a line of variable throat venturi-cyclonic units which operate at minimum pressure drop.*

**Ans:** Mr. Leyshon's comments will be taken at face value without further comment from me. Uhde can design certain types of scrubbers associated with certain vendors. We have the impression that we have more knowledge about the conditions in scrubbers than they have and also have better feedback from our clients which they tend not to have. Working in this way, we tend to avoid the kind of problems that Mr. Leyshon refers to.

**PAPER 10** Life extension and modernization of an ammonia-urea complex  
S. Stalin, SPIC, India

No question and no comment.

**PAPER 11** ISO 9002 - Four years of certification  
D.C. Thompson, ICI Fertilizers, United Kingdom

No question and no comment.

**PAPER 12** The Tunisian chemical group and environment management  
M. Dekhil, SIAPE, Tunisia

**Q - P. Becker, France**

*1. Could you explain shortly what system was eventually chosen for phosphogypsum disposal in Tunisia?*

**Ans: 1.** After a comprehensive environmental assessment, we decided to select slurry pumping, up to 10, 15 or 20 km depending on the final storage area that will be selected. Sluice water after overflowing the settling pond will be recycled back to the plant. There will be soil protection by liners.

**Q - 2.** *How about evaporation and water balance?*

**Ans: 2.** There will be evaporation losses but we also envisaged closed cycle sea water transportation.

**Comments from Mr. P. Becker:**

*With water transportation, the final gypsum deposit will have to cope with phosphoric/hydrofluosilicic acid impregnation, with sea water, it will be phosphoric/hydrofluosilicic acid plus chlorides impregnation.*

**PAPER 13** Pusri's strategy to meet Indonesian environment standards  
Suardin, Suhardi Rachman, M.S. Zuber and A. Mochtar, PT Pupuk Sriwidjaja (Pusri), Indonesia

**Q - A. Ashour, Abu-Qir Fertilizers & Chemical Inc. Co., Egypt**

*1. Is there any white material (triurea) found in the second stage evaporators in urea plants and if yes, what can you do to avoid it?*

*2. Are you suffering from accumulation of urea on the scraper arms and if yes, what do you do to remove it mechanically or how do you reduce it?*

*The liquid effluent from the desorber in urea plants contains about 1% wt. urea and about 0.06% wt. ammonia. What steps do you take to recover these pollutants and thus minimize the effect on the environment and at the same time improve the cost of production? In our urea plant (1550 mt/d), we discharge 40 m<sup>3</sup>/hr waste water to the sewer with the above-mentioned quantities of urea and NH<sub>3</sub>.*

**Ans:** Please be informed that apparently Pusri' urea plant process is different to the Abu-Qir's plant.

During discussion with Mr. Ashour, after my presentation, it revealed that Abu-Qir's urea plant process is of Stamicarbon process where Pusri's plant process is Mitsui/Toyo process of Japan, which is quite different in the process features.

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

*In your table for environmental limits to water, do the concentration limits refer to instantaneous values or to an average concentration over a period of time?*

**Ans:** These values are over a period of 24 hours.

**Paper 14** Evolution in fertilizer regulations and standardization in the European Union  
F. Samec, Grande Paroisse S.A., France

**Q - A. van Brempt, Kemira Agro Benelux, Belgium**

*Subject: Standardization "Crushing strength measurement"*

*1. We are surprised to learn that no reliable method for crushing strength measurement could be defined!*

*2. Crushing strength is an important parameter on physical quality.*

*So we believe that the CEN working group should not give up the work on the standardization of the crushing strength measurement - Please, your reaction!*

**Ans:** If someone can come up with a good idea, then this could be considered. However, too much time has been spent (already on this subject) without reaching a sensible conclusion.

## **PARALLEL SESSION: "NITROGEN I"**

**Chairman:** L. Pritchard, Kemira Ince Limited, United Kingdom

**Rapporteurs:** J. Sinden, Fosfertil, Brazil

D.C. Thompson, ICI Fertilizers, United Kingdom

**PAPER 15** SAFCO's experience with fluidized bed urea granulation process  
A.M. Al-Shamrani and K. Juma, SAFCO, Saudi Arabia

**Q - V.M. Olevsky, GIAP, Russia**

1. *What is the price difference between prilled and granulated urea in your Dammam and Jubail plants?*
2. *What typical crushing strength do you obtain for prilled and granulated urea?*

**Ans:** 1. This information would be available from the marketing department.

2. The figure for the crushing strength of the granulated material is confidential at the present time. For prills the strength is around 2 kg.

**Q - A. Corchia, Snamprogetti SpA, Italy**

1. *Granular urea is a premium product - that means that a better price can be obtained as compared to prilled urea or simply that clients ask for granular urea only.*
2. *Volume of recycle tank?*

**Ans:** 1. No comment.

2. The recycle tank is 16 m<sup>3</sup> in volume.

**Q - A. Ashour, Abu-Qir Fertilizers & Chemicals Ind. Co., Egypt**

1. *During the washing of the granulating system which takes about 6 hours and may extend to 8 or 10 hours until adjusting the restart and loading, you decrease the load to 70% of the plant. Would it be better to add a stand-by granulator with the same feed bin to avoid losses during washing and maintenance?*
2. *To avoid caking in the start-up bin, you introduce a relatively colder urea (see item 17, in Table 3), to what limit is the temperature away from the crystallization temperature?*

**Ans:** 1. Because the operating team are now more familiar with the system, the time required for washing has been reduced from 6 to 3 hours. The washings are recovered, they are collected in the drains tank and recycled to the granulator. A second granulator would be too costly. It is better to reduce the plant rate (to 60/70%) while washing. During discussion an example was quoted where a plant retained the ability to produce prills even after a granulator was installed.

2. This is not a problem in Europe; in hotter countries (Malaysia, Saudi Arabia) discussions are being held with the licensor to reduce the temperature to 30 or 40 degrees.

**Q - Suhardi Rachman, PT Pupuk Sriwidjaja, Indonesia**

*Have you experience of producing large scale/forestry grade supergranules? If so, what is the performance of the plant in term of efficiency, dust formation and emission?*

**Ans:** This grade has not been made; the plant is capable of making it by changing the screen meshes.

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

*1. What type of wet scrubber is used on the granulator air?*

*2. Have you tried to remove the ammonia from the exhaust gas in the granulator air? Do you consider an emission of 1050 kg of ammonia per day to be BAT?*

**Ans:** 1. The scrubber is a normal venturi equipped with a demister.

2. An attempt has been made to reduce the ammonia and urea dust levels by reducing the temperature of the urea melt to 130°, a temperature indicator has been provided. This avoids biuret formation in the line. The vacuum has also been increased slightly.

To reduce dust, the quantity of air has been reduced from 185 to 175.

**Q - J.A. Benes, Uhde GmbH, Germany**

*1. Where do the ammonia losses come from:*

- a. the urea-synthesiser*
- b. the granulation plant by decomposition of urea?*

*2. Are you aware of differences in ammonia content in the urea melt between the Stamicarbon and Snamprogetti urea synthesis processes?*

**Ans:** 1. The ammonia losses come from synthesis and from the melt line which transfers the urea from synthesis to granulation. The steam temperature in the jacket has been reduced to give the 130° discussed above.

2. The author has only seen small differences. Mr. Benes commented that he had seen differences when he was evaluating synthesis units to feed an NSM granulation unit in Trinidad.

**PAPER 16** Ammonia plant reformed gas waste heat boiler leak and its effect on high temperature shift converter catalyst  
P. Ravichandran and O. Al-Mulhem, SAFCO, Saudi Arabia

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

*You ran the plant for two months with the leak. There is always pressure from our commercial colleagues to carry on running. If you have a further leak of this nature, would you have continued operation for two months (or longer) or tried to persuade your commercial colleagues that the leak was sufficiently serious to justify an earlier shutdown.*

**Ans:** This depends upon the situation. We had to plan all the maintenance activities for the shutdown, we also had to consider the life of the HT shift catalyst and the life of the downstream catalysts. The final decision would depend upon the location and the particular plant. We stopped the plant immediately, we found the first leak, but not the second time, so there is no single solution.

The technical staff were pressing for an earlier shutdown because the catalyst may be damaged completely. In the end, the technical staff proposed that only part of the catalyst be replaced.

Because of urgent commercial needs for both ammonia and urea, it was decided to run with the leak to the end of the year.

The Chairman commented that his ammonia plant was very similar in design, a waste heat boiler had been replaced. The good news is that "annual" shutdowns are now performed every 4 years.

**PAPER 17** A new way to produce urea-superphosphate fertilizers: the AZF USP process  
L. Limousin, B. Neveu and J.B. Peudpièce, Grande Paroisse S.A., P. Achard and Y. Schwob, Ecole des Mines de Paris, France

**Q - M. Sipilä, Kemira Oy, Finland**

*Do you think that this USP method is feasible with nitrate containing fertilizers for example in bulk blends?*

**Ans:** We have no experience with this.

**Q - O. Al-Mulhem, SAFCO, Saudi Arabia**

*What kind of anticaking agent are you using and how much is the cost involved?*

**Ans:** The anticaking agent is the same as we use on the NPK Plant, it is a traditional amine/clay together with oil. Because we have not any caking problems with the product, this point has not been investigated in detail.

**Q - P. Christensen, Kemira Denmark AS, Denmark**

*What is the level of corrosion in the plant for USP-production compared to normal SSP-production - the rubber-lining is of special interest?*

**Ans:** The interior of the den drum is rubber lined following our experience with SSP. The rubber both protects the carbon steel drum from corrosion and it also reduced build up.

**Q - N. Louzos, Moretco (Drapetsona Fertilizers), Greece**

*1. Could you please comment on the materials of construction especially regarding the mixing tank, agitator and cooling/heating coil of the preparation of the reagent?*

*2. What is the final concentration of the reagent in terms of sulphuric acid?*

*3. Is it necessary to allow powder USP to mature in the storage house before feeding it to granulation as it is the practice for SSP? (curing process).*

**Ans:** 1. Because the temperature is controlled to 70°C, as a maximum, stainless steel grade 316L can be used throughout the process.

2. The molar ratio is 3.6:1.1.

3. Yes, it is necessary to mature but further trials are been carried out.

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

1. Have GP/School of Mines looked at coatings on granular USP to minimize the effect of moisture absorption above the critical relative humidity?

2. Which phosphate rocks have been tested so far?

3. Will the reagent preparation tolerate high strength fluosilicic acid scrubbing liquor recycle and is there any fluorine re-evolved in this operation?

**Ans:** 1. We coat the product to prevent caking. We have not specifically investigated how to reduce moisture adsorption.

2. Several rocks including Morocco, Syria, China and Israel have been tested to date.

3. In the laboratory we have tested 15% fluosilicic acid recycle and there is no fluorine emission to the stack. We have not yet no fluorine emission to the stack. We have not yet measured fluorine in the recycle material.

**Q - J.A. Benes, Uhde GmbH, Germany**

1. Can USP - powder be granulated immediately after its production or is it necessary to cure the powder before granulation?

2. How does the evolution of fluor - compounds in the production of powdered and granular USP compared with that in the production of SSP?

**Ans:** 1. Our experience indicates that we prefer to store the powder for 2-5 days; we do not yet have complete data on phosphate solubility, this is one parameter which needs to be obtained.

2. The easiest way to compare this is to compare the amount of scrubbing equipment that is needed, for USP only a single stage is required.

**Q - L.K. Rasmussen, Kemira Oy, Finland**

1. What is the pH of the 20-10-0?

2. Is a similar reaction possible with  $H_3PO_4$  or mixtures of  $H_3PO_4/H_2SO_4$ ?

3. You indicate that 15 kg/t  $NH_3$  is added during the granulation of the USP. The content of ammoniacal N = 1.6%. If 1.2% comes from the  $NH_3$  added, can one then conclude that the difference = 0.4% N originates from hydrolyzed urea?

4. Do you have any reference plants?



- Ans:** 1. The powder has a pH of 2.5 to 2.8, the granular material is 4.8. NPK has a pH of 5.0.
2. Priority has been given to  $H_2SO_4$  in the present programme.
3. This comment is correct.
4. This is a new process, we only have the plant at Bordeaux.

**Q - J. Sinden, Fosfertil, Brazil**

1. *Has any work been done on the 1.8:1.1 mole ratio product? What analyses does it produce?*
2. *Does the process work with igneous phosphate rocks?*

- Ans:** 1. Most work to date has been performed on 3.6:1.1 because it produces a better quality product. Work on 1.8:1.1 may proceed later.
2. We have not yet tested igneous rocks as the attack is more difficult than with sedimentary materials.

**Q - R. Perander, Kemira Oy, Finland**

1. *Where do you see the markets for this product?*
2. *Which is the stage of commercialization of the process and the product?*

- Ans:** 1. This is a question for the agronomists and marketing, not the technical staff. There is not a large market for urea in Europe.
2. No comment.

**PAPER 18** Effective maintenance techniques for higher productivity at IFFCO's Kandla unit  
T.S. Bhinder, IFFCO, India

No question and no comment.

**PAPER 19** A new conception of an ammonia production unit with a low energy consumption  
S.P. Sergeev, E.A. Novikov and I.M. Kisil, GIAP, Russia

**Rapporteurs Comment:** *Two questions were asked:*

**Q - L. Pritchard, Kemira, Ince, United Kingdom**

1. *I am interested in the tubular reactor. Am I right in saying that it is the same design that is described in the Tandem concept at the 1991 Moscow Conference as operating since 1988 on a plant of 1500 te/day ammonia. Do you have any useful experiences from this plant in metallurgical or heat transfer terms.*

- Ans:** 1. This reactor is the same as you mentioned. From 1988 no fundamental work has been required. The reactor is still in operation, everything is alright, no metallurgical problems. One tube was removed for inspection, no metal dusting was found; the tube was completely clean and suitable for further use.

We have prepared several further schemes, but none have been installed.

**Q - 2.** *In your new concept, what do you see as being the design limitation in terms of capacity.*

**Ans: 2.** Our future concept is for 1550 te/day ammonia and 1000 methanol.

**Q - J. Hashmi, SAFCO, Saudi Arabia**

*In one of the answers, it was mentioned that reformer tube sample was cut to inspect against "metal dusting".*

**1.** *What materials are used in the plant and was any inspection done in downstream waste heat recovery areas?*

**2.** *What causes "metal dusting" and is it related to low energy plants?*

**Ans: 1.** We have used the steel of kind 20X23H18 (*in Russian terms*) for the reformer tubes. The composition of such kind of steel is: C - 0.2%, Cr - 23%, Ni - 18%, Fe - balance. The sample of tube was cut from tube part where the waste gas temperature is equal 1000-1040°C.

**2.** We did not find any symptom of "metal dusting". The low energy plant reformer will be operating at more soft condition than the demonstration reactor at Grodno's ammonia plant. Thus, the metal dusting problem will not take place in the low energy plant.

**PAPER 20** Prospective methods of production of slow-release capsulated fertilizers with regulable nutrient release  
V.M. Olevsky and M.K. Rustambekov, GIAP, A.L. Taran, Agrotekhnologiya, Russia

**Rapporteur Comment:**

**Q - P. Deigner, BASF, Germany**

*What is the ratio between the coating and the nutrient (by weight)?*

**Ans:** This is typically 3-4%, but differs for different encapsulants.

**Q -** *What is the normal leaching time for total release of the nutrient from the capsule?*

**Ans:** This depends upon how you measure the speed of dissolution in the soil, the soil is very different between (for example) Jordan and Germany. The speed of dissolution into water is also very different.

For comparative tests you must use the same conditions of temperature, humidity, etc. This can give useful comparative data.

In field conditions the usual encapsulated fertilizer will release in 1-3, perhaps 4 months. A sample of potassium nitrate was made which, as required by the client, did not dissolve in 4 months.

**Q -** *Am I right in thinking that the average cost of this product is 20% higher than the normal product?*

**Ans:** Yes, you have the correct figure.

**Q - What happens to the coating material which is left in the soil?**

**Ans:** This is normally destroyed by microbial action, nothing is left after 1 year.

**Q - O.S. Eanadeen, National Chemical Fertilizers Co., Saudi Arabia**

*What is the difference, if any, if the encapsulating material is sulphur, in the speed of nutrient release into soil?*

**Ans:** Sulphur would only be used if it were needed by the soil. The speed of release can be controlled by altering the thickness of the encapsulating layer to give the required release rate. Sulphur requires up to 20%, a much thicker layer than for polyethylene wax (2-6%) for a prolonged period of dissolution. Sulphur is not generally economic. If sulphur is very cheap (locally) then a separate calculation must be performed. The accumulation of sulphur in the soil must also be considered, especially if 2 or 3 crops are grown in each year.

**Q - R. Perander, Kemira Oy, Finland**

*1. Do you have any field test results with field crops (cereals)?*

*2. How much are the shown half dissolution times influenced by different weather conditions (dry, rainy)?*

**Ans:** 1. The results which are listed in Table 6 were obtained by our collaborators in agricultural scientific institutes in the Ukraine. They have performed tests on their experimental plots for many, many fertilizers and different conditions. When they give us results it is very important that we can compare results with conventional fertilizers.

2. The shown half dissolution times in water cell are about 10 times less than in a wet soil and may be up to 30-80 times less than in a dry soil depending on the meeting conditions.

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

*1. What is the nature of the "control" column in Tables 5 and 6? Is the control zero fertilizer?*

*2. Was the "usual urea" applied as a single dressing or split into multiple applications?*

*3. What is the strength of the coated layer with respect to abrasion in mechanical handling equipment?*

**Ans:** 1. In this case zero fertilizer was used, the nature of the control is determined by the agronomic experts.

2. A single dressing was used.

3. This also depends upon the encapsulant. Sulphur coating is worse than polyethylene wax. The nature of the storage and handling must also be considered - is the fertilizer sent directly to the field or does it encounter severe conditions such as bulk blending.

**Q - A. Ashour, Abu-Qir Fertilizers and Chemical Ind. Co., Egypt**

*The paper describes the encapsulation of granules, is it possible to use fine powder instead of urea granules in these capsules? What encapsulant would be used?*

**Ans:** Encapsulation is too complicated and expensive to simply avoid the formation of dust. Scrubbing and filtration are better routes.

It would be too expensive to encapsulate small prills.

The choice of encapsulant depends upon the raw material price and availability at your particular location. Polyethylene wax plus a hydrophobic agent (applied as a melt not a solution) is often the best encapsulant.

**PAPER 21** Simulation of ammonia synthesis loop  
P. Umasankar and K. Vasudeva, Indian Institute of Technology, S. Nand, FAI, India

No question and no comment.

**PAPER 22** Co-production of methanol in ammonia plants  
H. Holm-Larsen, Haldor Topsoe A/S, Denmark

**Q - Suhardi Rachman, PT Pupuk Sriwidjaja, Indonesia**

*Does the syngas leaving methanolation affect the synthesis section of the ammonia plant? As we know, the gas leaving methanolation may still contain small amount of CO and CO<sub>2</sub> or even methanol. Does this have an adverse effect on the ammonia converter catalyst?*

**Ans:** Because the methanator operates at a higher pressure than you see even less CO and CO<sub>2</sub> than you would see at lower pressure. One of the slides in the written paper shows the effect of not compensating for the hydrogen consumption in methanol. The hydrogen:nitrogen ratio will drop from 3 to 2.5 or less. This will give a large amount of inert nitrogen in the synthesis loop. We have realised that going from about 1% of methane to 2% in the synthesis gas gives you less inerts, and that this is the better option. You also have to realise that when you go from 100 to 70% ammonia, then you have spare capacity in your synthesis loop to cope with extra inerts.

**Q - A. More, British Sulphur Publishing, United Kingdom**

*In comparison with the Egyptian coproduction plant, the carbon conversion for the Terra plant (93% vs. 99%) seems very low. Why is that?*

**Ans:** The Egyptian plant is of a high pressure design. It was built in 1967 with an interstage pressure of 200 atmosphere.

**Q - E.A. Novikov, GIAP, Russia**

*How much energy is needed for 1 tonne methanol production in your coproduction process?*

**Ans:** The energy consumption in an ammonia plant is usually given by the efficiency of the reformer. Since we do not touch the reformer, then the efficiency of methanol is usually lower (perhaps 95%) than for the ammonia. The reason that this is lower is because you do not have to compress the extra gas.

**Q - B.M. Blythe, Jacobs International Inc., USA**

*1. The gas feed to the methanator contains di-methyl ether and other light hydrocarbons, do those affect the ammonia loop?*

**2. Amines formed with high nitrogen contents in the methanol loop give methanol a fishy smell. This does not affect federal specifications, but makes the product difficult to sell. How is it handled?**

- Ans:**
1. It is correct that these are formed, but they are completely destroyed in the methanator. This has been confirmed by actual measurements. (Note that this is the new methanator which replaced the existing methanator).
  2. We have had one incident in the Egyptian plant where the methanol had a fishy smell. This was a one-off and has not been found in the Terra plant. In order to produce methylamines you have to have ammonia in the synthesis gas. This is not likely on a normal plant and methylamines are removed in the distillation column.

**Q - V.M. Olevsky, GIAP, Russia**

*You give a value of UK  $15.5 \times 10^6$  Dollars for the conversion at Terra, what did this include?*

- Ans:** This figure includes all costs which are external to Terra, i.e. equipment, piping, erection. Terra supplied purchasing and project management, this would add perhaps  $2 \times 10^6$  Dollars to the cost for the 400 te/day plant.

## **PARALLEL SESSION : "POTASH"**

**Chairman:** N. Sadoun, Arab Potash Company, Jordan  
**Rapporteurs:** S.A. Amarnah, Arab Potash Company, Jordan  
 S.A. Rahim, Arab Potash Company, Jordan

**PAPER 23** Salt mushrooms in the Arab Potash Company's solar evaporation system  
 R. Soub, Arab Potash Company, Jordan

**Q - G. Derwish, Jordan University, Jordan**

1. *Did you observe any seasonal variation in mushroom formation? If so, was it dependent on temperature changes?*
2. *Since the mixing model proposed by the author is expected to be highly sensitive to temperature, it would be interesting to study the temperature effect?*
3. *Have any measurements of temperature been carried out of the Artesian and pond brine and water at the locations where possible growth of mushroom is anticipated?*

- Ans:**
1. Seasonal variations were observed as in winter the precipitation of salt occurs due to cooling of the brine. In addition, the brine depth affects the mushroom formation because if the mushroom position is deep in the brine then it cannot reach the supersaturation state and hence will not have the circular shape. This was concluded after draining N°2 precamallite pan (PC2) as some mushrooms were found but did not grow since they were below the supersaturation zone.
  2. Yes, that is correct - another model will be made in the lab to study many variations such as temperature effect and brine depth effect, etc. after that, an outside model would be constructed to carry out further testing.
  3. Many samples were taken from borehole # 2 (BH2) in the period 1991-1994 and there is variation of temperature because the water underneath the pond is surface water collected from the Wadys adjacent to the solar evaporation system. In winter, the brine temperature drops and in summer it rises so the difference between the salt pond brine temperature and the artesian brine temperature increases causing more precipitation of NaCl and hence mushroom growth.

**PAPER 24** The Werra production center of the newly formed Kali und Salz GmbH - complex raw ore and diversified product lines  
 D. Kunze and I. Stahl, Kali und Salz GmbH, Germany

No question and comment.

**PAPER 25** Potash beneficiation "from hot to cold crystallization"  
 J. Amira and M. Saket, Arab Potash Company, Jordan

**Q - P. Castro, Ministry of Commerce and Industry, Oman**

1. *Who designed the cold crystallization plant? Who developed the process and who owns it?*

2. *Maximum, minimum and average brine temperatures half way through the salt ponds?*
3. *Percent sulfate of the brine at the inlet and outlet of the salt ponds?*
4. *Are plastic membranes used anywhere in the pond system and if so, of which material and thickness?*

**Ans:** 1. The Arab Potash Company has gained good experience in potash industry over the years. All design data and testing needed for cold crystallization were carried out by APC. The data collected along with the experience of operation since 1982 until 1990 regarding the carnallite characteristics with high and low NaCl content in fine fraction, crystal growth, etc. were tested on small scale in the laboratory and all the results were given to MDPA & Wellman to be used for pilot plant design. MDPA and Wellman used to come for consultation from time to time but APC operated the pilot plant and also APC owns the process.

Questions 2 & 3 were answered in the content of Paper 23.

4. Yes. In 1980, during construction of the solar pan system. Membranes made of 2 mm polyethylene sheets were installed 12 m deep along Dike One between the salt pan and truce channel. Special cutters were used to cut the salt layers.

**PAPER 26** New modification of potash fertilizer drying in fluidized bed (FB)  
 Yu.Ya. Kaganovich, Niigiprochim and M.M. Vavara, Byeloruskali, Russia  
*(for circulation only)*

**Q - B. Christensen, Kemira Denmark, Denmark**

*You are indicating the possibility for drying  $MgSO_4 \cdot 7H_2O$  (Epsom Salt) which is known to be very heat sensitive.*

*Can you give a description of the process condition for drying of this salt?*

**Ans:** The technology is suitable for processing the initial material in the form of a solution of any concentration or crystal hydrate  $MgSO_4 \cdot 7H_2O$ . In both cases, dehydration process is steady, without thermal decomposition and results in granulated  $MgSO_4 \cdot H_2O$  production.

Temperature of gases fed into the apparatus can reach 650 to 700°C, temperature of fluidized bed is 120 to 130° and this ensures monohydrate formation. Specific consumption of air is about 6000 Nm<sup>3</sup> per m<sup>2</sup> of grid per hour. At such operating conditions, the specific capacity can amount to 2000-3000 kg of evaporated water per 1 m<sup>2</sup> of grid.

The most suitable equipment for dehydration is the FB apparatus developed by AO NIIGYPROKHIM which is equipped with fan-shaped slot grids.

Some difficulties connected with thermal sensitivity of the material arose during dehydration of magnesium sulphate compounds as the result of its thermal hydrolysis.

AO NIIGYPROKHIM has developed a double-state dehydration process with the second state to be carried in fluidized bed of inert material, thus achieving reduction in thermal hydrolysis.

**PAPER 27** Automation of the mining process in Saskatchewan potash mines  
G.W. Moore, S.J. Fortney and J.L. Lewis, Potash Corporation of Saskatchewan Inc., Canada

No question and comment.

**PAPER 28** The use of Jameson cell flotation technology at Cleveland Potash  
M.J. Burns, G. Coates and L. Barnard, Cleveland Potash Limited, United Kingdom

**Q - B. Christensen, Kemira Denmark, Denmark**

*Have you considered using Jameson cells for phosphate or another material? Is patent?*

**Ans:** MTM supplied the Jameson cell to Cleveland Potash. MTM is owned by MI Holdings Ltd. (Sister Company). The idea was to advance the Jameson cell through industrial minerals market, tested the cell with fluor (Spar) and potash successfully and looking for testing on phosphates. The Jameson cell has only been working with Cleveland for one month. It is patent and the cell has replaced the 16 traditional cells (working admirably on the slime circuit).

**Q - J. Amira, Arab Potash Company, Jordan**

1. *With Jameson cell, do you still need conditioning tank?*
2. *What % of solid is in the slurry feeding the new cell?*

**Ans:** 1. The old slime circuit needed two conditioning tanks with two impellers and two outers, but with Jameson cell conditioning is minimal so there is no need for specialized equipment to condition the reagent just add the reagents into a normal pump box and this suffices to give the grade and recovery and yet the additional revenue seen on the balance sheet.

2. The density 10% solids by weight never really fluctuates. A problem may occur when the cell is moved to the standard circuit where the feed is 20-25% solids by weight then this feed has to be diluted by brine. Few problems and few variables have to be overcome when moving from the slime circuit to the standard circuit where the biggest amount of revenue is probably to be realized. This revenue can be reviewed later on the standard circuit. Planning to convert 75% of the present flotation circuit to use Jameson cell and the rest will remain using traditional agitated cells. An MIBC frother have to be added and that is one of the critical parameters of the Jameson cell itself. It actually needs a very closely controlled dosage of frother. The addition expense incurred by the frother was offset by the maintenance savings and electrical savings of using the Jameson cell.

**Q - N. Sadoun/S. Abdulrahim/S. Amarneh, Arab Potash Company, Jordan**

1. *Is there any special lining for Jameson cells?*
2. *Is the flotation introduced to the manifold?*
3. *Any difficulties in mode of control?*
4. *Is there any possibilities of visiting the site in order to look at the cell?*
5. *How does the geographical and shape of the vessel affect the design?*



- Ans:**
1. Rubber lining is used with the cell. The actual downcomer pipes are made of HDP plastics. The main ware is confined to the nozzle head. The slurry directly hits orifice plate to give the profile jet needed for the performance at 2.5. bar.
  2. The flotation reagent is actually fed into a pump box on the bottom floor  $\approx$  150 feet below the cell's position. Amine and Starch are used. No serious problems with level controller. Blockage of the bubble (probe) is minimal, it actually occurred once in the first two weeks of operation and problem could be rectified in 5 minutes. Developed site programme for operators which they can spot the problem and solve it. Continuous purge with a small amount of fresh water help keep the probe clean.
  - 3 and 4 Automatic larocks valve situated on the tailings discharge. Basic single controller linked directly to the larocks valve via bubble probe and differential pressure transmitter. Actually, it is very simple level control technique not advanced at all except for may be its presentation at Cleveland as they have good set up but, the actual principles of controls are extremely simple. The bubble probe itself with the application has the capability to be washed out with sea brine if indeed there is a problem with the present value dropping to zero which can happen with bubble problems if for instance the inner ball is restricted giving false reading of the pressure at depth in the cell.
  5. The main parameter of the geometry of the vessel is the diameter, it actually determines the superficial rise velocity of the air when designing the vessel. This superficial velocity (JG) factor has to be correct. The pilot plant supplied during testing made it possible to do that. The Jameson cell as operating now is operating to design parameters established on the pilot scale which means it was a good scale up procedure.

The diameter of vessel is dependent on the flow. At the moment, the flow through the cell is 370 m<sup>3</sup>/h therefore 6 downcomers are required and to accommodate them a vessel of 3 m diameter is needed.

If the flow is reduced to 200 m<sup>3</sup>/h, then a diameter of 2 m may be used so primarily it is a volume variable but the JG factor must be established by measuring the amount of induced air into the cell, if too much air is induced, this can exceed the JG factor which is dependent on the diameter of the cell, so there is a lot of interacting variables between the volume of the cell expect to cope with and the air intake which is the amount of air that the potash actually requires.

**PAPER 29** Use of process management computer in sylvinite thermal treatment at Alsace potash mine  
J.P. Rulleau, Mines de Potasse d'Alsace, France

**Q - M.J. Burns, Cleveland Potash Ltd, United Kingdom**

*How do you measure the feed grade and the product grade to the crystallizers?*

**Ans:** We don't measure them by the same way. We continuously measure the feed grade by gammametry (K40) and the product grade by flame photometry. Our original feed grade contains only KCl and NaCl. We take a sample of the feed and dissolve in water to measure the level of KCl and NaCl. The knowledge of the feed grade is necessary to calculate as exactly as possible the amount of water injection. In this way, we can manage the grade of the product.

**Q - S. Abdulrahim, Arab Potash Company, Jordan**

*1. How many cristallizers do you have?*

**Ans:** We have three crystallization lines: two lines MESSO - one line LURGI. One line MESSO includes 7 bodies (7 stages); and the LURGI includes 6 bodies divided in three or four parts (21 stages).

The crystallizers MESSO have been modified to produce only standard grade. To reduce the size of the product, we change the rate of circulation and we extract the slurry only after the last body.

On the average, the size of the product is about 0.3 mm (5% less than 0.1 mm and 5% more than 0.5 mm).

We analyze the grade of each crystallizer.

**Q - 2.** What temperature is used?

**Ans:** The temperature of the feed brine is about 100°C and the output slurry is about 30°C.

**Q - 3.** What is the mode of cooling?

**Ans:** The brine is cooled by partial evaporation at a reduced pressure. Between 100°C and 50°C, the steam is condensed in exchangers, in which the mother liquor is warmed from 30°C to 80°C by counter-current.

Between 50°C and 30°C, the steam under very low pressure is condensed with cold water. We use a lot of water: 60.000 m<sup>3</sup> per day. Then, this water is used to dissolve the NaCl of the residues; after that the brine is discharged to the Rhine river.

**Q - 4.** Do you use that water for heat recovery?

**Ans:** No, the temperature of this water is too low. We have two heat recoveries at Marie-Louise:

- the heat recovery from the steam of the crystallizers between 100°C and 50°C
- the heat recovery from the exhaust fumes of the gas turbines. We have two gas turbines of 17 MW power and 80 t/h steam each. We recover the exhaust fumes of each turbine 10 MW of heat carried by water at 122°C and 7 bars. This heat is used to warm the mother liquor from 80°C to 90°C. We use the steam above 90°C.

**Q -** You said that you have introduced circulation - What did you mean?

**Ans:** Yes, the principle of the crystallizers MESSO as Swenson is based on recirculation of the brine in the body (7 to 10 times) to help to increase the size of the particles of KCl. But now, it's not our object. The recirculation requires also a lot of power. The greatest difference of temperature at each body helps also to increase the size of particles. But, the heat recovery decreases, based on the principle of Carnot.

**Q - M. Al-Saket, Arab Potash Company, Jordan**

*What quality control samples do you use in the plant? Analysis by computer*

**Ans:** We have a usual laboratory for analysis of the finished products (certification for customers) and quantitative analysis made during the day. On the other hand, to manage the process, we installed a continuous laboratory behind the control room. This laboratory requires automatic flame photometers and samplings. It runs by itself. We analyze the quality of the wastes (residues, brine that we send to the Rhine) and the quality of all the products. All the analyses are managed by the computer. Once a shift, a chemist verifies that all is in order.

## PARALLEL SESSION: "PHOSPHATES I"

**Chairman:** J. Basset, Grande Paroisse S.A., France

**Rapporteurs:** J. Allot, S.A. Engrais Rosier, Belgium

F. Samec, Grande Paroisse S.A., France

**PAPER 30** Granulation and partial acidulation of Egyptian phosphate for application as direct fertilizer

Nagui A. Abdel-Khalek, N.A. El-Hussiny and M.E.H. Shalabi, CMRDI, Egypt

**Q - M.S. Smani, Groupe Office Chérifien des Phosphates, Morocco**

*What is the amount of sulfide released during the acidulation with  $H_2SO_4$ ,  $H_3PO_4$ ?*

**Ans:** Sorry we do not measure the amount of hydrogen sulfide evolved during the reactions.

**PAPER 31** Flexibility in rock phosphate flowsheets to meet the specific requirements of individual plants

N. Hummadi, I. Owels and M. Mubaideen, JPMC, Jordan

**Q - A.R. van Brempt, Kemira SA/NV, Belgium**

*The  $SO_4$  content in reactors is manually sampled and analysed.*

*1. Have you experience with on line measurement for the  $SO_4$  content?*

*2. Is there in your opinion a substantial benefit to install such on line measurement (costs versus benefit)?*

**Ans:** Actually we are evaluating an  $SO_4$  analyser. It is working wonderfully. Those who are going to Aqaba will have the opportunity to see it. Our experience extends for only nine months. I can not really tell whether it is a complete success or not, but it is recommended because it gives you the opportunity to control the  $SO_4$  excess in the reactor which means better control of the attack and better control of the gypsum formation and obviously of the overall economy of the sulfuric acid.

**Q - D.W. Leyshon, Jacobs Engineering, USA**

*Is there any comparative data on boil out cycle time for evaporators between acid from Jordan rock vs acid from Morocco rock or Florida rock? Perhaps, this question can be answered by a producer who processes Jordan rock among others.*

**Ans:** What I can tell Mr. Leyshon and the audience is that during the past nine months we experienced the boiling-off cycle in the concentration being between two and three weeks. For at least once, we exceeded the boiling-off cycle for one month. For Florida and Morocco, I know that there are some plants that depend obviously on the process that they apply, but that's it, so we are happy that we are now joining the club. Is Mr. Leyshon kindly willing to comment or add something to that?

**Comment from D.W. Leyshon:**

Well I think that there will have to be a comparison run on identical equipment to have any validity. We know that in one plant for example, in the United States, an acid made from Morocco rock had a boil out cycle of perhaps five weeks versus three weeks for Florida, an order of magnitude like that. I was trying to establish whether there was any data which put the Jordan acid into a context like that, with some experience outside of Jordan because you obviously run only on Jordan rock.

**Comment from N. Hummadi:**

In a paper that will be presented this afternoon we will have a slide showing the boiling-off performances with Jordan rock in our plant in Aqaba.

**Q - A.R. van Brempt, Kemira SA/NV, Belgium**

*Can you give us an indication on the quantity of clay containing 15-20%  $Al_2O_3$  and 48-51%  $SiO_2$  you added to your rock in order to obtain a significant improvement on filtration?*

**Ans:** A very good question. Clearly it is a case of what rock quality you are using. As you have seen in the paper, we are using a variety of grades in Jordan. Depending on what grade you are using, we experienced adding some 3 to 5 kg when using high grade rock. High grade means 33 / 35 Jordan rock which can give the cluster shape crystal of gypsum which improves significantly the filtration rate.

**Comment:**

At Central Prayon dihydrate/semihydrate plant with mixture phosphates we add up to 5% aluminum depending on the rock. We add both aluminum silicate and silica because we run at 37%  $P_2O_5$  in a dihydrate form but, depending, as Mr. Hummadi says, on the quality of the rock, the additive can be even up to 5% of the total rock feed by weight.

**Q - F. Doudou, ICS, Senegal**

*What is the result, concerning the crystalline form, of mixing two rock phosphates?*

- *Does each phosphate keep its crystalline form in the mixture?*
- *If the mixture has a different crystalline form in relation with the original rocks, how does it change according to the proportions in the mixture?*
- *Did you note an optimum proportion for a better filtrability?*

**Ans:** We have not been so far in the evaluation of the phosphate. We make a mixture and the result is an improved crystallization. Whether it is due to N°1 or N°2 phosphate is really difficult to say. I believe it is a very good research topic, but I cannot tell which of the two components induces the improvement. We know the crystallization is improved by increasing the content of silica, as well as alumina. We also know that a few other elements affect crystallization but it is really difficult to say which of the two, or three components produces the improvement. I hope I answered the question.

**PAPER 32** Farmland Hydro L.P. increases efficiency with 495 t/d additional phosphoric acid evaporator capacity  
R.E. Boillat, Chas. S. Lewis & Co. and J.M. Friedman, Farmland Hydro L.P., USA

No question and comment.

**PAPER 33** Joint venture phosphoric acid project in Jordan  
 B.T. Crozier, Hydro Agri International, Belgium and D. Lefort, Krebs & Cie S.A.,  
 France

**Q - D.W. Leyshon, Jacobs Engineering, USA**

*We see a dotted line from the cooling towers in the water distribution diagram labelled "blow down".*

*1. What is this quantity?*

*2. What is the predicted  $F$  and  $P_2O_5$  concentration of the cooling tower circulating water?*

**Ans:** 1. Concerning the first point, the blow-down for the sulphuric acid cooling tower is 105 m<sup>3</sup>/h.

2. The answer to the second point: I have not exactly the value in mind, I will give the answer later.

**Comment from D.W. Leyshon:**

I requested for the quantity on the second cooling tower.

**Ans:** The quantity of the blow down from the phosphoric acid cooling tower is 99.5 m<sup>3</sup>/h in this case which is a little less than that from the sulfuric acid tower.

**Q - M. Takagaki, Mitsubishi Chemical Corporation, Japan**

*"The sludge which is raked in the storage tank returns to the filtration section" in your paper. Are there any trouble of reduction of filtration capacity?*

**Ans:** In our experience at our plant in Holland which also uses Jordan rock and recycles sludge in this way, there is no effect on the filtration rate at all.

**PAPER 34** Check-up for phosphoric acid units  
 P. Becker, France

**Q - D.W. Leyshon, Jacobs Engineering, USA**

*Your work seems to have been done mostly at high filter acid strengths, above 28%  $P_2O_5$ .*

*1. Do you believe the filtration rate vs residence time will be a flatter curve at lower strengths like 26%  $P_2O_5$ ? Some Florida producers see very high filtration rates at retentions of about 2 hours, providing the acid strength is low.*

*2. What can you say about rocks other than Togo and Senegal, with respect to filtration vs residence time?*

**Ans:** As I told you, the survey was made with operating plants and the plants I visited did not operate below 28 (% $P_2O_5$ ), they operated between 28 and 32, because with Togo and Senegal rock you can easily go up to 32% and you save a lot of steam. And I am sorry I can't ask the plant owner: "could you put your plant at 26% because I want to make a crystal diagram." I think that those plant owners who run at 26%, usually they had originally a plant with a smaller capacity and they have to overload it; if they have enough energy and they do it. Of course you can run it higher but you have also the viscosity interfering. What I was demonstrating here was not filtration capacity, it was crystal size diagrams with effect on filtration. It is clear that your filtration increases with the same crystal size distribution but a lower viscosity that also affects filtration of course and it is a direct function of the viscosity.

But I am sure that if they had a retention time of two hours, the crystals were smaller, its very simple: a crystal grows as long as a crystal is in a reactive slurry; it does not stop growing. And the growth rate is not proportional to the feed rate. I haven't measured it on Florida of course, but we made some diagrams and some isolated and I didn't see any big difference. The only thing that can happen or that will probably happen, if you have a heavy foaming rock, is that you need more agitation and maybe the parameters then are somewhat different from the Togo and Taiba diagrams because they have only 1.6% CO<sub>2</sub>.

Q - P.A. Smith, Société Chimique Prayon-Rupel S.A., Belgium

Do you have any indication of the effect of the residence time distribution and thus the crystal size distribution on the filtration rate. Or to put in a different way, how much do the 10% smallest crystals reduce the filtration rate compared with how much improvement do the largest 10% crystals make?

Prayon has generally used relatively large reaction volumes and thus longer retention times due to the ease of construction of such reactors with the multi-compartment design, even for large daily tonnages. But we have found that even though the mean residence times of units of the Mark 3 and Mark 4 designable or the same value the filtration rates of the mark 4 are superior even though the mean crystal size is not very different. The difference being that the crystal size distribution is much narrower in the case of the mark 4 design.

The "digestion" section of the Prayon process is included to narrow the residence time distribution and as such the crystal size distribution is narrowed as well thus increasing filtration rate.

Ans: I will answer one by one. OK. What means residence time distribution, whether you have a multi-tank system with a circulation or a single tank, there isn't much change because the circulation inside the multi-tank system is much higher than the flow in the filter so that you can consider that your crystals are homogeneous within the whole unit and the size distribution is a very strict mathematical law which is the same so there cannot be changes within size distribution because there is so much over-flow, so many stay inside, so many go out, you have always the same diagram. You cannot have a diagram with irregularities. If you have such, either your screening or your measurement was wrong or something happened; you have a break-down in the mean or a stop or a restart, you cannot have the lines crossing each other, it's impossible. If you have a high growth rate or a low growth rate, it will be steady. Then the lines keep separate.

Now the second question was: ten per cent of the smallest and the largest. It is essentially the smallest crystals that affect the filtration rate. And this is definitely because some of the units you see on the diagram, they have a very small volume and they have up to 40, sometimes 60% material below 40 microns. This is a big difference when you compare with the filtration rate when you only have 15 or 20% below 40 microns. It is essentially with the small fraction that you find out the reason for your high or low filtration rate. The 10% of the biggest have not such a strong effect. Conditions are a little bit changed with the very big fractions because what makes the crystal grow is that it must get the feed material from the ions from the solution, and the crystal displaces himself through the liquid by gravity, the difference of specific gravity. Now, you agitate, everything flows, but the differential speed between the crystal and the liquid is all the same, this is why agitation for crystallisation has a very, very small effect from the moment you have everything in suspension. Now, some people here would say "no, no we need two horsepower", and I agree. I have written it in my book, you need the high horsepower, because when you introduce the material, you have to mix it very quickly and very thoroughly. Number two; you have CO<sub>2</sub>, you have foam, you have to break the foam, this is your energy consumer, but, for the crystal, we made crystal-growth studies with energy variation one to ten and didn't find a measurable difference. So the next question was about the narrowing of the crystal spectrum; narrowing the spread pattern would mean a smaller volume.

What happened with Mark 4 is that they had the reaction section reduced and the buffer tank increased. Now this is a little bit tricky situation because in the buffer tank the feed rate is lowest, you can only desupersaturate and its about half an hour retention time that is used for crystallisation in the buffer tank. I am not talking about the sludge set, the secondary elements crystallisation; the effect of the Mark 4 is not always the same when you use different rocks. For example in Italy, of two Mark 2, one was converted to Mark 4 and when they run Togo in the Mark 4 it wasn't running better than in the Mark 2. I am sorry Paul but that is only for Togo, they didn't use Morocco rock.

And it depends on how you measure the crystal sizes and I'm afraid I may not have all the elements to give a precise answer, and again, I want to underline that we made that study only on Togo and Taiba. We made partial studies on Texasgulf and we could find similar reactions but we could not draw the whole diagram. I have only a few results on Morocco rock.

**Q - B. Crozier, Hydro Fertilizer Technology B.V., Belgium**

*In our plants, we have found that the  $SO_4/CaO$  ratio in the reactor has an effect on crystal size measures by specific surface area. This effect is in addition to that caused by residence time. Can you explain?*

**Ans:** It is probable that with different sulfate to calcium ratios you have different nucleation rates. I have not worked on hemihydrate, but it is so with the dihydrate system and there is no reason it should be different with hemihydrate.

## PARALLEL SESSION: "NITROGEN II"

**Chairman:** V.M. Olevsky, GIAP, Russia  
**Rapporteurs:** P. Ravichandran, SAFCO, Saudi Arabia  
 Z. Vybrál, Lovochemie AS, Czech Republic

**PAPER 35** Nitrogen oxide formation and reduction in steam reformers  
 R.R. Martin, Callidus Technologies Inc., USA  
 (Presented by J. Gillepsie, Callidus Technologies Inc., USA)

### **Comment from Z. Vybrál, Lovochemie AS, Czech Republic**

*We use a selective catalyst of vanadium base in our small nitric acid plant in Lovochemie and has good performance even after 14 years of operation.*

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

*When you took out the LP purge gas, where did you put it?*

**Ans:** They clean out the ammonia in the LP purge gas.

**Q - V.M. Olevsky, GIAP, Russia**

*The degree of purification of NO<sub>x</sub> is not very high in your country - 30 to 50% is enough?*

**Ans:** The highest standard for NO<sub>x</sub> emission today in USA is in Southern California - 0.031 lb/MMBTU heat release.

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

*Can you give some idea of the relative cost of the different NO<sub>x</sub> reduction methods detailed in the paper?*

**Ans:** With the use of internal recirculated burners, the fortune ball of a particular unit is actually replacing existing burners in the existing holds of the furnace. With the catalytic, non-catalytic SCR units, they require ducting, ammonia injection beds; in the ducting, some of these ductings are huge, plus all the temperature control equipment, ammonia storage, the need to drive the ammonia into the system with steam or other fuel. Cost of the catalytic beds - dependent on the contaminants in the particular stream that will determine the life span of the beds.

**Q - V.M. Olevsky, GIAP, Russia**

*Are your catalysts affected by poisons?*

**Ans:** Callidus is strictly in the burner business. All the catalysts we have observed can be contaminated by different chemicals. The most common is plugging and this can be removed by specific chemicals for that particular catalyst.



**Comments from V.M. Olevsky, GIAP, Russia**

**Summary:** You would notice that the NO<sub>x</sub> standards are very different worldwide. Further, the technology to reduce NO<sub>x</sub> emissions are also different. In our country, we begin with the catalytic purification and we had more than 20 years ago reduced the NO<sub>x</sub> emission to not more than 50 ppm. Although different catalytic materials are being used in all the nitric acid plants throughout Russia and other republics in the former Soviet Union, the end results are the same.

**PAPER 36** New honeycomb catalysts for SCR NO<sub>x</sub> abatement  
L.M. Marzo and J. Marzo, ESPINDESA, Spain

**Q - V.M. Olevsky, GIAP, Russia**

1. *Please give the pressure drop figures in comparable conditions for the usual and honeycomb catalyst abators in your installations?*
2. *What is the price of 1 m<sup>3</sup> of ordinary and honeycomb catalysts?*
3. *In the case of honeycomb catalyst: do you need the same volume of reactor for accomplishing the reduction process to a given degree? What will be the capacity of the unit under construction?*

- Ans:**
1. Depending on the volume of catalyst, the pressure drop of a granular catalyst varies from 400 to 700 mm w.c. In comparable conditions, the pressure drop of a honeycomb catalyst is in the order of one tenth of the above figures.
  2. For obvious reasons, we cannot disclose the prices of our catalysts, but it can be said that the cost per m<sup>3</sup> is higher for honeycomb than for granular catalyst and that the volume of catalyst needed for a given degree of NO<sub>x</sub> reduction is about the same.
  3. The unit under construction contains 1000 litres of catalyst.

**Q - J.A. Benes, Uhde GmbH, Germany**

*In the catalytic conversion of ammonia to nitrogen oxides over Pt-Rh catalysts in the order of 1% of incoming ammonia is oxidized to di-nitrogen-oxides (N<sub>2</sub>O). Could you inform us on your work on incorporating the catalytic destruction of this ozone-killer on your catalyst?*

*At what temperature level would N<sub>2</sub>O be destroyed on your catalyst?*

- Ans:** When developing our catalyst, our main aim has been achieving a catalyst which abates efficiently NO<sub>x</sub> without formation of undesirable N<sub>2</sub>O and we have got it.

**PAPER 37** G.P.'s experience for selective catalytic reduction in nitric acid plants  
P. Gry, Grande Paroisse S.A., France

**Q - B. Christensen, Kemira Denmark, Denmark**

*Do you recommend the GP deNO<sub>x</sub> process for tail-gases in the temperature range of 170-180°C without any preheater?*

**Ans:** At present, we don't recommend to operate at such a low temperature. One of our plants at Toulouse operates at 190°C, but at 170-180°C, we prefer to add a preheater. When we start up our plants, we do not add ammonia immediately, we start up at 180°C but we do not operate continuously. In our laboratory, we managed to operate at 140-150°C, but at full scale we do not take the risk to do it, we prefer to add preheating.

**Q - J.A. Benes, Uhde GmbH, Germany**

*In your introduction, you mention the composition of nitric acid plant tail-gas: 500-3,500 ppm (vol) N<sub>2</sub>O. This would mean that between 0.9 and 6 percent of all incoming ammonia would be oxidized to N<sub>2</sub>O. This poses a considerably higher danger to our environment (N<sub>2</sub>O is an ozone-killer more powerful than CFC's). Could you explain what you are doing to incorporate the destruction of N<sub>2</sub>O on your selective catalyst?*

**Ans:** The purpose of this paper was to deal with NO<sub>x</sub> reduction. For that purpose, we carried out N<sub>2</sub>O control in nitric acid units. The N<sub>2</sub>O content usually varies between 500 and 2000 ppm, that is what we measured in our plants. We have values, from the other colleagues and we obtain fairly constant values. I can say that this catalyst does not produce N<sub>2</sub>O. We do concentrate on trying to reduce N<sub>2</sub>O. We have something ready, we have a patent. It is not a thermal decomposition, it is a catalyst but I cannot say more for the time being. I may be able to make a presentation next time on N<sub>2</sub>O reduction but we have something ready.

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

*What is the accuracy of the "Nicolet" analyser system compared to chemiluminescence techniques?*

**Ans:** These two apparatus are very different. Chemiluminescence enables to measure NO and NO<sub>2</sub> but not ammonia and N<sub>2</sub>O. Nicolet is an infrared apparatus developed by Fourier. We developed it in the laboratory pilot; we tried to find an apparatus which could measure the four parameters: NO, NO<sub>2</sub>, ammonia and N<sub>2</sub>O. It is presently the only equipment available on the market; it is fairly expensive but we thus have one apparatus instead of two; it is reliable, in spite of our fears before installing it; we have it on all our units except one or two on which we did not use it. Otherwise, we use it extensively, in a protected atmosphere; there is no problem. We are very satisfied with the results. This is its advantage. There might be others, but, for the time being, I only know Nicolet as a system.

**Q - V.M. Olevsky, GIAP, Russia**

*What pressure differences have you registered in your axial and radial reactors?*

**Ans:** Generally, we operate before the release turbine; we thus have a sufficient pressure and operate between 3 and 8 bars. It could obviously be included after the turbine, but, at atmospheric pressure, we need a much bigger tank which is not economical. There is a much bigger pressure drop. In that case, a radial equipment is more interesting; there is less pressure drop. In that kind of equipment, pressure drops are not very important: about 50 to 100 g/cm<sup>2</sup>. It is acceptable, but after the release turbine, there is an additional energy consumption. As far as possible, we try to put it before.

**PAPER 38** Improving productivity in ammonia and urea plants at GNFC  
G.K. Parikh and K.M. Jani, Gujarat Narmada Valley Fertilizers Company Limited,  
India

No question and no comment.

**PAPER 39** The Camit ammonium nitrate process - an emphasis on energy efficiency and environmental compatibility  
**J. Brandt, Kemira Engineering Oy, Finland and J. Rennotte, Kemira S.A., Belgium**

**Q - V.M. Olevsky, GIAP, Russia**

1. Which type of high-efficiency scrubbers are used?
2. Do you use a special type of pH-meters for AN-solution control and regulation?
3. What are the investment costs and the operational of AN<sup>+</sup> produced by Camit process compared with the ordinary process of the same capacity?

**Ans:** 1. They are of special design - back scrubbers in the packing tower, and of proprietary design and was first constructed in co-operation with earlier Kemira set-up.

2. This is also another proprietary design by Kemira and is a specialty of the Camit process.

3. For the basic Camit process, the price should be the same with very little difference. The low investment will be cheaper but would depend on the site conditions, highly dependent on how one would adapt the Camit system. On the operation, there is one person manning the plant - he is manning the granulation plant as well, and there is half-person around the plant. The whole operation is like a train and very reliable. During the 18 months of operation, the plant had been stopped only 5 months.

**Q - 4. In terms of overall reliability and taking into consideration all the constraints, how does the Camit plant compare with the ordinary plant?**

**Ans:** In our 4 years' experience, the Camit plant has been shown to be more reliable; we do not have the corrosion problem since the loop is alkaline.

**Q - 5. Does that mean that when Kemira wishes to sell the process in future, it will be the Camit process?**

**Ans:** Yes.

**Q - S.R. Fitzpatrick, CSBP & Farmers Ltd., Australia**

*Is there any evidence of NO<sub>x</sub> emissions in the continuous purge of non-condensibles from the process?*

**Ans:** No, there are no problems. This gas is related to the granulation plant and is taken off by the scrubbers in the plant. These are very small and is related to the inerts in the feed and the leaks.

**Q - D.C. Thompson, ICI Fertilizers, United Kingdom**

1. What do you take for safety precautions on the ammonium nitrate pumps?

**Ans:** Due to the alkaline solution, the risk of explosion is very much smaller. Further, we are operating at a pressure higher than the vapour pressure of the solution.

**Q - 2. I was thinking of the high temperature trips in case of anyone interfering closer to the delivery valve.**

**Ans:** The highest temperature we have in the Camit unit is in the loop itself where the concentration is rather low (80%).

**Q - 3.** *I am thinking of the operators inadvertently closing off the delivery valve and the pump is still running.*

**Ans:** There are three trips for that function. In fact, there are so many trips installed on this plant that when it was made ready for the first operation, sceptics said the plant would not operate for more than five minutes.

**Q - V.M. Olevsky, GIAP, Russia**

*What precaution do you take to prevent explosion due to entry of foreign material. Do you have any explosion in Kemira connected to the production of ammonium nitrate?*

**Ans:** We have trips linked to the computer that automatically would enable us to flush down the system immediately. We did have explosions in the outdated units, previously but not in any of the Camit plants.

## PARALLEL SESSION: "PHOSPHATES II"

**Chairman:** K.C. Knudsen, Kemira Denmark AS, Denmark  
**Rapporteurs:** P. Christensen, Kemira Denmark AS, Denmark  
 A.R. Van Brempt, Kemira SA/NV, Belgium

**PAPER 40** Use of divers' liquids in the reduction of heavy metals during the production of phosphorus fertilizers by nitric acid-ammonia process  
 Z. Krawiec, Physicochemical and Environmental Laboratory and B. Waligora, Jagellon University, Poland and X. Nguyen, Pedagogical Institute, Vietnam

**Q - R. Perander, Kemira Oy, Finland**

1. *In which scale has the new process been demonstrated?*
2. *What is the additional cost per ton of  $P_2O_5$ ?*
3. *Can the concept be used for cleaning phosphogypsum from heavy metals?*

- Ans:**
1. Physicochemical and Environmental Laboratory is a small enterprise so we have developed our method in laboratory and large laboratory scale. We use in our words micro system, developed by Laboratory and we can measure physicochemical equilibria under or above atmospheric pressure, as well as chemical reaction, extraction in non aqueous environment, etc.
  2. If we compare the cost of different method for elimination of cadmium from phosphoric acid or phosphoric compounds MAP, DAP, NPK, NPK Mg or NP, it is far less than the other methods in large laboratory scale.
  3. This is very interesting question concerning the chemistry in liquid non aqueous system. The answer is positive - our method can be used for cleaning phosphogypsum from cadmium and some heavy metals especially when it exists great difference between solubility products of phosphogypsum and sulfate of heavy metals or when exist possibility of formation of complexes with ammonia. I think this problem is of great importance - could we collaborate to research this problem?

**PAPER 41** Rehabilitation of JPMC phosphoric acid plant in Aqaba  
 N. Hummadi, JPMC, Jordan, P.A. Smith, Société Chimique Prayon-Rupel and  
 P. Pluvinage, Coppée-Lavalin, Belgium

**Q - D.W. Leyshon, Jacobs Engineering, USA**

*What was the chemical analysis of the rock used during the test runs, particularly the  $Al_2O_3$  content and was clay added as described in paper N° 31?*

**Ans:** The chemical analysis contractual agreed upon by JPMC was  $P_2O_5$  between 32-34% and  $R_2O_3$  about 0.66% (R = Fe, Al). It was difficult to obtain phosphate rock with  $P_2O_5$  less than 32% in the tests as almost all Jordanian grades of phosphate rock contain more than 32%.

The performance tests were made with phosphate rocks containing 31.8-9%  $P_2O_5$ . The content of silica was about 4.5%,  $Al_2O_3$  about 0.3% and  $Fe_2O_3$  about 0.25%. Clay was not added. The only addition to the reactor was by-product silica from the aluminium fluoride plant. This by-product addition is an integrated part of the Prayon process.

**Q - M.A. Riponleml, Kemira Oy, Finland**

1. *Before rehabilitation, the capacity of weak acid production was about 60-73% of the nameplate capacity. What was the primary reason for the production problems around filtration section, poor crystal formation and therefore low filtration rate or problems with scaling of filter clothes or mechanical problems?*
2. *What is the present running period between washings in weak acid production if the need of maintenance work is also taken into account?*

**Ans:** 1. The limitation on capacity was mainly a limitation on cooling capacity and residence time. The scaling of the filter is due to high temperature operation in the reactor, which again is due to limited volume of the reactor and low residence time.

2. Presently, the running period between washings is 2-3 weeks depending on filter cloth quality. There is limited need for maintenance, so washings, cloth change and maintenance can be done in the same shutdown period about every 3 weeks.

**Q - A.R. Van Brempt, Kemira SA/NV, Belgium**

*Have you knowledge or experience with special packing placed in fluorine scrubbers in the concentration sections in order to improve the fluor recovery efficiency?*

**Ans:** There isn't any packing placed in the fluorine scrubbers at the Aqaba plant. The scrubbing system is a scrubbing vessel with nozzles, water-addition and recycle of scrubber liquid.

Prayon offers a proprietary design for fluorine recovery. There are two critical factors in fluorine recovery, the fluorine entering the scrubber and the entrainment of fluosilicic acid droplets leaving the scrubber. The loss of fluosilicic acid in a conventional scrubbing system with a high recycle-ratio can become 100%. In the Prayon proprietary system for fluorine recovery, there is a narrow scrubbing tower with relatively low liquid recycle ratio followed by a special designed droplet separator to recover carry-over fluosilicic acid droplets. The first scrubbing tower is a void tower with one nozzle.

**Q - D.W. Leyshon, Jacobs Engineering, USA**

1. *The cooling tower is described as an 18 cell forced draft unit. Why so many cells?*
2. *What special design is used to minimize drift?*
3. *What does the cooling water analyse in mg/l  $P_2O_5$  and mg/l of fluoride, now that the modified plant has been in operation for some time?*

**Ans:** 1. It is because of the chosen design for the cooling tower ventilator. The requirement was to cool down the total water amount from 40°C down to 30°C. The needed consumption of power was 90 GCal per hour.

2. To combat the drift, special design of mist eliminator was used, although the guaranty was less than 0.02% - the measured value was 0.0004%.

3. It depends on operational conditions for the plant. How often the plant is shutdown? How often the tower is emptied? After the rehabilitation of the plant and with normal running conditions, the content of fluoride is about 0.5% and the content of  $P_2O_5$  is about 0.2 g/l.

**Q - F. Doudou, ICS, Senegal**

*Concerning yield: what is the distribution of losses before and after rehabilitation?*

- unattacked
- syncrystallized
- water-soluble

**Ans:** Unfortunately, I have no comprehensive answer to that question, but, at this stage, we can say that the  $P_2O_5$  recovery in the dilute acid section before revamping was about 94%. The average recovery is included in the paper.

If you want further information on the paper, you will get them after the Conference.

Concerning the present recovery, after revamping, we never went down below 95.25%; we always stayed above 95.25% and sometimes exceeded 95.87%

It depends on the capacity, the operational mode and the way you manage your plant.

**PAPER 42** Studies and research on processes for the elimination of cadmium from phosphoric acid  
A. Davister, Belgium

**Comment from M. Sipilä, Kemira Oy, Finland**

The actual emission figure shown yesterday in our paper included the total emission in phosphoric acid production, including the pond area and the gypsum pile i.e.

phosphoric acid plant + pond area + gypsum pile = 0.050 kg F/ $P_2O_5$

Compound fertilizer plant 0.0022 kg F/kg product ( $P_2O_5$  on average 10% in the NPK's produced)

**Q - F. Samec, Grande Paroisse S.A., France**

*Is it not illusory to speak about valorization in the present and forecasted context of the market of non-ferrous metals?*

**Ans:** I agree, the cadmium market is already flooded with non ferrous products and by-products and adding the cadmium contained in our phosphates would be difficult, especially if you have to fix a price.

But there are other valorizations, in particular in the case of the co-crystallization process. There is an important valorization in the fact of having a concentrated merchant-grade phosphoric acid, which has no tendency to precipitate, while 52-54%  $P_2O_5$  merchant acids must always be given a sufficient desaturation period in the tank before delivery. Generally, it raises problems of solid precipitation.

It is sure that, after the very hard treatment which consists in the co-crystallization of cadmium in anhydrite, these acids have not more tendency to precipitate.

There is another possible valorization, which is mentioned by some authors and Mr. P. Becker among others, namely the rare metal valorization, present in the phosphate and which co-precipitate with cadmium in anhydrite.

**Q - P. Suppanen, Kemira Agro, Finland**

**1. Where are the industrial scale cadmium removal systems?**

2. *What are the processes?*

3. *Is international support/money available for such projects?*

**An:** 1 and 2

The PP-route (precipitation) is in industrial operation at Groupie Chimique Tunisien plant. The decadmiated acid is used in manufacturing of animal feed. The SX-route (solvent extraction) is in industrial operation in Budenheim in Germany. The decadmiated acid is used in manufacturing of food grade phosphates. None of the decadmiated acids are used in manufacturing of fertilizers.

3. It is possible to get EEC-support for the CC-route. One project is ready to start.

**Q - R. Vermeul, Hydro Agri Rotterdam, Netherlands**

*Concerning the PP-route:*

*Thiophosphates are known for their toxicity and smell. Is the treated acid absolutely free from thiophosphates and the terrible smell?*

*Have any specific precautions been taken in the full-scale process to neutralize these effects?*

**Ans:** The conditions under which phosphoric acid is treated with big molecules containing sulphide ions will precipitate CdS and destroy the used "molecules" and liberate some H<sub>2</sub>S. Removal of H<sub>2</sub>S can be done with air blown through the acid or by agitating the acid. In practice, both lab and full scale, there seems to be no problem with smell.

**PAPER 43** - Advanced-ammonia phosphate scrubbing with minimum water discharge  
S.V. Houghtaling and V.J. Margiotti, Jr., Hitech Solutions, Inc., USA

**Q - D.W. Leyshon, Jacobs Engineering, USA**

1. *In the flowsheet Figure 1, what is the quantity of pond water scrubber solution that must be absorbed in the reaction system?*

2. *You are also absorbing the condensate produced in Figure 2. What effect do these 2 dilution streams have on the feed acid strength? Isn't this significant?*

3. *It would seem that a simpler system, more adaptable to existing scrubber systems, would be to vaporize ammonia by a heat exchanger utilizing hot recycled tail-gas scrubber water. CFI uses this system. What are the disadvantages?*

**Ans:** 1. 10 gpm - 2.3 m<sup>3</sup>/hr.

2. The condensate is very clean (see the paper) and is not absorbed in the DAP process. This stream can be used in other places on site or sent to the pond.

3. The process discussed in the paper does not need a tail gas scrubber to meet EPA regulations. The process suggested by Mr. Leyshon does require a tail gas scrubber to meet EPA regulations, which is very expensive to install and to operate. The disadvantage in using hot recycled tail gas scrubber is a tail gas scrubber is required.



**PAPER 44 Environment-friendly production of phosphoric acid**

R.M. Vermeul, C.G.H. van Ede, P.C.M. Mutsaers and N.W. Kolmeijer, Hydro Agri Rotterdam, Netherlands

**Q - P. Becker, France**

*What are the max-minimum temperatures to operate the ion-exchange beads?*

**Ans:** During one year, all the tests were performed with an acid of 70°C. The beads were examined with a microscope every month. There was no attrition of the granules and tests showed no less of capacity for the resin.

**Q - N. Hummadi, JPMC, Jordan**

*1. In which form do you add the chlorine?*

*2. How does chlorine effect the material of construction and the quality of product acid?*

*3. What would be the cost of Cd removal by the ion-exchange method? (per ton of P<sub>2</sub>O<sub>5</sub> or per kg of Cd removed?)*

*4. What is the capacity of the pilot plant used for this study?*

**Ans:** 1. Chlorine is added as a saturated NaCl-solution.

2. The choice for filter was a belt filter with very few metal parts. Rubber lining and plastic parts were used, where it was possible. When metal parts were unavoidable, the choice was Hastelloy C-22.

All the excess chloride is removed, when the concentrated acid is made by evaporation. The decadmating treatment does not affect the quality of the acid.

3. Is answered later.

4. The capacity is normally 100 litres per hour.

**Q - M. Sabbah, SIAPE, Tunisia**

*1. Is the system at the level of the ionic exchanger managed by computer? If yes, what is the cycle?*

*2. Did you find some difficulties in the regeneration of the resin?*

**Ans:** 1. The rotational speed of the carousel used by HAR is normally 3-4 hours per cycle. The nature of the acid determines the amount of residence time in the carousel. The content of Mg and Cd is of importance. HAR has a computer model for calculating diffusion of Cd into the granules, which determines the amount of residence time. The viscosity is also of importance.

2. No, because it is anion-exchange. The cadmium chloride complexes have very high affinity, higher than phosphate- and sulphate anions. This means that cleaning with water is enough to decompose cadmium chloride complexes and get a solution with high cadmium and chloride concentrations and low phosphate and sulphate concentrations (fluoride too).

**Q - M.S. Smani, OCP, Morocco**

*Among the main processes tested to eliminate cadmium, you conclude that ion exchange is the process chosen by HAR.*

1. *What is the pre-treatment to which the acid should be subjected before treatment of the resin?*
2. *What is the stability of the precipitates of Cd and As obtained? How do you intend to manage these precipitates?*
3. *What is the content of Cd in the expected effluents which are discharged into the Rhine?*
4. *What is the cost of decadmiation by resin?*

**Ans:** 1. Most decadmiation processes are insensitive to solids in the acid (See Paper 42). The pilot tests performed by HAR might be different from full scale operation, but the chosen process will not give any problems. If the arsenic removal is not included, it might be necessary to do further pretreatment after the settling step. These treatments could be flocculation or filtration.

2. The arsenic sulphide precipitate is quite stable and H<sub>2</sub>S-emission can be avoided by adding "some components" - it is not a problem. The cadmium will be precipitated by hydroxide or phosphate addition. The disposal must be made in a proper way to avoid leaking. The amount of disposals will be limited, and in practice, the disposal will not be a problem. The arsenic sulphide will be filtered in a pressure filter and disposed in containers. This will be done with precautions in handling. Cadmium cake disposal will be similar to arsenic disposal except maybe an extra settling step.

3. The content of Cd can be reduced to a level below the detection limit by adding enough chloride to the slurry. The chloride addition will be stopped at this point. The slurry will be recycled to the HDH-process (if a plant is built).

4. Is answered later.

**Q - P. Suppanen, Kemira Agro, Finland**

*What is the cost of cadmium removal in Vlaardingen, including investment and increased running cost?*

**Ans:** The total cost including arsenic removal, cadmium precipitation and disposal of cakes is \$ 20-40 per mt of P<sub>2</sub>O<sub>5</sub> at a capacity of 100,000 mt P<sub>2</sub>O<sub>5</sub> per year. The total cost for this treatment depends on the rock used. HAR has not yet built a full scale plant for cadmium removal.

**Q - A.D. Ghosheh, JPMC, Jordan**

1. *Can you specify the Cd content in the feed phosphate?*

2. *Do different rocks have a different behaviour as regards Cd content in phosphogypsum?*

**Ans:** 1. The cadmium concentration in Jordanian phosphate rock on average is 7 mg/kg.

2. The cadmium distribution depends in general on factors like type of process, anhydrite formation, degree of supersaturation (influenced by alumina, excess sulphate, etc.). In the HDH-extra-process, these factors are carefully controlled hence rather stable distributions occur.

By adding chloride, we can influence the distribution to obtain the gypsum quality required. The HDH-extra-process with acid purification (Cd- and As-removal) is patented.

# ERRATA

**PAPER 16** Ammonia plant reformed gas waste heat boiler leak and its effect on high temperature shift converter catalyst  
P. Ravichandran and O. Al-Mulhem, SAFCO, Saudi Arabia

Page 162: Item 4 - 1st line

*Read: 366 numbers instead of 366 number*

Page 162: FIRST TIME LEAK IN RGWHB - 1st line:

*Read: After 20 years instead of After more than 20 years*

Page 163: A. CO SLIP: 2nd paragraph - 1st line:

*Read: values analysed instead of values analyses*

Page 167: FIGURE 2

*Read: DOWNCOMERS (12 NO.) instead of DOWNCOMERS (6 NO.)*

**PAPER 43** Advanced ammonia phosphate scrubbing with minimum water discharge  
S.V. Houghtaling and V.J. Margiotti, Jr., Hitech Solutions, Inc., USA

Page 466: Item 6 - line 5

*Read: per 60 tons of DAP product instead of per ton of DAP product.*